B L W F 58

USER'S GUIDE

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Contents.

1. GENERAL CODE STRUCTURE

General code structure is shown in figure on the next page. The initial main data file **fn.dat** (default file's name is **BLWF58.DAT**) contains the configuration geometry, the information about computational mode and computational parameters.

Also, the set of additional data files can be used, depending on a particular problem:

beam.dat - for the calculation in view of elastic strains of configuration (see **Appendix A**);

rotation.dat – for the calculation under a condition of steady manoeuvre (see **Appendix B**);

aileron.dat – for the calculation taking into account the deflection of the control surfaces on the wing and tail (see **Appendix C**).

fan.dat – for the calculation taking into account the propeller slipstream (see **Appendix D**).

The following data is read out from main **fn.dat** file: the grid number (NM), from which the calculation will start; index ICONT, indicating whether the calculation will start from the beginning (ICONT=0), or the initial potential field will be read out from the file **fn.sav**.(ICONT=1); the indicator ICONTM which tells the manner of obtaining the information about mesh node types and about the nodes interpolation parameters; the control parameters for the plotting and printing.

If ICONT=1, then the initial potential field is read out from the file fn.sav and the calculation will start from the grid on which the potential field was recorded.

After the meshes generation for wing/body/winglets, nacelle and tails, the illustrative pictures of the computational grids can be formed (plot files **101.ps-105.ps, 111.ps-113.ps, 121.ps-, 123.ps, 181.ps-185.ps, 191.ps-195.ps**).

Then if FCONTM= 0. and the nacelle or/and tail are present, then the code makes the analysing procedure for obtaining the information about the mesh nodes types and the interpolation parameters, the results are recorded to file **fn.msh**. If the overlapping of the computational grids is not suitable, then the code is terminated and the picture **110.ps** is formed which clear up the situation.

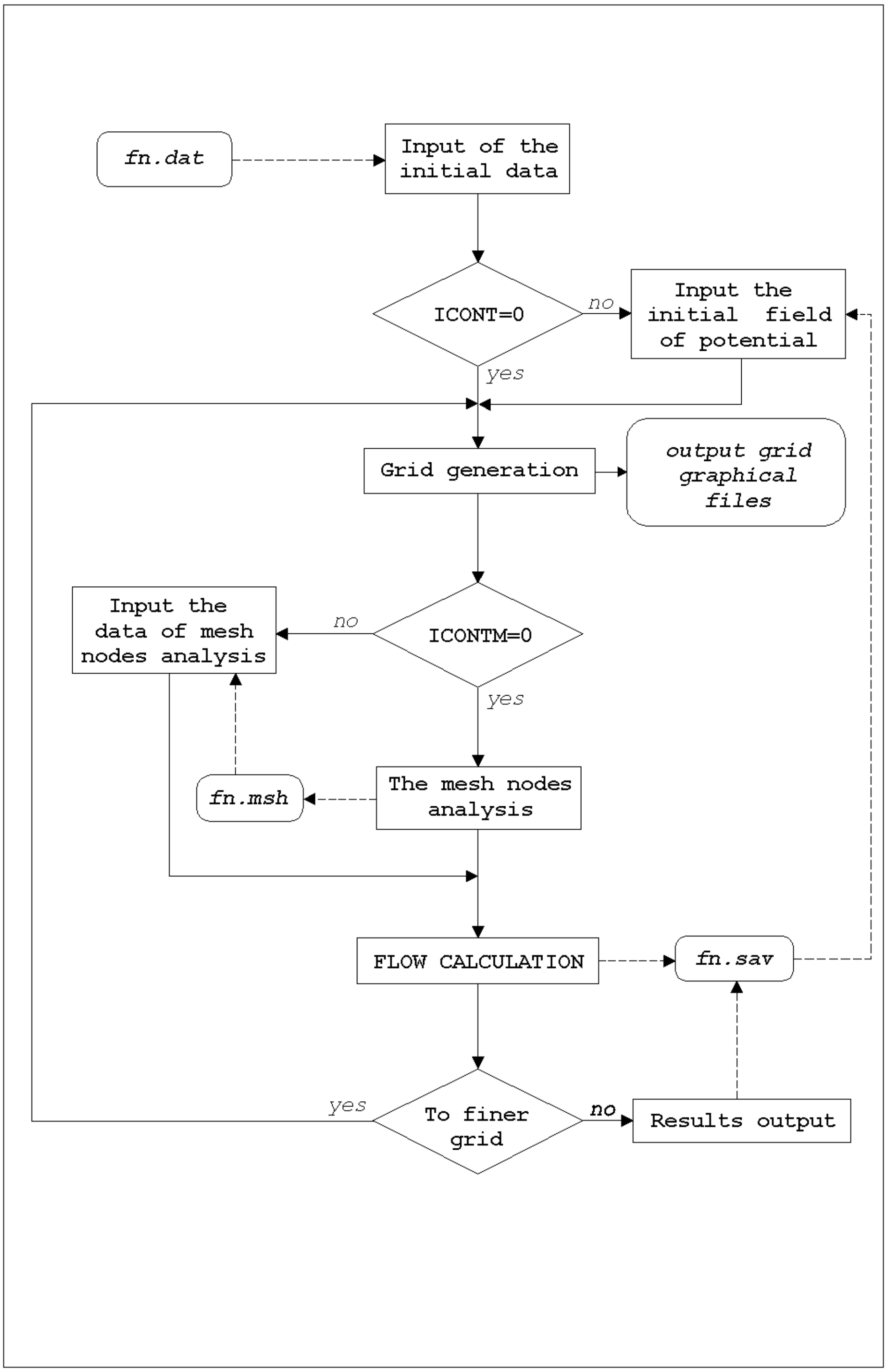
If FCONTM=1., then the information about the nodes tipes and interpolation parameters is read out from the file **fn.msh**.

While the viscous-inviscid calculation is carried out, the potential field is recorded into the file **fn.sav** before each calculation of boundary layer parameters.

After the specified amount of iterations is fulfilled on the given grids, the potential field is recorded into the file **fn.sav** and the calculation continues on finer grids, if there is any.

If no - then integral characteristics of the flow over the configuration are calculated and the result are presented in the set of graphic files 010.ps-099.ps and in the set of ASCII files fn.pl0**, fn.pl4, fn.cp**, …….

In the process of computation the code forms the text file **BLWF58.out**, which contains the information about computational procedure.


fn.dat
Input of the initial data
ICONT=0
no
Input the initial field of potential
yes
Grid generation
output grid graphical files
Input the data of mesh nodes analysis
no
ICONTM=0
yes
The mesh nodes analysis
fn.msh
FLOW CALCULATION
fn.sav
yes
To finer grid
no
Results output

2. THE INITIAL DATA FILE FOR CODE BLWF58

2.1 Description of the initial data file.

Example of the initial data files (for wing/body + two nacelles + tail) is presented in **Section 2.6**. Note, that the input data file for **BLWF58** differs from that file for **BLWF52** version. The changed and added items are marked in the example with "*".

All data (except for name of configuration) are introduced based on the F10.5 format (and should include ".").

1. <u>Title of configuration (80 characters)</u>

2. <u>MACH, ALPHA, BETA, RE, CAX, SW</u>

MACH - The free stream Mach number.

ALFA - The angle of attack in degrees.

BETA - The yaw angle in degrees. If BETA>0 then right half-wing is an upwind one (see also **item.70**)

The side flow will be taken into account during calculation, only if the prescribed grid overlapping parameter NY_BETA≠0. (see **item 70**)

RE - Reynolds number.

CAX - Reference length for Reynolds number.

SW – Half of the reference wing area.

If SW=0. in the input data file, then the code sets SW equal to the total area of the prescribed half wing.

3. <u>ICL, CL, DCLDA</u>

ICL - control parameter for calculation when target lift coefficient is prescribed

ICL = 0. – calculation with prescribed angle of attack;
ICL = 1. – calculation with prescribed lift coefficient;

If ICL=1. then the following two parameters are used:

CL - target value of lift coefficient;

DCLDA – rough estimation of value $dCl/d\alpha$ for configuration (as a rule DCLDA=.15). When ICL=1. the code realizes set of calculation selecting necessary angle of attack. The code uses the prescribed input angle as a starting value. So it is better if the input angle of attack corresponds roughly to the target CL value.

4. <u>PSE, DELWING, IBEAM, IAIL, IROT, IFAN</u>

PSE - Control parameter for the nonisentropic correction

PSE=1. - the nonisentropic correction is used,

PSE=0. - no correction.

DELWING – control parameter for the calculation without the wing.

DELWING = 0. – the wing is taking into account;

DELWING = 1. - wing is excluded from the calculation;

About calculation when the wing is excluded see **section 2.4: Elimination of a wing from a configuration**

IBEAM - control parameter for realisation of calculations in view of elastic strains of a wing and horizontal tail using the simple beam theory. About such calculation see **Appendix A: The calculation taking into account the elastic deformation**

IBEAM = 0. – calculation without elastic deformations;

IBEAM = 1. - elastic deformations are taking into account;

IAIL - control parameter for realisation of calculations taking into account the deflection of the control surfaces on the wing and tail. About such calculation see **Appendix C**

IAIL = 0. – calculation without control surfaces;

IAIL = 1. – the control surfaces are taking into account;

IROT - control parameter for realisation of calculation under a condition of steady manoeuvre. About such calculation see **Appendix B**

IROT = 0. – calculation without the manoeuvre condition;

IROT = 1. – the steady manoeuvre is taking into account;

IFAN - control parameter for realisation of calculations taking into account propeller slipstream. About such calculation see **Appendix D**

IFAN = 0. – calculation without propeller slipstreams;

IAIL = 1. – the propeller slipstreams are taking into account;

5. PA1

PA1 - The streamtube area ratio at the inflow face of the first (inboard) nacelle.

Here: "inflow face" - is a surface bounded by the leading edges of the nacelle chordwise sections

6. PA2

PA2 - The streamtube area ratio at the inflow face of the second (outboard) nacelle.

If PA1=0. or PA2=0. (in case of one nacelle) or PA1=PA2=0. (in case of two nacelle), then nacelle flow computation is carried out in a regime when the nacelle has a transparent duct. Note, the efficient flowfield computation in this regime is possible only under the condition of the supersonic region absence in the nacelle duct. When the supersonic region appears in the duct, the rate of flow through the nacelle becomes fixed, the task loses one degree of a freedom and the fulfilment of the smooth flow of the nacelle trailing edge becomes by problematical.

Lets note, in case of two nacelles, if input value of PA1=0.,then the code automatically sets PA1=PA2 and , if input value of PA2=0., then the code automatically sets PA2=PA1.

In principal the prescribed values of PA1 and PA2 must be closed to the streamtube area ratios at the nacelle outlets obtained while flow calculation (parameters **OUTFLOW** in the output files, see **Section 3.1**).

7. IBL_W, IBL_HT, IBL_VT, IBL_UG, IBL_LG, IBL_F

These controlling parameters show for what elements of configuration the influence of viscosity will be realized.

IBL_W - control parameter for the main wing

IBL_W = 1. – viscosity on a wing;

IBL_W = 0. – no viscosity on a wing;

IBL_HT - control parameter for the horizontal tail

IBL_HT = 1. – viscosity on a horizontal tail;

IBL_HT = 0. – no viscosity on a horizontal tail;

IBL_VT - control parameter for the vertical tail

IBL_VT = 1. – viscosity on a vertical tail;

IBL_VT = 0. – no viscosity on a vertical tail;

IBL_UG - control parameter for the upper winglet

IBL_UG = 1. – viscosity on a upper winglet;

IBL_LG = 0. – no viscosity on a upper winglet;

IBL_LG - control parameter for the lower winglet

IBL_LG = 1. – viscosity on a lower winglet;

IBL_LG = 0. – no viscosity on a lower winglet;

IBL_F - control parameter for boundary layer calculation on the body surface

IBL_F = 1. – boundary layer calculation on the body surface;

IBL_F = 0. – without boundary layer calculation on the body surface;

8. REFCHD, REFSPN, REFXOC, REFXCG, REFYCG

REFCHD – the prescribed reference chord for the momentum calculations;

If REFCHD=0., then the code prescribes REFCHD=SW/REFSPN (**see item 2**)

REFSPN – the prescribed reference halfspan for the wing section results output (**see item 47**). If in the input file REFSPN=0. Then the code sets REFSPN equal to real wing halfspan.

REFXOC – the reference coordinate (in fraction of the local wing chord) relative of which the local pitching moment of the wing and tail sections is calculated.

REFXCG – X-coordinate relative of which the total moments are calculated. If the prescribed value of REFXCG=0., then the moments are calculated relative of X-coordinate of the leading edge of the first input wing section (**see item 76**).

REFYCG – Y-coordinate relative of which the total moments are calculated. If the prescribed value of REFYCG=0., then the moments are calculated relative of Y-coordinate of the leading edge of the first input wing section (**see item 76**).

9. <u>THREE free lines</u>

<u>LOCATION OF THE TRANSITION LINE FOR WING</u>

10. <u>NTR_W</u>

NTR_W - number of points located spanwise, which prescribe the position of the transition line on the wing surface (NTR_W<12.)

If* NTR_W ≠ 0.*, then the lines 11 follow.

11. <u>SPAN_W, XTRU_WL, XTRL_WL, XTRU_WR, XTRL_WR - define the configuration of the transition line on upper and lower wing surfaces</u>

SPAN_W - the spanwise coordinate (in the wing span fraction);

XTRU_WL - the X-coordinate of the transition line in the wing cross section (in the local chord fraction) on the upper surface for the left half-wing;

XTRL_WL - the X-coordinate of the transition line in the wing cross section (in the local chord fraction) on the lower surface for the left half-wing;

XTRU_WR, XTRL_WR – configuration of the transition line for right half-wing;

If XTRU_WR, XTRL_WR parameters do not present in the input data file, or calculations are carried out in regime without side flow (NY_BETA=0., see **item 70**), then the transition line configurations for right half-wing are considered the same as for left half-wing.

12. <u>ONE free line</u>

<u>LOCATION OF THE TRANSITION LINE FOR HORISONTAL TAIL</u>

13. <u>NTR_TH</u>

NTR_TH- number of points located spanwise, which prescribe the position of the transition line on the horizontal tail surface (NTR_TH < 12)

If* NTR_TH ≠ 0.*, then the lines 14 follow.

14. <u>SPAN_TH, XTRU_HL, XTRL_HL, XTRU_HR, XTRL_HR - define the configurations of the transition lines on upper and lower surfaces for the horizontal tail</u>

SPAN_TH - the spanwise coordinate (in the horizontal tail span fraction);

XTRU_HL - the X-coordinate of the transition line in the horizontal tail cross section (in the local chord fraction) on the upper surface for the left part of the horizontal tail;

XTRL_HL - the X-coordinate of the transition line in the horizontal tail cross section (in the local chord fraction) on the lower surface for the left part of the horizontal tail;

XTRU_HR, XTRL_HR – configuration of the transition line for right part of the horizontal tail;

> If XTRU_HR, XTRL_HR parameters do not present in the input data file, or calculations are carried out in regime without side flow (NY_BETA=0., see **item 70**), then the transition line configurations for right part of the horizontal tail are considered the same as for left part.

15. <u>ONE free line</u>

<u>LOCATION OF THE TRANSITION LINE FOR VERTICAL TAIL</u>

16. <u>NTR_TV</u>

NTR_TV - number of points located spanwise, which prescribe the position of the transition line (NTR_TV < 12)

If* NTR_TV ≠ 0.*, then the lines 17 follow.

17. <u>SPAN_TV, XTR_VL, XTR_VR - define the configuration of the transition line on left and right surfaces of the vertical tail</u>

SPAN_TV - the spanwise coordinate (in the span fraction);

XTR_VL - the X-coordinate of the transition line in the vertical tail cross-section (in the local chord fraction) for the left side of vertical tail;

XTR_VR – prescribes the transition line configuration for right surface of vertical tail;

> If XTR_VR parameters do not present in the input data file, or calculations are carried out in regime without side flow (NY_BETA=0., see **item 70**), then the transition line configuration for the right upper winglet is considered the same as for the left upper winglet.

18. <u>ONE free line</u>

<u>LOCATION OF THE TRANSITION LINE FOR UPPER WINGLET</u>

19. <u>NTR</u>

NTR - number of points located spanwise, which prescribe the position of the transition line on the upper winglet surfaces (NTR < 12)

If* NTR ≠ 0.*, then the lines 20 follow.

20. <u>SPAN, XTRI_L, XTRO_L, XTRI_R, XTRO_R - define the configurations of the transition lines on inboard and outboard surfaces for the upper winglet</u>

SPAN - the spanwise coordinate (in the upper winglet’s span fraction);

XTRI_L - the X-coordinate of the transition line (in the local chord fraction) on the upper winglet’s inboard surface for the left halfwing;

XTRO_L - the X-coordinate of the transition line (in the local chord fraction) on the upper winglet’s outboard surface for the left halfwing;

XTRI_R, XTRO_R – configuration of the transition lines for the upper winglet of right halfwing;

If XTRI_R, XTRO_R parameters do not present in the input data file, or calculations are carried out in regime without side flow (NY_BETA=0., see **item 70**), then the transition line configurations for right upper winglet are considered the same as for left upper winglet.

21. <u>ONE free line</u>

<u>LOCATION OF THE TRANSITION LINE FOR LOWER WINGLET</u>

Follow the data set, which prescribes the transition lines locations for lower winglet (similar to items 19,20).

22. <u>ONE free line</u>

<u>LOCATION OF THE TRANSITION FOR BODY</u>

23. <u>XTR_F</u>

XTR_F - location of the transition for the boundary layer calculation on the body surface (in body lengths fraction);

24. <u>TWO free lines</u>

<u>CALCULATION PARAMETERS</u>

25. <u>FCONT, FCONTM, KGMRES</u>

FCONT - indicator that tells the manner of starting the program.

FCONT= 0. - the calculation starts from the beginning;

FCONT= 1. - the calculation is to be continued from a previous calculation. The potential field and is read from a file where it was previously stored (file **fn.sav**).

FCONTM - indicator that tells the manner of obtaining the information about mesh node types and about the nodes interpolation parameters

FCONTM= 0. - the code obtains this information while making the analysing procedure for the mesh nodes; the results are recorded to file **fn.msh**;

FCONTM= 1. - the information is read out from the file **fn.msh**

KGMRES - The max. number of the approximate solution vectors employed in GMRES algorithm (KGMRES<11.).

Usually:

KGMRES =8.-9.

<u>WARNING!!! THE ITEMS 26-40 ARE DEFINED FOR EACH CALCULATION GRID</u>

26. <u>TWO free lines</u>

<u>WING/BODY CALCULATION PARAMETERS</u>

27. NIT, NORD1, NORD2, FH (see fig.12)

NIT - total number of wing/body flowfield calculation iterations on a given grid;

The NIT number depends upon the configuration under consideration, usually:

For wing/body and for wing/body/nacelle configuration when there is no side flow:

NIT=30-40 on first grid

NIT=25-35 on second grid

If the configuration contains tail or/and winglets or for side flow regimes:

NIT=40-50 on first grid

NIT=40-45 on second grid

N0RD1 - number of the leading wing/body flowfield iterations which be carried out by using the first order artificial dissipation in the supersonic zones;

Usually:

NORD1> NIT on first grid (only the first order dissipation is used)

NORD1= 1. on second grid

N0RD2 - the iteration number the computation with the second order dissipation starts from is carried out;

Usually:

NORD2=20. on first grid

NORD2=10. on second grid

The transient from first order dissipation to second order dissipation is carried out on the iterations with the number N: NORD1 < N < NORD2.

FH - parameter of the continuation of the calculation on the next fine grid:

FH =0. – finish of the calculation on the current grid;

FH =1. – continuation of the calculation on the next fine grid.

28. P1W, P2W, P4W, PLWF, PHWF, FLHWF, PWF_WF

P1W - the relaxation parameter for the wing/body flowfield computation

Usually:

P1W=1.30 on the first grid

P1W=1.30 on the second grid

At the complicated regimes it is useful to reduce the P1WF value by ~ 0.1-0.4.

P2W - the parameter of dumping for the wing/body flowfield computation.

Usually:

P2W=1. ~ 1.001 on first grid;

P2W=1.002 on second grid;

P4WF= 1. - this parameter must be set equal to 1.

PLWF - min. value of acceleration parameters for the wing/body flowfield computation.

Usually:

PLWF=.7 on first grid;

PLWF=.7 on second grid.

PHWF - max. value of acceleration parameters for the wing/body flowfield computation

usually:

PHWF=1.5 on first grid;

PHWF=1.5 on second grid.

FLHWF - number of intermediate values of the acceleration parameters for the wing/body flowfield computation.

Usually:

FLHWF=4. on first grid

FLHWF=5. on second grid

PWF_WF - the relaxation coefficient for the parameters interchanging between left half-space and the right half-space wing/body computational grids. This parameter is used only when side flow is present.

Usually:

PWF_WF= 1.5 on first grid

PWF_WF= 1.4~1.5 on second grid

At the complicated regimes it is useful to reduce the PWF_WF values by ~ 0.1-0.3.

29. <u>ONE free line</u>

<u>TAIL CALCULATION PARAMETERS</u>

30. <u>NIT2_T, NIT3_T, NORD1_T, NORD2_T (see fig.12)</u>

NIT2_T, NIT3_T - after each NIT2_T the wing/body flowfield iterations the NIT3_T tail flowfield iterations be done;

Usually:

NIT2_T= 1., NIT3_T= 2. on first grid

NIT2_T= 1., NIT3_T= 2. on second grid

If NIT2_T > NIT (**see item 27**), then the calculation be made without taking into account the tail.

N0RD1_T - number of the leading wing/body flowfield iterations for which the tail flowfield calculation be carried out by using the first order artificial dissipation;

Usually:

NORD1_T> NIT (**see item 27**) on first grid (only the first order dissipation is used for tail flowfield calculation)

NORD1_T= 1.   on second grid

N0RD2_T - the wing/body flowfield iteration number, after which the tail computation with the second order dissipation starts from is carried out;

usually:

NORD2_T=20.   on first grid

NORD2_T=10.   on second grid

For tail calculation the transient from first order dissipation to second order dissipation is carried out on the wing/body iterations with the number N: NORD1_T < N < NORD2_T.

31. <u>P1T, P2T, P4T, PLT, PHT, FLHT</u>

P1T - the relaxation parameter for the tail flowfield computation

Usually:

P1T=1.30   on the first grid

P1T=1.30   on the second grid

At the complicated regimes it is useful to reduce the P1T value by ~ 0.1-0.3.

P2T - the parameter of dumping for the tail flowfield computation

usually:

P2T=1. ~ 1.001   on first grid

P2T=1.002   on second grid

P4T= 1. - this parameter must be set equal to 1.

PLT - min. value of acceleration parameters for the tail flowfield computation

usually:

PLT=.7   on first grid

PLT=.7   on second grid

PHT - max. value of acceleration parameters for the tail flowfield computation

usually:

PHT=1.5   on first grid

PHT=1.5   on second grid

FLHT   - number of intermediate values of the acceleration parameters for the tail flowfield computation

usually:

FLHT=4.   on first grid

FLHT=4.-5.   on second grid

32. <u>PWF_TAL, PTAL_WF, PTAL_TAL</u>

PWF_TAL - the relaxation coefficient for the parameters interpolation from the tail meshes to the wing/body mesh

PTAL_WF - the relaxation coefficient for the parameters interpolation from the wing/body mesh to the to the tail meshes

PTAL_TAL - the relaxation coefficient for the parameters interpolation from the horizontal tail mesh to the vertical tail mesh and for the parameters interpolation from the vertical tail mesh to the horisontal tail mesh and

usually:

PWF_TAL= 1.5

PTAL_WF= 1.5 on first grid

PTAL_TAL=1.5

PWF_TAL= 1.4~1.5

PTAL_WF= 1.4~1.5 on second grid

PTAL_TAL=1.3~1.4

At the complicated regimes it is useful to reduce the PWF_TAL, PTAL_WF values by ~ 0.2-0.4 and PTAL_TAL value by ~ 0.1-0.3

33. <u>ONE free line</u>

<u>NACELLE CALCULATION PARAMETERS</u>

34. <u>NIT2_N, NIT3_N (see fig.12)</u>

NIT2_N, NIT3_N - after each NIT2_N the wing/body flowfield iterations the NIT3_N nacelle flowfield iterations be done;

Usually:

NIT2_N= 1., NIT3_N= 4. on first grid

NIT2_N= 1., NIT3_N= 4. on second grid

If NIT2_N > NIT (**see item 27**), then the calculation be made without taking into account the nacelle.

35. <u>P1N, P2N, P4N, PLN, PHN, FLHN</u>

P1N - the relaxation parameter for the nacelle flowfield computation

usually:

P1N=1.2 on the first grid

P1N=1.2 on the second grid

At the complicated regimes it is useful to reduce the P1WF value by ~ 0.1-0.2.

P2N - the parameter of dumping for the nacelle flowfield computation

usually:

P2N=1. on first grid

P2N=1.001 on second grid

P4N= 1. - this parameter must be set equal to 1.

PLN - min. value of acceleration parameters for the nacelle flowfield computation usually:

PLN=.05   on first grid

PLN=.05   on second grid

PHN - max. value of acceleration parameters for the nacelle flowfield computation

usually:

PHN=1.8~1.7   on first grid

PHN=1.8~1.7   on second grid

FLHN   - number of intermediate values of the acceleration parameters for the nacelle flowfield computation

usually:

FLHWF=4.   on first grid

FLHWF=4.~ 5. on second grid

36. PWF_NAC, PNAC_WF, PNAC_NAC

PWF_NAC - the relaxation coefficient for the parameters interpolation from the nacelle mesh to the wing/body mesh

PNAC_WF - the relaxation coefficient for the parameters interpolation from the wing/body mesh to the to the nacelle mesh

PNAC_NAC - the relaxation coefficient for the parameters interpolation from the mesh of the first nacelle to the mesh of the second nacelle

usually:

PWF_NAC= 1.5

PNAC_WF= 1.5   on first grid

PNAC_NAC=1.3

PWF_NAC= 1.4~1.5

PNAC_WF= 1.4~1.5   on second grid

PNAC_NAC=1.2~1.3

At the complicated regimes it is useful to reduce the PWF_NAC, PNAC_WF values by ~ 0.2-0.4 and PNAC_NAC value by ~ 0.1-0.3

37. ONE free line

CALCULATION PARAMETERS FOR VISCOUS-INVISCID ITERATIONS

38. NBL - total number of the boundary layer calculations for the current grid (NBL < 20), see fig.12.

If* NBL ≠ 0., *then the lines 39,40 follow.

39. IBL

IBL - numbers of inviscid wing/body flowfield calculation iteration after which the boundary layer is calculated for the elements indicated in **item 7**

40. PB_W, PB_HT, PB_VT, PB_UG, PB_LG - parameters of viscous relaxation for the elements of configuration indicated in item 7.

PB_W - viscous relaxation for the main wing;

PB_HT - viscous relaxation for the horizontal tail;

PB_VT - viscous relaxation for the vertical tail;

PB_UG - viscous relaxation for the upper winglet;

PB_LG - viscous relaxation for the lower winglet;

Usually the viscous relaxation parameters can be given PB = 1. But in case of stretched separation on the element (for example, the unclosed separation induced by a shock wave), the value of viscous relaxation parameter for the corresponding element should be reduced:

PB =0.5-0.8 on first grid

PB =0.2-0.5 on second grid

IBL_T - numbers of wing/body inviscid iteration after which the boundary layer on the tail surfaces is calculated

PB_T - parameter of viscous relaxation for tail (0. < PB_T < 1.) usually PB_T=1.0.

In case of stretched separation on the tail (for example, the unclosed separation induced by a shock wave):

PB_T=0.5-0.8 on first grid;

PB_T=0.2-0.5 on second grid.

Warning! The items 26-40 are defined for every calculation grid

41. TWO free lines

BOUNDARY LAYER PARAMETERS

42. NDF, NVB, CFXMIN

NDF= 5. - parameter defines the b.l. calculation mode

NVB - parameter defines the type of device for plotting:

NVB= 0. - to screen;

NVB= 2. - to postscript file.

CFXMIN - friction limiter, the min. value of the friction for the b.l. computation,

Usually:

CFXMIN=-10.

43. THREE free lines

FLOW PLOTTING PARAMETERS FOR WING-BODY AND WINGLETS

44. FPLOT1, FLPLOT2, FPLOT3, FPLOT4, FPLOT5, FPLOT6, FPLOT7, FPLOT8 - the parameters control of the wing/body/winglets calculation results plotting

(**see Sections 3.1,3.2: Graphical representation of the computational results.**)

FPLOT1=1. - plot **011.ps** generation

FPLOT1=0. - no plot generation

FPLOT2=1. - plot **012.ps** generation

FPLOT2=0. - no plot generation

FPLOT3=1. - plot **013.ps** (or **013_L.ps**, **013_R.ps**) generation

FPLOT3=0. - no plot generation

FPLOT4=1. - plot **014.ps** (or **014_L.ps**, **014_R.ps**) generation for main wing;

plot **064.ps**, **074.ps** (or **064_L.ps**,**064_R.ps**,**074_L.ps**,**074_R.ps**) generation for lower and upper winglets

FPLOT4=0. - no plot generation

FPLOT5=1. - plot **015.ps** (or **015_L.ps**, **015_R.ps**) generation

FPLOT5=0. - no plot generation

FPLOT6=1. - plot **016.ps** (or **016_L.ps**, **016_R.ps**) generation

FPLOT6=0. - no plot generation

FPLOT7=1. - plot **017.ps** (or **017_L.ps**, **017_R.ps**) generation for main wing;

plot **067.ps**, **077.ps** (or **067_L.ps**,**067_R.ps**,**077_L.ps**,**077_R.ps**) generation for lower and upper winglets

FPLOT7=2. - plot **019.ps** (or **019_L.ps**, **019_R.ps**) generation for main wing,

plot **069.ps**, **079.ps** (or **069_L.ps**,**069_R.ps**,**079_L.ps**,**079_R.ps**) generation for lower and upper winglets

FPLOT7=3. - plot **017.ps** (or **017_L.ps**,**017_R.ps**) and **019.ps** (or **019_L.ps**,**019_R.ps**) generation for main wing;

plot **067.ps**, **077.ps** (or **067_L.ps**,**067_R.ps**,**077_L.ps**,**077_R.ps**) and **069.ps**, **079.ps** (or **069_L.ps**,**069_R.ps**,**079_L.ps**,**079_R.ps**) generation for lower and upper winglets

FPLOT7=0. - no plot generation

FPLOT8=1. - plot **018.ps** (or **018_L.ps**, **018_R.ps**) generation for main wing;

plot **068.ps**, **078.ps** (or **068_L.ps**,**068_R.ps**,**078_L.ps**,**078_R.ps**) generation for lower and upper winglets

FPLOT8=2. - plot **020.ps** (or **020_L.ps**, **020_R.ps**) generation for main wing,

plot **070.ps**, **080.ps** (or **070_L.ps**,**080_R.ps**,**070_L.ps**,**080_R.ps**) generation for lower and upper winglets

FPLOT8=3. - plot **018.ps** (or **018_L.ps**,**018_R.ps**) and **020.ps** (or **020_L.ps**,**020_R.ps**) generation for main wing;

plot **068.ps**, **078.ps** (or **068_L.ps**,**068_R.ps**,**078_L.ps**,**078_R.ps**) and **070.ps**, **080.ps** (or **070_L.ps**,**070_R.ps**,**080_L.ps**,**080_R.ps**) generation for lower and upper winglets

FPLOT8=0. - no plot generation

45. <u>CPMINW, CPMINF</u>

CPMINW - the minimum CP level for scaling the plot **014.ps**, **064.ps**, **074.ps** (Cp distribution for wing and for winglet sections);

CPMINF - the minimum CP level for scaling the plot **015.ps, 016.ps** (Cp distribution for body sections)

46. <u>NZOUT , NFOUT, NXOUT, NZOUT_G - number of a wing, body and winglets sections for plotting a pressure distribution (NZOUT<21, NFOUT<21, NXOUT<21, NZOUT_G<21)</u>

NZOUT – number of wing sections for plotting pressure distribution and boundary layer parameters;

NFOUT – number of body polar angle section for plotting pressure distribution;

NXOUT - number of body X=const sections for plotting pressure distribution.

NZOUT_G – number of winglet sections for plotting pressure distribution and boundary layer parameters;

47. <u>ZOUT, FOUT, XOUT, ZOUT_G - coordinates of wing, body and winglets sections for plotting the Cp distribution</u>

ZOUT - the Z-coordinates (in the **REFSPN** fractions, **see item 8**) of the wing sections for plotting the pressure distribution and b.l. parameters (plot **014.ps**,**017.ps**,**018.ps**);

ZOUT=-30. – plotting the Cp distribution for the curvilinear wing section, which contains the intersection line of the wing and winglet’s inboard surface;

ZOUT=+30. – plotting the Cp distribution for the curvilinear wing section, which contains the intersection line of the wing and winglet’s outboard surface;

If the calculation is carried out without the winglets, then ZOUT=±30. corresponds to Cp plotting at the wing tip section.

FOUT - the polar angle coordinates (in degrees) of the body sections for plotting the pressure distribution (plot **015.ps**);

XOUT - the X-coordinates (in the body length fractions) of the body sections for plotting the pressure distribution (plot **016.ps**).

ZOUT_G - the span-coordinates (in the winglet span fractions) of the winglet sections for plotting the pressure distribution and b.l. parameters (plot **064.ps**,**067.ps**,**068.ps**, **074.ps**,**077.ps**,**078.ps**);

48. <u>ONE free line</u>

<u>FLOW PLOTTING PARAMETERS FOR TAIL</u>

49. <u>TPLOT1, TLPLOT2, TPLOT3, TPLOT4, TPLOT5, TPLOT6, TPLOT7,TPLOT8 - the parameters control of the tail calculation results plotting</u>

(**see Sections 3.1,3.2: Graphical representation of the computational results**.)

TPLOT1=1. – at the moment this parameter is not used;

TPLOT2=1. - plot **082.ps** and **092.ps** generation

TPLOT2=0. - no plot generation

TPLOT3=1. - plot **083.ps** (or **083_L.ps**,**083_R.ps**) and **093.ps** (or **093_L.ps**,**093_R.ps**) generation

TPLOT3=0. - no plot generation

TPLOT4=1. - plot **084.ps** (or **084_L.ps**,**084_R.ps**) and **094.ps** (or **094_L.ps**,**094_R.ps**) generation

TPLOT4=0. - no plot generation

TPLOT5 - at the moment the parameter is not used

TPLOT6 - at the moment the parameter is not used

TPLOT7=1. - plot **087.ps** (or **087_L.ps**,**087_R.ps**) and **097.ps** (or **097_L.ps**,**097_R.ps**) generation

TPLOT7=2. - plot **089.ps** (or **089_L.ps**,**089_R.ps**) and **099.ps** (or **099_L.ps**,**099_R.ps**) generation

TPLOT7=3. - plot **087.ps**, **097.ps**, **89.ps**,**099.ps** (or **087_L.ps**,**087_R.ps, 097_L.ps**,**097_R.ps**, **089_L.ps**,**089_R.ps**, **099_L.ps**,**099_R.ps**) generation

TPLOT7=0. - no plot generation

TPLOT8=1. - plot **088.ps** (or **088_L.ps**,**088_R.ps**) generation

TPLOT8=2. - plot **090.ps** (or **090_L.ps**,**090_R.ps**) generation

TPLOT8=3. - plot **088.ps** and **090.ps** (or **088_L.ps**,**088_R.ps**, **090_L.ps**,**090_R.ps**) generation

TPLOT8=0. - no plot generation

50. CPMINT

CPMINT -the minimum CP level for scaling the plot **084.ps** and **094.ps**

51. NZOUT - number of a tail sections for plotting a pressure distribution (NZOUT<21)

52. ZOUT - the Z-coordinates (in the tail spanwise fractions) of the tail sections for plotting the pressure distribution and b.l. parameters

53. ONE free line

FLOW PLOTTING PARAMETERS FOR NACELLE

54. NPLOT4

(**see Sections 3.1,3.2: Graphical representation of the computational results.**)

NPLOT4- the parameter controls of the nacelle calculation results plotting

NPLOT4=1. - plot **024.ps** and **034.ps** (or **024_L.ps**,**024_R.ps**, **087_L.ps**,**087_R.ps**)generation

NPLOT4=0. - no plot generation

55. CPMINN

CPMINN -the minimum CP level for scaling the plot **024.ps** and **034.ps**

56. NFOUT - number of nacelles sections for plotting a pressure distribution (NFOUT<21)

57. FOUT - the polar angle coordinates (in degrees) of the nacelle sections for plotting the pressure distribution

58. ONE free line

ISOBAR LEVELS

59. NCPOUT - the number of pressure levels for plotting isobars (NCPOUT<21)

60. CPOUT - the CP-levels for plotting isobars

61. THREE free lines

MESH PLOTTING PARAMETERS FOR WING/BODY AND WINGLETS.

62. FPICT1, FPICT2, FPICT3, FPICT4, FPICT5, TP1, TP3

FPICT1, FPICT2, FPICT3, FPICT4, FPICT5, - the parameters control the wing/body and winglets mesh plotting:

FPICT1=1. - plot of the wing/body grid on the body and at the plane of symmetry (generation file **101.ps**);

FPICT1=0. - no plot;

FPICT2=1. - plot of the wing/body grid view in a neighbourhood of a wing tip, generation file **102.ps**;

FPICT2=0. - no plot;

FPICT3=1. – in case when winglets are present, plot of the grid view in a neighbourhood of winglets (generation file **103.ps**)

FPICT3=0. - no plot;

FPICT4=1. - plot of a top view of the wing/body surface grid (file **104.ps**);

FPICT4=0. - no plots;

FPICT5>0. - plot of the front view an axial wing/body grid section (file **105.ps**).

The value of this parameter specifies the X-location of plotted wing/body grid section. (The distance ***L*** between the plotted grid section and the leading edge of the root wing section is ***L=FPICT5 b***, where ***b*** is a chord of the root wing section).

FPICT5=0. - no plots;

FTP1, FTP3 - the parameters control the creating the ASCII output files for Tecplot.

FTP1 = 1. - creating the output file **tp1.dat** for Tecplot. The file contains coordinates of computation nodes, Cp and Mach number distribution on the surfaces of configuration;

FTP1 = 0. – no creating;

FTP3 = 1. - creating the output file **tp3.dat** for Tecplot. The file contains coordinates of computation nodes, Cp and Mach number distribution and flow velocity components in the 3-dimensional computation region over configuration;

FTP3 = 0. – no creating;

63. XMIN, XMAX, YMIN, YMAX, ZMIN, ZMAX - X,Y and Z coordinates of window boundaries for a plot of wing/body grid view.(YMAX-YMIN =XMAX-XMIN , ZMAX-ZMIN=1.5*(XMAX-XMIN)).

64. ONE free line

MESH PLOTTING PARAMETERS FOR TAIL

65. FTPICT1, FTPICT2, FTPICT3, FTPICT4, FTPICT5 - the parameters control the tail mesh plotting

FTPICT1=1. - plot of the tail grids on the body surface (generation file **181.ps** for horisontal tail grid and/or file **191.ps** for vertical tail grid);

FTPICT1=0. - no plot;

FTPICT2=1. - plot of side view of tail grids on a tail tip coordinate surface (generation file **182.ps** and/or file **192.ps**);

FTPICT2=0. - no plot;

FTPICT3 - at the moment the parameters is not used;

FTPICT4=1. - plot of a top view of tail surface grids (files **184.ps** and/or **194.ps**)

FTPICT4=0. - no plots;

FTPICT5>0. - plot of the front view of an axial tail grids section (files **185.ps** and/or **195.ps**).

The value of this parameter specifies the x-location of plotted tail grids section. (The distance ***L*** between the plotted tail grid section and the leading edge of the tail root section is ***L=FTPICT5 b*** , where ***b*** is a chord of the tail root section).

FTPICT5=0. - no plots;

66. XMIN, XMAX, YMIN, YMAX, ZMIN, ZMAX - X,Y and Z coordinates of window boundaries for a plot of tail grid view.(YMAX-YMIN =XMAX-XMIN , ZMAX-ZMIN=1.5*(XMAX-XMIN)).

67. ONE free line

MESH PLOTTING PARAMETERS FOR NACELLES

68. FNPICT1, FNPICT2, FNPICT3, FNPICT4, FNPICT5- the parameters control the nacelle mesh plotting

FNPICT1=1 - plot of side view of nacelle grid section (file **111.ps** for first nacelle, file **121.ps** for second nacelle);

FNPICT1=0. - no plot;

FNPICT2>0. - plot of the front view af an nacelle axial grid section (files **112.ps**,**122.ps**). The value of this parameter specifies the x-location of plotted nacelle grid section. The distance between the plotted grid section and the nacelle leading edge is ***L=FNPICT5 b*** , where ***b*** is the nacelle base chord (about nacelle base chord see **item 92**.)

FNPICT2=0. - no plot;

FNPICT3, FNPICT4, FNPICT5 -at the moment, these parameters are not used

69. TWO free lines

WING/BODY MESH PARAMETERS AND WING POSITION

70. NY, NZ, NT, NTN1, NTN2, NY_BETA (see fig.1,13,14)

NY -The number of wing/body mesh cells in the direction normal to the wing surface (Y – direction) for the initial computational grid (it is usually set NY=12.)

NZ -The total number of wing/body mesh cells in the wing spanwise direction (Z – direction) for the initial computational grid. NZ depends on a prescribed number NT of grid intervals on the wing surface spanwise (about NT parameter look bellow). Usually NZ=NT+6.

NT -The number of intervals on the wing surface spanwise for the initial wing/body computational grid. For clean wing NT=10., but if nacelle or winglets or control surfaces are present, then it is necessary to supply spanwise compression of wing/body grid near these elements. So it can be useful to increase the input NT value up to NT=12.-14.

In the present code it's possible to control a spanwise nodes distribution for wing/body mesh in the vicinity of one or two wing sections. It's made for more detailed flowfield calculation near the nacelle, and for spanwise mesh compression near the side boundaries of the control surfaces on the wing.

Here, these mesh sections are named: "wing section a" and "wing section b ".

NTN1 - the number of spanwise mesh cells between the body and wing ***section a***.

The NIT1 value depends upon the nacelle spanwise position. As a rule NTN1=3.~ 4.

If NTN1=0., then it is assumed that the wing ***section a*** is absent.

NTN2 - the number of spanwise mesh cells between the wing ***section a*** and wing ***section b***. . As a rule NTN2= 3.~ 4.

If NTN1=0., then NTN2 is the number of spanwise mesh cells between the body and wing ***section b***

If NTN2=0., then it is assumed that wing ***section b*** is absent.

For additional information about these parameters see section 2.2, 2.3

NY_BETA -number of the mesh sells for the intersection region between left half-space and right half-space wing/body grids.

The parameter prescribes the size of spreading of the wing/body computational grid into another half/space when calculation with side flow is carried out.

NY_BETA is a control parameter:

NY_BETA = 0. – the calculation is carried out in a regime when side flow is absent and the prescribed yaw angle value BETA is skipped (**item 2**). In this case the flow is symmetrical and only left half-space is calculated.

NY_BETA ≠ 0. – general case, side flow is possible. Flow about total configuration is calculated (even when the prescribed yaw angle BETA=0.).

NY_BETA=2.~3. – for calculation with side flow

71. <u>NXS, NXW1, NXW2, NXW3 - parameters define the numbers of the mesh cells in chordwise direction on the wing surface and on the wing wake surface for the initial wing/body computational grid (see fig.13).</u>

NXS – parameters defines the number of the mesh cells on the wing upper surface in chordwise direction for the initial wing/body computational grid.

Usually NXS=32.

Parameters NXW1, NXW2, NXW3 define the number of the mesh cells on the wing wake surface in chodwise direction for wing/body mesh. If the configuration contains a tail, then the wing/body grid must be enough dense in a neighbourhood of a tail mesh region. To ensure this requirement, there is a possibility to divide a wing wake into three zones: **1**,**2** and **3**, as shown in **fig.13.** The **zone 2** should be placed in a neighbourhood of a tail. The **zone 3** reaches from **zone 2** up to the output boundary of calculated field. The coordinates of the boundaries of zones are prescribed as input data, see **item 72**.

NXW1 – parameters defines the number of the mesh cells on the wing wake surface in chordwise direction at **zone 1** ,for the initial wing/body computational grid.

The NXW1 value depends upon tail location, as rule NXW1=10.

NXW2 – parameters defines the number of the mesh cells on the wing wake surface in chordwise direction at **zone 2**, for the initial wing/body computational grid.

Usually set NXW2 =6.- 8.

If NXW2 = 0., then it is assumed that **zone 2** is absent. In this case the total number of the mesh cells on the wing wake surface in chordwise direction is NXW1+NXW3

NXW3 – parameters defines the number of the mesh cells on the wing wake surface in chordwise direction at **zone 3**, for the initial wing/body computational grid.

Usually set NXW3 =8.

72. XW12, PXW12, XW23, PXW23 – the parameters define the location of zone 2 for the wing wake surface, and the mesh nodes distribution for wing wake (see fig.13)

XW12 – X-coordinate of the boundary between **zone 1** and **zone 2** at the plane of symmetry (Z=0.). Approximately the coordinate should correspond to a region of the leading edge of the tail root sections.

Code can specify the XW12 value by itself in the vicinity of the tail root section leading edge. For this, the prescribed input value of XW12 must be XW12=0. and NXW2≠0. Also the vertical or horizontal tail geometry must be presented in the input data file (ITH≠0. or/and ITV≠0., see **items 78.**, **84.**)

PXW12 – the parameter controls of the mesh node compression in chordwise direction at the boundary between **zone 1** and **zone 2**. 0.< PXW12 < 1. Decreasing of the PXW12 compresses the node distribution in the vicinity of this boundary.

Usually PXW12=1.

XW23 – X-coordinate of the boundary between **zone 2** and **zone 3** at the plane of symmetry (Z=0.). Approximately the coordinate should correspond to a region of the trailing edge of the tail root sections.

Code can specify the XW23 value by itself in the vicinity of the tail root section trailing edge. For this, the prescribed input value of XW23 must be XW12=0. and NXW2≠0. Also the vertical or horizontal tail geometry must be presented in the input data file (ITH≠0. or/and ITV≠0., see **items 78.**, **84.**)

PXW23 – the parameter controls of the mesh node compression in chordwise direction at the boundary between **zone 2** and **zone 3**. 0.< PXW23 < 1. Decreasing of the PXW12 compresses the node distribution in the vicinity of this boundary.

Usually PXW23=1.

73. PZROOT, PZTIP, PXLE, PXTE, PYTE, PZA, PZB (see fig.14-16)

PZROOT - The parameter that controls the spanwise nodes distribution near the wing root (0 <PZROOT< 1), usually PZROOT=.25

PZTIP - The parameter that controls the spanwise nodes distribution near the wing root (0 <PZTIP< 1), usually PZTIP=.25 , when winglets are absent.

> ***Decreasing or increasing of these parameters leads to condensation or sparseness of the computational grid at the corresponding region.***

Note that the parameter PZTIP is important when winglet is present. In such case the PZTIP value is a principal tool for providing of a necessary spanwise grid condensation in winglet's region (see. **items 99-103 and section 2.4**)

PXLE - The parameter that controls nodes distribution along the normal to the leading edge of wing cross section (0 < PXLE),usually PXLE=1.

PXTE - The parameter that controls nodes distribution in the chordwise direction near the trailing edge (0.< PXTE < 5.) usually PXTE=1.

PYTE - The parameter that controls nodes distribution along the normal to the trailing edge of wing cross section (0 < PYTE), usually PYTE=1.

> Decreasing or increasing of PXLE, PXTE, PYTE parameters leads to condensation or sparseness of the computational grid in the corresponding direction as shown in **fig.15**.

PZA,PZB - the parameters modificate the wing/body mesh nodes distribution near the wing/body intersection (if it is necessary).

> These parameters controls angle between surface of body and coordinate lines going from body, see **fig.16.**
>
> Usually, there is not a necessity to modificate the wing/body mesh at the pointed region and the parameters PZA, PZB may be set equal to zero. But in case of too lower or too upper wing position, the mesh lines coming from the body may turn out to be parallel to body surface, and the grid modification is necessary (**see fig.16.**)
>
> The grid modification is performed if PZA does not equal to zero, and PZB does not equal to zero.
>
> If PZA>0 and PZB>0, the grid is modified only for the upper surface of the body.
>
> If PZA<0 and PZB<0, the grid is modified only for the lower surface of the body.
>
> If PZA*PZB<0 , the grid is modified for the upper and lower surfaces of the body.
>
> If |PZA| rise, then the grid modification region becomes more wide along the span direction.
>
> While |PZB| rise, then angles between the body surface and the mesh lines coming from the body surface are increased.
>
> The typical values of PZA, PZB for lower wing position are:
>
> PZA= -0.07~ -0.10
>
> PZB= -1.~ -3.
>
> ***The goal is: to remove situation when the mesh lines coming from the body are parallel to the body surface.***

74. Z1, PZ11, PZ12 (see fig.13,14.)

Z1 - the Z-coordinate (in the spanwise fraction) of the wing **section a**;

PZ11 - the parameter that controls the spanwise nodes distribution near the wing **section a** from the wing root side, PZ12 - the parameter that controls the spanwise nodes distribution near the wing **section a** from the wing tip side

0.< PZ11 < 1., 0.< PZ12 < 1.

The decreasing of these parameters leads to condensation of the computational mesh near the wing **section a**. The values of the parameters depend upon the spanwise nacelle location, the wing geometry, the values of the other parameters (NT,NTN1, NTN2, PZ21, PZ22, PZROOT,PZTIP,..).

The Z1 coordinate must correspond approximately to the spanwise position of the first (inner) nacelle.

The values of PZ11,PZ12 must ensure the uniform spanwise mesh condensation near the wing **section a**.

If parameter NTN1 = 0., then the parameters Z1, PZ11, PZ12 are not used at all while computation, and may be set arbitrarily.

For additional information about these parameters see section 2.2, 2.3

75. Z2, PZ21, PZ22 (see fig.13,14.)

Z2 -the Z-coordinate (in the spanwise fraction) of the wing **section b**;

PZ21 - the parameter that controls the spanwise nodes distribution near the wing **section b** from the wing root side,

PZ22 - the parameter that controls the spanwise nodes distribution near the wing **section b** from the wing tip side

0.< PZ21 < 1., 0.< PZ22 < 1.

The decreasing of these parameters leads to condensation of the computational mesh near the wing **section b**. The values of the parameters depend upon the spanwise nacelle location, the wing geometry, the values of the other parameters (NT,NTN1,NTN2, PZ11, PZ12, PZROOT,PZTIP,..).

The Z2 coordinate must correspond approximately to the spanwise position of the second (outer) nacelle.

The values of PZ21,PZ22 must ensure the uniform spanwise mesh condensation near the wing **section b**.

If parameter NTN2 = 0., then the parameters Z2, PZ21, PZ22 are not used at all while computation, and may be set arbitrarily.

For additional information about these parameters see section 2.2, 2.3

76. XLEW, YLEW - define the location of a wing with respect to a fuselage (see fig.18.)

XLEW - X-coordinate of the l.e. of the first input wing section in the body-fitted coordinate system

YLEW - y-coordinate of the l.e. of the first input wing section in the body-fitted coordinate system

For additional information see item 108.

77. TWO free lines

HORISONTAL TAIL MESH PARAMETERS AND HORISONTAL TAIL POSITION

78. ITH – control parameter for horisontal tail data

ITH - parameter indicates does the horizontal tail data are specified in the input data file. And if this data are present, then this parameter indicates the type of horizontal tail and does the horizontal tail is included in to configuration:

ITH = 0. – there are not a horizontal tail data in the input data file;

ITH =-1. – the horizontal tail data are specified in the input data file but the configuration is considered without the horizontal tail;

If ITH > 0., then the horizontal tail data are specified in the input data file and the configuration contains the horizontal tail. In this case the value of parameter ITH indicates the type of horizontal tail:

ITH =1. – the horisontal tail is located on the fuselage;

ITH =2. – the T-type horizontal tail.

If ITH $\neq$ 0., then the lines 79-82 follow

79. NX_TH, NY_TH, NZ_TH, NT_TH

NX_TH - the number of horizontal tail mesh cells in the X -direction (chordwise direction) for the initial computational grid. It is usually set NX=96.

NY_TH - the number of horizontal tail mesh cells in the direction normal to the horizontal tail surface (Y –direction) for the initial computational grid. It is usually set NY_TH=6.-10.

NZ_TH - the number of horizontal tail mesh cells in the spanwise direction (Z –direction). It is usually set NZ_TH=13.~16.

NT_TH - the number of intervals on the horizontal tail surface spanwise for the initial horizontal tail computational grid. It is usually set NT_TH=10.

80. PZROOT, PZTIP, PXLE, PXTE, PYTE.

PZROOT - The parameter that controls the spanwise nodes distribution near the horisontal tail root (0 <PZROOT< 1), usually PZROOT=.25

PZTIP - The parameter that controls the spanwise nodes distribution near the horisontal tail tip (0 <PZTIP< 1), usually PZTIP=.25

PXLE - The parameter that controls nodes distribution along the normal to the leading edge of horisontal tail cross section (0 < PXLE),usually PXLE=1.

PXTE - The parameter that controls nodes distribution in the chordwise direction near the trailing edge of the horizontal tail (0.< PXTE < 5.) usually PXTE=1.

PYTE - The parameter that controls nodes distribution along the normal to the trailing edge of horisontal tail cross section (0 < PYTE), usually PYTE=1.

These parameters are similar to the wing/body mesh control parameters from item 73, see also fig.14,15. Decreasing or increasing of these parameters leads to condensation or sparseness of the computational grid at the corresponding region.

81. XRB_TH, YRB1_TH, YRB2_TH, ZRB_TH – parameters prescribe the sizes of the horizontal tail mesh region (see. fig.19,20)

Parameters **XRB_TH, YRB1_TH, YRB2_TH** are specified in fraction of the **'horizontal tail root chord'**. Here the **'horizontal tail root chord'** – is the chord of the first input horizontal tail cross section, see **item 119.** Parameter ZRB_TH is specified in fraction of the **horizontal tail halfspan**.

Let's note, that the total set of parameters XRB_TH, YRB1_TH, YRB2_TH, ZRB_TH is used only in case, when the horizontal tail is located on a fuselage. In case of the T-type horizontal tail the sole parameter ZRB_TH is used and three other parameters are skipped.

XRB_TH – the max. distance from the front part of the mesh external boundary to the leading edge of the horizontal tail, see **fig.19**.

As a rule XRB_TH = .5

YRB1_TH – the parameter specifies the max. distance between the horizontal tail surface and the lower part of external boundary of the horizontal tail mesh, see **fig.19.**

YRB1_TH = .3~1., but as a rule YRB1_TH=.5. Note that the position of the lower boundary of the horisontal tail mesh can affect to the position of the main wing's wake. Because the wings wake turns the horizontal mesh region round when necessary.

YRB2_TH – the parameter specifies the max. distance between the horizontal tail surface and the upper part of external boundary of the horizontal tail mesh, see **fig.19.**

ZRB_TH - the parameter specifies the distance between the root of horizontal tail (Z=0.) and the side part of external boundary of the horizontal tail mesh, see **fig.19,20**

Parameter ZRB_TH is specified in fraction of the **horizontal tail halfspan**. Usually ZRB_TH= 1.2~1.5

82. <u>XLETH, YLETH define the location of a horizontal tail with respect to a fuselage (see fig.23a.)</u>

XLETH - X-coordinate of the l.e. of the first input horizontal tail section in the body-fitted coordinate system

YLETH - Y-coordinate of the l.e. of the first input horisontal tail section in the body-fitted coordinate system

For additional information see **item 119**.

83. <u>TWO free lines</u>

<u>VERTICAL TAIL MESH PARAMETERS AND VERTICAL TAIL POSITION</u>

84. <u>ITV– control parameter for vertical tail data</u>

ITV - parameter indicates does the vertical tail data are specified in the input data file. And if this data are present, then this parameter indicates does the vertical tail is included in to configuration:

ITV = 0. – there are not a vertical tail data in the input data file;

ITV = 1. – the vertical tail data are specified in the input data file and the configuration contains the vertical tail;

ITV =-1. – the vertical tail data are specified in the input data file but the configuration is considered without the vertical tail;

If ITV $\neq$ 0., then the lines 85-88 follow

85. NX_TV, NY_TV, NZ_TV, NT_TV

NX_TV - the number of vertical tail mesh cells in the X -direction (chordwise direction) for the initial computational grid. It is usually set NX=96.

NY_TV - the number of vertical tail mesh cells in the direction normal to the vertical tail surface for the initial computational grid. It is usually set NY_TV=6.-10.

NZ_TV - the number of vertical tail mesh cells in the spanwise direction. It is usually set NZ_TH=13.~16.

NT_TV - the number of intervals on the vertical tail surface spanwise for the initial vertical tail computational grid. It is usually set NT_TV=10.

86. PZROOT, PZTIP, PXLE, PXTE, PYTE

PZROOT - The parameter that controls the spanwise nodes distribution near the vertical tail root (0 <PZROOT< 1), usually PZROOT=.25

PZTIP - The parameter that controls the spanwise nodes distribution near the vertical tail tip (0 <PZTIP< 1), usually PZTIP=.25

PXLE - The parameter that controls nodes distribution along the normal to the leading edge of vertical tail cross section (0.< PXLE), usually PXLE=1.

PXTE - The parameter that controls nodes distribution in the chordwise direction near the trailing edge of the vertical tail (0.< PXTE < 5.) usually PXTE=1.

PYTE - The parameter that controls nodes distribution along the normal to the trailing edge of vertical tail cross section (0 < PYTE), usually PYTE=1.

These parameters are similar to the wing/body mesh control parameters from item 73, see also fig.14 15. Decreasing or increasing of these parameters leads to condensation or sparseness of the computational grid at the corresponding region.

87. XRB_TV, ZRB_TV, YRB_TV – parameters prescribe the sizes of the vertical tail mesh region (see. fig.21,22)

Parameters **XRB_TV, ZRB_TV** are specified in fraction of the **'vertical tail root chord'**. Here the **'vertical tail root chord'** – is the chord of the first input vertical tail cross section, see **item 122.** Parameter **YRB_TV** is specified in fraction of the **vertical tail span**.

XRB_TV – the max. distance from the front part of the mesh external boundary to the leading edge of the vertical tail, see **fig.21**,**22**

As a rule XRB_TH = .5

ZRB_TV – the parameter specifies the max. distance between the vertical tail surface and the side part of external boundary of the vertical tail mesh, see **fig.21,22**.

Usually ZRB1_TV = 1.~1.2

YRB_TV - the parameter specifies the distance between the vertical tail root and the upper part of external boundary of the vertical tail mesh, see **fig.21.** This parameter is used in cases when there is no horizontal tail at all or horizontal tail is located on the fuselage. If there is T-type horizontal tail this parameter is skipped (see **fig.22**).

Parameter YRB_TH is specified in fraction of the **vertical tail span**. Usually YRB_TV= 1.2~1.5

88. XLETV, YLETV define the location of a vertical tail with respect to a fuselage (see fig.23b)

XLETV - X-coordinate of the l.e. of the first input vertical tail section in the body-fitted coordinate system

YLETV - Y-coordinate of the l.e. of the first input vertical tail section in the body-fitted coordinate system

For additional information see **item 122**.

89. TWO free lines

FIRST (INBOARD) NACELLE MESH PARAMETERS AND NACELLE POSITION

90. INAC1 - control parameter for first nacelle data

INAC1 - parameter indicates does the input data for the first nacelle are specified in the input data file (**items 91-95**). And if this data are present, then this parameter indicates does this nacelle is included in to configuration:

INAC1 = 0. – there are not a nacelle data in the input data file;

INAC1 = 1. – the first nacelle data are specified in the input data file and the configuration contains the nacelle;

INAC1 =-1. – the first nacelle data are specified in the input data file but the configuration is considered without the first nacelle;

If INAC1 $\neq$ 0., then the lines 91-95 follow

91. NYN, NZN –parameters specify the number of nacelle mesh cells for the initial computational grid.

NYN -The number of nacelle mesh cells in the direction normal to the nacelle cowl (NYN=6.)

NZN -The number of nacelle mesh cells in the polar angle direction (NZN=8)

92. NXNS, NXNW1, NXNW2, NXNA1, NXNA2, DXW1 (see fig.24)

These parameters specify the nacelle mesh cells distribution in chordwise direction at the start of calculation

NXNS -The number of nacelle mesh cells in chordwise direction at the nacelle's upper surface used at the start of the calculation, **see fig.24**. (It is usually set NXNS=12-16.)

NXNW1 -The number of mesh cells in chordwise direction at the nacelle **'near wake'** (as a rule NXNW1=0., or NXNW1=4.~8.)

NXNW2 -The number of mesh cells in chordwise direction at the nacelle **'far wake'**.(It is usually set NXNW2=8.)

NXNA1 -The number of the mesh cells between the nacelle outflow surface and nacelle trailing edge.(It is usually set NXNA1=2.)

NXNA2 -The number of the mesh cells between the nacelle inflow surface and nacelle leading edge. (It is usually set NXNA2=6.)

DXW1 - Length of the nacelle **'near wake'**. This parameter is specified in fraction of the **nacelle base chord**. (DXW1>0.)

The **nacelle base chord** - is the chord of the first input section of the nacelle under consideration.

If NXNW1=0. or DXW1=0., then it is assumed that the **near wake** is absent. In such case the total number of the chordwise mesh cells at the nacelle wake is equal NXNW1+NXNW2.

The necessity of **near wake** arises in cases when, for example, the wing section chord is too large and the absence of the **near wake** cells leads to the rough nacelle mesh in chordwise direction near the wing's lower surface.

In such cases it is useful to set NXNW1=4.-8., and the length of the **'near wake'** (DXW1) must be approximately equal to the local wing chord.

93. PXLEN, PYTEN, PXTEN1, PXTEN2, PXNW1, PXNW2 (see fig.24)

These parameters control the nacelle mesh nodes distribution in chordwise direction

PXLEN - The parameter that controls nodes distribution along the normal to the leading edge of nacelle section (0 <PXLEN), usually PXLEN=1.

PYTEN - The parameter that controls nodes distribution along the normal to the trailing edge of wing nacelle section (0 < PYTEN), usually PYTEN=1.

PXTEN1 - The parameter that controls nodes distribution near the nacelle trailing edge from the nacelle side (0. < PXTEN1 < 5.), usually PXTEN1=2.

PXTEN2 - The parameter that controls nodes distribution near the nacelle trailing edge from the wake side (0. < PXTEN1 < 5.).

PXNW1 - The parameter that controls nodes distribution near the end of **'near wake**' from the nacelle side (0. < PXNW1 < 5.).

PXNW2 - The parameter that controls nodes distribution near the end of **'near wake' from** the **'far wake'** side (0.< PXNW2).

Decreasing or increasing of these parameters leads to condensation or sparseness of the computational grid in the corresponding directions. The values of the parameters must ensure the uniform chodwise mesh condensation at the nacelle wake.

If the **'near wake'** is absent, in such case only parameters PXTEN1 and PXTEN2 are used, and as a rule PXTEN2=PXTEN1=2.

94. XLERN, RB1, RB2, RB3, RB4, YOB, DYBW, DYBN - the parameters that specify the position of the outer boundary of the nacelle computational mesh, see fig.25.

These parameters are specified in fraction of the **nacelle base chord** (see **item 92**).

The view of the nacelle mesh outer boundary is presented in **fig.4,25**. The front inflow part of the external boundary of the computational domain has a flat form. Four ellipses arcs form its contour. Radii RB1, RB2, RB3, RB4 and the distance XLERN from the front part of the external boundary to the leading edge of the nacelle are user-defined. The part of the side boundary of the nacelle computational domain must be transformed when necessary so that the side boundary turns the wing surface and its vortex sheet surface round. The undeformed part of the side boundary is a cylindrical surface.

XLERN - the distance XLERN from the front part of the external boundary to the leading edge of the nacelle, see **fig.25.**

RB1, RB2, RB3, RB4 - the radii of the nacelle computational domain.

The values of the parameters must ensure the appropriate overlapping of the nacelle and wing/body computational meshes.

As a rule XLERN = 1.0~1.5 and RB(1-4) =0.5~1.5.

For additional information about these parameters see Section 2.3.

YOB =0. - the parameter must be set equal to zero;

DYBW =0.~.1 - the parameter limits the min. distance between the deformed external boundary of the nacelle mesh and the cowl wake surface. If the distance became less then **DYBW+.5*DYBN**, then the nacelle's grid region bounded with the wake surface of the fan cowl are shifted down, as shown in **fig.25,4**. The shifting can be useful for an appropriate intersection of the wing/body computational grid and nacelle grid (see **Section 2.3**), but as a rule DYBW=0.

DYBN - the min. distance between the deformed external boundary of the nacelle mesh and the wing or wing's vortex sheet surface, as a rule DYBN=0.02 (see **fig.25**).

95. XLEN, YLEN, ZLEN, NIUL - define the location of a nacelle, as shown in fig.26.

XLEN - X-coordinate of the l.e. of the first input nacelle section in the body-fitted coordinate system;

YLEN - Y-coordinate of the l.e. of the first input nacelle section in the body-fitted coordinate system;

ZLEN - Z-coordinate of the l.e. of the first input nacelle section in the body-fitted coordinate system

NIUL =0., -1. - nacelle under the wing;

NIUL =1. - nacelle above the wing (in this case, it the calculation of the configuration with tail).

96. TWO free lines

97. INAC2- control parameter for second nacelle data

INAC2 - parameter indicates does the input data for the second nacelle are specified in the input data file. And if this data are present, then this parameter indicates does second nacelle is included in to configuration:

INAC2 = 0. – there are not a second nacelle data in the input data file;

INAC2 = 1. – the second nacelle data are specified in the input data file and the configuration contains the second nacelle;

INAC2 =-1. – the second nacelle data are specified in the input data file but the configuration is considered without the second nacelle;

If INAC2 $\neq$ 0., then the data similar to that for first nacelle (**items 91-95**) follow

98. TWO free lines

UPPER WINGLET MESH PARAMETERS. WINGLET POSITION.

99. IG - control parameter for the upper winglet data

IG - parameter indicates does the input data for the upper winglet are specified in the input data file (**items 100-103**). And if this data are present, then this parameter indicates does upper winglet is included in to configuration:

IG = 0. – there are not a winglet data in the input data file;

IG = 1. – the upper winglet data are specified in the input data file and the configuration contains the upper winglet;

IG =-1. – the upper winglet data are specified in the input data file but the configuration is considered without the upper winglet;

If IG ≠ 0., then the lines 100-103 follow

100. GAMMA, FI – angles of the winglet installation

In **fig.27** the upper view of the wing tip region with upper winglet is shown. The point **A** is a cross point of a winglet leading edge and a wing surface. The point **B** is a cross point of a winglet trailing edge and a wing surface.

GAMMA – angle (in degrees) between the plane of symmetry and the vertical plane, which contains the points **A** and **B**. (GAMMA > 0. - the deviation of winglet leading edge outboard). Note that spanwise location of the point **B** strictly coincides with a prescribed wing tip section. So when the GAMMA varies then the spanwise position of a point **A** varies.

FI – angle (in degrees) of winglet installation in plane (Y,Z), **see fig.27**. More precisely, (90^0-FI) is an angle between the vertical plane, which contains the points **A** and **B**, and the **base plane** of the winglet. (About winglet's **base plane** see **items 129,130**).

101. XLEGW, NXLEGW, PXLEGW –parameters define the winglet's leading edge location and computational grid about the winglet (see section 2.4 and fig.29)

XLEGW – the location of the winglet's leading edge at the wing section (point **A** in **fig.27**). This parameter is specified in fraction of the local wing chord. XLEGW>0

NXLEGW – the number of the wing/body mesh cells in chordwise direction between the leading edge of the wing tip and the winglet's leading edge for first computational grid (**fig.29**)

NXLEGW depends upon the XLEGW parameter strongly. Also this parameter for upper winglet should be in the correspondence with similar parameter for lower winglet, when both winglets are present and the chorwise locations of their leading edges are different. The recommended values of NXLEGW as a function of XLEGW values are shown in **fig.30.** We don't recommend specifying too small values of the XLEGW (say, less .03), otherwise the small values of the NXLEGW parameter do not ensure the proper density of a computational grid in a region in front of winglet's leading edge.

PXLEGW – the parameters controls the chordwise nodes condensation near the winglet leading edge, see **fig.29**. (0.<PXLEGW≤1.)

PXLEGW depends upon XLEGW, NXLEGW parameters. Usually PXLEGW=.4~.8.

102. XTEGW, NXTEGW, PXTEGW –parameters define the winglet trailing edge location and computational grid about the winglet (see section 2.4 and fig.29)

XTEGW – the location of the winglet's trailing edge at the wing tip section (point **B** in **fig.27**). This parameter is specified in fraction of the local wing chord, XTEGW<1.

NXTEGW – the number of the wing/body mesh cells in chordwise direction between the trailing edge of the wing tip and the winglet's trailing edge for first computational grid (**fig.29**), NXTEGW>0

NXTEGW depends upon the XTEGW parameter strongly. Also this parameter for upper winglet should be in the correspondence with similar parameter for lower winglet, when both winglets are present and the chorwise locations of there trailing edges are different. The recommended values of NXTEGW as a function of XTEGW values are shown in **fig.30.**

PXTEGW – the parameters controls the chordwise nodes condensation near the winglet trailing edge, see **fig.29**., (0.<PXTEGW≤1.)

PXTEGW depends upon XTEGW, NXTEGW parameters. Usually PXTEGW=.3~1.

103. NYJTEG, NYJB, NZKB, PZROOTG, PZTIPG -parameters define the winglet's spanwise nodes distribution and define the region of wing/body grid modification when obtaining wing/body/winglets computational grid.(See fig.28,29 and section 2.4.)

As pointed in **Section 2.4** the generation of the wing/body/winglets computation grid is performed by modification the initial wing/body grid in a vicinity of the wing tip (the winglet incorporation into wing/body grid). The sizes of the grid modification area depend upon winglet's sizes and must be set by the user.

NYJTEG – number of mesh cells of the wing/body/winglet greed between the wing surface and the winglet's tip for first computational grid (**fig.29**). This parameter depends upon winglet span. Usually, when the winglet's span is about the wing tip chord, then NYJTEG=4.~5. If winglet span exceeds the wing tip chord noticeably, then NYJTEG=6.

NYJB, NZKB – parameters define the region of wing/body grid modification, when the wing/body/winglets grid is generated (see **fig.28,29**).

Usually: NYJB=3.~4., NZKB=2.~3.

PZROOTG – parameters controls the winglet's spanwise grid compression at the winglet root region (0.<PZROOTG<1.). Usually PZROOTG=.2~.5.

PZTIPG – parameters controls the winglet's spanwise grid compression at the winglet tip region (0.<PZTIPG<1.). Usually PZTIPG=.4~.6

104. TWO free lines

LOWER WINGLET MESH PARAMETERS. WINGLET POSITION.

105. IG - control parameter for the lower winglet data

IG - parameter indicates does the input data for the lower winglet are specified in the input data file. And if this data are present, then this parameter indicates does lower winglet is included in to configuration:

IG = 0. – there are not a lower winglet data in the input data file;

IG = 1. – the lower winglet data are specified in the input data file and the configuration contains the lower winglet;

IG =-1. – the lower winglet data are specified in the input data file but the configuration is considered without the lower winglet;

If IG ≠ 0., then the lower winglet data similar to that for the upper winglet (lines 100-103) follow

106. TWO free lines

WING/BODY DATA

107. FNS

|FNS| - The number of span station at which the wing sections are defined from the root to the wing tip. (|FNS|<51).

The sign of the FNS parameter controls the wing section data printing

FNS > 0. - full printing

FNS < 0. - short printing

Warning! The items 108-112 are defined for every wing section

108. ZLE, XLE, YLE, CHORD, THICK, EPSIL, FSEC (see fig.17a) - the parameters specify the wing section geometry. The parameters Z, XLE, YLE can be defined in the wing's own coordinate system.

ZLE - Span location of the reference section

Note , that the first reference wing section can be located off the symmetry plane. If the first reference station is set not in the symmetry plane (ZLE(1) is not equal 0.), then an additional reference station in the symmetry plane is formed by the code at the initial stages of wing/body grid generation. The airfoil shape and the twist of this additional station are the same as of the first given reference cross section. Forming of the chord and leading edge coordinates of the additional station is shown in fig.18b. It is necessary to have an additional cross section located completely inside the body.

Otherwise the code can't determine the intersection line of the wing and wing's vortex sheet with the body.

Similarly, if the first input reference section is set in symmetry plane, then the section must be located completely inside the body

XLE - the X-coordinate of the wing section leading edge.

YLE - the Y-coordinate of the wing section leading edge.

CHORD - the local chord

THICK - modifies the section thickness. The Y coordinates are multiplied by THICK.

EPSIL - The angle through which the section is rotated to introduce twist. This angle is measured in the free stream direction

FSEC - indicates whether the geometry for a new profile is supplied or not

FSEC= 0. - The section obtained by scalling the profile used at the previous span section according to the parameters CHORD, THICK, EPSIL. No further strings are read for this span station, and the next string should be the string for the next span station, if any.

FSEC= 1. - The coordinates for a new profile are read from the data strings, which follow.

109. YSYM, NU, NL

YSYM - Indicates the type of a profile.

YSYM= 1.- denotes a symmetric profile. A table coordinates is read for the upper surface only;

YSYM= 0.- denotes a cambered profile. Coordinates are supplied for upper and lower surfaces, each ordered from nose to tail with the leading edge included in both surfaces.

NU - the number of upper surface coordinates,

NL - the number of lower surface coordinates. For YSYM=1., NL=NU even though no lower surface coordinates are given.

NL+NU-1 < 151.

110. XSING, YSING, TRAIL, SLOPT (see fig.17a)

TRAIL - the included angle at the trailing edge in degrees. The profile may be open, in this case the difference occurs in the angle between the upper and lower surfaces.

SLOPT - the tangent of the slope of the mean camber line at the trailing edge.

XSING, YSING - the coordinates of the transformation singular line.

YSING ≅ YU(1)=YL(1) (see **item 111,112.)**

XSING ≅ XU(1)+.5 R_L ,

Where RL - the nose profile radius

111. XU, YU

XU,YU - the coordinates of the airfoil upper surface. (from the leading to trailing edges)

112. XL, YL

XL,YL - the coordinates of the airfoil lower surface. (from the leading to trailing edges). The leading edge point is the same as the upper surface leading edge point. The trailing edge point may be different if the profile has an open tail.

BODY DATA

113. XLEF, YLEF, XTEF, YTEF, XTEF0, NSF (see fig.17b)

XLEF - X- coordinate of the leading point of the fuselage

YLEF - Y- coordinate

XTEF - X- coordinate of the trailing point of the fuselage

YTEF - Y- coordinate

XTEF0 - X- coordinate of the initiation of the semi-infinite body tail (for computation).

XTEF0 < XTEF

The cross section of the semi-infinite body tail is the same as the body cross-section at X=XTEF0.

It is not recommended XTEF0 to be very close to XTEF, so that the tail radius constitutes ~5%-20% of the body radius.

|NSF| - number of the body intermediate sections (|NSF| < 60.)

The sign of the NSF parameter controls the body section data printing

NSF > 0. - full printing

NSF < 0. - shot printing

Warning! The items 114-116 are defined for every fuselage section

114. XF , YF, RF, FSEC (see fig.17b)

XF - X- coordinate of the fuselage section (XLEF < XF < XTEF)

YF - Y- coordinate of the body mid line

RF - half-width of the fuselage section

FSEC - indicates whether the geometry for a new section is supplied or not

FSEC= 0. - the section is defined from the previous section

FSEC= 1. - the coordinates for a new section are read from the data strings which follow.

115. NS - the number of the body section coordinates. (NS<61)

116. YSF, ZSF

YSF,ZSF - the coordinates of the body section. These coordinates can be prescribed in own coordinate system, see **fig.17b.**

117. TWO free lines

HORISONTAL TAIL SECTION DATA

118. <u>NC</u>

NC - the number of the horisontal tail input sections ($0. \le NC < 11.$)

NC = 0. – the horisontal tail input sections are absent. In this case the configuration is without the horisontal tail, so the parameter ITH from **item 78** must be: ITH=-1. Or ITH=0.

If $NC \neq 0.$, then the item 119 is defined for every input horisontal tail section.

119. <u>ZLE, XLE, YLE, CHORD, THICK, EPSIL, ANT (see fig.23a)- the parameters specify the horisontal tail section geometry.</u>

The parameters XLE, YLE can be defined in the horisontal tail own coordinate system.

ZLE - the spanwise position of the input section;

Warning! The first input section can be located off the symmetry plane. In any case, the horisontal tail surface must intersect the body

XLE - the X- coordinate of the horisontal tail section leading edge;

YLE - the Y- coordinate of the horisontal tail section leading edge;

CHORD - the local chord;

THICK - modifies the section thickness. The Y coordinates of the section airfoil are multiplied by THICK.

EPSIL - the twist angle in degrees;

ANT - the index of the airfoil at the horisontal tail section, ANT is less or equal |NA| (see **item 134**)

120. <u>TWO free lines</u>

<u>VERTICAL TAIL SECTION DATA</u>

121. <u>NC</u>

NC - the number of the vertical tail input sections ($0. \le NC < 11.$)

NC = 0. – the vertical tail input sections are absent. In this case the configuration is without the vertical tail, so the parameter ITV from **item 84** must be: ITV=-1. Or ITV=0.

If $NC \neq 0.$, then the item 122 is defined for every input vertical tail section.

122. <u>ZLE, XLE, YLE, CHORD, THICK, EPSIL, ANT (see fig.23b)- the parameters specify the vertical tail section geometry.</u>

The parameters XLE, YLE can be defined in the vertical tail own coordinate system.

ZLE =0. – Z-coordinate of the section’s l.e. location;

Warning! In any case, the vertical tail surface must intersect the body

XLE - the X- coordinate of the vertical tail section leading edge;

YLE - the Y- coordinate of the vertical tail section leading edge;

CHORD - the local chord;

THICK - modifies the section thickness. The Y coordinates of the section airfoil are multiplied by THICK.

EPSIL =0. - the twist angle in degrees;

ANT - the index of the airfoil at the vertical tail section, ANT is less or equal |NA| (see **item 134**).

Warning! For vertical tail section, the index ANT must correspond to symmetrical airfoil.

123. <u>TWO free lines</u>

<u>SECTION DATA FOR FIRST NACELLE</u>

124. <u>NC</u>

NC - the number of the first nacelle input sections (0.≤ NC<11.)

NC = 0. – input sections are absent for first nacelle. In this case the configuration is without the first nacelle, so the parameter INAC1 from **item 90** must be: INAC1=-1. or INAC1=0.

If NC≠0., then the item 125 is defined for every input nacelle section.

125. <u>FNLE, XNLE, RNLE, CHORDN, THICK, EN, AN (see fig.25)- the parameters specify the nacelles section geometry.</u>

The parameters XNLE can be defined in the nacelles own coordinate system.

FNLE - the polar angle of the input section (in degrees).

Warning! The first section must corresponds to FNLE=0.

XNLE - the X-coordinate of the nacelle section leading edge.

RNLE - the radial coordinate of the nacelle section leading edge;

CHORDN - the local chord

THICKN - modifies the section thickness. The Y coordinates of nacelle section airfoil are multiplied by THICK.

EN - the angle through which the section is rotated to introduce twist. This angle is measured in the free stream direction

AN - the index of the airfoil at the nacelle section, AN is less or equal |NA| (see **item 134**)

126. <u>TWO free lines</u>

<u>SCTION DATA FOR SECOND NACELLE</u>

127. <u>NC</u>

NC - the number of the second nacelle input sections (0.≤ NC<11.)

NC = 0. – input sections are absent for second nacelle. In this case the configuration is without the second nacelle, so the parameter INAC2 from **item 97** must be: INAC2=-1. Or INAC2=0.

If NC≠0., then the lines similar to the **item 125** are defined for every input nacelle section.

128. <u>TWO free lines</u>

<u>UPPER WINGLET SECTION DATA</u>

129. <u>NC</u>

NC - the number of input sections for upper winglet($0. \le NC < 11.$)

NC = 0. – the upper winglet input sections are absent. In this case the configuration is without the upper winglet, so the parameter IG from **item 99** must be: IG=-1. or IG=0.

If $NC \neq 0.$, then the item 130 is defined for every input upper winglet section.

130. <u>ZLE, XLE, YLE, CHORD, THICK, EPSIL, AG (see fig.27)- the parameters specify the upper winglet section geometry.</u>

The parameters ZLE, XLE, YLE can be defined in the upper winglet own coordinate system XG,YG,ZG (see fig.27), here the plane (XG,ZG) – is a base plane of the winglet. Also, any linear dimensions can be used (the actual winglet's size is specified by a location on a wing surface the leading and trailing edges of a winglet's root section, see items 101,102).

ZLE - the spanwise position of the winglet input section;

XLE - the X- coordinate of the section leading edge;

YLE - the Y- coordinate of the section leading edge;

CHORD - the local chord;

THICK - modifies the section thickness. The Y coordinates of the section airfoil are multiplied by THICK.

EPSIL - the twist angle in degrees (if EPSIL>0, then the winglet section's trailing edge moves outboard);

AG - the index of the airfoil at the winglet section, AG is less or equal |NA| (see **item 134**)

131. <u>TWO free lines</u>

<u>LOWER WINGLET SECTION DATA</u>

132. <u>NC</u>

NC - the number of input sections for lower winglet($0. \le NC < 11.$)

NC = 0. – the lower winglet input sections are absent. In this case the configuration is without the lower winglet, so the parameter IG from **item 105** must be: IG=-1. or IG=0.

If $NC \neq 0.$, then the lines similar to **item 130** are defined for every input lower winglet section.

133. <u>TWO free lines</u>

<u>AIRFOIL DATA FOR NACELLE, TAIL AND WINGLET SECTIONS.</u>

134. <u>NA</u>

|NA| - the number of airfoils that can be used for the nacelle, tail and winglet input section definition. (NA<21).

The sign of the NA parameter controls the airfoils data printing

NA > 0. - full printing

NA < 0. - shot printing

Warning! The items 135-138 - are defined for every airfoil

135. <u>YSYM, NU, NL</u>

YSYM - Indicates the type of a profile.

YSYM= 1.- denotes a symmetric profile. A table coordinates is read for the upper surface only.

YSYM= 0.- denotes a cambered profile. Coordinates are supplied for upper and lower surfaces, each ordered from nose to tail with the leading edge included in both surfaces.

NU - the number of upper surface coordinates;

NL - the number of lower surface coordinates;

NU+NL-1 < 151

For YSYM=1., NL=NU even though no lower surface coordinates are given.

136. <u>XSING, YSING, TRAIL, SLOPT</u>

XSING, YSING - the coordinates of the transformation singular line.

YSING = YU(1)=YL(1)

XSING = XU(1)+.5 R_L ,

Where R_L - the nose profile radius

TRAIL - the included angle at the trailing edge in degrees. The profile may be open, in this case the difference occurs in the angle between the upper and lower surfaces.

SLOPT - the tangent of the slope of the mean camber line at the trailing edge.

137. <u>XU, YU</u>

XU,YU - the coordinates of the airfoil upper surface. (from the leading to trailing edges)

138. <u>XL, YL</u>

XL,YL - the coordinates of the airfoil lower surface. (from the leading to trailing edges). The leading edge point is the same as the upper surface leading edge point. The trailing edge point may be different if the profile has an open tail.

2.2 Initial data file and control of the geometry.

Here we present some examples of an initial data file modification for calculation the different configuration.

Example 1.

The example of initial data file for wing/body + two nacelle + horisontal tail + vertical+ tail + two winglets is presented in **Section 2.6.** Some fragments of this file are presented here:

```
                 ………………………….
                 ………………………….
77.              c--------------------------------------------------------
                      HORISONTAL TAIL MESH PARAMETERS AND HORISONTAL TAIL
                 POSITION
78.              [  ITH   ]
                    1.
79.              [  NX_TH ][  NY_TH ][  NZ_TH ][ NT_TH  ]
                    96.      6.       14.      10.
                 ………………………….
                 ………………………….
83.              c---------------------------------------------------------
                      VERTICAL TAIL MESH PARAMETERS AND VERTICAL TAIL POSITION
84.              [  ITV   ]
                    1.
85.              [  NX_TV ][  NY_TV ][  NZ_TV ][ NT_TV ]
                    96.       8.      14.       10.
                 ………………………….
                 ………………………….
89.              c----------------------------------------------------------
                            FIRST NACELLE MESH PARAMETERS AND NACELLE POSITION
90.              [  INAC1  ]
                    1.
91.              [   NYN  ][   NZN  ]
                     6.       8.
                 ………………………….
                 ………………………….
96.              c----------------------------------------------------------
                            SECOND NACELLE MESH PARAMETERS AND NACELLE POSITION
97.              [  INAC2  ]
                    1.
                 [   NYN  ][   NZN  ]
                     6.       8.
                 ………………………….
                 ………………………….
98.*             -------------------------------------------------------------
                        UPPER WINGLET MESH PARAMETERS. WINGLET POSITION.
99.*             [   IG   ]
                    1.
100.*            [ GAMMA  ][   FI   ]
                    1.       80.
                 ………………………….
                 ………………………….
104.*            -------------------------------------------------------------
                        LOWER WINGLET MESH PARAMETERS. WINGLET POSITION.
105.*            [   IG   ]
                    1.
                 [ GAMMA  ][   FI   ]
                    1.       80.
                 ………………………….
                 ………………………….

117.            c--------------------------------------------------------------
                           HORISONTAL TAIL SECTION DATA
118.            [  NC   ]
                   2.
```

```
119.    [ ZLE  ][  XLE  ][  YLE  ][ CHORD ][ THICK ][ EPSIL ][ AHT  ]
          0.      0.      0.     2.11      1.      0.      2.
        [ ZLE  ][  XLE  ][  YLE  ][ CHORD ][ THICK ][ EPSIL ][ AHT  ]
          5.    2.8868    .0     .633      1.      0.      2.
120.    c-----------------------------------------------------------------
                   VERTICAL TAIL SECTION DATA
121.    [  NC  ]
          2.
122.    [ ZLE  ][  XLE  ][  YLE  ][ CHORD ][ THICK ][ EPSIL ][ AHT  ]
          0.      0.      0.     2.11      1.      0.      2.
        [ ZLE  ][  XLE  ][  YLE  ][ CHORD ][ THICK ][ EPSIL ][ AHT  ]
          0.    2.8868    5.     .633      1.      0.      2.
123.    c-----------------------------------------------------------------
                   SECTION DATA FOR NACELLE  1
124.    [  NC  ]
          3
125.    [  FN  ][ XNLE ][ RNLE ][ CHORDN ][ THICKN ][  EN  ][  AN  ]
           0.      0.     .6      3.       .5       2.      1.
        [  FN  ][ XNLE ][ RNLE ][ CHORDN ][ THICKN ][  EN  ][  AN  ]
          90.      0.     .6      3.       .5       2.      1.
        [  FN  ][ XNLE ][ RNLE ][ CHORDN ][ THICKN ][  EB  ][  AN  ]
         180.      0.     .6      3.       .5       2.      1.
126.    c-----------------------------------------------------------------
                    SECTION DATA FOR NACELLE  2
127.    [  NC  ]
          3.
        [  FN  ][ XNLE ][ RNLE ][ CHORDN ][ THICKN ][  EN  ][  AN  ]
           0.      0.     .6      3.       .5       2.      1.
        [  FN  ][ XNLE ][ RNLE ][ CHORDN ][ THICKN ][  EN  ][  AN  ]
          90.      0.     .6      3.       .5       2.      1.
        [  FN  ][ XNLE ][ RNLE ][ CHORDN ][ THICKN ][  EB  ][  AN  ]
         180.      0.     .6      3.       .5       2.      1.
128*    -----------------------------------------------------------------
                   UPPER WINGLET SECTION DATA
129*    [  NC  ]
          2.
130*    [ ZLE  ][  XLE  ][  YLE  ][ CHORD ][ THICK ][ EPSIL ][  AG  ]
          0.      0.      0.     2.11      1.      0.      2.
        [ ZLE  ][  XLE  ][  YLE  ][ CHORD ][ THICK ][ EPSIL ][  AG  ]
          5.    2.8868    .0     .633      1.      0.      2.
131.    -----------------------------------------------------------------
*                  LOWER WINGLET SECTION DATA
132.    [  NC  ]
*         2.
        [ ZLE  ][  XLE  ][  YLE  ][ CHORD ][ THICK ][ EPSIL ][  AG  ]
          0.      0.      0.     2.11      1.      0.      2.
        [ ZLE  ][  XLE  ][  YLE  ][ CHORD ][ THICK ][ EPSIL ][  AG  ]
          5.    2.8868    .0     .633      1.      0.      2.
133.    ------------------------------------------------------------------
              SECTION AIRFOIL DATA FOR NACELLE, TAIL AND WINGLETS
        ................................
        ................................
```

Example 2.

The simplest way to exclude for example the first (inner nacelle), the horisontal tail and lower winglet from calculation is to set parameters ITH=-1., INAC1=-1. and IG=-1. (for lower winglet), without any other changing in the data file:

```
77.     c---------------------------------------------------------
            HORISONTAL TAIL MESH PARAMETERS AND HORISONTAL TAIL
        POSITION
78.     [ ITH  ]
          -1.
79.     [ NX_TH ][ NY_TH ][ NZ_TH ][ NT_TH ]
           96.      6.      14.     10.
        ................................
        ................................
```

```
83.      c---------------------------------------------------------
              VERTICAL TAIL MESH PARAMETERS AND VERTICAL TAIL POSITION
84.      [  ITV   ]
            1.
85.      [  NX_TV ][  NY_TV ][  NZ_TV ][ NT_TV ]
            96.       8.       14.       10.
         ................................
         ................................
89.      c---------------------------------------------------------
                   FIRST NACELLE MESH PARAMETERS AND NACELLE POSITION
90.      [  INAC1  ]
           -1.
91.      [   NYN  ][   NZN  ]
             6.       8.
         ................................
         ................................
96.      c---------------------------------------------------------
                   SECOND NACELLE MESH PARAMETERS AND NACELLE POSITION
97.      [  INAC2  ]
            1.
         [   NYN  ][   NZN  ]
             6.       8.
         ................................
         ................................
98.*     --------------------------------------------------------------
                UPPER WINGLET MESH PARAMETERS. WINGLET POSITION.
99.*     [   IG   ]
            1.
100.*    [ GAMMA  ][   FI   ]
            1.       80.
         ................................
         ................................
104.*    --------------------------------------------------------------
                LOWER WINGLET MESH PARAMETERS. WINGLET POSITION.
105.*    [   IG   ]
           -1.
         [ GAMMA  ][   FI   ]
            1.       80.
         ................................
         ................................
```

Note that in this case the “HORISONTAL TAIL SECTION DATA” or/and “SECTION DATA FOR NACELLE 1” or/and “LOWER WINGLET SECTION DATA” can be excluded from the initial data file, for example:

```
117.     -----------------------------------------------------------------
                     HORISONTAL TAIL SECTION DATA
118.     [   NC   ]
            0.
120.     -----------------------------------------------------------------
                     VERTICAL TAIL SECTION DATA
121.     [   NC   ]
            2.
122.     [  ZLE   ][   XLE  ][   YLE  ][  CHORD ][  THICK ][  EPSIL ][  AHT   ]
            0.        0.        0.       2.11       1.       0.        2.
         [  ZLE   ][   XLE  ][   YLE  ][  CHORD ][  THICK ][  EPSIL ][  AHT  ]
            0.     2.8868     5.       .633       1.       0.        2.
123.     -----------------------------------------------------------------
                     SECTION DATA FOR NACELLE  1
124.     [   NC   ]
            0.
126.     -----------------------------------------------------------------
                      SECTION DATA FOR NACELLE  2
127.     [   NC   ]
            3.
         [   FN   ][  XNLE  ][  RNLE  ][ CHORDN ][ THICKN ][   EN   ][   AN   ]
             0.       0.       .6        3.        .5        2.        1.
         [   FN   ][  XNLE  ][  RNLE  ][ CHORDN ][ THICKN ][   EN   ][   AN  ]
            90.       0.       .6        3.        .5        2.        1.
         [   FN   ][  XNLE  ][  RNLE  ][ CHORDN ][ THICKN ][   EB   ][   AN  ]
           180.       0.       .6        3.        .5        2.        1.
```

```
128*      -------------------------------------------------------------------
                    UPPER WINGLET SECTION DATA
129*      [   NC   ]
             2.
130*      [  ZLE   ][   XLE  ][   YLE  ][  CHORD ][  THICK ][  EPSIL ][   AG   ]
             0.        0.        0.       2.11        1.       0.        2.
          [  ZLE   ][   XLE  ][   YLE  ][  CHORD ][  THICK ][  EPSIL ][   AG   ]
             5.    2.8868      .0       .633       1.       0.       2.
131.      -------------------------------------------------------------------
*                   LOWER WINGLET SECTION DATA
132.      [   NC   ]
*            0.
133.      --------------------------------------------------------------------
               SECTION AIRFOIL DATA FOR NACELLE, TAIL AND WINGLETS
          ................................
          ................................
```

Example 3.

The identical to Example 2 results can be obtained if the horisontal tail, first nacelle and lower winglet are excluded from the initial data file directly:

```
77.         c-----------------------------------------------------------
                HORISONTAL TAIL MESH PARAMETERS AND HORISONTAL TAIL POSITION
78.         [  ITH   ]
               0.
83.         c------------------------------------------------------------
                VERTICAL TAIL MESH PARAMETERS AND VERTICAL TAIL POSITION
84.         [  ITV   ]
               1.
85.         [  NX_TV ][  NY_TV ][  NZ_TV ][ NT_TV ]
               96.        8.       14.       10.
            ................................
            ................................
89.         c-------------------------------------------------------------
                     FIRST NACELLE MESH PARAMETERS AND NACELLE POSITION
90.         [  INAC1  ]
               0.
96.         c-------------------------------------------------------------
                     SECOND NACELLE MESH PARAMETERS AND NACELLE POSITION
97.         [  INAC2  ]
               1.
            [   NYN  ][   NZN  ]
                6.        8.
            ................................
            ................................
98.*        ----------------------------------------------------------------
                  UPPER WINGLET MESH PARAMETERS. WINGLET POSITION.
99.*        [   IG   ]
               1.
100.*       [ GAMMA  ][   FI   ]
               1.        80.
            ................................
            ................................
104.*       ----------------------------------------------------------------
                  LOWER WINGLET MESH PARAMETERS. WINGLET POSITION.
105.*       [   IG   ]
               0.
106.        --------------------------------------------------------------
                                 WING/BODY DATA
            ................................
            ................................
```

Similar to the Example 2, the “HORISONTAL TAIL SECTION DATA” or/and the “SECTION DATA FOR NACELLE 1” or/and “LOWER WINGLET SECTION DATA” can be excluded from the initial data file in this case.

Example 4.

When the input data from **Example 1** is used, then the tail (vertical and horizontal) or/and nacelles can be excluded from the calculation by setting the values of NIT2_T or/and NIT2_N grater then the NIT value (see **items 27.,30.,33.**) for each calculation grid:

```
         ................................
         ................................
26.      ------------------------ FOR FIRST MESH -----------------
                      WING-BODY CALCULATION PARAMETERS
27.      [   NIT  ][  NORD1 ][  NORD2 ][   FH   ]
            55.      1000.      20.       1.
28.      [   P1W  ][  P2W   ][  P4W   ][  PLWF  ][  PHWF  ][  FLHWF ] [ PWF_WF ]
            1.3     1.001      1.        .7        1.5        4.        1.5
29.                   TAIL CALCULATION PARAMETERS
30.      [ NIT2_T ][ NIT3_T ][ NORD1_T][ NORD2_T]
           100.       2.      1000.       10.
31.      [   P1T  ][  P2T   ][  P4T   ][  PLT   ][  PHT   ][  FLHT  ]
            1.3      1.001      1.        .7       1.5        4.
32.      [ PWF_TAL][ PTAL_WF][PTAL_TAL]
            1.5       1.5       1.5
33.                   NACELLE CALCULATION PARAMETERS
34.      [ NIT2_N ][ NIT3_N  ]
           100.       4.
35.      [   P1N  ][  P2N   ][   P4N  ][  PLN   ][  PHN   ][  FLHN  ]
            1.2      1.001      1.       .05       1.7        4.
         ................................
         ................................
         ---------------------- FOR SECOND MESH --------------------
                      WING-BODY CALCULATION PARAMETERS
         [   NIT  ][  NORD1 ][  NORD2 ][   FH   ]
            46.       100.      20.       0.
         [   P1W  ][  P2W   ][  P4W   ][  PLWF  ][  PHWF  ][  FLHWF ][ PWF_WF ]
            1.3      1.002      1.        .7        1.5        5.       1.4
                     TAIL CALCULATION PARAMETERS
         [ NIT2_T ][ NIT3_T ][ NOR1_T ][ NOR2_T ]
           100.       2.       1000.       20.
         [   P1T  ][  P2T   ][  P4T   ][  PLT   ][  PHT   ][  FLHT  ]
            1.3      1.001      1.        .7       1.5        5.
         [ PWF_TAL][ PTAL_WF][PTAL_TAL]
            1.4       1.4      1.4
                     NACELLE CALCULATION PARAMETERS
         [ NIT2_N ][ NIT3_N  ]
           100.       4.
         [   P1N  ][  P2N   ][   P4N  ][  PLN   ][  PHN   ][  FLHN  ]
            1.2      1.001      1.       .02       1.7        4.
         ................................
         ................................
```

In such case the code generates tail and nacelle’s calculation grids, develops the nodes analysing procedure, but does not produce the calculations on the tail’s and/or nacelle’s meshes. Such type of calculation can be useful for comparison results with and without tails in case when horizontal tails mesh considerably influences on the wing wake geometry.

2.3 Supplying of the proper mesh generation for calculation with nacelles and tail.

The nacelles and tail are included in to the flow calculation by using the Chimera grid embedding technique. According to a Chimera technique the flow field calculation of the complicated configuration is carried out with the help of a set overlapped grids. Each grid for the separate element is generated rather independently from other elements. In the present paper three-dimensional grids for wing-body, tail and for nacelles and are used, as shown in **fig.1-9**. Wing-body grid is a main one, it fills in all calculated field and intersects nacelles and tail. Grids for nacelles, horizontal and vertical tails are totally inside the wing-body grid. Let's term these grids as **element's grids**. The element's grids can intersect each other. Note, the structure of the tail grids strongly depends on a type of a horizontal tail **fig.6-9**. In case of T-type horizontal tail the code forms the thin elliptical fairing in the root of horizontal tail.

The integration of the full potential equation is completed for each computation grid in turn.

For example, consider the computational procedure for nacelle. The calculation on the nacelle mesh is carried out with specified potential values (and other necessary parameters) on the external boundary of the computation domain. These boundary values are estimated by interpolation of the potential, obtained on a wing-body grid or, may be, by interpolation of the potential obtained on the grid of the neighbouring nacelle.

On the other hand, the wing-body mesh intersects nacelles. Some nodes of this grid are inside the nacelle and the domain restricted by the nacelle vortex sheet. These nodes we will call the hole or fiction nodes. The full potential equation for these nodes is not solved. The hole nodes are surrounded by internal boundary nodes. The internal boundary nodes must be embedded into the region of the nacelle mesh. The calculation on the body-wing mesh is completed with specified potential values (and other necessary parameters) at internal boundary nodes. These values are estimated by interpolation of the potential calculated on the nacelle grid. The successive calculation on each grid must provide the obtaining of the consistent solutions for all grids.

Note the structure of the tail grids strongly depends on a type of a horizontal tail. In case of usual horizontal tail **fig.6,7** the horizontal (and vertical) tail grid adjoins to a fuselage and does not intersect other elements of configuration and wing vortex sheet. So the interaction between wing/body grid and tail grids is quite similar to that between wing/body grid and nacelle grid.

Contrary to this, in case of T-type horizontal tail the structure of the horizontal tail grid is similar to that of wing-body grid **fig.8,9**. The grid can intersect vertical tail, body, wing and wing sheet. So the horizontal tail grid can by itself contain the hole nodes and inner boundary nodes. Therefore, to conduct calculation on a horizontal tail grid the interpolation of parameters not only to external boundary but also to internal boundary nodes is necessary. So the internal boundary nodes of the horizontal tail grid must be inside the flow region of wing/body or vertical tail grid.

Thus for successful flowfield computation, the sufficient overlapping of the main wing-body computational grid and element's grids is necessary. After the computational grids generation and before the flowfield computation, the code develops the analysing procedure for the mesh nodes. The analysing procedure consists of the following steps:

- - to find the hole nodes of the wing-body grid in the nacelle and tail regions. In case of T-type horizontal tail it is necessary to find also the hole nodes of horizontal tail grid;
- - to find the internal boundary nodes of the wing-body grid (and horizontal tail grid when necessary);
- - to define the parameters for an interpolation of the potential values in these nodes;

- - to define the parameters for an interpolation of the potential values in the external boundary nodes of the nacelle and tail grids.

If the grids intersections are inappropriate, then the problems arise in the analysing procedure. In such case the code is terminated and the picture **110.ps** is formed witch clear up the situation. The problems may be overcome by changing some of the input mesh generation parameters.

As for nacelle mesh generation, these parameters are: **Z1, NTN1, PZ11, PZ12, Z2, NTN2, PZ21, PZ22, XLERN, RB1, RB2, RB3, RB4, PZROOT, PZTIP, NT, DYBW, DYBN**.

And for tail mesh generation, these control parameters are: **NXW1, NXW2, NXW3, XW12, PXW12, XW23, PXW23, XRB_TH, YRB1_TH, YRB2_TH, ZRB_TH, XRB_TV, YRB_TV, ZRB_TV**.

To clarify the role of these parameters it is useful to briefly consider the structure of the element's grids and consider the nodes analysing procedure for nacelle and tail.

2.2.1. The nodes analysing procedure for nacelle

The structure of the computational nacelle grid is illustrated in **fig.3,4,25**. The front inflow part of the external boundary of the computational domain has a flat form. Its contour is formed by four ellipses arcs, as shown in **fig.4,25.** Radii RB1, RB2, RB3, RB4 and the distance from the front part of the external boundary to the leading edge of the nacelle are user-defined. The part of the side boundary of the nacelle computational domain must be transformed when necessary so that the side boundary turns the wing surface and its vortex sheet surface round. The undeformed part of the side boundary is a cylindrical surface.

The analysing of the wing-body grid nodes starts from the search of the internal hole nodes, which are located in the nacelle duct and in the region bounded by the nacelle potential discontinuity surface. After all hole nodes have been defined, the internal boundary nodes of the wing-body grid are determined. The search is accomplished by looking over all the found hole nodes. For each hole node twenty-six neighbouring nodes are analysed. If such a neighbouring node is not a hole node, then this node is defined as a internal boundary node.

The same procedure is accomplished for the second nacelle if it's present.

Note, that all the internal boundary nodes of the wing-body grid must be located inside the nacelle mesh. If it's not the case, the program terminated and the diagnostics and the picture illustrating situation are formed (postscript file **110.ps**). The example of such a picture is shown in **fig.31**. In the picture the small cross denotes the location of the internal hole node P_0 of the wing-body mesh. The large cross denotes its neighbouring internal boundary node P1. The front view shows the nacelle section contours and the external boundary section of the nacelle grid corresponding to the x-coordinate of the internal boundary node P_1. (Since x - coordinates of the nodes P_0 and P_1 differ, the hole node P_0 may look in the picture lying outside the nacelle contour. Actually it's located inside the nacelle contour.) As the picture shows, node P_1 is located outside the nacelle grid.

The way to correct this situation is to expand the nacelle grid region, for example, in this case, by increasing the radius RB2. This is the most radical way. But this problem may be overcome by the other ways. For example, we can enlarge the spanwise compression of the wing-body grid in the vicinity of the nacelle (input parameters Z1,NTN1,PZ11,PZ12 Z2,NTN2,PZ21,PZ22). Then the node P_1 is shifted to the left and, perhaps, it can appear inside of the nacelle grid. We can also, vice versa, try to decrease the spanwise compression of the wing-body grid. Then the node P_0 is shifted to the right and, perhaps stops being the hole node.

Also the parameter DYBW (see **item 94**) can be useful for overcoming the problem, especially in case illustrated in **fig.32,25** (when the fan cowl wake is too close to the wing wake). As shown in the **fig.32** the node P_1 is near the wing vortex sheet. The nacelle mesh region is not wide here. As the wing sheet limits the radii of the nacelle mesh, an increasing the values of RB1 or RB2 does not produce grate effect to the position of the nacelle mesh external boundary here. An increasing the value of DYBW parameter can shifts the nacelle wake and axes of the wake down. Such shifting makes the nacelle mesh region wider just under the wing sheet, so the node P_1 can appear inside the nacelle mesh. Also such shifting shifts the region of hole nodes of wing/body mesh down, so the node P0, perhaps, stops being the hole node.

Another way to overcome the situation is to increase the wing-body nodes density in spanwise direction by increasing the input number of the mesh sells NT along span (see **item 70**). Of course in this case it is necessary to correct some of the parameters NZ, NTN1, NTN2, PZ11, PZ12, PZ21, PZ22, PZROOT, PZTIP (**items 70,73,74,75**).

Note, that the mentioned problems may be overcome only once when defining a new configuration and choosing its grid parameters. Besides, if these problems have been overcome for the coarse computational grid then they do not have place on the finer grids.

After the nodes of the wing-body grid have been analysed, the external boundary nodes of the nacelle grid are processed. For each external boundary node of the nacelle grid the search of the wing-body grid cell containing this node is accomplished.

If the grids of two nacelles intersects (as a rule, this is the case) the situation is possible when the considered external boundary node of the first nacelle grid is located in the wing-body mesh cell and one vertex of this cell is the hole node, located inside the second nacelle. So the interpolation from the wing-body grid is impossible. In such case it is assumed that the parameters are interpolated to this external boundary from the second nacelle mesh. So the search of the second nacelle grid cell containing mentioned node is carried out.

Two problems may appear when processing the external boundary nodes of the nacelle grid.

First, the external boundary nodes of one nacelle mesh may be located inside neighbouring nacelle. The possibility of such situation is analysed before the start of the nodes processing. If this situation appears the code is terminated and the corresponding diagnostics is printed.

Second, the external boundary nodes may appear outside the computational domain, for example, inside the body or in the half-space $z<0$. In this case, the code execution stops, code prints diagnostics and forms the picture illustrating the situation (postscript file **110.ps**). The example of such picture is shown in **fig.33**.

Entirely, these problems may be overcome by correct definition of the location of the nacelle grid external boundary by parameters RB1, RB2, RB3, RB4.

Note that the mentioned problems may be absent on coarse grids but may appear on finer grids because the finer grids are more convex.

2.2.2. The nodes analysing procedure for tail

The structure of the computational tail grids is illustrated in **fig.5-9,19-22**. The grids for horizontal and vertical tail can intersect each other. The structure of the tail grids strongly depends on a type of a horizontal tail. In case of usual horizontal tail **fig.6,7** the horizontal tail grid adjoins to a fuselage and does not intersect other elements of configuration and wing vortex sheet. Contrary to this, in case of T-type horizontal tail the structure of the horizontal tail grid is similar to that of wing-body grid **fig.1,8,9**. The grid can intersect vertical tail, body, wing and wing sheet.

At first let’s consider the nodes analysing procedure for the case of usual horizontal tail.

Horizontal tail on a fuselage.

Parameters XRB_TH, YRB1_TH, YRB2_TH, ZRB_TH, XRB_TV, YRB_TV, ZRB_TV are user defined (**items 81,87**). These parameters limit distances between tail’s surfaces and exterior boundaries of the tail grids.

Note that the wake mesh surface of the main wing must be off the horizontal tail's mesh region. When necessary, the code deforms the geometry of the wing wake automatically so the wing's wake turns the horizontal mesh region round, as shown in **fig.7,19**. Thus the prescribed position of the lower boundary of the horizontal tail mesh region can effect to the position of the wing vortex sheet. And, in an ideal, user should be sure, that this deformation does not carry on to an essential modification of outcomes. (The check can be done by realisation of test calculations with a various position of a low boundary of the horizontal tail mesh.)

The nodes analysing procedure for tail is similar to that for nacelle. The wing-body mesh nodes just contiguous to a tails and tail wakes are considered as hole nodes. Then the internal boundary nodes of the wing-body grid are determined in the tail region. The search is accomplished by looking over all the found hole nodes. For each hole node twenty-six neighbouring nodes are analysed. If such a neighbouring node is not a hole node, then this node is defined as a internal boundary node.

All the internal boundary nodes of the wing-body grid must be located inside the tail meshes. If it's not the case, the program terminated and the diagnostics and the picture illustrating situation are formed (postscript file **110.ps**). The example of such a picture for vertical tail region is shown in **fig.34**. In the picture the cross denotes the location of the inner boundary node P_1 of the wing-body mesh. The front view shows the vertical tail section contours and the external boundary section of the tail grid corresponding to the x-coordinate of the internal boundary node P_1. As the picture shows, node P_1 is located outside the vertical tail grid region.

The way to correct this situation is to expand the vertical tail grid region, for example, in this case, by increasing the distance XRB_TV and ZRB_TV (see **fig.21**).

Note, that for the tail regions the problems of an appropriate inner boundary nodes location appears simpler in comparison with that for nacelle. As a rule, if these problems have been overcome for the coarse computational grid then they do not have place on the finer grids.

After the nodes of the wing-body grid have been analysed, the external boundary nodes of the tail grids are processed.

If there is only one tail element (horizontal tail or vertical tail), then for each external boundary node of the tail grid the search of the wing-body grid cell containing this node is accomplished.

If there are two tail elements (horisontal tail and vertical tail), then the tail grids intersect each other as a rule. In such case some external boundary nodes of one tail mesh are located inside another tail mesh. For these nodes it is assumed that the flow parameters are interpolated not from the wing-body grid but from the grid of second tail element. So, for the each external boundary node the search of the second tail grid cell containing mentioned node is carried out at first. If the search is failure, then node is located outside the second tail grid, and the search is accomplished by looking over wing-body mesh cells.

If the code can not find the address of the external boundary node (it's location is outside the computation region), then calculation is terminated and code prints diagnostics and forms the picture illustrating the situation (postscript file **110.ps**).

T-type horizontal tail.

The structure of the T-type horizontal tail grid is illustrated in **fig.8,9,20,22**. The single parameter ZRB_TH defines the location of the external boundary of the mesh region. The grid can intersect vertical tail, body, wing and wing's sheet. So contrary to usual horizontal tail, the grid for T-type horizontal tail can by itself contain the hole and inner boundary nodes. Thus the procedure for searching these nodes should be added.

The code treats the horizontal tail grid nodes, as a hole one, if it is located inside a body or it is just contiguous to a vertical tail and vertical tail's sheet, or if it is located bellow the wing and wing sheet. (Note, that T-type horizontal tail grid does not act to a wing sheet position). Then the internal boundary nodes of the horizontal tail grid are determined. For each hole node the neighbouring nodes are analysed. If such a neighbouring node is not a hole node, then this node is defined as a internal boundary node of horizontal tail grid. And the code tries to find the address of this node at first in region of the vertical tail grid (if vertical tail is present) and then (if the search is failure) the code continues searching in wing/body grid. All the internal boundary nodes of the T-type horizontal tail grid must be located inside the vertical tail mesh or inside the flow region of the wing/body mesh. If it's not the case, the program terminated and the diagnostics and the picture illustrating the situation are formed (postscript file **110.ps**).

2.4 Supplying of the proper mesh generation for calculation with winglets.

Contrary to nacelles and tail the winglets are directly incorporated into the main wing/body grid as shown in **fig.10,11,28**.

The generation of a resulting wing/body/winglets grid is carried out in two stages (see **fig.28**). At first phase the base wing/body grid is formed with the minimal account of the further inclusion of the winglets. An incorporation of winglets into a computational grid is carried out at the second stage by deformation of an initial grid in the vicinity of the wing tip, **fig.28,29**. Sizes of grid modification regions for upper and lower winglets are prescribed by user in terms of parameters NYJTEG, NYJB, NZKB (**item 103**). Also user must prescribe the set of parameters, which control distribution of mesh nodes on winglet surface and in a neighborhood of a winglet (**items 101-103**).

As the form, the sizes and position of winglets can be various, it is impossible precisely specify concrete values of these parameters. The recommendations, which are given in **items 101-103**, are no more than recommendations. So, as a rule, at creation of a new data file the choice of winglet mesh parameters should be realized step by step. In such process it is convenient to use the plot file **103.ps** (see **item 62**) for the analysis of an obtained grid over winglets. An example of the **103.ps** picture is presented in **fig.35**. Note, that it is meaningful to analyze a fine (final) computational grid.

The main features of a “good” grid over winglets are as follows:

- The computational mesh must be dense enough in chordwise direction at winglet’s leading and trailing edge regions (compression parameters PXLEGW, PXTEGW of **items 101,102**). The formal rule is: in winglet leading edge region the fine computational mesh should be dense enough to correctly describe the geometry of the winglet’s leading edge. (Note that too strong grid compression here can lead to a bad situation when the mesh lines going along a wing will be almost parallel to a winglet leading edge surface. In such case the reducing of parameter NXLEGW (**item 101**) can correct a situation.)
- It is necessary to ensure mesh compression in winglet spanwise direction near the winglets tip and (may be) root (parameters PZTIPG, PZROOTG of **item 103**). At winglet tip the size of mesh step in winglet spanwise direction should be about 10% of winglet’s span.
- It is very important to supply proper mesh compression near the winglet in wing spanwise direction (direction normal to winglet’s plane). Such compression of grid here is controlled by a parameter PZTIP of **item 73**. At the wing tip the size of mesh step in wing spanwize direction should be about (or less) 10% of winglet’s root chord.

When the new input data file is created, the following order of operations for a choice of the winglet mesh parameters seems reasonable. At first, the parameters, which set the mesh sells numbers NXLEGW, NXTEGW, NYJTEG, NYJB, NZKB should be prescribed according to recommendations of **items 101-103**, simultaneously the preliminary values of mesh compression parameters (PXLEGW, PXTEGW, PZROOTG, PZTIPG) should be given not small (PXLEGW=PXTEGW=PZROOTG=PZTIPG=1., PZTIP=.25). Then, after analyzing the obtained grid (picture **103.ps**), the mesh compression parameters can be reduced (step by step, may be) for obtaining a “good” grid.

2.5 Elimination of a wing from a configuration.

If the input parameter DELWING=1.(**item 4** of initial data file), then the main wing will be excluded from the calculation (flow calculation over isolated body or over body+tail+nacelle configuration).

Note that the input wing geometry must be present in the data file in any case. If DELWING=1. then the input wing is used only for mesh generation as a fiction wing. While mesh generation, the thickness of the fiction wing is considered equal to zero, so the section geometry of input wing can be arbitrary. But the plan form of the fiction wing is equal to that of the input wing, so the plan form of the input wing acts to the mesh over the body (the prescribed input mesh compression parameters work also).

Such organisation of computation is useful for more accurate comparing results for configuration with and without the wing, because the used computational meshes are rather similar in both cases.

From the other hand, if DELWING=1 and the problem of comparison configuration with and without wing is not actual, then the prescribed input wing geometry (and the mesh compression parameters) can be considered as a tool for improving the mesh over a body. For example, the shifting of the wing location forward makes the computational grid denser near the body leading edge. Note, if DELWING=1., than the grid compression near the wing tip and wing trailing edge is not necessary (parameters **PZTIP**, **PXTE** from **item 73** of initial data file). From the other hand, it can be useful to compress the grid near body surface (parameter **PZROOT** of **item 73**). The prescribed fiction wing can be the simple, no-swept, rectangular one. In this case the computation grid will be orthogonal near the body.

Use output pictures **101.ps**, **104.ps** and **105.ps** for analysing the computational grid near the body.

2.6 Examples of the initial data file.

Items:

```
1.          TEST ONERA_M5 + TAIL + NACELLE + WINGLETS
2.      [  MACH  ][  ALPHA ][  BETA  ][   RE   ][  CAX   ][   SW   ]
          .84       3.       1.     3000000.   2.8     27.43
3.*     [   ICL  ][   CL   ][  DCLDA ]
           0.       .4      .15
4.*     [  PSE   ][ DELWING][  IBEAM ][  IAIL  ][  IROT  ][  IFAN  ]
           0.       0.       0.       0.       0.       0.
5.      [  PA1   ]
          .65
6.      [  PA2   ]
          .7
7.*     [  IBL_W ][ IBL_HT ][ IBL_VT ][ IBL_UG ][ IBL_LG ][ IBL_F  ]
           0.       0.       0.       0.       0.       0.
8.      [ REFCHD ][ REFSPN ][ REFXOC ][ REFXCG ][ REFYCG ]
           0.       0.       0.       0.       0.
9.      ------------------------------------------------------
                  LOCATION OF THE TRANSITION LINE
                        FOR WING
10.     [  NTR_W ]
           2.
11.     [ SPAN_W ][ XTRU_WL][ XTRL_WL][ XTRU_WR][ XTRL_WR]
           0.      .02      .02      .02      .02
           1.      .02      .02      .02      .02
12.                     FOR HORISONTAL TAIL
13.     [  NTR_TH]
           2.
14.     [ SPAN_TH][ XTRU_HL][ XTRL_HL][ XTRU_HR][ XTRL_HR]
           0.      .02      .02      .02      .02
           1.      .02      .02      .02      .02
15.                     FOR VERTICAL TAIL
16.     [  NTR_TV]
           2.
17.     [ SPAN_TV][ XTR_VL ][ XTR_VR ]
           0.      .02      .02
           1.      .02      .02
18.*                   FOR UPPER WINGLET
19.*    [   NTR  ]
           2.
20.*    [  SPAN  ][ XTRI_L ][ XTRO_L ][ XTRI_R ][ XTRO_R ]
           0.      .02      .02      .02      .02
           1.      .02      .02      .02      .02
21.*                   FOR LOWER WINGLET
*       [   NTR  ]
           2.
*       [  SPAN  ][ XTRI_L ][ XTRO_L ][ XTRI_R ][ XTRO_R ]
           0.      .02      .02      .02      .02
           1.      .02      .02      .02      .02
22.*                   FOR  BODY
23.*    [  XTR_F ]
          .01
24.     -------------------------------------------------------
                     CALCULATION PARAMETERS
25.     [  FCONT ][ FCONTM ][ KGMRES ]
           0.       0.      -9.
26.     ------------------------ FOR FIRST MESH -----------------
                  WING-BODY CALCULATION PARAMETERS
27.     [   NIT  ][  NORD1 ][  NORD2 ][   FH   ]
          55.    1000.      20.       1.
28.*    [   P1W  ][  P2W   ][  P4W   ][  PLWF  ][  PHWF  ][  FLHWF ] [ PWF_WF ]
          1.3    1.001      1.       .7      1.5       4.      1.5
29.                TAIL CALCULATION PARAMETERS
30.     [ NIT2_T ][ NIT3_T ][ NORD1_T][ NORD2_T]
           1.       2.     1000.     10.
```

31*. [P1T][P2T][P4T][PLT][PHT][FLHT]
1.3 1.001 1. .7 1.5 4.

32. [PWF_TAL][PTAL_WF][PTAL_TAL]
1.5 1.5 1.5

33. NACELLE CALCULATION PARAMETERS

34. [NIT2_N][NIT3_N]
1. 4.

35. [P1N][P2N][P4N][PLN][PHN][FLHN]
1.2 1.001 1. .05 1.7 4.

36. [PWF_NAC][PNAC_WF][PNAC_NAC]
1.5 1.5 1.3

37.* CALCULATION PARAMETERS FOR VISCOUS-INVISCID ITERATIONS

38.* [NBL]
6.

39.* [IBL]
4.
12.
22.
30.
38.
46.

40.* [PB_W][PB_HT][PB_VT][PB_UG][PB_LG]
1. 1. 1. 1. 1.

---------------------- FOR SECOND MESH --------------------
WING-BODY CALCULATION PARAMETERS
[NIT][NORD1][NORD2][FH]
46. 100. 20. 0.
[P1W][P2W][P4W][PLWF][PHWF][FLHWF][PWF_WF]
1.3 1.002 1. .7 1.5 5. 1.4
TAIL CALCULATION PARAMETERS
[NIT2_T][NIT3_T][NOR1_T][NOR2_T]
1. 2. 1000. 20.
[P1T][P2T][P4T][PLT][PHT][FLHT]
1.3 1.001 1. .7 1.5 5.
[PWF_TAL][PTAL_WF][PTAL_TAL]
1.4 1.4 1.4
NACELLE CALCULATION PARAMETERS
[NIT2_N][NIT3_N]
1. 4.
[P1N][P2N][P4N][PLN][PHN][FLHN]
1.2 1.001 1. .02 1.7 4.
[PWF_NAC][PNAC_WF][PNAC_NAC]
1.5 1.5 1.3
CALCULATION PARAMETERS FOR VISCOUS-INVISCID ITERATIONS
[NBL]
5.
[IBL]
6.
14.
22.
30.
38.
[PB_W][PB_HT][PB_VT][PB_UG][PB_LG]
.7 .7 .7 .7 .7

41. c---
BOUNDARY LAYER PARAMETERS

42.* [NDF][NVB][CFXMIN]
5. 1. -0.5

43. c---
FLOW PLOTTING PARAMETERS
FOR WING-BODY AND WINGLETS

44. [FPLOT1][FPLOT2][FPLOT3][FPLOT4][FPLOT5][FPLOT6][FPLOT7][FPLOT8]
1. 1. 1. 1. 1. 1. 3. 3.

45. [CPMINW][CPMINF]
-2.0 -1.

46.* [NZOUT][NFOUT][NXOUT][NZOUT_G]
6. 5. 6. 6.

```
47.*      [  ZOUT  ][  FOUT  ][  XOUT  ][ ZOUT_G ]
            .15      -90.      .1       .03
            .25      -45.      .3       .2
            .75       0.       .4       .4
            .97       45.      .5       .6
           -30.       90.      .7       .8
            30.                .9       .99
48.                  FOR TAIL
49.       [ TPLOT1 ][ TPLOT2 ][ TPLOT3 ][ TPLOT4 ][ TPLOT5 ][ TPLOT6 ][ TPLOT7 ][ TPLOT8]
             1.       1.       1.       1.       0.       0.       3.       3.
50.       [ CPMINT ]
            -2.0
51.       [  NZOUT ]
             6.
52.       [  ZOUT  ]
            .15
            .25
            .35
            .55
            .75
            .95

53.                  FOR NACELLE
54.       [ NPLOT4 ]
             1.
55.       [ CPMINN ]
            -2.4
56.       [  NFOUT ]
             4.
57.       [  FOUT  ]
             0.
             90.
            180.
            270.
58.                  ISOBAR LEVELS
59.       [  NCPOUT]
             20.
60.       [  CPOUT ]
            -1.5
            -1.4
            -1.3
            -1.2
            -1.1
            -1.0
             -.9
             -.8
             -.7
             -.6
             -.5
             -.4
             -.3
             -.2
             -.1
             0.0
              .1
              .2
              .3
              .4
61.       c-----------------------------------------------------------------
                     MESH PLOTTING PARAMETERS
                     FOR WING-BODY
62.*      [ FPICT1 ][ FPICT2 ][ FPICT3 ][ FPICT4 ][ FPICT5 ][  FTP1  ][  FTP3  ]
             1.       0.       0.       1.       .4       1.       1.
63.       [  XMIN  ][  XMAX  ][  YMIN  ][  YMAX  ][  ZMIN  ][  ZMAX  ]
            7.       17.      -5.       5.       .0       15.
64.                  FOR TAIL
65.       [ FTPICT1][ FTPICT2][ FTPICT3][ FTPICT4][ FTPICT5]
             1.       1.       0.       1.       .4
66.       [  XMIN  ][  XMAX  ][  YMIN  ][  YMAX  ][  ZMIN  ][  ZMAX  ]
            7.       17.      -5.       5.       .0       15.
67.                  FOR NACELLE
68.       [ FNPICT1][ FNPICT2][ FNPICT3][ FNPICT4][ FNPICT5]
             1.       .5       0.       0.       0.
```

```
69.   c---------------------------------------------------------
               WING/BODY MESH PARAMETERS AND WING POSITION
70.   [   NY   ][   NZ   ][   NT   ][   NTN1 ][  NTN2  ][ NY_BETA]
         12.       20.       14.       4.       4.       0.
71.   [  NXS   ][  NXW1  ][  NXW2  ][  NXW3  ]
         32.       10.       6.        8.
72.   [   XW12 ][ PXW12  ][  XW23  ][  PXW23 ]
          0.       1.        0.        1.
73.   [ PZROOT ][ PZTIP  ][  PXLE  ][  PXTE  ][  PYTE  ][   PZA  ][   PZB  ]
        .25      .25        1.        1.        1.       0.        0.
74.   [   Z1   ][  PZ11  ][  PZ12  ]
        .35       .6        .5
75.   [   Z2   ][  PZ21  ][  PZ22  ]
        .65       .5        .6
76.   [  XLEW  ][  YLEW  ]
       7.2273     .0
77.   c---------------------------------------------------------
          HORISONTAL TAIL MESH PARAMETERS AND HORISONTAL TAIL POSITION
78.   [  ITH   ]
         1.
79.   [  NX_TH ][  NY_TH ][  NZ_TH ][ NT_TH  ]
         96.       6.        14.      10.
80.   [ PZROOT ][  PZTIP ][  PXLE  ][  PXTE  ][  PYTE  ]
         .25      .25        1.        1.       1.
81.   [ XRB_TH ][ YRB1_TH][ YRB2_TH][ ZRB_TH ]
         .5        .5        1.       1.4
82.   [  XLETH ][ YLETH  ]
        18.2      .0
83.   c---------------------------------------------------------
          VERTICAL TAIL MESH PARAMETERS AND VERTICAL TAIL POSITION
84.   [  ITV   ]
         1.
85.   [  NX_TV ][  NY_TV ][  NZ_TV ][ NT_TV ]
         96.       8.       14.       10.
86.   [ PZROOT ][  PZTIP ][  PXLE  ][  PXTE ][  PYTE  ]
         .4        .4        1.        1.      1.
87.   [ XRB_TV ][ ZRB_TV ][ YRB_TV ]
         .5        1.2       1.4
88.   [ XLETV  ][ YLETV  ]
        18.2       0.
89.   c---------------------------------------------------------
               FIRST NACELLE MESH PARAMETERS AND NACELLE POSITION
90.   [  INAC1  ]
         1.
91.   [   NYN  ][   NZN  ]
          6.       8.
92.   [   NXNS ][  NXNW1 ][  NXNW2 ][ NXNA1  ][  NXNA2 ][  DXW1  ]
          16.      8.        8.       2.        6.      2.4
93.   [  PXLEN ][  PYTEN ] [ PXTEN1 ][ PXTEN2 ][  PXNW1 ][ PXNW2 ]
          1.       1.        2.       0.3       4.      15.
94.   [  XLERN ][   RB1  ][  RB2   ][  RB3   ][   RB4  ][  YOB   ][  DYBW  ][  DYBN ]
          1.       1.       .7        .8        .7       .0        .06     .02
95.   [  XLEN  ][  YLEN  ][  ZLEN  ][  NIUL  ]
        7.51      -.4       4.       -1.
96.   c---------------------------------------------------------
               SECOND NACELLE MESH PARAMETERS AND NACELLE POSITION
97.   [  INAC2  ]
         1.
      [   NYN  ][   NZN  ]
          6.       8.
      [   NXNS ][  NXNW1 ][  NXNW2 ][ NXNA1  ][  NXNA2 ][  DXW1  ]
          16.      8.        8.       2.        6.      2.4
      [  PXLEN ][  PYTEN ] [ PXTEN1 ][ PXTEN2 ][  PXNW1 ][ PXNW2 ]
          1.       1.        2.       0.3       4.      15.
      [  XLERN ][   RB1  ][  RB2   ][  RB3   ][   RB4  ][  YOB   ][  DYBW  ][  DYBN ]
          1.       1.       1.        .8        .65      .0        .06      .02
      [  XLEN  ][  YLEN  ][  ZLEN  ][  NIUL  ]
        9.232     -.3       7.       -1.
```

98.* --

UPPER WINGLET MESH PARAMETERS. WINGLET POSITION.

99.* [IG]
1.

100.* [GAMMA][FI]
1. 80.

101.* [XLEGW][NXLEGW][PXLEGW] Winglet l.e. position at the wing
.2 10. .52

102.* [XTEGW][NXTEGW][PXTEGW] Winglet t.e. position at the wing
.90 6. .3

103.* [NYJTEG][NYJB][NZKB][PZROOTG][PZTIPG]
6. 3. 3. .1 .3

104.* --

LOWER WINGLET MESH PARAMETERS. WINGLET POSITION.

105.* [IG]
1.

[GAMMA][FI]
1. 80.

[XLEGW][NXLEGW][PXLEGW] Winglet l.e. position at the wing
.2 10. .52

[XTEGW][NXTEGW][PXTEGW] Winglet t.e. position at the wing
.90 6. .3

[NYJTEG][NYJB][NZKB][PZROOTG][PZTIPG]
6. 3. 3. .1 .3

106. --

WING/BODY DATA

107. [FNS]
2.

108. [ZLE][XLE][YLE][CHORD][THICK][EPSIL][FSEC]
0. 0. 0. 4.22 1. 0. 1.

109. [YSYM][NU][NL]
0. 33. 33.

110. [XSING][YSING][TRAIL][SLOPT]
.005 .000 14.14 .0

111. [XU][YU]

```
 .00000   .00000
 .00022   .00249
 .00088   .00525
 .00223   .00824
 .00429   .01134
 .01092   .01763
 .02154   .02320
 .03671   .02728
 .05701   .03064
 .08370   .03424
 .11876   .03800
 .15813   .04125
 .19633   .04369
 .23362   .04554
 .27027   .04693
 .30656   .04791
 .34274   .04849
 .37912   .04865
 .41595   .04836
 .45350   .04758
 .49207   .04627
 .53191   .04442
 .57329   .04201
 .61651   .03904
 .66183   .03554
 .70953   .03153
 .75989   .02699
 .81318   .02183
 .86966   .01580
 .92575   .00918
 .96297   .00458
 .98589   .00175
1.00000   .00000
```

112. [XL][YL]

```
 .00000   .00000
 .00022  -.00249
 .00088  -.00525
```

```
 .00223   -.00824
 .00429   -.01134
 .01092   -.01763
 .02154   -.02320
 .03671   -.02728
 .05701   -.03064
 .08370   -.03424
 .11876   -.03800
 .15813   -.04125
 .19633   -.04369
 .23362   -.04554
 .27027   -.04693
 .30656   -.04791
 .34274   -.04849
 .37912   -.04865
 .41595   -.04836
 .45350   -.04758
 .49207   -.04627
 .53191   -.04442
 .57329   -.04201
 .61651   -.03904
 .66183   -.03554
 .70953   -.03153
 .75989   -.02699
 .81318   -.02183
 .86966   -.01580
 .92575   -.00918
 .96297   -.00458
 .98589   -.00175
1.00000   -.00000
[   Z   ][   XLE  ][   YLE  ][  CHORD ][  THICK ][  EPSIL ][  FSEC  ]
  10.00    5.7735     .0      1.266       1.       0.       0.
```

113.

```
[  XLEF  ][  YLEF  ][  XTEF  ][  YTEF  ][  XTEF0 ][   NSF  ]
   .0      .0      22.35      0.      22.2      25.
```

114.

```
[   XF   ][   YF   ][   RF   ][  FSEC  ]
 .04078    .0      .1452     1.
```

115.

```
[   NS   ]
   31.
```

116.

```
[   YF   ][   ZF   ]
 -1.00000   0.00000
 -0.99452   0.10453
 -0.97815   0.20791
 -0.95106   0.30902
 -0.91355   0.40674
 -0.86603   0.50000
 -0.80902   0.58779
 -0.74314   0.66913
 -0.66913   0.74314
 -0.58779   0.80902
 -0.50000   0.86603
 -0.40674   0.91355
 -0.30902   0.95106
 -0.20791   0.97815
 -0.10453   0.99452
  0.00000   1.00000
  0.10453   0.99452
  0.20791   0.97815
  0.30902   0.95106
  0.40674   0.91355
  0.50000   0.86603
  0.58779   0.80902
  0.66913   0.74314
  0.74314   0.66913
  0.80902   0.58779
  0.86603   0.50000
  0.91355   0.40674
  0.95106   0.30902
  0.97815   0.20791
  0.99452   0.10453
  1.00000   0.00000
[   XF   ][   YF   ][   RF   ][  FSEC  ]
 .08370    .0     0.2050     0.
[   XF   ][   YF   ][   RF   ][  FSEC  ]
 .16741    .0     0.2889     0.
```

```
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         .29404     .0      0.3804       0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         .6288      .0      .5492       0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         1.2577      .0      .756        0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         2.0991      .0      .9391       0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         3.7996      .0      1.1545      0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         6.2993      .0      1.26        0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         7.         .0      1.26        0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         8.         .0      1.26        0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         11.        .0      1.26        0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         13.        .0      1.26        0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         14.281      .0      1.26        0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         15.5412     .0      1.247       0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         16.3804     .0      1.2238      0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         17.2196     .0      1.188       0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         18.900      .0      1.0731      0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         19.321      .0      1.0341      0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         19.7414     .0      .9897       0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         20.16       .0      .9425       0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         20.581      .0      .895        0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         20.9176     .0      .8572       0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         21.4628     .0      .7959       0.
        [   XF   ][   YF   ][   RF   ][  FSEC  ]
         22.        .0      .5000       0.
117.    c-------------------------------------------------------------------
                  HORISONTAL TAIL SECTION DATA
118.    [   NC   ]
           2.
119.    [  ZLE   ][   XLE  ][   YLE  ][  CHORD ][  THICK ][  EPSIL ][  AHT   ]
           0.        0.        0.       2.11        1.       0.        2.
        [  ZLE   ][   XLE  ][   YLE  ][  CHORD ][  THICK ][  EPSIL ][  AHT  ]
           5.     2.8868     .0        .633        1.       0.        2.
120.    c-------------------------------------------------------------------
                  VERTICAL TAIL SECTION DATA
121.    [   NC   ]
           2.
122.    [  ZLE   ][   XLE  ][   YLE  ][  CHORD ][  THICK ][  EPSIL ][  AHT   ]
           0.        0.        0.       2.11        1.       0.        2.
        [  ZLE   ][   XLE  ][   YLE  ][  CHORD ][  THICK ][  EPSIL ][  AHT  ]
           0.     2.8868      5.       .633        1.       0.        2.
123.    c-------------------------------------------------------------------
                  SECTION DATA FOR NACELLE  1
124.    [   NC   ]
           3.
125.    [   FN   ][  XNLE  ][  RNLE  ][ CHORDN ][ THICKN ][   EN   ][   AN   ]
            0.       0.       .6        3.        .5        2.        1.
        [   FN   ][  XNLE  ][  RNLE  ][ CHORDN ][ THICKN ][   EN   ][   AN  ]
           90.       0.       .6        3.        .5        2.        1.
        [   FN   ][  XNLE  ][  RNLE  ][ CHORDN ][ THICKN ][   EB   ][   AN  ]
          180.       0.       .6        3.        .5        2.        1.
126.    c-------------------------------------------------------------------
                   SECTION DATA FOR NACELLE  2
```

```
127.     [   NC   ]
            3.
         [   FN   ][  XNLE  ][  RNLE  ][ CHORDN ][ THICKN ][   EN   ][   AN   ]
            0.       0.       .6        3.       .5        2.       1.
         [   FN   ][  XNLE  ][  RNLE  ][ CHORDN ][ THICKN ][   EN   ][   AN   ]
           90.       0.       .6        3.       .5        2.       1.
         [   FN   ][  XNLE  ][  RNLE  ][ CHORDN ][ THICKN ][   EB   ][   AN   ]
          180.       0.       .6        3.       .5        2.       1.
128.*    ------------------------------------------------------------------
                      UPPER WINGLET SECTION DATA
129.*    [   NC   ]
            2.
130.*    [  ZLE   ][   XLE  ][   YLE  ][  CHORD ][  THICK ][  EPSIL ][   AG   ]
            0.       0.       0.      2.11      1.       0.       2.
         [  ZLE   ][   XLE  ][   YLE  ][  CHORD ][  THICK ][  EPSIL ][   AG   ]
            5.    2.8868      .0      .633      1.       0.       2.
131.*    ------------------------------------------------------------------
                      LOWER WINGLET SECTION DATA
132.*    [   NC   ]
            2.
         [  ZLE   ][   XLE  ][   YLE  ][  CHORD ][  THICK ][  EPSIL ][   AG   ]
            0.       0.       0.      2.11      1.       0.       2.
         [  ZLE   ][   XLE  ][   YLE  ][  CHORD ][  THICK ][  EPSIL ][   AG   ]
            5.     2.8868     .0      .633      1.       0.       2.
133.     -------------------------------------------------------------------
                 SECTION AIRFOIL DATA FOR NACELLE, TAIL AND WINGLETS
134.     [   NA   ]
           -2.
135.     [  YSYM  ][    NU  ][    NL  ]           section 1
            0.        47.      51.
136.     [  XSING ][  YSING ][  TRAIL ][  SLOPT ]
           0.01    0.00000    10.7    -0.1384
137.     [    XU   ][    YU   ]
          0.000000  0.000000
          0.000015  0.000560
          0.000079  0.001201
          0.000209  0.001918
          0.000424  0.002719
          0.000754  0.003623
          0.001193  0.004564
          0.002130  0.006067
          0.003748  0.007928
          0.005498  0.009559
          0.007245  0.011018
          0.008947  0.012292
          0.010671  0.013439
          0.012817  0.014718
          0.015544  0.016164
          0.018999  0.017791
          0.023363  0.019619
          0.028854  0.021668
          0.035737  0.023950
          0.044309  0.026507
          0.054923  0.029348
          0.067986  0.032486
          0.083984  0.035925
          0.103344  0.039592
          0.126722  0.043458
          0.154578  0.047402
          0.187522  0.051288
          0.226207  0.055180
          0.270335  0.058709
          0.316131  0.061324
          0.362356  0.063166
          0.408373  0.064153
          0.453464  0.064334
          0.497133  0.063691
          0.538885  0.062262
          0.580587  0.059955
          0.627489  0.056367
          0.677338  0.051448
          0.724766  0.045964
```

```
        0.769317  0.040186
        0.810711  0.034194
        0.848786  0.028223
        0.883458  0.022440
        0.914810  0.016902
        0.942915  0.011660
        0.967910  0.006799
        1.000000  0.000000
```

138.

```
       [   XL   ][    YL  ]
        0.000000 -0.000000
        0.000024 -0.000577
        0.000081 -0.001101
        0.000168 -0.001601
        0.000281 -0.002101
        0.000423 -0.002623
        0.000602 -0.003178
        0.000816 -0.003748
        0.001069 -0.004349
        0.001371 -0.004980
        0.001721 -0.005606
        0.002124 -0.006213
        0.002601 -0.006834
        0.003183 -0.007503
        0.003915 -0.008243
        0.004856 -0.009114
        0.005983 -0.010087
        0.007300 -0.011142
        0.008857 -0.012279
        0.010833 -0.013567
        0.013403 -0.015055
        0.016864 -0.016823
        0.021571 -0.018944
        0.027426 -0.021302
        0.035364 -0.024075
        0.045972 -0.027312
        0.059717 -0.030918
        0.078361 -0.035096
        0.100875 -0.039413
        0.129274 -0.043970
        0.163892 -0.048535
        0.204271 -0.052839
        0.249697 -0.056573
        0.299301 -0.059350
        0.353097 -0.060561
        0.408132 -0.059363
        0.463467 -0.055579
        0.518351 -0.049849
        0.572082 -0.042915
        0.624116 -0.035663
        0.674099 -0.028197
        0.721484 -0.021301
        0.766104 -0.015127
        0.807721 -0.009918
        0.846135 -0.005699
        0.881232 -0.002507
        0.913066 -0.000337
        0.941683  0.000813
        0.967178  0.001002
        0.978813  0.000805
        1.000000  0.000000
       [  YSYM  ][   NU   ][   NL   ]          section 2       - ONERA airfoil
          1.        33.       33.
       [ XSING  ][ YSING ][  TRAIL ][  SLOPT ]
        .005       .000      14.14      .0
       [   XU   ][   YU   ]
        .00000   .00000
        .00022   .00249
        .00088   .00525
        .00223   .00824
        .00429   .01134
        .01092   .01763
        .02154   .02320
        .03671   .02728
        .05701   .03064
```

.08370	.03424
.11876	.03800
.15813	.04125
.19633	.04369
.23362	.04554
.27027	.04693
.30656	.04791
.34274	.04849
.37912	.04865
.41595	.04836
.45350	.04758
.49207	.04627
.53191	.04442
.57329	.04201
.61651	.03904
.66183	.03554
.70953	.03153
.75989	.02699
.81318	.02183
.86966	.01580
.92575	.00918
.96297	.00458
.98589	.00175
1.00000	.00000

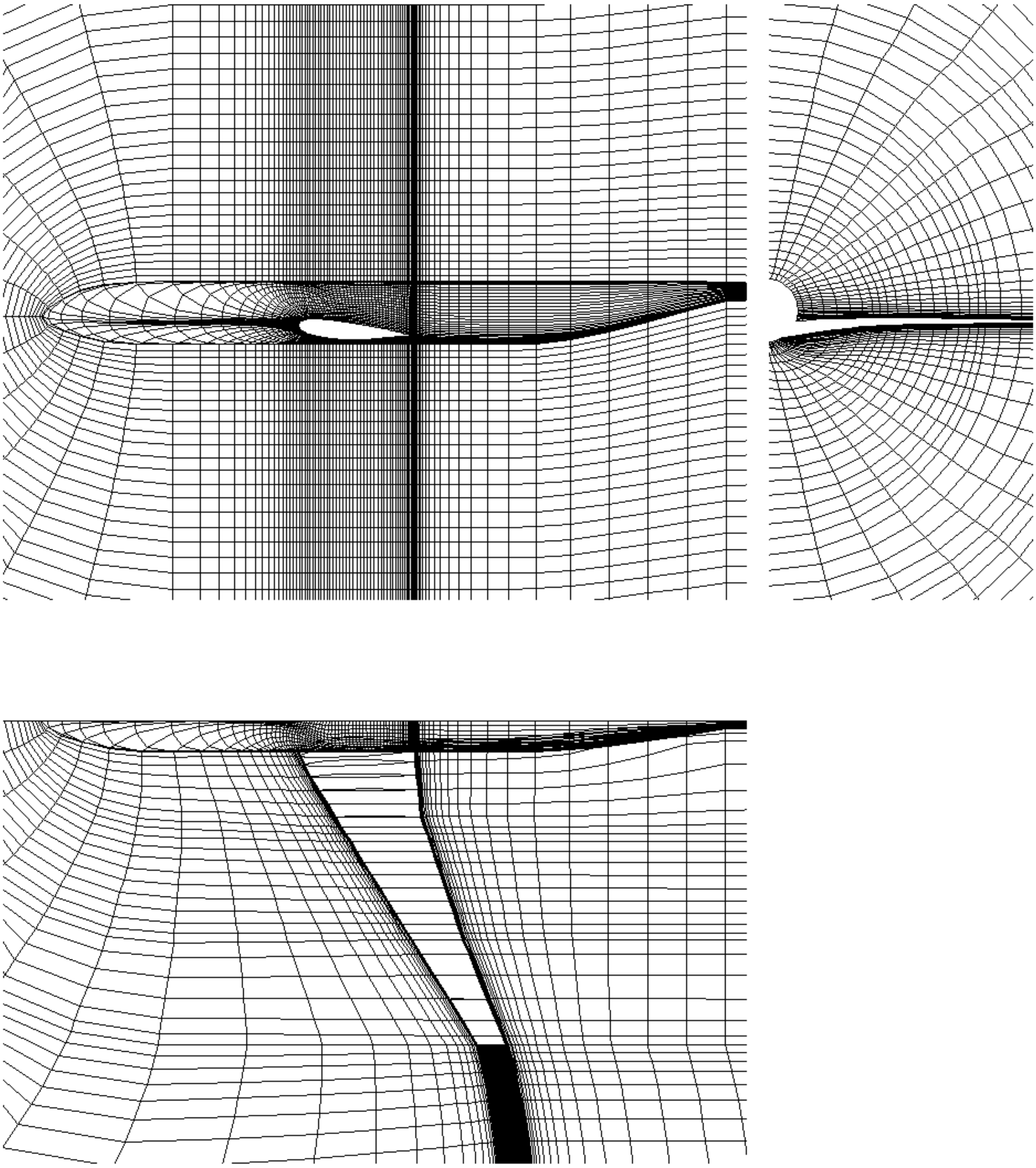


fig. 1

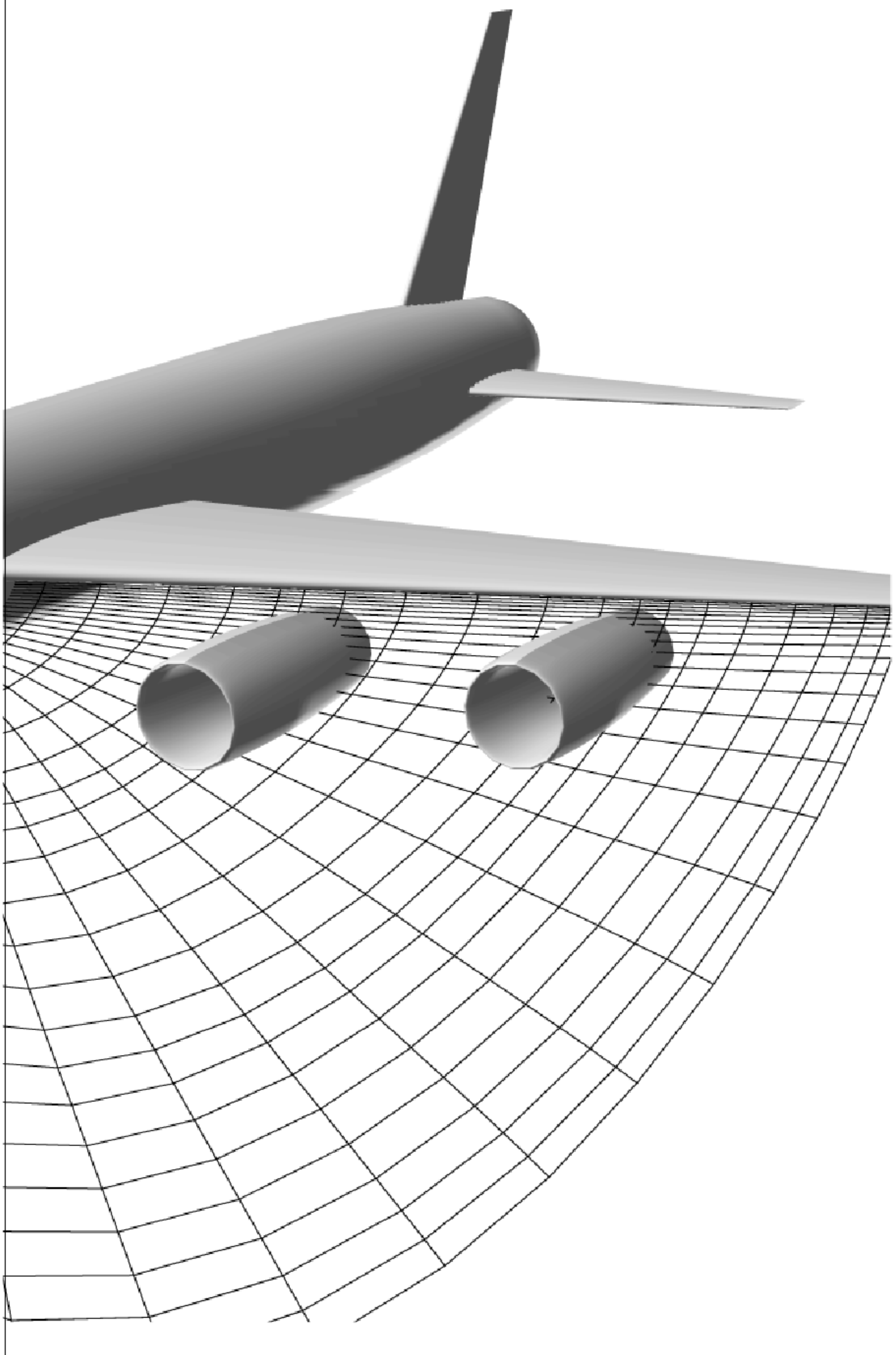


fig.2

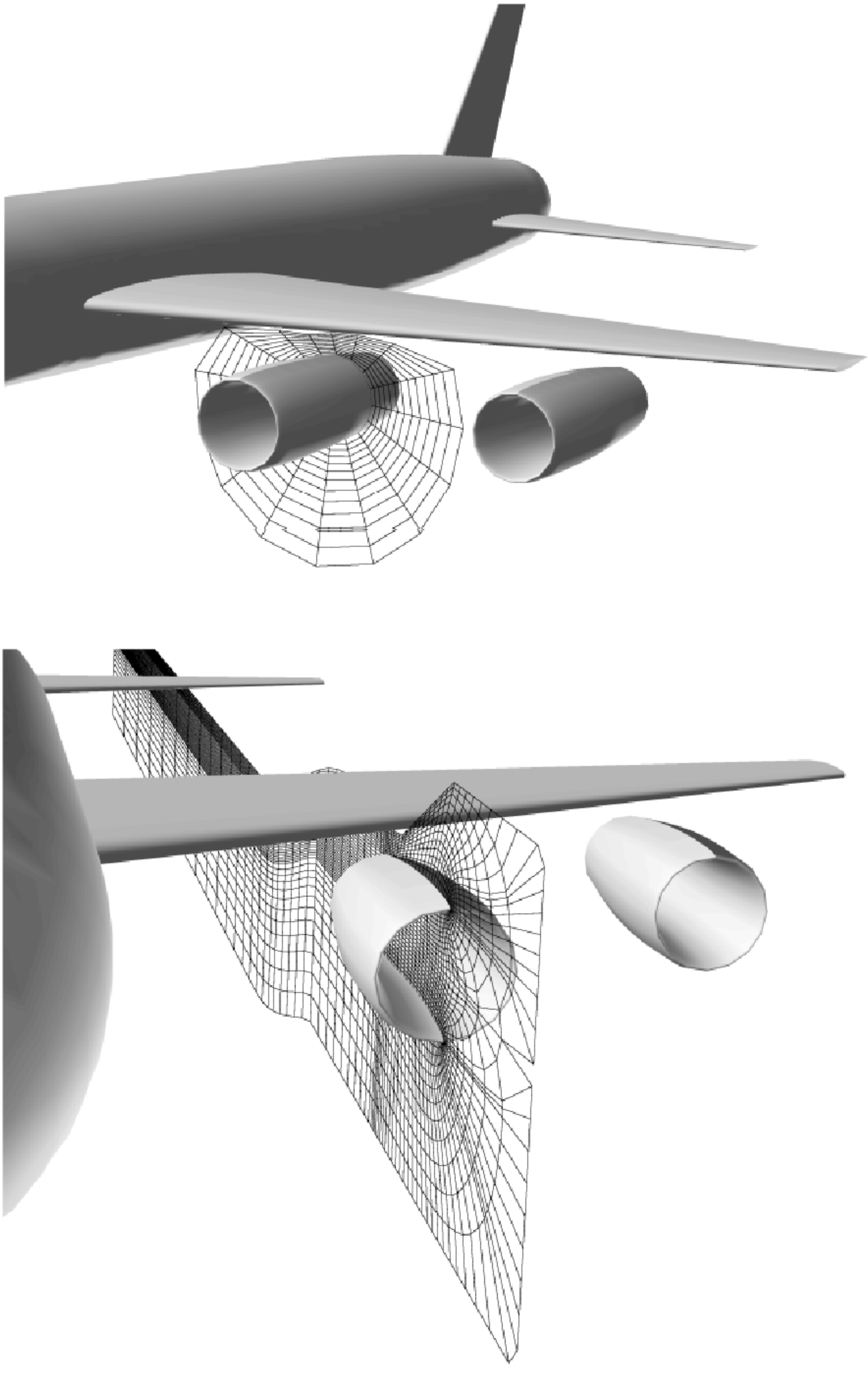


fig.3

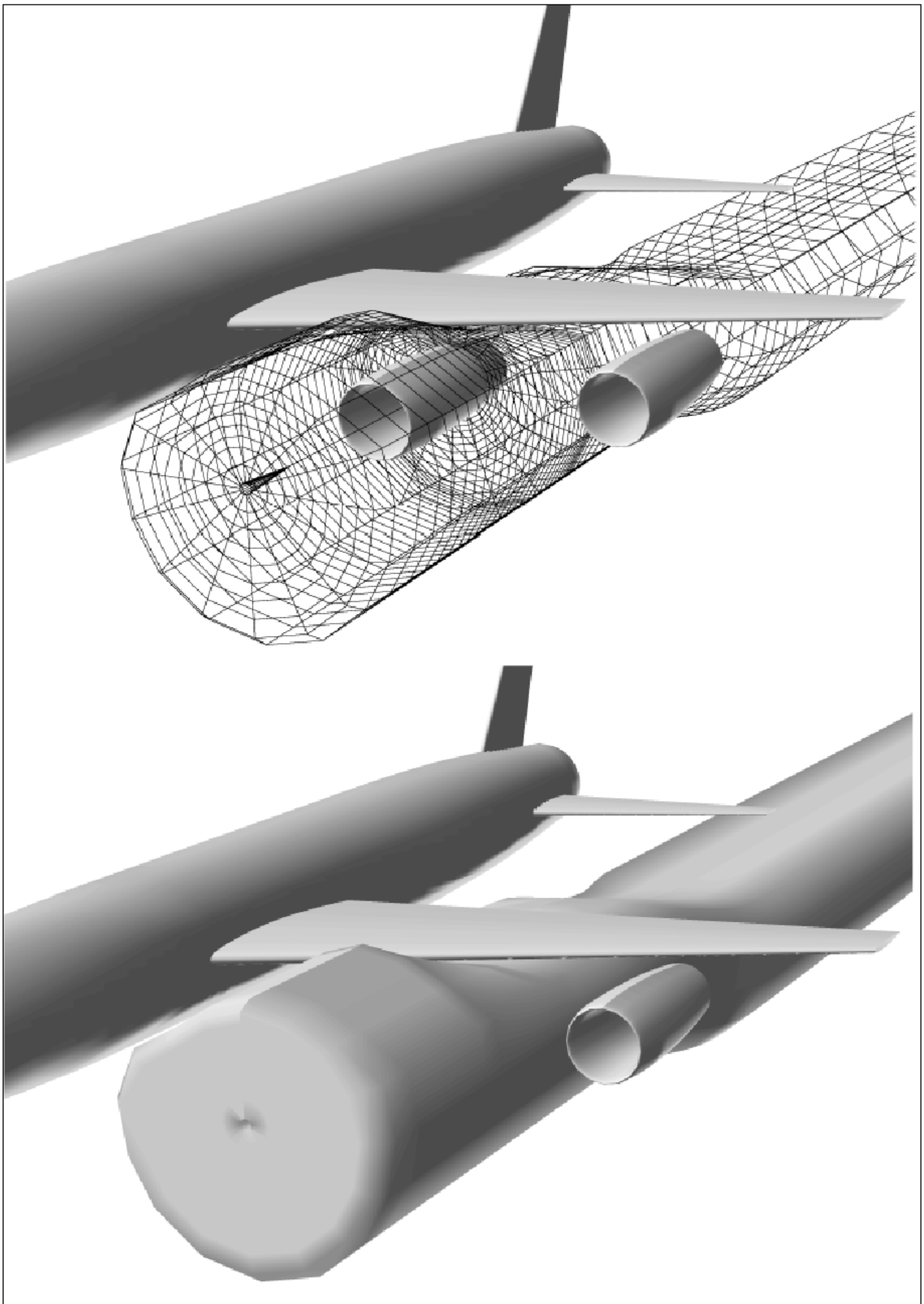


fig.4

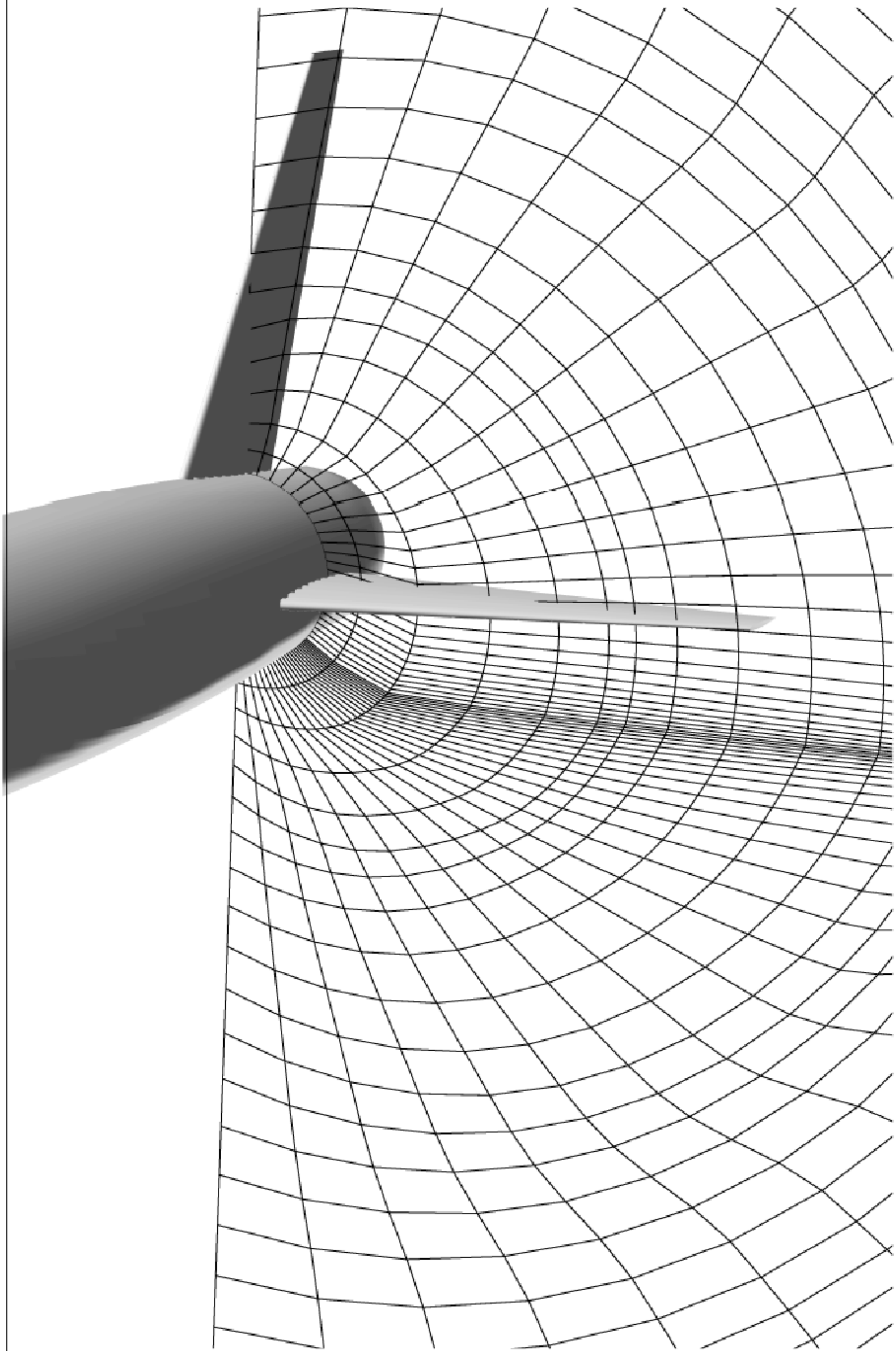


fig.5

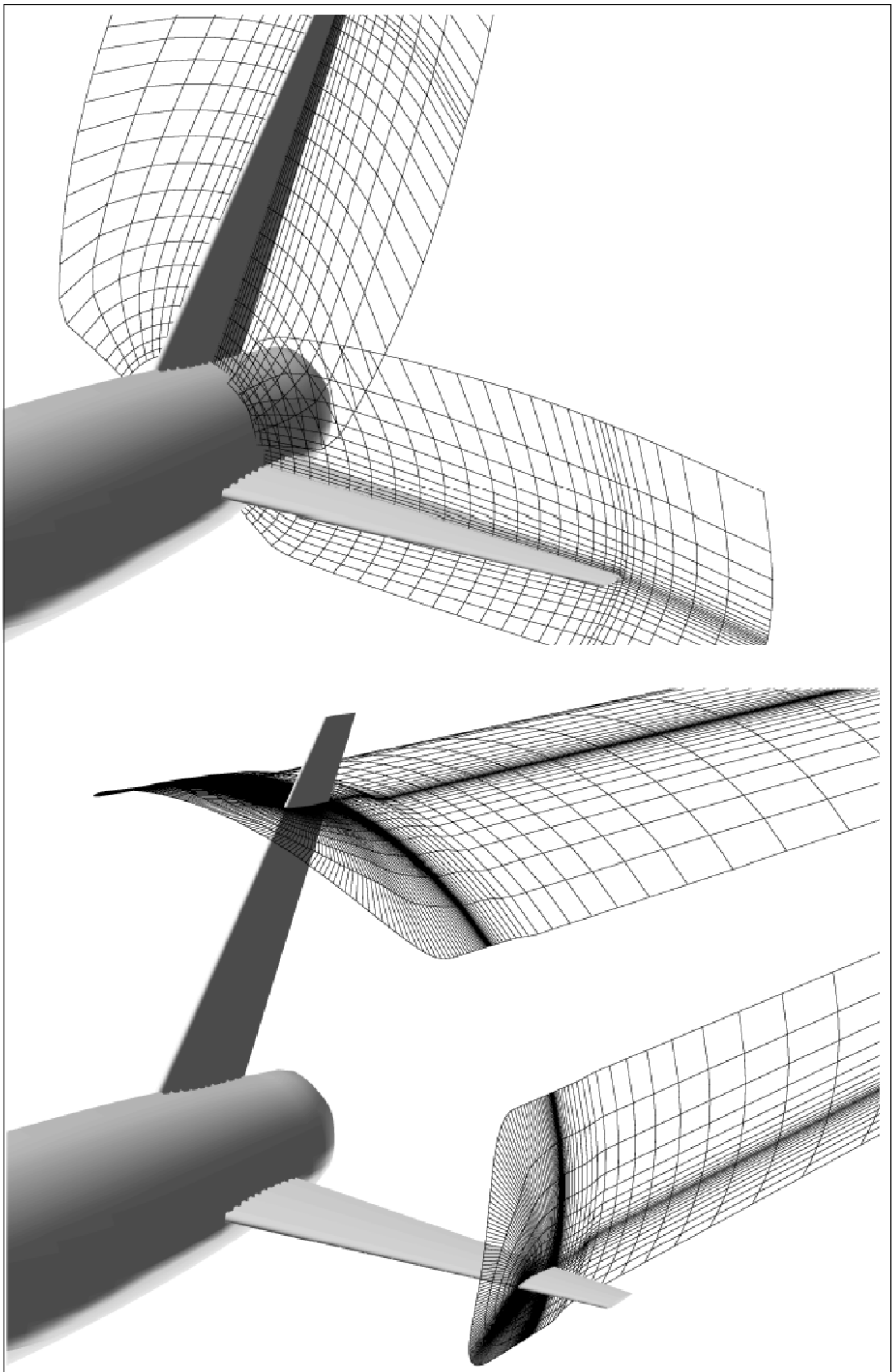


fig.6

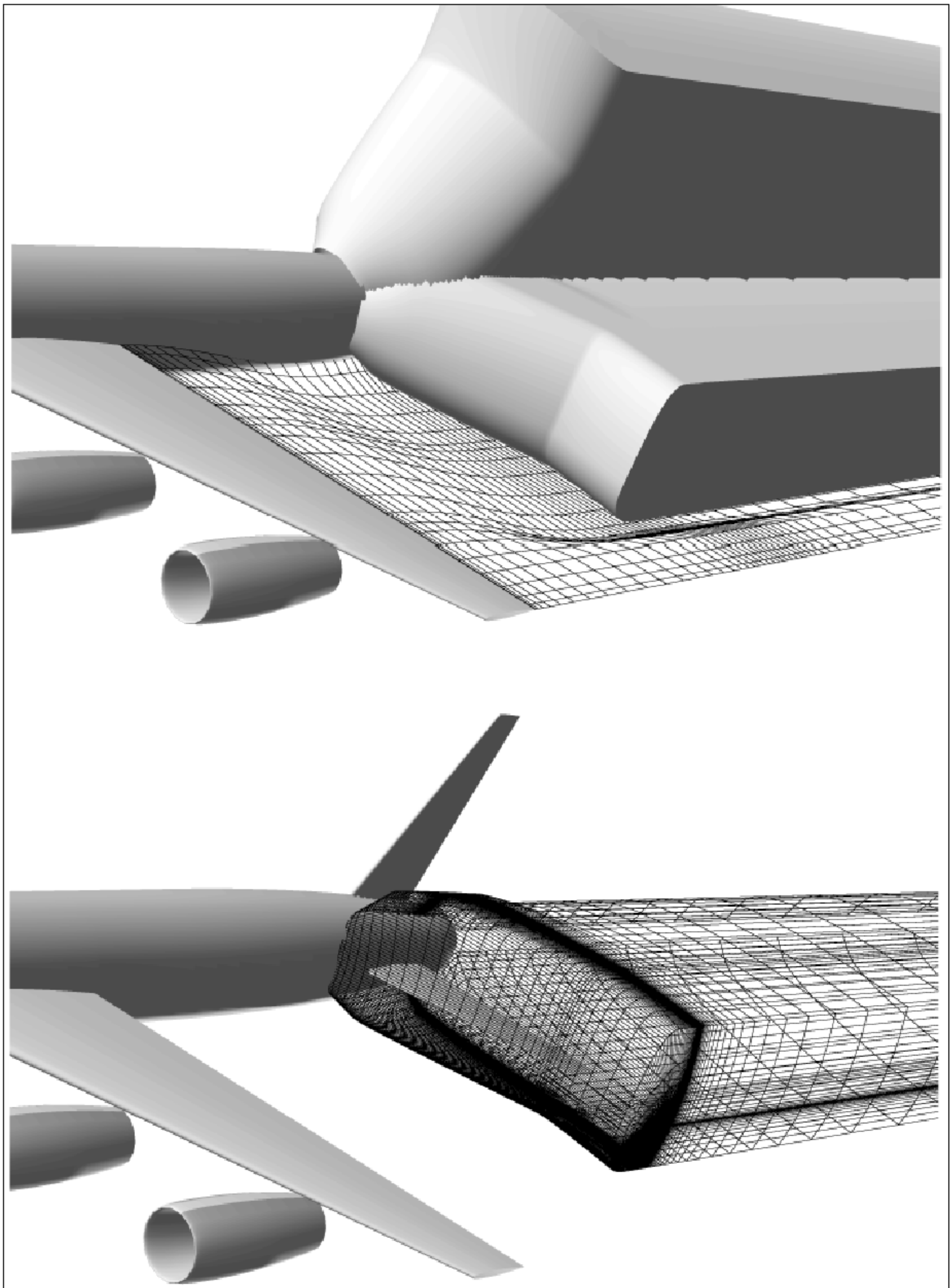


fig.7

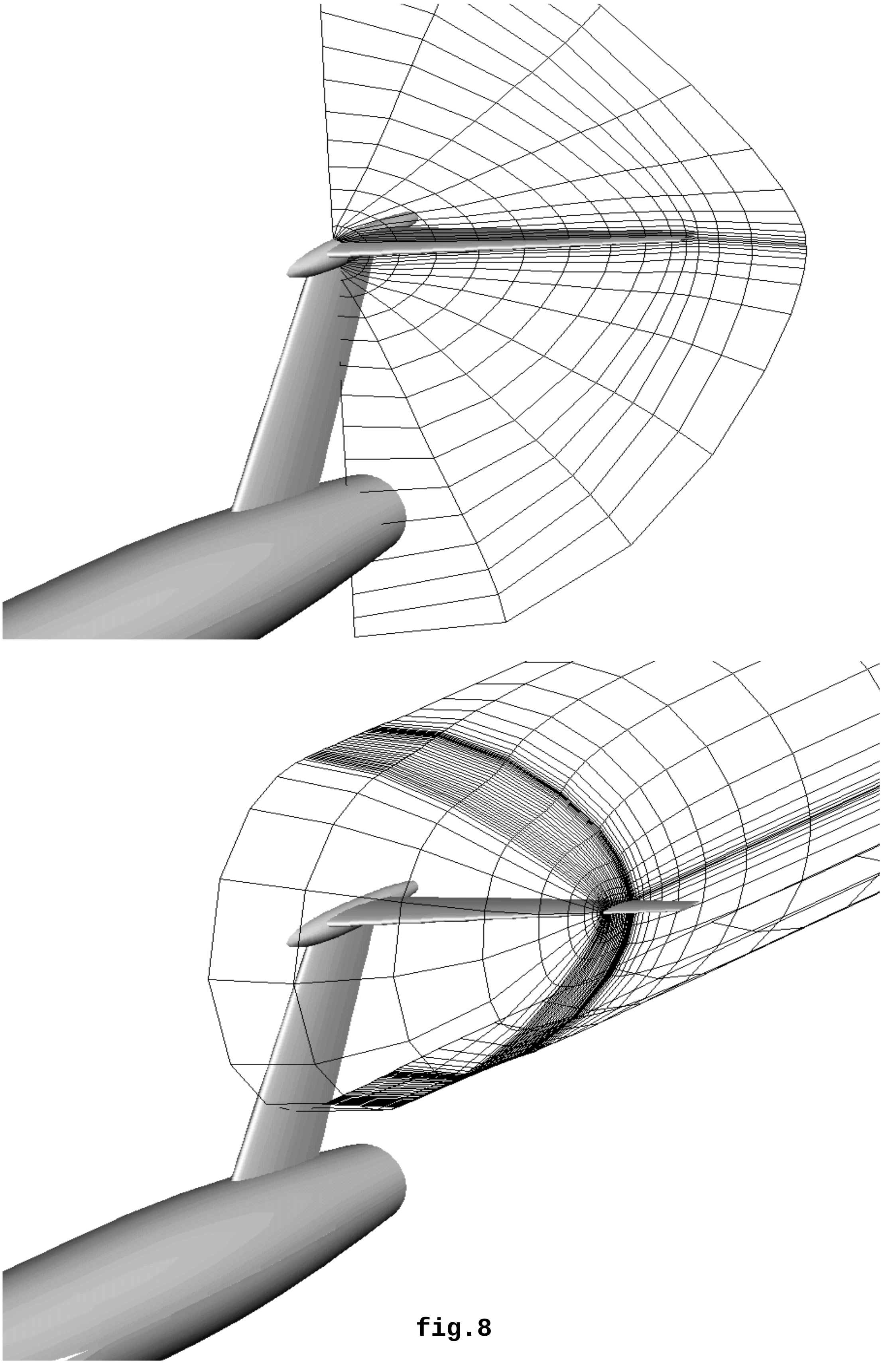


fig.8

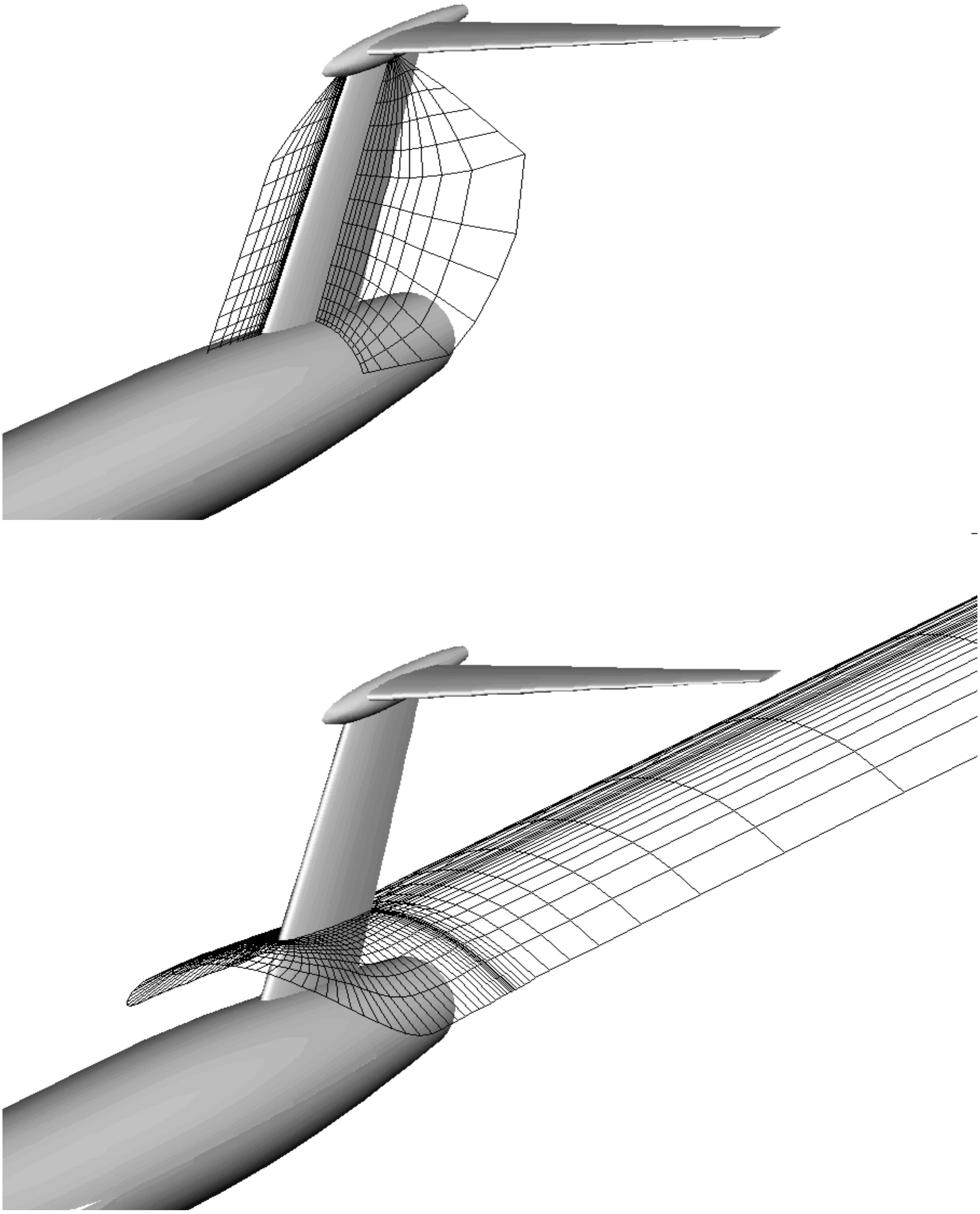


fig.9

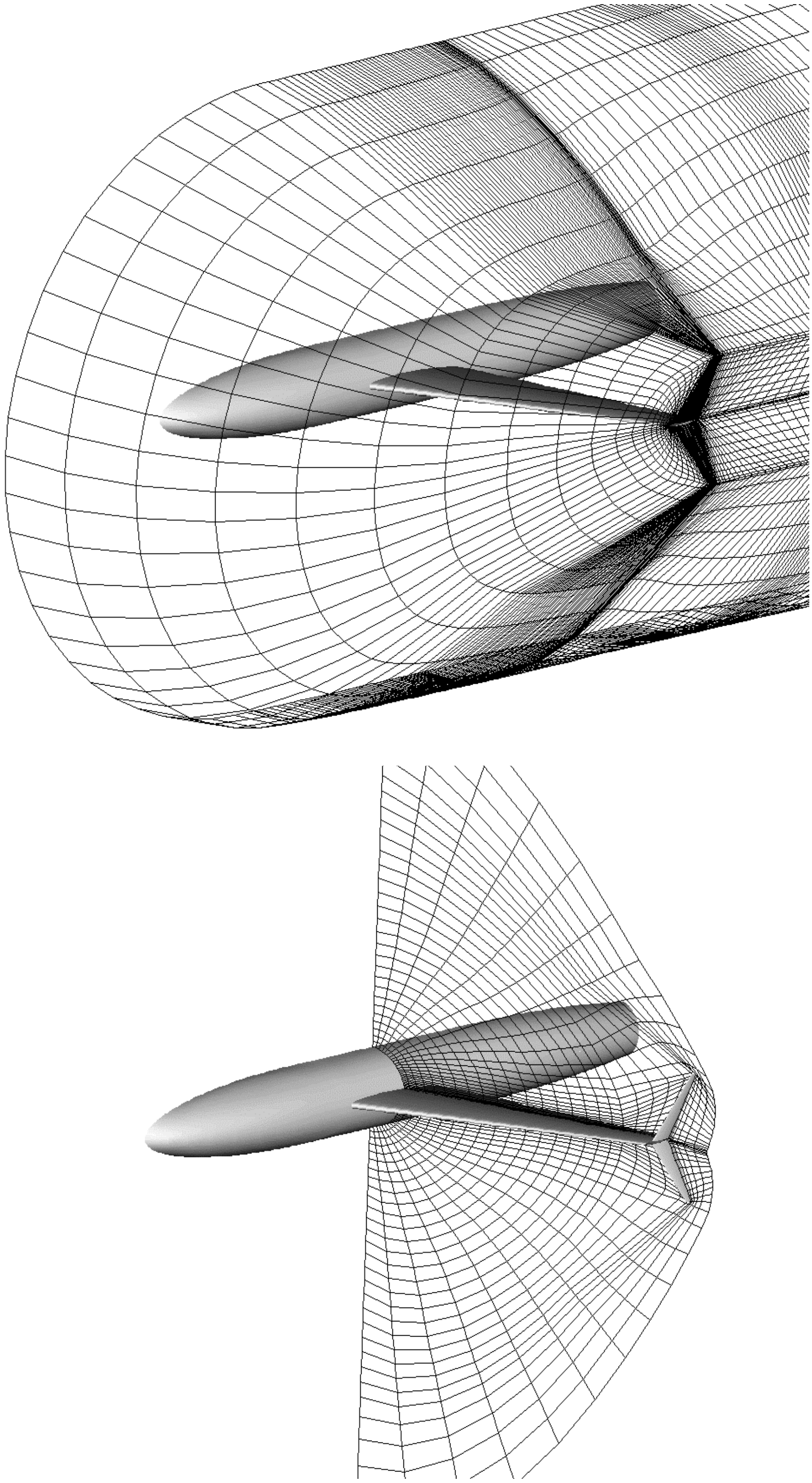


fig. 10

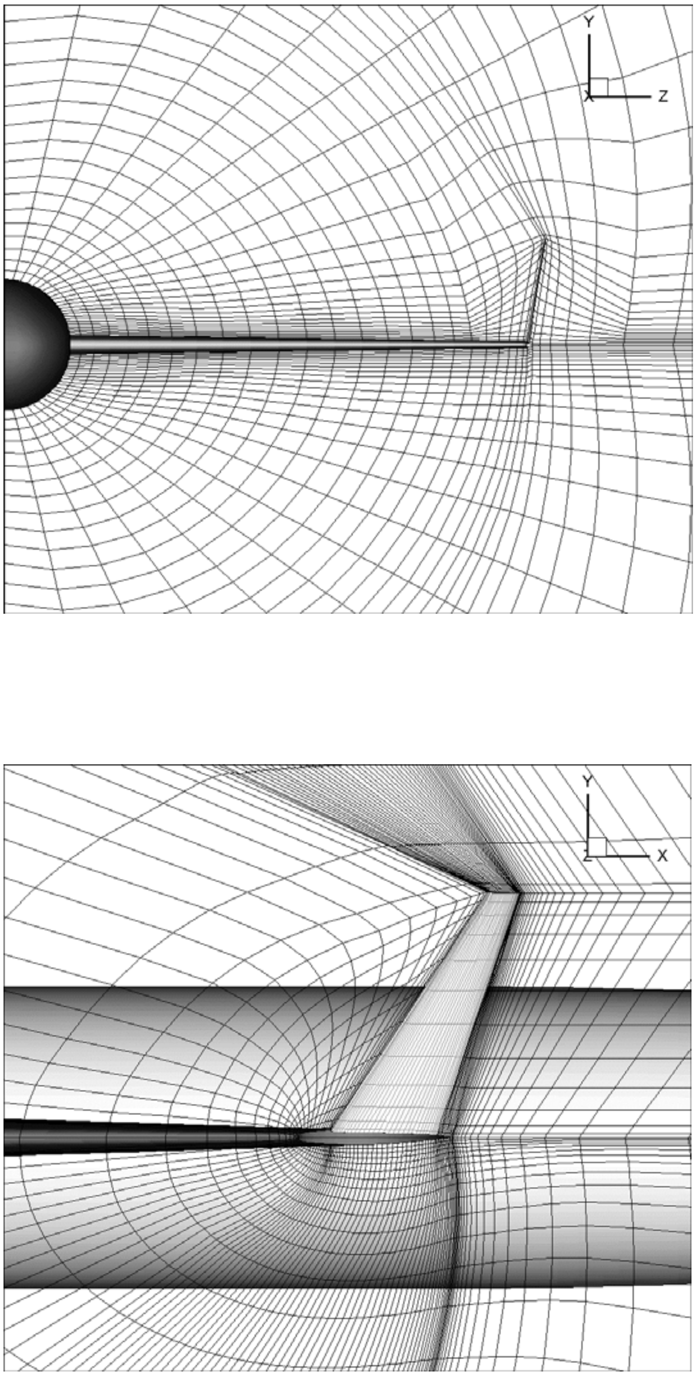


fig. 11

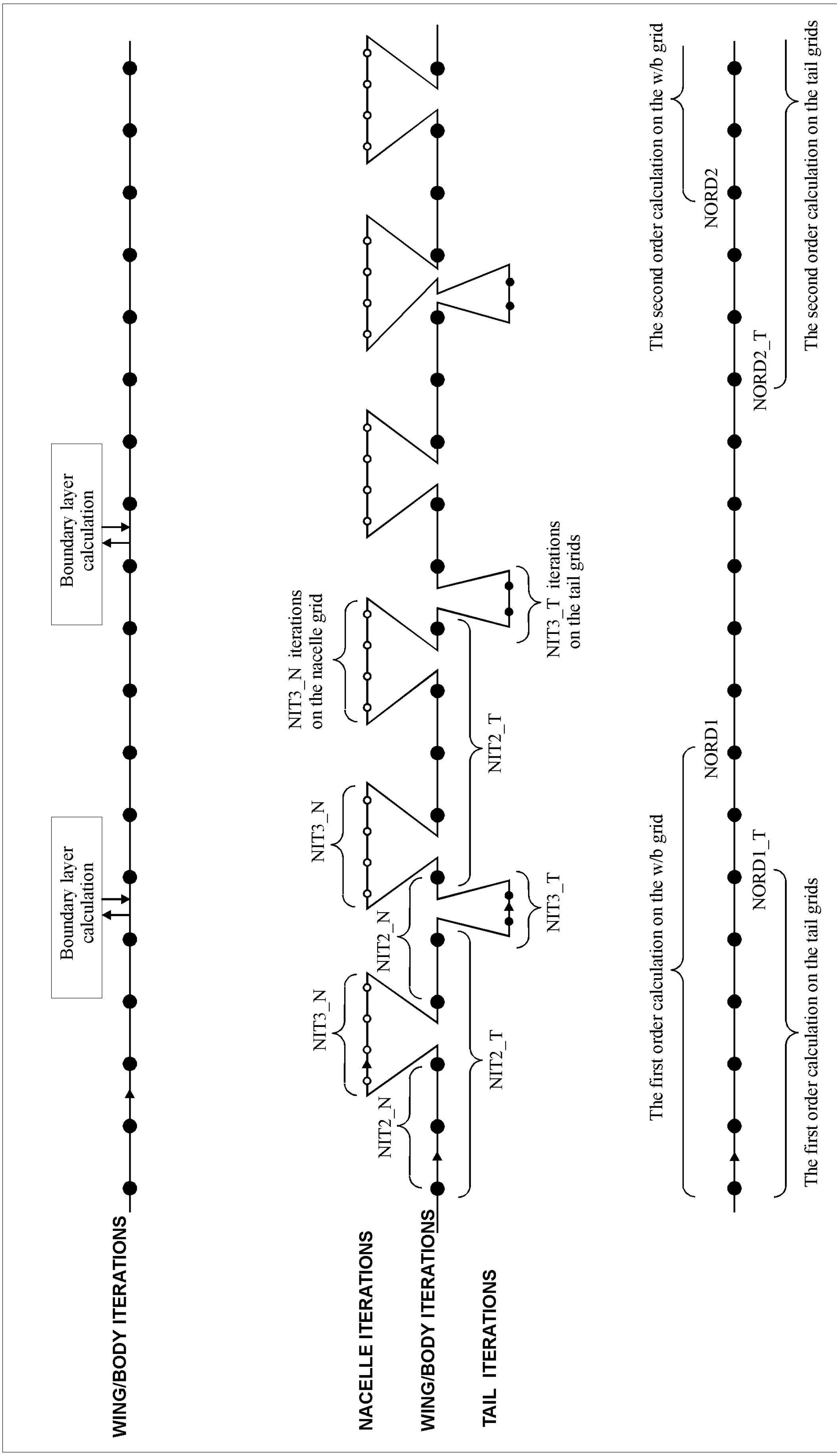

WING/BODY ITERATIONS
Boundary layer calculation
Boundary layer calculation
NACELLE ITERATIONS
WING/BODY ITERATIONS
TAIL ITERATIONS
NIT2_N
NIT3_N
NIT2_T
NIT2_N
NIT3_N
NIT3_T
NIT2_T
NIT3_N iterations on the nacelle grid
NIT3_T iterations on the tail grids
The first order calculation on the w/b grid
NORD1
NORD1_T
The first order calculation on the tail grids
The second order calculation on the w/b grid
NORD2
NORD2_T
The second order calculation on the tail grids

fig. 12

CONTROL PARAMETERS FOR NODE DISTRIBUTION
ON WING IN SPAN DIRECTION

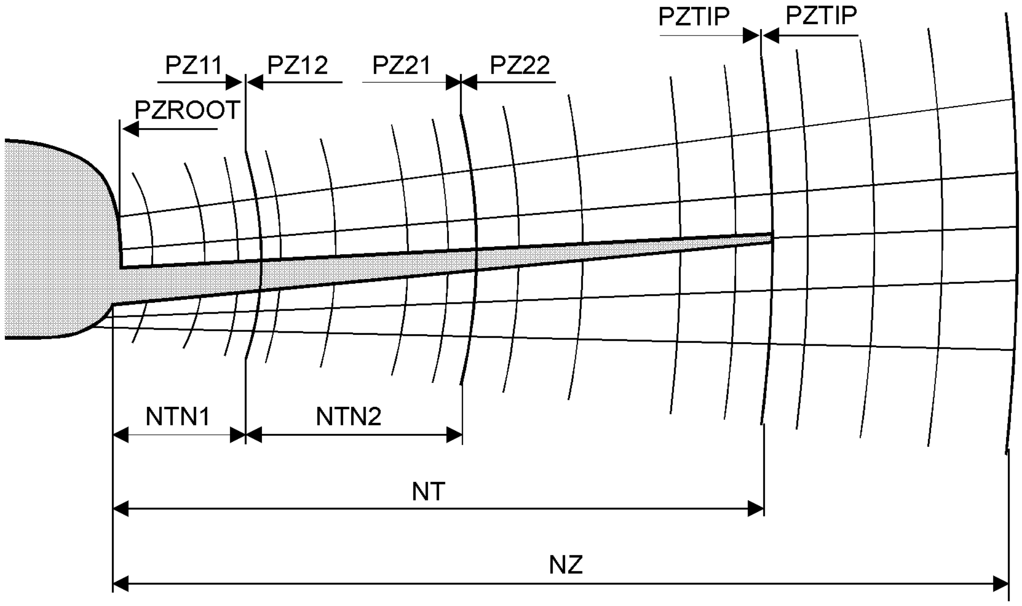


fig.13a

CONTROL PARAMETERS FOR NODE DISTRIBUTION
ON WING WAKE IN TAIL REGION

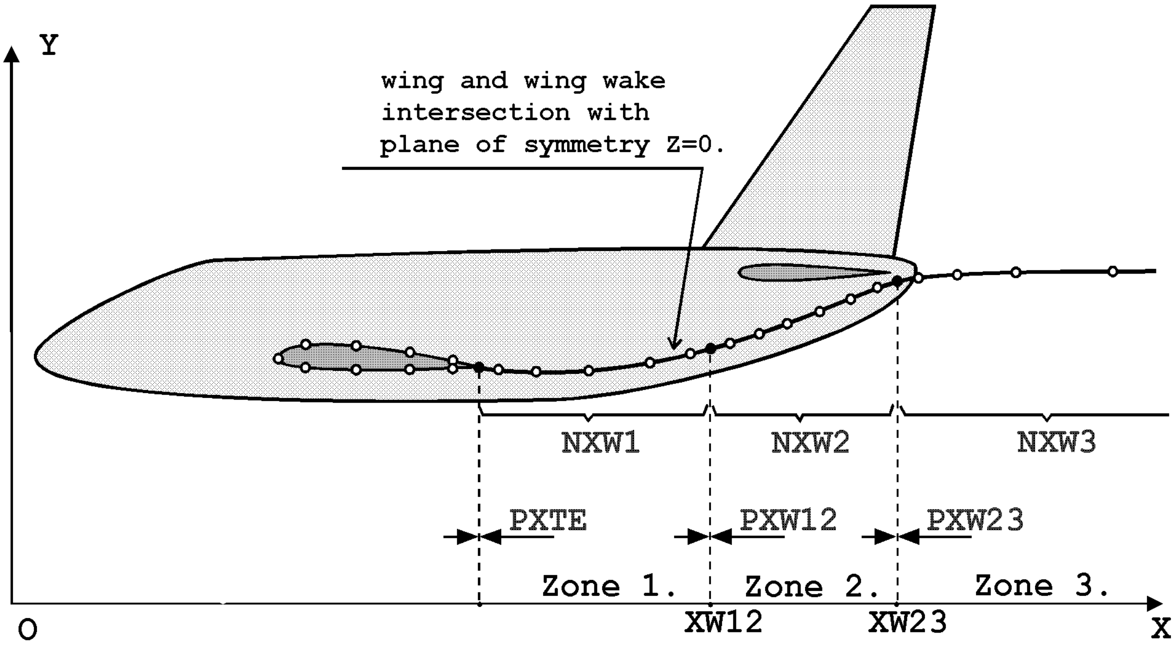
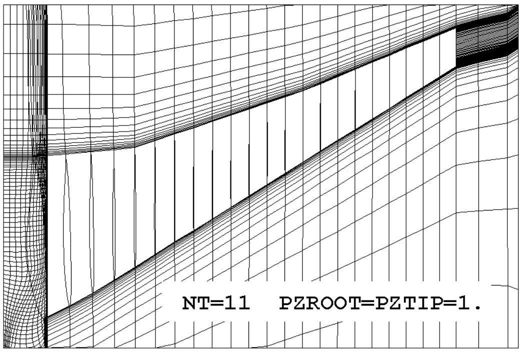
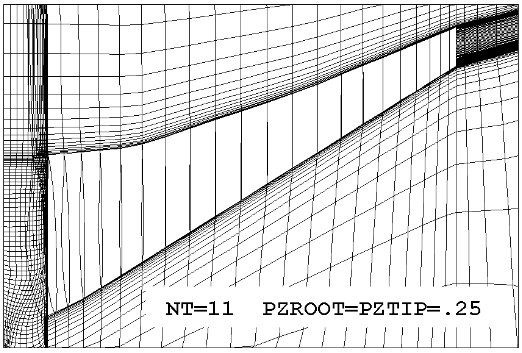


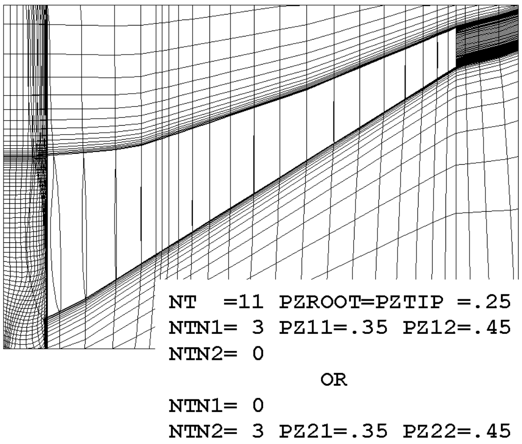
fig.13b

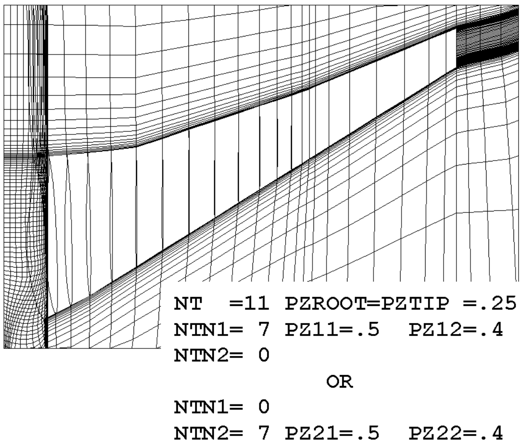
NO SPECIAL SECTIONS



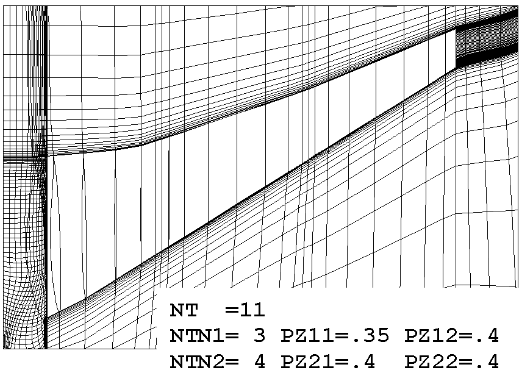


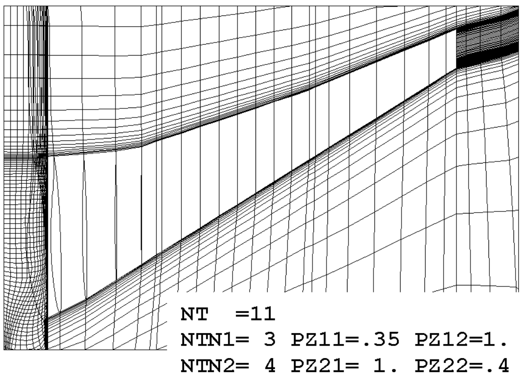
ONE SPECIAL SECTION





TWO SPECIAL SECTIONS





The second (fine) computational mesh are presented. The indicated values of the parameters NT, NTN1, NTN2 correspond to first mesh (i.e. the values are the input data values).

fig. 14

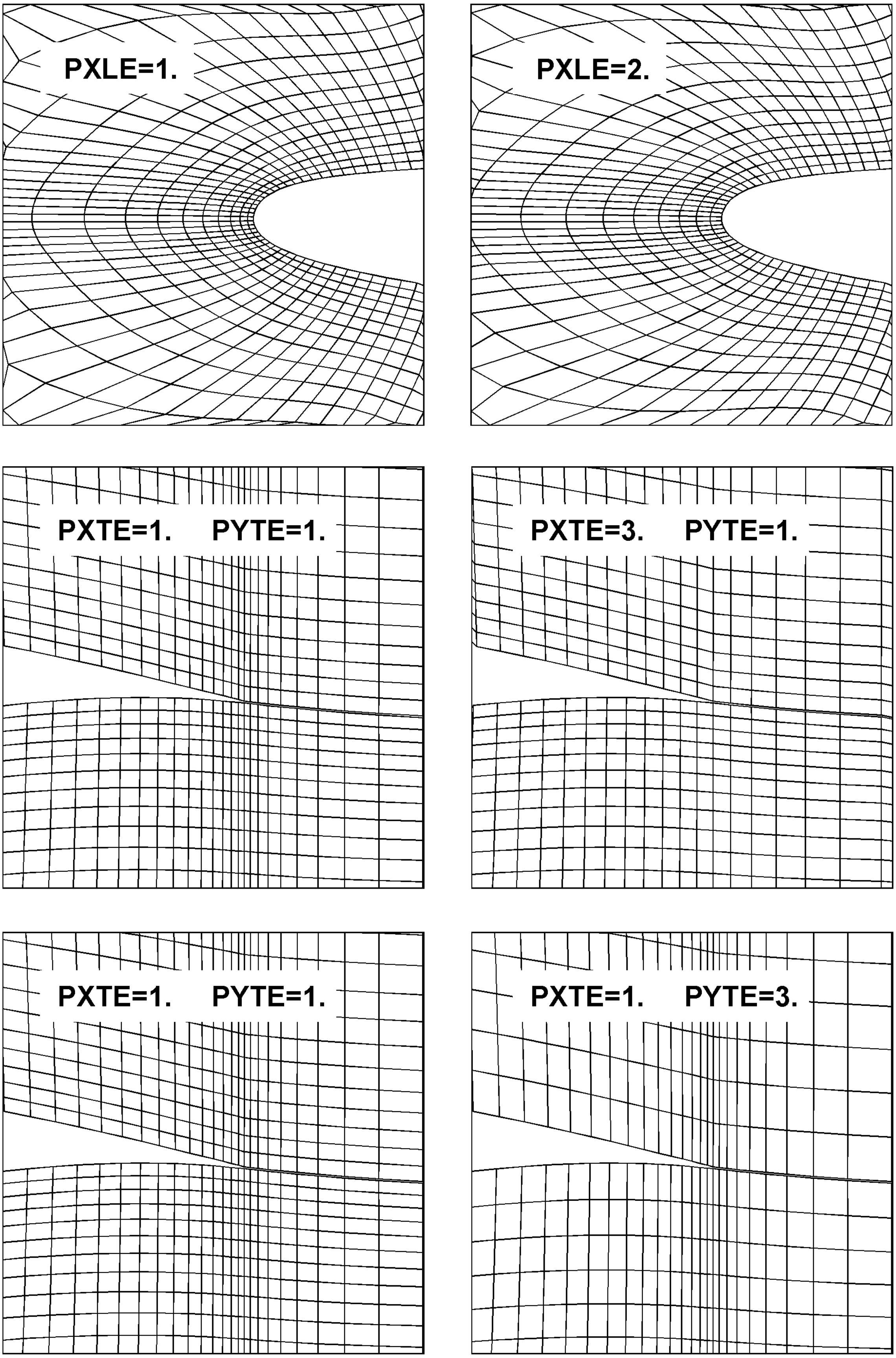

PXLE=1.
PXLE=2.
PXTE=1. PYTE=1.
PXTE=3. PYTE=1.
PXTE=1. PYTE=1.
PXTE=1. PYTE=3.

fig. 15

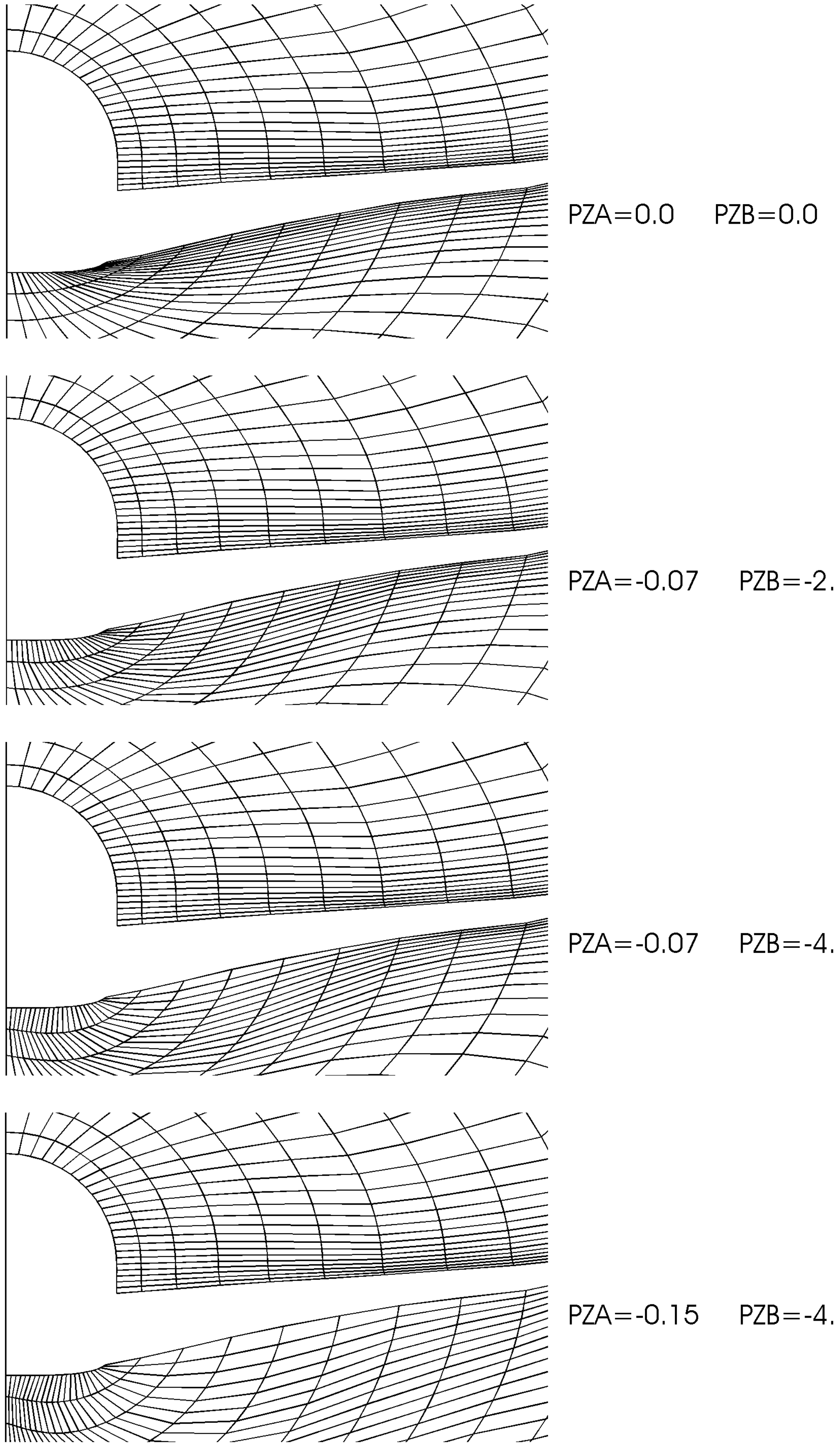


fig. 16

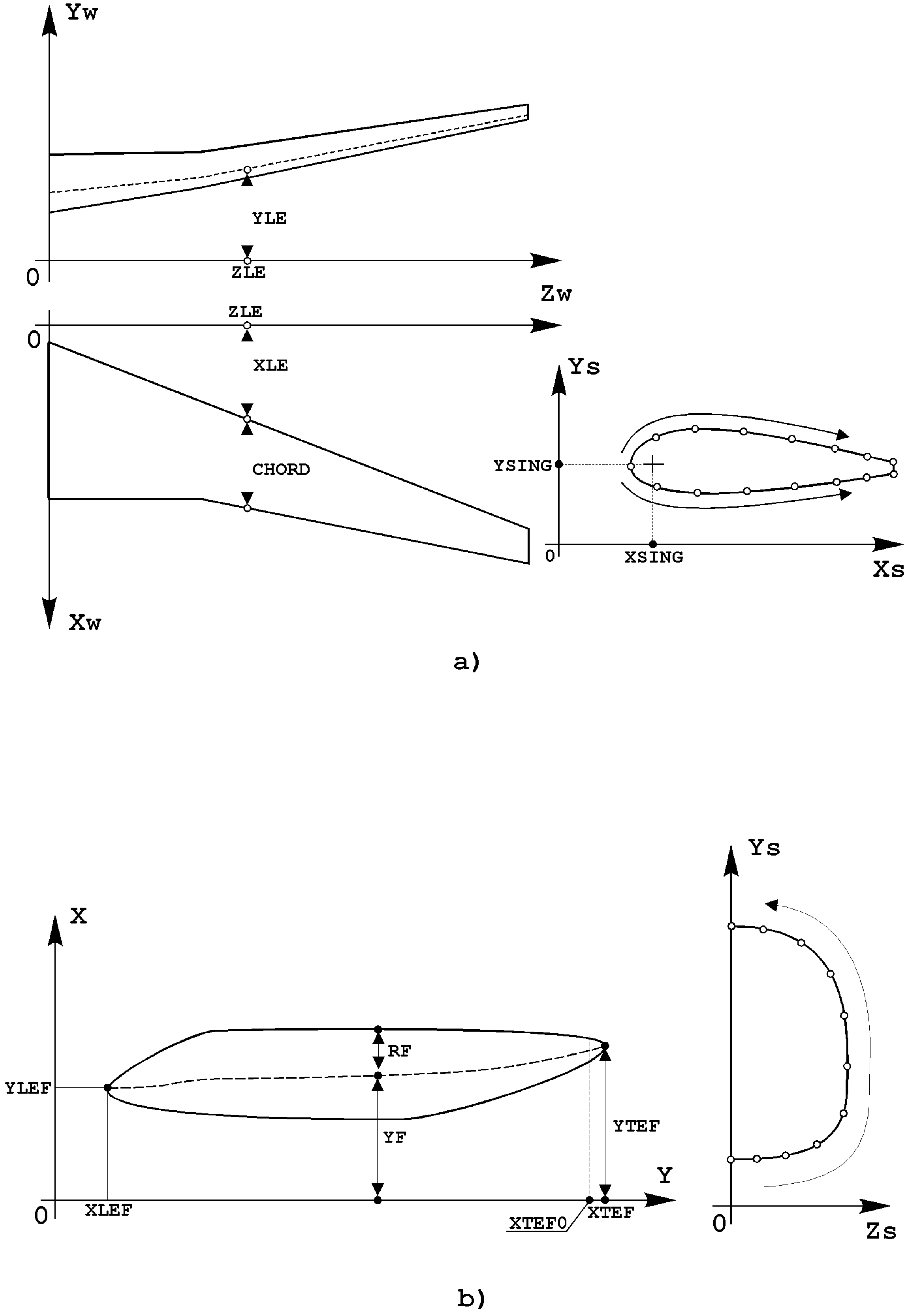
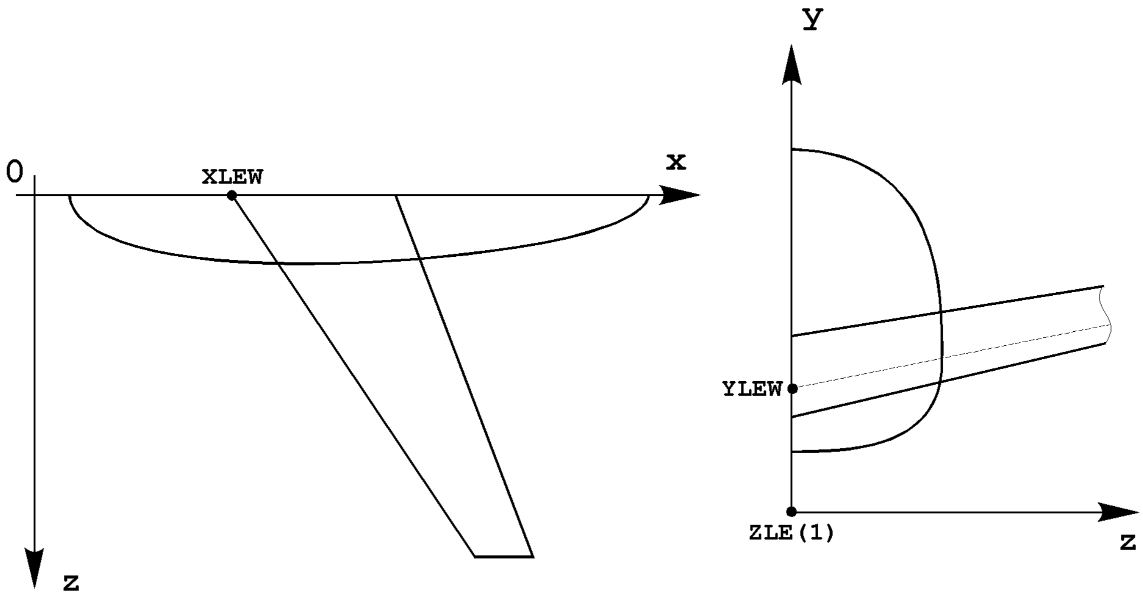
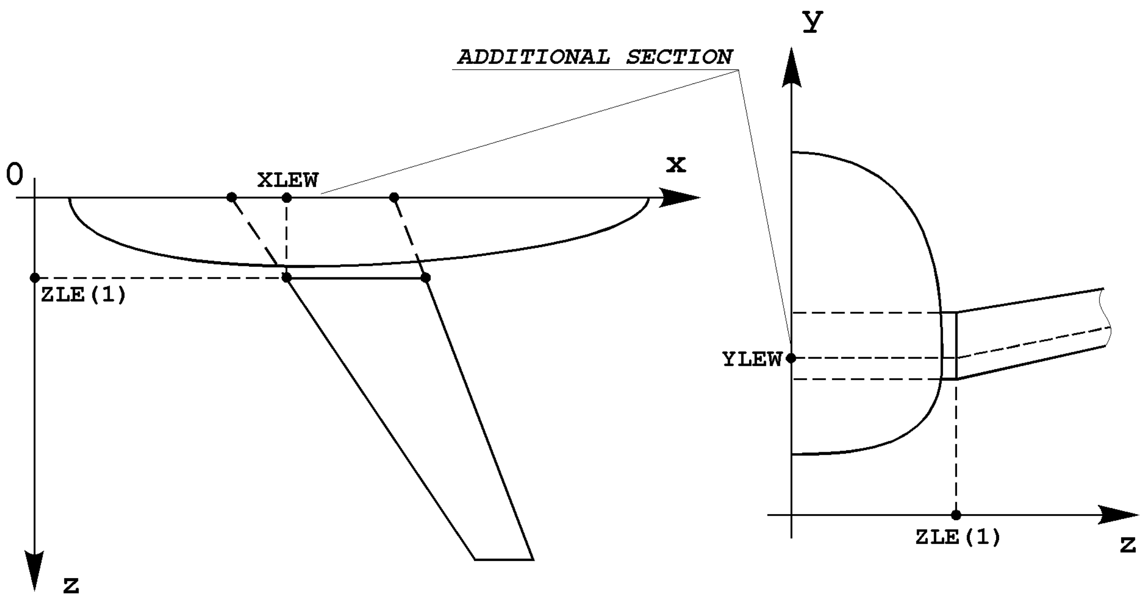

Yw
YLE
ZLE
0
Zw
ZLE
0
XLE
CHORD
Xw
Ys
YSING
0
XSING
Xs
a)
X
YLEF
RF
YF
YTEF
Y
0
XLEF
XTEF0
XTEF
Ys
0
Zs
b)

fig. 17



a) First wing input section at Z=0.



b) First wing input section at Z > 0.

fig. 18

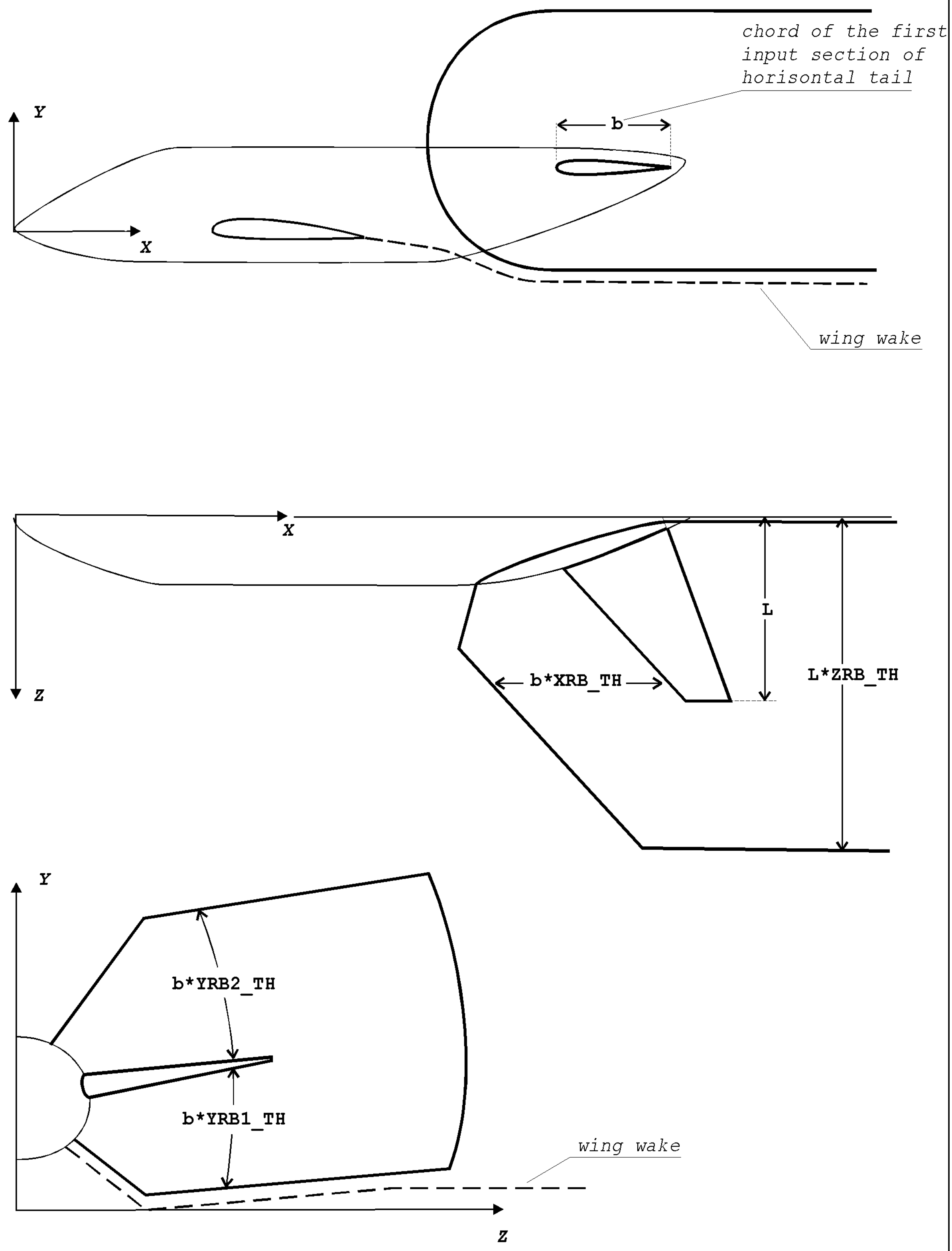

chord of the first
input section of
horisontal tail
Y
b
X
wing wake
X
L
L*ZRB_TH
b*XRB_TH
Z
Y
b*YRB2_TH
b*YRB1_TH
wing wake
Z

fig. 19

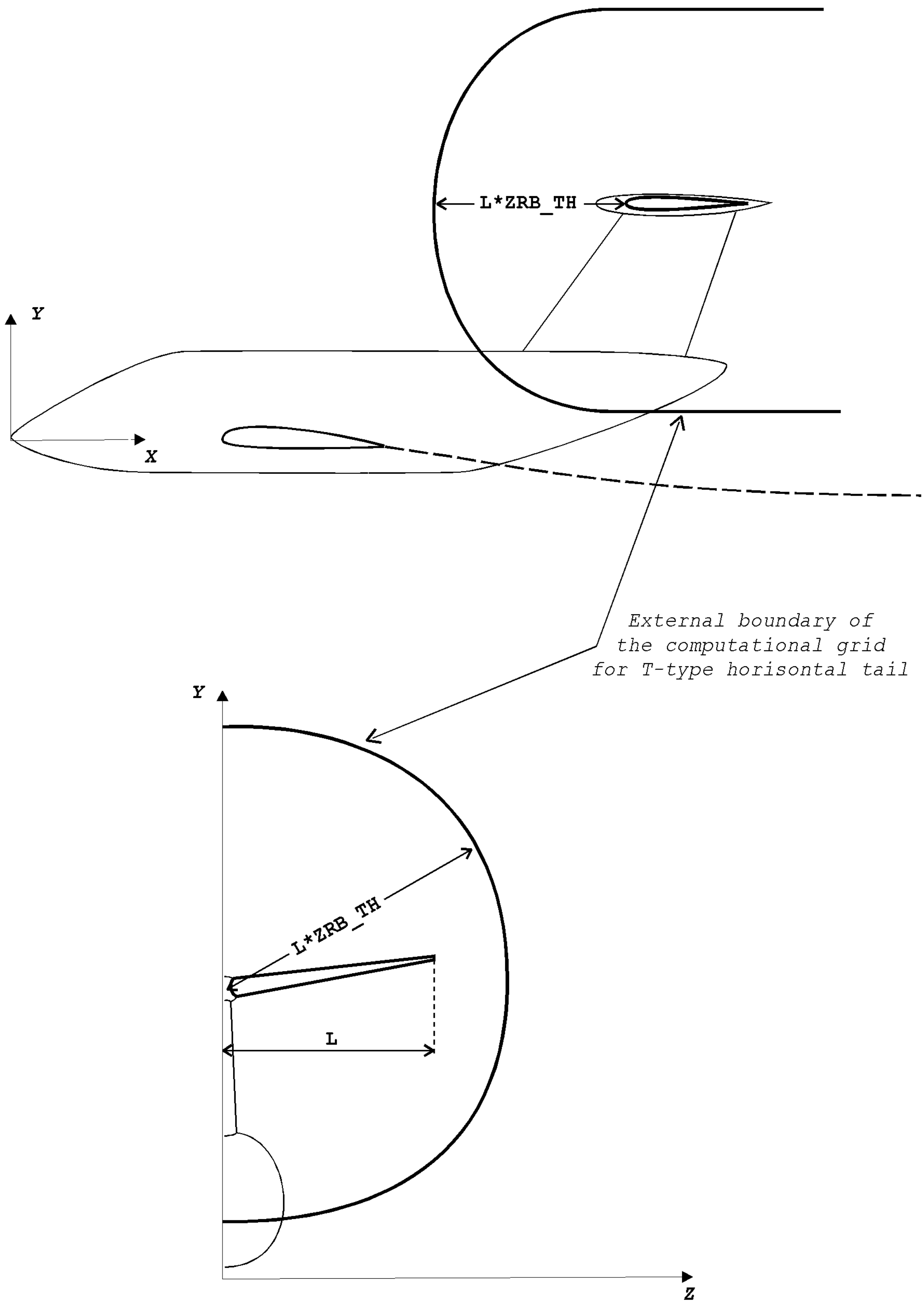

L*ZRB_TH
Y
X
External boundary of
the computational grid
for T-type horisontal tail
Y
L*ZRB_TH
L
Z

fig. 20

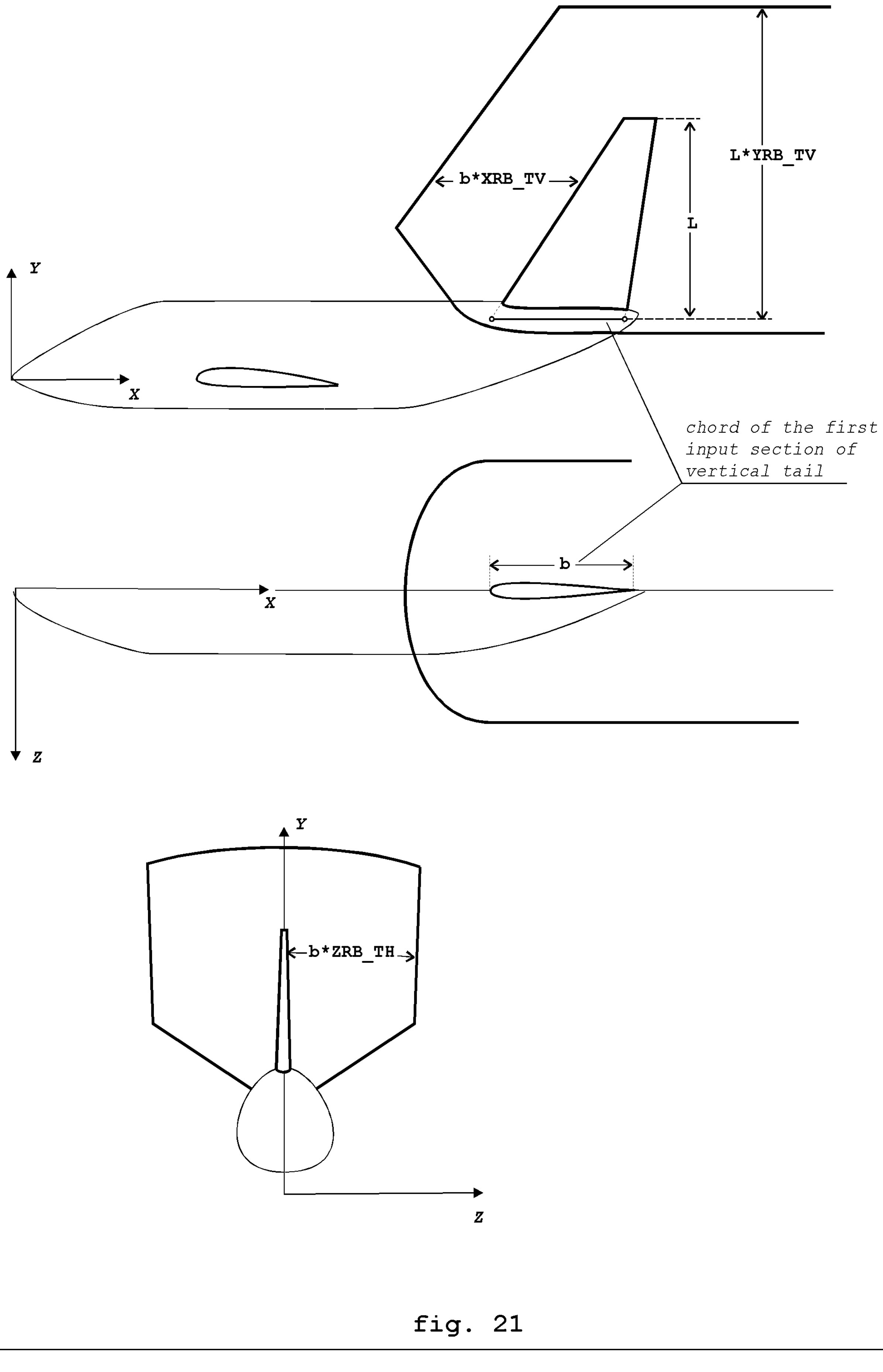

L*YRB_TV
b*XRB_TV
L
Y
X
chord of the first
input section of
vertical tail
b
X
Z
Y
b*ZRB_TH
Z

fig. 21

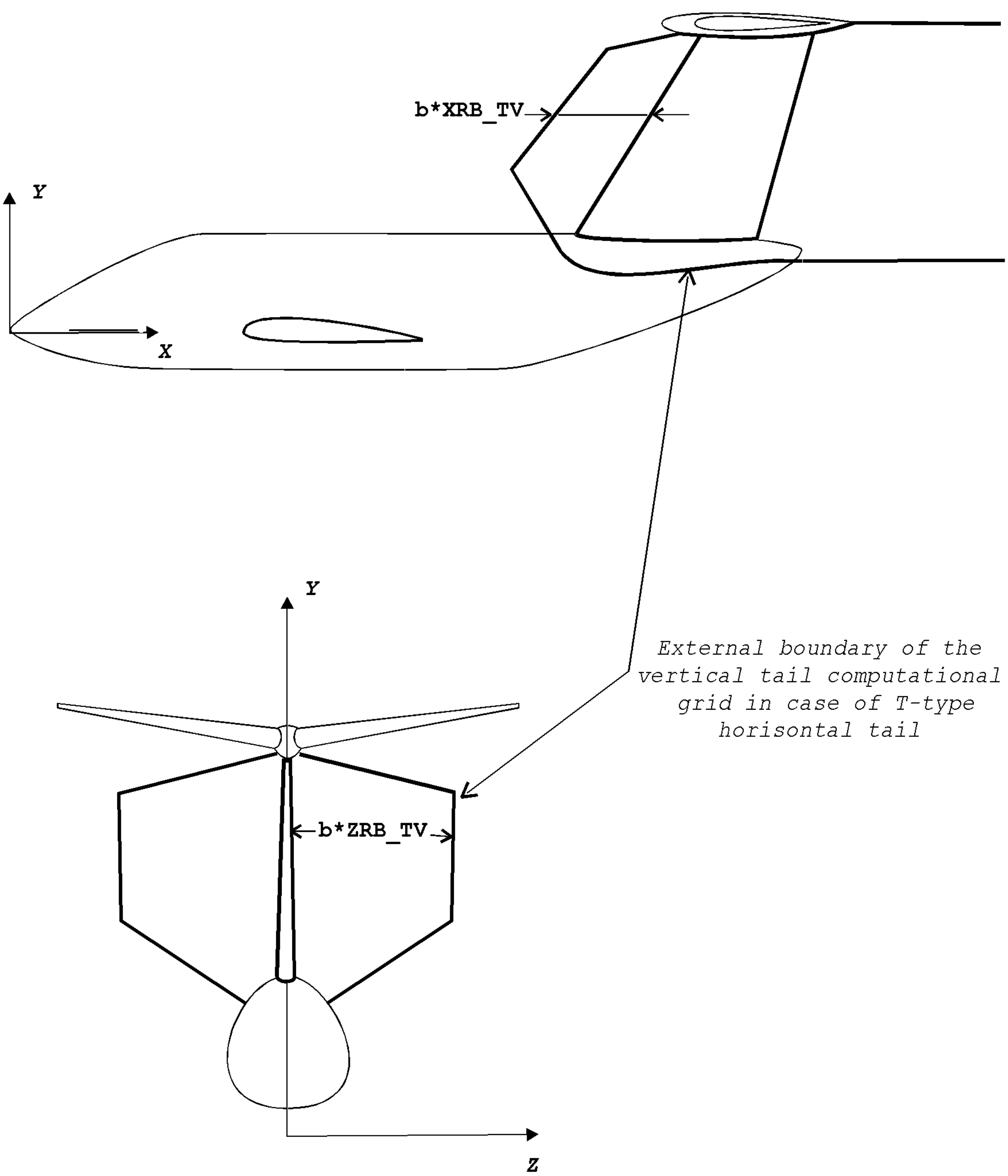
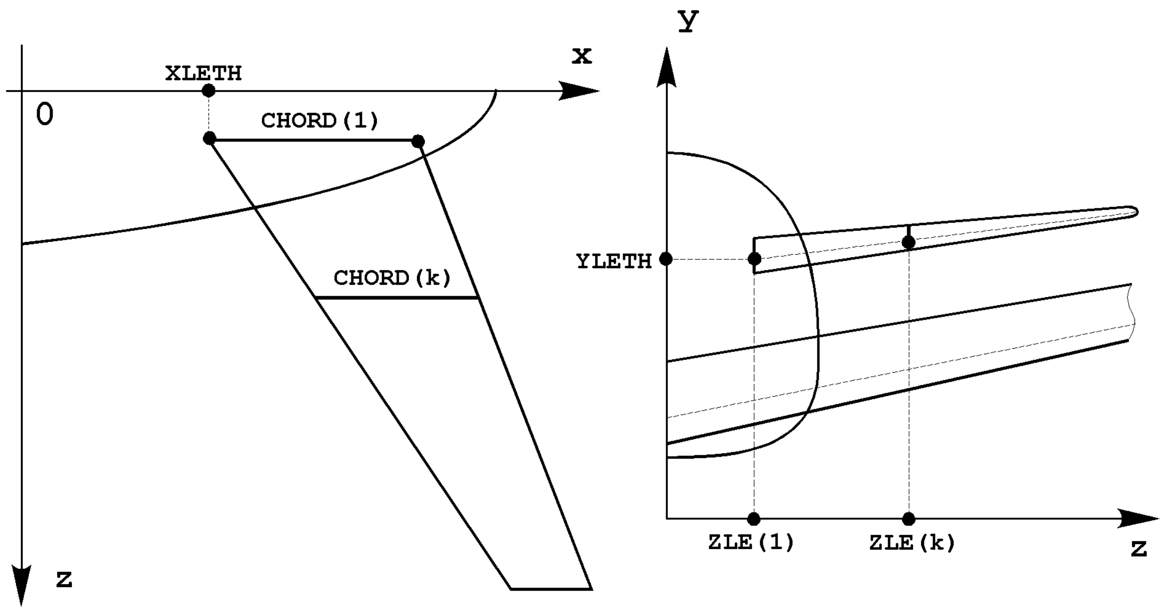
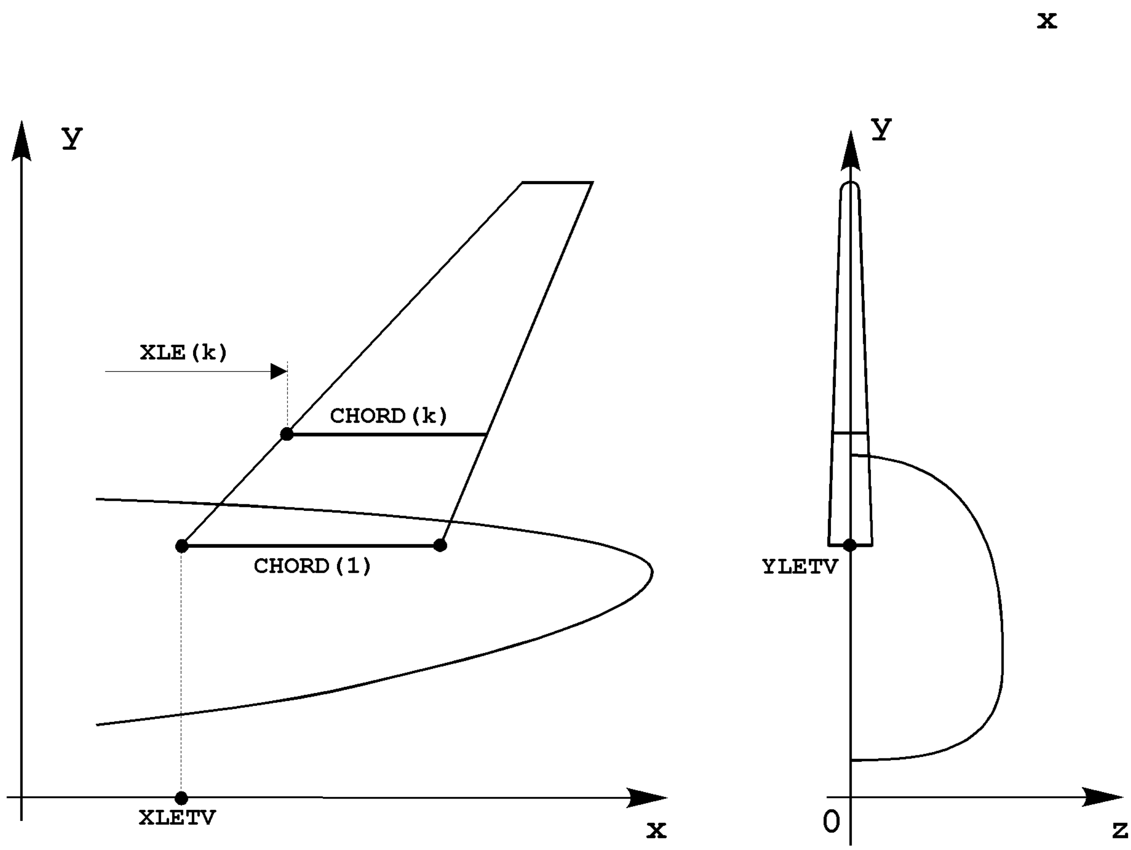

b*XRB_TV
Y
X
Y
External boundary of the
vertical tail computational
grid in case of T-type
horisontal tail
b*ZRB_TV
Z

fig. 22



a) Input data for horizontal tail location



b) Input data for vertical tail location

fig. 23

CONTROL PARAMETERS OF THE NODE DISTRIBUTION IN THE NACELLE GRID

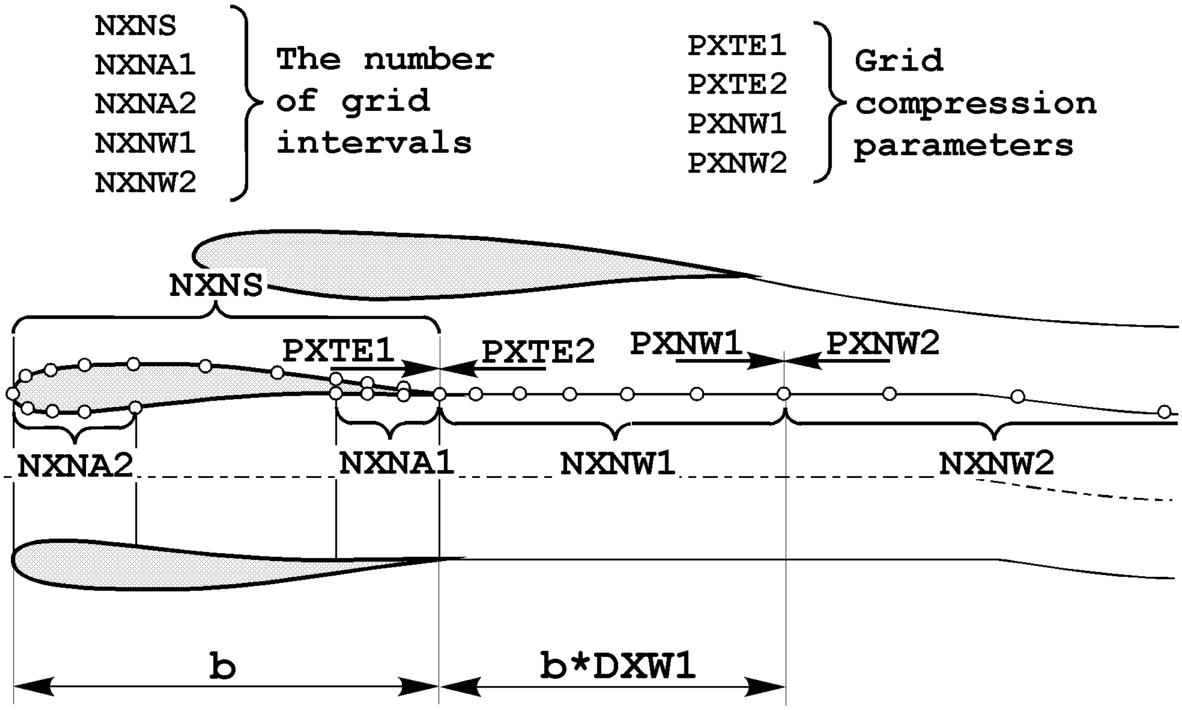
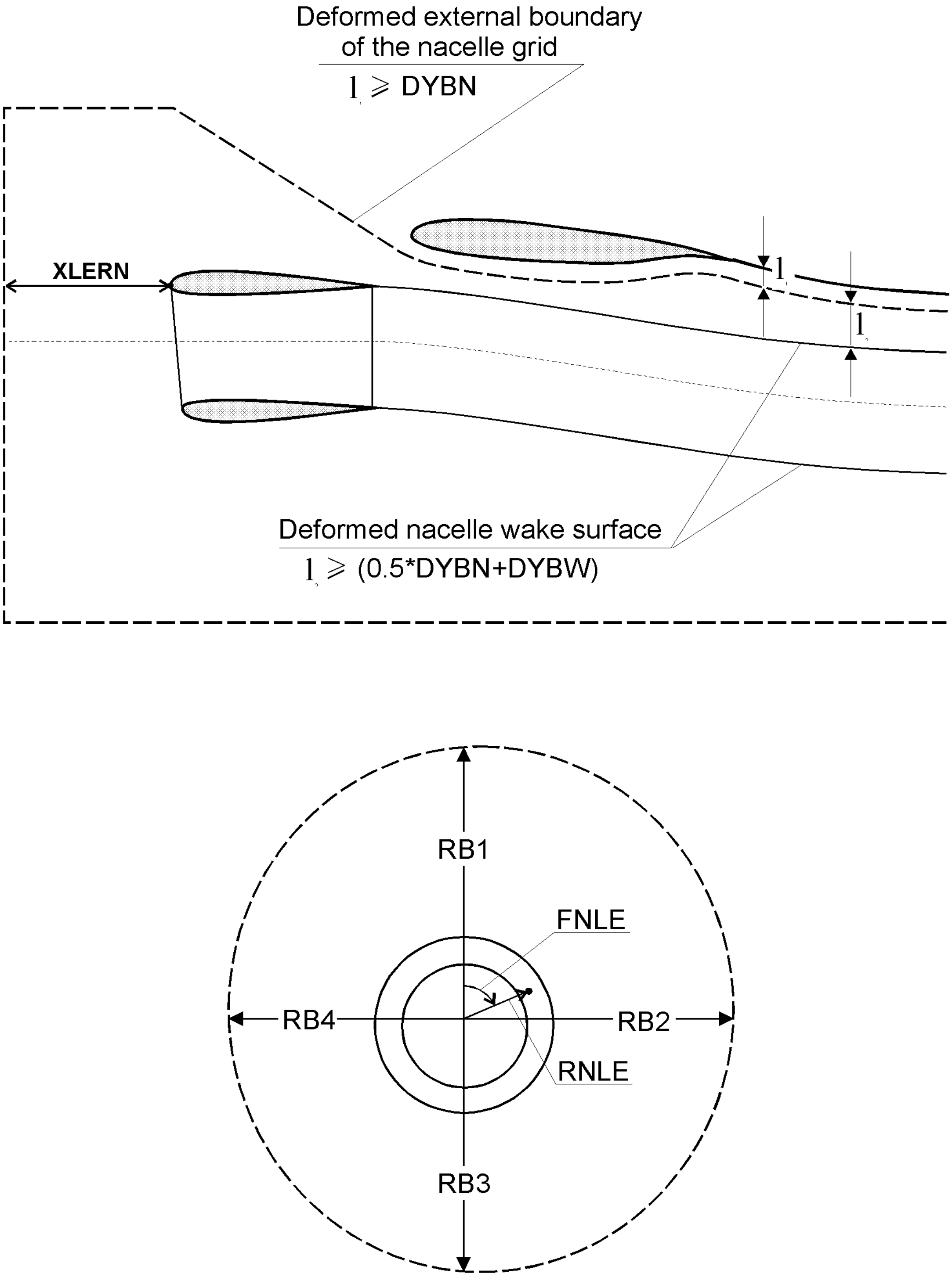


fig. 24



Deformed external boundary
of the nacelle grid
l ⩾ DYBN
XLERN
l
l
Deformed nacelle wake surface
l ⩾ (0.5*DYBN+DYBW)
RB1
FNLE
RB4
RB2
RNLE
RB3

fig. 25

CONTROL PARAMETERS FOR SPECIFY OF THE NACELLE POSITION

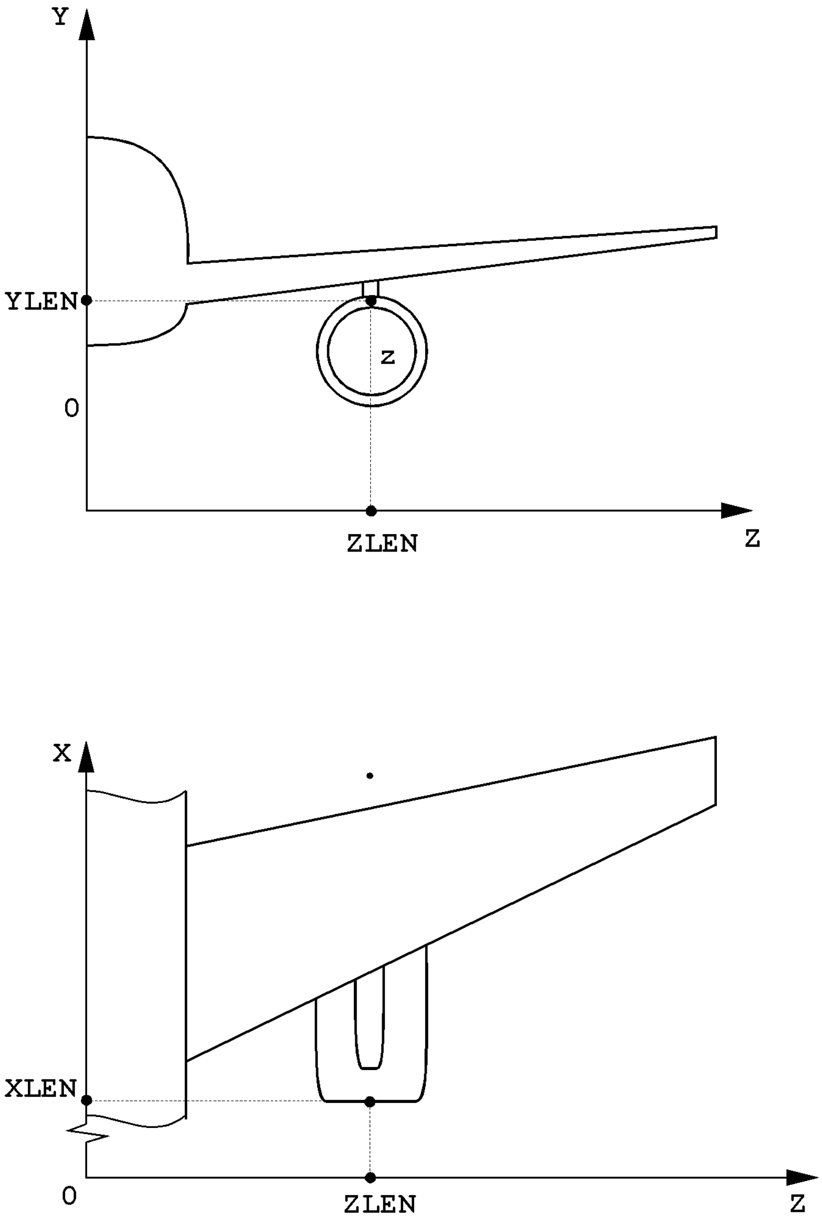


fig. 26

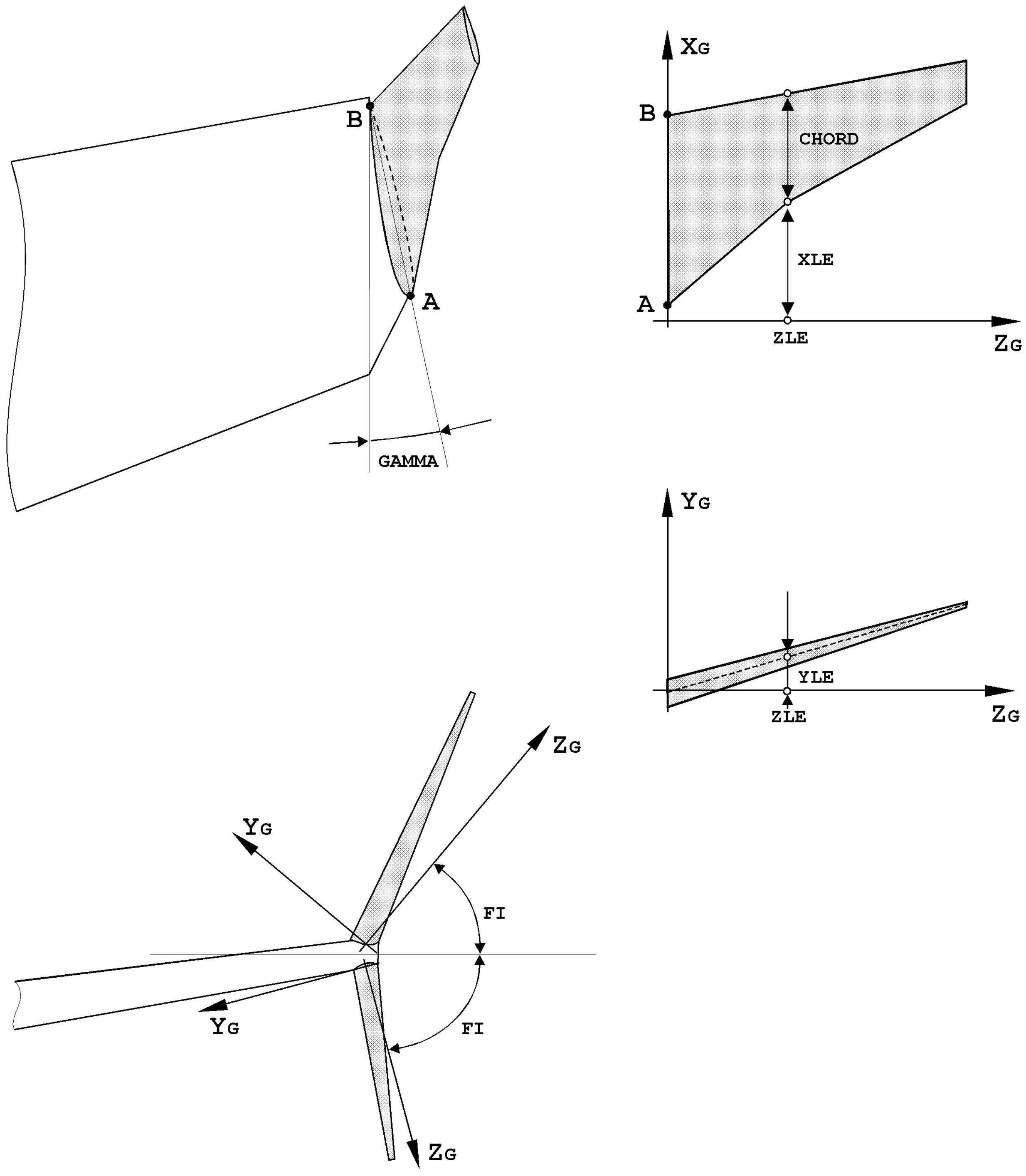
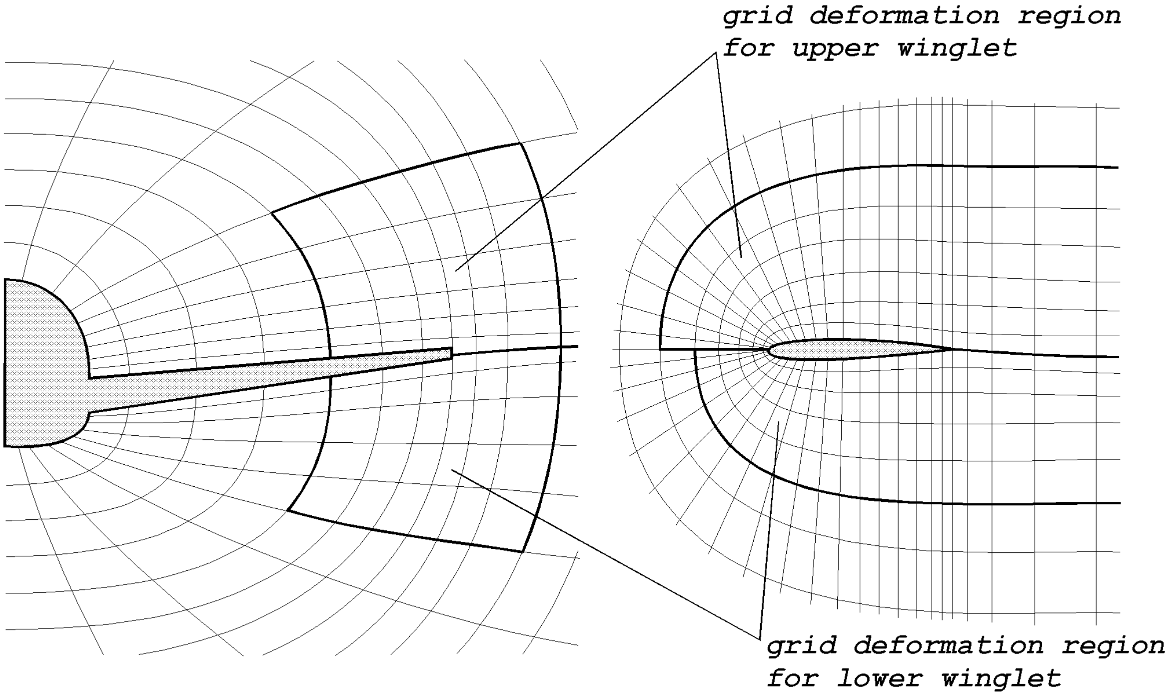
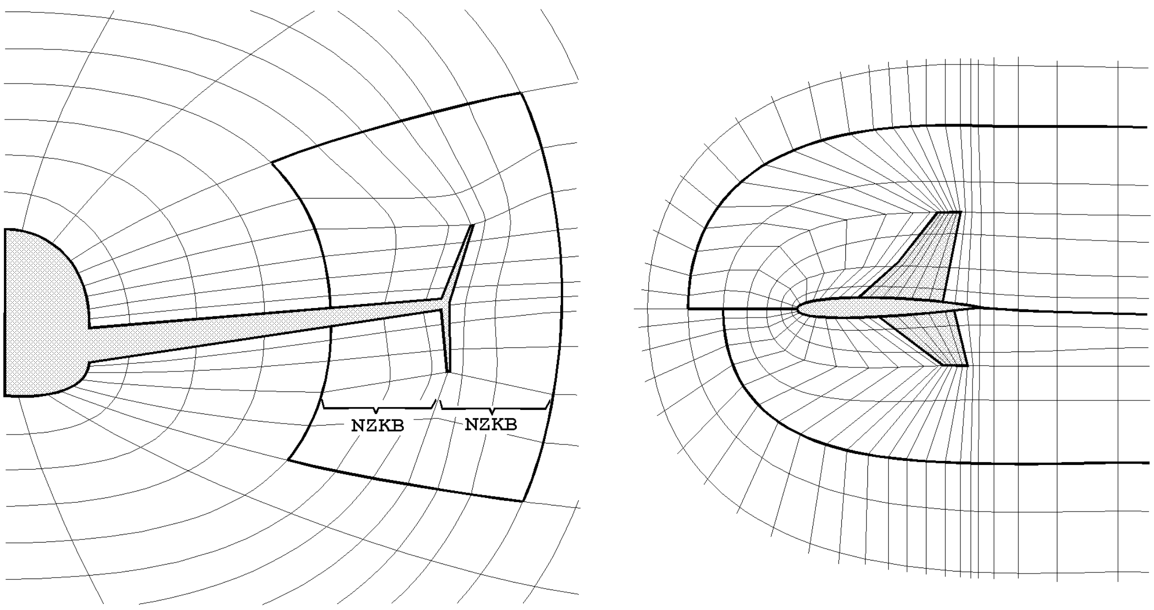


fig. 27



Initial wing-body grid



Deformed wing-body-winglets grid

fig. 28

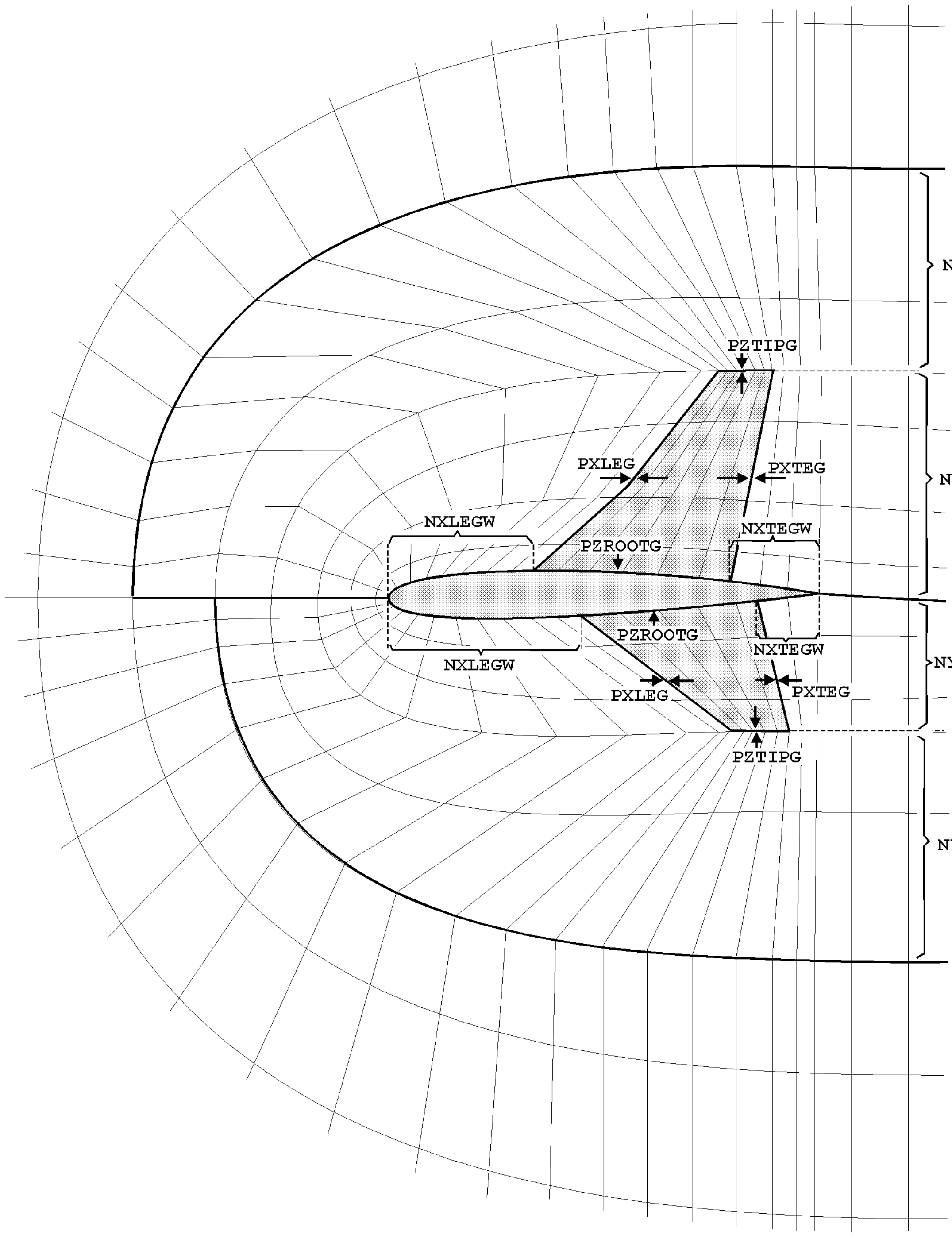

NYJB
PZTIPG
PXLEG
PXTEG
NYJTEG
NXLEGW
NXTEGW
PZROOTG
PZROOTG
NXTEGW
NXLEGW
NYJTEG
PXLEG
PXTEG
PZTIPG
NYJB

fig. 29

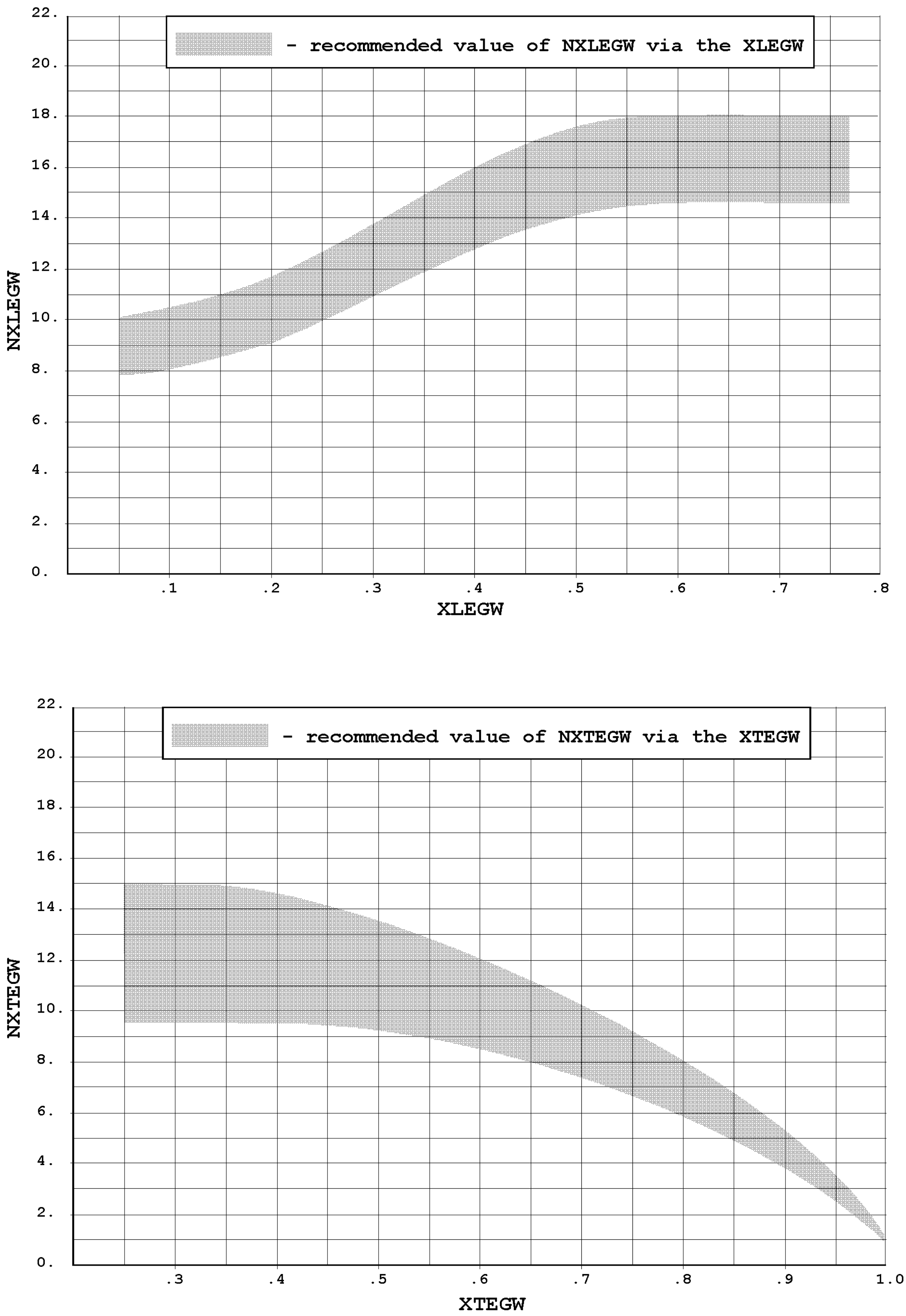

- recommended value of NXLEGW via the XLEGW
NXLEGW
XLEGW
22.
20.
18.
16.
14.
12.
10.
8.
6.
4.
2.
0.
.1
.2
.3
.4
.5
.6
.7
.8
- recommended value of NXTEGW via the XTEGW
NXTEGW
XTEGW
.3
.4
.5
.6
.7
.8
.9
1.0

fig. 30

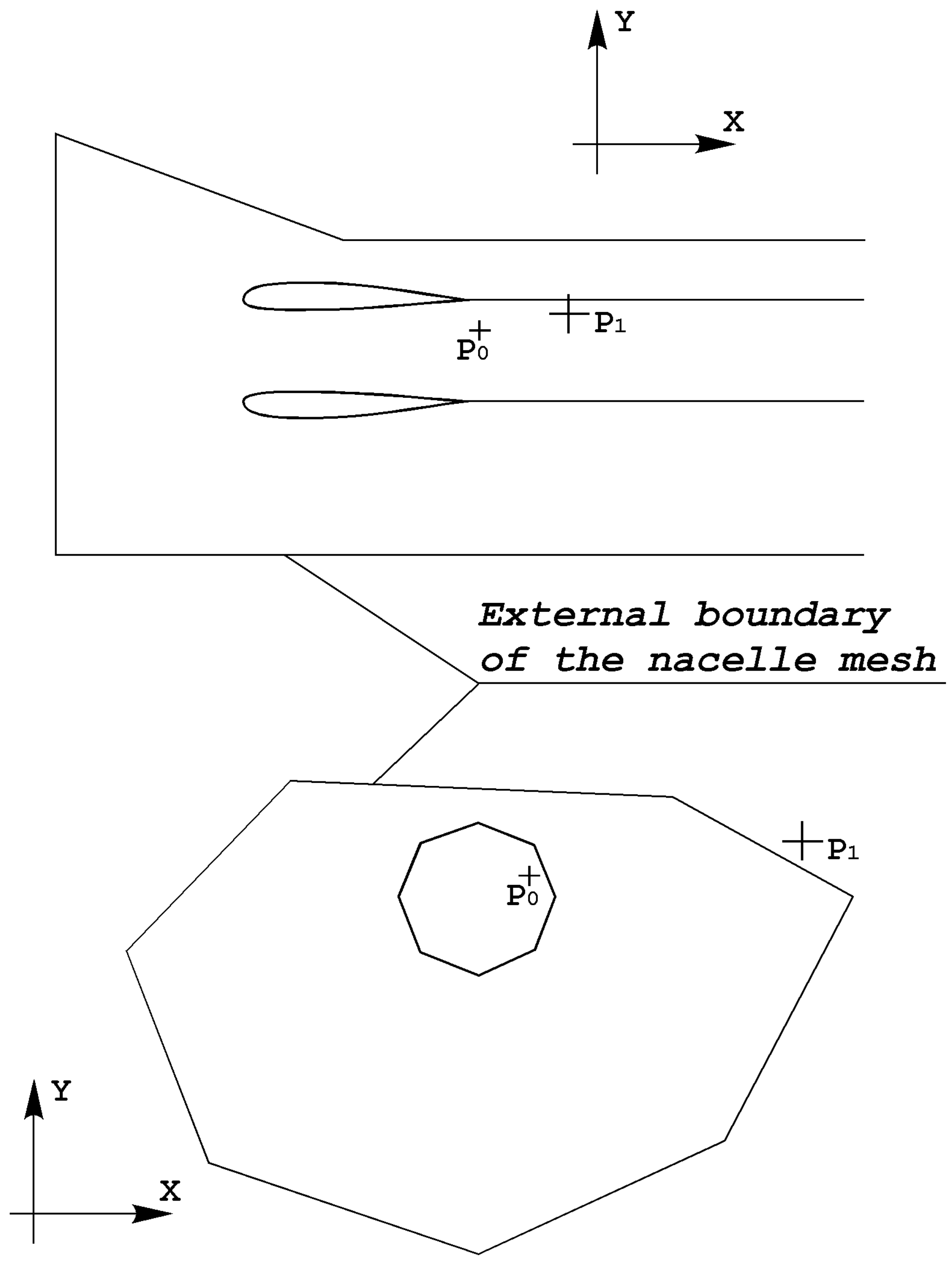
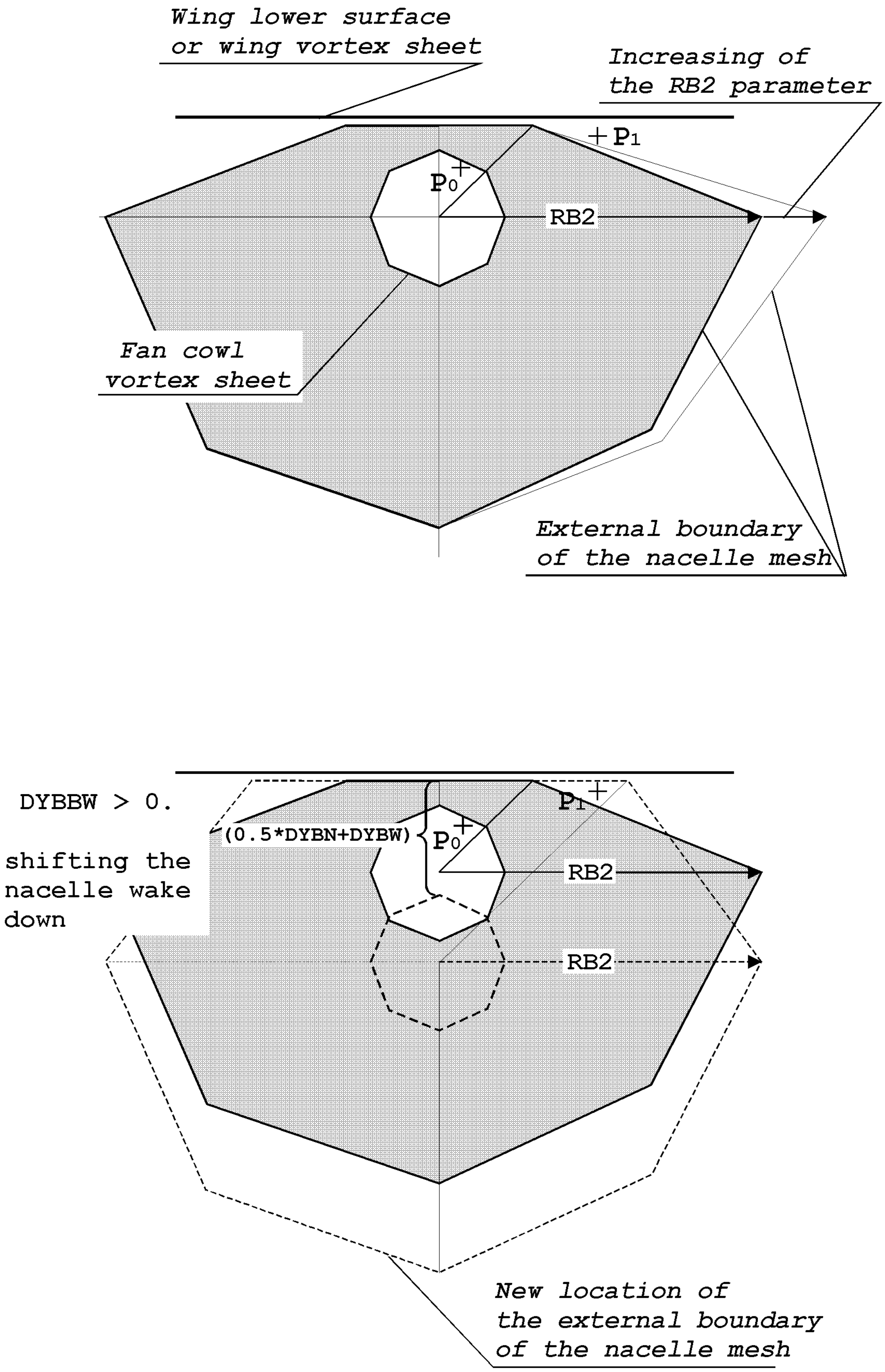


fig. 31



Wing lower surface
or wing vortex sheet
Increasing of
the RB2 parameter
P1
P0
RB2
Fan cowl
vortex sheet
External boundary
of the nacelle mesh
DYBBW > 0.
(0.5*DYBN+DYBW)
P1
P0
RB2
shifting the
nacelle wake
down
RB2
New location of
the external boundary
of the nacelle mesh

fig. 32

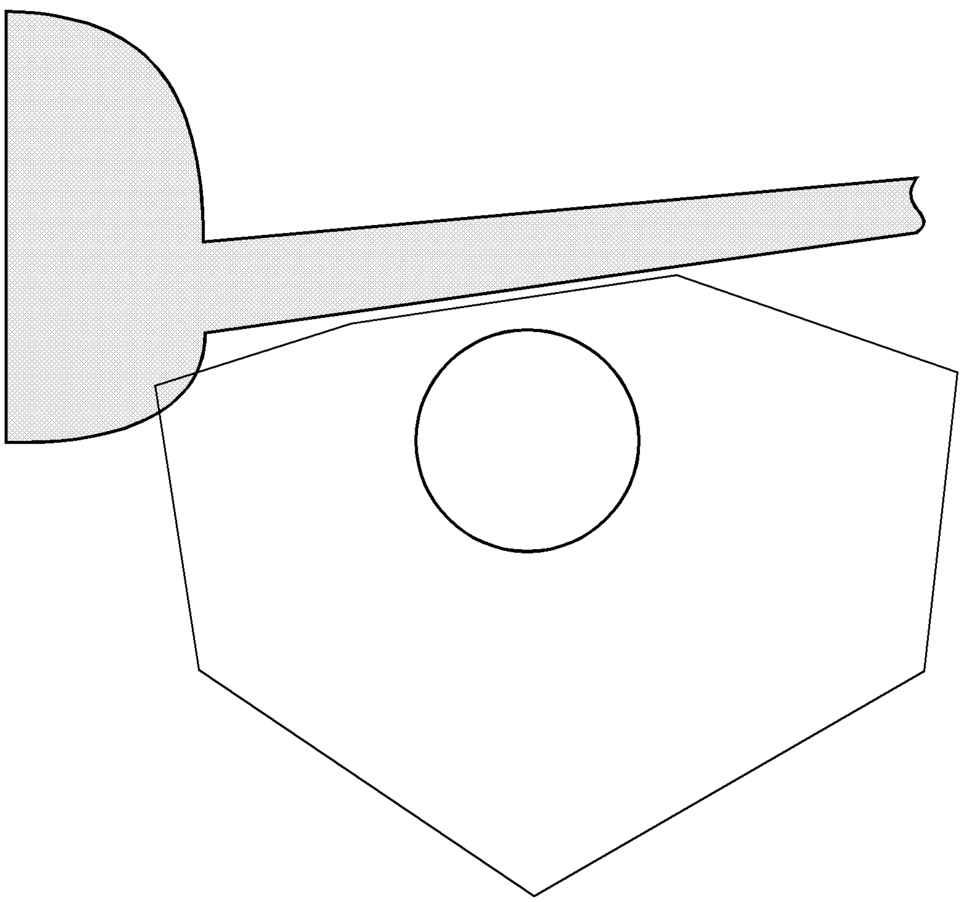


fig. 33

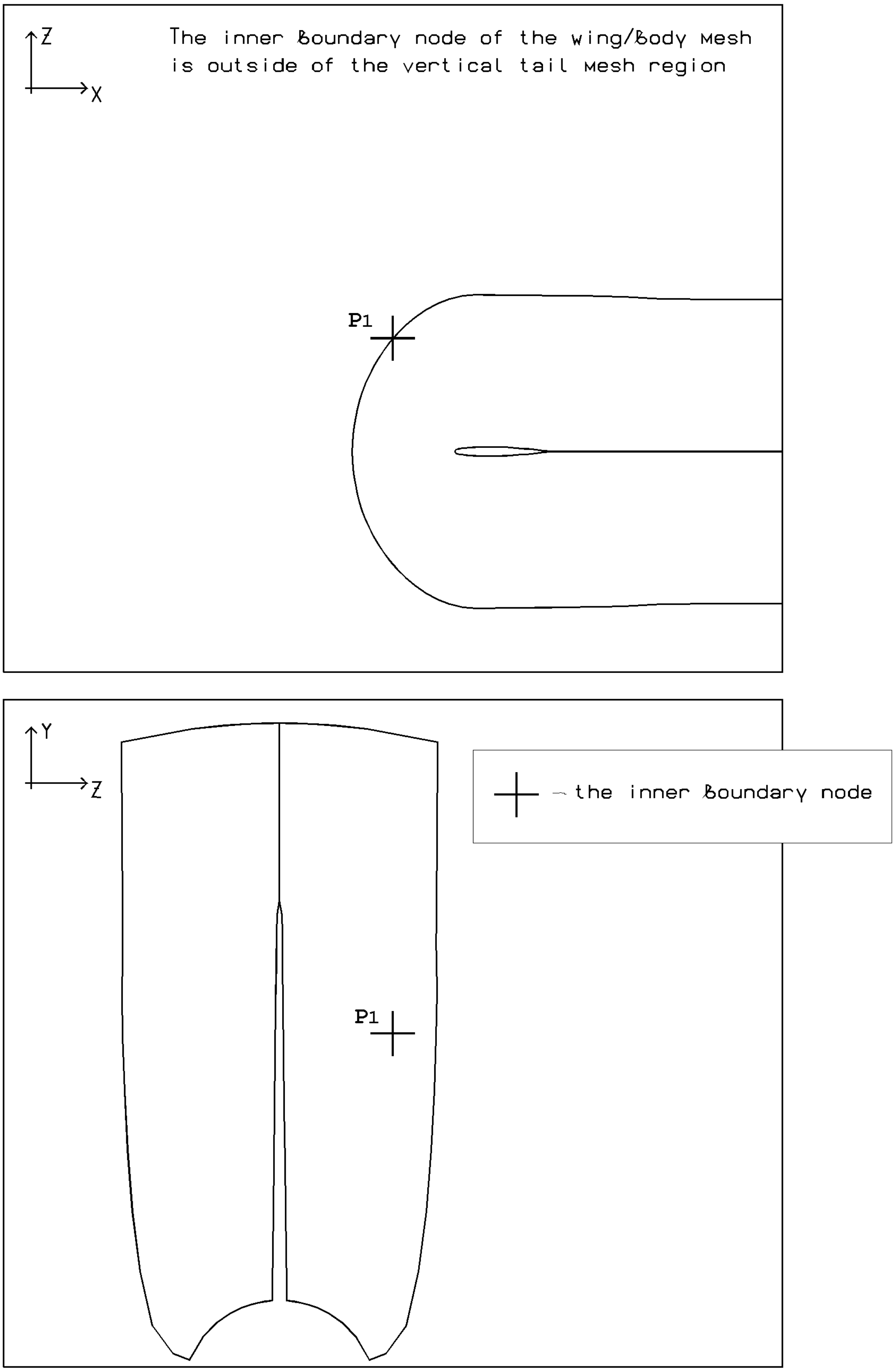

Z
X
The inner boundary node of the wing/body mesh
is outside of the vertical tail mesh region
P1
Y
Z
P1
– the inner boundary node

fig. 34

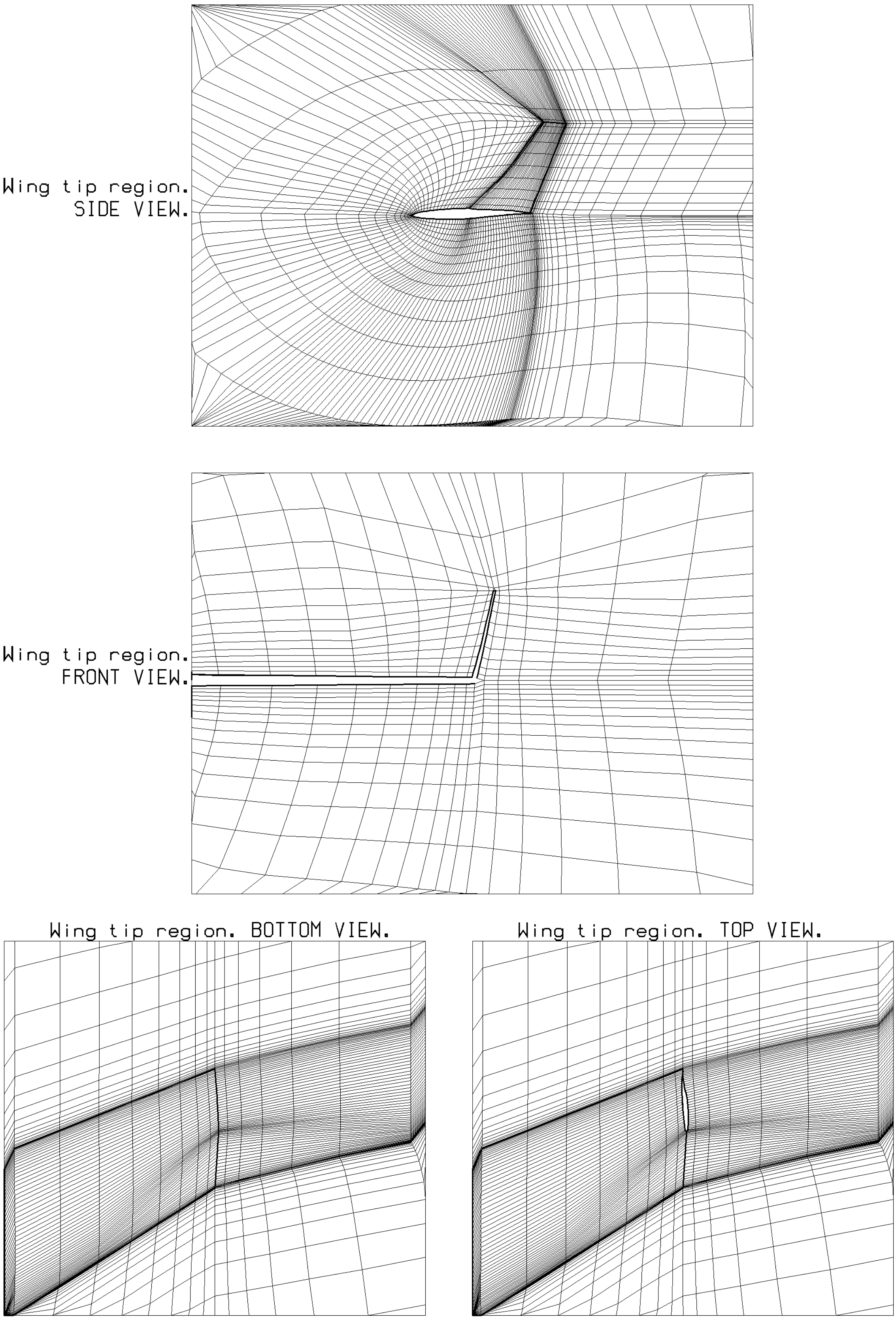

Wing tip region.
SIDE VIEW.
Wing tip region.
FRONT VIEW.
Wing tip region. BOTTOM VIEW.
Wing tip region. TOP VIEW.

fig. 35

3. REPRESENTATION OF THE COMPUTATIONAL RESULTS.

3.1 Graphical representation of the computational results.

The computational results are presented in the set of graphic files.

If the calculation is carried out in regime without side flow (NY_BETA=0.) then the names of these files are:

11.ps–20.ps	for wing and body
24.ps, 34.ps	for nacelle
82.ps-84.ps, 87.ps-90.ps	for horizontal tail
92.ps-94.ps, 97.ps-99.ps	for vertical tail
64.ps, 67.ps-70.ps	for lower winglet
74.ps, 77.ps-80.ps	for upper winglet
260.ps-261.ps	for boundary layer parameters at a body surface

If the side flow is present, then some of these files are duplicated (left and right part of configuration). In such case the file for left part contains additional symbol "**_L**" in its name and file for the right part contain symbol "**_R**".

The examples of these files are presented in **Section 3.2**

File 11.ps:

Three projections of the wing/body/nacelle/tail/winglets configuration. If calculation was carried out without nacelle or tail or winglets, then the nacelle or tail or winglets are not plotted. If nacelle calculation was carried out in a regime when the nacelle has a transparent duct, then the inflow and outflow surfaces are not plotted.

Files 12.ps , 82.ps:

Files represent the information about lift for elements of configuration:

12.ps – for wing body configuration;

82.ps – for horizontal tail.

Files include the following information:

- the values CL are the lift coefficients for the element of configuration and for total configuration;
- the diagram of the spanwise lift coefficient distribution CL(SPAN).

File 92.ps:

File represent the information about side force for vertical tail:

File include the following information:

- the values CZ is the side force coefficients for the vertical tail;
- the diagram of the spanwise side force coefficient distribution CZ(SPAN).

Files 13.ps (13_L.ps,13_R.ps)

Files represent the information about drag for wing+body+winglets and for total configuration:

Here:

- - the CDP values are the total pressure drag coefficients for the wing+winglets+body and for the total configuration. It is integral of the pressure distribution (momentum integral for nacelle);
- - the CDW values are the wave drag coefficients for the wing+winglets+body and for the total configuration. Wave drag is estimated by integrating equivalent entropy increment along the shock wave fronts;
- - the CDI value for total configuration is the total induced drag;
- - the CDS value are the drag caused by the difference of the mass flow through the nacelle inlet and outlet surfaces;
- - the CDFP values are profile drag coefficients for the wing+winglets and for the total configuration (wing+winglets+tails). These values are calculated with the help of Square-Young's formula;
- - the CDF values are friction drag coefficients for the wing+winglets and for the total configuration (integrals of the friction distribution over surfaces);
- - the diagrams of the wing spanwise pressure drag coefficient distribution and the wing spanwise distribution of the profile drag coefficient;
- - the diagrams of wing wave drag coefficient distribution for upper and lower surface.

Files 83.ps (83_L.ps,83_R.ps), 93.ps:

Files represent the information about drag for horizontal and vertical tail:

83.ps – for horizontal tail;

93.ps – for vertical tail.

Here:

- - the CDP value is the pressure drag coefficient for the total horizontal or vertical tail. It is integral of the pressure distribution;
- - the CDW value is the wave drag coefficient for the total horizontal or vertical tail. Wave drag is estimated by integrating equivalent entropy increment along the shock wave fronts;
- - the CDFP value is profile drag coefficient for the total horizontal or vertical tail calculated with the help of Square-Young's formula;
- - the CDF value is friction drag coefficient for the total horizontal or vertical tail (integral of the friction distribution over the tail surface);
- - the diagrams of the spanwise pressure drag coefficient distribution and the spanwise distribution of the profile drag coefficient;
- - the diagrams of wave drag coefficient distribution for upper and lower surface.

Files 14.ps (14_L.ps,14_R.ps):

Files represent the pressure distribution at prescribed wing sections; also some integral parameters are represented:

Here:

- - the CL values are the total lift coefficients of the wing/body/winglets configuration and of the total configuration (integral of the pressure distribution and the momentum integral for the nacelle);
- - the CDP values are the total pressure drag coefficient of the wing/body/winglets configuration and of the total configuration (integral of the pressure distribution)
- - the CDW values are the wave drag (wave drag is estimated by integrating equivalent entropy increment along the shock wave fronts);
- - the CDI value for total configuration is the total induced drag;
- - the CMZ value is the pitching moment relative to prescribed point REFXCG, REFYCG (see **item 8**, **Section 2.1**)
- - the CDS value is the total drag coefficient caused by the difference of the mass flow through the nacelle inlet and outlet surfaces;
- - the diagrams of the chordwise pressure coefficient distribution CP(x) in the specified sections of wing (span location =const). **Note, if the prescribed section intersects the body, then the pressure diagram is not plotted at such section.**

In the diagrams the values are presented:

CL is the lift coefficient of the wing section

CD is the pressure drag coefficient of the wing section

MZ is the moment coefficient of the section relative of the prescribe REFXOC chord point (see **item 8**, **Section 2.1**)

Files 84.ps (84_L.ps,84_R.ps), 94.ps :

Files represent the pressure distribution at prescribed sections for horizontal and vertical tail (also some integral parameters are represented):

84.ps – for horizontal tail;

94.ps – for vertical tail;

Here:

- - the CL value is the lift coefficients of the total horizontal tail (integral of the pressure distribution);
- - the CZ value is the side force coefficients of the vertical tail (integral of the pressure distribution);
- - the CDP value is the total pressure drag coefficient of the total horizontal tail or vertical tail (integral of the pressure distribution)
- - the CDW value is the wave drag coefficient of the total horizontal tail or vertical tail (wave drag is estimated by integrating equivalent entropy increment along the shock wave fronts);
- - the CMZ value is the pitching moment of the total horizontal tail relative to prescribed point REFXCG, REFYCG (see **item 8**, **Section 2.1**)
- - the CMZ value is the pitching moment of the total horizontal tail relative to prescribed point REFXCG, REFYCG (see **item 8**, **Section 2.1**)
- - the CMX value is the roll moment of the total horizontal tail or vertical tail relative to prescribed point REFXCG, REFYCG (see **item 8**, **Section 2.1**)

- - the CMY value is the Y moment of the vertical tail relative to prescribed point REFXCG, REFYCG (see **item 8**, **Section 2.1**)

- - the diagrams of the chordwise pressure coefficient distribution CP(x) in the specified sections of tail (span location =const). **Note, if the prescribed section intersects the body, then the pressure diagram is not plotted at such section.**

Files 24.ps (24_L.ps,24_R.ps), 34.ps (34_L.ps,34_R.ps):

Files represent the pressure distribution at prescribed sections for nacelle, also some integral parameters are represented:

24.ps – for first (inboard) nacelle;

34.ps – for second (outboard) nacelle.

Files include the following information:

- - the CLN value is the nacelle lift coefficient;
- - the CDPN value is nacelle drag coefficient obtained by the integrating of the momentum;
- - the CDWN value is the nacelle wave drag coefficient estimated by integrating equivalent entropy increment along the shock wave inside the nacelle computational mesh;
- - the CDSN value is the drag caused by the difference of the mass flow through the nacelle inlet and outlet surfaces;
- - the CZN value is the nacelle side force coefficient;
- - the PAI value is the nacelle mass flow coefficient calculated at the nacelle inlet surface;
- - the PAO value is the nacelle mass flow coefficient calculated at the nacelle outlet surface.
- - the diagrams of the chordwise pressure coefficient

Files 64.ps (64_L.ps,64_R.ps), 74.ps (74_L.ps,74_R.ps):

Files represent the pressure distribution at prescribed sections for winglet, also some integral parameters are represented:

64.ps – for lower winglet;

74.ps – for upper winglet.

Files include the following information:

- - the CL value is the winglet lift coefficient;
- - the CDP value is the winglet pressure drag coefficient (pressure integral over the winglet);
- - the CZ value is the winglet side force coefficient;
- - the CMZ value is the winglet pitching moment relative to prescribed point REFXCG, REFYCG (see **item 8**, **Section 2.1**);
- - the CMX value is the winglet roll moment relative to prescribed point REFXCG, REFYCG (see **item 8**, **Section 2.1**);

- - the diagrams of the chordwise pressure coefficient (here: the solid line corresponds to winglet's inboard surface; the dotted line corresponds to winglet's outboard surface)

File 15.ps (15_L.ps,15_R.ps), 16.ps (16_L.ps,16_R.ps):

Files represent the pressure distribution at prescribed body sections (also some integral parameters are represented):

15.ps – Cp distribution at prescribed polar angle body section;

16.ps – Cp distribution at prescribed X-constant body sections;

Here:

- - the CL values are the body lift coefficients and the lift of the total configuration;
- - the CDP values are the pressure drag coefficient of the body and of the total configuration (integral of the pressure distribution)
- - the CMZ value is the body pitching moment relative to prescribed point REFXCG, REFYCG (see **item 8**, **Section 2.1**)
- - the CDW values are the wave drag for total configuration;
- - the CDI value for total configuration is the total induced drag;
- - the CDS value is the total drag coefficient caused by the difference of the mass flow through the nacelle inlet and outlet surfaces;
- - the diagrams of the pressure coefficient distribution CP(x) at the specified polar (or X=const) body sections.

Files 17.ps (17_L.ps,17_R.ps), 18.ps (18_L.ps,18_R.ps),
87.ps (87_L.ps,87_R.ps), 88.ps (88_L.ps,88_R.ps),
97.ps (97_L.ps,97_R.ps)
67.ps (67_L.ps,67_R.ps), 68.ps (68_L.ps,68_R.ps)
77.ps (77_L.ps,77_R.ps), 78.ps (78_L.ps,78_R.ps):

Files represent the boundary layer parameters on the element's surfaces:

17.ps – upper wing surface;

18.ps – lower wing surface;

87.ps – upper surface of horizontal tail;

88.ps – lower surface of horizontal tail;

97.ps – vertical tail surface.

67.ps – inboard surface of lower winglet;

68.ps – outboard surface of lower winglet;

77.ps – inboard surface of upper winglet;

78.ps – outboard surface of upper winglet;

Files include the following information:

- - configurations of limits streamlines, transition line and line of separation are presented;
- - the total value of the skin friction coefficient CDf for the upper or lower wing surface;
- - the diagram of the spanwise distribution of the skin friction coefficient $CD_{fsec}(z)$ for upper or lower wing surface;
- For specified sections of wing the following results are presented:

  - the diagrams of the velocity components $u_e(\bar{x})/u_\infty$ (solid line) and $w_e(\bar{x})/u_\infty$ (dotted line) on external edge of the boundary layer;

  - the diagrams of the friction components $C_{fx}(\bar{x})$ (solid line) $C_{fz}(\bar{x})$ (dotted line);

  - the diagrams of the chordwise displacement thickness $\delta_c^*(\bar{x})$ (solid line) and the chordwise momentum thickness $\theta_c(\bar{x})$ (dotted line);

  - the diagrams of the angle deviation of external streamline $\beta_e(\bar{x})$ (solid line) and of limits streamline $\beta_w(\bar{x})$ (dotted line) from chordwise direction.

Files 19.ps (19_L.ps,19_R.ps), 20.ps (20_L.ps,20_R.ps), 89.ps (89_L.ps,89_R.ps), 90.ps (90_L.ps,90_R.ps), 99.ps (99_L.ps,99_R.ps) 69.ps (69_L.ps,69_R.ps), 70.ps (70_L.ps,70_R.ps) 79.ps (79_L.ps,79_R.ps), 80.ps (80_L.ps,80_R.ps):

Files represent the configuration of limit streamlines, transition line position and the isobars on element's surfaces:

19.ps – upper wing surface;

20.ps – lower wing surface;

89.ps – upper surface of horizontal tail;

90.ps –lower surface of horizontal tail;

99.ps – vertical tail surface.

69.ps – inboard surface of lower winglet;

70.ps – outboard surface of lower winglet;

79.ps – inboard surface of upper winglet;

80.ps – outboard surface of upper winglet;

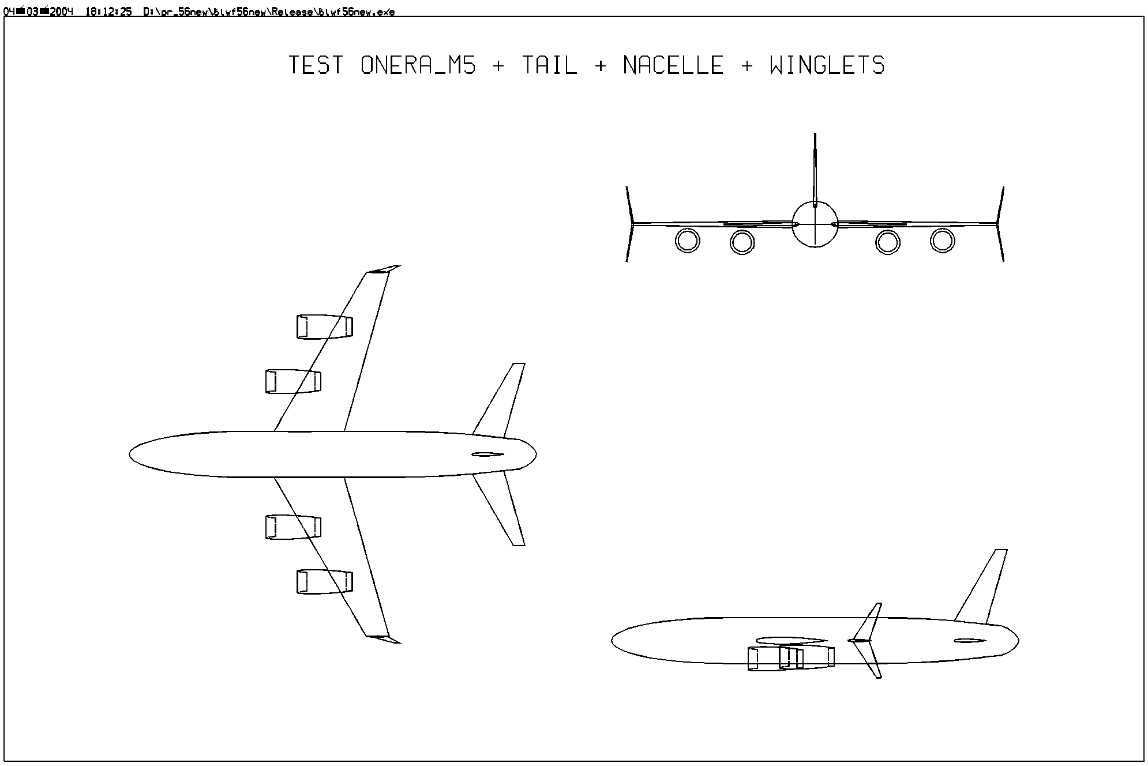
Files 260.ps, 261.ps:

Files represent the configuration of external streamlines and limits streamlines, on the surface of fuselage:

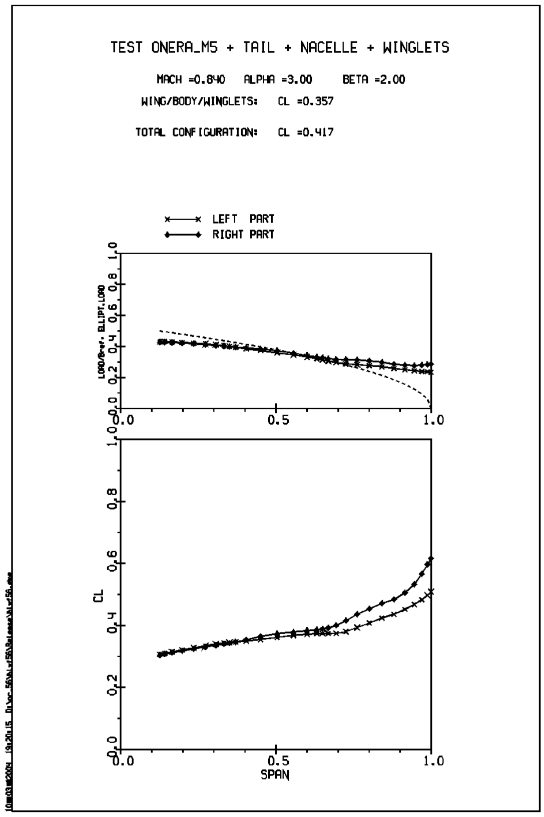
260.ps – streamlines of external flow;

261.ps – limits streamlines;

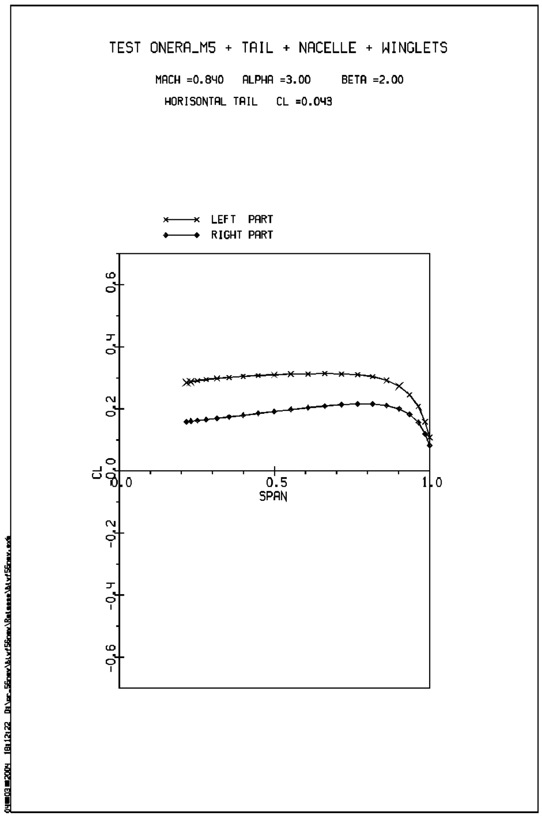
3.2 Examples of the graphical representation of the computational results.



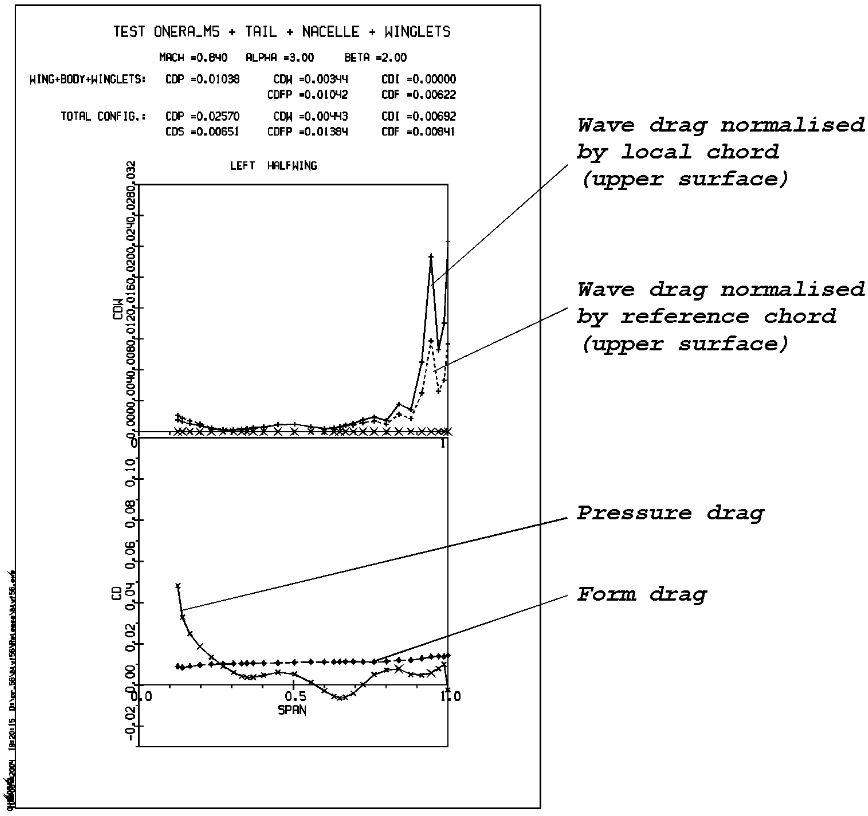
File 11.ps



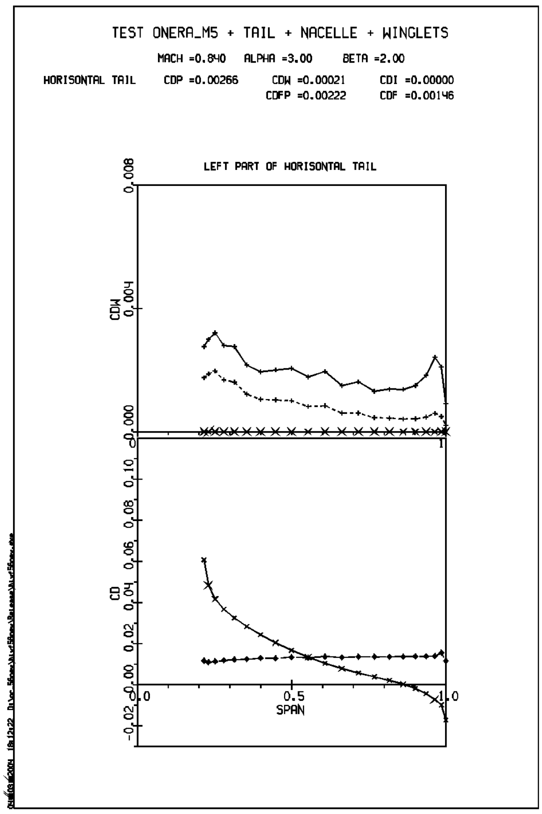
File 12.ps



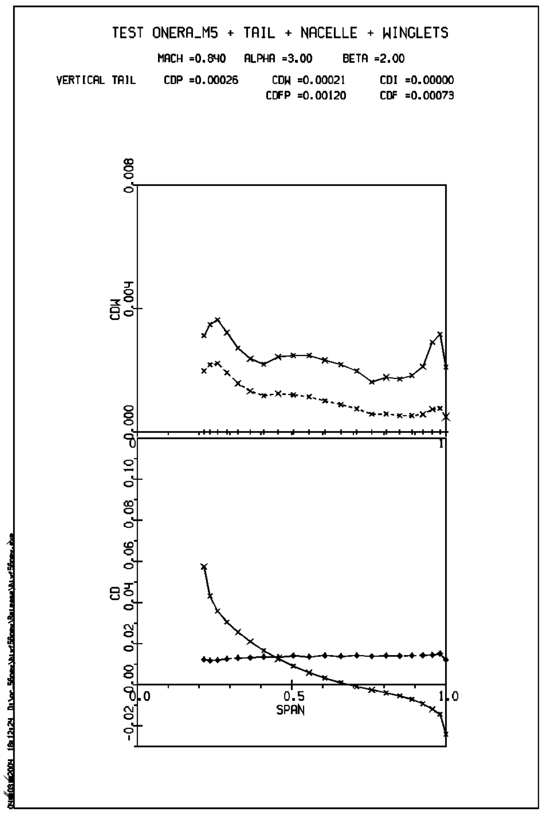
File 82.ps (92.ps)



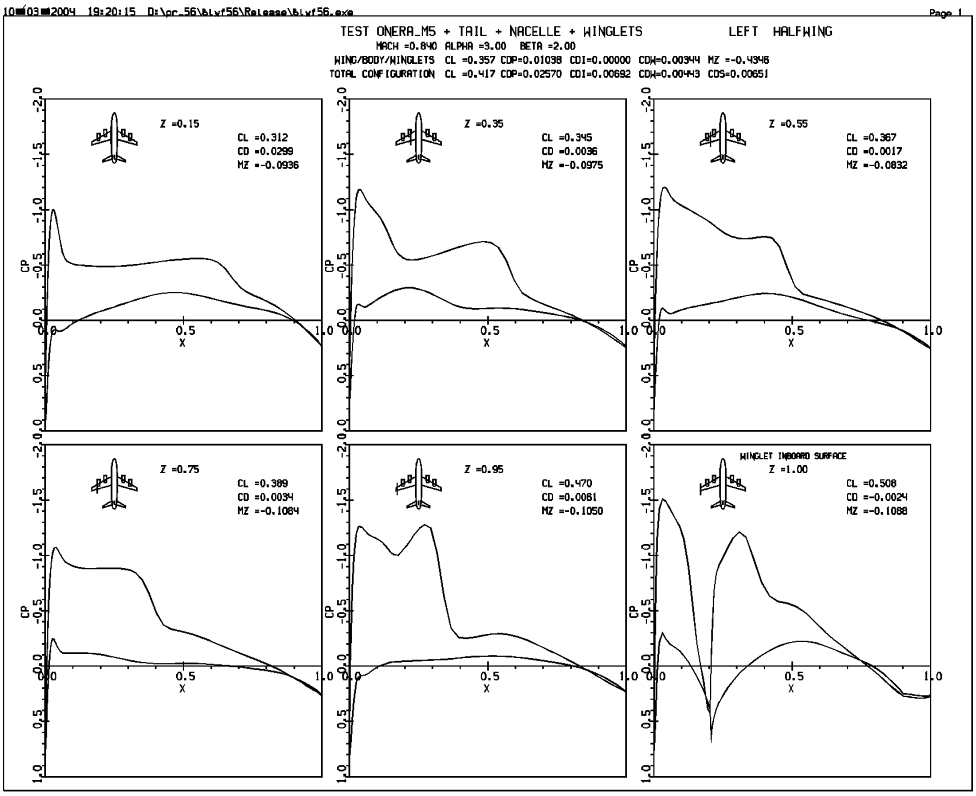
File 13_L.ps (13.ps, 13_R.ps)



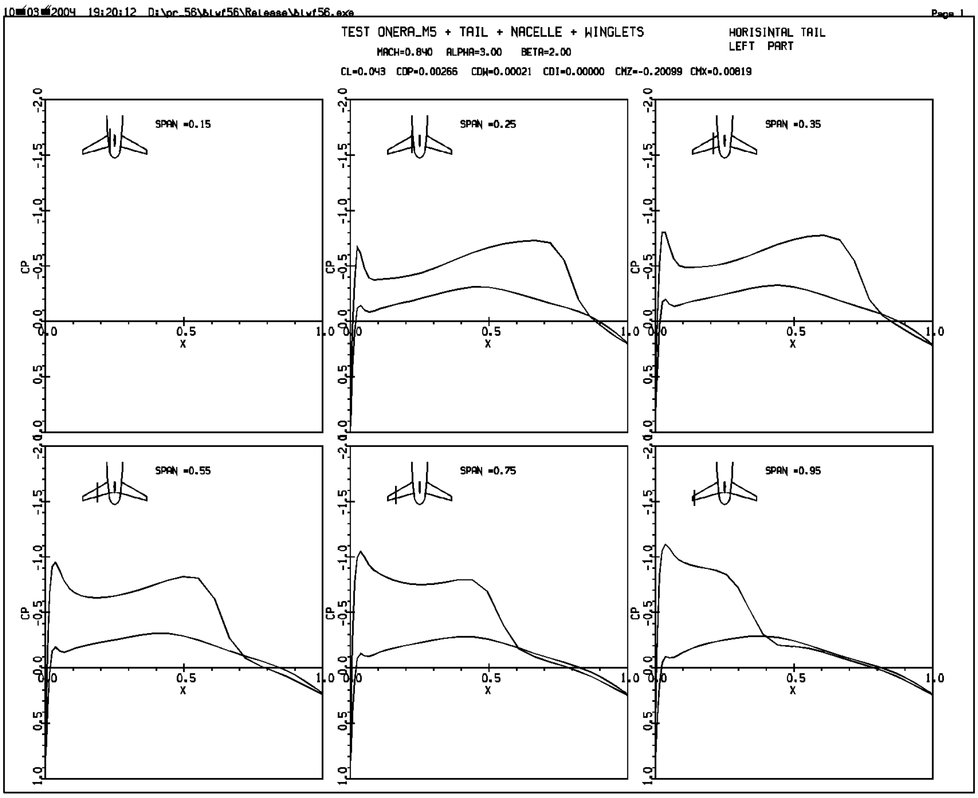
File 83_L.ps (83.ps, 83_R.ps)



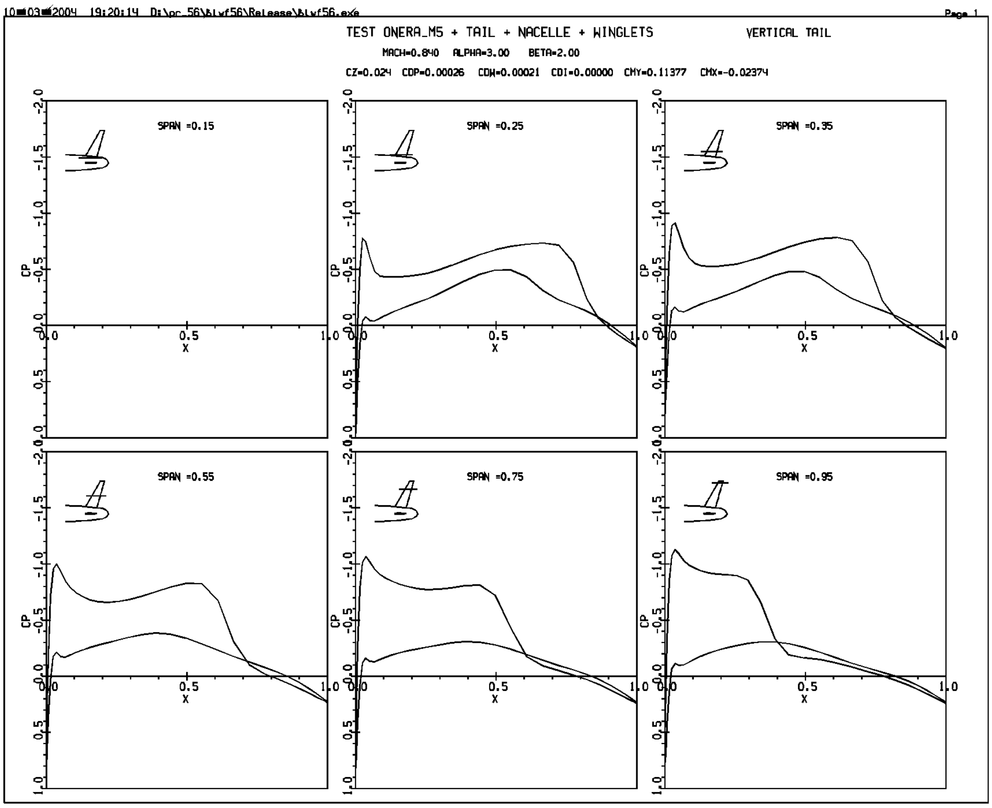
File 93.ps



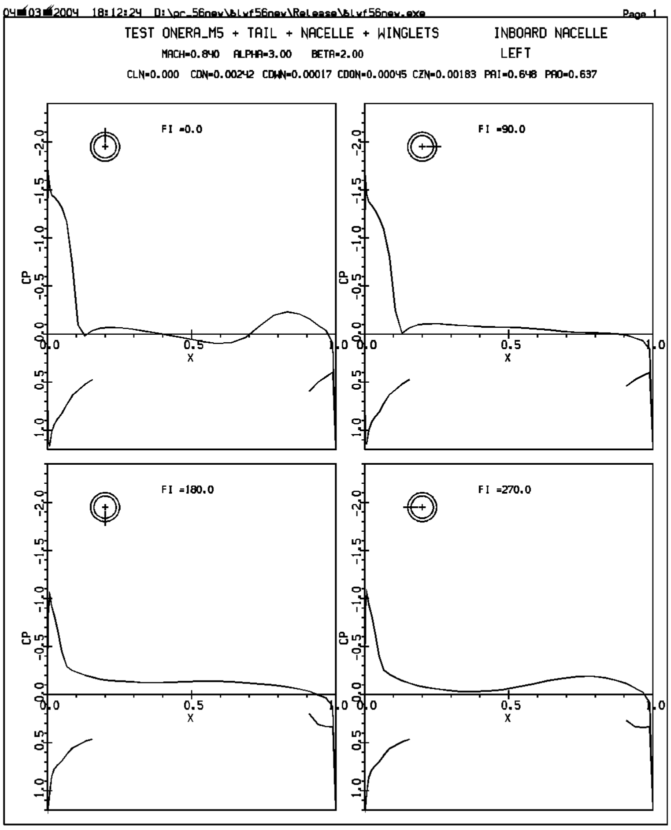
File 14_L.ps (14.ps,14_R.ps)- wing



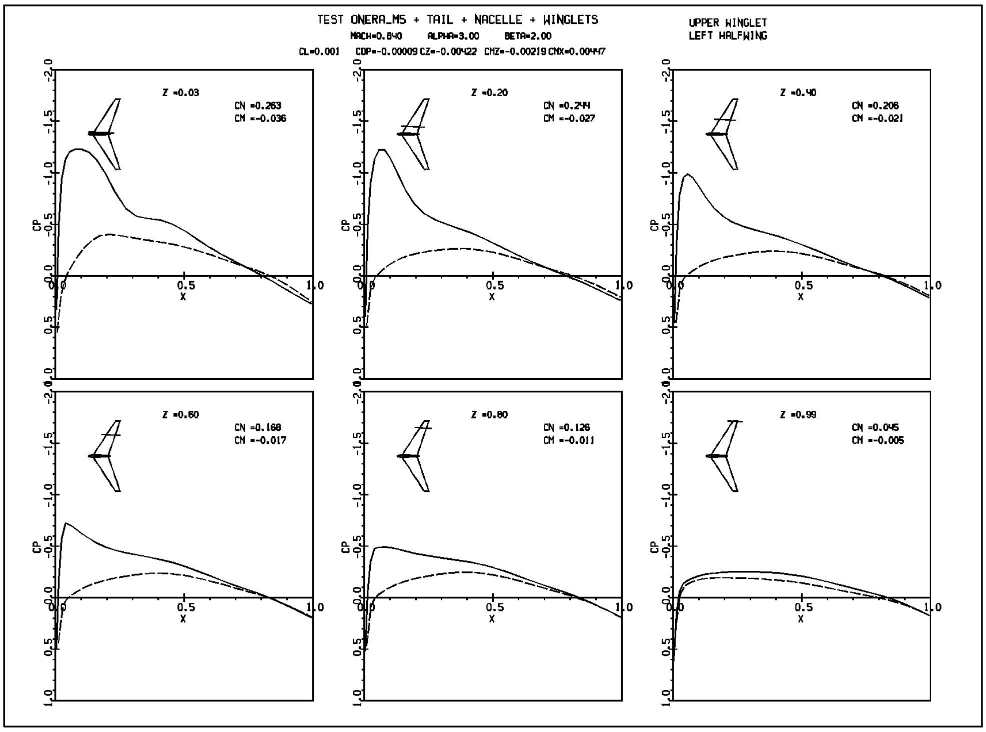
File 84_L.ps (84.ps,84_R.ps)- horisontal tail



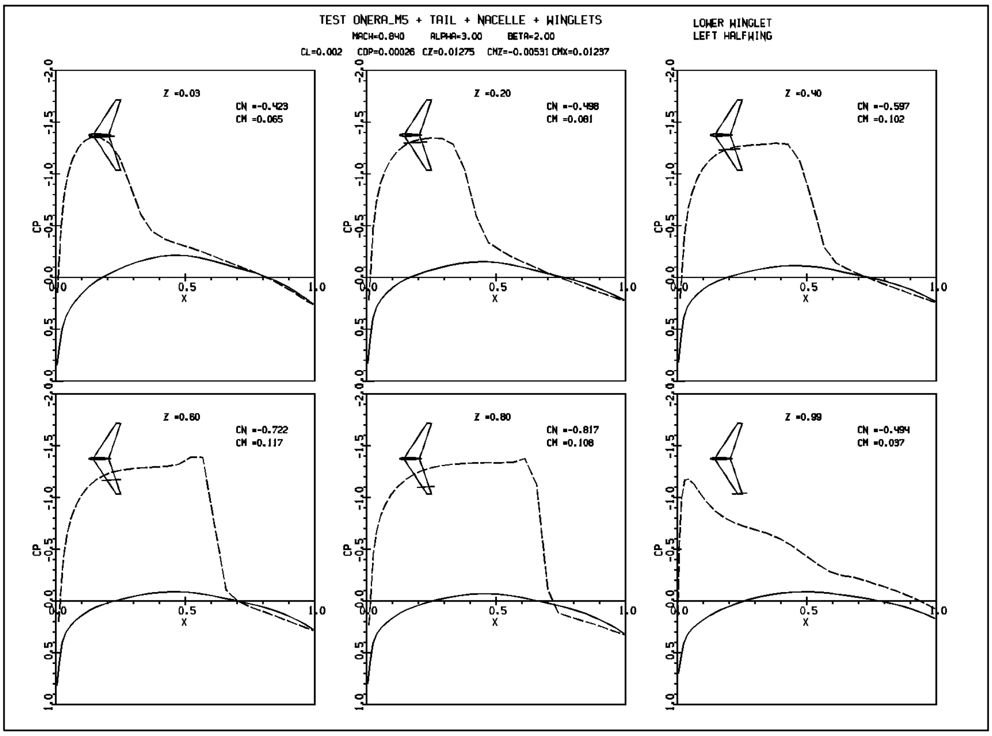
File 94.ps - vertical tail



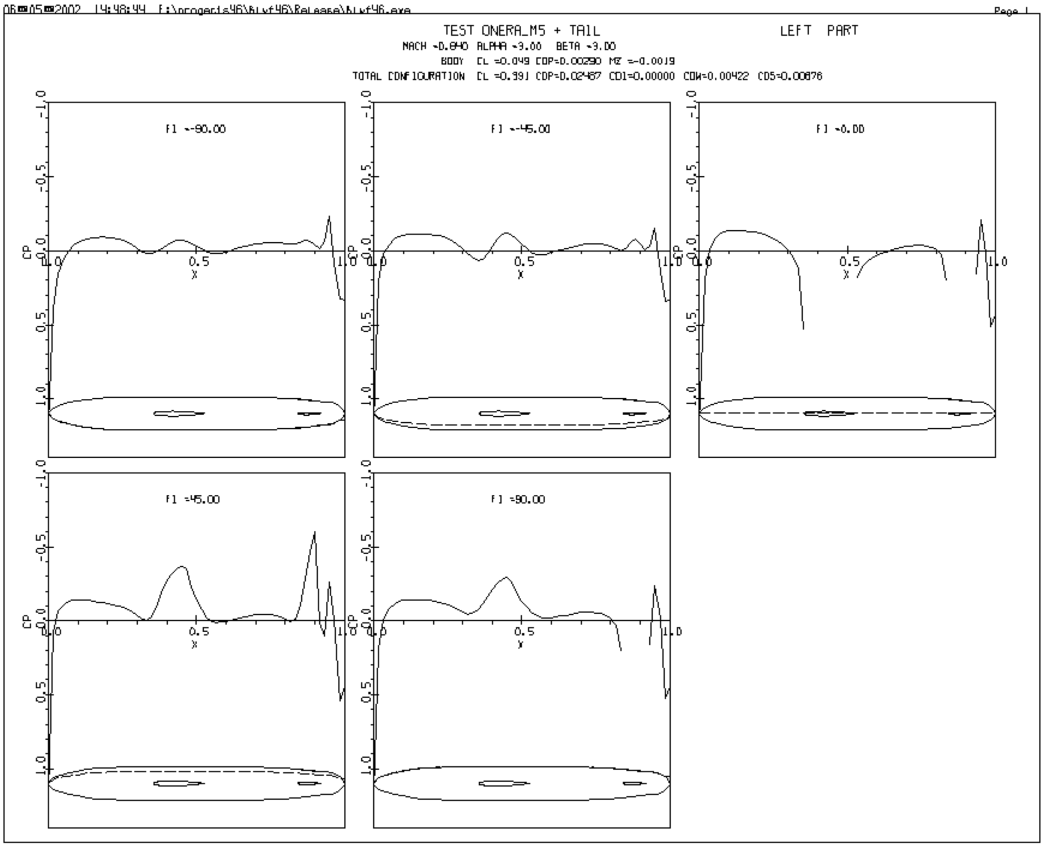
File 24_L.ps (24.ps,24_R.ps)- inboard nacelle
File 34_L.ps (34.ps,34_R.ps)- outboard nacelle



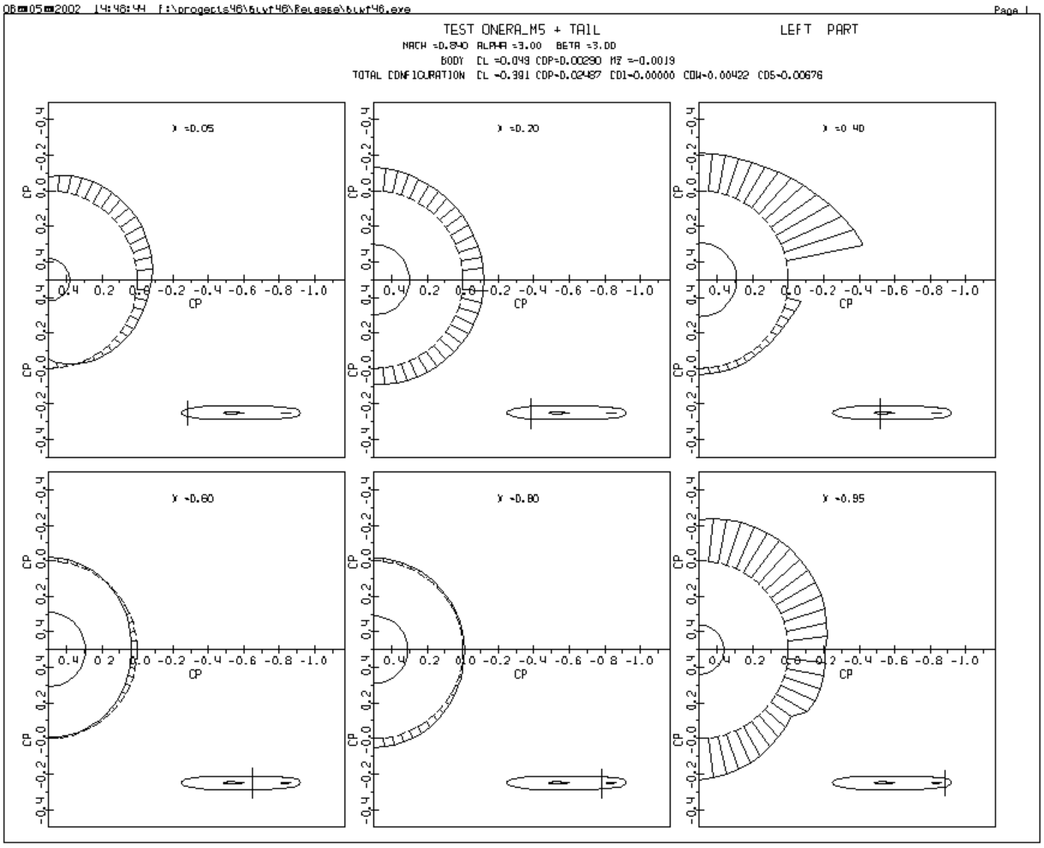
File 74_L.ps (74.ps,74_R.ps)- upper winglet



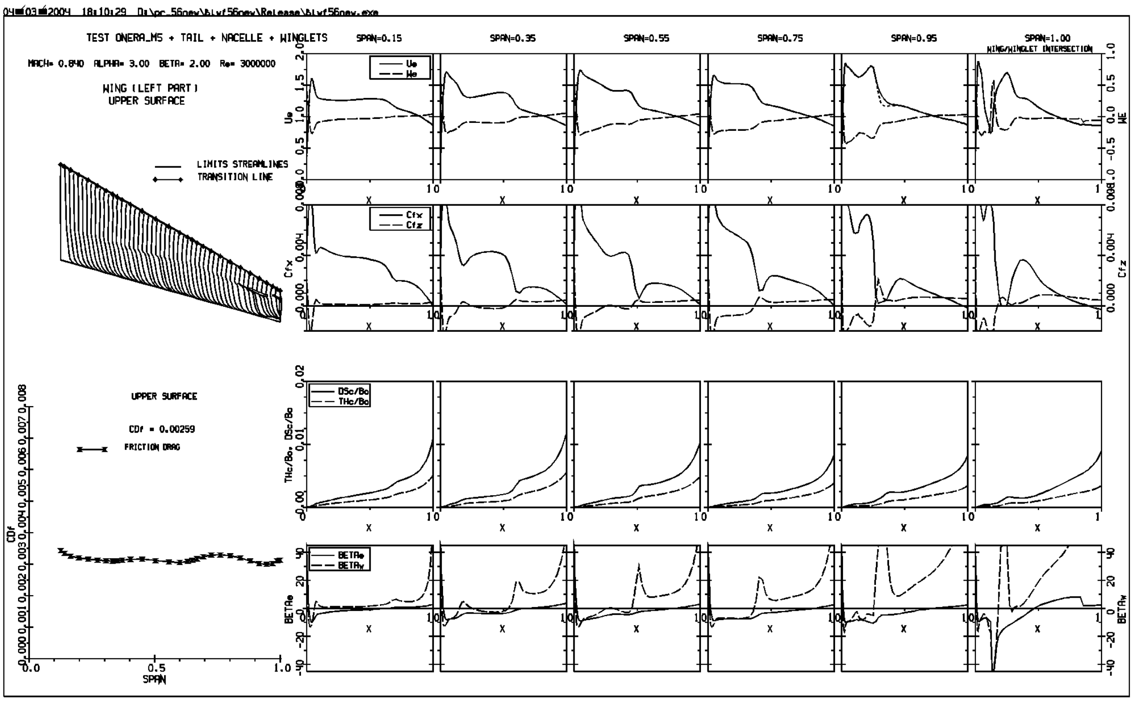
File 64_L.ps (64.ps,64_R.ps)- lower winglet



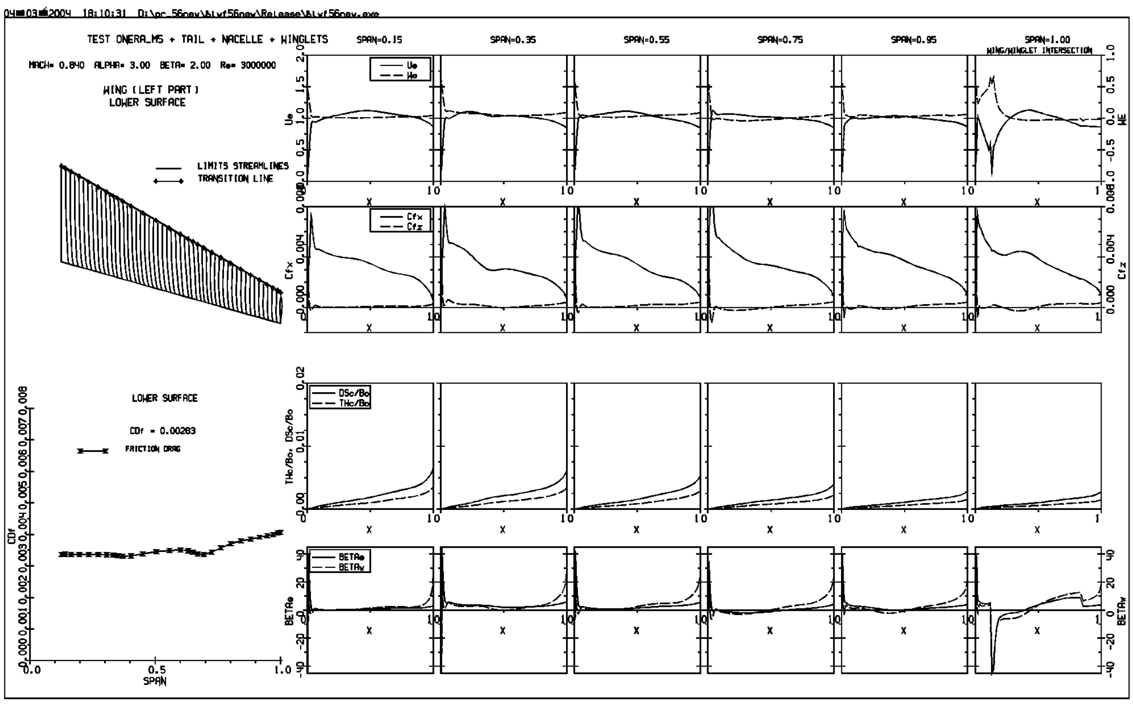
File 15_L.ps (15.ps,15_R.ps)



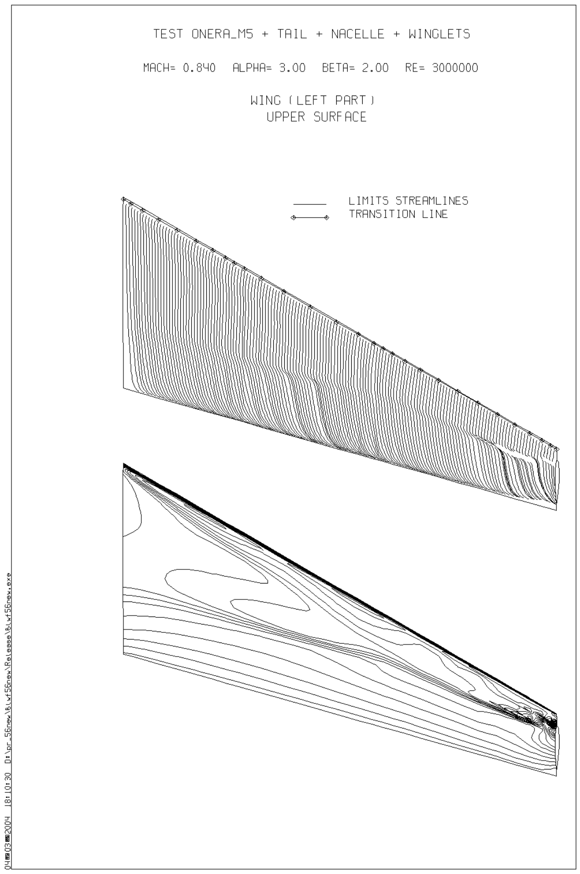
File 16_L.ps (16.ps,16_R.ps)




```
File  17_L.ps,17.ps,17_R.ps - wing, upper surface
      87_L.ps,87.ps,87_R.ps - horisontal tail, upper surface
      97_L.ps,97.ps,97_R.ps - vertical tail surfaces
      77_L.ps,77.ps,77_R.ps - upper winglet, inboard surface
      67_L.ps,67.ps,67_R.ps - lower winglet, inboard surface
```




```
File  18_L.ps,18.ps,18_R.ps - wing, lower surface
      88_L.ps,88.ps,88_R.ps - horisontal tail, lower surface
      78_L.ps,78.ps,78_R.ps - upper winglet, outboard surface
      68_L.ps,68.ps,68_R.ps - lower winglet, outboard surface
```



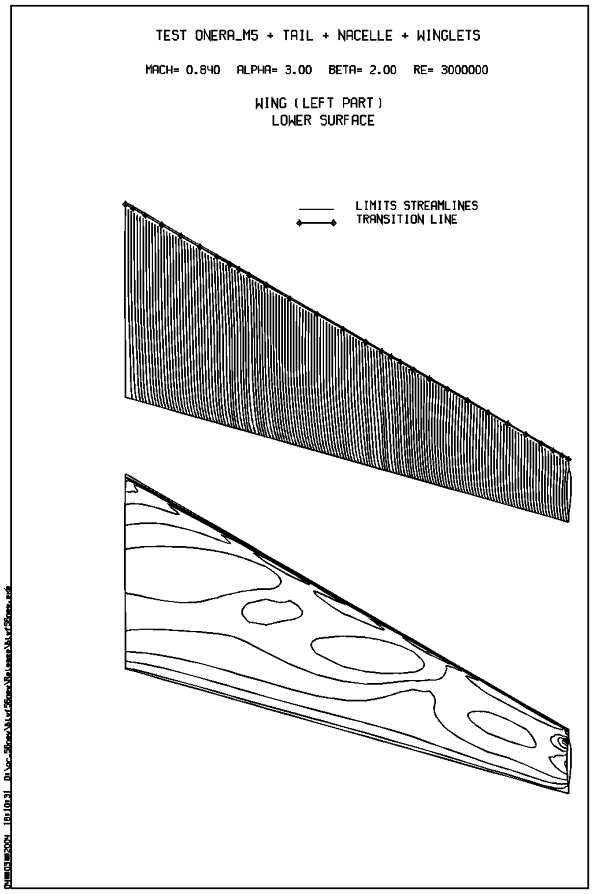
File
    19_L.ps,19.ps,19_R.ps
        wing, upper surface

    89_L.ps,89.ps,89_R.ps
        horisontal tail,
        upper surface

    99_L.ps,99.ps,99_R.ps
        vertical tail surfaces

    79_L.ps,79.ps,79_R.ps
        upper winglet,
        inboard surface

    69_L.ps,69.ps,69_R.ps
        lower winglet,
        inboard surface

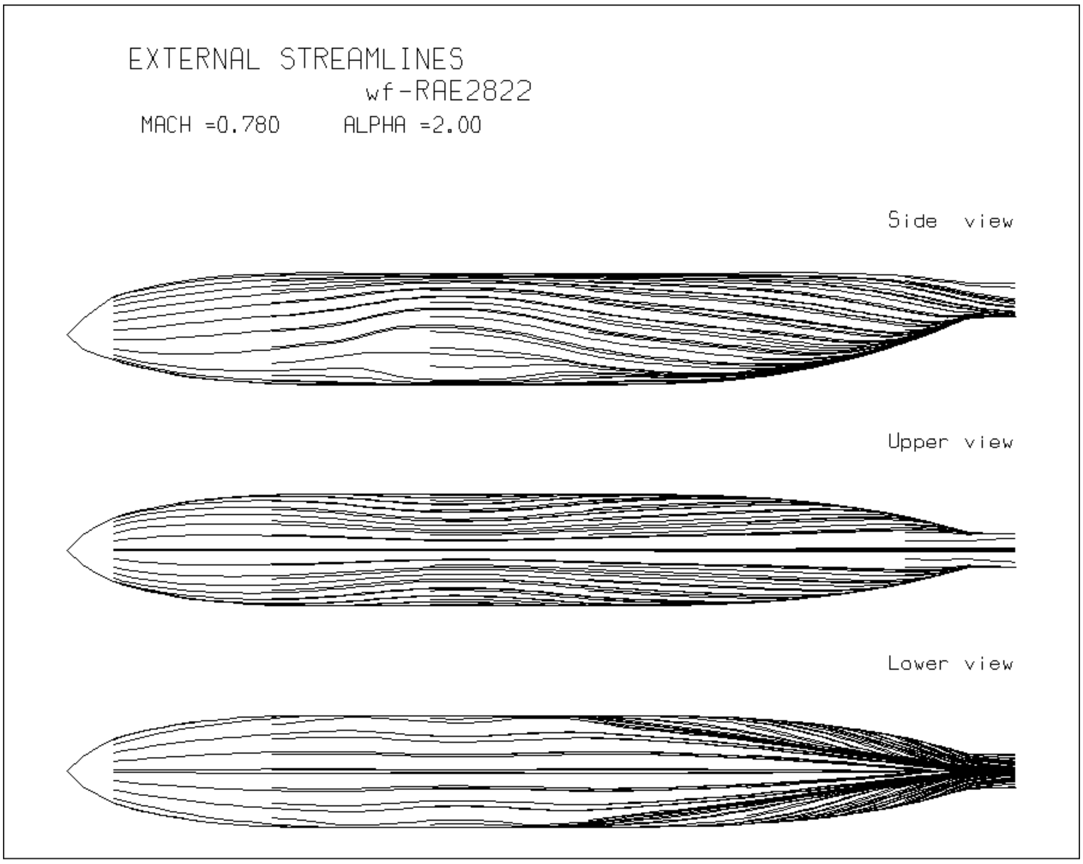


File
    20_L.ps,20.ps,20_R.ps
        wing, lower surface

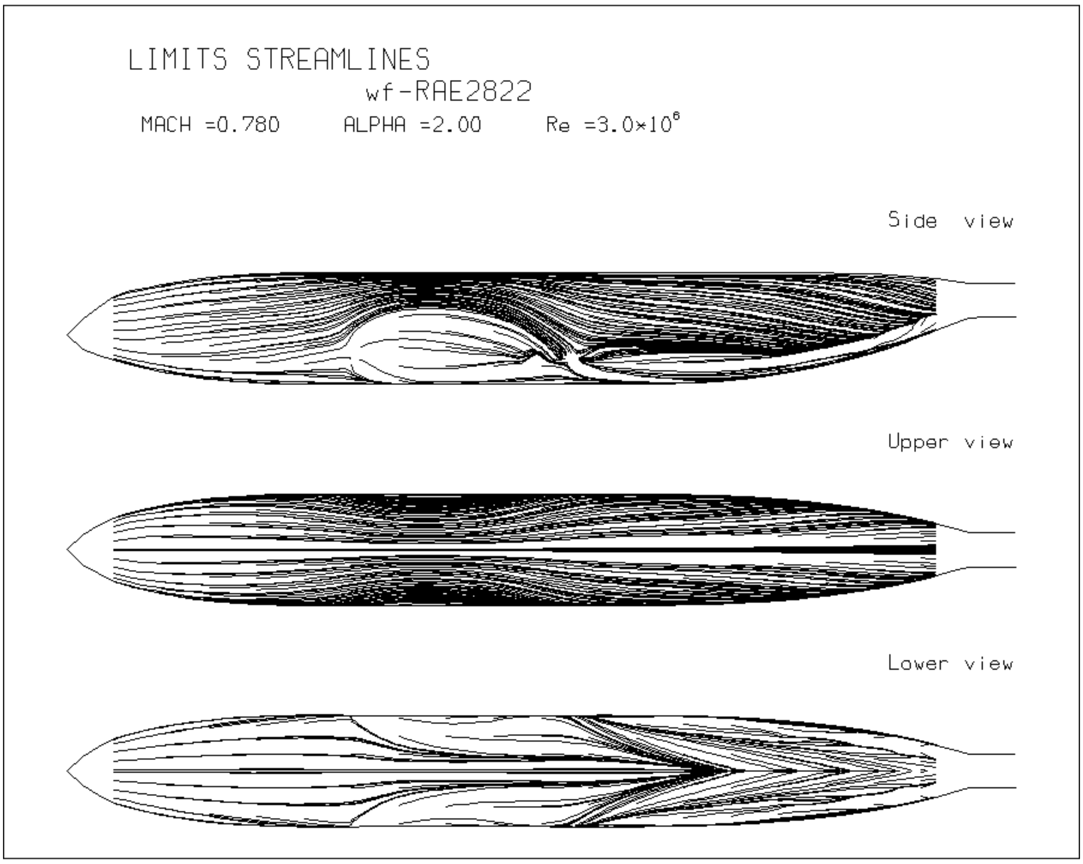
    90_L.ps,90.ps,90_R.ps
        horisontal tail,
        lower surface

    80_L.ps,80.ps,80_R.ps
        upper winglet,
        outboard surface

    70_L.ps,70.ps,70_R.ps
        lower winglet,
        outboard surface



File 260.ps



File 261.ps

3.3 Printing in the process of computation. Output printing.

In the process of computation the code forms the file **blwf58.out,** which contains the main information about computation procedure. At the end of this file the main integral results are presented. Also these integral results are presented in the short text file **fn.pl0** (text output file of integral parameters).

The distributed parameters for the prescribed sections of wing, winglets, tail and nacelles are printed to the text file **fn.pl4** (text output file of the distributed parameters).

Here we consider the structure of the file **blwf58.out**. The main notations will be explained.

Printing in the process of the meshes generation and nodes analysing procedure.

Here the printing indicates the main steps in the process of meshes generation and nodes analysing procedure:

```
 ...........................
WING/BODY MESH GENERATION.
  START
  FINISH


  MESH GENERATION FOR FIRST NACCELE
  START
  FINISH

  THE STREAMTUBE AREA RATIO
  AT INFLOW FACE INSIDE THE NACELLE:
  PA=   0.9047772


  MESH GENERATION FOR SECOND NACCELE
  START
  FINISH


  THE STREAMTUBE AREA RATIO
  AT INFLOW FACE INSIDE THE NACELLE:
  PA=   0.9743754



  DEFINITION THE WING/BODY MESH NODES
  WHICH ARE INSIDE THE NACCEL            1
  START
  FINISH



  DEFINITION THE WING/BODY MESH
  INNER  BOUNDARY  NODES  WHICH
  CORRESPOND TO NACCELE            1
  START
  FINISH

  NUMBER OF INNER BOUNDARY NODES WHICH
  CORRESPOND TO NACCEL            1
  N =          456

  THE NEAREST TO NACCELE BLOCK BOUNDARY
  NODE IS:
  PAH =   50.51073
  PBH =   2.550395
  PCH =   3.167137
```

```
DEFINITION THE WING/BODY MESH NODES
WHICH ARE INSIDE THE NACCEL            2
START
FINISH



DEFINITION THE WING/BODY MESH
INNER  BOUNDARY  NODES  WHICH
CORRESPOND TO NACCELE           2
START
FINISH

NUMBER OF INNER BOUNDARY NODES WHICH
CORRESPOND TO NACCEL           2
N =         629

THE NEAREST TO NACCELE BLOCK BOUNDARY
NODE IS:
PAH =   38.07495
PBH =   2.301948
PCH =   8.941887



DEFINITION POSITION OF THE FIRST NACCELE
BLOCK BOUNDARY  NODES IN THE MESH OF THE
SECOND NACCELE
START
FINISH

THE NUMBER OF THE FIRST NACCELE BLOCK
BOUNDARY NODES IN SECOND NACCELE MESH
N =          25



DEFINITION POSITION OF THE FIRST NACCELE
BLOCK BOUNDARY NODES IN THE WING/BODY MESH
START
FINISH



DEFINITION POSITION OF THE SECOND NACCELE
BLOCK BOUNDARY  NODES IN THE MESH OF THE
FIRST NACCELE
START
FINISH

THE NUMBER OF THE SECOND NACCELE BLOCK
BOUNDARY NODES IN FIRST  NACCELE MESH
N =          29



DEFINITION POSITION OF THE SECOND NACCELE
BLOCK BOUNDARY NODES IN THE WING/BODY MESH
START
FINISH



DEFINITION THE WING/BODY MESH
HOLE AND INNER  BOUNDARY  NODES
WHICH CORRESPOND TO HORISONTAL
TAIL
START
FINISH

NUMBER OF INNER BOUNDARY NODES WHICH
```

```
CORRESPOND TO HORISONTAL TAIL
N =         149

THE NEAREST TO HORISONTAL TAIL BLOCK BOUNDARY
NODE IS:
PAH =   43.01386
PBH =   2.511297
PCH =   4.869230



DEFINITION THE WING/BODY MESH
HOLE AND INNER  BOUNDARY  NODES
WHICH CORRESPOND TO VERTICAL
TAIL
START
FINISH

NUMBER OF INNER BOUNDARY NODES WHICH
CORRESPOND TO VERTICAL TAIL
N =         117

THE NEAREST TO VERTICAL TAIL BLOCK BOUNDARY
NODE IS:
PAH =   36.76381
PBH =   2.237759
PCH =   8.722192



DEFINITION POSITION OF THE HORISONTAL TAIL
BLOCK BOUNDARY  NODES IN THE MESH OF THE
VERTICAL TAIL
START
FINISH

THE NUMBER OF THE HORISONTAL TAIL BLOCK
BOUNDARY NODES IN THE VERTICAL TAIL MESH
N =         171



DEFINITION POSITION OF THE HORISONTAL TAIL
BLOCK BOUNDARY NODES IN THE WING/BODY MESH
START
FINISH



DEFINITION POSITION OF THE VERTICAL TAIL
BLOCK BOUNDARY  NODES IN THE MESH OF THE
HORISONTAL TAIL
START
FINISH

THE NUMBER OF THE VERTICAL TAIL BLOCK
BOUNDARY NODES IN THE HORISONTAL TAIL MESH
N =         169



DEFINITION POSITION OF THE VERTICAL TAIL
BLOCK BOUNDARY NODES IN THE WING/BODY MESH
START
FINISH
..............
```

Pay attention to the parameter "PA". It is the streamtube area ratio calculated at the inflow mesh surface inside the nacelle. This value corresponds to the prescribed inlet streamtube area ratio, but due to the areas of the inlet surface and the inflow mesh surface inside the nacelle are different, the PA differs from the prescribed one.

Printing in the process of the external flow calculation.

Example of the printing in the process of the external flow calculation is presented bellow:

```
    N   CORRECTION  IC  JC  KC    RESIDUAL   IR  JR  KR    P1       P3
 WF_L  1 -1.69573E-01  58   5   2 -3.54712E-01  58   5   2  5.200E-01  1.500E+00
 WF_R  1 -1.69601E-01  58   5   2 -3.54712E-01  58   5   2  5.200E-01  1.500E+00

  VT   1  9.25638E-02  10  10   2  5.64051E-02  10   3   2  6.500E-01  1.500E+00
  HTL  1  1.27269E-01  10   3   3  3.30056E-02  90   3   2  6.500E-01  1.500E+00
  HTR  1  1.08320E-01  10   3   3  2.87753E-02  90   3   2  6.500E-01  1.500E+00
  VT   2  1.17237E-01  10  10   2  3.60961E-02  10   3   2  9.750E-01  1.163E+00
  HTL  2  1.32353E-01  90  10   2  3.43624E-02  90   3   2  9.750E-01  1.163E+00
  HTR  2  9.82094E-02  90  12   2  2.82813E-02  90   3   2  9.750E-01  1.163E+00


  N1L  1 -7.81975E-02  46   3   2 -1.79964E-02  28   8   3  6.000E-01  1.700E+00
  N2L  1 -6.05773E-02  47   3   2  1.84246E-02  48   8   4  6.000E-01  1.700E+00
  N1L  2 -4.39227E-02  28   8   3 -2.02801E-02  45   3   9  6.000E-01  5.248E-01
  N2L  2 -3.31001E-02  29   8   3 -2.29924E-02  45   3   9  6.000E-01  5.248E-01
  N1L  3 -5.06130E-02  28   8   3 -1.53478E-02  45   3   9  6.000E-01  1.620E-01
  N2L  3 -3.99337E-02  29   8   3 -1.72907E-02  45   3   9  6.000E-01  1.620E-01
  N1L  4 -5.31154E-02  28   3   3 -1.34191E-02  45   3   9  6.000E-01  5.000E-02
  N2L  4 -4.41500E-02  29   3   3 -1.58009E-02  45   3   9  6.000E-01  5.000E-02
  N1R  1 -1.03281E-01  46   3   2 -1.79965E-02  28   8   9  6.000E-01  1.700E+00
  N2R  1 -7.44427E-02  47   3   2  1.76024E-02  48   8   8  6.000E-01  1.700E+00
  N1R  2 -4.49715E-02  28   8   9 -2.38847E-02  45   3   9  6.000E-01  5.248E-01
  N2R  2 -3.40056E-02  29   8   9 -2.81949E-02  45   3   9  6.000E-01  5.248E-01
  N1R  3 -5.31882E-02  28   8   9 -1.72841E-02  48   3   3  6.000E-01  1.620E-01
  N2R  3 -4.19354E-02  29   8   9 -1.91044E-02  45   3   9  6.000E-01  1.620E-01
  N1R  4 -5.65398E-02  28   3   8 -1.49965E-02  48   3   3  6.000E-01  5.000E-02
  N2R  4 -4.69986E-02  29   3   8 -1.70964E-02  45   3   9  6.000E-01  5.000E-02

 WF_L  2  1.72337E-01 108  11   2 -2.42398E-01 106  11   3  8.320E-01  1.163E+00
 WF_R  2  1.64884E-01 108   2   2 -2.35016E-01 108   2   2  8.320E-01  1.163E+00

  VT   1  1.18846E-01  10   9   2  4.14243E-02  10   3   2  1.137E+00  9.025E-01
  HTL  1  1.23858E-01  90   9   2  2.56522E-02  90   3   2  1.137E+00  9.025E-01
  HTR  1  8.35529E-02  90  12   2  1.79213E-02  90   3   2  1.137E+00  9.025E-01
  VT   2  1.09942E-01  11   4   2  3.85666E-02  11   3   2  1.219E+00  7.000E-01
  HTL  2  1.07571E-01  89   8   2  2.48748E-02  89   3   2  1.219E+00  7.000E-01
  HTR  2  6.66029E-02  83  13   2  1.34933E-02  89   3   2  1.219E+00  7.000E-01


  N1L  1 -5.26322E-02  65   3   2 -1.22265E-02  45   3   9  9.000E-01  1.700E+00
  N2L  1 -2.12401E-02  28   8   3 -1.50768E-02  45   3   9  9.000E-01  1.700E+00
  N1L  2 -2.97773E-02  28   8   3 -1.15244E-02  45   3   9  9.000E-01  5.248E-01
  N2L  2 -2.53138E-02  28   8   3 -1.01984E-02  45   3   9  9.000E-01  5.248E-01
  N1L  3 -4.37487E-02  28   3   3 -9.54355E-03  28   3   7  9.000E-01  1.620E-01
  N2L  3 -3.56288E-02  28   3   3 -8.14548E-03  45   3   9  9.000E-01  1.620E-01
  N1L  4 -4.82559E-02  28   3   3 -8.21329E-03  45   3   9  9.000E-01  5.000E-02
  N2L  4 -3.94821E-02  28   3   3 -9.96134E-03  65   3   8  9.000E-01  5.000E-02
  N1R  1 -5.80743E-02  65   3   2 -1.35392E-02  48   3   3  9.000E-01  1.700E+00
  N2R  1 -2.33040E-02  65   3   9 -1.62268E-02  45   3   9  9.000E-01  1.700E+00
  N1R  2 -3.17809E-02  28   8   9 -1.27774E-02  45   3   9  9.000E-01  5.248E-01
  N2R  2 -2.66251E-02  28   8   9 -1.07139E-02  45   3   9  9.000E-01  5.248E-01
  N1R  3 -4.72453E-02  28   3   9 -1.01267E-02  28   3   5  9.000E-01  1.620E-01
  N2R  3 -3.81165E-02  28   3   9 -8.19533E-03  28   3   5  9.000E-01  1.620E-01
  N1R  4 -5.26526E-02  28   3   8 -8.88614E-03  45   3   4  9.000E-01  5.000E-02
  N2R  4 -4.27896E-02  28   3   8 -1.13624E-02  65   3   8  9.000E-01  5.000E-02

 WF_L  3  1.95143E-01 108   6   2 -2.43072E-01 108   6   2  1.019E+00  9.025E-01
 WF_R  3  1.96757E-01 108   4   2 -2.55706E-01 108   2   2  1.019E+00  9.025E-01

   ..................
```

Here: the lines that have the symbols "WF_L" ("WF_R") at the beginning correspond to iterations on the wing/body computational mesh for left (right) half-space.

The lines that start from the symbols "VT" correspond to the iterations on the vertical tail computational mesh.

The lines that start from the symbols "HTL" ("HTR") correspond to the iterations on the horizontal tail computational mesh for left (right) half-space.

The lines that start from the symbols "N1L" ("N1R") correspond to the iterations on the inboard nacelle computational mesh for left (right) half-space.

The lines that start from the symbols "N2L" ("N2R") correspond to the iterations on the outboard nacelle computational mesh for left (right) half-space.

N - the iteration number;

CORRECTION - the maximum value of the correction to the potential on the iteration;

IC,JC,KC - indexes of the mesh node the max. correction is achieved at;

RESIDUAL - the maximum value of the residual;

IR,JR,KR - indexes of the mesh node the max. residual is achieved;

P1 - the current value of the relaxation parameter;

P3 - the current value of the acceleration parameter;

Printing in the process of the boundary layer computation

Printing in the process of the boundary layer computation

The boundary layer computation is carried by the marching (predictor-corrector) method along x chordwise coordinate.

The boundary layer is calculated separately for upper an lower surfaces.

The computation for each surface is started from the boundary layer calculation on the stagnation line along the leading edge.

NX - number of the computation plane z=const

XC - x/c – the location of the computation plane z=const on the wing

NP - a number of the computational nodes in the boundary layer thickness.

Z*10+1 – the calculation node number in the spanwise direction

CFC - the projection of the friction vector on the chordwise direction

RTHETA – Ue*THETA/Nue - the Reynolds number calculated by the thickness momentum

CCZ = (We)**2/(dUe/dx*NUe)

```
     NX= 1  XC= 0.001  NZ NP     Z     CFN       RTHETA      CCZ
*-- STAGNAT. LINE *--   1 21  0.000  0.161E-06  0.537E+01  0.396E+00
*-- STAGNAT. LINE *--   2 21  0.071  0.830E-03  0.233E+03  0.888E+07
*-- STAGNAT. LINE *--   3 21  0.143  0.799E-03  0.211E+03  0.819E+07
*-- STAGNAT. LINE *--   4 21  0.214  0.105E-02  0.163E+03  0.639E+07
*-- STAGNAT. LINE *--   5 21  0.286  0.888E-03  0.149E+03  0.533E+07
*-- STAGNAT. LINE *--   6 21  0.357  0.114E-02  0.132E+03  0.547E+07
*-- STAGNAT. LINE *--   7 21  0.429  0.101E-02  0.135E+03  0.578E+07
*-- STAGNAT. LINE *--   8 21  0.500  0.126E-02  0.125E+03  0.614E+07
*-- STAGNAT. LINE *--   9 21  0.571  0.111E-02  0.128E+03  0.634E+07
*-- STAGNAT. LINE *--  10 21  0.643  0.139E-02  0.115E+03  0.635E+07
*-- STAGNAT. LINE *--  11 21  0.714  0.122E-02  0.116E+03  0.635E+07
*-- STAGNAT. LINE *--  12 21  0.786  0.151E-02  0.106E+03  0.640E+07
*-- STAGNAT. LINE *--  13 21  0.857  0.132E-02  0.110E+03  0.656E+07
```

```
 *-- STAGNAT. LINE *--  14 21  0.929  0.162E-02  0.104E+03  0.696E+07
 *-- STAGNAT. LINE *--  15 21  1.000  0.134E-02  0.971E+02  0.573E+07
...
...
```

After completion of the boundary layer calculation in the current computation plane NX (x=const) for each z-location on the wall the values of Cfx*sqrt(Re) = Vw=dU/dY is printed (on 1-st and 2-nd grids – in each z-nodes, on 3-rd grid – only in odd z-nodes), 1-st line – predictor step,2-nd line – corrector step, for example:

```
NX= 5 XC= 0.025     1st - pred.  2nd - corr.
  4.458  5.349  6.033  7.091  8.441  9.449 10.387 10.740   - predictor step
  4.578  5.444  5.816  6.511  7.959  8.917  9.861 10.128   - corrector step

...
...
...
NX= 1 XC= 0.001     1st - pred.  2nd - corr.
  3.732  4.702  5.188  5.736  6.261  6.918  7.295  6.665
 NX= 3 XC= 0.008     1st - pred.  2nd - corr.
  3.531  4.084  6.317  8.706  8.953 10.017 10.820 11.238
  3.746  4.657  7.044  9.033  9.023 10.155 11.183 11.716
 NX= 4 XC= 0.015     1st - pred.  2nd - corr.
  3.964  5.049  6.752  8.917  9.844 11.016 11.941 12.338
  4.165  5.414  6.954  9.020 10.108 11.310 12.301 12.645
 NX= 5 XC= 0.025     1st - pred.  2nd - corr.
  4.458  5.349  6.033  7.091  8.441  9.449 10.387 10.740
  4.578  5.444  5.816  6.511  7.959  8.917  9.861 10.128
...
...
...
NX=14 XC= 0.218     1st - pred.  2nd - corr.
  7.833  8.914  9.682  9.920 10.971 12.371 13.224  9.401
  7.577  8.691  9.516  9.733 10.852 12.263 12.319  6.828
 NX=15 XC= 0.255     1st - pred.  2nd - corr.
  7.445  8.494  9.309  9.518 10.583 11.839 10.473  4.067

  WARNING! The friction is limited at XC=  0.2547176      NZ=          15

 NX=15 XC= 0.255  NP TR NV     Z     CFC       RTHETA    DVISC  DVINV   UEBL
 ---I.S.W---      38  2  0  1.000 -0.110E-04  0.785E+04  1.210  0.008  1.210
  7.223  8.200  8.987  9.201 10.162 11.141  8.932 -0.030
 NX=16 XC= 0.296     1st - pred.  2nd - corr.
  7.051  7.982  8.745  9.090 10.022 11.258  9.818  4.664
  6.794  7.664  8.384  8.879  9.736 10.984 10.330  8.512
...
```

If the value of the chordwise friction is decreased below of the prescribed (in input file) minimum level that boundary layer computation is carried out by inverse method with prescribed skin friction an the following message is printed:

```
  WARNING! The friction is limited at XC=  0.2547176      NZ=          15
```

If the value of the chordwise friction is decreased below of the specified level that the table of the following parameters is printed:

I.S.W   infinite swept wing (for the boundary layer calculation on the root and tip of a wing is used this algorithm)

G.C. – general case of the boundary layer computation.

NP   - a number of the computational nodes in the boundary layer thickness.

TR   - TR=1 - laminar b.l.   TR=2 - turbulent b.l.

NV   NV=0 - inverse mode   NV=0 - direct mode

Z*10+1 – the calculation node number in the spanwise direction

CFC - the projection of the friction vector on the chordwise direction

RTHETA – Ue*THETA/Nue - the Reynolds number calculated by the thickness momentum

DVISC - Uvi(n-1)-Uvi(n) – the difference of the velocities between of two successive viscous-inviscid iterations.

DVINV - Uv-Ui the difference of the velocities. (Uv – chordwise velocity from the inverse boundary layer calculation, Ui – chordwise velocity from the inviscid flow calculation)

UEBL - Uv – chordwise from the inverse boundary layer calculation.

```
…
…
…
NX=32 XC= 0.994     1st - pred.  2nd - corr.
 0.700  0.719  0.740  1.173  0.922  1.129  1.113  2.784
 NX=32 XC= 0.994  NP TR NV    Z     CFC       RTHETA    DVISC  DVINV   UEBL
 ---I.S.W---     45  2  0  0.000  0.126E-03  0.115E+06  0.871  0.075  0.871
 --- G.C.---     45  2  0  0.143  0.165E-03  0.924E+05  0.880  0.062  0.880
 --- G.C.---     45  2  0  0.214  0.161E-03  0.805E+05  0.891  0.068  0.891
 0.339  0.443  0.525  1.023  0.828  1.070  1.139  2.864
 NX=33 XC= 1.000     1st - pred.  2nd - corr.
 0.204  0.342  0.481  1.020  0.654  0.833  0.889  1.998
 NX=33 XC= 1.000  NP TR NV    Z     CFC       RTHETA    DVISC  DVINV   UEBL
 ---I.S.W---     45  2  0  0.000 -0.265E-04  0.122E+06  0.855  0.089  0.855
 --- G.C.---     45  2  0  0.071  0.343E-04  0.106E+06  0.852  0.069  0.852
 --- G.C.---     45  2  0  0.143  0.148E-04  0.960E+05  0.863  0.074  0.863
 --- G.C.---     45  2  0  0.214  0.316E-04  0.832E+05  0.876  0.079  0.876
 --- G.C.---     45  2  0  0.286  0.950E-04  0.779E+05  0.888  0.083  0.888
 --- G.C.---     45  2  0  0.571  0.478E-04  0.653E+05  0.874  0.036  0.874
 --- G.C.---     45  2  0  0.643  0.489E-04  0.668E+05  0.881  0.036  0.881
 --- G.C.---     45  2  0  0.714  0.651E-04  0.512E+05  0.854  0.000  0.854
 --- G.C.---     45  2  0  0.786  0.384E-04  0.584E+05  0.886  0.022  0.886
 --- G.C.---     45  2  0  0.857  0.790E-04  0.465E+05  0.869 -0.012  0.869
 --- G.C.---     45  2  0  0.929  0.118E-03  0.492E+05  0.896 -0.017  0.896
 ---I.S.W---     45  2  0  1.000  0.128E-03  0.321E+05  0.914 -0.064  0.914
 -0.071  0.040  0.255  0.856  0.128  0.175  0.212  0.344
```

Printing at the end of calculation.

At the end of calculation some integral results are printing. Also this information is copied to the text file **fn.pl0** (text output file of integral parameters):

```
        TEST ONERA_M5 + TAIL + NACELLE + WINGLETS
     MACH        ALPHA       BETA        RE       RE LENGTH
    0.8400      3.0000      2.0000    0.3000E+07   0.2800E+01

  REF AREA     REF SPAN    REF CHORD    REFXCG      REFYCG      REFZCG
 0.2743E+02   0.1000E+02   0.2743E+01   0.7227E+01   0.0000E+00   0.0000E+00


    WING  RESULTS

 LEFT PART OF WING

  N  SPAN    CL      CD       CM       CDFP    CDFU    CDFL    CPTE   XTRU   XTRL
  1 0.123  0.3064  0.04812  -0.09696  0.00897  0.00343  0.00337  0.221  0.020  0.020
  2 0.138  0.3100  0.03288  -0.09449  0.00841  0.00334  0.00337  0.236  0.020  0.020
  3 0.162  0.3150  0.02485  -0.09216  0.00903  0.00326  0.00336  0.239  0.020  0.020
  4 0.195  0.3210  0.01873  -0.09051  0.00958  0.00320  0.00336  0.240  0.020  0.020
……………………………………
```

```
.........................................
      27 0.985  0.4830   0.00792  -0.11222  0.01383  0.00302  0.00400  0.241  0.020  0.020
      28 1.005  0.4974   0.01005  -0.11949  0.01377  0.00311  0.00406  0.263  0.020  0.020
      29 1.016  0.5083  -0.00238  -0.10876  0.01430  0.00313  0.00406  0.253  0.020  0.020
      30 1.016  0.0125  -0.02698   0.04673  0.00000  0.00000  0.00000  0.253  0.000  0.000

       N  SPAN     CDWU     CDWL      CDWUC     CDWLC      LOAD
       1 0.123   0.00150   0.00000   0.00211   0.00000   0.42976
       2 0.138   0.00125   0.00000   0.00174   0.00000   0.42991
       3 0.162   0.00102   0.00000   0.00139   0.00000   0.42853
       4 0.195   0.00076   0.00000   0.00101   0.00000   0.42548
.........................................
.........................................
      27 0.985   0.01058   0.00000   0.00523   0.00000   0.23849
      28 1.005   0.01404   0.00000   0.00666   0.00000   0.23605
      29 1.016   0.02462   0.00000   0.01136   0.00000   0.23460
      30 1.016   0.00776   0.17360   0.00358   0.08012   0.00576
.........................................
.........................................

       LEFT PART OF WING
          CL       CDP      CZ         CMZ       CMX      CMY
      0.28978   0.00607   0.01012  -0.39238   0.54411   0.03591
         CDFP      CDFU      CDFL
      0.00873   0.00259   0.00283

       LOWER WINGLET (LEFT HALFWING)
          CL       CDP      CZ         CMZ       CMX      CMY
      0.00211   0.00026   0.01275  -0.00531   0.01237   0.03101
         CDFP      CDFI      CDFO
      0.00040   0.00011   0.00009

       UPPER WINGLET (LEFT HALFWING)
          CL       CDP      CZ         CMZ       CMX      CMY
      0.00092  -0.00009  -0.00422  -0.00219   0.00447  -0.00962
         CDFP      CDFI      CDFO
      0.00030   0.00009   0.00010


       RIGHT PART OF WING

       N  SPAN    CL       CD        CM       CDFP     CDFU     CDFL    CPTE   XTRU   XTRL
       1 0.123  0.3040   0.04598  -0.09863  0.00904  0.00341  0.00336  0.227  0.020  0.020
       2 0.138  0.3076   0.03117  -0.09662  0.00920  0.00328  0.00333  0.240  0.020  0.020
       3 0.162  0.3120   0.02398  -0.09497  0.00993  0.00320  0.00333  0.239  0.020  0.020
       4 0.195  0.3176   0.01892  -0.09458  0.01013  0.00316  0.00335  0.243  0.020  0.020
.........................................
.........................................
.........................................

       RIGHT PART OF WING
          CL       CDP      CZ         CMZ       CMX      CMY
      0.31230   0.01056  -0.00929  -0.43728  -0.60167  -0.02601
         CDFP      CDFU      CDFL
      0.00928   0.00261   0.00287

       LOWER WINGLET (RIGHT HALFWING)
          CL       CDP      CZ         CMZ       CMX      CMY
      0.00010   0.00019  -0.00061  -0.00032  -0.00060  -0.00075
         CDFP      CDFI      CDFO
      0.00028   0.00011   0.00010

       UPPER WINGLET (RIGHT HALFWING)
          CL       CDP      CZ         CMZ       CMX      CMY
      0.00362  -0.00024   0.01825  -0.00902  -0.01915   0.04336
         CDFP      CDFI      CDFO
      0.00044   0.00008   0.00010



           WING TOTAL RESULTS (WINGLETS ARE INCLUDED)
          CL       CDP      CZ         CMZ       CMX      CMY
      0.30779   0.00844   0.02660  -0.43166  -0.03169   0.06896
```

```
    BODY RESULTS
   CL      CDP      CZ        CMZ       CMX      CMY
0.04871  0.00194  0.00457  -0.00292  0.00000  -0.01527


    WING+BODY RESULTS
   CL      CDP      CZ        CMZ       CMX      CMY
0.35650  0.01038  0.03117  -0.43458  -0.03168   0.05369
  CDIND   CDWAVE    CDFP     CDF
0.00000  0.00344  0.01042  0.00622
```

Here:

RE_LENGTH - the prescribed reference length for Reynolds number;

REF_AREA - the prescribed (or calculated) **one half** of the total wing's Reference area (REF_AREA=SW, see **item 2** of **Section 2.1**);

REF_SPAN - the prescribed (or calculated) wing's half span;

REF_CHORD - the prescribed (or calculated) reference chord;

REF_XCG, REF_YCG, REF_ZCG - x, y and z coordinates of the point relative of which the total moments are calculated;

WING RESULTS.

For each half-wing the following section information is printed (the wing section parameters are normalized by local chord):

SPAN - the spanwise location of the section;

CL - the section lift coefficient;

CD - the section pressure drag coefficient (integral of the pressure distribution);

CM - the section pitching moment coefficient, it is calculated relative to the section reference coordinate REFXOC (see **item 8** of the **Section 2.1**);

CDFP - the section profile drag coefficient (calculated with the help of Square-Young's formula applied to far field viscous wake);

CDFU - the friction drag coefficient for the section's upper surface;

CDFL - the friction drag coefficient for the section's lower surface;

CPTE - the pressure coefficient at the section's trailing edge;

XTRU - the transition line's position for the upper surface;

XTRL - the transition line's position for the lower surface;

CDWU – an estimation of the section wave drag for upper surface, it is normalised by local wing's chord;

CDWL – an estimation of the section wave drag for lower surface, it is normalised by local wing's chord;

CDWUC, CDWLC – an estimation of the section wave drag for upper and lower surface, contrary to CDWU and CDWL these values are normalised by the prescribed reference chord REFCHD (see **item 8** of the **Section 2.1**);

Then integral parameters for the half-wing (**without winglets**) are printed:

CL - the half-wing lift coefficient. Integral of the pressure distribution over the half-wing surface normalised by the half of the total reference area (SW);

CDP - the half-wing pressure drag coefficient. Integral of the pressure distribution over the half-wing surface normalised by the half of the reference area (SW);

CZ - the coefficient of the side force for the half-wing. It is a side force integral over half-wing normalised by the half of the reference area (SW).

The following half-wing moment coefficients are calculated relative to the prescribed point REF_XCG, REF_YCG (see **Section 2.1**, **item 8**):

CMZ - the half-wing pitching coefficient. It is calculated as an pitching moment integral over half-wing. Then the integral is normalised by half of reference area (SW) and by reference chord (REFCHD);

CMX - the half-wing roll coefficient. It is calculated as an roll moment integral over half wing. Then the integral is normalised by half of reference area (SW) and by reference chord (REFCHD);

CMY - Y-moment coefficient. It is calculated as an Y-moment integral over half wing. Then the integral is normalised by half of reference area (SW) and by reference chord (REFCHD);

CDFP - the half-wing profile drag coefficient normalised by half of reference area (SW);

CDFU - the friction drag coefficient for the half-wing upper surface normalised by half of reference area (SW);

CDFL - the friction drag coefficient for the half-wing lower surface normalised by half of reference area (SW);

Then integral parameters for the lower and upper winglets of the current half-wing are printed (note, contrary to the half-wing results the winglet's integral results are normalised by the total reference area 2*SW):

CL - the winglet's lift coefficient. Integral of the pressure distribution over the winglet's surface normalised by the total reference area (2*SW);

CDP - the winglet's pressure drag coefficient. Integral of the pressure distribution over the winglet's surface normalised by the total referance area (2*SW);

CZ - the coefficient of the side force for the winglet. It is a side force integral over winglet normalised by the total reference area (2*SW).

The following winglet's moment coefficients are calculated relative to the prescribed point REF_XCG, REF_YCG (see **Section 2.1**, **item 8**):

CMZ - the winglet's pitching coefficient. It is calculated as a pitching moment integral over winglet. Then the integral is normalised by total reference area (2*SW) and by reference chord (REFCHD);

CMX - the winglet's roll coefficient. It is calculated as an roll moment integral over winglet. Then the integral is normalised by the total reference area (2*SW) and by reference chord (REFCHD);

CMY - Y-moment coefficient. It is calculated as an Y-moment integral over winglet. Then the integral is normalised by the total reference area (2*SW) and by reference chord (REFCHD);

CDFP - the winglet's profile drag coefficient normalised by total reference area (2*SW);

CDFI - the friction drag coefficient for the winglet’s inboard surface normalised by the total reference area (2*SW);

CDFO - the friction drag coefficient for the winglet’s outboard surface normalised by total reference area (2*SW);

WING TOTAL RESULTS

The integral parameters for the total wing + winglets follow. The parameters are obtained by pressure integration over wing and winglets surfaces. The coefficients are normalised by total reference area (2*SW) and by reference chord (REFCHD).

BODY RESULTS.

The integral parameters for the body follow. The parameters are obtained by pressure integration over body surface. The normalisation is similar to that for total wing integral results.

WING+BODY RESULTS.

The integral parameters for wing+body+winglets configuration follow (CL, CDP, CZ, CMZ, CMX, CMY). The parameters are normalised by the total reference area (2*SW) and by reference chord (REFCHD).

Then the following information is printed:

CDWAVE - the wave drag coefficient for the wing+body+winglets estimated by integrating an equivalent entropy increment along the shock wave fronts at the wing/body/winglets computational meshes;

CDFP - the total wing+winglets profile drag coefficient;

CDF - the total wing+winglets friction drag coefficient;

HORISONTAL TAIL RESULTS

Then the results for horizontal tail are printed. The notations are similar to that for wing results.
Integral parameters for left and right part of the horizontal tail are normalised by half of reference area (SW).
Integral parameters for the total horizontal tail are normalised by total reference area (2*SW).

HORISONTAL TAIL RESULTS

LEFT PART OF HORISONTAL TAIL

N	SPAN	CL	CD	CM	CDFP	CDFU	CDFL	CPTE	XTRU	XTRL
1	0.179	0.2838	0.06073	-0.13395	0.01172	0.00422	0.00405	0.181	0.020	0.020
2	0.194	0.2870	0.04828	-0.13222	0.01096	0.00418	0.00406	0.199	0.020	0.020
3	0.217	0.2907	0.04167	-0.12960	0.01127	0.00412	0.00405	0.204	0.020	0.020
4	0.247	0.2943	0.03675	-0.12600	0.01187	0.00407	0.00404	0.207	0.020	0.020
………………………………										
………………………………										
20	0.985	0.1578	-0.00974	-0.01402	0.01546	0.00383	0.00490	0.220	0.020	0.020
21	1.000	0.1077	-0.01711	-0.03369	0.01162	0.00417	0.00483	0.187	0.020	0.020

```
 N  SPAN    CDWU     CDWL     CDWUC    CDWLC     LOAD
 1 0.179   0.00277  0.00000  0.00176  0.00000  0.18098
 2 0.194   0.00300  0.00000  0.00188  0.00000  0.18088
 3 0.217   0.00321  0.00000  0.00198  0.00000  0.17991
 4 0.247   0.00280  0.00000  0.00168  0.00000  0.17785
……………………………………
……………………………………
20 0.985   0.00210  0.00000  0.00050  0.00000  0.03758
21 1.000   0.00092  0.00000  0.00021  0.00000  0.02485

   CL      CDP      CZ       CMZ      CMX      CMY
0.05178  0.00322  0.00127  -0.24499  0.04998  0.00670
  CDFP     CDFU     CDFL
0.00230  0.00070  0.00075


RIGHT PART OF HORISONTAL TAIL

 N  SPAN   CL      CD       CM       CDFP     CDFU     CDFL    CPTE  XTRU  XTRL
 1 0.179  0.1582  0.04538  -0.05860  0.01046  0.00408  0.00407  0.215  0.020  0.020
 2 0.194  0.1601  0.03308  -0.05757  0.01025  0.00402  0.00404  0.227  0.020  0.020
……………………………………
……………………………………
……………………………………

     HORISONTAL TAIL TOTAL RESULTS
   CL      CDP      CZ       CMZ      CMX      CMY
0.04251  0.00266  0.00004  -0.20099  0.00819  0.00030
  CDIND   CDWAVE    CDFP     CDF
0.00000  0.00021  0.00222  0.00146
```

VERTICAL TAIL RESULTS

Then the results for vertical tail are printed. The notations are similar to that for wing results.
Integral parameters for the vertical tail are normalised by total reference area (2*SW).

```
 VERTICAL TAIL RESULTS

 N  SPAN   CZ      CD       CM       CDFP     CDFU     CDFL    CPTE  XTRU  XTRL
 1 0.179  0.2472  0.05735  -0.10078  0.01231  0.00415  0.00422  0.167  0.020  0.020
 2 0.199  0.2512  0.04309  -0.09919  0.01174  0.00415  0.00417  0.187  0.020  0.020
 3 0.225  0.2556  0.03591  -0.09776  0.01203  0.00414  0.00409  0.193  0.020  0.020
 4 0.257  0.2605  0.03045  -0.09639  0.01264  0.00413  0.00404  0.195  0.020  0.020
……………………………………
……………………………………
20 0.980  0.1813  -0.01432  -0.01197  0.01513  0.00485  0.00376  0.229  0.020  0.020
21 1.000  0.1276  -0.02394  -0.02103  0.01210  0.00477  0.00394  0.229  0.020  0.020

 N  SPAN    CDWU     CDWL     CDWUC    CDWLC     LOAD
 1 0.179   0.00000  0.00312  0.00000  0.00198  -0.15763
 2 0.199   0.00000  0.00349  0.00000  0.00218  -0.15766
 3 0.225   0.00000  0.00364  0.00000  0.00223  -0.15713
 4 0.257   0.00000  0.00290  0.00000  0.00173  -0.15605
……………………………………
……………………………………
20 0.980   0.00000  0.00316  0.00000  0.00076  -0.04361
21 1.000   0.00000  0.00210  0.00000  0.00048  -0.02945

   CL      CDP      CZ       CMZ      CMX      CMY
0.00074  0.00026  0.02411  -0.00395  -0.02374  0.11377
  CDIND   CDWAVE    CDFP     CDFU     CDFL
0.00000  0.00021  0.00120  0.00038  0.00035
```

Note that for vertical tail:
 CDFU - friction drag of right surface;
 CDFL – friction drag of left surface.

NACELLE RESULTS

Then the results for nacelle are printed. The notations are similar to that for wing results:

```
   INBOARD NACELLE RESULTS

   LEFT NACELLE
    CL      CDP      CZ        CMZ       CMX      CMY
0.00031   0.00242   0.00183   0.00019   0.00131  -0.00508
 CDWAVE   CDSORCE    INFLOW    OUTFLOW
0.00017   0.00045   0.64837   0.63705

   RIGHT NACELLE
    CL      CDP      CZ        CMZ       CMX      CMY
0.00002   0.00245   0.00122   0.00009   0.00023   0.00473
 CDWAVE   CDSORCE    INFLOW    OUTFLOW
0.00015   0.00041   0.64837   0.63823


   OUTBOARD NACELLE RESULTS

   LEFT NACELLE
    CL      CDP      CZ        CMZ       CMX      CMY
0.00208   0.00395   0.00197  -0.00249   0.00649  -0.00985
 CDWAVE   CDSORCE    INFLOW    OUTFLOW
0.00015   0.00286   0.69877   0.62748

   RIGHT NACELLE
    CL      CDP      CZ        CMZ       CMX      CMY
0.00183   0.00397   0.00180  -0.00243  -0.00461   0.01221
 CDWAVE   CDSORCE    INFLOW    OUTFLOW
0.00011   0.00278   0.69877   0.62955
```

Here CL, CDP, CZ, CMZ, CMX, CMY – forces and moments which correspond to one nacelle. These and other nacelle values are normalised by total reference area (2.*SW) and by reference chord (REFCHD).

CDWAVE - the wave drag coefficient for the nacelle estimated by integrating an equivalent entropy increment along the shock wave fronts at the nacelle computational mesh;

CDSORCE - the drag coefficient caused by the difference of the nacelle inlet and outlet mass flows;

INFLOW - the mass flow coefficient calculated at the nacelle inlet surface;

OUTFLOW - the mass flow coefficient calculated at the nacelle outlet surface;

TOTAL RESULTS.

At the end of the file the integral parameters for total wing+winglets+body+nacelles+tails configuration are printed. The main notations are similar to that used for the elements of configuration. Here output parameters are normalised by total reference area (2*SW) and by reference chord (REFCHD).

```
   TOTAL RESULTS :
    CL      CDP      CZ        CMZ       CMX      CMY
```

```
0.41741   0.02570   0.06425  -0.70543  -0.04382   0.17900
  CDIND    CDWAVE    CDSORCE     CDFP      CDF
0.00692   0.00443   0.00651   0.01384   0.00841
```

CDIND - the induced drag coefficient for total configuration;

CDWAVE - the wave drag coefficient for the total configuration;

CDSORCE - the total drag coefficient caused by the difference of the nacelle inlet and outlet mass flows;

CDFP - the total profile drag coefficient (profile drag of the wing + profile drag of the tail+ winglet's profile drag);

CDF - the total friction drag coefficient (friction on the wing+tail+winglets surfaces).

Appendix A:

THE CALCULATION TAKING INTO ACCOUNT THE ELASTIC DEFORMATION

It is possible to produce a calculation taking into account the elastic deformation of the main wing and/or tail and/or body torsion elastic deformation.

The simple beam theory is used. Wing deformations correspond to curving and torsion of an elastic beam conterminous to wing's axes of rigidity. Torsion deformation of the body rigidity axes leads to a changing of tail orientation.

If elastic effects are taking into account the additional input data file **beam.dat** is used. The file prescribes configuration of the wing, tail's and body's axes of rigidity, the torsion and flexural stiffness. Also the file can contains the information about elastic deformation, which already are taken into account in the input wing and horizontal tail geometries.

During the flow computational, the code periodically calculates the moments acting on the wing and tail's sections and redefines the elastic deformations (wing and tail curving and twist). Also torsion deformations of the body are recalculated, and the addition changing of the tail geometry is redefined.

Influence of the elastic deformations on external flow is simulated by modification of the boundary condition (transpiration) on the surfaces of the initial (undeformed) wing and tail. Thus, this influence is simulated just approximately.

At the end of calculation the code creates the output ASCII file **beam.out** and graphic postscript files which contain an information about changing of the wing's, tail's and body twist and curving (files **210.ps, 210_L.ps, 210_R.ps, 280.ps, 280_L.ps, 280_R.ps, 280_V.ps, 280_B.ps**)

Also at the end of computation the code produces the additional output files **wgeom.out** and/or **hgeom.out**. These files contain the full geometry of deformed wing (**wgeom.out**) and geometry of deformed horizontal tail (**hgeom.out**). The structures of these files correspond to a format used for the main input data file of BLWF58. Thus, if it is necessary, the user can easily generate new main initial data file for BLWF58, containing new deformed wing and horizontal tail geometry. Also, if user will add into **beam.dat** information about deformations already taken into account in new main initial data file, then it will be possible to make a new calculation of configuration with elastic effect. Basically such recalculation is not necessary. But the recalculation can diminish errors, which are due to using the "transpiration" scheme for simulation influence of the surface deformation to the external flow.

A.1 Additional initial data file for calculation in view of elastic strains.

Example of an additional data file **beam.dat** for calculations taking into account the elastic strains of a wing, tail and body is presented bellow.

For wing and tail the file prescribes configuration of the axes of rigidity and stiffness parameters. Also the file can contains the information about elastic deformation, which already are taken into account in the input wing and horizontal tail geometry. (Note the input airplane geometry must be symmetrical, so it is impossible to prescribe directly deformed vertical tail geometry, and tail deformations due to body torsion in the main input data file for BLWF58).

All numerical data are introduced based on the F10.5 format (and should include ".").

```
1.        DATA FOR ONERA TEST
2.      [   Q8   ][   P1   ][  NIT2  ]
           8000.      .7        5.
3.      --------------------------------------------------------------
                         WING DATA
4.      [   IW   ][ LR_OUT ]
            1.       .5
5.       RIGIDITY AXSIS LOCATION.  RIGIDITY AND STIFFNESS PARAMETERS
6.      [  NEA   ][ INDEA  ]
            2.       1.
7.      [   ZEA  ][   XEA  ][   EI   ][   GJ   ]
           0.1       .25    8000000.  8000000.
           1.0       .25    8000000.  8000000.
8.      DEFORMATIONS ALREADY TAKEN INTO ACCOUNT IN THE INPUT GEOMETRY DATA FILE
9.      [   ID   ]
           -1.
10.     [   ND   ][  INDD  ]
            7.        1.
11.     [    Z   ][   DY   ][   DE   ]
          0.000000  0.000000  0.000000
          0.124640  0.000000  0.000000
          0.255696  0.024160 -0.800205
          0.470466  0.138316 -1.519193
          0.711762  0.320605 -1.788177
          0.901760  0.476871 -1.817864
          1.000000  0.558412 -1.816766
12.     ----------------------------------------------------------
                   HORISONTAL TAIL DATA
        [   IH   ]
            1.
        RIGIDITY AXSIS LOCATION.  RIGIDITY AND STIFFNESS PARAMETERS
        [  NEA   ][ INDEA  ][ LR_OUT ]
            2.        1.       .5
        [   ZEA  ][   XEA  ][   EI   ][   GJ   ]
           0.1       .25     800000.   800000.
           1.0       .25     800000.   800000.
        DEFORMATIONS ALREADY TAKEN INTO ACCOUNT IN THE INPUT GEOMETRY DATA FILE
        [   ID   ]
           -1.
        [   ND   ][  INDD  ]
            7.        1.
        [    Z   ][   DY   ][   DE   ]
          0.000000  0.000000  0.000000
          0.179424  0.000000  0.000000
          0.282526  0.002635 -0.231794
          0.476161  0.018251 -0.497440
          0.703262  0.046041 -0.616754
          0.896898  0.072517 -0.635060
          1.000000  0.086809 -0.635045
13.     ----------------------------------------------------------
                   VERTICAL TAIL DATA
        [   IV   ]
            1.
```

```
         RIGIDITY AXSIS LOCATION.  RIGIDITY AND STIFFNESS PARAMETERS
         [  NEA   ][ INDEA  ]
            2.        1.
         [   YEA  ][   XEA  ][   EI   ][   GJ   ]
           0.1       .25     800000.   800000.
           1.0       .25     800000.   800000.
14.      -------------------------------------------------------
                         BODY DATA
15.      [   IB   ]
            1.
16.      RIGIDITY AXSIS LOCATION.  RIGIDITY AND STIFFNESS PARAMETERS
17.      [  NEA   ][ INDEA  ]
            2.        1.
18.      [   XEA  ][   YEA  ][   GJ   ]
           0.1       .1     1600000.
           1.0       .9     1600000.
19.          FORCE POINTS FOR WING, HORISONTAL AND VERTICAL TAIL
20.      [  INDFP ]
            0.
21.      [  XFP_W ][  XFP_H ][  XFP_V ]
           7.2273    18.2      18.2
```

Here:

1. <u>ONE free line</u>

2. <u>Q8, P1, NIT2</u>

Q8 - value of freestream flax.

P1 - the relaxation parameter for updating deformations

usually: P1=.7

NIT2 - after each NIT2 the wing/body flowfield iterations the recalculation of elastic deformation be done.

usually: NIT2=5.

3. <u>TWO free lines</u>

4. <u>IW, LR_OUT</u>

IW - parameter indicates does the data for the wing are specified in the current file. And if this data are present, then this parameter indicates whether the calculation will be carried out in view of strains of a wing.

IW = 0.. – there are not data for wing in the file;

IW = 1. – the wing data are specified in the file and the calculation will be carried out in view of strains of a wing;

IW =-1. – the wing data are specified in the file but the calculation will be carried without taking into account the strains of a wing;

If IW ≠ 0., then the lines 5-11 follow

LR_OUT - parameter controls the creating of output file **wgeom.out**.

At the end of computation the code produces the additional output files **wgeom.out** and/or **hgeom.out**. These files contain geometry of deformed wing (**wgeom.out**) and geometry of deformed horizontal tail (**hgeom.out**) in format used for the main input data file of BLWF58. Thus, if it is necessary, the user can easily generate new main initial data file for BLWF58, containing new deformed wing and horizontal tail geometry, and if necessary to make a new recalculation of configuration with elastic effect. Such recalculation can diminish errors, which are due to using the “transpiration” scheme for simulation influence of the surface deformation to the external flow.

Note that the input geometry of the configuration must be symmetrical. At the same time, in case when side flow is present the deformations of the left and right half-wings are different. Parameter LR_OUT indicates what deformations must be taken in to account in **wgeom.out** file:

LR_OUT= 0.. – the **wgeom.out** file will correspond to left half-wing deformation;

LR_OUT= 1... – the **wgeom.out** file will correspond to right half-wing deformation;

0.<LR_OUT<1. – an intermediate deformation will be incorporated into **wgeom.out** file.

Note that similar parameter LR_OUT must be prescribed for creating the file hgeom.out, which contains the deformed geometry of the horizontal tail.

5. <u>ONE free line</u>

6. <u>NEA, INDEA</u>

NEA - number of points located spanwise, which prescribe the configuration of the axis of stiffness and stiffness parameters (NEA<31.)

INDEA – control parameter indicates how the geometry of stiffness axis is prescribed:

INDEA = 0. – the real spanwise and chordwise coordinates are used;

INDEA = 1. – the referenced coordinates are used. The spanwise coordinates are prescribed in fraction of the total wing halfspan, and chordwise coordinates - in fraction of the local wing chord.

7. <u>ZEA, XEA, EI, GJ</u>

ZEA – spanwise coordinate of the stiffness axis;

XEA – chordwise coordinate of the stiffness axis;

EI - flexural stiffness of the wing stiffness axis;

GJ - torsion stiffness of the wing stiffness axis;

Note, parameters EI and GJ should be in agreement with the linear dimensions used for prescribing the geometry of configuration.

8. <u>ONE free line</u>

9. <u>ID - control parameter</u>

ID - parameter indicates does the current file contain information about elastic deformations already taken into account in the input wing geometry. And if this information is present, then this parameter indicates whether this information should be taken into account at realization of calculations.

ID = 0. – there is not information;

IW = 1. – current file contains the information about wing elastic deformations already taken into account in the wing input geometry, and this information should be used at realisation of calculation;

IW =-1. – – current file contains the information about wing elastic deformations already taken into account in the wing input geometry, but this information should be skipped at realisation of calculations;

If ID $\neq$ 0., then the lines 10-11 follow

10. ND, INDD

ND - number of points located spanwise, which prescribe the wing elastic deformations already taken into account in the wing input geometry (ND<31.)

INDD – control parameter indicates how the spanwise coordinates are prescribed:

INDD = 0. – the real spanwise coordinates are used;

INDD = 1. – the spanwise coordinates are prescribed in fraction of the total wing halfspan

11. Z, DY, DE - parameters describing elastic strains which have been already taken into account in input wing geometry:

Z – spanwise coordinate;

DY – the curving of the wing rigidity axis (in real coordinates);

DE – the elastic changes of wing section twist (in degrees).

12. ..... *Then the similar information for horisontal tail follows*

13. ..... *Then the similar information for vertical tail follows. Information about deformation already taken into account in the main input data file is absent for vertical tail. It is because the main input configuration must be symmetrical and it is impossible to include deformed vertical tail into main input data file.*

14. TWO free line

15. IB - control parameter for the body data

IB - parameter indicates does the data for the body are specified in the current file. And if this data are present, then this parameter indicates whether the calculation will be carried out in view of body twist.

IB = 0.. – there are not data for body in the file;

IB = 1. – the body data are specified in the file and the calculation will be carried out in view of body torsion deformation;

IB =-1. – the body data are specified in the file but the calculation will be carried without taking into account the body twist;

If IB $\neq$ 0., then the lines 16-21 follow

16. ONE free line

17. NEA, INDEA

NEA - number of points located along the body, which prescribe the configuration of the axes of body rigidity and stiffness parameters (NEA<31.)

INDEA – control parameter indicates how the geometry of body rigidity axis is prescribed:

INDEA = 0. – the real coordinates are used;

INDEA = 1. – the referenced coordinates are used. The X coordinates are prescribed in fraction of the total body length, and vertical coordinates - in fraction of the body local vertical diameter.

18. XEA, YEA, GJ

XEA – X coordinate of the body rigidity axis;

YEA – vertical coordinate of the body rigidity axis;

GJ - torsion stiffness of the body rigidity axis;

Note, parameter GJ should be in agreement with the linear dimensions used for prescribing the geometry of configuration.

19. ONE free line

20. INDFP

INDFP – control parameter indicates how the locations of "force points" are prescribed. Here the "force points" are the points at which the wing's and tail's loads act to the body.

INDFP = 0. – the real X coordinates are used;

INDFP = 1. – the referenced coordinates are used. The X coordinates are prescribed in fraction of the total body length.

21. XFP_W, XFP_H, XFP_V

XFP_W – X coordinate of the wing "force point". The body torsion deformations start at this point

XFP_H – X coordinate of the "force point" for the horizontal tail, at this point the horizontal tail forces acts to a body (in case of usual horizontal tail) or acts to a vertical tail (in case of T-type tail).

XFP_V – X coordinate of the "force point" for the vertical tail.

A.2 Output files of calculation in view of elastic strains.

Postscript graphic output files.

The code creates a set of postscript graphic files of elastic deformation results. Examples of some of these output files are presented bellow.

210.ps -corresponds to main wing deformation (no side flow case).

210_L.ps – left half-wing deformation (side flow case).

210_R.ps – right half-wing deformation (side flow case).

280.ps - horizontal tail deformation (no side flow case).

280_L.ps – deformation of the left part of horizontal tail (side flow case).

280_R.ps – deformation of the right part of horizontal tail (side flow case).

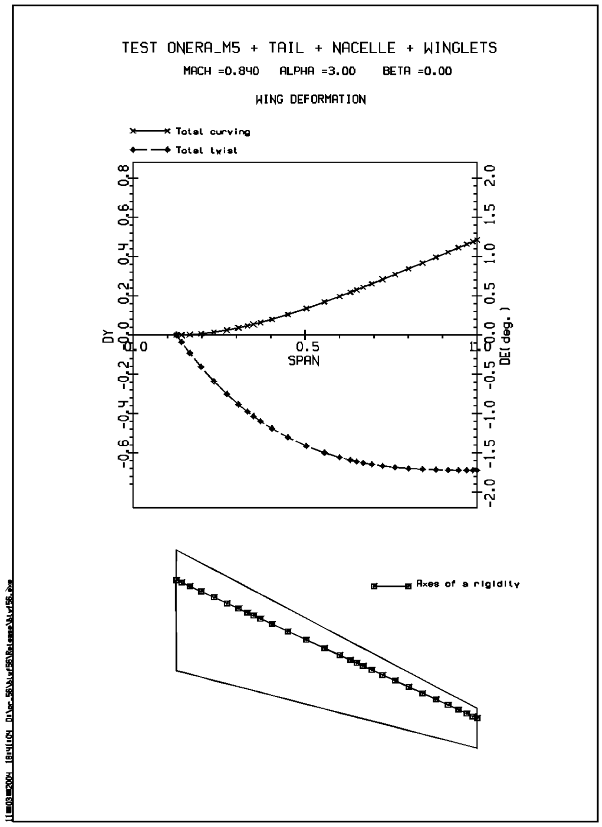
280_V.ps – vertical tail deformation (side flow case).

These files have the identical structure. For example (see figures) files **210.ps** and **280.ps** represent the following information

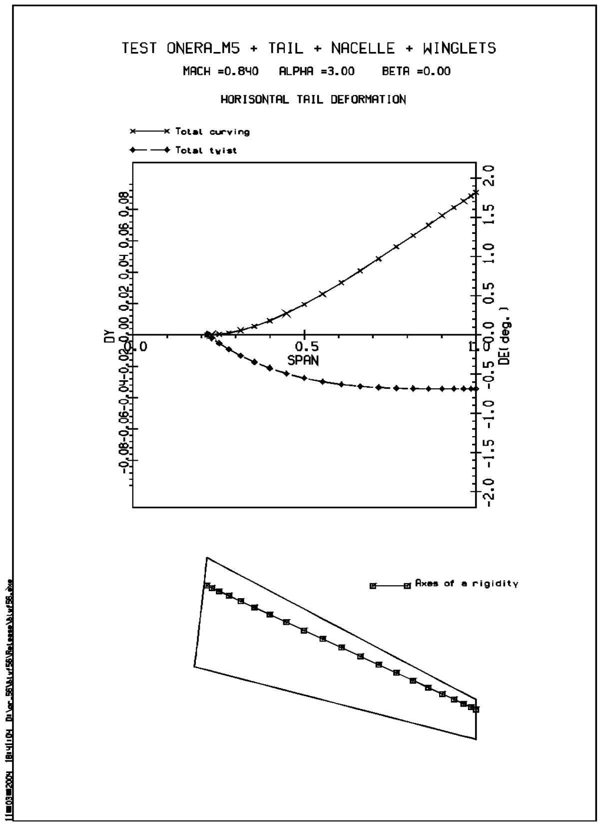
- - the spanwise distribution DY(z) of the total elastic curving of wing's rigidity axis (in real coordinates);
- - the spanwise distribution DE(z) of total changing of wing's sections twist (in degrees);
- also the prescribed configuration of rigidity axis is plotted.

File **280_B.ps** presents the body deformation parameters (see figures):

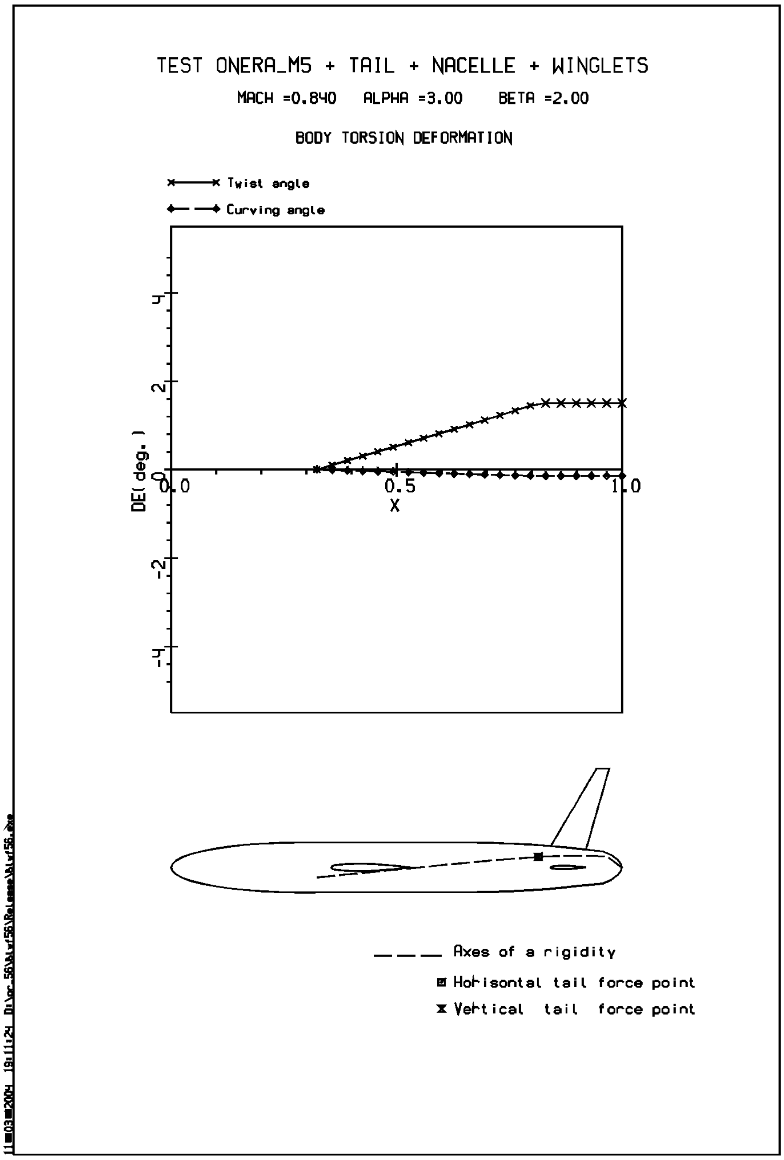
- - the distribution of the body twist angle;
- - the distribution of the body curving angle (due to torsion deformations of body axis);
- also the prescribed configuration of body rigidity axis is plotted, and the locations of the "force points" is indicated.



File 210.ps



File 280.ps


TEST ONERA_M5 + TAIL + NACELLE + WINGLETS
MACH =0.840 ALPHA =3.00 BETA =2.00
BODY TORSION DEFORMATION
Twist angle
Curving angle
DE(deg.)
X
0.0
0.5
1.0
4
2
0
-2
-4
Axes of a rigidity
Horisontal tail force point
Vertical tail force point

File 280_B.ps

Output file **beam.out.**

Fragments of output file **beam.out** are presented bellow. File contains the resulting elastic deformation parameters.
Structures of the output dates for wing, horizontal and for vertical tail are similar to each other. The elastic curving of the rigidity axis (DY) is presented in real coordinates; the changing in twist of wing and tail sections (DE) is presented in degrees. (Here titles for parameters are in general similar to that used in input data file **beam.dat**.)

For wing and for horizontal tail two sets of output parameters are presented. The first set (named “TOTAL DEFORMATION”) is the total elastic deformations of the element. Second set (named “DEFORMATION OF INPUT GEOMETRY”) is the elastic deformations of the input geometry. These sets can be distinguished from each other in case when the used input geometry was generated in view of strains (and the information about strains already incorporated into input geometry was presented in the input file **beam.dat**):

“DEFORMATION OF INPUT GEOMETRY”	=	“TOTAL DEFORMATION”	-	“DEFORMATIONS ALREADY INCORPORATED INTO INPUT GEOMETRY”

As for vertical tail, the set “DEFORMATION OF INPUT GEOMETRY” is absent, because the input configuration must be symmetrical and so there is not possibility to use deformed vertical tail geometry in main input data file.

The output dates for body contain the distribution of section twist (DET) in degrees, and the distribution of the angle of the body axes curving (DEX) due to torsion twisting in case when the body axis is not a straight one (in degrees).
At the end of the file the angles of deflection for horizontal and vertical tail are presented. Also the “force points” X-coordinates (in fraction of body lengths) are presented for vertical and horizontal tail (XREF).

```
                TEST ONERA_M5 + TAIL


   WING

  LEFT PART, TOTAL DEFORMATION
[   ID   ]
  1.000000
[   ND   ][  INDD  ]
 12.000000  1.000000
[  SPAN  ][   DY   ][   DE   ]
  0.000000  0.000000  0.000000
  0.125997  0.000000  0.000000
  0.207427  0.008731 -0.480354
 ................
  0.961462  0.475085 -1.601975
  1.000000  0.503901 -1.601514

  LEFT PART, DEFORMATION OF THE INPUT GEOMTRY
[  SPAN  ][   DY   ][   DE   ]
  0.000000  0.000000  0.000000
  0.125997  0.000000  0.000000
  0.207427  0.008731 -0.480354
...............
  0.961462  0.475085 -1.601975
  1.000000  0.503901 -1.601514

 RIGHT PART, TOTAL DEFORMATION
[   ID   ]
  1.000000
[   ND   ][  INDD  ]
 12.000000  1.000000
[  SPAN  ][   DY   ][   DE   ]
```

```
  0.000000  0.000000  0.000000
  0.125997  0.000000  0.000000
  0.207427  0.010388 -0.585782
................
  0.961462  0.572945 -2.028616
  1.000000  0.607883 -2.028315

 RIGHT PART, DEFORMATION OF THE INPUT GEOMTRY
[  SPAN  ][   DY   ][   DE   ]
  0.000000  0.000000  0.000000
  0.125997  0.000000  0.000000
  0.207427  0.010388 -0.585782
................
  0.961462  0.572945 -2.028616
  1.000000  0.607883 -2.028315


    HORISONTAL TAIL

  LEFT PART, TOTAL DEFORMATION
[   ID   ]
  1.000000
[   ND   ][  INDD  ]
 12.000000  1.000000
[  SPAN  ][   DY   ][   DE   ]
  0.000000  0.000000  0.000000
  0.215938  0.000000  0.000000
  0.251824  0.000429 -0.131126
................
  0.964114  0.090254 -0.818648
  1.000000  0.095950 -0.818666

  LEFT PART, DEFORMATION OF THE INPUT GEOMTRY
[  SPAN  ][   DY   ][   DE   ]
  0.000000  0.000000  0.000000
  0.215938  0.000000  0.000000
  0.251824  0.000429 -0.131126
 ...............
  0.964114  0.090254 -0.818648
  1.000000  0.095950 -0.818666

 RIGHT PART, TOTAL DEFORMATION
[   ID   ]
  1.000000
[   ND   ][  INDD  ]
 12.000000  1.000000
[  SPAN  ][   DY   ][   DE   ]
  0.000000  0.000000  0.000000
  0.215938  0.000000  0.000000
  0.251824  0.000443 -0.111636
.................
  0.964114  0.098497 -0.761883
  1.000000  0.104805 -0.761926

 RIGHT PART, DEFORMATION OF THE INPUT GEOMTRY
[  SPAN  ][   DY   ][   DE   ]
  0.000000  0.000000  0.000000
  0.215938  0.000000  0.000000
  0.251824  0.000443 -0.111636
 ................
  0.964114  0.098497 -0.761883
  1.000000  0.104805 -0.761926


     VERTICAL TAIL

   TOTAL DEFORMATION
[   ID   ]
  1.000000
[   ND   ][  INDD  ]
 12.000000  1.000000
[  SPAN  ][   DZ   ][   DE   ]
  0.000000  0.000000  0.000000
  0.215938  0.000000  0.000000
```

```
  0.251824  0.000502 -0.132799
 ..................
  0.964114  0.105576 -0.814688
  1.000000  0.112222 -0.814677


   BODY TORSION DEFORMATION

[  XREF  ][    DET  ][    DEX  ]
  0.323369  0.000000  0.000000
  0.357201 -0.616797  0.061742
  0.391032 -1.233449  0.123484
  0.424864 -1.849320  0.185257
.....................
  0.932337 -8.976369  0.852724
  0.966169 -8.976369  0.852724
  1.000000 -8.976369  0.852724

  FOR HORISONTAL TAIL:

[  XREF  ][    DET  ][    DEX  ]
  0.814318 -8.817618  0.843566

  FOR  VERTICAL  TAIL:

[  XREF  ][    DET  ][    DEX  ]
  0.814318 -8.817618  0.843566
```

Output files wgeom.out , hgeom.out.

Fragments of output files **wgeom.out** and **hgeom.out** are presented bellow. These files contain the geometry of deformed wing (**wgeom.out**) and geometry of deformed horizontal tail (**hgeom.out**). The files are created according to parameters **LR_OUT** for wing and for horizontal tail from file **beam.dat** (see **item.4** for example).
At the beginning of the files the information about deformation taken into account is presented in a format corresponding to file **beam.dat** (sections "DEFORMATIONS ALREADY TAKEN INTO ACCOUNT..."). Then the geometry data follows. Note, if the winglets are present, then the file **wgeom.out** contains the new values of the winglets installation angles (GAMMA and FI, see **item 100** of **Section 2.1**).
The structures of these geometry data correspond to a format used for the main input data file of BLWF58. So parameters from these files can be easily used for creating the new main initial data file for BLWF58, containing new deformed wing and horizontal tail geometry. If it is necessary to continue the calculation using this new input data file, then the information about elastic deformations already taken into account in new input geometry must be incorporated into additional input file **beam.dat**. This information can be extracted also from the beginning parts of the output files **wgeom.out** and **hgeom.out**.

Example of output file wgeom.out for wing:

```
 TEST ONERA_M5  + TAIL
```

```
    DEFORMATION ALREADY TAKEN INTO ACCOUNT IN THE DATA FILE
[    ID    ]
   1.00000
[    ND    ][   INDD  ]
  12.00000   1.00000
[  SPAN  ][    DY    ][    DE    ]
   0.00000   0.00000   0.00000
   0.12600   0.00000   0.00000
   0.20743   0.00956  -0.53307
   0.33267   0.05545  -1.12209
   0.40000   0.09233  -1.34133
   0.49815   0.15606  -1.56670
   0.63770   0.25984  -1.74286
   0.73000   0.33359  -1.79314
   0.79834   0.38940  -1.80954
   0.88724   0.46265  -1.81596
   0.96146   0.52401  -1.81532
   1.00000   0.55589  -1.81494


   LOWER WINGLET. NEW ORIENTATION
[ GAMMA  ][    FI    ]
   1.00000  75.67016

   UPPER WINGLET. NEW ORIENTATION
[ GAMMA  ][    FI    ]
   1.00000  84.32983


[  XLEW  ][  YLEW  ]
   7.22730   0.00000


 [    NSW   ]
  12.00000
 [     Z    ][   XLE   ][    YLE   ][  CHORD ][  THICK ][  EPSIL ][  FSEC  ]
   0.00000   0.00000   0.00000   4.22000   1.00000   0.00000   1.00000
 [  YSYM  ][    NU    ][    NL    ]
   0.00000  33.00000  33.00000
 [  XSING ][  YSING ][  TRAIL ][  SLOPT ]
   0.00500   0.00000  14.12768   0.00000
 [    XU    ][    YU    ]
   0.00000   0.00000
   0.00120   0.00615
   0.00482   0.01199
.......
.......
   0.98806  -0.00148
   1.00000   0.00000
 [     Z    ][   XLE   ][    YLE   ][  CHORD ][  THICK ][  EPSIL ][  FSEC  ]
   1.24639   0.71960  -0.00002   3.85182   1.00000  -0.00050   1.00000
 [  YSYM  ][    NU    ][    NL    ]
   0.00000  33.00000  33.00000
 [  XSING ][  YSING ][  TRAIL ][  SLOPT ]
   0.00500   0.00000  14.12770   0.00000
 [    XU    ][    YU    ]
   0.00000   0.00000
   0.00120   0.00615
.......
.......
```

Example of output file hgeom.out for horisontal tail:

```
TEST ONERA_M5 + TAIL


   DEFORMATION ALREADY TAKEN INTO ACCOUNT IN THE DATA FILE
[    ID    ]
   1.00000
[    ND    ][   INDD  ]
  12.00000   1.00000
```

```
[  SPAN  ][    DY    ][    DE    ]
   0.00000   0.00000   0.00000
   0.21594   0.00000   0.00000
   0.25182   0.00044  -0.12138
   0.31445   0.00309  -0.29865
   0.39912   0.00981  -0.47981
   0.49947   0.02126  -0.62527
   0.60797   0.03646  -0.71915
   0.71647   0.05338  -0.76701
   0.81682   0.06981  -0.78514
   0.90149   0.08391  -0.78967
   0.96411   0.09438  -0.79027
   1.00000   0.10038  -0.79030


 [  XLETH ][  YLETH ]
  18.20000   0.00000


         HORISONTAL TAIL SECTION DATA
 [    NC    ]
  12.00000
 [  ZLE    ][    XLE   ][    YLE   ][  CHORD ][  THICK ][  EPSIL ][    ANT  ]
   0.00000   0.00000   0.00000   2.11000   1.00000   0.00000   1.00000
 [  ZLE    ][    XLE   ][    YLE   ][  CHORD ][  THICK ][  EPSIL ][    ANT  ]
   0.89712   0.51796  -0.00131   1.84499   1.00000  -0.04070   2.00000
 [  ZLE    ][    XLE   ][    YLE   ][  CHORD ][  THICK ][  EPSIL ][    ANT  ]
   1.08494   0.62640  -0.00032   1.78951   1.00000  -0.08994   3.00000
 [  ZLE    ][    XLE   ][    YLE   ][  CHORD ][  THICK ][  EPSIL ][    ANT  ]
   1.41272   0.81565   0.00184   1.69268   1.00000  -0.19458   4.00000
 [  ZLE    ][    XLE   ][    YLE   ][  CHORD ][  THICK ][  EPSIL ][    ANT  ]
   1.85586   1.07150   0.00678   1.56178   1.00000  -0.32730   5.00000
 [  ZLE    ][    XLE   ][    YLE   ][  CHORD ][  THICK ][  EPSIL ][    ANT  ]
   2.38101   1.37470   0.01553   1.40664   1.00000  -0.45293   6.00000
 [  ZLE    ][    XLE   ][    YLE   ][  CHORD ][  THICK ][  EPSIL ][    ANT  ]
   2.94877   1.70251   0.02776   1.23892   1.00000  -0.54541   7.00000
 [  ZLE    ][    XLE   ][    YLE   ][  CHORD ][  THICK ][  EPSIL ][    ANT  ]
   3.51650   2.03029   0.04186   1.07122   1.00000  -0.59836   8.00000
 [  ZLE    ][    XLE   ][    YLE   ][  CHORD ][  THICK ][  EPSIL ][    ANT  ]
   4.04157   2.33346   0.05585   0.91612   1.00000  -0.62073   9.00000
 [  ZLE    ][    XLE   ][    YLE   ][  CHORD ][  THICK ][  EPSIL ][    ANT  ]
   4.48457   2.58922   0.06798   0.78526   1.00000  -0.62681  10.00000
 [  ZLE    ][    XLE   ][    YLE   ][  CHORD ][  THICK ][  EPSIL ][    ANT  ]
   4.81224   2.77840   0.07703   0.68846   1.00000  -0.62748  11.00000
 [  ZLE    ][    XLE   ][    YLE   ][  CHORD ][  THICK ][  EPSIL ][    ANT  ]
   5.00000   2.88681   0.08223   0.63300   1.00000  -0.62747  12.00000



 SECTION AIRFOIL DATA FOR HORISONTAL TAIL
 [    NA    ]
   12.00000
 [  YSYM  ][    NU    ][    NL    ]
   0.00000  33.00000  33.00000
 [  XSING ][  YSING ][  TRAIL ][  SLOPT ]
   0.00500   0.00000  14.12767   0.00000
 [    XU    ][    YU    ]
   0.00000   0.00000
   0.00120   0.00615
.......
.......
   0.97119  -0.00357
   0.98806  -0.00148
   1.00000   0.00000
 [  YSYM  ][    NU    ][    NL    ]
   0.00000  33.00000  33.00000
 [  XSING ][  YSING ][  TRAIL ][  SLOPT ]
   0.00500   0.00018  14.10783  -0.00067
 [    XU    ][    YU    ]
   0.00000   0.00000
   0.00121   0.00615
   0.00482   0.01199
.......
.......
```

Appendix B:

THE CALCULATION UNDER A CONDITION OF STEADY MANOEUVRE

The calculation of a flow in conditions when the airplane realizes steady maneuver is possible.

Here the "steady maneuver" is understood as a driving of airplane along a trajectory representing an arbitrary oriented spiral, as shown in **fig.B1**. The orientation of the airplane concerning velocity vector is arbitrary and does not vary in time (**fig.B2**). The airplane rotates, but the angle of attack and yaw angle do not vary in time. Particular cases of such motion are, for example, fixed turn, and also flight with steadied rotation on a roll.

In an airplane coordinate system the flow is stationary and can be considered as a potential flow. Thus in the airplane coordinate system the problem can be reduced to calculation of configuration in an irregular curvilinear steady flow of a compressible gas. Here this problem is solved approximately. The inaccuracy of the solution is caused by that the bending of a vortex wake is not taken into account.

To set the initial parameters of flow and motion it is necessary to select any point (point **P** in **fig.B2**) in airplane coordinate system and to prescribe for this point the local free stream flow vector (for example, in terms of Mach number, angle of attack and yaw angle). Also it is necessary to prescribe the components of airplane's angular-velocity vector and Strouhal number.

If rotation effects are taking into account, the above-stated additional input data are read out from additional input file **rotation.dat**.

B.1 Additional initial data file for calculation in view of steady manoeuvre.

Example of an additional data file **rotation.dat** for calculation under a condition of steady manoeuvre is presented bellow.

Note that for rigorous calculation in view of manoeuvre it is necessary, that the mode with oblique ventilation be established in the main input data file (NY_BETA≠0., see **item 70** of the main input data file, **Section 2.1**). Otherwise, the flow will be considered as symmetrical and the input rotation parameters, which upset this condition, will be skipped.

All numerical data are introduced based on the F10.5 format (and should include ".").

```
1.        MAME OF CONFIGURATION
      ------------------------------------------------
              ROTATION DATA
2.    [   IR   ]
         1.
3.    [   XP   ][   YP   ][   ZP   ]
         9.        0.        0.
4.    [ IND_OM ]
         0.
```

5. [OMEG_X] [OMEG_Y] [OMEG_Z]
6. 0. 0.
6. [SH_NUM] [SH_LEN]
.025 2.

Here:

1. **THREE free lines**

2. **IR - control parameter**

IR - this parameter indicates whether the calculation will be carried out in view of steady manoeuvre or not.

IR = 1. – the calculation will be carried out in view of steady manoeuvre;

IR =-1. – the calculation will be carried without taking into account the steady manoeuvre;

3. **XP, YP, ZP**

XR, YR, ZR - the coordinates of the reference point (point **P** in **fig.B2**) in airplane coordinate system. (Hereinafter "the airplane coordinate system" is a coordinate system in which the input geometry of configuration is prescribed.). It is considered that the prescribed values of free stream Mach number, angle of attack and yaw angle correspond to this point.

4. **IND_OM – control parameter**

IND_OM – the parameter indicates, in what coordinate system the angular-velocity vector of rotation of an airplane will be prescribed.

IND_OM = 0. – the airplane coordinate system is used (X-axis is directed backward along a body; Y-axis is located in symmetry plane and upwards; Z-axis is directed sideward in left wing's direction);

IND_OM = 1. – the local velocity coordinate system is used (X-axis is directed along a freestream at reference point **P**; Y-axis is located in symmetry plane of configuration; Z-axis makes with X and Y axes the right coordinate system)

5. **OMEG_X, OMEG_Y, OMEG_Z**

OMEG_X, OMEG_Y, OMEG_Z - components of airplane angular-velocity vector (in degrees per second).

OMEG_X.>.0. - left half-wing down, right half-wing upward;

OMEG_Y > 0. – left half-wing backward, right half-wing forward;

OMEG_Z > 0. – airplane tail down, airplane nose upward.

6. **SH_NUM, SH_LEN**

SH_NUM – Strouhal number. The parameter is used for calculation of the free-stream velocity value q_∞. Here SH_NUM= b/q_∞, where: b - reference length;

SH_LEN – reference length for Strouhal number. SH_LEN should be given in the same values, as input geometry data.

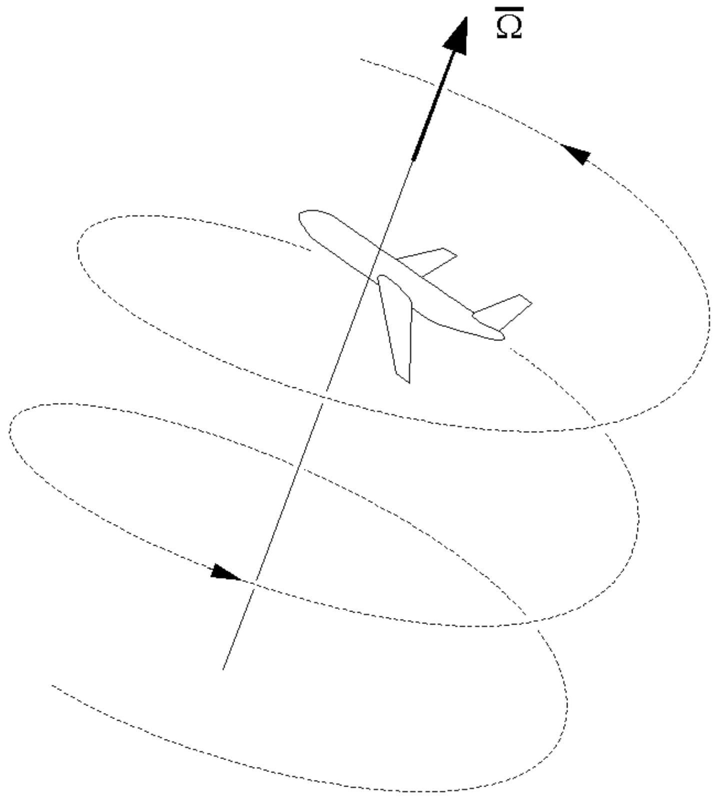


fig.B1

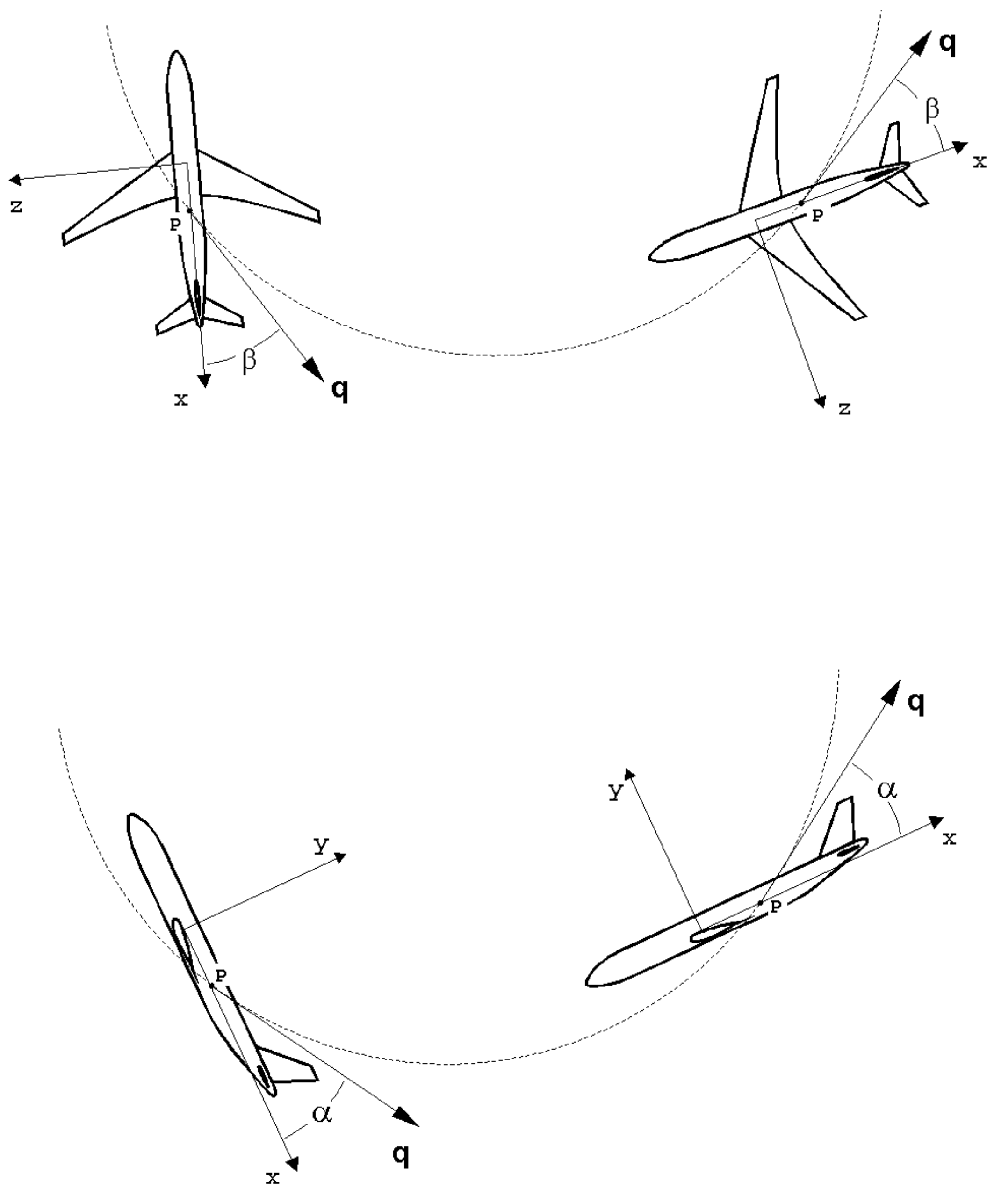


fig.B2

Appendix C:

THE CALCULATION TAKING INTO ACCOUNT THE DEFLECTION OF THE CONTROL SURFACES

It is possible to produce an approximate calculation in view of deflection of parts of a wing and tail surfaces. So it is possible to simulate the influence of control surfaces such as ailerons, elevators, rudders (and other tools without slots).

The deflection is simulated in calculation just approximately by modification of the boundary condition (transpiration) on the surfaces of the initial (undeformed) wing and tail.

If deflections are taking into account the additional input data file **aileron.dat** is used. The file prescribes configuration of the wing's and tail's control surfaces, orientation of axes of a turn and turn angles. Structure of file **aileron.dat** is described bellow.

Note, that after mesh generation the code creates a set of additional postscript graphic files (**11_al.ps, 81_al.ps, 91_al.ps,** see **fig.C2**), which illustrate a position of prescribed control surfaces, and also show the location of the surface mesh nodes in relation to the control surfaces. Some recommendations touching the surface mesh nodes distributions are presented in **section C.2**.

C.1 Additional initial data file for calculation in view of control surfaces.

Example of an additional data file **aileron.dat** for calculation taking into account the deflection of the control surfaces on the wing and tail is presented bellow.

All numerical data are introduced based on the F10.5 format (and should include ".").

```
1.                    NAME OF CONFIGURATION
          C--------------------------------------------------------
                      WING DATA
2.                  LEFT-HAND  WING
3.        [   IW   ]
              1.
4.        [  NAI   ]
              2.
5.        [ EPSIL  ][ IND_XZ ]
              2.       1.
6.        [   Z_AI ][ XLE_AI ][ XTE_AI ][ XRA_AI ]
              .2       .8        1.01        .8
              .5       .8        1.01        .8
          [ EPSIL  ][ IND_XZ ]
               5.       1.
          [   Z_AI ][ XLE_AI ][ XTE_AI ][ XRA_AI ]
              .6       .8        1.01        .8
              .9       .8        1.01        .8
7.                    RIGHT-HAND  WING
```

```
[   IW   ]
    1.
[  NAI   ]
    2.
[ EPSIL  ][ IND_XZ ]
    -2.       1.
[   Z_AI ][ XLE_AI ][ XTE_AI ][ XRA_AI ]
    .6       .8         1.01        .8
    .9       .8         1.01        .8
[ EPSIL  ][ IND_XZ ]
    -5.       1.        0.
[   Z_AI ][ XLE_AI ][ XTE_AI ][ XRA_AI ]
    .6       .8         1.01        .8
    .9       .8         1.01        .8
```

8.

```
C-------------------------------------------------------
              HORISONTAL TAIL DATA
              LEFT-HAND  WING
[   IW   ]
    -1.
[  NAI   ]
    2.
[ EPSIL  ][ IND_XZ ]
     2.       1.
[   Z_AI ][ XLE_AI ][ XTE_AI ][ XRA_AI ]
    .2       .8         1.        .8
    .5       .8         1.        .8
[ EPSIL  ][ IND_XZ ]
     1.       1.
[   Z_AI ][ XLE_AI ][ XTE_AI ][ XRA_AI ]
    .6       .8         1.        .8
    .9       .8         1.        .8
              RIGHT-HAND  WING
[   IW   ]
    -1.
[  NAI   ]
    2.
[ EPSIL  ][ IND_XZ ][ IND_R  ]
     2.       1.        0.
[   Z_AI ][ XLE_AI ][ XTE_AI ][ XRA_AI ]
    .2       .8         1.        .8
    .5       .8         1.        .8
[ EPSIL  ][ IND_XZ ][ IND_R  ]
     1.       1.        0.
[   Z_AI ][ XLE_AI ][ XTE_AI ][ XRA_AI ]
    .6       .8         1.        .8
    .9       .8         1.        .8
```

9.

```
C-------------------------------------------------------
              VERTICAL TAIL DATA
              LEFT-HAND  WING
[   IW   ]
    1.
[  NAI   ]
    2.
[ EPSIL  ][ IND_XZ ]
     2.       1.
[   Y_AI ][ XLE_AI ][ XTE_AI ][ XRA_AI ]
    .2       .8         1.        .8
    .5       .8         1.        .8
[ EPSIL  ][ IND_XZ ][ IND_R  ]
     2.       1.        0.
[   Y_AI ][ XLE_AI ][ XTE_AI ][ XRA_AI ]
    .6       .8         1.        .8
    .9       .8         1.        .8
```

Here:

1. TREE free lines

2. ONE free line ***Then the information follows for left half-wing***

3. IW - control parameter

IW - parameter indicates does the current file contains an information about control surfaces for the left half-wing. And if this information is present, then this parameter indicates whether this information should be taken into account at realization of calculations.

IW = 0. – there is not information;

IW = 1. – current file contains the information about control surfaces for the left half-wing, and this information should be used at realisation of calculation;

IW =-1. – – current file contains the information about control surfaces for the left half-wing, but this information should be skipped at realisation of calculations;

If IW $\neq$ 0., then the lines 4-6 follow

4. NAI

NAI - the number of the control surfaces on the left half-wing (NAI<11)

Then the information (items 5,6) follows for each control surface.

5. EPSIL, IND_XZ

EPSIL – turn angle of the control surface in degrees. If EPSIL>0 - the trailing edge moves downwards (for vertical tail if EPSIL>0. then the trailing edge moves in left-hand wing direction);

IND_XZ – control parameter indicates the mode of prescribing the configuration of the control surface

IND_XZ = 0. – the real spanwise and chordwise coordinates are used;

IND_XZ =1. - the referenced coordinates are used. The spanwise coordinates are prescribed in fraction of the total wing halfspan, and chodwise coordinates - in fraction of the local wing chord.

6. Z_AI, XLE_AI, XTE_AI, XRA_AI

Parameters prescribe the configuration of the control surface on the wing and location of the turn axis (see **fig.C1**). There are two lines of data. The first one corresponds to inboard boundary of the control surface. The second one corresponds to the outboard boundary.

Z_AI – spanwise location of the boundary;

XLE_AI – chordwise location of the leading edge of the control surface at section Z_AI;

XTE_AI – chordwise location of the trailing edge of the control surface at section Z_AI;

(Note, that in the example data file the values of XTE_AI are a little bit greater than 1. Due to this there is a warranty, the trailing edge of a wing will be necessary belong to an aileron region.)

XRA_AI – chordwise location of the turn axis at section Z_AI.

7. ..... *Then the similar information for right-hand wing follows*

8. **<u>.....</u>** ***The information for horisontal tail follows.***

9. **<u>.....</u>** ***The information for vertical tail follows***

IND_XZ – control parameter indicates the mode of prescribing the configuration of the control surface

IND_XZ = 0. – the real spanwise and chordwise coordinates are used;

IND_XZ =1. - the referenced coordinates are used. The spanwise coordinates are prescribed in fraction of the total wing halfspan, and chodwise coordinates - in fraction of the local wing chord.

C.2 Some recommendation.

The main recommendations are devoted to distribution of mesh nodes in relation to control surfaces. After mesh generation the code creates additional postscript graphic files (**11_al.ps** –for main wing**, 81_al.ps** – for horizontal tail**, 91_al.ps** – for vertical tail**,** see **fig.C2**), which illustrate the location of the surface mesh nodes and position of the control surfaces. The best situation is if the side boundaries of the control surfaces are approximately half-space shifted in spanwise direction in comparison with the mesh lines for fine grids, as shown in **fig.C2.** Such mesh nodes distribution can be carried out with the help of parameters **PZROOT**, **PZTIP** (see **Items 73,80,85** of **Section 2.1**) and for the wing with the help of parameters **Z1, PZ11, PZ12, Z2, PZ21, PZ22** (**Items 74,75** of **Section 2.1**).

Also for the wing case it is useful to provide some compression of the computation grid in spanwise direction near the side boundaries of the control surfaces (**fig.C2**). The last group of above control parameters (**Z1, PZ11, PZ12, Z2, PZ21, PZ22)** can be used for these purposes. Lets note, a main role of these parameters is to provide a necessary condensation of a grid in region of nacelles. But as a rule the locations of flap's and aileron's side boundaries are in consistence with the nacelle position. Therefore the mentioned parameters can be used for fulfilment of a double function if the nacelles are present.

As for the ruder and elevator the situation with the mesh compression near side boundaries is more simple. As a rule the side boundaries of this devices are located in the root and tip regions, where the computational mesh is dense enough in spanwise direction.

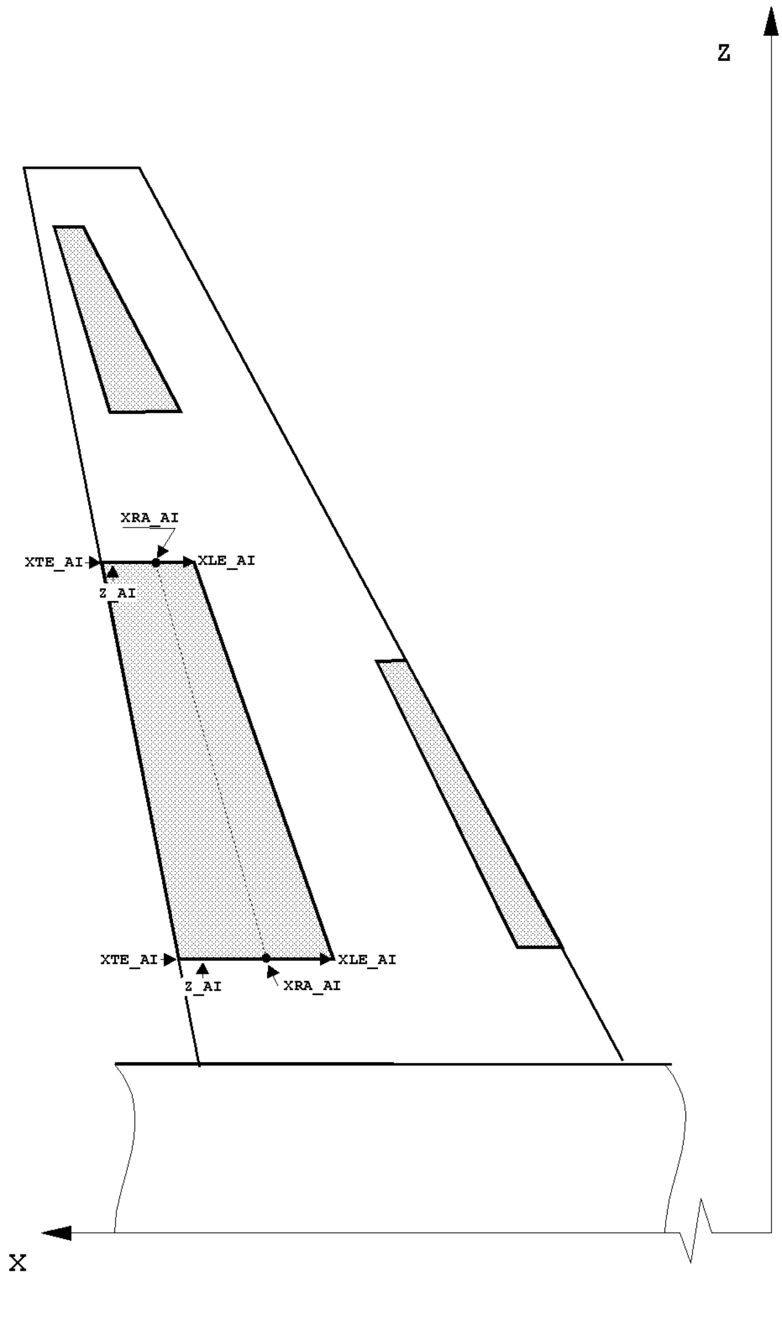


fig. C1

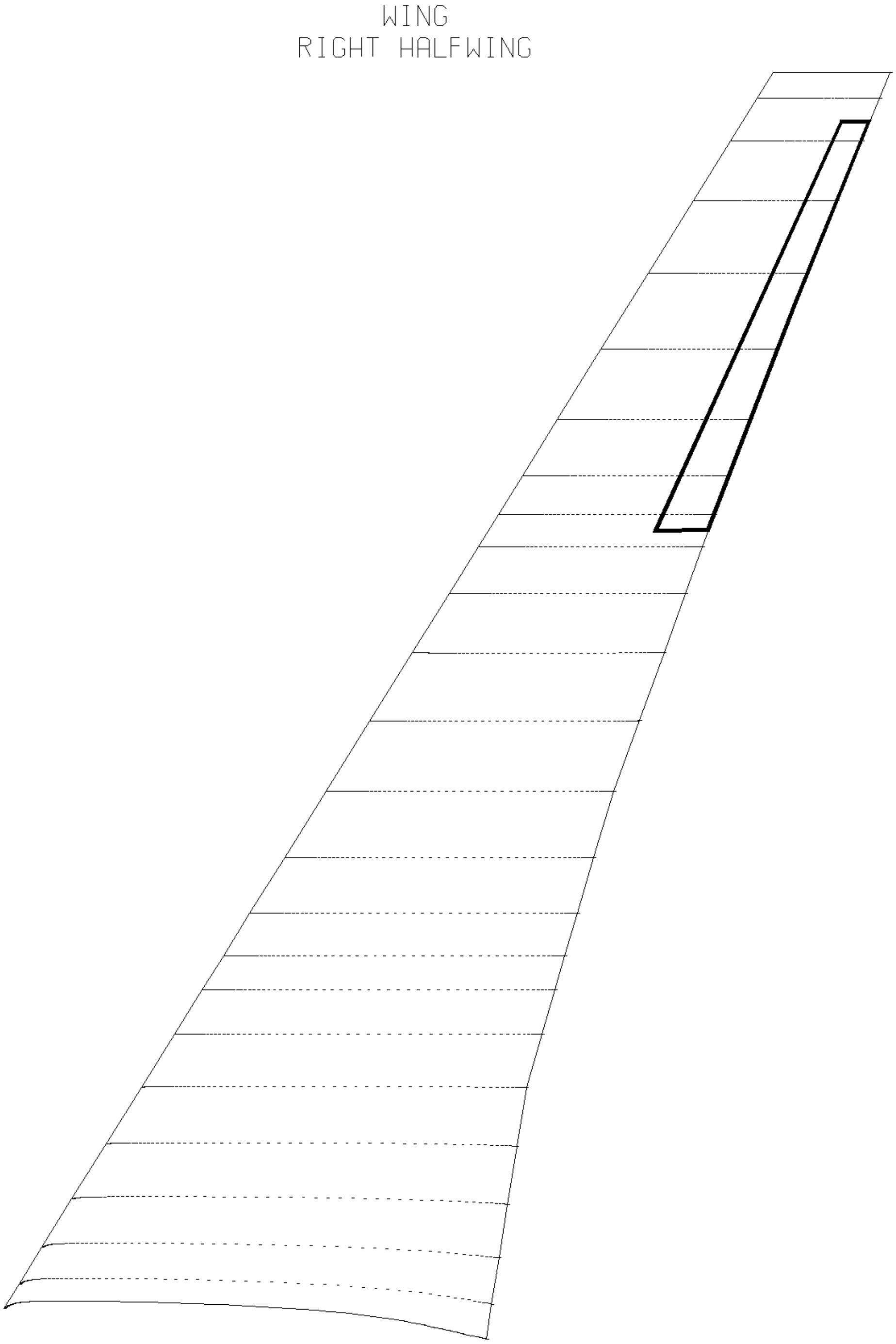


fig. C2

Appendix D:

THE CALCULATION TAKING INTO ACCOUNT THE PROPELLER SLIPSTREAMS EFFECT.

It is possible to produce a calculation by taking into account approximately the effects of propeller slipstreams.

Here an actuator disk model is used for the propeller simulation, see **fig.D1**. The actuator disk model is a specific boundary conditions applied on a window of the computational grid, which ensure the flow discontinuities, depending on the propeller characteristics. Here the flow discontinuities are expressed in term of jumps $\Delta H(r)$ in total enthalpy and azimuth flow deviation angle $\Delta\varepsilon(r)$ in the local propeller axis system. These discontinuities are depending on the radial position on the propeller and should be prescribed, as input data.

The slipstream simulation is carried out approximately within the framework of the linear theory. It is supposed, that the perturbed velocities, both in jet, and outside of it are small. So the propeller slipstream is considered as cylindrical and straight one. Distribution of an enthalpy and the stream twist in cross sections of a jet is identical for different sections. And the velocity vector inside the jet can be approximately expressed as

$$\vec{q} = grad\varphi + \vec{Q}(r,\theta)$$

$grad\varphi$ - the potential component of velocity vector (should be found).

$\vec{Q}(r,\theta)$ - known vector of additional velocity induced by propeller. Here, according to linear theory this vector is formed by two components. The value of chordwise component Q_X is defined by an increase of an enthalpy; the value of azimuth component Q_T is determined by the twist of a stream:

$$Q_X(r) = \Delta H(r) / q_\infty$$

$$Q_T(r) = q_\infty \tan(\Delta\varepsilon(r))$$

q_∞ - free stream velocity.

The potential φ should be defined from a solution of continuity equation

$$div(\rho\vec{q}) = 0 .$$

Where density ρ must be calculated taking into account the local enthalpy value.

Certainly, such slipstream simulation is rather approximate one. As a jet in calculation remains cylindrical and straight, and the perturbed velocities are considered small, the calculation can be acceptable only on conditions of flight, close to cruise.

If the slipstreams are included in calculation the additional input data file **fan.dat** is used. The file prescribes the location of propellers and the propeller characteristics.

Additional initial data file for calculation in view of propeller slipstream effects.

Example of an additional data file **fan.dat** for calculation taking into account the propeller slipstream is presented bellow.
All numerical data are introduced based on the F10.5 format (and should include ".").

```
1.                NAME OF CONFIGURATION
2.      C
                   LEFT HALFSPACE
3.      C------------------------------------------------------
                  FIRST PROPELLER DATA
4.      [   IF   ]
           1.
5.      [   XPR  ][  YPR   ][  ZPR   ][  RPR   ]
            9.      .0        5.       1.5
6.      [   NR   ][ IND_R  ]
           3.       1.
7.      [   R    ][   DQ   ][   ET   ]
           .0       .15       0.
           .99      .15       0.
           1.       .15       0.
8.      C------------------------------------------------------
                   SECOND PROPELLER DATA
        [   IF   ]
           0.
9.      C
                   RIGHT HALFSPACE
        C------------------------------------------------------
                   FIRST PROPELLER DATA
        [   IF   ]
           1.
        [   XPR  ][  YPR   ][  ZPR   ][  RPR   ]
            9.      .0       -5.       1.5
        [   NR   ][ IND_R  ]
           3.       1.
        [   R    ][   DQ   ][   ET   ]
           .0       .15      -2.
           .99      .15      -2.
           1.       .15      -2.
        C------------------------------------------------------
                   SECOND PROPELLER DATA
        [   IF   ]
           0.
```

Here:

1. <u>**ONE free line**</u>

2. <u>**TWO free line.**</u> ***Then the information follows for the propellers of the left halfspace.***

3. <u>**TWO free line.**</u> ***Then the information follows for the FIRST propeller of the left halfspace.***

4. <u>**IF - control parameter**</u>

IF - parameter indicates does the current file contains an information for the first propeller of the left halfspace. And if this information is present, then this parameter indicates whether this information should be taken into account at realization of calculations.

IF = 0. – there is not information;

IF = 1. – current file contains the information about first propeller for the left half halfspace, and this information should be used at realisation of calculation;

IF =-1. – – current file contains the information for the propeller, but this information should be skipped at realisation of calculations;

If IF ≠ 0., then the lines 5-7 follow

5. **XPR, YPR, ZPR, RPR – parameters define the position and size of propeller (see fig.D2)**

XPR, YPR, ZPR – coordinates of the propeller's centre (in real coordinates);

RPR – radius of a propeller;

Note, the propeller can intersect the elements of configuration;

6. **NR, IND_R**

NR - number of stations located along the propeller's radius, in which the local propeller characteristics are prescribed (NR<21.);

IND_R – control parameter indicates how the positions on a propeller radius are prescribed:

IND_R = 0. – the real radiuses are used;

IND_R = 1. – the radiuses prescribed in fraction of the total propeller radius;

7. **R, DQ, ET - propeller characteristics**

R – station position on a propeller radius;

DQ – an equivalent increase of a referenced chrdwise velocity induced by a propeller. This value is connected to a local increase of a full enthalpy $\Delta H(r)$ by a relation:

$$\text{DQ} = \Delta H(r) / q_\infty^2 \; ;$$

ET – local angle of an azimuth stream twist, induced by a propeller (in degrees). The positive values of ET correspond to counter-clockwise rotation on the front view (for both half-spaces), as shown in **fig.D2**.

Lets note, the flow will be nonsymmetric if in right and left-hand half-spaces the propellers rotate in the same directions. In such case for rigorous calculation it is necessary, that the mode with oblique ventilation be established in the main input data file (NY_BETA≠0., see **item 70** of the main input data file, **Section 2.1**). Otherwise, the flow will be considered as symmetrical (in a right half-space the same propellers, as well as in left-hand, but with opposite direction of rotation). And input propeller data for right half-space will be skipped.

8. ***Then the information follows for the SECOND propeller of the LEFT halfspace. (Lines similar to items 3-7).***

9. ***The information follows for RIGHT halfspace propellers (Lines similar to items 2-8).***

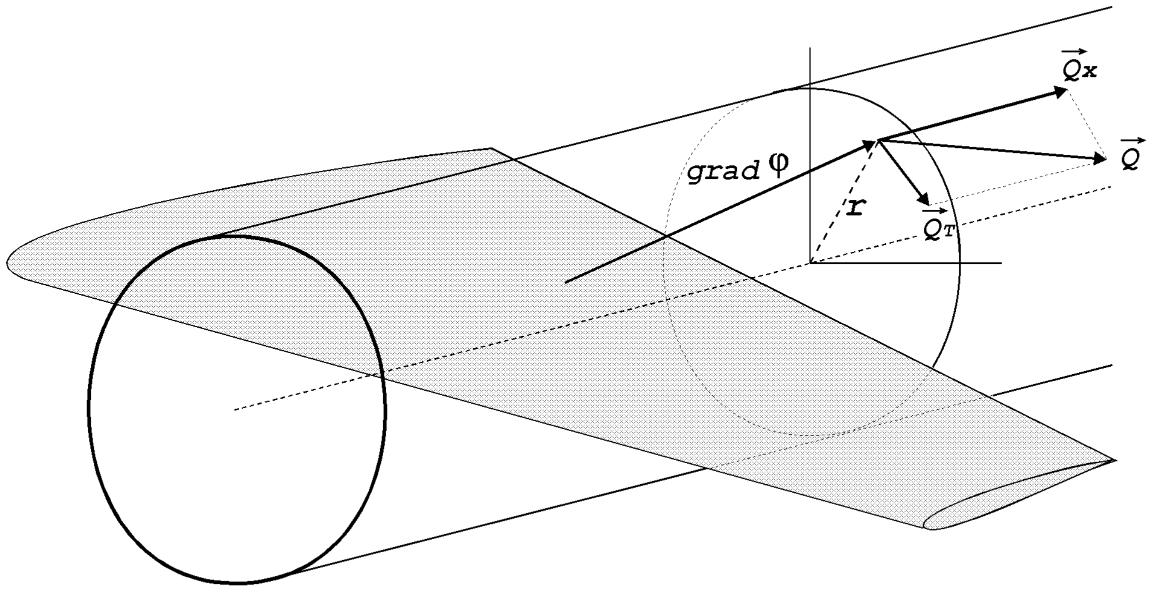


fig. D1

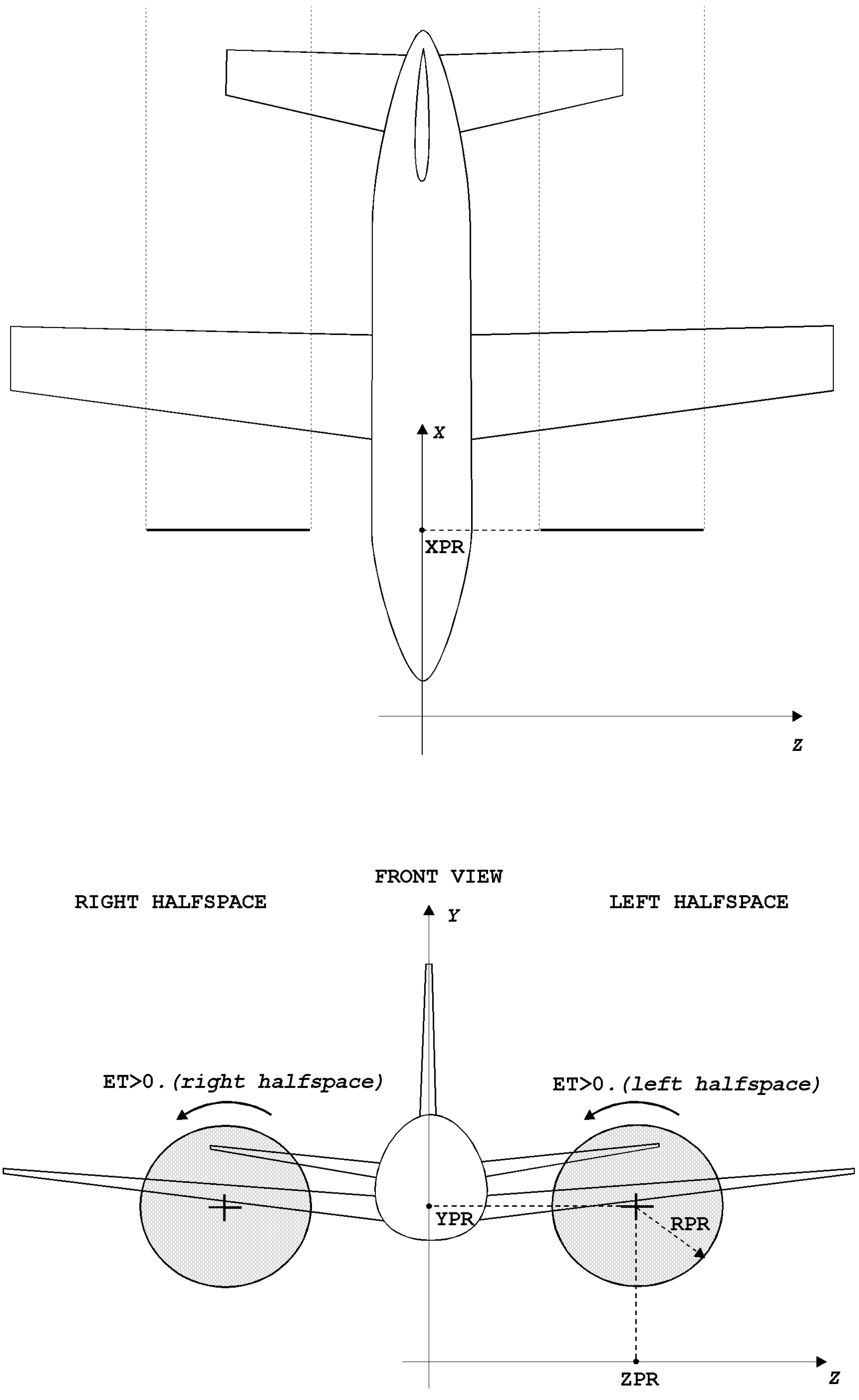

X
XPR
Z
FRONT VIEW
RIGHT HALFSPACE
LEFT HALFSPACE
Y
ET>0.(right halfspace)
ET>0.(left halfspace)
YPR
RPR
ZPR
Z

fig. D2