UPDATES to the MULTALL based design system.

21/3/2017   Add STAGEN-17.2 and MEANGEN-17.2.

The only difference is that MEANGEN now passes the gas constant and specific heat ratio to STAGEN as its first line of data. Previously they were set in STAGEN by default. The STAGEN data sets provided have been updated to allow for this and will no longer work with STAGEN-17.1.

26/5/2017   Add MULTALL-OPEN-17.4, STAGEN-17.3   and MEANGEN-17.3 .

MULTALL-OPEN-17.4 has a few improvements and a few bug fixes but no change to the data input. The most noticeable change is that the smoothing and damping are increased over the first 100 time steps when starting from a restart file. Previously they were not increased at restart. Also the mass flow ratio, which is printed out every 200 steps, is now corrected to allow for shroud leakage flow so even when there is shroud leakage the flow ratio should become closely 1.0 . In throughflow mode the incidence it decreased gradually over the first 1/3 of the grid points on the blade and the deviation is built up over the last 1/2 of the grid points on the blade. The bugs mainly involved the calculation of wall shear stress when there is surface roughness. Also the restart option could not be used when using the SA turbulence model because the turbulent viscosity was not being sent to the restart file.

STAGEN-17.3 allows KTIPS to be set to -1 in the input data file to request data for shrouded blades to be added at the end of the STAGE_NEW.DAT file. However, the data must still be added manually. Also IF_CUSP_OUT can be set in the defaults to decide whether or not to ask MULTALL to generate a cusp. There is no change to the input data.

MEANGEN-17.3 allows FLO_TYPE to be changed from AXI to MIX or vice-versa within a data set, so that part of a machine can be designed as AXI and part as MIX. It also makes an estimate of the mid-span density to give better accuracy in evaluating the annulus area. There are no changes to the data input.

15/8/2017   Add MULTALL-OPEN-17.5

Version 17.5 has a bug fix and several additions. The bug fix is because previous versions did not always allow correctly for the relative motion of the hub or casing in unshrouded blade rows, the end wall was sometimes treated as rotating as the same speed as the blade row. This was correct in subroutine LOSS but wrong in subroutines NEW_LOSS and SPAL_LOSS. It was done correctly in all subroutines in all versions up to MULTALL-15 but somehow got changed in MULTALL-OPEN. Copy the changes from 17.5 if using previous versions of MULTALL_OPEN.

The first addition is to include an option to use the wall functions proposed by Shih et al in NASA/TM-1999-209398. They suggest two terms in the wall function, one based on the velocity near the wall and the other based on the pressure gradient. The velocity term gives very similar results to the existing function in MUTALL It is used by setting YPLUSWALL to any value between -1.0 and -10.0 . The pressure term is new and it is used in combination with the velocity term if YPLUSWALL is set to a

value less than -10.0 . There is as yet little experience of how much difference this makes but so far it seems to have remarkable little effect.

The second addition is to make the changes to the turbulent viscosity source term, ST0, in the Spalart-Allmaras model which were proposed by Lee, Wilson & Vahdati in ASME paper GT2017-63245. They add factors to increase the source term , ST0, when there is streamwise vorticity (helicity) and when there is an adverse pressure gradient and claim that this gives better agreement with predictions of the flow in transonic fans, especially with predictions of the stall point.

      The vorticity term is used if the value of FAC_VORT set to be greater than zero. The maximum magnitude of the increase in set equal to FAC_VORT and Lee et al suggest a value of 0.9191 for this.

       The pressure gradient term is not so straight-forward since the scaling factor on dimensionless pressure gradient is not given. The original Chinese paper on which the method is based uses a constant scaling factor of 10^6 , however, this makes the term depend on viscosity, which does not seem realistic. Hence it was decided to multiply the term by the Reynolds number, which gives it a reasonable value and makes it independent of viscosity. The value of the term varies inversely as the sixth power of velocity and so it is concentrated in regions where there is low velocity and an adverse pressure gradient. The term is used if FAC_PGRAD is greater than zero and its maximum magnitude is set equal to FAC_PGRAD. Lee et al suggest a value = 0.6565 for this.

      There is little experience of using these options yet but previous experience suggests that the source term in the SA model usually needs to be increased and they certainly seem to extend the operating range of axial compressors before stall. However, use of the pressure gradient term is dubious for centrifugal machines where the "centrifugal force", which balances the pressure gradient, acts equally on the boundary layer and mainstream.

      Both FAC_VORT and FAC_PGRAD are read in at the end of the line of data giving FAC_ST0, etc for the scaling factors on the Spalart-Allmaras terms. The default is that they are both zero.

      Two new test cases, 3stg-compr+samods-17.5.dat   and   r37+samods-17.5.dat, both of which use all the new features, are provided in the "multall-test-cases" folder.

3/10/2017   MEANGEN-17.4   and   CONVERT-TO-TECPLOT added.

MEANGEN-17.4 includes several new features which are described in the MEANGEN-INSTRUCTIONS file. Because of the changes previous MEANGEN.IN data sets are not quite compatible with the new version. Several sample data sets for the new version are proved.

CONVERT-TO-TECPLOT.F is a fortran program which reads in the plotting files "flow_out" and "grid_out" written by MULTALL and converts them to a file "tecplot-input.dat"   which can be read by the commercial plotting program TECPLOT. The number of blade passages to be plotted can be chosen and the output is much clearer if two or more passages are used, although the data file can then become quite large.

3/4/2018   Add   MULTALL-OPEN-18.2

MULTALL-OPEN-18.2 has no major changes compared to version 17.5 but has a good deal of "tidying up" and a few minor bug fixes. The most significant changes are :

The calculation of local mass flow rate is tidied up so that it is clear which is the blade flow and which is the total flow including leakage flows, coolant flow and bleed flows. The calculation of power when there are coolant flows has been corrected to use the correct mass flow.

The average change in a conserved variable which is used to set the negative feedback in subroutine TSTEP was the average for the whole flow field. It was realised that for multistage machines with a very high pressure ratio the average change will vary through the machine, i.e. the changes in density and in mass flux, will tend to be proportional to the local values. This will tend to make the negative feedback more powerful in regions of high density and less powerful in regions of low density and will delay convergence. It has been modified so that the average change is evaluated for each blade row and then smoothed to prevent discontinuities in the change. This seems to be of some benefit even in cases without high pressure ratio. It also speeds up the calculation slightly.

The application of the limiting Mach number, MACHLIM, has been tidied up. The limiting velocity and density are based on limiting Mach number and the relative stagnation values at mid-pitch and mid-span at the leading edge of each blade row. The maximum velocity and minimum density in the blade row are then limited to these values. In most cases the limiting Mach number should be chosen so high that the limit will not be applied.

The initial guess of tangential velocity has been changed to prevent any discontinuity at a leading edge or trailing edge. This reduces initial transients and usually improves convergence.

A sample data set with blade cooling, cooltest-18.2.dat, has been added.

There is no change to the input data relative to version 17.5.

17/5/2018   Add MULTALL-OPEN-18.3

The only change in this version is the inclusion of a second option for specifying the cooling flows. The input variable IFCOOL can be set to be 1 or 2 .

If COOLIN = 1 the cooling model is the same as in previous versions using subroutine COOLIN_1 . The coolant ejection velocity is set by its Mach number, which is input as data, and is uniform over the cooling patch.

 If IFCOOL = 2 then a new cooling subroutine, COOLIN_2, is called. This calculates the coolant ejection velocity using the coolant stagnation pressure, which is input, and the local static pressure, and allows it to vary over the cooling patch.

There is also a correction to a minor bug which occurred if using the surface roughness option in subroutine NEW_LOSS.

The data input is the same for both options and is not changed from that in previous versions.

5/07/2018   Add STAGEN-18.1.F

STAGEN-18.1 contains a new option for generating the blade centre line. The centre line is defined by its leading edge and trailing edge angles and a table of values of the relative curvature of the centre line. Only the relative values of curvatures need be input the absolute value is obtained by fitting it to the leading and trailing edge angles. This gives more control over the local blade curvature and is now the preferred method for generating the centre line. This option is chosen by setting INTYPE = 4. There is no change to previous options.