PUFFIn: Quick start with foils

1 How to use PUFFIn

Two files are necessary for computations with PUFFIn. The first one contains the input parameters for the computation and the second one the mesh. By default, the program searches for an input file called "flow.dat" in the same directory than the executable PUFFIn. In this case, the outputs files are also written in the same directory. The mesh file location should be given in the "flow.dat" file (see section 2). If the input file is called "flow.dat" and is located in the same directory than the executable, the computation can be run with the simple command line:

./PUFFIN

The input file might also be located in a different folder with a different name (input.in in the following example) using the command option "flow=":

./PUFFIN flow=pathofthefile/input.in

In that case, the outputs are written in the same directory as the input file.

Parts of the code are parallelized with OpenMP, and the program may by run on several cpus (the number of cpus is provided in the input file). Note that for computations with free surface, the z axis is used for the vertical direction. The free surface is meshed along the x and y directions.

2 List of inputs

A brief description of the options in the input file used for computation with free surface and dynamic positioning is presented in this section. All the parameters given in the input file should be written as:

\+
++ **parameterName** ++
+++
parameterValues

A few mandatory parameters have to be given in the input file. Optional parameters could be omitted and in that case the default value is assumed. The parameters can be written in any order in the input file. An example of input file is given in **??**.

2.1 General parameters

- ***Name*** (mandatory): a string to to choose the name of the log file.
- ***No. bodies*** (mandatory): an integer to provide the number of body in the computation. A mesh file should be provided for each body. Each body is associated with a number i, allowing to apply different parameters for several bodies (see following lines).
- ***Body i: Mesh*** (mandatory): a string to provide the path of the mesh file for body i.
- ***Body i: Lifting*** (mandatory): an integer to select if the body should generate a wake (value 1) or not (value 0).

- ***Body i: Mesh: Rotations*** (Optional, default value: 0.0 0.0 0.0): 3 angles in degrees (floats) might be given to apply rotations around axis x,y and z. The rotation are succesively applied in that order (first around x direction, then y-direction, ...). The center of rotation is the same for the three rotations and is provided with the following option.
- ***Body i: Mesh: Center of rotations*** (Optional, default value: 0.0 0.0 0.0): 3 floats to provide the coordinates of the center used for rotations.
- ***Body i: Mesh: Translations*** (Optional, default value: 0.0 0.0 0.0): a translation might be applied by providing the three components in x,y and z direction (three floats). **Rotations are performed first and then the translation**.
- ***Free stream velocities*** (mandatory): three floats to provide the free stream velocity components (x,y and directions) in m/s.
- ***Fluid density*** (mandatory): a float to provide the fluid density (in kg/m^3).
- ***Number of time steps*** (mandatory): an integer for the number of time steps to do. This is mandatory even for steady computation since the wake is generated in a Lagrangian way based on the time step value.
- ***Time step value*** (mandatory): a float providing the value of the time step in seconds.
- ***Wake: limitation method ?*** (optional, default is 0): an integer to choose if the number of panels in the wake should be limited: 0 –> no limitation; 1–> no. panels is limited.
- ***Wake: limitation: value*** (optional, mandatory if the wake limitation parameter is set to 1): an integer to provide the number of panels in the wake if the wake limitation active.
- ***Steady ?*** (optional, default is 0): an integer accelerate convergence when a steady solution is seek. The acceleration is on for a value equal to 1.
- ***Probes interval*** (optional, default is 0): positive integer to provide the number of time step between two probes. If zero, no probes are written.
- ***Check convergence ?*** (optional, default value is 0): for a steady computation the convergences of the forces might be estimated over the last time steps to stop the simulation. An integer is expected providing the number n of last time steps to consider for convergence estimation.
- ***Convergence tolerance ?*** (optional, default value is 0.005): a float providing the the relative tolerance required for convergence. A value of 0.005 means a variation of less than 0.5% of the m last time step compared to the mean value (over the m last time step) is needed to consider the forces as converged.
- ***Reference point*** (optional, default is 0.0 0.0 0.0): three floats to provide the coordinates x,y and z of the point used to compute the moments.
- ***No. cores*** (optional, default value is 2): an integer to choose the number of cpus used for parallel computations.

2.2 Free surface parameters

- ***Free Surface ?*** (optional, default value is 0): a positive integer to consider free surface in the computation. If the integer value is greater than zero, the free surface taken into account in the simulation. **With the current implementation, the integer value should be 5**.
- ***Free Surface: initial position*** (optional, default value is 0.0): a float to give the initial z coordinate of the free surface.

- ***Free Surface: boundaries*** (optional, mandatory if free sruface is active): 4 floats to provide the boundaries of the free surface (in meters). The first and second values are respectively the minimum and maximum along x. The third and fourth values are respectively the minimum and maximum along y.
- ***Free Surface: no. panels*** (optional, mandatory if free surface is active): two integers to provide the number of panels in x and y direction used for the free surface.

2.3 Dynamic positionning parameters

- ***Dynamic positioning ?*** (optional, default value is 0): if the value is set to 1, dynamic positioning of the body is active to reach target forces F_y^t and F_z^t provided by the user.
- ***Dynamic positioning: target forces*** (mandatory if dynamic positioning is active): two float to provide the values of the target forces F_y^t and F_z^t for the dynamic positioning procedure.
- ***Dynamic positioning: start*** (optional, mandatory if dynamic positioning is active): an integer providing the number of the time step at which the first call to the dynamic positioning procedure is made.
- ***Dynamic positioning: frequency*** (optional, mandatory if dynamic positioning is active): an integer providing the number of the time step between two succesive calls to the dynamic positioning procedure.
- ***Dynamic positioning: reference point*** (optional, default is 0.0 0.0 0.0): three floats to provide the coordinates x,y and z of the center of rotation used in the dynamic positioning procedure
- ***Dynamic positioning: accelerate ?*** (optional, default is 1): an integer to choose if an acceleration method should be used for the dynamic positioning procedure. This method limits the number of calls to the dynamic positioning procedure needed to reach convergence in most cases. A value of 0 switch off the acceleration method.
- ***Dynamic positioning: tolerance ?*** (optional, default is 0.005): the relative tolerance for the differences between the forces and the target forces.

3 Output files

Several output files (ASCII) are generated by the program :

computationName.log: this file contains global informations about the computation.

Cp_body_i_last_PUFFIn.dat: a file is created for each body ***i*** of the computation containing the solution obtained at the last time step. This file contains the velocity, source, doublet and pressure coefficient distributions on the body surface. These files can be opened with Tecplot.

Cp_body_i_PUFFIn.dat: probes files similar to the files **Cp_body_i_last_PUFFIn.dat**. These files can be opened with Tecplot.

Wake_body_i_last_PUFFIn.dat: this file contains the solution on the wake panels at the last time step. This file can be opened with Tecplot.

Wake_body_i_PUFFIn.dat: probes file similar to the file **Wake_body_i_last_PUFFIn.dat**. This file can be opened with Tecplot.

free_surface_last_PUFFIn.dat: this file contains the solution on the free surface panels at the last time step and can be opened with Tecplot.

free_surface_PUFFIn.dat: probes file similar to the file **free_surface_last_PUFFIn.dat**. This file can be opened with Tecplot.

forces_body_i_PUFFIn.dat: this file contains the forces on the body i computed at each time step. The quantities F_x, F_y and F_z are the total forces, while F_xPres, F_yPres and F_zPres are the hydrodynamic contributions (total forces minus the static contributions). This file can be opened with Tecplot.

moments_body_i_PUFFIn.dat: similar to the files **forces_body_i_PUFFIn.dat** but contain the moments on body i instead of the forces. This file can be opened with Tecplot.

dynPos_results.dat: this file contains the results from the dynamic positioning procedure (if active) during the computation. Particularly, it contains the final angles ϕ_y and ϕ_z computed by the procedure. This file can be opened with Tecplot.

residuals_PUFFIn.dat: this file contains the L2-norm of the residuals duraing the computaiton. This file can be opened with Tecplot.

time_per_step.dat: this file contains the real time used to compute each time step.

status.dat: this file contains an integer to gives information about a running computation. This integer can be changed to 1 or 2 to stop the computation. Potential values and meanings are:

- -1 : the program is still running
- 0 : the program normally ended
- 1 : if the user change the value to 1 the program will stop and the solution at last time step will be saved
- 2 : if the user change the value to 2 the program will stop without saving the solution
- 10 : an error occured during the computation

4 An example of input file

```
############################################################
##### Input file for computations ###
############################################################
+
++ Name ++
+++
simulation_foil

+
++ No. bodies ++ # number of bodies
+++
1

+
++ Body 1: Mesh++ # mesh file
+++
foil.dat

+
++ Body 1: Mesh: Translations++ # translation to apply (default 0 0 0)
+++
0.0 0.0 0.0

+
++ Body 1: Mesh: Rotations++ # rotation to apply (default 0 0 0)
+++
0.0 0.0 0.0

+
++ Body 1: Mesh: Center of rotations ++ # center of rotation (default 0 0 0)
+++
0.0 0.0 0.0
```

```
+
++ Body 1: Lifting ++ # should be 1 for foils
+++
1

+
++ Free stream velocities ++ # velocity coordinates in x,y,z-directions (m/s)
+++
-8.0 0.0 0.0

+
++ Fluid density ++ # kg/m3
+++
1026.021

+
++ Number of time steps ++
+++
200

+
++ Time step value ++ # in seconds
+++
0.004

+
++ Wake: limitation method ?++ # 0=no, 1= limit the number of panels in the wake
+++
1

+
++ Wake: limitation: value ++ # expects one integer if "limitation method ?"=1
+++
50

+
++ Free Surface ? ++ # 0= no FS (default), >0= FS considered (optional) should be 5 !
+++
5

+
++ Free Surface: initial position ++ # z coordinate of the initial FS (optional) (default=0.0)
+++
0.2

+
++ Free Surface: boundaries ++ # size of the FS domain min(x), max), min(y), may)
+++
-3.5 +1 -1.5 1.5

+
++ Free Surface: no. panels ++ # no. panels in x-y directions
+++
70 40

+
++ Probes interval ++ # 0=no probes (default), or provide the number of time step between probes (optional)
+++
10

+
++ Steady ? ++ # remove time dependance # should be used for steady computations
+++
1

+
++ Check convergence ? ++ # computation stop if convergence is obtained within n iterations
+++
30

+
++ Convergence tolerance ? ++
+++
0.005

+
++ Dynamic positioning ?++ # for automative positioning
+++
1

+
++ Dynamic positioning: start ++ # start at iteration n
+++
10
```

```
+
++ Dynamic positioning: frequency ++ # dynamic positioning called after n iterations
+++
10

+
++ Dynamic positioning: target forces ++ # target forces to reach for dynamic positioning (Fy, and Fz)
+++
150.0 800.0

+
++ Dynamic positioning: reference point ++ # reference point for rotations in the positioning
+++
0.0 0.0 0.0

+
++ Dynamic positioning: accelerate ? ++ # default is =1, helps for faster convergence in most cases
+++
1

+
++ Dynamic positioning: tolerance ? ++ # default 0.005 -> 0.5%
+++
0.005

+
++ No. cores ++ # number of cores to use, defaults is 2
+++
6
```