AFiD-BVI example: Normal Blade Vortex Interaction with a Thin Cylinder

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This document serves as an example to simulate Normal Blade Vortex Interaction (BVI) with a thin cylinder using the AFiD-BVI code.

The interaction between the vortex and a body, such as a blade or a cylinder, depends on various parameters, such as body velocity, vortex core radius, vortex swirl velocity, body geometry and size, and turbulence within the body's boundary layer. In particular, for a body impacting a vortex with no axial flow, three dimensionless parameters are relevant. These parameters are: the impact parameter ($I_P = 2\pi\sigma_0 V/\Gamma$), which is the ratio of the body's free-stream velocity to the maximum vortex swirl velocity, where σ_0 is the radius of the vortex, V the velocity of the body, and Γ the vortex's circulation; the vortex Reynolds number ($Re_\Gamma = \Gamma/\nu$), where ν is the kinematic viscosity; and the body thickness parameter ($T = D/\sigma_0$), which is the ratio of a characteristic length D such as the blade's curvature or the cylinder diameter D, to the vortex core radius σ_0.

For this simulation, we will set the impact parameter $IP = 0.25$, the thickness parameter $T \approx 1$, and the vortex Reynolds number $Re = 1000$.

1 Setting Up Simulation

1. Download and compile the code, ensuring all prerequisite modules are met.

2. Input parameters are set in the bou.in, mlspart.in and spos.in files. Changing these parameters does not require a recompilation of the code. Check the manual on the main page for details on input configurations.

3. For this example, we will use the cylinder.gts file in the main page. The computational domain should the large enough to reduce inference from the periodic boundaries, so $XLEN = YLEN = 3.0$ and $ZLEN = 9.0$. The provided cylinder will have a length of 8.0 and a diameter of 0.1. The grid resolution will taken as $N1M = 624$, $N2M = 624$, $N3M = 1872$. The vortex is initialized with a vortex core radius of 0.095. The vortex Reynolds number is set to $Re = 1000$, and the vortex speed is set to 0.419. Given these values, the impact parameter will be $IP = 0.25$, the thickness parameter $T \approx 1$, and the vortex Reynolds number $Re = 1000$.

2 Running the Simulation

1. Ensure NREAD and PREAD are 0 in the input files when running the simulation for the first time.

2. Start the simulation by submitting a sbatch job. The executable is boutnp and job.sbatch is a sample sbatch job script.

3. A list of output files generated by the code is given in the manual on the main page.

References

[1] Erwin P. Van Der Poel, Rodolfo Ostilla-Mónico, John Donners, and Roberto Verzicco. A pencil distributed finite difference code for strongly turbulent wall-bounded flows. *Computers & Fluids*, 116:10–16, 2015.

[2] Vamsi Spandan, Valentina Meschini, Rodolfo Ostilla-Mónico, Detlef Lohse, Giorgio Querzoli, Marco D de Tullio, and Roberto Verzicco. A parallel interaction potential approach coupled with the immersed boundary method for fully resolved simulations of deformable interfaces and membranes. *Journal of computational physics*, 348:567–590, 2017.