Particles in a Periodic Double Shear Flow - Pre-Analysis & Start-Up

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Pre-Analysis & Start-Up

In the *Pre-Analysis & Start-Up* step, we'll review the following:

- **Theory for Fluid Phase**
- **Theory for Particle Phase**
- **Choosing the Cases**

Pre-Analysis:

A particle laden flow is a multiphase flow where one phase is the fluid and the other is dispersed particles. Governing equations for both phases are implemented in Fluent. To run a meaningful simulation, a review of the theory is necessary.

Fluid Phase:

In the simulations considered for this tutorial, the fluid flow is a 2D perturbed periodic double shear layer as described in the first section. The geometry is Lx = 59.15m, Ly = 59.15m, and the mesh size is chosen as Unable to find DVI conversion log file. in order to resolve the smallest vorticies. As a rule of thumb. One typically needs about 20 grid points across the shear layers, where the vorticies are going to develop. The boundary conditions are periodic in the x and y directions. The fluid phase satisfies the Navier-Stokes Equations:
-Momentum Equations

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-Continuity Equation

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where Unable to find DVI conversion log file. is the fluid velocity, Unable to find DVI conversion log file. the pressure, Unable to find DVI conversion log file. the fluid density and Unable to find DVI conversion log file. is a momentum exchange term due to the presence of particles. When the particle volume fraction Unable to find DVI conversion log file. and the particle mass loading Unable to find DVI conversion log file. are very small, it is legitimate to neglect the effects of the particles on the fluid: Unable to find DVI conversion log file. can be set to zero. This type of coupling is called one-way. In these simulations the fluid phase is air, while the dispersed phase is constituted of about 400 glass beads of diameter a few dozens of micron. This satisfies both conditions Unable to find DVI conversion log file. and Unable to find DVI conversion log file.

One way-coupling is legitimate here. See ANSYS documentation (16.2) for further details about the momentum exchange term.

Particle Phase:

The suspended particles are considered as rigid spheres of same diameter d, and density Unable to find DVI conversion log file.. Newton's second law written for the particle i stipulates:

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where Unable to find DVI conversion log file. is the velocity of particle i, Unable to find DVI conversion log file. the forces exerted on it, and Unable to find DVI conversion log file. its mass.
In order to know accurately the hydrodynamic forces exerted on a particle one needs to resolve the flow to a scale significantly smaller than the particle diameter. This is computationally prohibitive. Instead, the hydrodynamic forces can be approximated roughly to be proportional to the drift velocity ref3:

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where Unable to find DVI conversion log file. is known as the particle response time, Unable to find DVI conversion log file. the particle density and D the particle diameter. This equation needs to be solved for all particles present in the domain. This is done in Fluent via the module: Discrete Phase Model (DPM).

Choosing the Cases:

The particle response time measures the speed at which the particle velocity adapts to the local flow speed. Non-inertial particles, or tracers, have a zero particle response time: they follow the fluid streamlines. Inertial particles with Unable to find DVI conversion log file. might adapt quickly or slowly to the fluid speed variations depending on the relative variation of the flow and the particle response time.

This rate of adaptation is measured by a non-dimensional number called Stokes number representing the ratio of the particle response time to the flow characteristic time scale.

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In these simulations, the characteristic flow time is the inverse of the growth rate of the vortices in the shear layers. This is also predicted by the Orr-Sommerfeld equation. For the particular geometry and configuration we used in this tutorial, the growth rate is Unable to find DVI conversion log file.. When St = 0 the particles are tracers. They follow the streamlines and, in particular, they will not be able to leave a vortex once caught inside.

When Unable to find DVI conversion log file., particles have a ballistic motion and are not affected by the local flow conditions. They are able to shoot through the vorticies without a strong trajectory deviation. Intermediate cases Unable to find DVI conversion log file. have a maximum coupling between the two phases: particles are attracted to the vorticies, but once they reach the highly swirling vortex cores they are ejected due to their non zero inertia.

In this tutorial, we will consider a nearly tracer case St = 0.2, an intermediate case St = 1 and a nearly ballistic case St = 5.

Go to Step 2: Geometry

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