Additional Reading Material

Grid Resolution and Convergence in OpenFOAM

Courant Number

The Courant Number for a cell is defined by

$$Co = \frac{\delta t |U|}{\delta x}$$

where δt is the time step,
$|U|$ is the magnitude of velocity, and
δx is the cell size along the direction of the velocity.

To ensure that the Courant number is less than 1, time-step should satisfy

$$\delta t < \frac{\delta x}{|U|}$$

This inequality needs to be satisfied for all the cells in the domain. Since the cell size is uniform throughout the domain, the goal is to find the cell(s) having the maximum magnitude of velocity. For the lid driven cavity flow, maximum velocity occurs in cells next to the lid. Therefore, the maximum magnitude of velocity in the domain is 1 m/s.

Now, let's consider 20 cells along the x and y directions in the domain. Since the domain is a 0.1 m edged square, the cell size is

$$\delta x = \frac{0.1}{20} = 0.005 \text{ m}$$

The time-step, therefore, to ensure that the Courant number is less than 1, should satisfy

$$\delta t < \frac{\delta x}{|U|} = \frac{0.005 \text{ m}}{1 \text{ m/s}} = 0.005 \text{ s}$$

Grid Independence Study

Increasing the number of cells does give more accurate results. But, it does so at the expense of computational time. Grid independence study helps tackle this problem by optimizing computational time.

The results of a grid independence study depends on the parameter being monitored and the tolerance we specify. Consider the following data from a grid independence study

Number of Cells	Pressure at the Centre of Domain (Pa)
20 X 20 = 400	0.00581712
40 X 40 = 1600	0.00412639
80 X 80 = 6400	0.00364832
160 X 160 = 25600	0.00355786

For a tolerance of 10^{-3}, the pressure value is can be considered to be invariant after 6400 cells. Had the tolerance been 10^{-4}, the study would have to be conducted for more refined mesh.