Design and Analysis of Fluid Structure Interaction for Elbow Shaped Micro Piping System

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Introduction: Fluid Structure Interaction in micro pipe lines helps in analyzing the deformation on the channel walls by fluid flow. Flexible obstacle when placed at different positions results in analysis of stress at different places for L, T & multiple pipe line intersections.

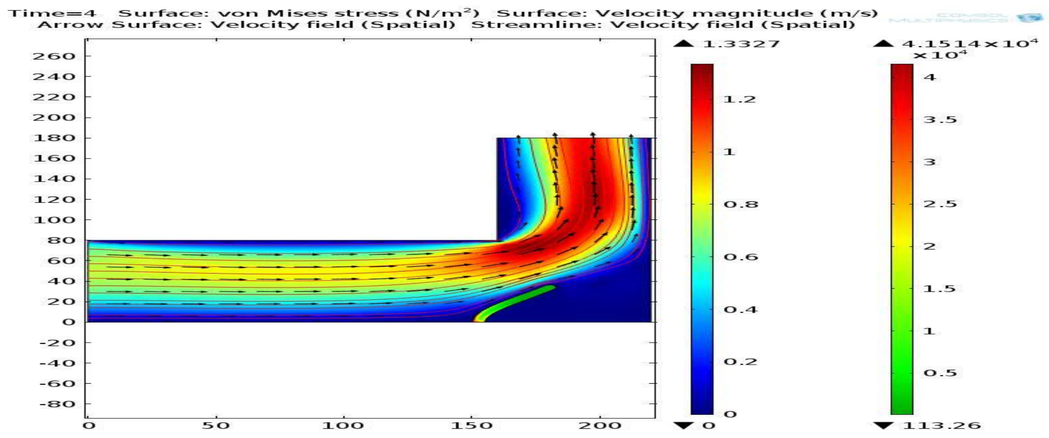

Figure 1. Von Mises Stress & Velocity Magnitude for elbow shaped pipe with one obstacle in flow channel.

Computational Methods: Identification of size and location of swirls in the flow channel are done by changing the inlet mean velocity. Navier-stroke equations are used here for defining the flow of incompressible fluid.

$$\rho\frac{\partial \mathbf{u}}{\partial t} - \nabla \cdot [-p\mathbf{I} + \eta(\nabla \mathbf{u} + (\nabla \mathbf{u})^T)] + \rho((\mathbf{u} - \mathbf{u}_m) \cdot \nabla)\mathbf{u} = \mathbf{F}$$

$$-\nabla \cdot \mathbf{u} = 0$$

Model geometry consists of elbow (L) shaped micro flow channel with inlet on the left boundary, with obstacle place at the end of right boundary. Vertical rectangular obstacle with 5 μm wide, 47.5 μm, with semicircular top sits 150 μm away from the channel left boundary.

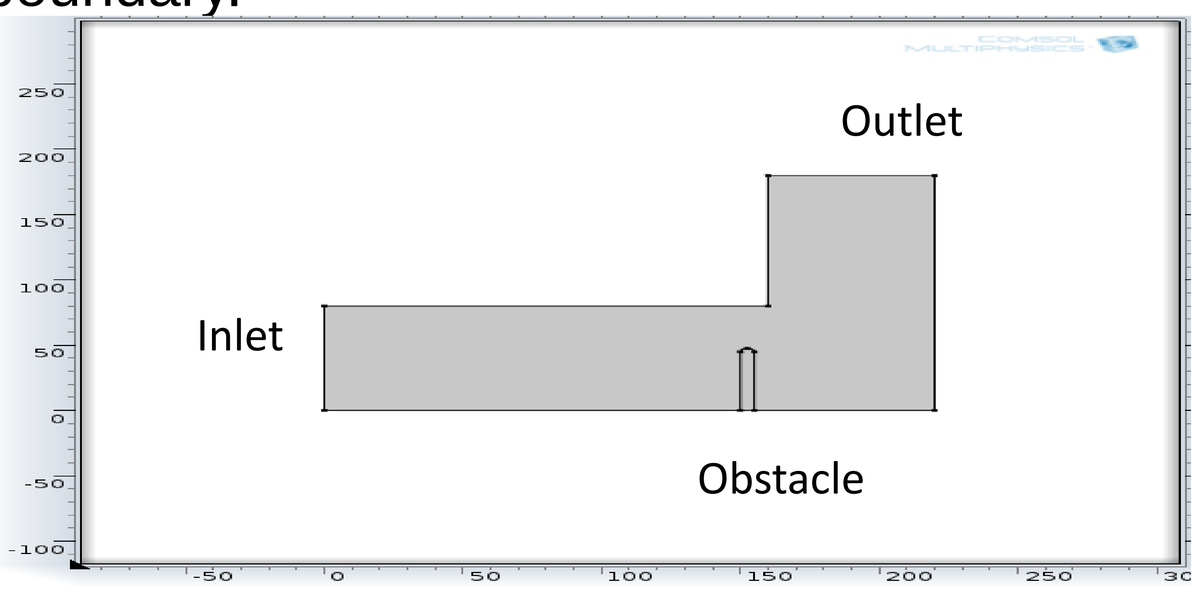

Figure 2. Model Geometry of Elbow Shaped Pipe Line.

Results: Flow vortices were introduced after first obstacle when two obstacles were placed in flow channel. Greater the obstacle displaced from its position, greater the stress on the walls being applied due to change in flow direction.

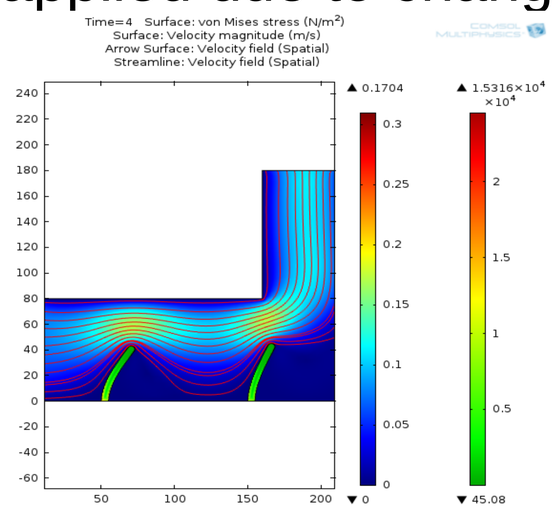

Figure 3. Streamlines of fluid Flow for two obstacles.

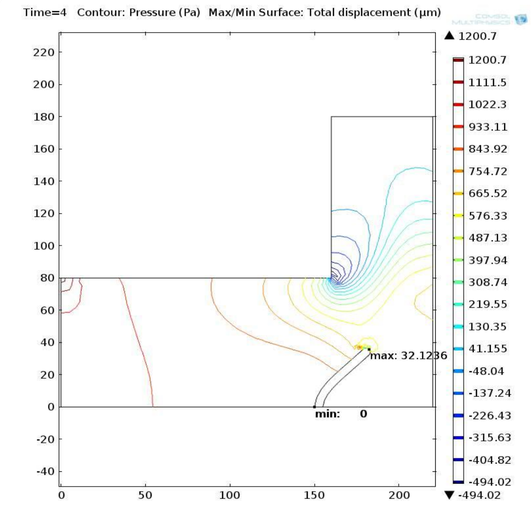

Figure 4. Max/ Min Total Displacement of obstacle.

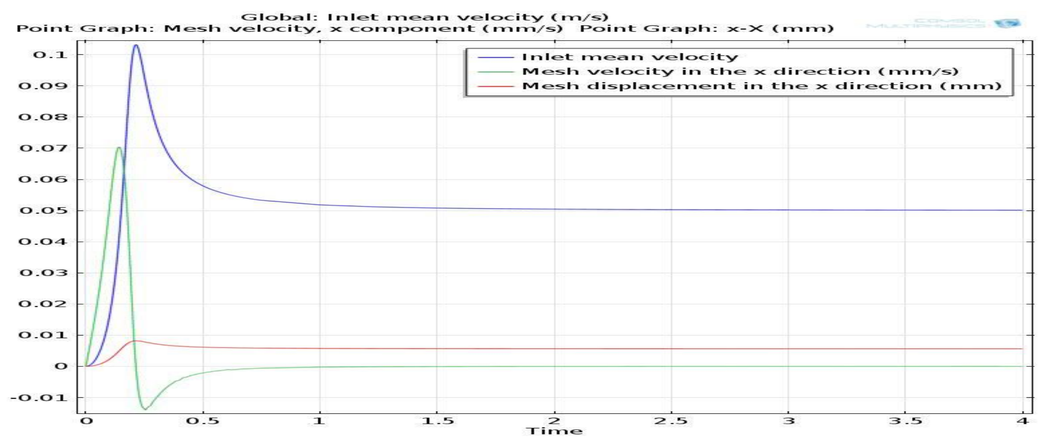

Figure 5. Inflow velocity (Blue), horizontal mesh velocity (Green) and mesh deformation (Red), with respect to time interval from T=0 Seconds to 4 Seconds.

Conclusions:

FSI takes place more when the obstacle is trying to be displaced from its normal position for increased variable inlet mean velocities. Flow channel position can be analyzed for different degrees & obstacle shapes can be changed from rectangular to circular, elliptical for future studies.

References:

1. C. S. W. Lavooij and A. S. Tijsseling, Fluid Structure Interaction In Liquid-Filled Piping Systems, Journal of Fluids and Structures, 5, Pg., 573-595, 1991.
2. www.comsol.co.in model/ fluid-structure-interaction-361.