Study of Flow Characteristics and Flow Optimization inside a Cylindrical Pipe

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Introduction: Fluid flow in a cylindrical pipe needs to be characterized for various applications. The flow ideally should be laminar in nature as it provides many benefits. But the flow is never completely ideal. The flow tends to form vortexes or becomes turbulent owing to many factors like inlet angle, inlet velocity, protrusions in the path of flow etc. This work focuses on studying the characteristic behaviour of flow inside a cylindrical pipe with non-laminar flow. It also aims at achieving laminar flow after a turbulence effect caused by some obtrusion in the flow path. It discusses the mechanisms in idealizing a flow and studies the effect of optimization methods employed like choosing a proper inlet angle, adjusting the inlet flow velocity, aligning the exhaust port. It also aims to discuss boundary layer effects when an obtrusive object placed in the flow and optimization of the flow with varying the object flow facing angle, characteristic length of preflow and post flow path of the fluid.

Computational Methods: The behavior of the fluid flow in the pipe depends on various material properties like density of the fluid, its dynamic viscosity, length of the flow and velocity of the flow. The model has a right angled inlet and outlet ports. The fluid flows over an obtrusion. Obtrusion causes boundary effect and intron turbulence.

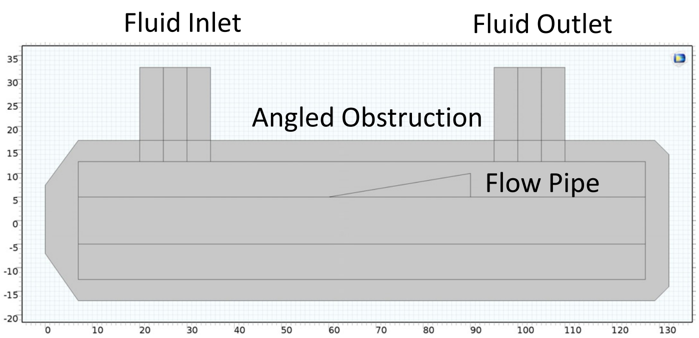


Figure 1. Geometry of the model

Initial and boundary conditions assumed are mentioned below.

$$\nabla.(\rho u) = 0$$

$$\rho(u.\nabla)u = \nabla.\left[-\rho l + \mu\left(\nabla u + (\nabla u)^T\right) - \frac{2}{3}\mu(\nabla.u)l\right] + F$$

$$\left[\mu\left(\nabla u + (\nabla u)^T\right) - \frac{2}{3}\mu(\nabla.u)l\right]n = 0$$

Results: The flow nature of a fluid in a cylindrical pipe was simulated. The turbulence caused by the flow into the pipe is mainly due to the inflow through narrow inlet port and the exhaust through a narrow outlet port. Obtrusion in the path of the flow caused boundary layer. Optimal placement of the obtrusion was decided based on suppression of boundary effect. The flow was further optimized to provide a laminar flow with low, non-zero velocity by orienting the obtrusion to an angle of 11 degrees facing the inlet fluid flow through the pipe

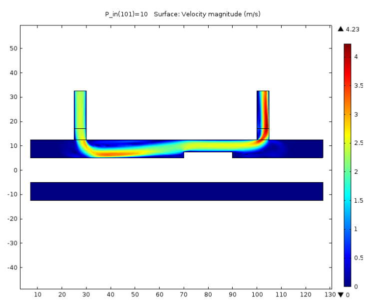


Figure 2. Boundary Layer

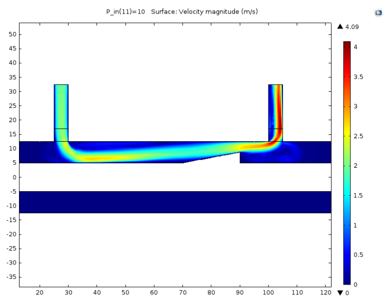
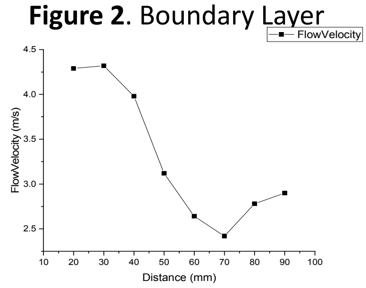


Figure 3. Angled Obtrusion



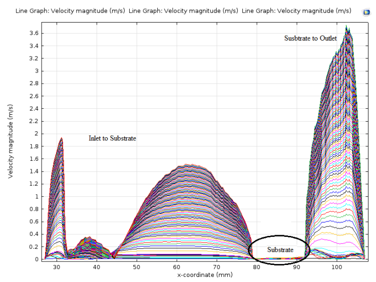


Figure 4. Velocity profile in Pipe **Figure 5**. Velocity Profile in Pipe

Conclusions: The study of fluid flow inside a cylindrical pipe with 90° aligned inlet and outlet ports was studied. Flow Characteristics when subjected to a obtrusion and its effect were analyzed. Optimal placement of obtrusion and angle was chosen to maximize laminar flow in the pipe.

References:

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