Change in the Flow Rate Through a Deformed Valve

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Introduction : Optimization is one of the greatest challenges in Engineering science. In this work, an optimization problem is solved for a pipe. By choosing the right geometry we were able to make the ratio of the flow in one direction to the opposite direction as maximum as possible.

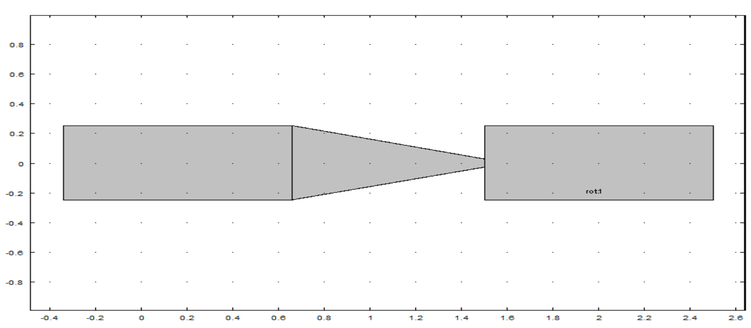

Figure 1. Geometry of the Pipe

Computational Methods: We used the turbulence flow module. It solves the Reynolds-Averaged Navier Stokes (RANS) equations which are the following

$$\rho\frac{\partial U}{\partial t}+\rho U.\nabla U+\nabla.\left(\rho u'\times u''\right)=-\nabla.P+\nabla.\mu\left(\nabla U+(\nabla U)^{T}\right)+F$$

$$\nabla.U=0$$

To design the pipe we used two rectangular figures that are connected to each other with a triangular like shape which we like to call it a “Deformed Valve”. The connection angle (marked in green ,Figure 2 and 3) is changed in a way that the length of the connection part stays the same.

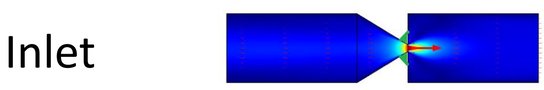

Figure 2. The C. angle is 60 D

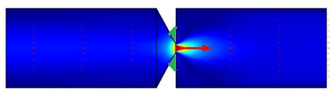

Figure 3. The C. angle is 30 D

Results: We Calculated the mean velocity of liquid water at the connection area for two cases.1-When the water is flowing from left to right (Figure 4).2-When the water is flowing from right to left (Figure 5).Then the ratio of the velocities in the 1st case to the 2nd are calculated for different angles and we found that for 75 the ratio is the biggest (Figure 6).

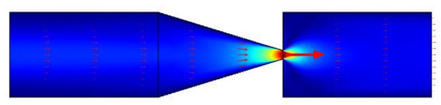

Figure 4. 1st case for 75 D

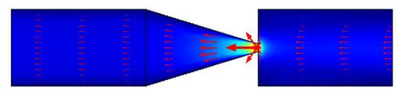

Figure 5. 2nd case for 75 D

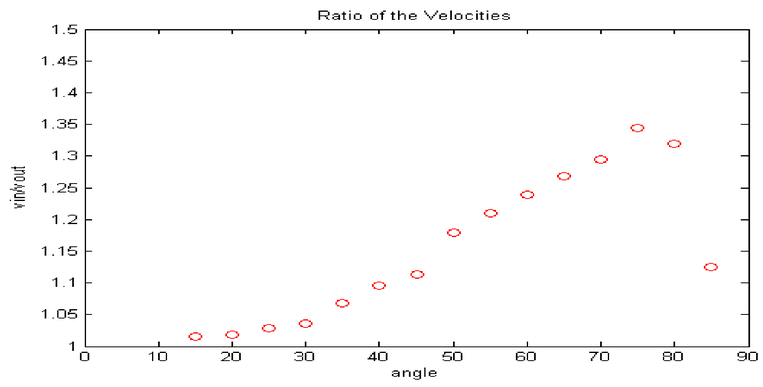

Figure 6. Ratio of the velocities vs. the connection angles

Conclusions: As a result, this kind of pipes can be utilized in Nuclear Reactors to decrease the flow of the coolant in the opposite direction if there is a pressure drop .In future, we expect to include heat transfer module to design refrigerators working with shock waves.

References:

1. D.C. Wilcox, “Turbulence Modeling for CFD,” 2nd ed., DCW Industries, 1998.