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CFD ANALYSIS OF HOT AND COLD STEAM FLOW IN AN ELBOW

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Abstract- Elbow is a device used for fluid mixing and heat transfer through fluids in pipes. The design of the Elbow affects its function. In this project, we have a deal with a particular case of Elbow in two different types of fluid flow i.e. laminar and turbulent flow and compared them. Here we are using a venturi pipe as a hot inlet for easy mixing of hot and cold water. In order to check the proper mixture output, the diameter of the pipe and the flow speed is To be varied and the results obtained from the solution will be compared with the normal existing one using ANSYS Software. At the end of the project, we get some useful flow pattern diagrams regarding velocity, pressure, and temperature inside the Elbow that can be used as a reference by any designer for Elbow.

Keywords: Elbow, laminar and turbulent flow, ANSYS Software

1. INTRODUCTION

Elbow is a device used in pipes to transfer, mixing of two dissimilar fluid of different parameters. This transfer, mixing of fluid plays a big role in the productivity. It is desirable that design of Elbow should be as finest as possible. To get a good design, it is important to know the flow distribution inside the Elbow, so that prediction can be done regarding flow distribution which can be used as reference for the design of Elbow. In this project, we have studied the Elbow to get such a solution which can use as reference for design. In this project report, we have made the CFD (Computer Fluid Dynamics) analysis of Elbow, to know the flow and heat transfer in Elbow. Since the Elbow configuration is encountered in piping in power plants and process industries. It is always important to predict the flow and temperature field in the part of the mixing area in order to properly design the junction. For this use we have used the ANSYS software to make the CFD i.e. Computer Fluid Dynamics analysis of Elbow. Now in present day ANSYS become the world's leading engineering software, and their solutions are very much accurate than other. Therefore, now a days all the industries are using this software for their job in different ways.

A. Aim of the paper

1. To study the Elbow and generate Fluid Flow pattern.

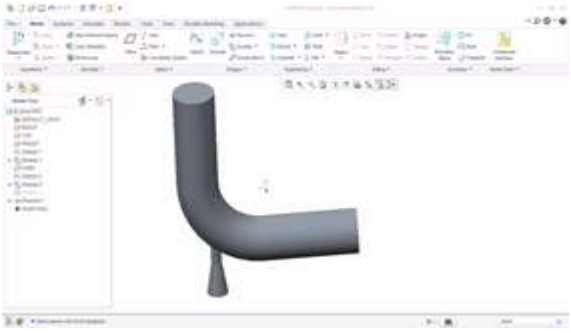
2. To get solution to know the heat transfer and flow pattern which can be used as reference for Elbow designing.

3. To analyze the pressure, velocity, temperature and mass transfer distribution through different flow pattern.

4. To analyze the difference in pattern by laminar and turbulent flow.

B. ELBOW

Elbow is a fluid flow device, which is used to mix, transfer two dissimilar fluids of either same type with varying parameters or of dissimilar types with same parameters. The Elbow used for study in this project have utilize the similar fluid water as working fluid but have dissimilar parameters like velocity and temperature. we are using a venture pipe as an hot inlet for easy mixing of hot and cold water.



2. LITERATURE REVIEW

Elbow has a major application in the field of heat and mass transfer by fluid. This directly affects the productivity of products, since it transfers, mixes the working fluid. The quality of transferring and mixing have proportional effect on the quality. Elbow has been used from the start of production but still the design of Elbow has not varied much. Still a traditional type Elbow are applied for liquid transfer. Only few works have done regarding the

development of Elbow design. In this series one of the major work was done by Quamrul H. Mazumder for mechanical engineering, University of Michigan-Flint, Flint, MI 48502, USA.

P.L. Spedding, E. Benard and N.M. Crawford have made another crucial study of Elbow regarding the Fluid flows through a vertical to horizontal 90 Elbow bend III three phase flow. This study also gave improvement in the Elbow.

3. PHASE OF WORKING

A. Modeling of Elbow

In this project, the design and meshing of Elbow has done with the using ANSYS fluent in ANSYS. The design and meshing have much importance regarding the quality of results.

B. Analysis in Laminar and Turbulent Flow

After finishing the geometry and meshing as per requirement, then analysis has done with two different case of flow i.e. firstly with laminar flow and then after with turbulent flow.

Comparison of Results

For the good design it should be necessary to know the differences in flow pattern with laminar and turbulent so that design should made by keeping both flow.

4. VENTURIMETER

When a venturimeter is attached in the pipe carrying the liquid whose flow rate to be measured, a pressure drop occurs between the inlet and throat of the venturimeter. This pressure drop is measured using a differential pressure sensor and by calibrated, this pressure drop becomes a measure of flow rate.

A.Applications:

- It is used where high pressure is required.
- Can be used in measuring flow rates of liquid,gases,suspended solids, and dirty liquids.
- Can measure high flow rates in pipes having minimum diameter.

B.Advantages of venturimeters

- Less chances of getting clogged.
- Coefficient of discharge is maximum.
- The behaviour can be predicted perfectly.
- Can be installed in any angle.

C. Limitations

They are large in size.

- High initial cost, installation and maintenance.
- Require long laying length. That is, the veturi has to be processed by straight pipe which is free from fittings to avoid turbulence in flow, for satisfactory operation.
- Pipes below 7.5cm diameter can not be used.

D. Types

1. Convergent venturi meter
2. Divergent venturi meter
3. Convergent-Divergent venturi meter

5. PROBLEM SOLVER AND PROCEDURE

A. Solution steps

I. Simple Solver

This solver is used to get the starting preliminary solution of the particular problem. This solver can solve with the accuracy of 90%. For the further development in solution coupled solver can used after this.

II. Coupled Solver

The Elbow solution computed in the initial part of this tutorial used the SIMPLE solver for pressure-velocity coupling. For general fluid-flow problems, convergence speed can be increased by using coupled solver. You will now swap the solution method to a coupled solver.

III. Adaptation

For the first two runs of tutorial, we have solved the Elbow problem using a coarse mesh. The Elbow solution can be increased further by refining the mesh to good resolve the flow details. ANSYS Fluent provides a built-in capability to easily adapt the mesh according to solution.

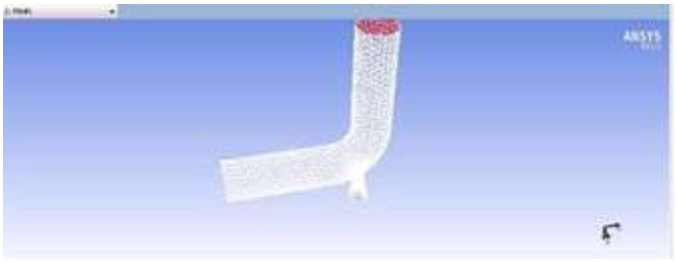
6. MODELING AND MESHING

A. Problem setup

The setup considered in these project is shown.

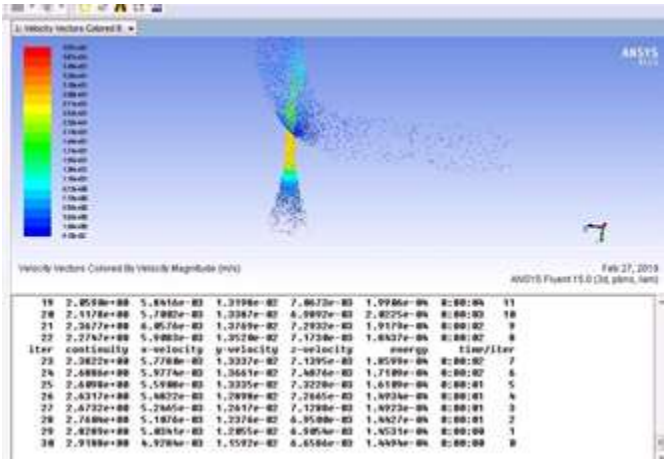
The cold fluid having temperature 293.15 K enters through the inlet of with the velocity of 0.4 m/s while the hot fluid of temperature 313.15 K enters through the venturi with velocity of 1.2 m/s. They mixed inside the Elbow and exchanges their heat and these flow pattern becomes major role in order to design a good Elbow.

B. Meshed design



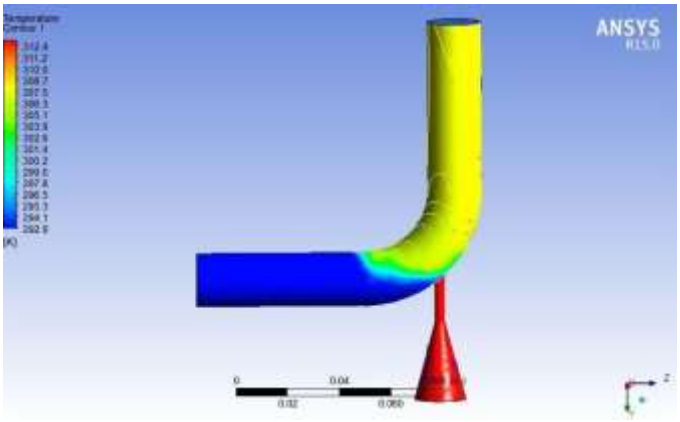
7. ANALYSIS AND SIMULATION

A. Velocity Comparison:



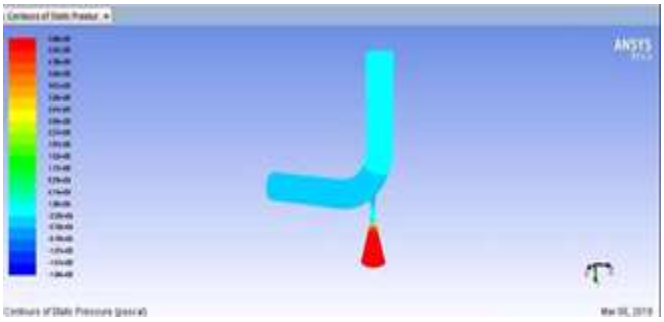
By referring to the above flow diagram, in the throat area of the venturi the velocity is at max range,by this principle, the laminar flow of the water is converted to turbulant flow and the mixing of hot and cold water is exact to the requirement.

B. Temperature Comparison:



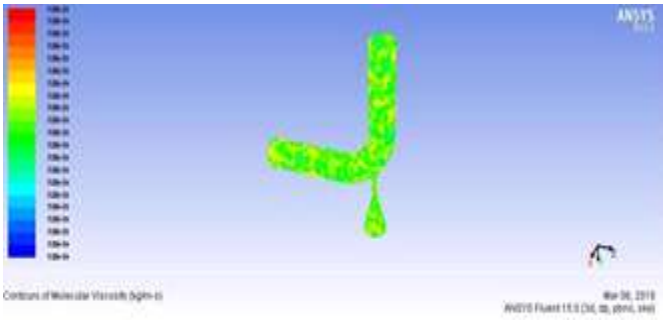
The above flow diagram show the temperature nature inside the elbow. The cold water from pipe inlet(293 K) and the hot water from venturi inlet(313 K) combines with help of turbulant nature of flow and becomes to moderate and the required temperature(307 K).

C.Pressure Comparison:



The above flow diagram shows the pressure nature inside the elbow. The hot water is sent as a maximum pressure(4.7 Bar) through the venturi, while reaching the venturi throat the velocity of water increases and the pressure decreases.(ie. When velocity increases, pressure decreases).Therefore the mixing of water is as our requirement. The elbow pressure rate is 0.27 Bar.

D.Viscosity comparison:



We have also taken the viscosity nature of the fluid inside the elbow pipe. The dynamic viscosity of water is **8.90** ⍰ **10^{-4} Pa**

8. APPLICATION AND BENEFITS

Elbow has variety of application in all manufacturing companies. The solution got through above analysis will also useful in many ways. It can be used as

- For the design of Elbow to have a best geometry.
- This is used for the analysis of laminar flow in Elbow.
- This report can used for the analysis ofturbulent flow in Elbow.
- This can be used for the study in difference design requirement for laminar and turbulent flow.

A. Benefits

This reports display the combine report on laminar and turbulent flow pattern. This provide a nice idea about the distribution and flow pattern of temperature, velocity, and pressure inside the Elbow.This provides a complete report on Elbow and fluid flow habits,so that it can used for a good design idea.

B. Final Report

The results obtained through the analysis of Elbow above can be used as reference for the design of Elbow.

This can be used for the design for both laminar and turbulent flow.

9. ACTUAL PROTOTYPE

The above shown picture is our actual prototype model. This prototype is made up of PLA material (polyLactic acid) using the method of 3d printing.

PLA is a type of plastic made up of FERMENTED PLANT STARCH, it is usually made from corn. It is biodegradable type of plastic.

Now-a-days is quickly becoming a popular alternative to traditional petroleum-based plastics.

10. DISCUSSION AND CONCLUSION

A number of concept and conclusion can be drawn through the results obtained, but we have focused on the pressure, velocity and temperature distribution in the Elbow under some specific parameters. The quality of result mostly depends on the software used and parameters given. In this project we have given the parameters obtained from a reputed reports, that have made the project on Elbow with some other concept and method.

This project, we have used the ANSYS 15.0 software for the analysis, which provides the solution that is reliable than the solution obtained from other software. In present, big organizations, companies are using this software and complete function depends upon this software.

Since we have focused on particular parameters, one can study all the parameters obtained through this analysis of Elbow for better design idea. Therefore this project have big field of research for obtaining a good solution. The Future scope of this project becomes high for a best analytical. At present time, the research regarding Elbow does not have a enough number. Only few research has done for this. Therefore there is many things that can be used for study in future.

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