



ELBOW MIXTURE ANALYSIS

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Abstract—The transfer and mixing of fluids is common procedure that happen almost in all manufacturing companies. The pipe which transfers and mixes heat have different sections, the quality and accuracy of product have directly related to the quality of heat transfer and mixing of fluids.

In this project, we have studied one of the device used for fluid mixing and heat transfer in pipes i.e. ELBOW MIXTURE. Elbow Mixture is a device used for fluid mixing and heat transfer through fluids in pipes. The design of Elbow mixture affects its function. Therefore for a designer of Elbow Mixture, it should be very necessary to have such a reference through which, he can predict the Fluid flow and Heat transfer phenomena inside the Elbow mixture.

Since, information about Elbow Mixture is rare, therefore in this project we have deal with a particular case of Elbow mixture in two different type of fluid flow i.e. laminar and turbulent flow, and compared them. So that a designer should ensure about the difference in flow pattern in both flows.

For these purpose, we have used the ANSYS software for analysis which becomes most reliable engineering software than other. For a quality solution, we have made the each type of flow in three different steps. Firstly we used simple solver, then after a improved method of coupled Solver available in ANSYS and then we use adaptation for checking any

further improvement by refining the cells in meshing.

At the end of project, we get some useful flow pattern diagrams regarding velocity, pressure and temperature inside the Elbow mixture that can be used as reference by any designer for Elbow mixture.

I. INTRODUCTION

Elbow Mixture is a device used in pipes to transfer and mixing of two different fluid of different parameters. This transfer and mixing of fluid plays big role in the productivity. Therefore, it is desirable that design of Elbow Mixture should be as optimum as possible.

To get a good design, it is essential to know the flow distribution pattern inside the Elbow Mixture, so that prediction can be made regarding flow distribution which can be used as reference for the design of Elbow mixture. In this project, we have studied the Elbow mixture 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 mixture, to determine the flow and heat transfer pattern in Elbow mixture. Since the mixing Elbow configuration is encountered in piping systems in power plants and process industries. It is often important to predict the flow field and temperature field in the area of the mixing region in order to properly design the junction.

We have analyzed the Elbow mixture in laminar as well as turbulent flow and compared them to see the difference in flow distribution so that design can be made with respect to both type of flow. Since it becomes very costly to prepare the Elbow mixture practically and have no means to analyze that in physical form. Therefore, all the studies and analysis have done through a engineering software.

For this purpose we have used the ANSYS software to make the CFD i.e. Computer Fluid Dynamics analysis of Elbow mixture. Now in present day ANSYS become the world's leading engineering software, and their solutions are very much reliable than other. Therefore, now a days all the organizations are using this software for their work in different ways.

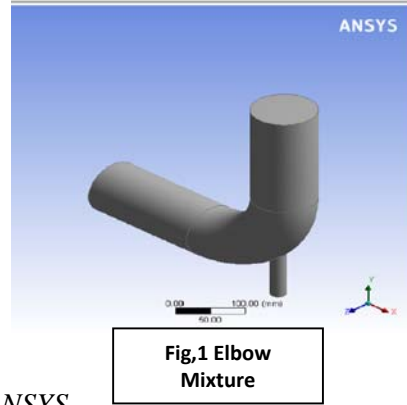
A. Aim of the project

The main objectives of our projects are listed below:-

1. To study the Elbow mixture and generate Fluid Flow pattern.
2. To get solution to determine the heat transfer and flow pattern which can be used as reference for Elbow mixture designing.
3. To analyze the pressure, velocity, temperature and mass transfer distribution and pattern through laminar and turbulent flow.
4. To analyze the difference in pattern by laminar and turbulent flow.

B. ELBOW Mixture

Elbow Mixture is a fluid flow device, which is used to mix and transfer two different fluids of either same type with different parameters or of different types with same parameters. The Elbow mixture used for study in this project have utilize the same fluid water as working fluid but have different parameters like velocity and temperature.



Fig,1 Elbow Mixture

C. ANSYS

ANSYS, Inc. is an engineering simulation software (computer-aided engineering, or CAE) developer headquartered south of Pittsburgh in the south pointe business park in Cecil township, Pennsylvania, United States. One of its most significant products is ANSYS CFD, a proprietary computational fluid dynamics (CFD) program.

ANSYS software is a combined unit of different individual software such as :-

1. ANSYS Fluent:- This part of ANSYS is used the CFD (Computer Fluid Flow) analysis of a solid as well as Fluid.
2. ANSYS Structure:- This part of ANSYS is used to solve the mechanics problem relating to stress, deformation, and loads.
3. ANSYS Thermal:- This part of ANSYS deal with the temperature relating problems like enthalpy, heat transfer etc.

II. LITERATURE REVIEW

Elbow Mixture has a wide application in the field of Mass and Heat transfer by fluid in pipes. This directly affects the productivity of products, since it transfers and mixes the working fluid. The quality of transferring and mixing have proportional effect on the product quality. Elbow mixture has been used from the beginning of production but still the design of Elbow mixture has not varied much. Still a traditional type Elbow mixture are applied for fluid transfer.

Only few works have made regarding the improvement of Elbow mixture 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.

Computational fluid dynamics (CFD) analysis was performed in four different 90 degree Elbows with air-water two-phase flows. The inside diameters of the Elbows were 6.35 mm and 12.7 mm with radius to diameter ratios (r/d) of 1.5 to 3. The pressure drops at two different upstream and downstream locations were investigated using empirical, experimental, and computational methods. The combination of three different air velocities, ranging from 15.24 to 45.72 m/sec, and nine different water velocities, in the range of 0.1–10.0 m/s, was used in this study.

CFD analysis of two-phase flow in a 6.35, and 12.7 mm pipe diameter with ratio of 1.5 and 3 was performed using commercially available CFD code FLUENT. Analysis was performed for three different air velocities between 15.24, 30.48, and 45.72 m/s and six different water velocities, ranging from 0.1 to 10.0 m/s, in each of the four Elbows. Pressure drop profiles and their respective cross-sectional pressure contour maps were presented for characteristic flow behaviors in multiphase flows. After these, there is not having any more study relating to Elbow mixture.

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

We can get some little bit information about the Elbow mixture through the tutorial guide of ANSYS fluent. This gives the dimensions and parameters which have used in this project for our analysis.

III. PHASE OF WORKING

A. Modeling of Elbow Mixture

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

B. Analysis in Laminar and Turbulent Flow

After creating 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.

C. Comparison of Results

For the proper design it should be necessary to understand the differences in flow pattern with laminar and turbulent so that design should made by keeping both type of flow.

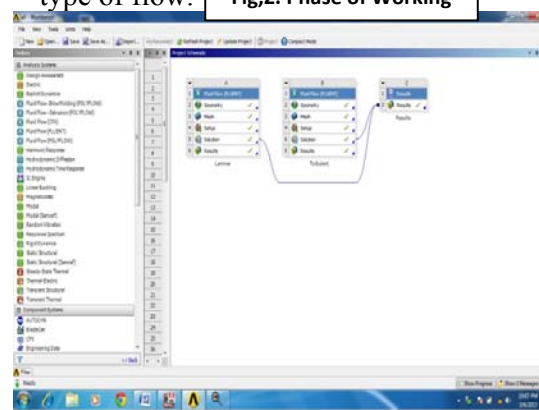


Fig.2. Phase of Working

IV. PROBLEM SOLVER AND PROCEDURE

A. Solution steps

For a reliable solution which can be accepted, the complete solution for each type of flow can be done in three steps.

I. Simple Solver

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

II. Coupled Solver

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

III. Adaptation

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

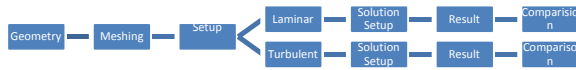


Fig.3. Working Procedure

V. MODELING AND MESHING

A. Problem setup

The setup of problem considered in these project is shown. The cold fluid having temperature 293.15 K enters through the inlet of large diameter with the velocity of 0.4 m/s while the hot fluid of temperature 313.15 K enters through the inlet of small diameter with velocity of 1.2 m/s. They both mixed inside the Elbow mixture and exchanges their heat and these flow pattern distribution becomes very important in order to design a good Elbow Mixture.

Figure T.1: Problem Specification

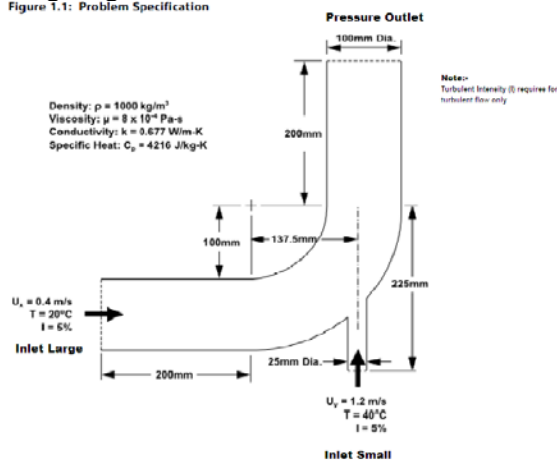
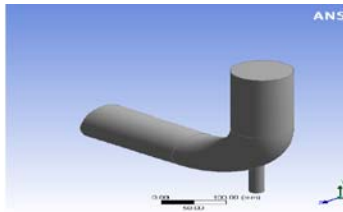
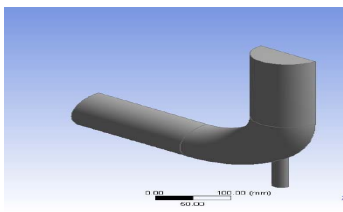


Fig.4. Problem Setup

B. Geometry

S.N	ANSYS Fluent	Geometry
1	Creating Main Pipe	1. Create- Primitives-Torous. Parameters- ➤ Base Y= -1 ➤ Base Z= 0 ➤ Angle 900 ➤ Inner Radius = 100mm

		➤ Outer Radius = 200mm 2. Extrude = 200mm for both ends.
2	Creating the Side Pipe	Create- Primitives-CylinderParameters – ➤ Base Plane- XY Plane ➤ Origin X - 137.5 ➤ Origin Y- -225 ➤ Origin Z -0 ➤ Axis Y -125 ➤ Radius-12.5  <p>Fig 5:- Elbow Mixture</p>
3	Symmetry	Tools- Symmetry-XY plane-Apply ➤ Generate.  <p>Fig 6:- Symmetry</p>

C. Meshing

S.No	ANSYS Fluent	Mesh
1	Create named selection	Mesh- Create Named Selection ➤ Velocity Inlet Large ➤ Velocity Inlet Small ➤ Pressure Outlet

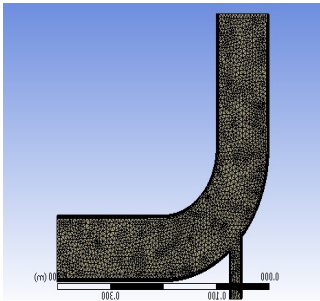
		➤ Symmetry.
2	Details of Meshing	<ol style="list-style-type: none"> 1. Physics Preference- CFD 2. Solver Preference- Fluent 3. Sizing <ul style="list-style-type: none"> ➤ Relevance Centre-Fine ➤ Smoothing- High 4. Inflation <ul style="list-style-type: none"> ➤ Use Automatic Inflation- Program Controlled 5. Generate.
		

Fig 7:- Meshing

D. Fluent Setup

S.NO	ANSYS Fluent	Setup
1	Fluent Launcher	<ol style="list-style-type: none"> 1. Dimension- 3D 2. Display Options:- <ul style="list-style-type: none"> ➤ Display Mesh After Reading ➤ Embed Graphics Windows ➤ Workbench Color Scheme 3. Processing Options- Serial

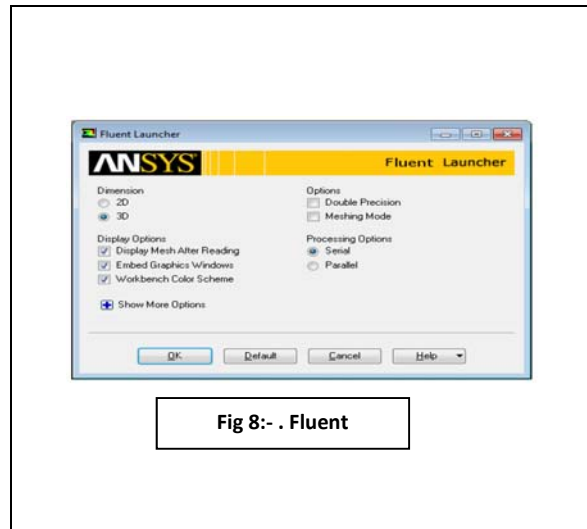


Fig 8:- . Fluent

VI. ANALYSIS AND SIMULATION

A. Solution Setup

Now after completing the first three steps of modeling, meshing and setup, the main body of analysis starts from here. In this part all the necessary steps are defined like types of flow, materials, modes and boundary conditions etc.

In this project, this step have done twice for laminar as well as turbulent flow, the whole procedure have definite importance.

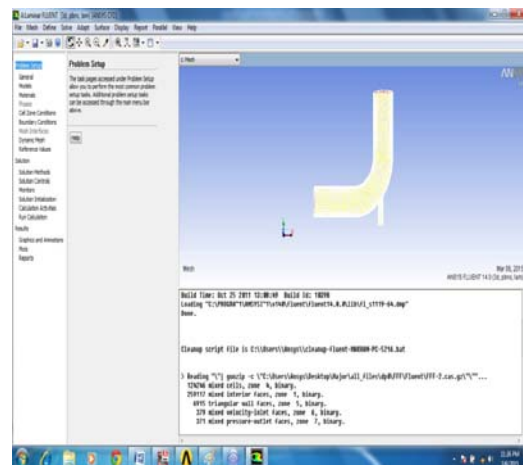
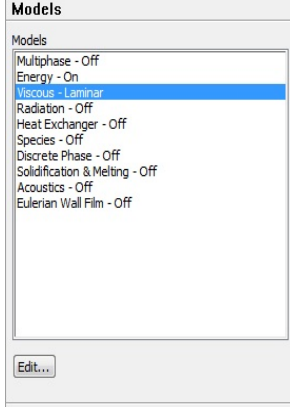


Fig 9:- Solution Setup

B. The two types of flow of analysis are as follows:-

- I. Laminar Flow
- II. Turbulent Flow

VII. LAMINAR FLOW ANALYSIS

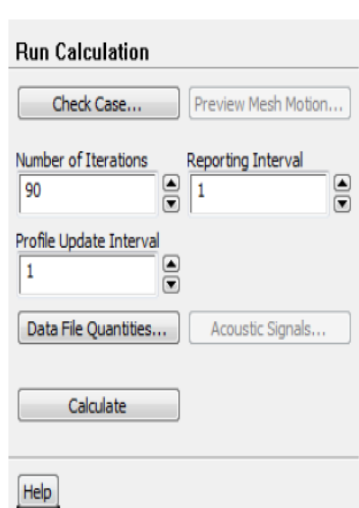
S.N O	General Mesh	<ol style="list-style-type: none"> 1. Check Mesh 2. Scale Units in mm 3. Report Quality. 4. Pressure Based Solver.
1	Models	<ol style="list-style-type: none"> 1. Energy on. 2. Viscous- Laminar.  <p style="text-align: center;">Fig 10:-Models</p>
2	Material	<p>Create Fluid Water:-</p> <ul style="list-style-type: none"> ➤ Density- 1000kg/m³ ➤ Specific heat- 4216j/kg-K ➤ Thermal Conductivity- 0.677 ➤ Viscosity- 0.0008 Ns/m²
3	Cell Zone Condition	Fluid- Water
4	Boundary Condition.	<ol style="list-style-type: none"> 1. Velocity inlet large <ul style="list-style-type: none"> ➤ Velocity- 0.4m/s in X direction. ➤ Temperature- 293.15K. 2. Velocity inlet Small- <ul style="list-style-type: none"> ➤ Velocity- 1.2 m/s in Y direction. ➤ Temperature- 313.15K

A. *Simpler Solver*

	SOLUTION	
1	Solution Method	Scheme- Simple Solver.
2	Monitors	<p>Surface Monitors-</p> <ul style="list-style-type: none"> ➤ Report type- Mass Weight Average. ➤ Field Variable- Temperature. ➤ Surface monitor- Pressure Outlet.
3	<u>Solution Initialization</u>	Hybrid Initialization- Initialize
4	Run Calculation	<ol style="list-style-type: none"> 1. Iteration- 150. 2. Calculate.
	REPORT AND RESULT	
1	Flux	<ol style="list-style-type: none"> 1. Mass Flow rate- (Kg/s) <ul style="list-style-type: none"> ➤ Pressure Outlet:- - 1.85*10⁻⁶ ➤ Inlet Large:- 1.56*10⁻⁶ ➤ Inlet Small:- 2.89*10⁻⁷ ➤ Net Mass Flow- - 3.014*10⁻¹⁰. 2. Heat Transfer:- <ul style="list-style-type: none"> ➤ Net Heat transfer 7.729*10⁻⁶ W.

The above solution obtained through Simpler solver can be improved by using coupled solver.

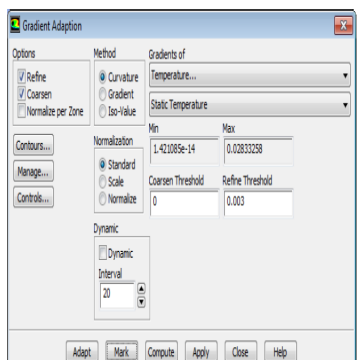
B. Coupled Solver

	SOLUTION	
1.	Solution Method	Scheme- Coupled Solver
2.	Solution Initialization	Hybrid Initialization- Initialize
3.	Run Calculation	Iteration- 90 ➤ Calculate.  Fig. 11:-Run Calculation
	REPORT AND RESULTS	
1.	Flux	1. Mass Flow rate- (Kg/s) ➤ Pressure Outlet:- - 1.8566×10^{-6} ➤ Inlet Large:- 1.566×10^{-6} ➤ Inlet Small:- 2.897×10^{-7}

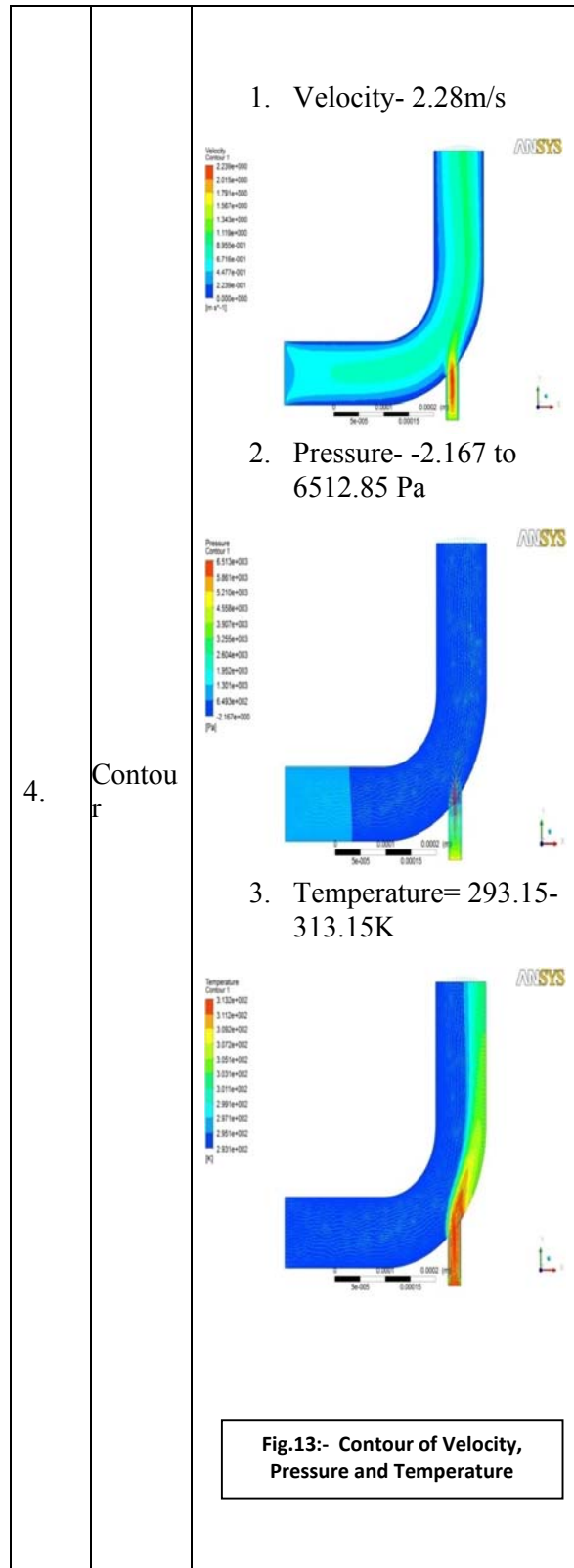
		<ul style="list-style-type: none"> ➤ Net Mass Flow- - 3.439×10^{-12}. 2. Heat Transfer:- ➤ Net Heat transfer 4.0624×10^{-6} W.
2.	Contours	1. Velocity- 2.238 m/s 2. Pressure- -2.177 Pa to 6512.83 Pa

The solution obtained from coupled solver can be further improved by refining their cell meshing. This can be done by using the **ADAPT** tool available in ANSYS software.

C. Adaptation

	ADAPTATION	
1.	Adapt	Gradient- <ul style="list-style-type: none"> ➤ Refine Threshold- 0.003 ➤ Cell Marked- Zero  Fig.12:- Gradient Adaptation
2.	Calculate	1. Iteration- 90 ➤ Calculate
	RESULT AND REPORT	
3.	Flux	1. Mass Flow rate- (Kg/s) ➤ Pressure Outlet:- - 1.86×10^{-6}

		<ul style="list-style-type: none"> ➤ Inlet Large:- 1.5697×10^{-6} ➤ Inlet Small:- 2.8973×10^{-7} ➤ Net Mass Flow- - 8.2422×10^{-13}.
		<p>2. Heat Transfer:-</p> <ul style="list-style-type: none"> ➤ Net Heat transfer - 2.352×10^{-6} W



Result:-
The above result for laminar flow in Elbow mixture can be used as reference for designing the Elbow mixture for laminar flow.

VIII. TURBULENT FLOW ANALYSIS

A. Simple Solver


1	General Mesh	<ol style="list-style-type: none"> 1. Check Mesh 2. Scale Units in mm 3. Report Quality. 4. Pressure Based Solver.
2	Models	<ol style="list-style-type: none"> 1. Energy on. 2. Viscous- K-epsilon (Turbulent Flow)  <p style="text-align: center;">Fig.14. Turbulent</p>
3	Material	<ol style="list-style-type: none"> 1. Create Fluid Water:- <ul style="list-style-type: none"> ➤ Density- 1000kg/m³ ➤ Specific heat- 4216j/kg-K ➤ Thermal Conductivity- 0.677 ➤ Viscosity- 0.0008 Ns/m².
4	Cell Zone Condition	Fluid- Water
5	Boundary Condition	<ol style="list-style-type: none"> 1. Velocity inlet large <ul style="list-style-type: none"> ➤ Velocity- 0.4m/s in X direction. ➤ Temperature- 293.15K. ➤ Turbulent intensity- 5% ➤ Hydraulic Diameter- 100mm



Fig.15 Velocity Inlet

		<ol style="list-style-type: none"> 2. Velocity inlet Small- <ul style="list-style-type: none"> ➤ Velocity- 1.2m/s in Y direction. ➤ Temperature- 313.15K ➤ Turbulent Intensity- 5% ➤ Hydraulic Diameter- 25mm
	SOLUTION	
1	Solution Method	Scheme- Simple Solver.
2	Monitors	Surface Monitors- <ul style="list-style-type: none"> ➤ Report type- Mass Weight Average. ➤ Field Variable- Fig.14:- Viscous Model Variable. ➤ Surface monitor- Pressure Outlet.
3	Solution Initialization.	Hybrid Initialization- Initialize
4	Run Calculation	<ol style="list-style-type: none"> 1. Iteration- 150. 2. Calculate.
	REPORT AND RESULT	
1	Flux	<ol style="list-style-type: none"> 1. Mass Flow rate- (Kg/s) <ul style="list-style-type: none"> ➤ Pressure Outlet:- - 1.867*10⁻⁶

		<ul style="list-style-type: none"> ➤ Inlet Large:- 1.5667*10⁻⁶ ➤ Inlet Small:- 2.897*10⁻⁷ ➤ Net Mass Flow- - 1.10702*10⁻¹⁰. 2. Heat Transfer:- ➤ Net Heat transfer 1.8605*10⁻⁵ W.
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		<ul style="list-style-type: none"> ➤ Inlet Small:- 2.897*10⁻⁷ ➤ Net Mass Flow- 1.620*10⁻¹² 2. Heat Transfer:- ➤ Net Heat transfer 2.5052*10⁻⁷ W.
2	Contours	<ol style="list-style-type: none"> 1. Velocity- 2.199 m/s 2. Pressure- -0.1285 Pa to 6246.11 Pa 3. Eddy Viscosity- ➤ 2.475*10⁻¹⁴ to 5.272*10⁻⁶ Pas

THE ABOVE SOLUTION CAN BE IMPROVED BY USING COUPLED SOLVER INSTEAD OF SIMPLE SOLVER IN SOLUTION METHOD

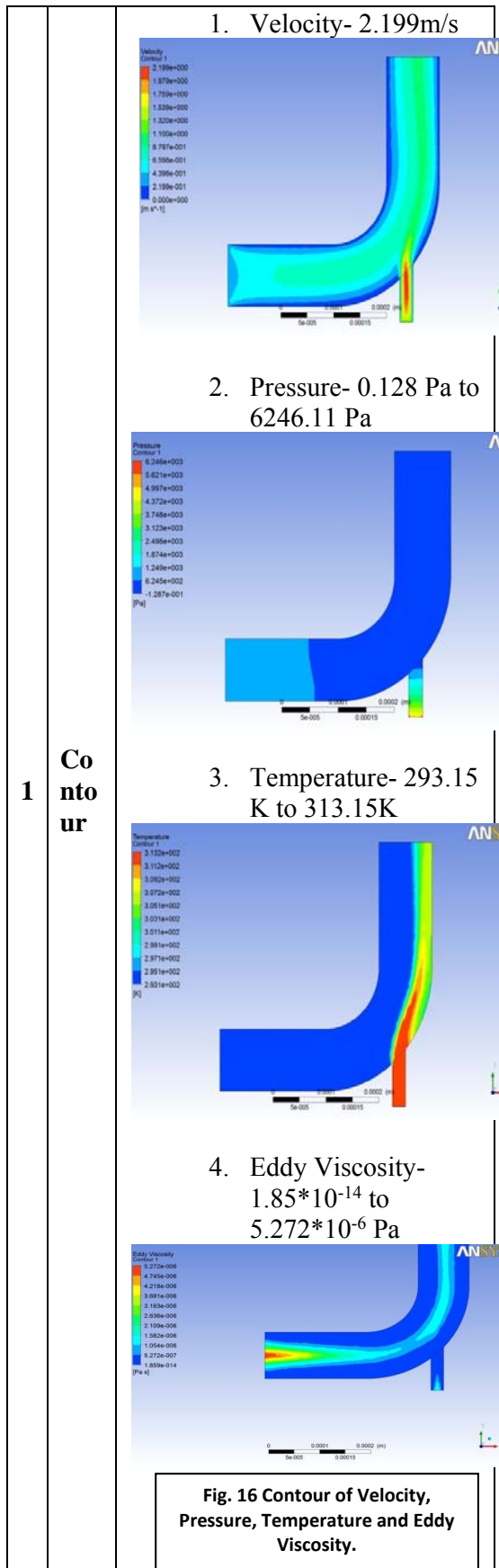
B. Coupled Solver

	SOLUTION	
1	Solution Method	Scheme- Coupled Solver
2	Solution Initialization	Hybrid Initialization- Initialize
3	Run Calculation	<ol style="list-style-type: none"> 1. Iteration- 90 2. Calculate.
	REPORT AND RESULTS	
1	Flux	<ol style="list-style-type: none"> 1. Mass Flow rate- (Kg/s) ➤ Pressure Outlet:- - 1.856*10⁻⁶ ➤ Inlet Large:- 1.566*10⁻⁶

The solution obtained from coupled solver can be further improved by refining their cell meshing. This can be done by using the **ADAPT** tool available in ANSYS software.

B. Adaptation

	ADAPTATION	
1	Adapt	Gradient- <ul style="list-style-type: none"> ➤ Refine Threshold- 0.003 ➤ Cell Marked- Zero
2	Calculate	<ol style="list-style-type: none"> 1. Iteration- 90 ➤ Calculate.
	RESULT AND REPORT	Net Mass Flow- 8.2422*10 ⁻¹³ Kg/s Net Heat transfer 1.303*10 ⁻⁸ W



Result:-

The above result for turbulent flow in Elbow mixture can be used as reference for designing the Elbow mixture for turbulent flow.

IX. APPLICATION AND BENEFITS

Elbow mixture has a wide variety of application in all manufacturing companies. Therefore, the solution obtained through above analysis will also serve many ways. It can be used as

- For the design of Elbow mixture to obtain a best geometry.
- This report can be used for the analysis of laminar flow in Elbow mixture.
- This report can be used for the analysis of turbulent flow in Elbow mixture.
- This report can be used for checking the difference in design requirement for laminar and turbulent flow.

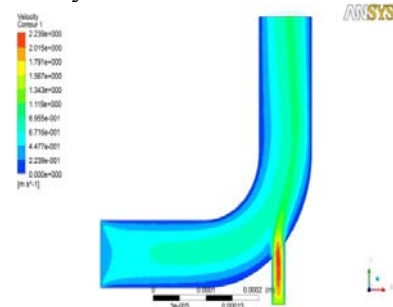
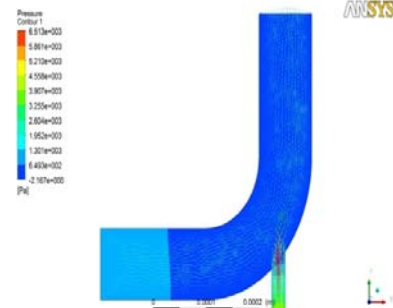
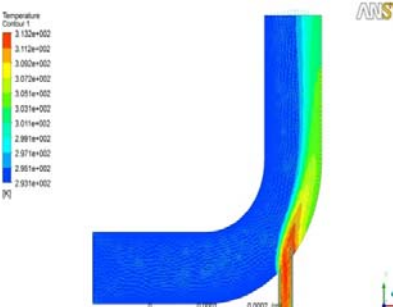
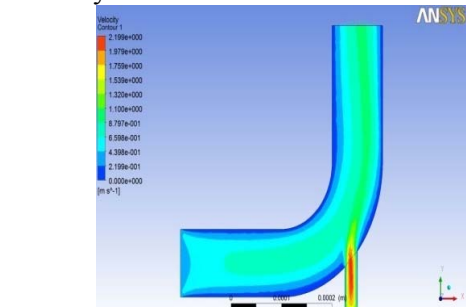
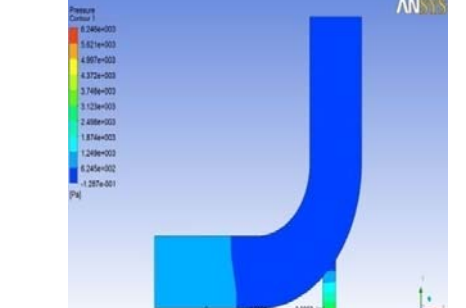
A. Benefits

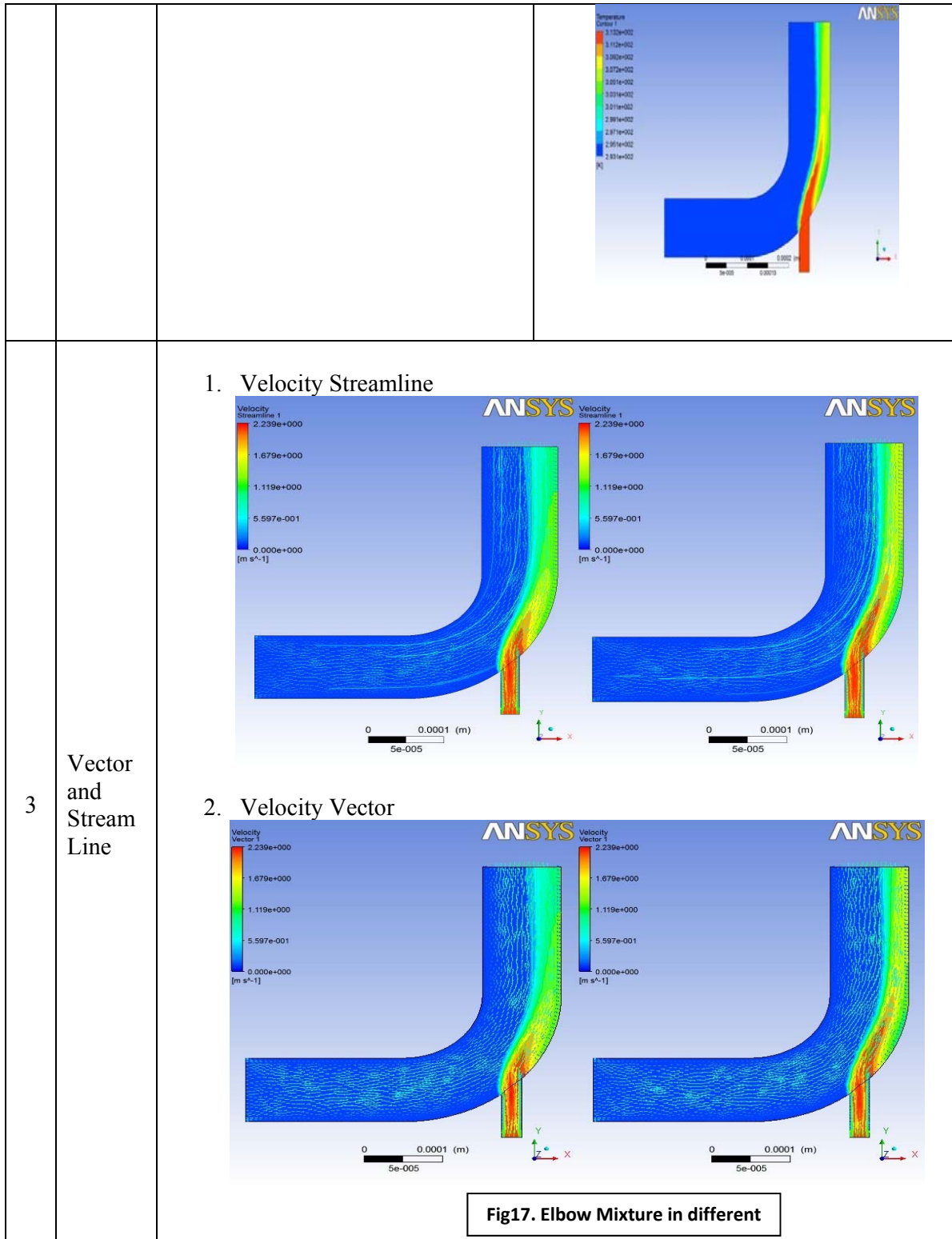
- This reports represents the combine report on laminar as well as turbulent flow pattern.
- This reports provide a good idea about the distribution and flow pattern of **temperature, velocity, and pressure** inside the Elbow mixture.
- This reports provides a complete report on Elbow mixture and fluid flow behavior, so that it can be used for a good design concept.

B. Final Report

The results obtained through the analysis of Elbow mixture above can be used as reference for the design of Elbow mixture. This results can be used for the design for laminar and turbulent flow both.

C. Comparison of laminar and turbulent flow

		LAMINAR	TURBULENT
1	Mass Flow Rate	<p>1. Mass Flow rate- (Kg/s)</p> <ul style="list-style-type: none"> ➤ Pressure Outlet:- 1.86×10^{-6} ➤ Inlet Large:- 1.5666×10^{-6} ➤ Inlet Small:- 2.897×10^{-7} <p>.....</p> <ul style="list-style-type: none"> ➤ Net Mass Flow- 8.2422×10^{-13} <p>2. Heat Transfer:-</p> <ul style="list-style-type: none"> ➤ Net Heat transfer 2.352×10^{-6} W 	<p>1. Mass Flow rate- (Kg/s)</p> <ul style="list-style-type: none"> ➤ Pressure Outlet:- -1.8567×10^{-6} ➤ Inlet Large:- 1.569×10^{-6} ➤ Inlet Small:- 2.897×10^{-7} <p>.....</p> <ul style="list-style-type: none"> ➤ Net Mass Flow- -8.2422×10^{-13} <p>2. Heat Transfer:-</p> <ul style="list-style-type: none"> ➤ Net Heat transfer 1.303×10^{-8} W
2	Contour	<p>Velocity- 2.28m/s</p>  <p>Pressure- -2.167 to 6512.85 Pa</p>  <p>Temperature:- 293.15K-313.15K</p> 	<p>Velocity- 2.199m/s</p>  <p>Pressure- --0.128 to 6246.11 Pa</p>  <p>Temperature:- 293.15K-313.15K</p>



X. DISCUSSION AND CONCLUSION

A number of concept and conclusion can be draw through the solution obtained above, but we have made focused on the pressure, velocity and

temperature distribution in the Elbow mixture under a specific parameters. The quality of solution mostly depends upon the software used and parameters selection. In this project we have used the parameters obtained from a reputed

report files, that have made the project on Elbow mixture with some other concept and method.

In this project, we have used the ANSYS 14.0 software for analysis, which provides the solution that is more reliable than the solution obtained from any other software. At present, all big organizations, companies are using this software and their complete function depends upon this software.

Since we have focused on particular parameters, so one can study all the parameters obtained through the analysis of Elbow mixture for better design concept. Therefore this project have vast field of research for obtaining a good result. Future scope for this project becomes high for a good analytical.

At present time, the research regarding Elbow mixture doesn't have a enough number. Only few research has done for these. Therefore there is a variety of things that can be used for study in future.

XI. References

1. CFD and Experimental Study of Fluid flow through a vertical to horizontal 90elbow bend III three phase flow by P.L. Spedding, E. Benard * , N.M. Crawford.
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3. CFD Analysis of Elbow mixture by Ansys Fluent Tutorial guide for tool practice.
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