To investigate Heat Loss of a Fluid flowing through a Pipeline for Turbulent Flow

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Abstract: This paper investigates heat energy losses of fluid while flowing through insulated long distance pipeline. The losses of heat energy at different steps of fluid flowing through insulated pipe line with turbulent flow characteristics are presented. In this project steam is a working fluid which is generated in the boiler and terminated process house. The study is carried out in three steps including development of theoretical model of the problem followed by solution of the defined problem obtaining the output for heat loss for different values of thickness of insulation, ANSYS steady state thermal was used and for obtaining the value of outlet temperature of steam at critical thickness of insulation ANSYS Fluent was used. For validation of our computational fluid dynamics (CFD) using ANSYS Fluent solution, the same model will be analyzed in using MATLAB. This study can be put to application in fast assessment of situation of heat dissipation during Steam transfer from one place to another passing through cold atmospheric conditions using MATLAB instead of much complex simulation software.

Keywords: Heat Energy loss, Pipe Design, Insulation Material, Critical thickness of insulation, ANSYS modelling and verification, Numerical simulation in MATLAB

I. INTRODUCTION

Pipeline transport is the transportation of goods (generally fluids) through a pipe. A quick determination the heat loss of a pipeline system has always been a difficult problem for engineers and pipe network designers as pipeline systems are complex and the ambient environment is highly variable. Mass flow rate through the pipe and the power require for a desirable flow rate are highly dependent on temperature of the fluid it is carrying. The pipe material and the insulation material have great effects on convective and conductive heat transfer inside the pipe wall. At a particular insulation thickness, viscous dissipation exactly equal to conductive heat loss. Steam stays at its ideal temperature throughout the length of pipeline and the need for heating stations is reduced. From a design standpoint, this insulation thickness is called optimal.

In this project steam is a working fluid and steam is generated in the boiler, the generated steam supplying through insulated pipe line. The steam is passing through long distance insulated pipe line and terminated process house. The process house consists of sizing, dyeing, bleaching, printing process etc. in the textile industry. The temperature of steam at boiler house (503K) and process houses (426K) are shown with huge difference. This temperature difference shows there is huge heat transfer dissipation takes place during steam flowing through pipe line. The project investigation of

steam energy losses and to minimize heat energy losses by designing critical thickness of insulating material (glass wool). The following study is carried out in three steps including development of theoretical model of the problem followed by solution of the defined problem obtaining the output for heat loss for different values of thickness of insulation, steady state thermal was used and for obtaining the value of outlet temperature of steam at critical thickness of insulation ANSYS Fluent was used. For validation of our computational fluid dynamics (CFD) using ANSYS Fluent solution, the same model will be analyzed in using MATLAB. This study can be used in fast assessment of situation of heat dissipation. Simulation can be done at the time of steam transfer from one place to another passing through cold atmospheric conditions by using MATLAB instead of much complex simulation software.

Problem Statement

Significance of steam is mandatory in the process industries like cement dry plant, sugar plant, fertilizer, and textile etc.; Generation of steam takes place in the boiler house. Generated steam is supplying to the process house through insulated pipe line. When steam flows through insulated pipe lines it loses its heat energy through pipe line and insulator. Which may lead to steam will become waste in the process industry. So necessary to determine critical insulator thickness to avoid heat loses during steam flows through insulator pipe line with uniform velocity.

Solution to the above defined problem statement can be achieved through these steps:

Solution Methodology

Parametric Modelling in ANSYS: With the help of ANSYS15 a parametric model study was carried out by which the heat transfer at various thickness of insulation was carried out. The output was taken from and the plot of heat transfer with increase in thickness of insulation was obtained. For temperature drop the model of the pipe parametric analysis was performed in ANSYS fluent and the temperature drop for various thickness of insulation was obtained.

Model Development

MATLAB Programming: Formulating a mathematical model from the given problem statement is most important prospect of engineering. So for this scenario, instead of Solving Log Mean Temperature Difference equation which is found by applying end boundary value to the energy equation governing heat transfer, numerically evaluation of the differential equation using a suitable solving scheme is carried out. The solution of the problem is obtained in MATLAB. The program was written in MATLAB for obtaining the critical thickness of insulation.

Theoretical Model

Below Figure shows a part of the pipeline, where the inner and outer surfaces are exposed to hot steam and air respectively. The heat transfer process includes the convection inside the pipe, the conduction through the pipe, and the convection outside the pipe. The pipe geometry is shown in the Figure below.
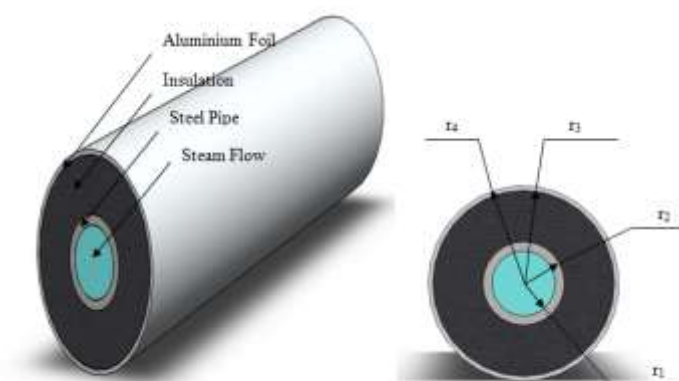
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Figure 1: Heat transfer process and temperature distribution through pipe wall

According to the thermal resistance theory, the heat transfer rate through the pipe wall is presented as,

$$q = \frac{(t_1 - t_6)}{\frac{1}{2\pi r_1 L h_1} + \frac{\ln\frac{r_2}{r_1}}{2\pi k_1 L} + \frac{\ln\frac{r_3}{r_2}}{2\pi k_2 L} + \frac{\ln\frac{r_4}{r_3}}{2\pi k_3 L} + \frac{1}{2\pi r_4 L h_0} + R_f} \quad \ldots\ldots\ldots\ldots(1)$$

Where, t stands for the temperature, r the radius, k the thermal conductivity, h the convection heat transfer coefficient, and L the length respectively. In practical analysis, although the outside air temperature t_6 is usually considered as a constant, the inside steam temperature t_1 is a variable since it varies along the flow direction. By analysis and calculation, it is concluded that the temperature Difference $(t_1 - t_6)$ may be assumed to be the log mean temperature difference.

Model Analysis

Validation: The value obtained from the critical thickness of insulation was considered and the geometry was changed and the new geometry with the thickness of insulation equal to the critical value of thickness of insulation was made. The CFD analysis was performed in ANSYS Fluent and the average temperature drop of the steam along 1m length of the pipe was found out.

II. LITERATURE REVIEW

Heat energy transfer in pipeline has been evaluated for almost 60 years. Nusselt's paper published in 1910 was the first paper in analyzing at scientific level. Later During subsequent years different investigators and scientists had studied flow through pipe for various fluids. As a result of this relation of Nusselt number with Reynold's number and Prandtl number were formulated [2].

Diessler considered the comparative approximations as like Graetz and gave the analytical solution for the problem for fully developed pipe flow in which fluid properties vary along the radius [1]. Heat transfer through pipe is dependent on wall thickness of the boundaries which was shown by by Adekunle O. Adelaga, JacoDirkir and Josua P. Meyar [9] Maintaining the Integrity of the Specifications.

CFD simulation of small and medium gauge 90° circular bend was done by Wan Kai and Wang Ping. They used standard k-ε model with FLUENT software on large diameter CFD numerical

simulation of air flow in a 90 ° twisted tube, are three dimensional stress field and velocity field in the pipe. To explore non-change law of fully developed pipe flow through CFD numerical simulation on large-diameter flue gas, lays the foundation for analysis and numerical simulation of non-circular cross section [7].

III. OBJECTIVES

- *To study flow of the steam through insulator pipe line and observe the steam flow type.*

- *To identify the thermal energy loses of steam while flowing through insulator pipe line:*

The analysis will perform in ANSYS considering thickness of insulation as a parameter which can be change and heat losses at different thickness of insulation can be obtain. The value of the critical thickness of insulation to be found out. And also heat loss at critical thickness of insulation will be found out.

The same analysis will be performing in MATLAB simulation software (Simscape). From this simulation will get the value of the critical thickness of insulation and heat loss at critical thickness of insulation.

- *To observe temperature loses and pressure loses of the steam from boiler house to process houses:*

The evaluation of the Temperature loss ANSYS software will be used. The results will obtain which can be used to predict the temperature loss along the length of the pipe for industrial pipelines which carry steam over long distances for industrial applications.

IV. PIPELINE DESIGN

Factors to be considered in designing

    A. *Industry Codes and Standards*

    B. *Effect of pressure on fluid flow through pipe*

The primary effect of friction in fluid flow is pressure drop, so any significant temperature change in the fluid is because of heat transfer. The average velocity Vavg at stream wise cross-section is determined from the requirement that the conservation of mass principle be satisfied. That is,

$$\dot{m} = \rho Vavg Ac = \int_{Ac} \rho u(r) dAc \ \dots\dots\dots\dots\dots(2)$$

Where *m* is the mass flow rate, *r* is the density, A_c is the cross-sectional area, and *u(r)* is the velocity profile. Then the average velocity for incompressible flow in a circular pipe of radius R can be expressed as,

$$Vavg = \int_{Ac} \frac{\rho u(r) dAc}{\rho Ac} = \int_0^R \frac{\rho u(r) 2\pi r dr}{\rho \pi R^2} = \frac{2}{R^2} \int_0^R u(r) dr \dots\dots\dots(3)$$

Therefore, when we know the flow rate or the velocity profile, the average velocity can be determined easily.

C. Turbulent Flow

For turbulent stream the entrance length is shorter due to the additional transport mechanism across the cross section. In this way in ordinary passage such as hydrodynamic lengths in turbulent stream are 10-15 times tube diameter and thermal entrance lengths are considerably littler than that. Therefore, in most of the engineering situations where in L/D 50, we use correlations for fully developed flow condition. Connection for turbulent stream is arranged relies on upon whether the inside wall of the tube is smooth / rough.

D. Smooth Tubes

The earliest correlation for turbulent heat transfer in a smooth tube is given by Dittus and Boelter, McAdams and Colburn. A common form to be used for fluids with Pr>0.5 is,

$$Nu = 0.023 \text{Re}^{0.8} \text{Pr}^{0.4} \quad \text{………………….. (4)}$$

The most usual we use this correlation, but in usual practice it is used even when the flow is in transit condition between laminar flow and turbulent flow for lack of better correlations. That is slightly more accurate a modern correlation for Nusselt no. is given by as follows,

$$Nu = \frac{f/8 \, (\text{Re} - 1000) \, \text{Pr}}{1 + 12.7[(f/8)^{1/2}(\text{Pr}^{2/3} - 1)]} \quad \text{……………….. (5)}$$

For low Prandtl number, special correlations to be used for conditions. Physical properties to be used in these correlations are evaluated at the average of the inlet and exit temperatures of the fluid. We know that 'f' is Darcy Friction Factor and according to Petukhov's it is evaluated as follows,

$$f = \frac{1}{[0.790 \ln(\text{Re}) - 1.64]^2} \quad \text{……………………….. (6)}$$

This result is good for turbulent flow in smooth pipe for Re $\leq$ 5 x 10^6.

E. Thermal Insulation

Thermal insulation is characterized as the reduction of heat transfer between objects in thermal contact or in scope of radiative impact.
Heat stream is an inescapable outcome of contact between objects of varying temperature. Thermal insulation gives a region of insulation in which thermal conduction is diminished and thermal radiation is reflected as opposed to consumed by the lower-temperature body.
The insulating capability of a material is measured with thermal conductivity (k). Low thermal conductivity is equal to high insulating capability (R-value). In thermal engineering, other critical properties of insulating materials are product density (ρ) and specific heat capacity (c).
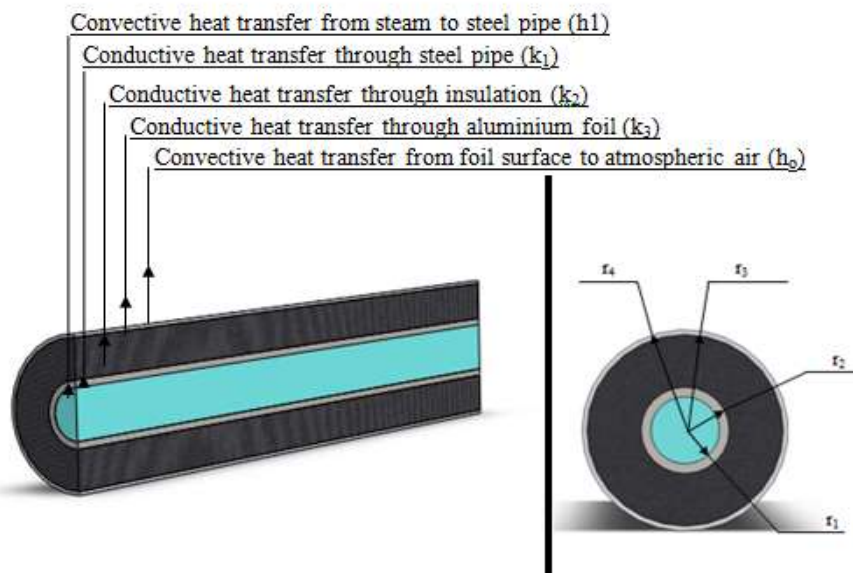
Figure 2: Temperature distribution trend in pipe wall and fluid

According to the thermal resistance theory, the heat transfer rate through the pipe wall is presented as,

$$q = \frac{(t_1 - t_6)}{\frac{1}{2\pi r_1 L h_1} + \frac{\ln\frac{r_2}{r_1}}{2\pi k_1 L} + \frac{\ln\frac{r_3}{r_2}}{2\pi k_2 L} + \frac{\ln\frac{r_4}{r_3}}{2\pi k_3 L} + \frac{1}{2\pi r_4 L h_0} + R_f} \quad \ldots\ldots\ldots\ldots\ldots\ldots(7)$$

By analysis and calculation, it is concluded that the temperature difference $(t_1 - t_6)$ may be assumed to be the log mean temperature difference. In above equation, there are three unknown variables, namely, inner convective heat transfer coefficient h_1, outer convective heat transfer coefficient h_2, and the outer wall temperature t_{out}.

V. ANSYS MODELING AND VERIFICATION

Analysis in Steady State Thermal for obtaining Critical Thickness of Insulation

A. Pre-processing: Engineering Data
In the engineering data the details for the materials considered for analysis were provided their properties. For thermal analysis the thermal conductivity of each material is a must.

1) Geometry

The geometry of the pipe with insulation and foil was made in ANSYS design modeler. For simplification and reduction of computational time the 1/4th model of the pipe was considered for ANALYSIS. Multiplying the obtained results by 4 will give the same results of that when considering the full model for ANALYSIS. The model is shown in the figure below. Each and every dimension of the pipe was taken as a parameter which can be changed externally for obtaining outputs at various thickness of insulation.
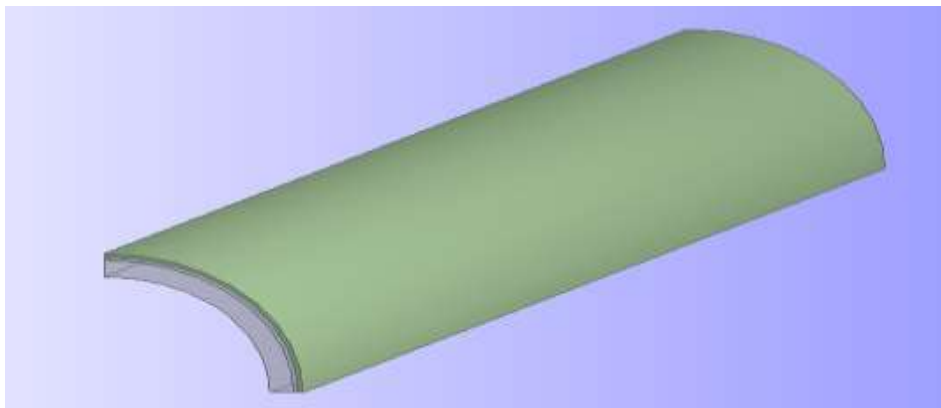
Figure 3: 1/4th model of the pipe

Details of Geometry
Inner Radius of steel: 0.07 m (Constant)
Outer Radius of steel pipe: 0.08 m (Constant)
Inner radius of insulation: 0.08 m (Constant)
Outer radius of insulation: 0.082 m (Variable Parameter)
Inner radius of foil: 0.082 m (Variable Parameter)
Outer radius of foil: 0.084 m (Variable Parameter)

2) Meshing

The next step is to divide the geometry into finite elements for problem simplification.
The edge sizing had been provided to all the edges of the geometry to obtain a good quality mesh.
Sweep method was used to give a sweep mesh along the whole length of the pipe with the particular number of divisions along the length for each material i.e. on pipe, insulation and foil.
Number of divisions for edge sizing A: 7 (Constant)
Number of divisions for edge sizing B: 2 (Variable Parameter)
Number of divisions for edge sizing C: 40 (Constant)
Number of divisions for edge sizing G: 2 (Constant)
Mapped Face Meshing for a uniform mesh along the whole geometry
Number of divisions in sweep for all the 3 bodies: Default (As determined by ANSYS).
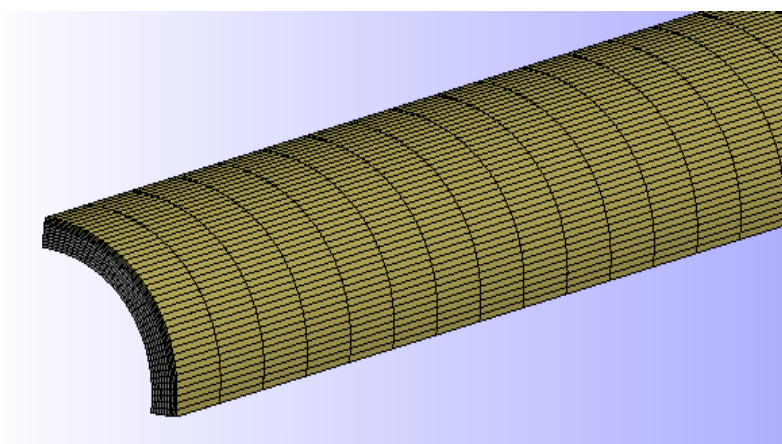The mesh obtained is as shown in the figure below.

Figure 4: Mesh Generated with the settings provided

3) Boundary Conditions

At the inner wall of the pipe the temperature at which steam is flowing along the pipe was considered. The outer surface of the foil was given a convection of 2 W/m^{2}K at atmospheric temperature of 28 degree Celsius.

B. Solution

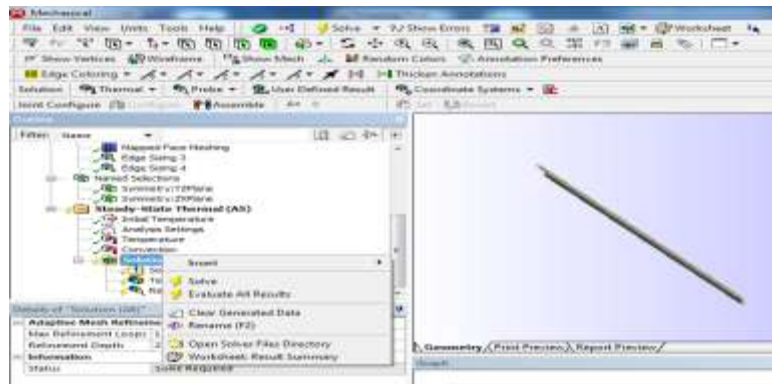The solution was obtained by right clicking on the solution and clicking solve,

Figure 5: Solution

C. Post Processing

Results for temperature plot considering 1/4th model of pipe

The results obtained for the ANSYS steady state heat transfer is shown in the Figure 2 for arbitrary value of thickness of insulation. 1/4th of the model is used for analysis for saving the computational time. The results for the model can be multiplied by 4 to obtain the true result. However the thickness of insulation can be given as a parameter and can be changed to obtain heat loss for various thickness of insulation. The graph shows the trend in which the heat loss varies with the thickness of insulation.
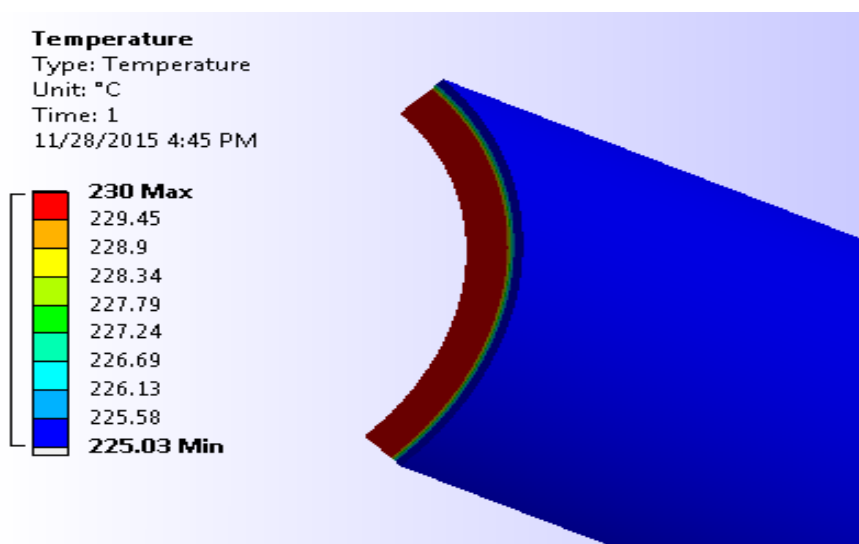

Figure 6: Temperature plot considering 1/4th model and arbitrary thickness of insulation

The result generated above is only for 1 thickness of insulation to obtain multiple results of heat loss

for various thicknesses of insulation parameters were used. The geometry was defined in such a way that the dimensions of the insulation and the foil can be changed externally and can be incorporated in the model rather than changing the geometry from the design modeller again and again and solving it for each value. The procedure for the same is explained with the help of a table below.

Figure 7: Parameters which are constant and varying

In the table it can be seen that parameter P13 and P14 represents the outer radius of the insulation and the foil. The parameter P18 gives the number of divisions that has to be given to the thickness of insulation for obtaining a mesh which gives accurate results. As the insulation thickness increases, it should be provided higher number of divisions for accurate results. Rest of the parameters are kept constant as described earlier. The parameter P7 gives the heat loss at different values of thickness of insulation.
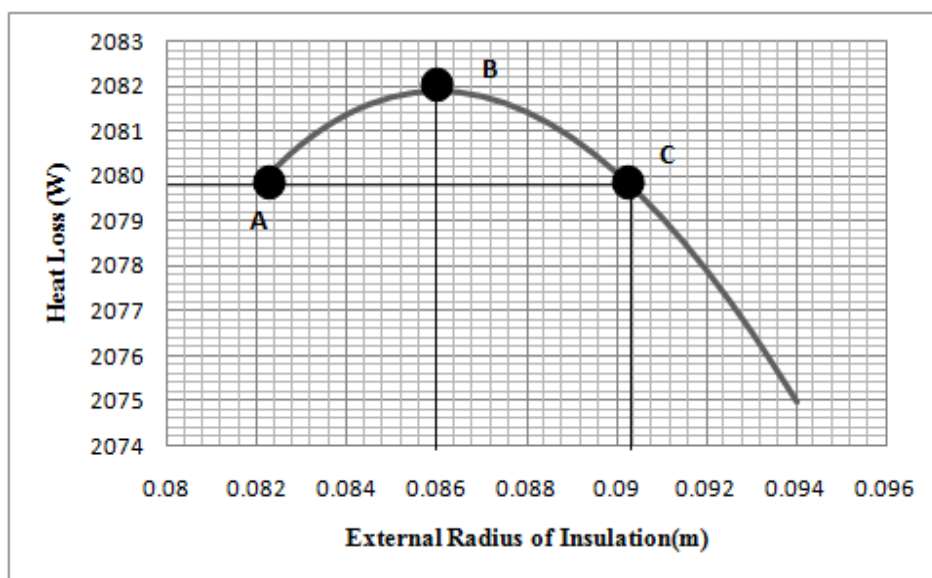
Graph 1: Heat loss Vs External Radius of Insulation

As observed from the graph, from point A the insulation thickness increases the heat loss increases. There comes a point B at which the thickness of insulation is such that it gives maximum heat loss which is 2081.88 W. Beyond that point with further increase in the thickness of insulation, the heat loss starts decreasing again. With further increase of thickness of insulation we will obtain various choices of thickness of insulation where the heat loss is less. Now the extent at which the insulation thickness is increased depends upon the other factors like saving the cost or having a target temperature at outlet. Higher the thickness of insulation beyond point C more will be the temperature of steam at outlet.

Analysis in ANSYS Fluent for obtaining temperature drop along the length of pipe

A. Pre Processing

Geometry: The full model of a 10 m along pipe was made along with the insulation and foil over it as shown in the figure below. The critical thickness of insulation obtained from the previous analysis was considered here and the insulation was given that particular dimension i.e. 6mm thickness giving an outer diameter of insulation to be 172 mm. The model of the same is shown in the figure below.
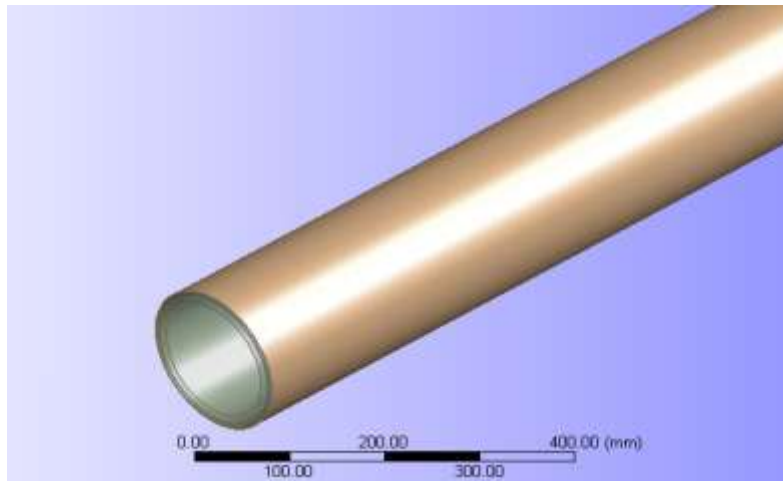

Figure 8: Model

The model contains a steam domain, a steel pipe over it and insulation connected to the steel pipe and finally a foil over the insulation.

Meshing: Face sizing command to give element length of 3mm to the steam domain Sweep Method to obtain a sweep mesh along the length of the pipe with the number of divisions to be 100.
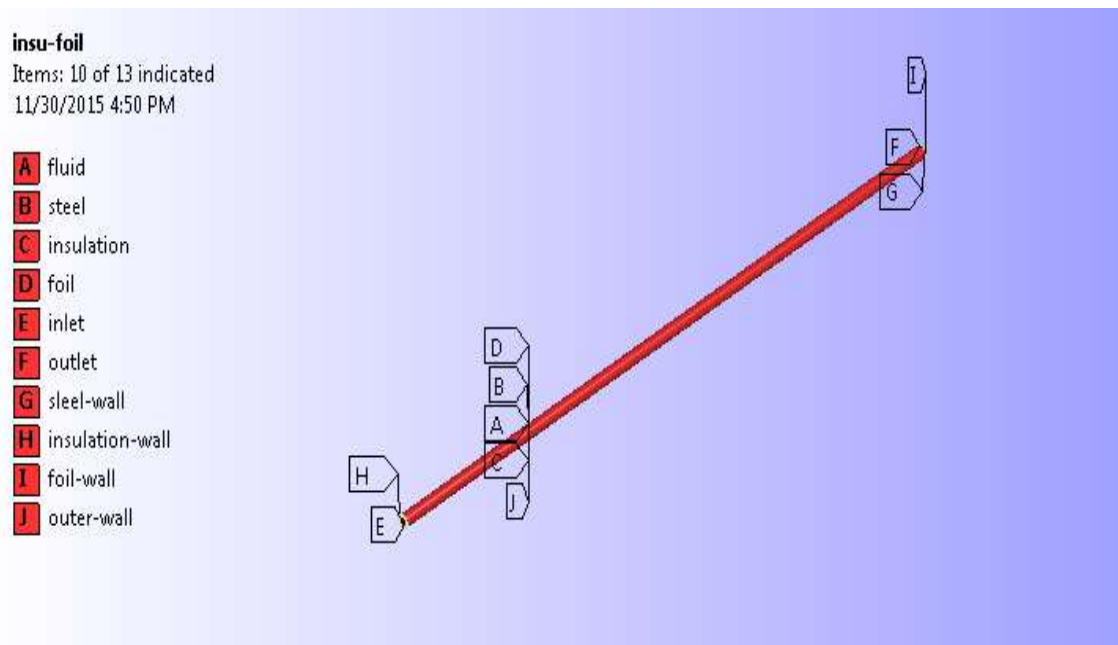
Figure 9: Named selection and application of boundary conditions on them

Boundary Conditions: Providing named selections to the each and every component and region of the geometry gives an ease to apply boundary conditions and inputs on the geometry. Following are the inputs, boundary conditions and materials assignments that are to be provided.

Fluid: Material Assigned: Water Vapour from ANSYS Fluent Database Considers thermal conductivity of steam and various other properties required for analysis.

Steel: Material Assigned: Steel from ANSYS Fluent Database considering thermal conductivity of steel.

Insulation: Glass Wool considering thermal conductivity of insulation assigned manually to the fluent database which is 0.18 W/mK.

Foil: Aluminium considering thermal conductivity of foil assigned manually to the fluent database which is 5 W/mK.

Inlet: The steam is known to enter the pipe at a velocity of 25 m/s and a pressure of 3.013 bar and with an initial temperature of 503 K.

Outlet: This is assigned to obtain the output at the other end of the pipe i.e. where the steam exits the pipe.

Steel, Foil and Insulation wall: These walls are assumed to be adiabatic that is there is no heat transfer through the wall ends of these materials.

Outer Wall: Here the effect of outer atmosphere with convection at ambient temperature is incorporated which is $2W/m^2K$ at 301 K.

B. Solution

The above problem was solved considering k epsilon model which is suitable for turbulent flows. Two-equation turbulence models allow the determination of both, a turbulent length and time scale by solving two separate transport equations. The standard *k – epsilon* model in ANSYS FLUENT falls within this class of models and has become the easy of practical engineering flow calculations in the time since it was proposed by Launder and Spalding. Robustness, economy, and reasonable accuracy for a wide range of turbulent flows explain its popularity in industrial flow and heat transfer

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simulations. It is a semi-empirical model, and the derivation of the model equations relies on phenomenological considerations and empiricism.

The standard k - epsilon model is a model based on model transport equations for the turbulence kinetic energy (k) and its dissipation rate (*epsilon*). The model transport equation for is derived from the exact equation, while the model transport equation for was obtained using physical reasoning and bears little resemblance to its mathematically exact counterpart.

In the derivation of the $k – epsilon$ model, the assumption is that the flow is fully turbulent, and the effects of molecular viscosity are negligible. The standard $k –epsilon$ model is therefore valid only for fully turbulent flows.

As the strengths and weaknesses of the standard $k –epsilon$ model have become known, modifications have been introduced to improve its performance. Two of these variants are available in ANSYS FLUENT: the RNG $k –epsilon$ model and the realizable $k –epsilon$ model.

C. Post Processing

The temperature drop was obtained from ANSYS Fluent as shown in the graph below. It shows the temperature drop of steam along the length of the pipe for the critical thickness of insulation of 6 mm. The temperature drop is found out to be 30 K for a length of 10 m.
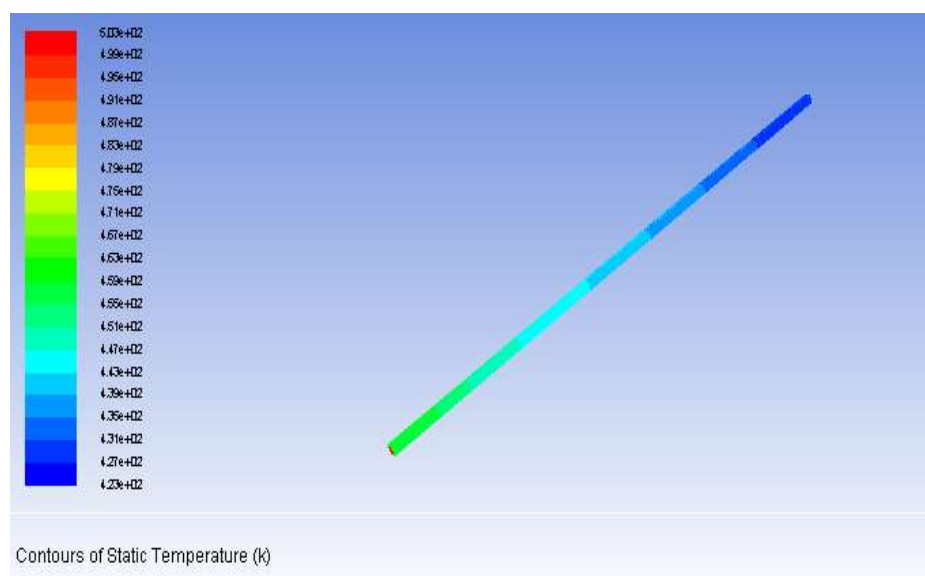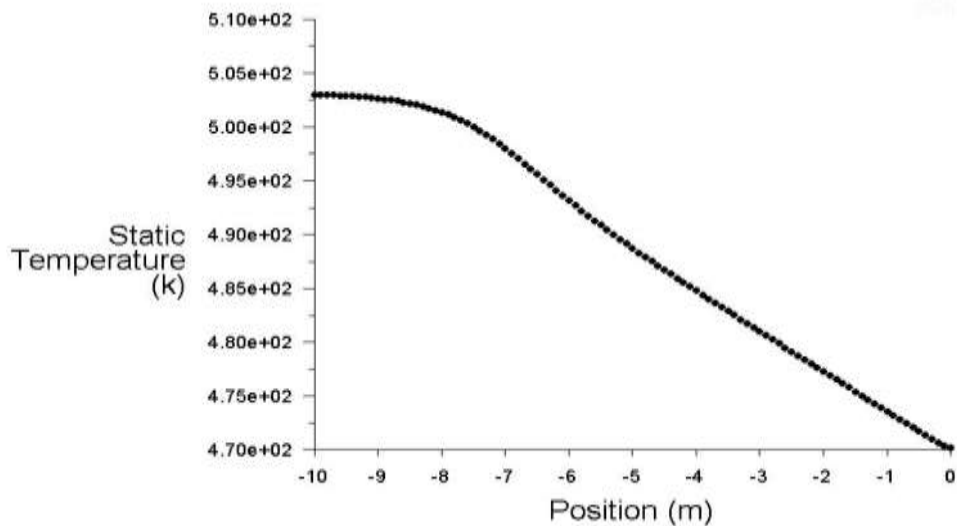

Figure 10: Temperature plot along the length of the pipe

The temperature plot along the length of the pipe is as shown in the graph below,

Graph 2: Temperature along the length of the pipe

## VI. NUMERICAL SIMULATION IN MATLAB

The model in this project is a steam pipeline segment. Steam enters the pipeline segment at a fixed temperature, 503 K with a fixed mass flow rate, $\dot{\upsilon} \times \rho_o$, where: $\dot{\upsilon}$ is the volumetric flow rate of steam through the pipe and ρ_o is the mass density of steam entering the pipeline segment.

To model and solve the problem in this project we are making the following viable assumptions:

- Flow through the pipeline is assumed to develop through its course.

- Velocity profile of the steam remains constant along the pipeline length.

- Steam is assumed to be compressible and in single phase.

- Shear stress is proportional to the shear strain.

- Mass density varies with both temperature and pressure.

- Pipe wall is thin and its material a good thermal conductor.

As we assume that pipe material is good conductor of heat, we can safely ignore its thermal resistance. The combined thermal resistance is then simply the sum of the insulation and Aluminum foil contributions, R_{ins} and $R_{Al\,foil.}$

A. *MATLAB model construction*
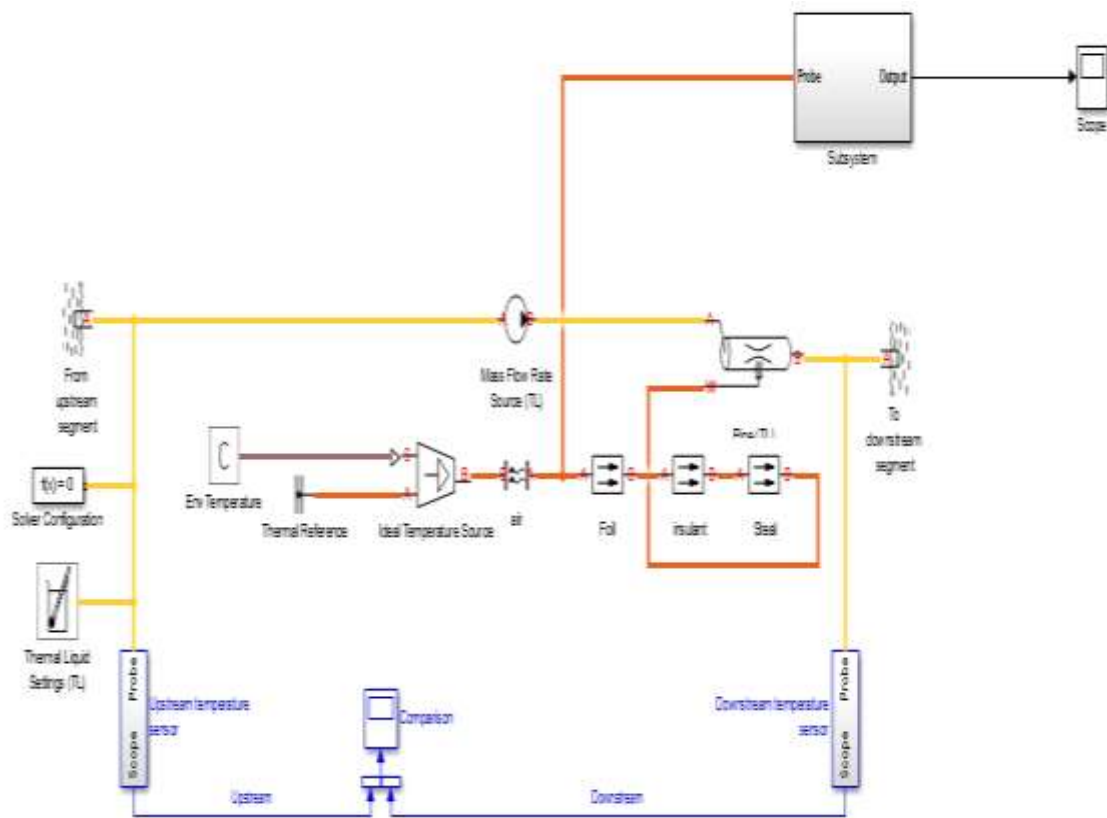
Pipeline Geometry for Heated Fluid Transportation

Figure 11: The Simscape Model

B. *Simscape Elements Information*

Thermal Conductivity of water vapors or steam= 0.261 W/mK
Inner Radius of tube= 70 mm.
Length of tube= 10 m
Outer Radius of tube=80 mm
Thermal Conductivity of steel= 16.27 W/mK
Coefficient of heat transfer between air and foil surface = 2 W/m²K
Temperature of water vapors or Steam= 503 K
Ambient Temperature= 301 K

C. *Details of the Simscape Elements*

For defining each element in the model following parameters were given:
Temperature Reservoir: Input parameter:
1. Reservoir temperature = 503 K
2. Inlet pipe cross-sectional area = 0.01539 m2

Mass Flow Rate Sensor (TL): Input Parameter:
1. Mass flow rate = 1.1 kg/s
2. Characteristic longitudinal length = 10 m
3. Pipe cross-sectional area = 0.01539 m^2

Pipe (TL): Input Parameter:
1. Geometry:
   Longitudinal length = 10 m
   Hydraulic diameter = 0.140 m
   Cross-sectional area = 0.01539m^2
2. Viscous Friction:
   Aggregate equivalent length of local resistances = 1 m
   Shape factor = 64
   Internal surface absolute roughness = 1.5*10^{-5}
   Laminar flow upper margin = 2000
   Turbulent flow lower margin = 4000
3. Heat Transfer:
   Laminar regime Nusselt number correlation coefficients = [4.36 0 0 0 0]
   Turbulent regime Nusselt number correlation coefficients = [0.023 0.8 0.33 0 0]
4. Effect and Initial Conditions:
   Fluid dynamic compressibility = off
   Initial fluid temperature inside the pipe = 503 K

Conductive Heat Transfer Foil and insulation: Input Parameter:
1. Thickness of foil= 2 mm
2. Thermal conductivity for the foil= 5 W/mK
3. Thickness of insulation= Varies for different values
4. Thermal Conductivity of insulation = 0.18 W/mK

Thermal Liquid Setting (TL): Input Parameter:
1. Valid pressure-temperature region parametrization = By Minimum and Maximum values
2. Minimum valid temperature = 545 K
3. Maximum valid temperature = 475 K
4. Minimum valid pressure = 0.1bar
5. Maximum valid pressure = 500 bar
6. Minimum thermal conductance = 0.001W/K
7. Atmospheric pressure = 1atm

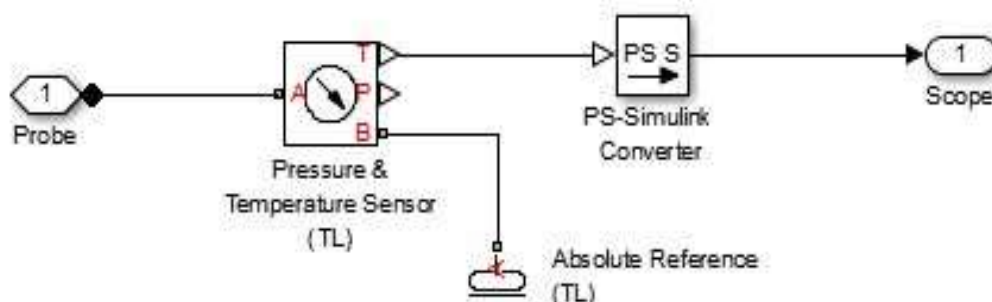In the above created model one subsystem is also created, for upstream temperature sensor.

Figure 12: Upstream temperature sensor sub-systems

D. Results in MATLAB

The mathematical model of the same is programmed in MATLAB and the script was run to find the value of critical thickness of insulation. The thickness of insulation was found to be 06 mm where there is maximum heat loss of 2081.888W.
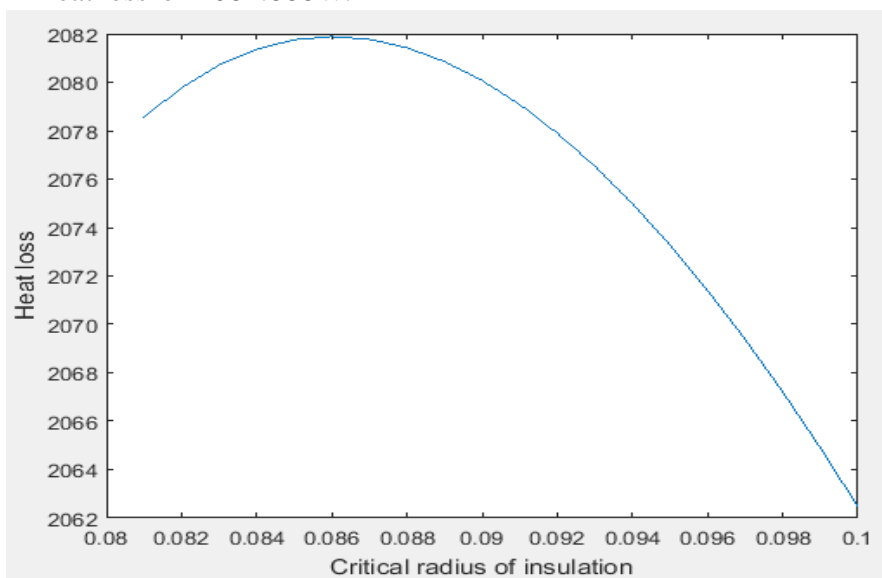
Graph 3: Static Temperature at the centre line along the length of pipe

VI.5 Verification and Validation between MATLAB and ANSYS

The graph shows a correlation between the heat loss trends obtained from MATLAB and ANSYS results. It was observed that there was very less difference obtained between the two. Hence From the procedure discussed one can easily find out the thickness of insulation over a pipe carrying steam at long distance.
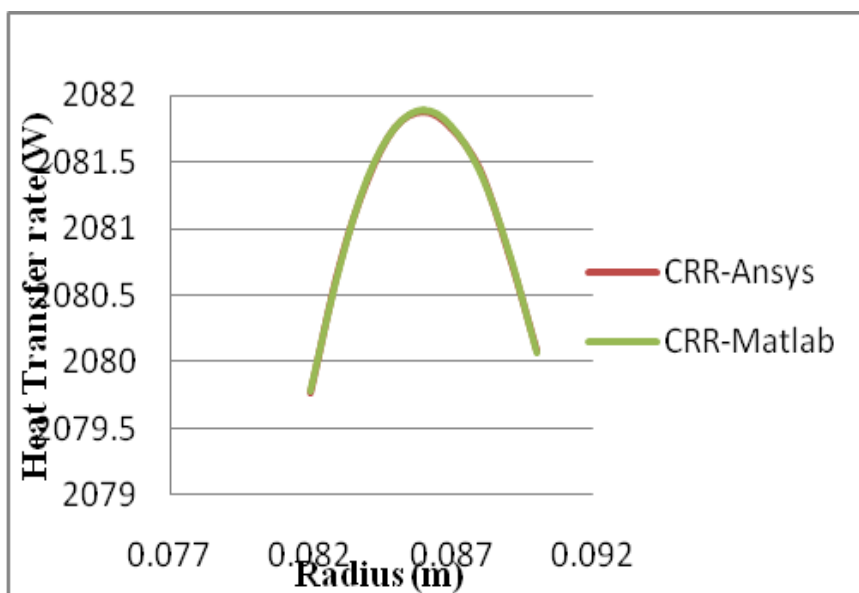

Graph 4: Correlation between heat loss trends in ANSYS and MATLAB

VII.   CONCLUSION

Pipe design is of crucial importance for industries dealing with bulk fluid motion and transport design factors like diameter, thickness and material selection are to be chosen esoterically within

economic and industrial capability constraints. The NPS and ASME codes discussed in above report are present industrial standards for pipe design. Other than design it is also necessary that the fluid should not change its state or properties while transportation. To prevent the same pipe insulation is of extreme importance.
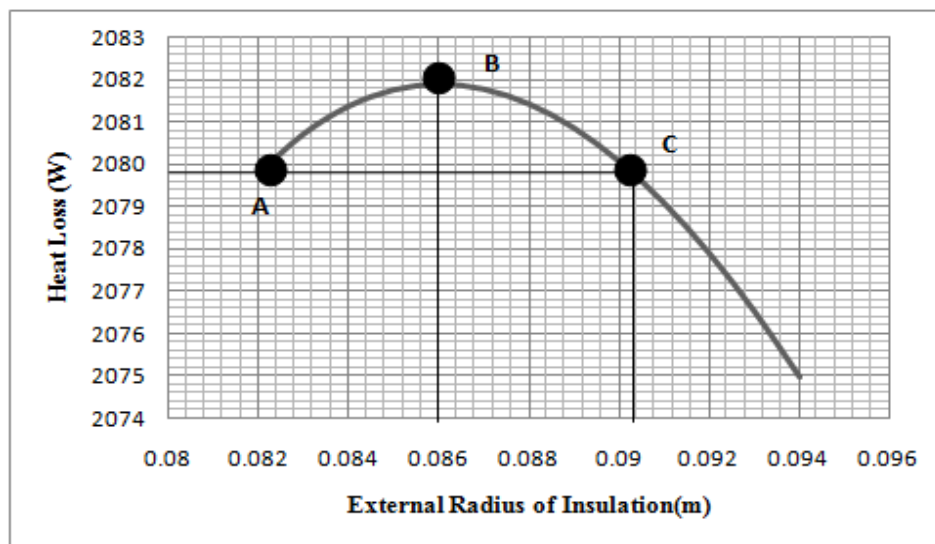
Graph 5: Heat loss Vs External Radius of Insulation (ANSYS)

As observed from the graph, from point A the insulation thickness increases the heat loss increases. There comes a point B at which the thickness of insulation is such that it gives maximum heat loss which is 2081.88 W. Beyond that point with further increase in the thickness of insulation, the heat loss starts decreasing again. With further increase of thickness of insulation we will obtain various choices of thickness of insulation where the heat loss is less. Now the extent at which the insulation thickness is increased depends upon the other factors like saving the cost or having a target temperature at outlet. Higher the thickness of insulation beyond point C more will be the temperature of steam at outlet. The analysis was performed in ANSYS considering thickness of insulation as a parameter which can be changed and heat losses at different thickness of insulation can be obtained. The value of the critical thickness of insulation was found out to be 6 mm. Heat loss at critical thickness of insulation is found to be 2081.88 W.

The mathematical model of the same is programmed in MATLAB and the script was run to find the value of critical thickness of insulation. The thickness of insulation was found to be 6 mm, where there is maximum heat loss of 2081.88W.

The problem was also analyzed in ANSYS fluent from which the temperature drop at the pipe outlet was obtained and for the critical thickness of insulation it was observed that the temperature drops to $30 \, {}^{0}K$ per 10 meters.

It can be seen that the result obtained from MATLAB lies in the region of precision of the result which was obtained from ANSYS fluent. Since the result of the MATLAB is found out analytically it can be considered as more accurate.

The evaluation of the temperature loss through ANSYS Software was carried out. The results obtained can be used to predict the temperature loss along the length of the pipe for industrial pipelines which carry steam over long distances for industrial applications.

VIII. SCOPE OF THE PROJECT

In process industries like Textile, cement, sugar etc., Steam is used for several processes of manufacturing operations. Steam plays an important role in the continuous process industries. Process industries faces the problem of retain the heat energy of steam while using in the manufacturing process and to prevent the losses of heat energy through critical designing of pipe line and insulator of pipe line and boiler while steam flows heat loss through these pipes.

To determination the heat loss of a pipeline system has always been a difficult problem for engineers and pipe network designers due to pipeline systems are complex and the ambient environment is highly variable. Mass flow rate through the pipe and the power require for a desirable flow rate are highly dependent on temperature of the fluid carries and flows through pipe line.

To change pipe material and insulator material, to increase the performance of energy storage of steam while flows from boiler house to process plant and optimize the pipe design with consideration of economic factors.

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