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# Analyzing the Temperature Distribution by Theoretical and FEA in Insulated Steam Pipe used in Industrial Piping System

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**Abstract:** The aim of this study was to analyze the transfer of steam in an insulated piping through different types of dielectric layers as an insulating materials covered for a Mild steel tube by the method of theoretical and finite element analysis

The results shows that in general impermeable materials offer better protection against hot steam, the conduction of heat from the steam to the insulating material is depends on the thermal conductivity and the insulation thickness. The mild steel piping and thermal insulation are designed to with stand thermal stress.

## I. INTRODUCTION

Use of thermal insulating materials is a very common practice for a wide range of applications [1]. They are utilized for reducing heat gain such as in refrigeration piping, cryogenics and chilled water loops. Insulating materials are also used to reduce heat loss such as in steam pipes, hot water pipes and furnaces. In at least one application, the insulating or coating materials are used to actually increase heat transfer [2]. For example, electrical wires carrying current. Here the thermal insulating material is in fact an electrical insulation that is needed for safety.

Thermal Insulation can refer to material used to preventing the heat loss or the methods and processes used reduce the heat transfer. In the past several years there has been a lot of development in the insulations around steam pipes. There is not being much development on the optimization of the insulation thickness of the steam pipe with the help of finite element method; it is made possible to find out critical insulation thickness. Here is the study of such insulation thickness for the steam pipe. A material that refers to the flow of heat with reasonable effectiveness is known as insulation. The thermal insulation can refer to the materials used to reduce the rate of heat transfer.

## II. OBJECTIVE OF THE STUDY

- Determination of critical insulation thickness under given thickness constrains.
- To determine heat loss from the pipe and the temperature distribution over each insulating material.
- Possible efforts to reduce the thermal gradient so that stress concentration can be reduced by providing natural convection (By drilling holes).
- To ensure whether theoretical results agrees with FEA results.

## III. Material Properties of Mild Steel and Insulation types

Material	K	$\alpha$	E
Mild steel	43.3	12.6	200
Silica	1.38	0.75	68
Glass wool	37.2e-3	9	68.9
Polyurethane puff	0.026	88	0.025
Wood Fiber	46.5e-3	8.2	30

## IV. THEORETICAL METHOD

Conduction is the mode of heat transfer in which energy exchange takes from the higher temperature region to that of low temperature region by kinetic motion or direct impact of molecules.

Fourier law of heat conduction

Rate of heat conduction  $q_x$  (Area) \* (Temperature difference) / Thickness

$$Q_x = KA (T_1 - T_2) / \Delta X \text{ ----- (1)}$$

$$q_x = -K dT/dX \text{ w/m}^2 \text{ -----(2) [4]}$$

Where  $q_x = Q_x/A = -K dX/dT$

### V. MODELLING AND ANALYSIS

a) *Modeling:* In the present simulation, a tool designs are considered for ANSYS Classical Work bench analysis. The modelling is done with Solid Edge V20 Design Modeller as shown in fig.1 and with a dimension for 1<sup>st</sup> trail are L=1m,  $t_{MS}=1\text{mm}$ ,  $t_{GW}=5\text{mm}$ ,  $t_{PP}=30\text{mm}$ ,  $t_{WF}=2\text{mm}$ , Tube inside diameter ( $D_i$ ) = 70mm, Outside Diameter ( $D_o$ ) = 78mm

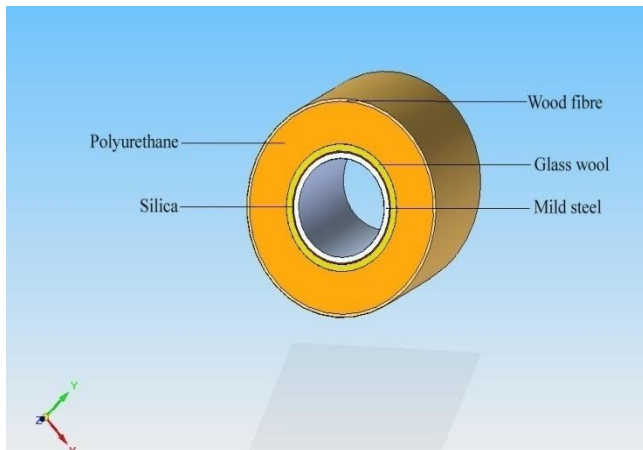


Fig 1: 3-D view of steel pipe with insulation

b) *Analysis:*

This analysis is done with ANSYS software as a transient Thermal problem.

Method

1. Selecting Simulation type
2. Selecting the Element type
3. Importing the geometry
4. Defining the material library
5. Solve

There is an inlet hole of diameter of the mild steel pipe is 70mm. The model is meshed using ANSYS Classical Mesh module and by considering element type is Brick 8 node 70(SOLID70) meshing method is adopted. The number of nodes generated is 69360 for the model and are shown in Figure 2. The quality of mesh is relevant for accurate results and with orthogonal quality approaching unity, yields better results ( ANSYS team [3]).

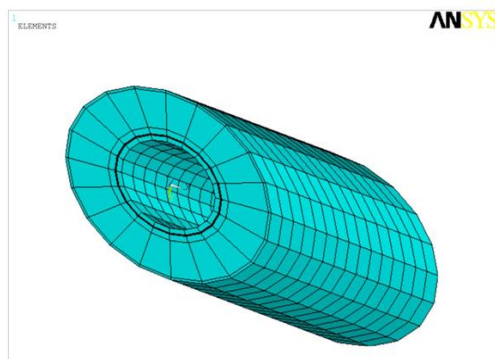


Fig 2: Meshed Model of Pipe with Insulation

### VI. BOUNDARY CONDITION

After having meshed model the next important step is to apply the boundary conditions. Since temperature is given as a input we first go for thermal analysis of the model. The entire inner surface of the pipe is selected and applied with 550<sup>o</sup>c. Since heat is dissipated through convection, at the outermost insulation surface heat transfer co-efficient is taken as 10w/m<sup>2</sup>k. The convection boundary condition will be as shown in Fig3.

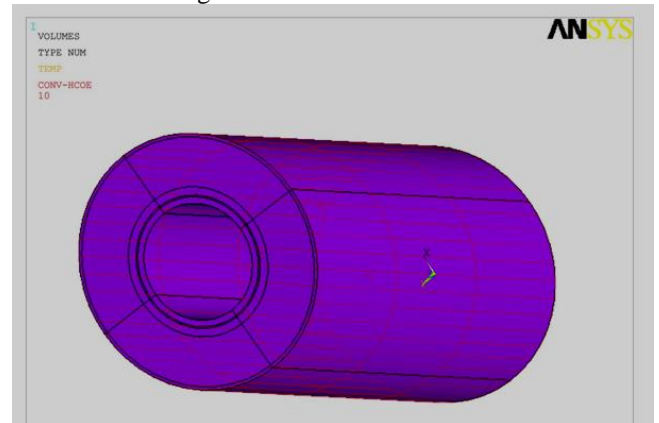


Fig 3: Thermal boundary condition for the problem

### VII. RESULTS AND DISCUSSION:

- Result obtained when couple field analysis is carried out for thermal deformation.
- From theoretical results it is found that trail 4 from theoretical calculations provide best insulation with surface temperature of 39.85<sup>o</sup>C.
- From Ansys analysis it is found that trail 3 provides best insulation with surface temperature 37.44<sup>o</sup>C.

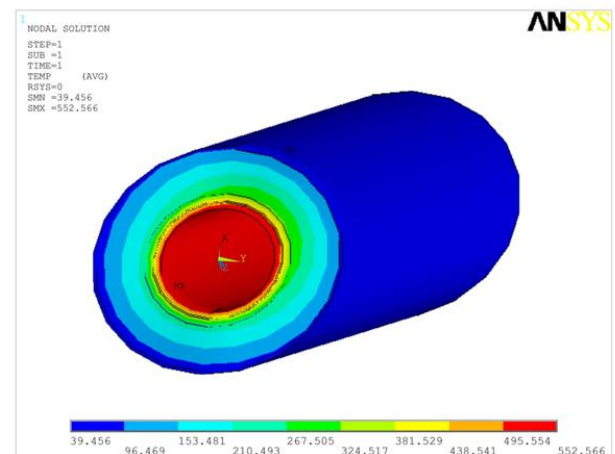


Fig 4: Temperature distribution

From above results we can conclude that surface temperature (fig 4) obtained is approximately equal to atmospheric temperature thus best insulation is achieved.

### VIII CONCLUSION:

To maintain a high level of availability and reliability in a fossil power plant, substantial consideration of failure by repeated thermal loading should be carried out.

- In this study, the transient temperatures and stresses distributions within a insulated steam flow in a pipe
- The maximum deformations are calculate in transient state condition within inner of the pipe
- Equivalent (von-Misses) Stress distribution in Transient condition.
- Total deformation and stress values are compared with analytical results calculated for 2D geometry.
- If the thermal gradient is great enough, the stress at the bottom of the threads may be high enough to cause the carking. The result shows the casing develops higher stress levels in startup condition.

### NOMENCLATURE

	Symbol	Unit
Thermal Conductivity	K	W/m°C
Thermal emissivity	$\epsilon$	$10^{-6}$ m/m°C
Young's Modulus	E	GPa
Thickness	t	Milimeters
Heat Flow	Q	Watts
Temperature	T	°C
Thermal Stress	$\sigma_{thermal}$	N/m <sup>2</sup>
Thermal Resistance	R	°C/Watts

Suffix

MS- Mild Steel

S-Silica

GW- Glass Wool

PP- Polyurethane puff

WB: Wood Fiber

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