A PROJECT REPORT

ON

"THERMAL INSULATION OF STEEL PIPE"

Submitted by

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CERTIFICATE

This is to certify that the project report titled, **"THERMAL INSULATION OF STEEL PIPE** "submitted to **Anjum-i-islam's Kalsekar Technical Campus, Panvel,** submitted by **Khan Abdul Karim**, **Faizan Sagir Khan, Chilwan Arbaz Ashraf, Kazi Aadil Noor Mohd.** In **MECHANICAL ENGINEERING** is the bonafide record of project work done by them under our supervision. The contents of this report, in full or in parts, have not been submitted to any other institute or university for the award of any degree or diploma.

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ACKNOWLEDGEMENTS

In the name of Allah, the Most Benevolent, the most Merciful. I wish to record immeasurable gratitude and thankfulness to the One and The Almighty Creator, the Lord and Sustainer of the universe, and mankind in particular. It is only through His mercy and help that this work could be completed and it is ardently desired that this little effort be accepted by Him to be of some service to the cause of humanity.

We wish to thank ***University of Mumbai*** and **A.I. KALSEKAR TECHNICAL CAMPUS** for giving us the opportunity to pursue our **BE project.**

First and foremost, we wish to express our sincere thanks to our guide Prof. Shakil Tadvi, for giving us the opportunity for doing a project work as our BE project in semester 8 and also for his encouragement, guidance and continuous criticisms. With his guidance, this project has been completed successfully. Also, we wish to thank our supportive group members for their fabulous work and valuable knowledge and last longer help that we have inherited during the work of project. We would like to take this opportunity to thank all those who contributed in our project work, especially project lab assistants who had helped us to complete our project. They have assisted us on various occasions that helped us to understand the technic to adjust or build a working model. We will never be able to thank them enough for their constant moral support, inspiration and many sacrifices. We would like to extend our sincere appreciation to all who have assisted us in one way or another, but whose names are not mentioned.

ABSTRACT

This article is about the effects of insulation thickness of steel pipes with different diameters and sensitivity to economic parameters. The Ansys Software were used with simple method and procedures are used for the optimization and sensitivity analyses. The insulation materials are Fiber Glass, Thermocol and Polystyrene the results show that consideration of all the physical and economic conditions appear with the optimum insulation thickness that varies from 5 cm to 16 cm unit cost of insulation are sensitive to the insulation thickness. Additionally, the increased discount rate and cost per unit volume of insulation material lowers the optimum insulation thickness. In conclusion, it is expected that this study will provide a guide for engineers, where insulation is used for large diameter pipes.

CONTENT

"THERMAL INSULATION OF STEEL PIPE"

CHAPTER 1

INTRODUCTION

1.1: Introduction

Thermal insulation is the reduction of heat transfer (i.e., the transfer of thermal energy between objects of differing temperature) between objects in thermal contact or in range of radiative influence. Thermal insulation can be achieved with specially engineered methods or processes, as well as with suitable object shapes and materials. Heat flow is an inevitable consequence of contact between objects of different temperature. Thermal insulation provides a region of insulation in which thermal conduction is reduced or thermal radiation is reflected rather than absorbed by the lower-temperature body.

Thermal conductivity k is measured in watts-per-meter
Per kelvin ($W \cdot m^{-1} \cdot K^{-1}$ or W/m/K). This is because heat transfer, measured as power, has been found to be (approximately) proportional to

- difference of temperature
- the surface area of thermal contact
- the inverse of the thickness of the material

From this, it follows that the power of heat loss is given by Thermal conductivity depends on the material and for fluids, its

Temperature and pressure. For comparison purposes, conductivity under standard conditions (20 °C at 1 atm) is commonly used. For some materials, thermal conductivity may also depend upon the direction of heat transfer.

The act of insulation is accomplished by encasing an object in material with low thermal conductivity in high thickness. Decreasing the exposed surface area could also lower heat transfer, but this quantity is usually fixed by the geometry of the object to be insulated.

Multi-layer insulation is used where radioactive loss dominates, or when the user is restricted in volume and weight of the insulation
(E.g. Emergency Blanket, radiant barrier)

Application:

1. Building: Maintaining acceptable temperatures in buildings (by heating and cooling) uses a large proportion of global energy consumption. Building insulations also commonly use the principle of small trapped air-cells as explained above, e.g. fiberglass (specifically glass wool), cellulose, rock Wool, polystyrene foam, urethane foam, vermiculite, perlite, cork, etc. For a period of time, Asbestos was also used, however, it caused health problems.

When well insulated, a building:

- Is energy-efficient, thus saving the owner money.
- Provides more uniform temperatures throughout the space. There is less temperature gradient both vertically (between ankle height and head height) and horizontally from exterior walls, ceilings and windows to the interior walls, thus producing a more comfortable occupant environment when outside temperatures are extremely cold or hot.
- Has minimal recurring expense. Unlike heating and cooling equipment, insulation is permanent and does not require maintenance, upkeep, or adjustment.

- Lowers the carbon footprint of a building.

Many forms of thermal insulation also reduce noise and vibration, both coming from the outside and from other rooms inside a building, thus producing a more comfortable environment.

Window insulation film can be applied

In weatherization applications to reduce incoming thermal radiation in summer and loss in winter.

In industry, energy has to be expended to raise, lower, or maintain the temperature of objects or process fluids. If these are not insulated, this increases the energy requirements of a process, and therefore the cost and environmental impact.

2. Mechanical: Space heating and cooling systems distribute heat throughout buildings by means of pipes or ductwork. Insulating these pipes using pipe insulation reduces energy into unoccupied rooms and prevents condensation from occurring on cold and chilled pipework.

Pipe insulation is also used on water supply pipework to help delay pipe freezing for an acceptable length of time.

Mechanical insulation is commonly installed in industrial and commercial facilities.

3. Refrigeration: A refrigerator consists of a heat pump and a thermally insulated compartment.

4. Automotive: Internal combustion engines produce a lot of heat during their combustion cycle. This can have a negative effect when it reaches various heat-sensitive components such as sensors, batteries, and starter motors. As a result, thermal

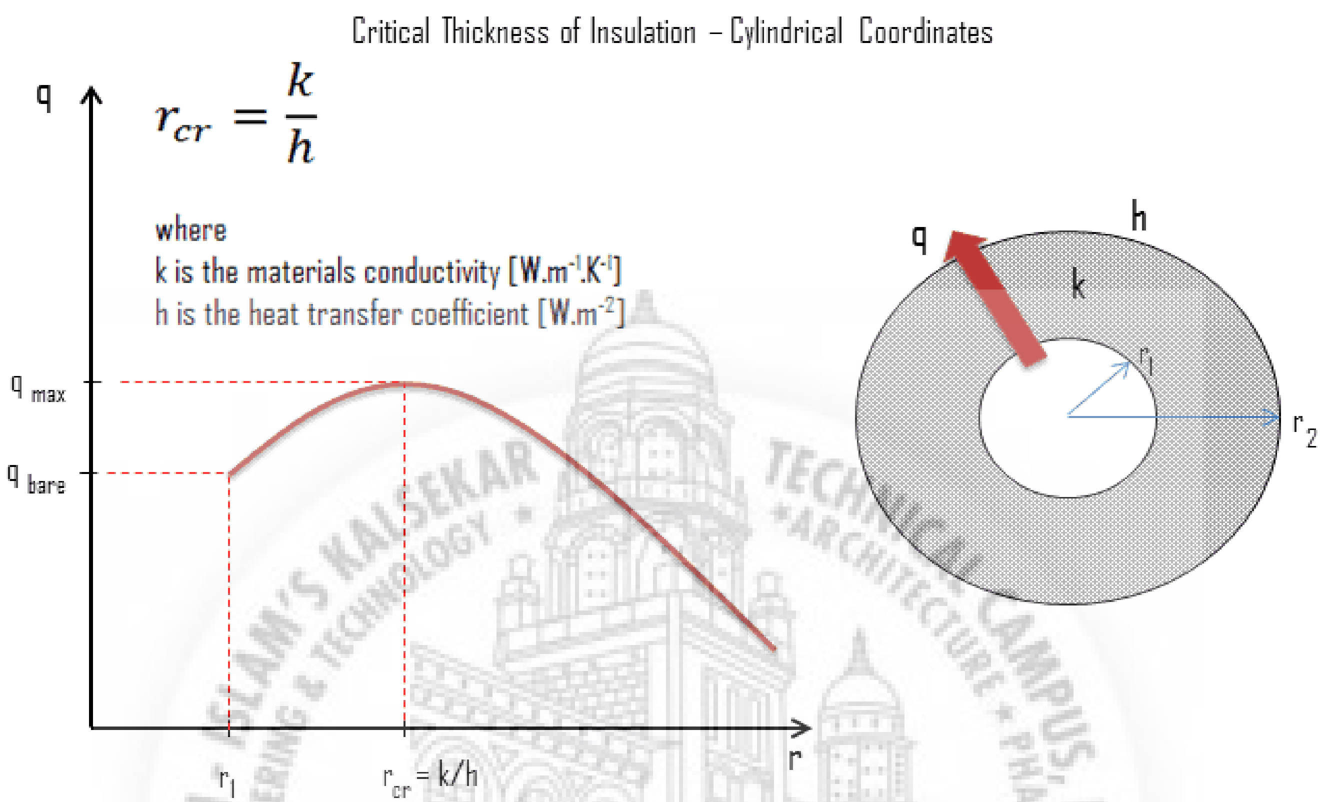
Insulation is necessary to prevent the heat from the exhaust from reaching these components.

High performance cars often use thermal insulation as a means to increase engine performance.

5. Heat shield is one of the most widely used heat management options available due to its relative low price and ease to fit. In the past it has usually been custom made from rigid steel; however, flexible aluminum is now the standard. The key difference between a heat shield and insulating the pipe, through either wrapping or thermal coating, is the air gap that exists between the exhaust and the shield.

Critical thickness of insulation:

Whenever we want to reduce the heat transfer, we will add insulation. So a layers added on a pipe (imagine A steam carrying pipe , which is losing heat to the environment and thereby before the steam reaches the turbine it is getting condense) . So I want to minimize the heat loss, so i will go for adding insulation on it. When I add insulation, the outer surface increases without insulation pipe radius is r1, with insulation
Pipe radius is r2 (r2> r1)



$$Q = \frac{\Delta T}{\frac{1}{2\pi k L} \ln \frac{r_2}{r_1} + \frac{1}{h_o 2\pi r_2 L}}$$

As we go on adding insulation, r2 increases as r2 increases, conductive resistance in the denominator increases and at the same time as r2 increases convective resistance decreases. At initial stages, decrease in convective resistance is dominant when compared to addition of conduction resistance. So overall resistance decreases and Q will increases.

As we go adding r2 , after some time conduction resistance starts dominating convective resistance and hence as conducting resistance increase more rapidly than decrement in convective resistance, the total resistance increases and heat transfer decreases,.

So if we plot a graph between Q and r it will seems like this

The point at which Q max occurs is called critical radius.

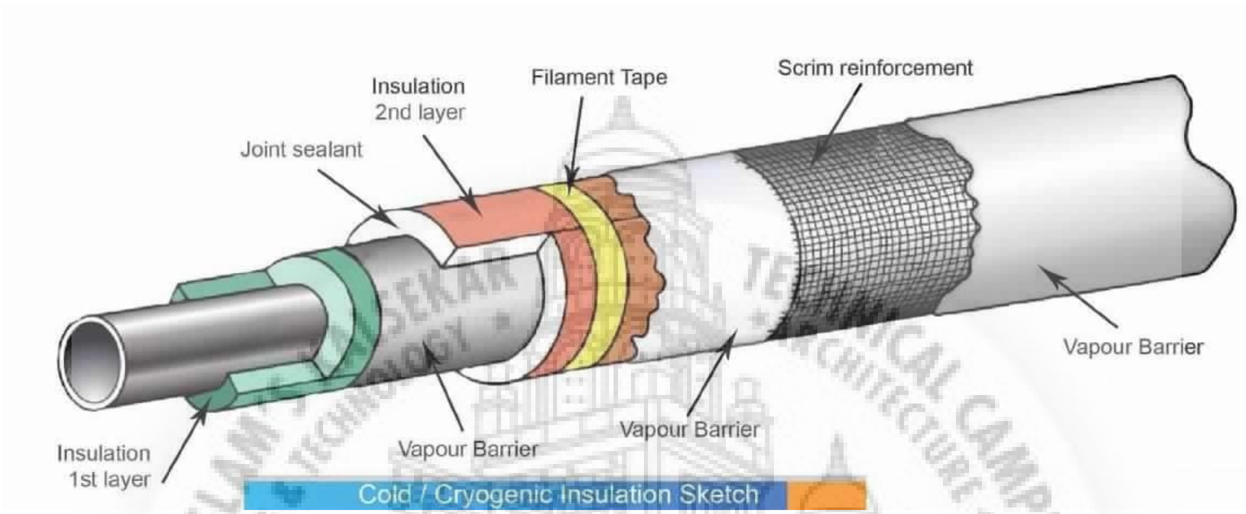
The radius at which Q will be Q max is called critical radius. (The below derivation is for cylinder

When we intend to reduce the heat loss by adding insulation it is essential that the final radius must be larger than critical radius.

1.2: Problem Definition

- In order to reduce the heat loss insulation is needed to be added to be system but in order to reduce the material consumption insulation is added at an optimum level this is known as critical thickness.
- Heat loss is reduced if we add insulation greater than critical thickness.
- Optimum level of insulation can be calculated by using analytical method for simple problems, but when the problem gets complicated analytical calculations becomes very difficult.
- The company that we visited. CHEMICAL PROCESS EQUIPMENTS PVT. LTD. are making storage vessels as their final product.
- First they make a mold of the vessel in the caster using pvc material, after making and solidification of the mold it is necessary to give it proper strength and toughness to withstand under working parameter
- To give it the strength it is required they coat it with a resin mixture /Composites in order to increase its strength and to withstand the working condition.
- The resin mixture/composite which is used is first heated to a temperature of 25^{0}C
- Then that heated mixture flows to the hose via pump pressure where a worker sprays that mixture to the surface of the storage vessel
- The main problem which is arising in the plant is that the heat loss in the pipe which contains the resin mixture/composite is more

Than they expected which causes to decrease in the resin mixture temperature.



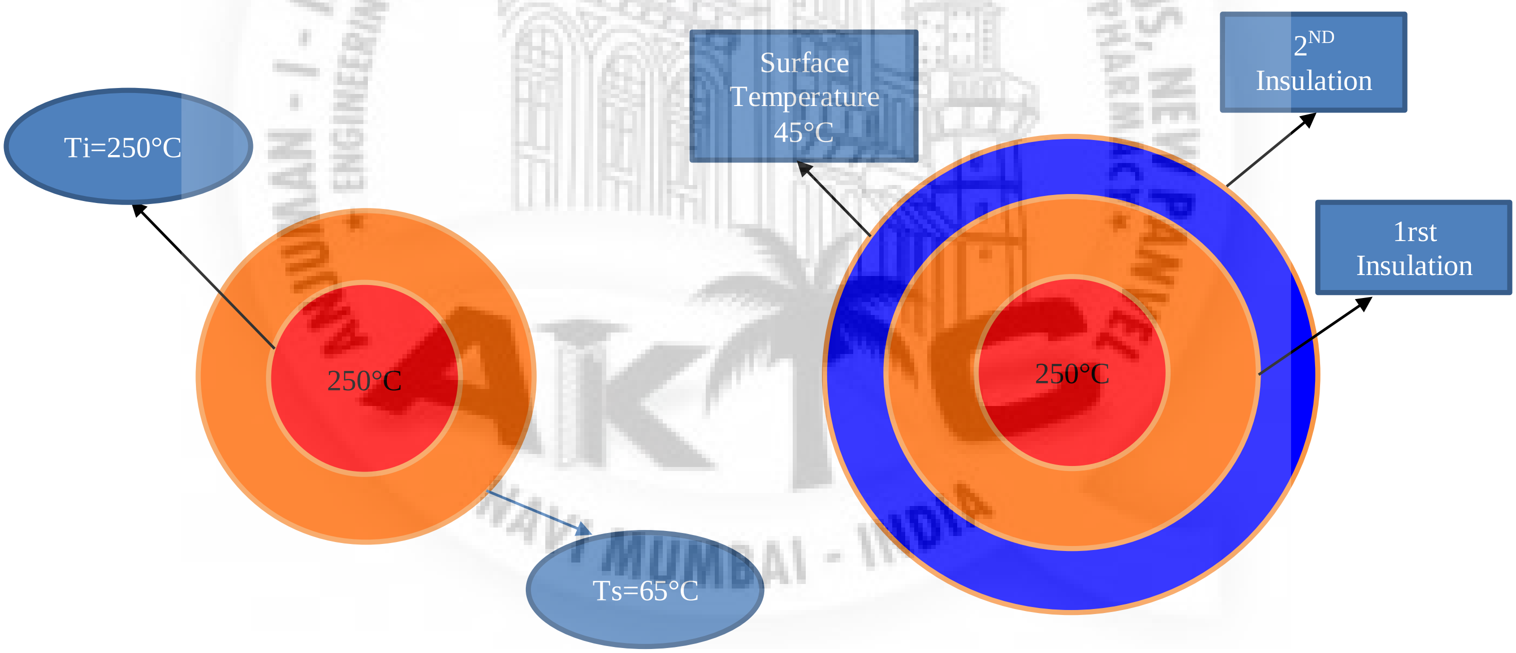
F.g.1. Cryogenic Insulation Sketch

- The decrease in the temperature of the resin causes some difficulty in the coating process
- So the output temperature that they require is less than 25⁰ C and in order to compensate for the heat loss the heating of the resin mixture has to be increased
- This increases the energy consumption of the plant and henceforth increases the cost of the final product.

1.3: Objective of the Study:

- In order to reduce the heat loss and subsequent cost we must change the existing insulation.
- The current insulation which the industry is using are thermocol on the steel pipe where the outside surface temperature is coming as 65°C.
- The surface temperature which is required in order to reduce the heat loss and to keep the energy consumption is 45°C.

f.g.2. Suggested idea to the industry



CHAPTER 2

LITERATURE REVIEW

LITERATURE SURVEY

2.1: List of Paper

Serial No.	Name of journal	Name of author	Title	Year	Short description
1	International journal of thermal sciences	Tolga Ural,Ali Dasdemir,Ali kecebas. From TURKEY	Analysis of optimum insulation thickness with air gap	2019	The use of effective insulation methods to reduce heat loss and minimize is economic and environmental effect in city pipe line system
2	International journal of thermal sciences	H. Zhu, B. V. Shankar	Optimization of metallic foam insulation using transient heat transfer	2004	Minimizing the maximum temp with foam insulation under transient heat condition
3	International journal of thermal sciences	Meral Ozel	Effect of insulation on building externals wall to optimize insulation thickness	2013	Optimization of insulation thickness are investigated numerically using an implicit finite difference method under steady condition.
4	International journals of Science.	Pierre Michel	Study on transient heat transfer through multilayer insulation	2010	Numerical and experimental study of heat transfer through two different multilayer insulation for building application

Serial No.	Name of journal	Name of Author	Title	Year	Short Description
5	Applied thermal engineering	Ali Bolatturk	Determination of optimum insulation for building walls with respect to various fuel and climate zone.	2005	Considerably energy saving can obtained by using proper use of insulation wit h the help of fuel used as coal and natural gas.
6	International Journals of Hydrogen Energy	Gulru Babac.	Two Dimensional Thermal Analysis Of liquid hydrogen tank insulation.	2009	Multilayer insulation and a Vapor cooled shield and liquid hydrogen is used to minimize the eat leakages.
7	Journal Heat Transfer Engineering	G. M. Zaki,A, M Al- Turki.	Optimization of Multilayer Thermal Insulation for Pipelines	2019	Thermal insulation economic analysis for a system of pipelines insulated by different materials composite layers is studied.
8	Thermal Engineering	Lili Zhang, Yating - Wang	Effect of the thermal insulation layer of wall dynamic thermal response rate under the air-conditioning intermittent operation	2017	Under the continuous and intermittent operation of air-conditioning, a experiment is built to analyze the effect of the thermal insulation.

2.2: Description:

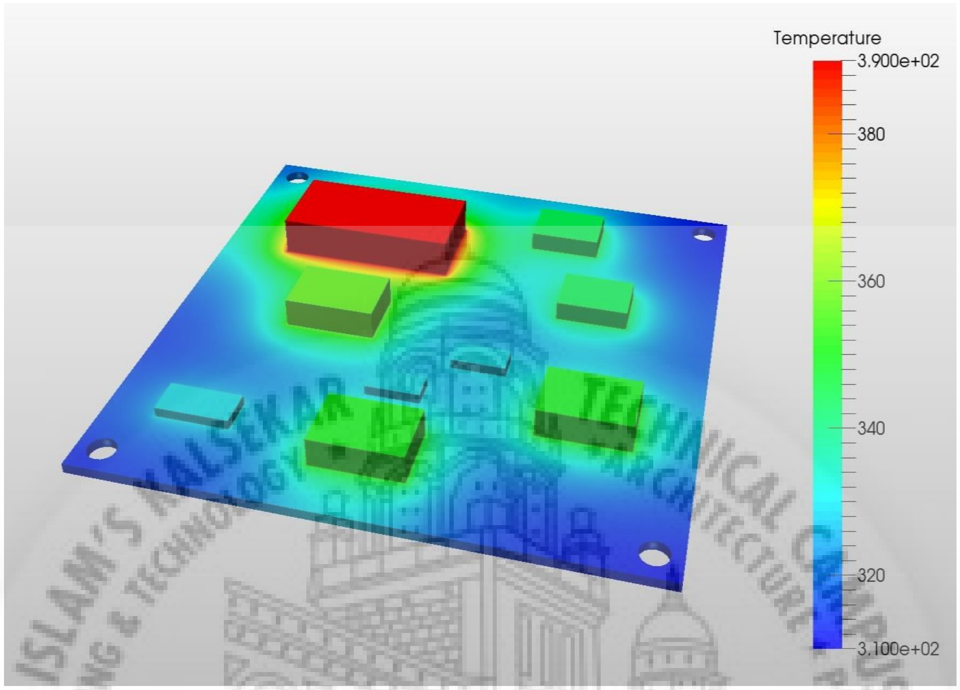
- International journal of thermal sciences in this literature we had seen experiment which is done on Analysis of optimum insulation thickness with air gap the main intention in this journal is to reduce the heat loss and minimize the economic. Which is published in the 2019. Author name Tolga Ural, Ali Dasdemir.

- International journal of thermal sciences in this journal there is a optimization of metallic foam insulation using Transient heat transfer main aim is to minimize the maximum temperature with foam insulation under Transient Heat Condition. Author is H. Zhu, B.V. Shankar published in 2004.

- Applied thermal Engineering in this literature survey we came to know about Determination of Optimum insulation for building walls with respect to various fuel and climate zone considerably energy saving can obtained by proper use of insulation with the help of fuel used as coal and natural gas. Author Ali Bolatturk, published in the year of 2005.

- In Thermal Engineering Effect of the thermal insulation layer of wall dynamic thermal responses rate under the air conditioning intermittent operation in short it is under the continuous and intermittent operation of air conditioning

- The Experiment is built to analyze the effect of the thermal insulation.



Lowing the different simulation settings you have to define are described in detail as well as the various options you can add.

The simulation type **Heat transfer** allows the calculation of the temperature distribution and heat flux in a solid under thermal loads as for example convection and radiation.

As a result you can analyze the temperature distribution in a steady state scenario as well as for example a transient heating process of a mechanical part. A negative heat flux over the borders of the domain illustrates the thermal power loss of e.g. a cooled device

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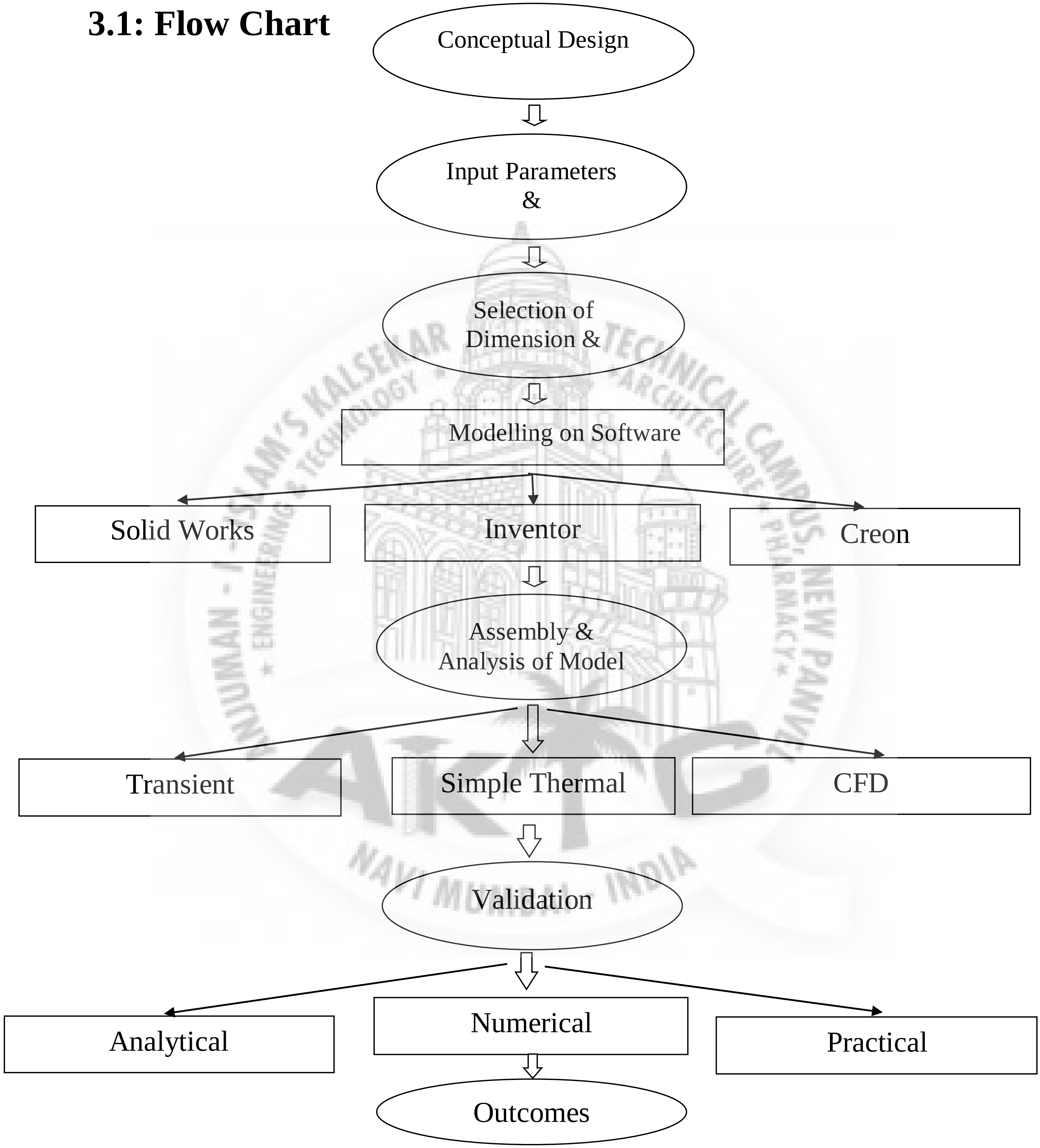
CHAPTER 3

METHODOLOGY

3.1: Flow Chart



3.2: Methods

Domain

In order to perform an analysis a given geometrical domain you have to discretize your model by creating a mesh out of it. Details of CAD handling and Meshing are described in the Pre-processing section.

After you assigned a mesh to the simulation you can add some optional domain-related settings and have a look on the mesh details. Please note that if you have an assembly of multiple bodies that are not fused together, you have to add Contacts if you want to build connections between those independent parts.

Materials

In order to define the material properties of the whole domain, you have to assign exactly one material to every part and define the thermal properties of those. Note that the specific heat is only needed for transient analyses.

1. Initial Conditions

For a time dependent behavior of a solid structure it is important to define the Initial Conditions carefully, since these values determine the solution of the analysis. If you chose to run a transient analysis the temperature depends on time. It is set to room temperature (293.15 K) by default and is also provided for steady-state simulations for convergence reasons.

2. Boundary conditions

You can define temperature and thermal load boundary conditions. If you provide a temperature boundary condition on an entity, the temperature value of all contained nodes is set to the given prescribed value. Thermal load boundary conditions define the heat flux into or out of the domain via different mechanisms. Note that a negative heat flux

Indicates a heat loss to the environment. As a temperature boundary condition of the domain it is not possible to simultaneously add a thermal load on that part.

3. Convective heat flux

This boundary condition is used to define a **Convective heat flux** from boundary faces of the domain to the environment. The magnitude of the heat flux as well as its direction (heat entering or leaving the body) is dependent on the reference temperature (also environmental temperature Tenv) and the convection coefficient h. Note that the
5Convection coefficient does not only depend on the surrounding fluid but is a property of the surrounding fluid flow. Including the calculated temperature TT on the surface of the domain the convective heat flux is given by:

$$q=h\,(T-T_{env})\quad q=h\,(T-T_{env})$$

4. Concentrated heat flux

The **Concentrated heat flux** boundary condition defines a heat source or a heat sink on a specific node. Note that if this boundary condition type is assigned to an edge, a surface or a volume, this holds for every single node lying on the chosen entity.

5. Turbulence boundary conditions

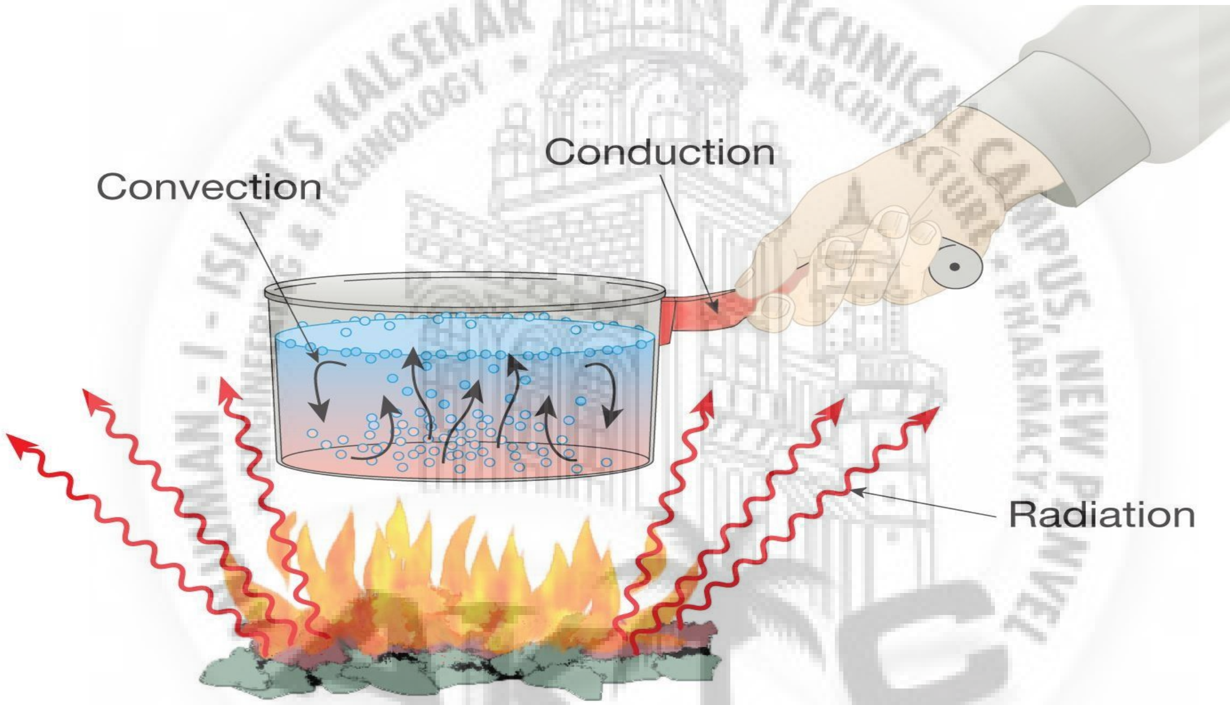
There is a lot of literature and good resources for adjusting the boundary conditions of the turbulence model that one uses for a fluid mechanics simulation. Find in the following some links to valuable resources to determine correct values for your simulation.

6. Radiation

A **Radiation** boundary condition defines the thermal radiation on a face or face set of the domain. It is defined by the reference temperature (sink temperature) and the emissivity ϵ. The radiation heat flux is then given, Involving the calculated temperature TT at the boundary and the Stefan Boltzmann constant σ, by:

$$q=\epsilon\sigma (T4-T4sink)$$

7. **Heat Transfer Methods**



F.g.1 Heat transfer taking place.

8. Surface heat flux

The **Surface heat flux** boundary condition describes a heat flux over boundary faces of the domain. As it is defined per unit surface area the total heat flux entering or exiting the domain is dependent on the surface area of the assigned faces.

9. Numeric

Under numeric you can set the equation solver of your simulation. The choice highly influences the computational time and the required memory size of the simulation.

10. Solver

Numerically, the last solution step during the calculation is to solve a linear system of equations. You can choose between different solvers. Generally one can distinguish direct and iterative solvers. Direct solvers often need more memory and are not as fast as iterative solvers.
However, they are quite robust and may be the better choice if the iterative solvers suffer from convergence problems.

10 Direct Solvers

- **Multi front** is a direct solver of the multi frontal type. It is easy to set up and behaves well for most problems.
- **MUMPS** is a general purpose direct solver of the multi frontal type. It provides a lot of parameter settings to allow the best fitting to your problems needs.
- **LDLT** is a direct solver which uses a Gaussian Algorithm. It is comparatively slow for big problems.

11. Iterative Solvers

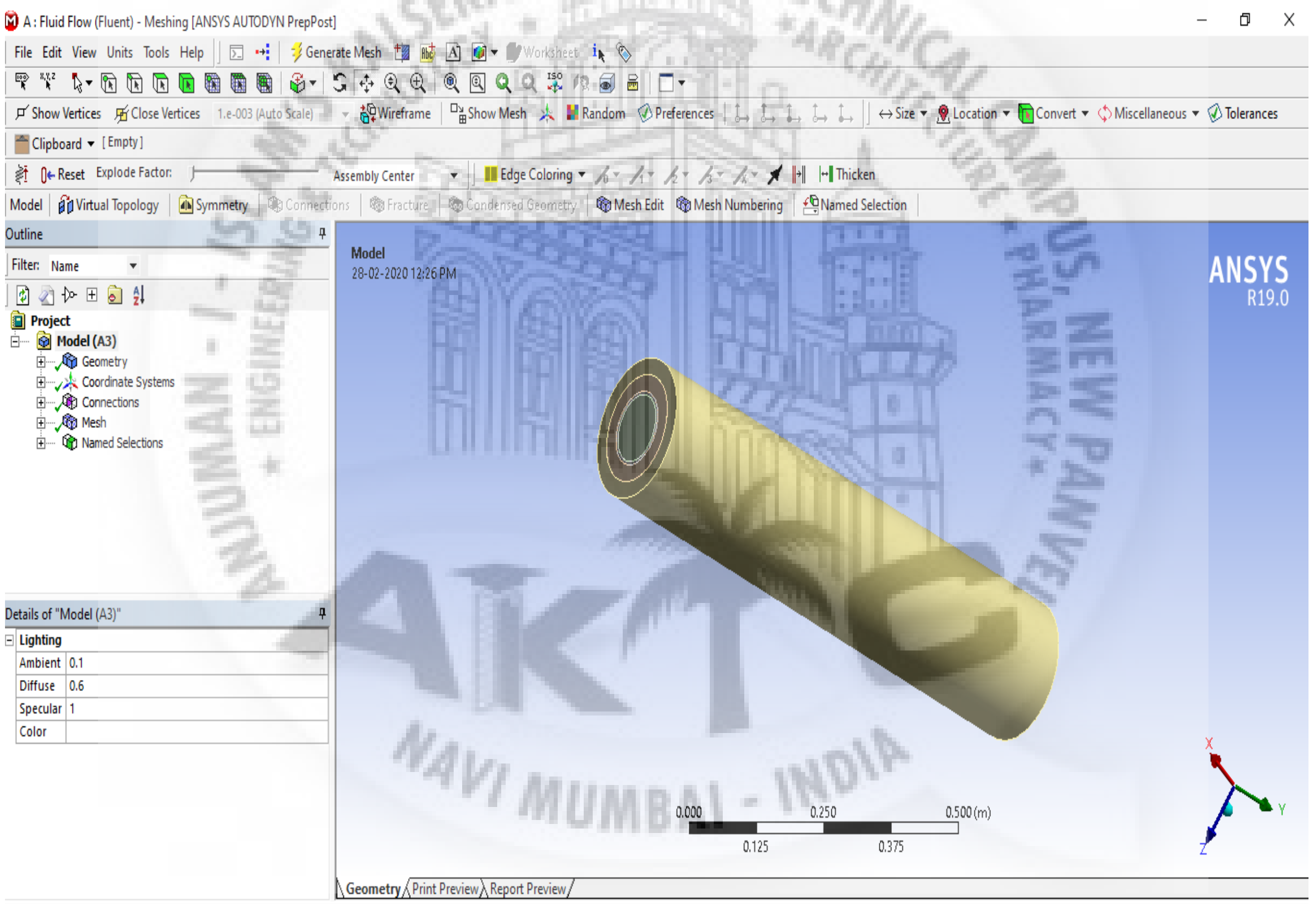
- **PETSC** is an iterative solver specially designed to deal with large systems. It scales very effectively in parallel and is the best choice for large problems.
- **GCPC** is an iterative solver of the pre-conditioned conjugate gradient type. It scales well in parallel and is also usable for large problems

CHAPTER 04

EXPERIMENTAL DETAILS

4.1: Model preparation

To produce the samples of steel pipe in order to test the Thermal properties i.e. Density, Heat Flux, Thermal conductivity, Thermal diffusivity, Total property, there is a need of model of a particular dimension as per the input parameters. So the model was made up of steel pipe and to create the model for testing on software had done are as follows: -



F.g.2 Modelling

4.1.1. Modelling Conductive and Convective Heat Transfer

Ansys fluent allow you to include heat transfer within the fluid and or solid region in your model problem ranging from thermal mixing within a fluid to conduction in Composite solid can thus be handled by **Ansys fluent**.

When you're **ANSYS FLUENT** model includes heat transfer you will need to activate the relevant physical models, supply thermal boundary of the setup. For information about setting up and using heat transfer in our **ANSYS FLUENT MODEL**,

4.1.2. Steps in Solving Heat Transfer Problems

The procedure for setting up a heat transfer problem is described below (Note that this procedure includes only those steps necessary for the heat transfer model itself ; you will need to set up other models boundary conditions ,etc. . as usual.)

1. To activate the calculation of heat transfer, enable the Energy Equation option in the Energy dialog box

- **Models** → **Energy** → **Edit….**

2. (Optional, pressure-based solver only.) if you are modelling viscous flow and you want to include the viscous heating items in the energy equation, enable the Viscous Heating option in the Viscous Model dialog box.

- **Models** → **Energy** → **Edit….**

3. The mass Conservation Equation

The equation for conversation of mass, or continuity equation, can be as follows:

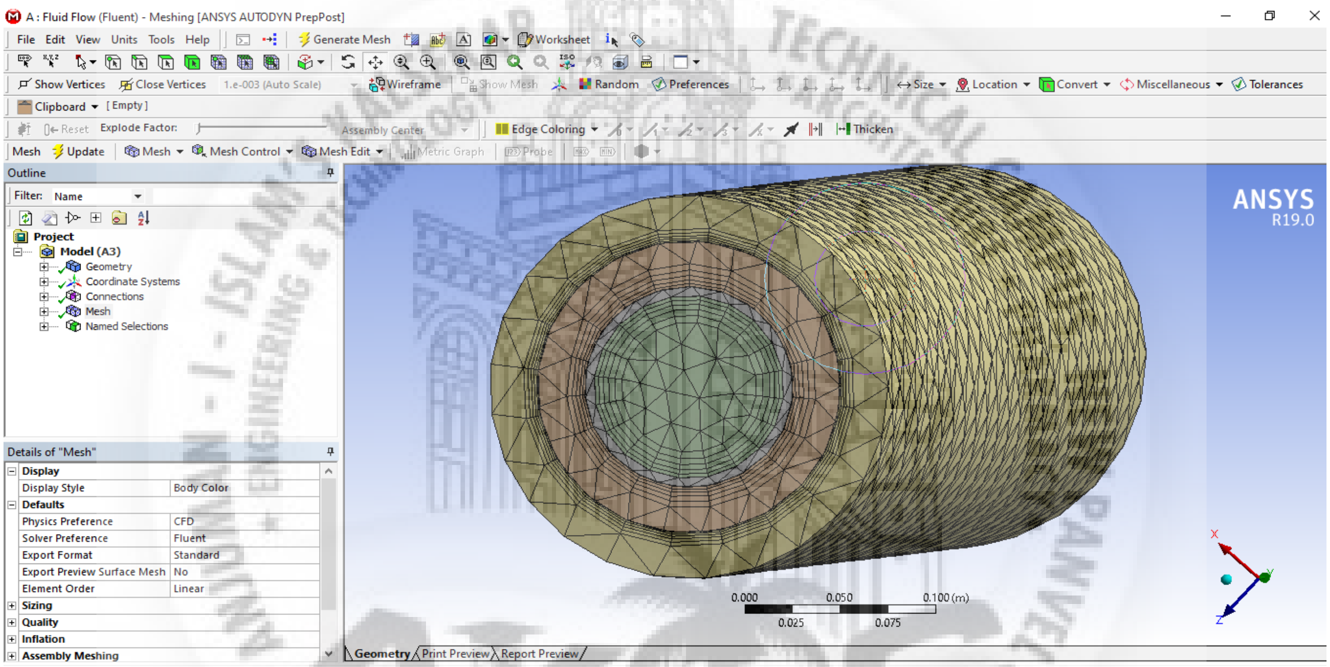
$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{v}) = 0,$$

4. The Continuity Equation is given by:

$$\frac{\partial}{\partial x}(\rho u) + \frac{\partial}{\partial y}(\rho v) + \frac{\partial}{\partial z}(\rho w) = 0$$

4.2: Meshing

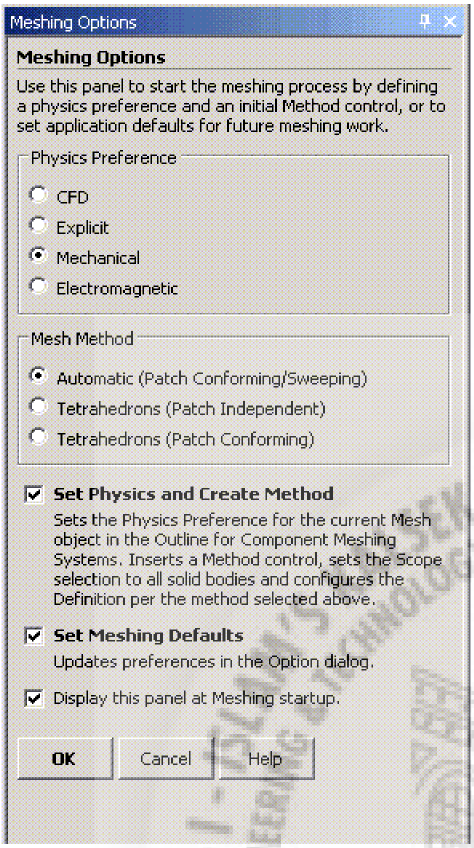
Meshing is an integral part of the engineering simulation process where complex geometries are divided into simple elements that can be used as discrete local approximations of the larger domain. The mesh influences the accuracy, convergence and speed of the simulation. Furthermore, since meshing typically consumes a significant portion of the time it takes to get simulation results, the better and more automated the meshing tools, the faster and more accurate the solution. It is a method of dividing the component into finite number of pieces known as ELEMENTS.



F.g.3. Meshing

The goal of meshing in ANSYS Workbench is to provide robust, easy to use meshing tools that will simplify the mesh generation process. These tools have the benefit of being highly automated along with having a moderate to high degree of user control.

Upon startup of the Meshing application from a Mesh system, you will see the Meshing Options panel shown below. This panel allows you to quickly and easily set your panel after startup, you can display the panel again by clicking the Options button from the Mesh toolbar.



4.2.1 Physics Preference Preprocessing

The first option the panel allows you to set is your **Physics Preference.** This corresponds to the **Physics Preference** value in the Details View of the **Mesh** folder. Setting the meshing defaults to a specified "physics" preference sets options in the **Mesh** folder such as **Relevance Center**, **midsize node behavior**, shape checking, and other meshing behaviors.

Mesh Method

Setting the Physics Preference option also sets the preferred Mesh Method option for the specified physics. All of the meshing methods can be used for any physics type, however we have found that some of our meshers are more suitable for certain physics types than others. The preferred ANSYS Workbench Mesh Methods are listed below grouped by physics preference.

Mechanical: The preferred meshers for mechanical analysis are the patch conforming meshers (Patch Conforming Tetrahedrons and Sweeping) for solid bodies and any of the surface body meshers.

Electromagnetics: The preferred meshers for electromagnetic analysis are the patch conforming meshers and/or the patch independent meshers (Patch Independent Tetrahedrons and MultiZone).

CFD: The preferred meshers for CFD analysis are the patch conforming meshers and/or the patch inde- pendent meshers. See *Method Control* for further details.

Explicit Dynamics: The preferred meshers for explicit dynamics on solid bodies are the patch independent meshers, the default sweep method, and the patch conforming mesher with Virtual Topologies. The preferred meshers for explicit dynamics on surface bodies are the uniform quad/quad-tri meshers or
The quad dominant mesher when used with size controls and Virtual Topologies.

Set Physics and Create Method

This option sets the Physics Preference for the current Mesh object in the Tree Outline for Mesh component systems. It inserts a Method control, sets the scope selection to all solid bodies, and configures the definition according to the Mesh Method that is selected on the panel. To enable this option, you must attach geometry containing at least one solid body and remove any existing mesh controls.

Set Meshing Defaults

This option updates your preferences in the Options dialog box. The Options dialog box is accessible by selecting Tools> Options from the main menu of the Meshing application.

If a Mesh Method has already been set for the current model and the Set Meshing Defaults option on the Meshing Options panel is unchecked, the OK button on the Meshing Options panel will be grayed out (unavailable). This is because in such cases where the Mesh Method has already been set, the Meshing Options panel would be useful only for setting meshing defaults in the Options dialog box. Thus if you uncheck Set Meshing Defaults, the Meshing Options panel cannot provide any additional functionality and the OK button is disabled.

Display This Panel at Meshing Startup

This option controls whether the Meshing Options panel appears at startup of the Meshing application.

Meshing Implementation in ANSYS Workbench

The meshing capabilities are available within the following ANSYS Workbench applications. Access to a particular application is determined by your license level.

Types of Meshing

The following types of meshing are discussed in this section. Meshing by Algorithm Meshing by Element Shape

Meshing by Algorithm

This section describes types of meshing in terms of two meshing algorithms: “patch conforming” and “patch independent”.

What is patch conforming meshing?

Patch conforming meshing is a meshing technique in which all faces and their boundaries (edges and vertices) [patches] within a very small tolerance are respected for a given part. Mesh based defeaturing is used to overcome difficulties with small features and dirty geometry. Virtual Topology can lift restrictions on the patches, however the mesher must still respect the boundaries of the Virtual Cells.

Patch conforming meshing is invariant to loads, boundary conditions, Named Selections, results or any scoped object. That is, when you change the scope of an object, you will not have to re-mesh.

Mesh Refinement is supported with all of the patch conforming meshers.

Applications

You can implement patch conforming meshing using settings related to any of the following mesh control options.

Meshing by Element Shape

This section describes types of meshing in terms of element shapes. Applicable mesh control Meshing by Element Shape

Tet Meshing

- Patch Conforming Tetrahedron Mesher
- Patch Independent Tetrahedron Mesher

Hex Meshing

- Swept Mesher
- Hex Dominant Mesher
- Thin Solid Mesher

Hex/Prism/Tet Hybrid Meshing

- MultiZone Mesher

Cartesian Meshing

- Cut Cell Mesher

Comparing Effects of Mesh Methods on Different Types of Parts

Certain characteristics of meshes differ depending on whether an assembly of parts, a multibody part, or a multibody part with imprint is being meshed:

Assembly of parts—Mesh of one part has no relation to mesh of other part unless there is contact sizing, and in this case the mesh is still not conformal.

Mesh Meth - od	Assembly of Parts	Multibody Part	Multibody Part with Im- print (Non-matched)	Multibody Part with Imprint (Matched)
Patch Con-form-ing	Each part is meshed sep-arately.	Multibody part is meshed at the same time to en-sure conformal mesh.	Multibody part is meshed at the same time, but mesh does not need to be conformal because the faces are meshed separ-ately.	Multibody part is meshed at the same time. Mesh is matched where match controls are defined.
Genre-al Sweep	Each part is meshed sep-arately.	Multibody part is meshed at the same time to en-sure conformal mesh.	Multibody part is meshed at the same time, but mesh does not need to be conformal because the faces are meshed separ-ately.	Multibody part is meshed at the same time. There is no guaran- tee that the mesh on the source faces will be matched. The mesh is likely to match if the source faces are map meshed, but will not match if the source faces are free meshed. Since side faces are map meshed, the mesh on the side faces is likely to match.
Thin Sweep	Each part is meshed sep-arately.	Multibody part is meshed at the same time to en-sure conformal mesh.	Multibody part is meshed at the same time, but mesh does not need to be conformal because the faces are meshed separ-ately.	Multibody part is meshed at the same time. There is no guar an- tee that the mesh on the source faces will be matched. The mesh is likely to match if the source faces are map meshed, but will not match if the source faces are free meshed. Since side faces are map meshed, the mesh on the side faces is likely to match.

Hex Dominant	Each part is meshed separately.	Multibody part is meshed at the same time to ensure conformal mesh.	Multibody part is meshed at the same time, but mesh does not need to be conformal because the faces are meshed separately.	Does not support match control? Users can attempt matching through mapped face control on common face or face sizing's, but there is no guarantee that the mesh will be matched.

Mesh Method	Assembly of Parts	Multibody Part	Multibody Part with Imprint (Non-matched)	Multibody Part with Imprint (Matched)
			Possible control is set to No.	
MultiZone	Each part is meshed separately.	Multibody part is meshed at the same time to ensure conformal mesh.	Multibody part is meshed at the same time. Mesh will generally be conformal, but it is not forced. Faces are meshed separately.	Does not support match control. Users can attempt matching through mapped face control on common face or face sizing's, but there is no guarantee that the mesh will be matched.
Cut Cell	Conformal mesh at the part level is not supported.	Multibody parts are meshed at the same time and the mesh across parts is conformal.	Multibody parts are meshed at the same time and the mesh across parts is conformal.	Does not support match control.

Overview of the Meshing Process in ANSYS Workbench

.

1. Select the appropriate template in the Toolbox, such as Static Structural. Double-click the template in the Toolbox, or drag it onto the Project Schematic.
2. If necessary, define appropriate engineering data for your analysis. Right-click the Engineering Data
Cell, and select Edit, or double-click the Engineering Data cell. The Engineering Data workspace appears, where you can add or edit material data as necessary.
3. Attach geometry to your system or build new geometry in the Design Modeler application. Right-click
The Geometry cell and select Import Geometry... to attach an existing model or select New Geometry....
To launch the Design Modeler application.
4. Access the Meshing application functionality. Right-click the Model cell and choose Edit. This step will launch the Mechanical application.

4.3: Setup

In setup we have to put Boundary condition at flow inlets, Flow outlets, and walls.

- Boundary Conditions

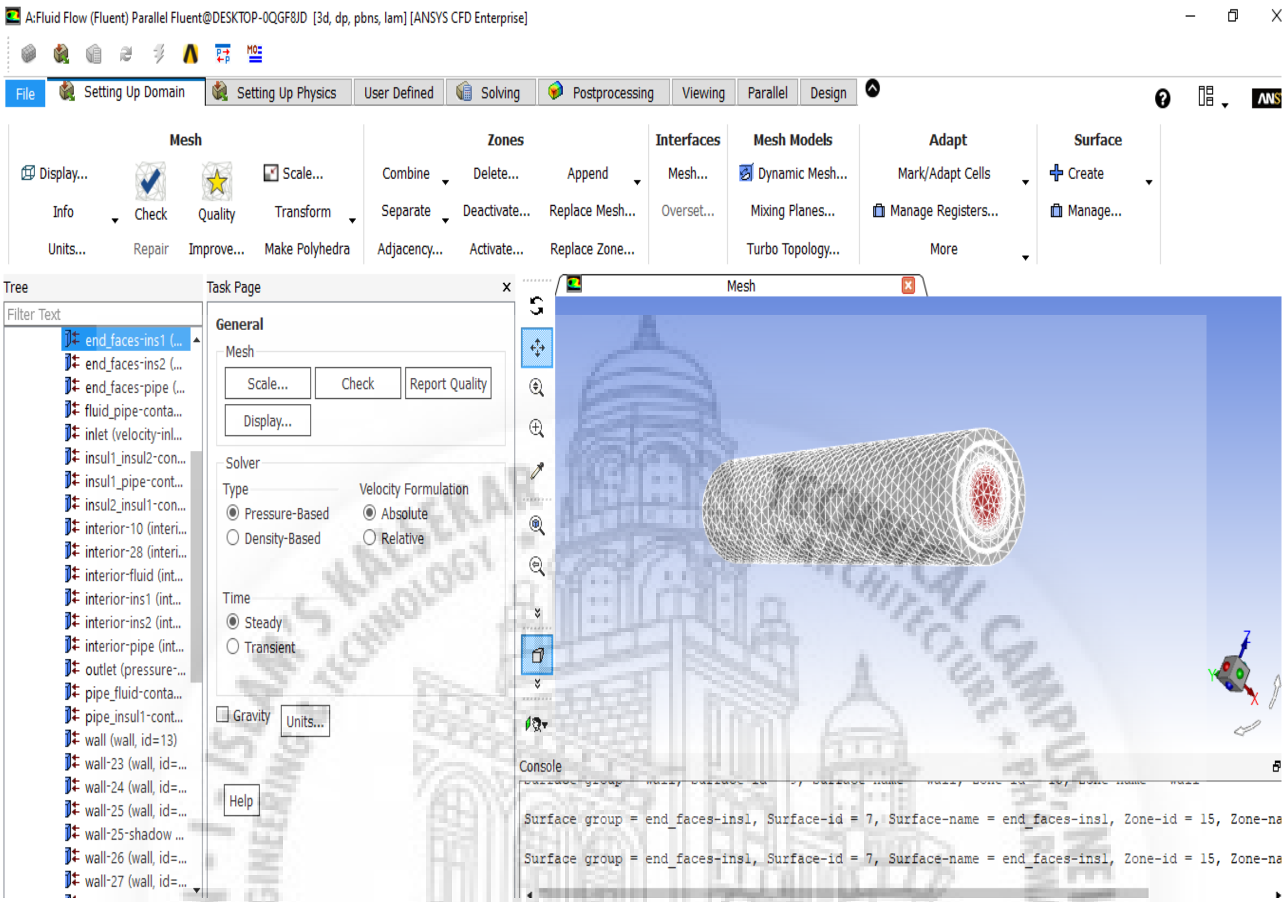
At flow inlets and exits you will set the temperatures; at walls you may use any of the following thermal conditions:

- Specified heat flux
- Specified temperature
- Convective heat transfer
- External radiation
- Combined external radiation and external convective heat transfer

ANSYS FLUENT provides reporting option for simulation involving heat transfer .You can generate graphical plots or reports of the following variables/function:

- Static Temperature
- Total Temperature
- Enthalpy
- Relative Total Temperature
- Wall Temperature (Outer Surface)
- Wall Temperature (Inner Surface)
- Total Enthalpy
- Total Enthalpy Deviation
- Entropy
- Total Energy
- Internal Energy
- Total Surface Heat Flux

The first 12 variables listed above are contained in the Temperature… categories of the variable selection drop-down list appears in post processing dialog box.



F.g.4. Setup with Mesh

- **CASE 1**:
- Calculate current heat transfer rate (Q) based on industrial dimension.
- Adding second insulation and calculating new heat transfer rate (Q1).
- Comparing (Q1) with (Q)
- **CASE 2**:
- Reducing the dimension of 1st insulation and adding of small composite layer.
- Calculating the new heat transfer rate (Q2).

- Adding different component material and finding their corresponding heat transfer with different thickness.
- **CASE 3**: Finding the optimum thickness till (Q2) is less than (Q) without any major increasing cost.

- **The Definition of enthalpy and in energy in reports and displays**

The definition of the reported values of enthalpy and energy will be different depending on whether the flow is compressible or incompressible.

- **Reporting heat transfer through boundaries**

You can use the Flux Report dialog box to compute the heat transfer through each boundary of the domain, or to sum the heat transfer through all boundaries to check the balance.

- **Reporting → Fluxes Set → Up**

It is recommended that you perform a heat balance check to ensure that your solution is truly converged

- **Reporting Heat Transfer through a Surface**

You can use the Surface Integral dialog box to compute the heat transfer through any boundary of any surface created using the methods described above.

Reports → Surface integral → Set Up…

To report the mass flow rate of enthalpy:

$$m^{\bullet} = \int_{A} \rho V_n dA \qquad \text{(kg/s)}$$

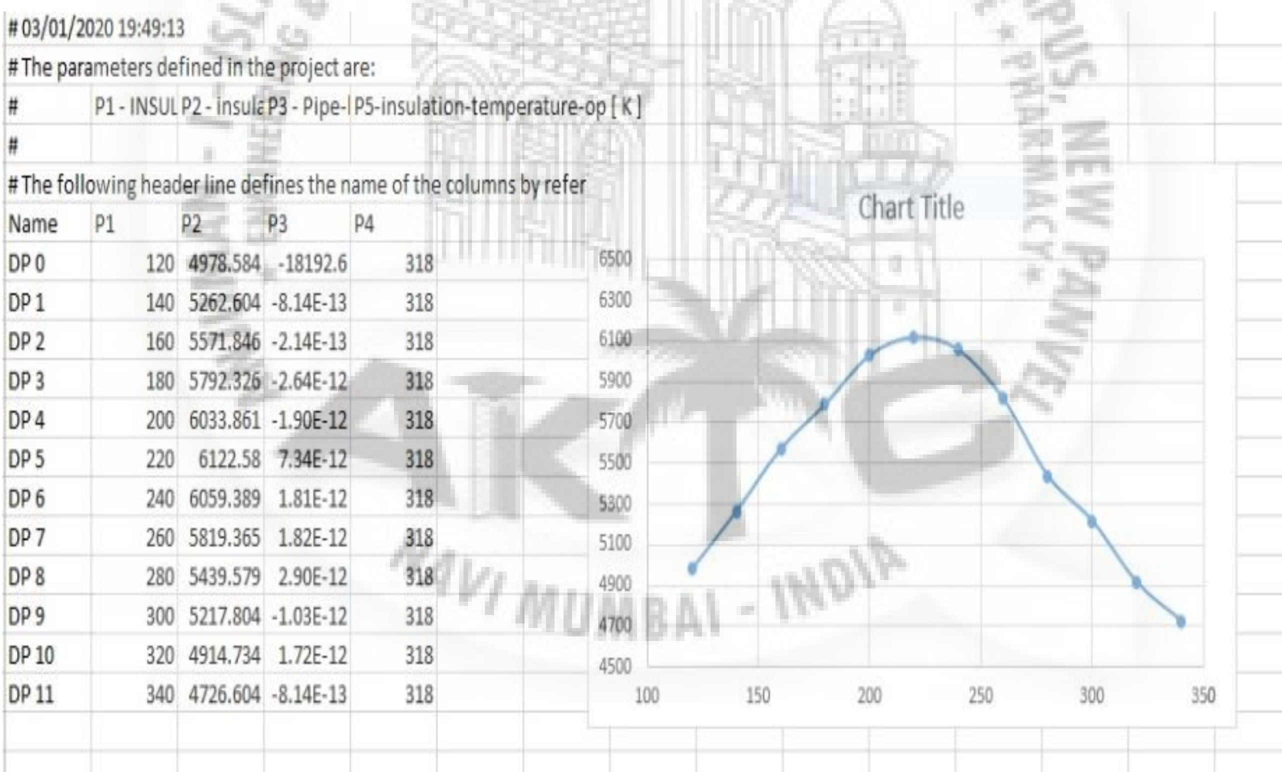
CHAPTER 5

TEST RESULTS

5.1: Thermal Analysis Result of Thermocol:

Physical Properties

Material	Thermocol
Density	20 kg/m^3
Internal Diameter	110 mm
Outer Diameter	160 mm
Thermal Conductivity	0.47 Wm/K



03/01/2020 19:49:13
The parameters defined in the project are:
P1 - INSUL P2 - insula P3 - Pipe-I P5-insulation-temperature-op [K]
#
The following header line defines the name of the columns by refer

Name	P1	P2	P3	P4
DP 0	120	4978.584	-18192.6	318
DP 1	140	5262.604	-8.14E-13	318
DP 2	160	5571.846	-2.14E-13	318
DP 3	180	5792.326	-2.64E-12	318
DP 4	200	6033.861	-1.90E-12	318
DP 5	220	6122.58	7.34E-12	318
DP 6	240	6059.389	1.81E-12	318
DP 7	260	5819.365	1.82E-12	318
DP 8	280	5439.579	2.90E-12	318
DP 9	300	5217.804	-1.03E-12	318
DP 10	320	4914.734	1.72E-12	318
DP 11	340	4726.604	-8.14E-13	318

F.g.5 Thermocol Result Chart

Material(s)

Name	Thermocol	
General Input	Mass Density	20 kg/m^3
	Internal Diameter	110 mm
	Outer Diameter	160 mm
Output/Outcomes	Heat Transfer	-6122.58 J/s
	Temperature	318 K
	At Thickness	220 mm

Temperature's taken (T):

F.g.6 Temperature Contour Diagram.

Result Summary:

Name	Output Result
Mass density	20 kg/m^3
Heat Transfer	-6122.58 J/s
Temperature	318k
Thickness Variation	120 to 340 mm

5.2: Thermal Analysis Result of Fiber Glass Material:

Physical Properties

Material	Fiber Glass
Density	30 kg/m^3
Thermal Conductivity	0.0732 Wm/K

03/05/2020 13:24:15
The parameters defined in the project are:
P1 - insula P2 - insula P3 - insulation-heat-flux-op [W m^-2]
#
The following header line defines the name of the columns by reference to the parameters.

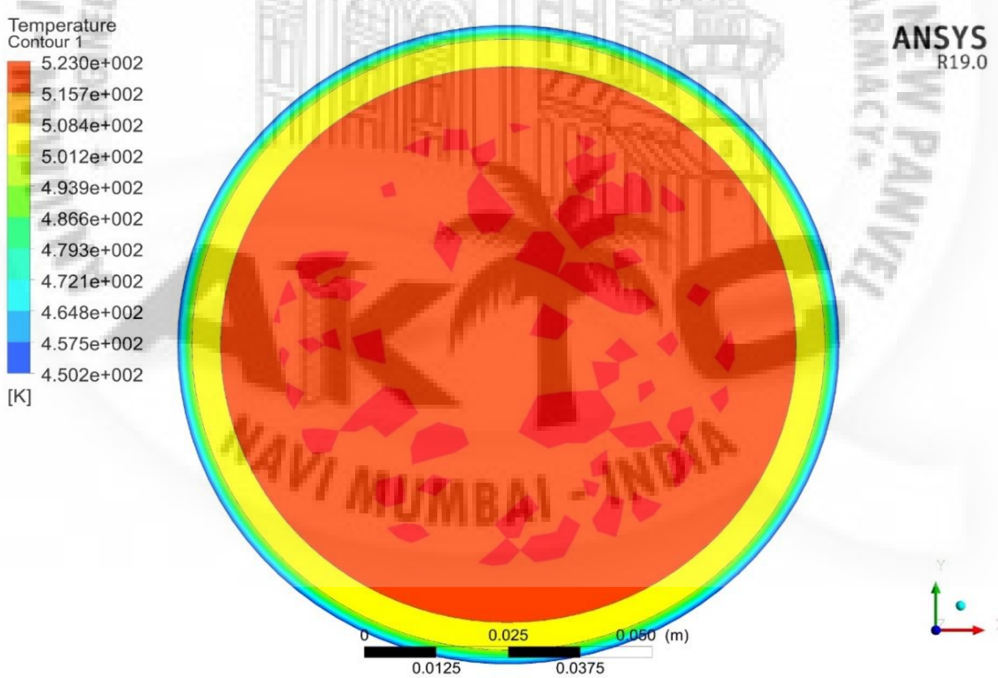
Name	P1	P2	P3
DP 0	115	451.8616	-1466.43
DP 1	120	429.2426	-1128.44
DP 2	123	419.1668	-994.099
DP 3	126	410.7525	-889.094
DP 4	128	405.8456	-830.766
DP 5	130	401.3945	-779.656
DP 6	133	395.4267	-713.745
DP 7	136	390.1548	-657.952
DP 8	140	383.9948	-595.563

F.g.7. Fiber Glass Chart.

Material(s)

Name	Fiber Glass	
General Input	Mass Density	30 kg/m^3
Output/Outcomes	Heat Transfer Rate	-830.766 J/s
	Temperature	383 K
	At Thickness	128 mm
	Internal Diameter	100 mm
	Outer Diameter	128 mm

Temperature's taken (T):



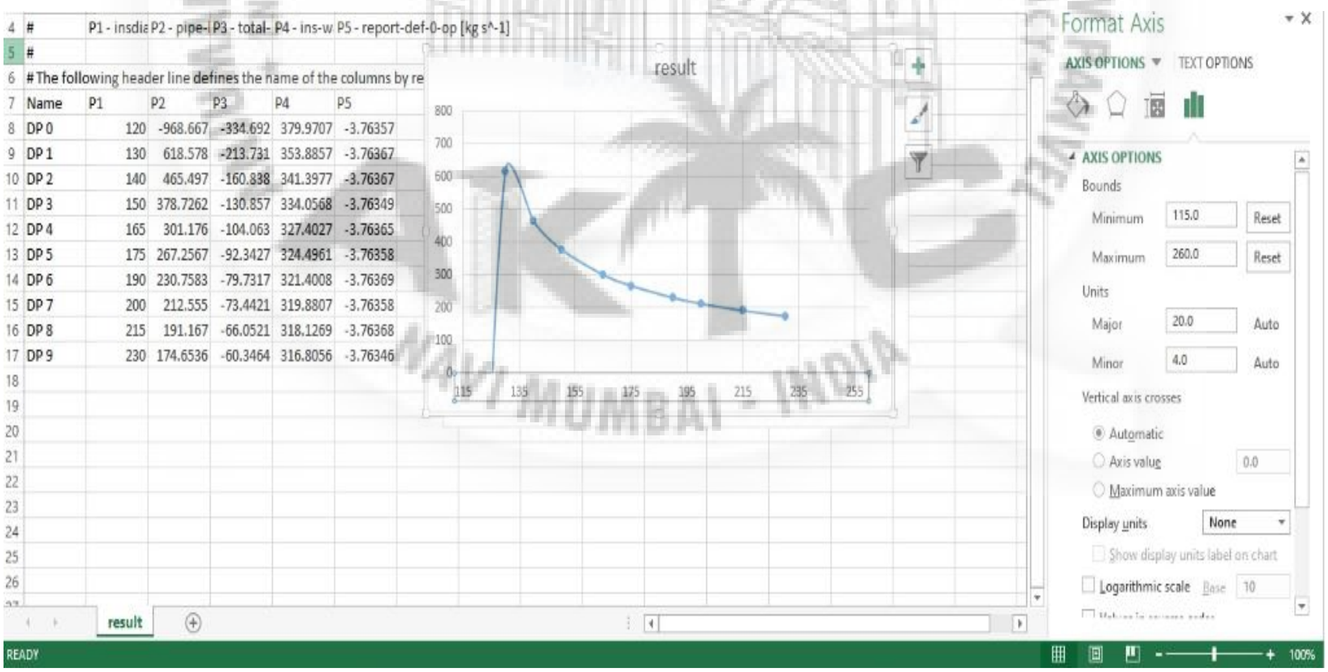
F.g.7 Temperature Contour Diagram.

Result Summary

Name	**Output Result**
Mass density	30 kg/m^3
Heat Transfer Rate	-830.66 J/s
Temperature	318 K
Thickness Variation	115 to 140 mm

5.3: Thermal Analysis Result of Polystyrene Material:

Material	Polystyrene
Density	19 kg/m^3
Thermal Conductivity	0.0402 Wm/K

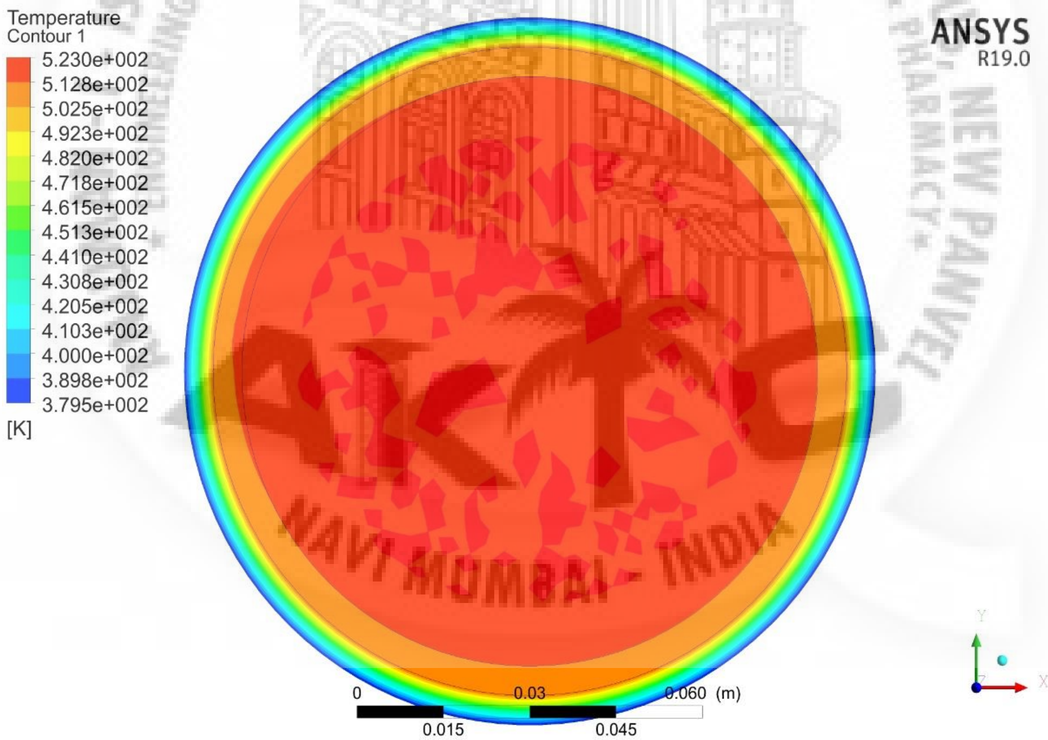


F.g.8 Temperature Contour Chart

Material(s)

Name		
General Input	Mass Density	19 kg/m^3
Output/Outcomes	Internal Diameter	100 mm
	Outer Diameter	130 mm
	Heat Transfer	-618.578 W/m^2
	Temperature	353.88 K
	At Thickness	30 mm

Temperature's taken (T):



F.g.9 Temperature Contour Diagram.

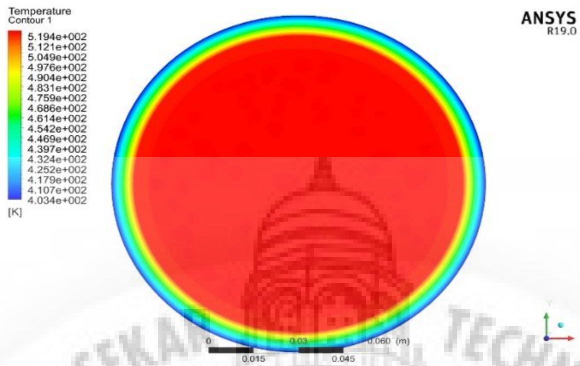
Result Summary:

Name	Output Result
Mass density	19 kg/m^3
Heat Transfer Rate	-618.578 J/s
Temperature	353.88 k
Thickness Variation	120 to 230 mm

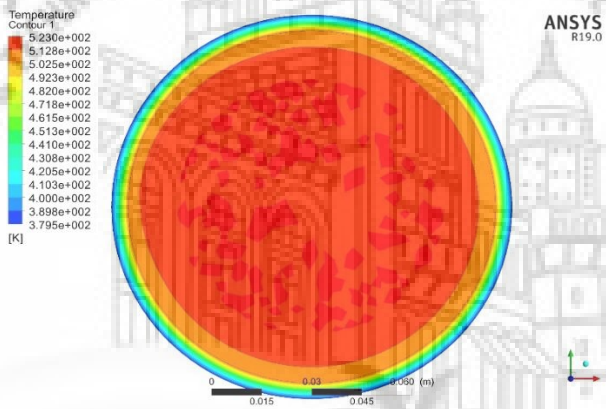
5.4: Future Scope:

- Some new composite or smart material can be added to further reduce the heat loss.
- It also reduce the thickness of insulation and hence reducing the energy consumption which is directly affected on the cost

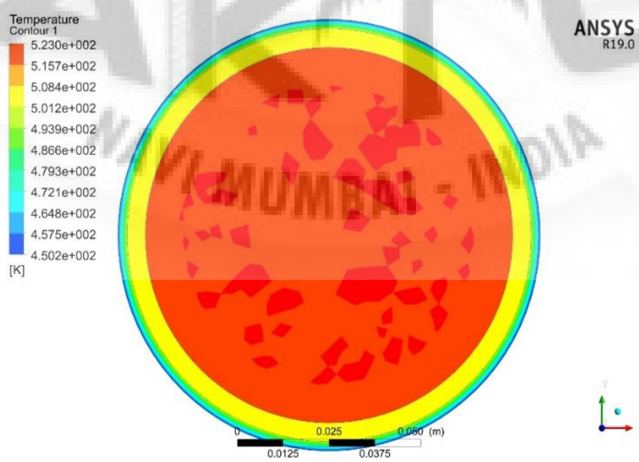
5.5: Comparison between Overall Result Temperatures Contour of all Materials.



Thermocol



Polystyrene



Fiber Glass

CHAPTER 6

CONCLUSION

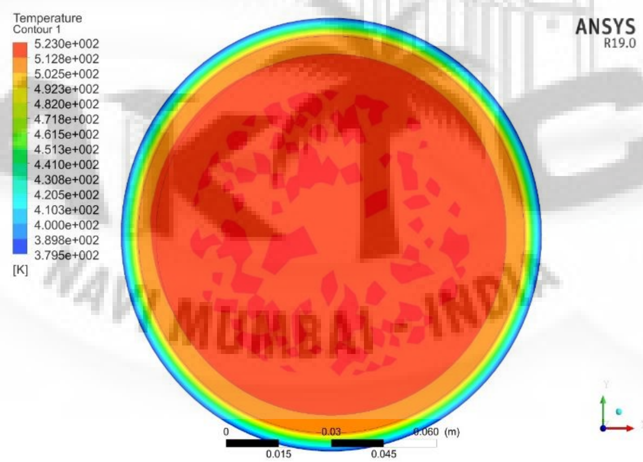
6.1 Conclusion:

As due to corona virus or COVID-19, tests are not possible practically, so in order to conclude this study with complete report. We had done testing or analysis in software such as **ANSYS** to get the idea of the composite Materials that is Polystyrene material insulation with a proper insulated on a steel pipe its result chart and Temperature Contour is shown in figure no.8 and 9.

According to the output Results are shown below of the **Polystyrene material** that the Result were produced during the experiment process by taking no. of iteration with varying different thickness to get a Critical Thickness of insulation Material as Shown below:-**Materials**

Name		
General Input	Mass Density	19 kg/m^3
Output/Outcomes	Internal Diameter	100 mm
	Outer Diameter	130 mm
	Heat Transfer	-618.578 W/m^2
	Temperature	353.88 K
	At Thickness	30 mm

Temperature's taken (T):



Temperature Contour of Polystyrene Material

It was observed from the results that, Polystyrene Material gave the best insulation properties and also to reduce the heat losses at the surfaces of Pipe.

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