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MODELING AND ANALYSIS OF NOZZLE AND EXHAUST PIPE OF A DIESEL LOCOMOTIVE

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ABSTRACT

Our main aim is to modify nozzle designs of a fuel injector in railway engine to generate more power as output by which rail engine can carry more load. There are many ways to increase the power generated from engine, by considering one of the best one among them through which power generated from the railway engine increases. The purpose of this is to calculate the design of fuel injectors plunger, barrel and nozzle for 450HP, V-16 diesel engine. In V-16 engine 16 similar fuel injectors supply the fuel as per the cam rotation, so we modify one of them and apply to all fuel injectors. In the case of high-pressure diesel fuel-injection the flow conditions inside the fuel injection holes have an important influence on the development of the spray. Therefore, the design of fuel injector nozzle is very important for engine performance. The injection pressure of this engine is 2700psi and compression ratio is 17. The large pressure differences across the fuel injector nozzle give higher jet velocity at nozzle exit. Fuel injected pressure and cylinder pressure derivations are carried out to provide for fuel injector nozzle's design. The simulated results show that the best design for a nozzle is by using smaller holes size where turbulent flow is well developed inside the nozzle and by modifying dimensions of plunger and barrel allows to hold more volume of fuel leads to increase horse power. To provide the materials to exhaust pipe of a diesel locomotive. In order to reduce of damage to turbine, we decided to provide material. We are considering two layers of absorption with 12mm thickness each. It is to achieve lower amount of heat transfer. As the engine is connected to turbocharger using exhaust pipe, this hot steam can be impregnated on to turbine at exhaust housing of turbocharger. So that efficiency also increases. In this project, we practically prove that two layers using various materials results in fast decrease in temperature. Of all the obtained results it is identified that, through materials maximum of temperature is minimized which results in good performance and lifetime for turbocharger. By this the people will not be affected. We must also consider the environmental conditions. Under all circumstances our project is successful. There may be heavy rains, or snow but the system must be capable of working in any environmental condition. There are coolants used to reduce of temperature amount. A material acts as a shield to the source. It's very light in weight

Keywords: *CATIA, ANSYS, Nozzle , Exhaust pipe.*

1. INTRODUCTION

1.1 Fuel Injector in Locomotive Engines:

Fuel injectors are the components that are responsible for the final stage of fuel delivery in fuel injection systems. High pressure fuelis delivered to the injector, which is activated by an engine control unit or fuel injector control module.

The injection nozzles and their respective nozzle holders are vitally important components situated between the in-line injection pump and the diesel engine, its functions are as metering the injection of fuel, management of the fuel, defining the rate-of-discharge curve, Sealing-off against the combustion, chamber.

1.2 Fuel Oil system:

The fuel oil system is designed to supply fuel to the engine in correct quantity and at the right time according to the engine requirements. The fuel oil system draws fuel from fuel tank, filter the fuel, pressurize the fuel, and inject the fuel into the engine in correct quantity in atomized condition.

Fuel oil system consists:

1. Fuel feed system
2. Fuel injection system

1.3 Location of fuel injectors:

Fuel injectors can be mounted in the cylinder head in CI engines with individual fuel injectors for each cylinder head.

1.4 In fuel injection system we have two types of pumps those are:

1. Fuel pump or booster pump used to pump the fuel from the tank.
2. Fuel injector pump used to increase the pressure to 1300 psi (15kg/cm2 =14.7psi)

Fig 1A.: Typical model of pump and types of nozzles

Fig 1B. Diesel locomotive shed:

1.5 Location of Exhaust system:

In the year 2004 have been transferred to Western Railway. Again 02 locos of Diesel Loco Shed, Moula-ali were transferred to this shed in the year 2004 leaving the effective holding of WDS $_4$locomotives at BZA to 20.In the year 2006, 13 locomotives have been condemned and auctioned and 02 locomotives were transferred to Shakurbasthi Shed, Northern Railway. *05* WDS $_4$ locomotives are proposed for premature condemnation. Railway Board had sanctioned vide letter no. M.66/DSL/COND underaged/120/Dec.06dt.24.02.10.

Diesel exhaust is the gaseous exhaust produced by a diesel type of internal combustion engine, plus any contained particulates. Its composition may vary with the fuel type or rate of consumption, or speed of engine operation.

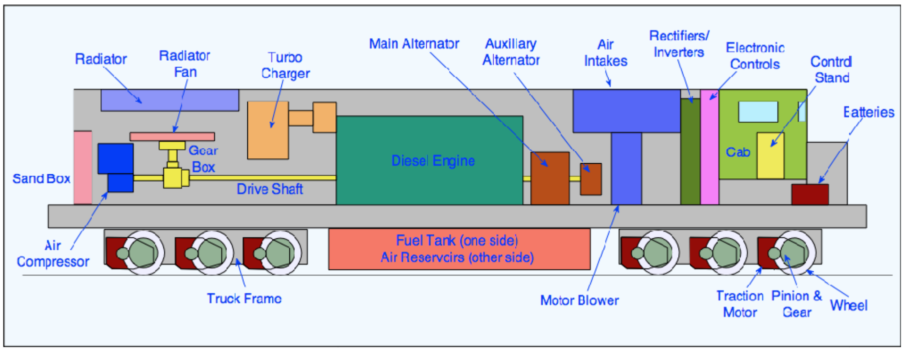

Fig 2 Exhaust system

2. LIETARATURE REVIEW

Ganesh Db executed project on “EXPERIMENTAL INVESTIGATION OF BIO-DIESEL ON ELECTRONIC DIRECT FUEL INJECTION SYSTEM” from GM Institute of Technology. The objective of this work is to study the effect on combustion and emissions of a bio-diesel fuelled Electronic direct fuel diesel engine. To use acid oil, a by-product of vegetable oil refining process for biodiesel production and study its feasibility. To suggest a suitable process for producing biodiesel from acid oil. Characterization of the biodiesel produced. To study the engine performance, emission and combustion characteristics of the biodiesel and its blends.

Linqian Yin and Changshui Wu executed project on “The Characteristic Analysis of the Electromagnetic Valve in Opening and Closing Process for the Gas Injection System” from School of Automotive Engineering, Shanghai University of Engineering Science, Shanghai, China.

In this paper, the mathematical model of solenoid valve in the fuel injection system of gas engine is built. Simulation software Mat-lab/Simulink are employed to analyse the impact which the voltage, number of the coil-turns and air gap width may produce to the open and close characteristics of the solenoid valve.

This work presents a thermal modelling of a new cold-start system technology designed for Otto cycle combustion based on the electromagnetic heating principle. Firstly, the paper presents a state-of-the-art review and presents the context of automobile industry where heated injectors are necessary. The novel method of electromagnetic heating principle to solve the cold-start problem is still in the development phase and it enables engine starting at low temperatures in vehicles powered by ethanol or flex-fuel vehicles (FFV). The study is based on the lumped system theory to model the ethanol heating process. From the analysis, two ordinary differential equations arise, which allowed an analytical solution. Particularly, an ethanol heating curve inside the injector was obtained, an important parameter in the process.

Wartinbee, Jr. (1971) conducted the emission study to determine the effects of oxygen enriched air on exhaust emissions. Compared to operation with lean air-fuel mixtures, the results indicated that hydrocarbon emissions were reduced substantially, carbon monoxide emissions were similar, and oxides of nitrogen emissions increased significantly. Octane requirements and fuel consumption were higher with oxygen

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enrichment. These emission and performance characteristics are due to the higher peak combustion temperatures associated with oxygen concentrations of greater than the 21% normally found in air.

Gerry and Martin (1973) filed an application for the pattern right for pure oxygen supply to an internal combustion engine. Considerable decreases in hydrocarbons and oxides of nitrogen from the exhaust system of an internal combustion engine were obtained. The pure oxygen may be created by storing a chemical compound in a chamber and heating the chamber so that the compound may release the oxygen, or oxygen can be created by electrolytic alloy decomposing water, passing oxygen generated by such decomposition into a storage tank coupled to the air intake means of the engine.

Jamil Ghojel et al (1983) has undergone a study on Effect of Oxygen Enrichment on the Performance and Emissions of I.D.I. Diesel Engines and investigated effect of the partial pressure of O2 in the intake charge of an I.D. Diesel engine on the various operating parameters and the exhaust emissions. The oxygen content in the intake was varied between 21% and 40% by volume. Engine performance and emissions were evaluated at a constant engine speed and injection timing while fuelling was varied. The research revealed that enriching the intake air with oxygen led to a large decrease in ignition delay and reduced combustion noise. The fuel economy, the power output and the exhaust temperature remained almost constant. HC and CO emissions decreased and smoke levels dropped substantially, while NOx emissions increased pro-rata with the O2 added.

Norimasa Iida et al (1986) has done the experimental effects of Intake Oxygen Concentration on the Characteristics of Particulate Emissions from a D.I. Diesel Engine. It was found that OEC reduces particulate emissions from a DI diesel engine for all operating conditions tested. Insoluble particulate is especially suppressed by OEC at high load conditions. Oxygen enriched charging has little effect on the particulate size distribution at high loads when the mass fraction of extractable is low. Fuel consumption, at constant injection timing, is improved a little by OEC. Emissions of NOx increase area.

3. Types Of Injection Systems And Parts Of Fuel Injector And Tests In Locomotives

There are five main types of mechanical diesel injection systems:

- In-line or rotary distributor pump Injection system.
- Individual control pump Injection system.
- Common rail Injection system.
- Unit injection system.
- Electronically Controlled Fuel Injection System.

3.1 In-line Distributor Pump Injection system:

An in-line injection pump fuel system layout is schematically shown in Fig. 4. Essentially all in-line diesel injection pumps use one or more cylinders, called barrels, where a reciprocating plunger produces very high pressures. Although various types of valve have been used for the start and end of injection,

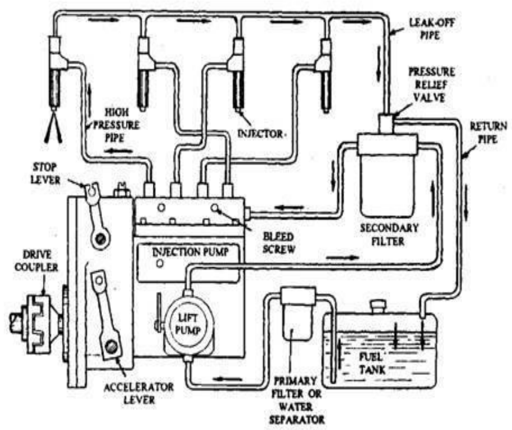


Fig 3 In-line injection pump fuel system layout.

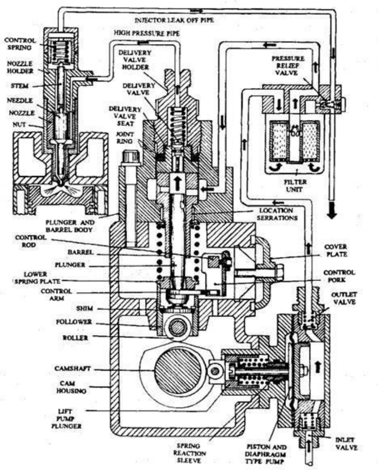


Fig-.4 Lucas Minimec (CAV) in-line pump.

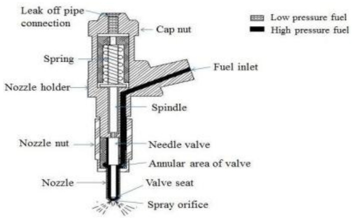


Fig 5- Dimensional Component of fuel injector nozzle.

Fig 6 Turbo Charger

APPLICATION	251B	251B
INJECTOR NO.	9 430 032 130	9 430 032 131
NOZZLE HOLDER	9 430 031 302 HB-KBA 242 T10	9 430 031 302 HB-KBA 242 T10
NOZZLE	9430033300HB-DL 157T1134	9 430 033 301 HB-DL157T1141
SPINDLE HOLE	9×ø0.35	9×ø0.38
PRESSURE STAGE	7×4	7×4
OPENING PRESSURE(BAR)	275+10 BAR	275+10 BAR
IDENTIFICATION	------------------------	GREEN

Table 1 Injection Features

Application	251B	251B
Nozzle	9 430 033 300 HB-DL 157 T 1134	9 430 033 301 HB-DL 157 T 1141
Spray hole	9×ø0.35	9×ø0.38
Pressure stage	7×4	7×4
Needle tip form	60^0	60^0
Sac hole ø, mm	1.8	1.8
Spray hole length	2.2	2.2
Stroke, mm	0.4	0.4
Stroke, mm maximum pressure, bar	1200	1200

Table 2 Nozzle Features

4. CATIA INTRODUCTION

4.1 INTRODUCTION TO CATIA V5R20

Welcome to CATIA (Computer Aided Three Dimensional Interactive Application). As a new user of this software package, you will join hands with thousands of users of this high-end CAD/CAM/CAE tool worldwide. If you are already familiar with the previous releases, you can upgrade your designing skills with the tremendous improvement in this latest release.

CATIA V5, developed by this assault Systems, France, is a completely re-engineered ,Next-generation family of CAD/CAM/CAE software solutions for Product Lifecycle Management. Through its exceptionally easy-to-use and state-of-the-art user interface, CATIA V5 delivers innovative technologies for maximum productivity and creativity, from the inception concept to the final product. CATIA V5 reduces the learning curve, as it allows the flexibility of using feature-based and parametric designs.

CATIA V5 provides three basic platforms:

P1, P2, and P3. P1 is for small and medium-sized process-oriented companies that wish to grow toward the large scale digitized product definition.P2 is for the advanced design engineering companies that require product, process, and resource modeling. P3 is for the high-end design applications and is basically for Automotive and Aerospace Industry, where high quality surfacing or Class-A surfacing is used. The subject of interpretability offered by CATIA V5 includes receiving legacy data from the other CAD systems and even between its own product data management modules. The real benefit t is that the links remain associative. As a result, any change made to this external data gets notified and the model can be updated quickly.

4.2 CATIA V5 WORKBENCHES

CATIA V5 serves the basic design tasks by providing different workbenches. A workbench is defined as a specified environment consisting of a set of tools that allows the user to perform specific design tasks. The basic workbenches in CATIA V5 are Part Design, Wireframe and Surface Design, Assembly Design, Drafting.

4.3 MODELLING OF NOZZLE AND EXHAUST PIPE IN CATIA

While designing the nozzle and exhaust pipe, whole structure is divided in to cell. The single cell is created first and mirrored to create entire structure. By considering the cell configuration dimensions i.e. cell angle $^{\theta}$, height h, and length l that were mentioned above in the geometrical dimensions and geometrical aspects, the nozzle and exhaust pipe design.

CASE 1

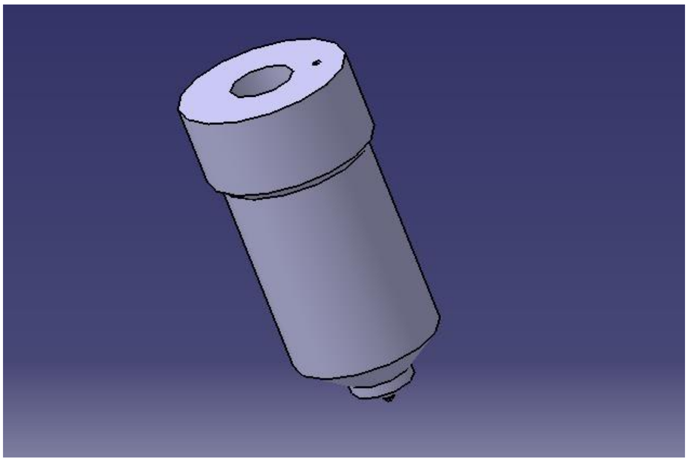
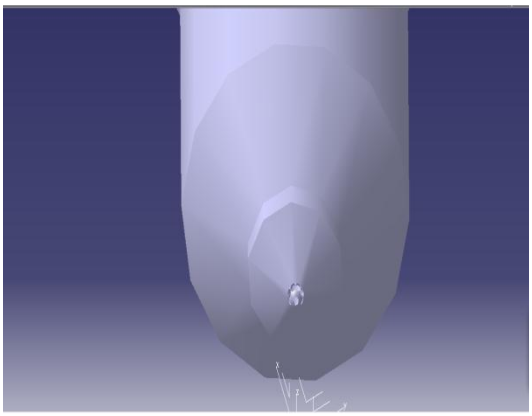


Figure 7 Nozzle cad model



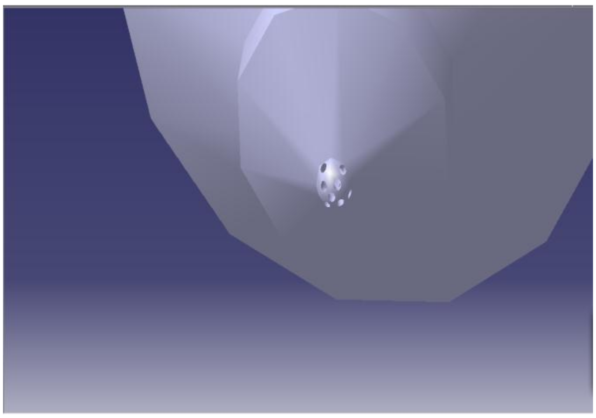


Figure8 Nozzle cad model with 9 holes (0.34dia) Figure 9 Nozzle cad model with 9 holes (0.38dia)

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CASE 2

Table5. 1: Dimensions of Exhaust Pipe	
Description	**Dimension Value**
Length (L)	9.81metre
Outer Radius of Exhaust pipe (Ro)	0.9metre
inner Radius of Exhaust pipe (RI)	0.89metre
Thickness of material	6mm+6mm

Table -3 **Dimensions of Exhaust Pipe**

Modeling of exhaust pipe of diesel locomotive

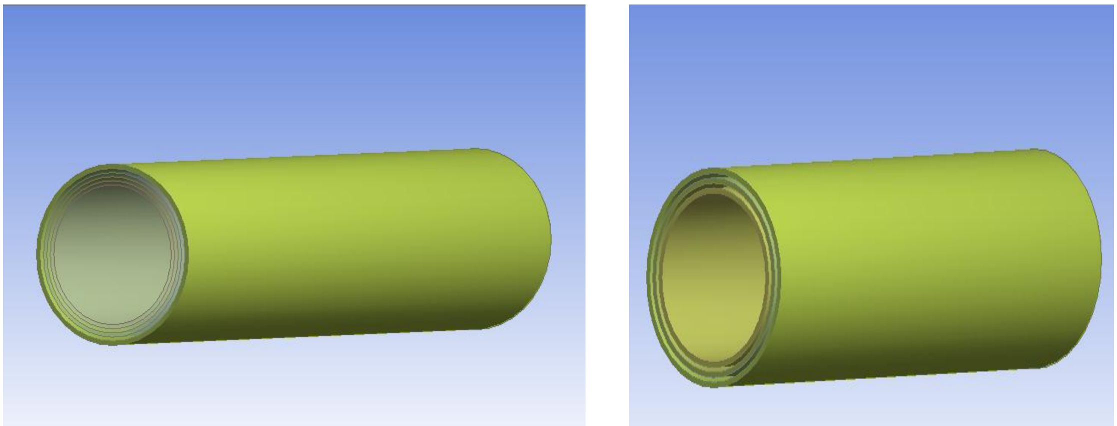

Figure 10 Exhaust pipe cad model

There are different combination of materials are provided on the exhaust pipe of diesel locomotives. The thickness of each layer is 6mm, so the thickness of combination of layers is 12mm.

5 ANALYSIS OF NOZZLE AND EXHAUST PIPE

In this section the 3D CAD models and 3D FEM Models along with loads and boundary conditions will be presented Using above mesh model with boundary and loading conditions in ANSYS 15.0 required results are predicted.

CASE 1

Meshing:

The design that is saved in its format is imported in Ansys work bench and engineering data is applied and by generating mesh ,nodes and elements are created ,as shown in the below figure nodes are 11309 and elements are 6436

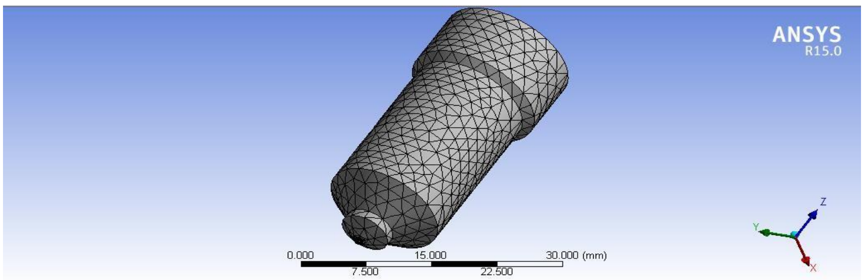

Figure 11 Meshing nozzle

CASE 2

The design that is saved in its format is imported in Ansys work bench and engineering data is applied and by generating mesh ,nodes and elements are created ,as shown in the below figure nodes are 16450 and elements are 15252

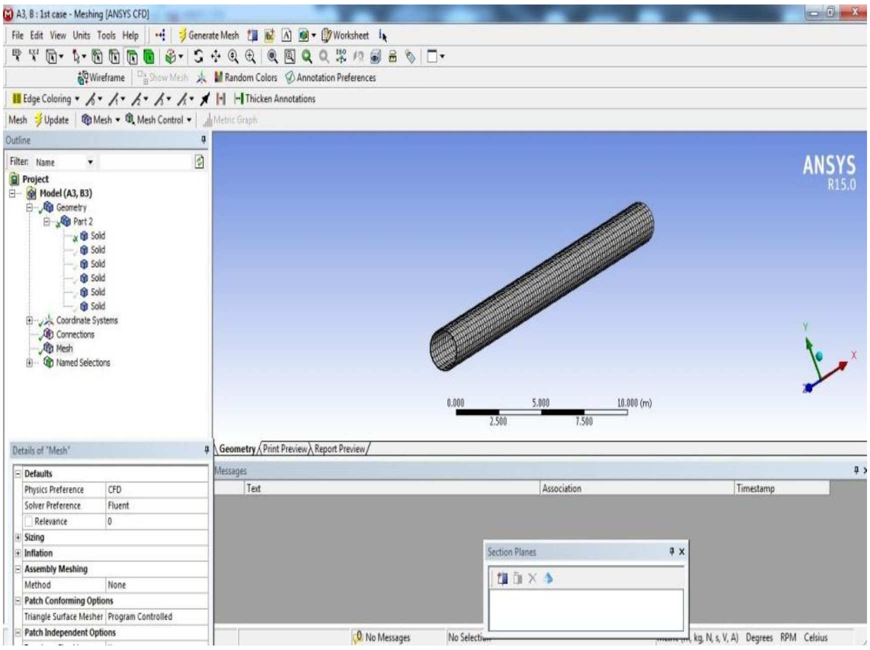

Figure 11 Meshing of exhaust pipe of diesel locomotive

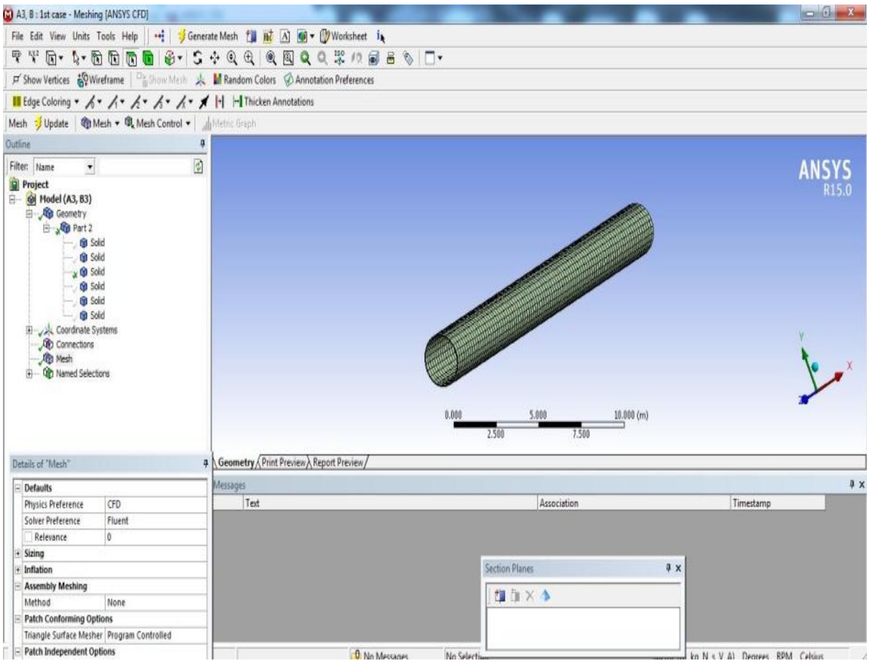

Figure 12 Meshing of outer layer of exhaust pipe of diesel locomotive

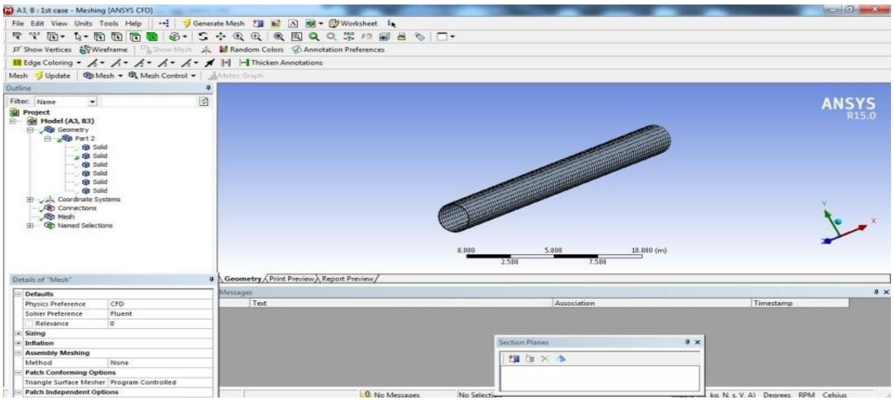

Figure 13 Meshing of intermediate layer of exhaust pipe of diesel locomotive

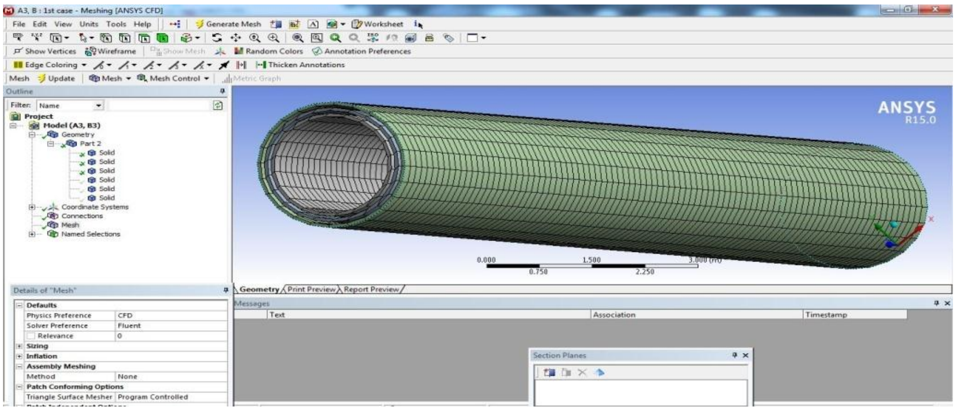

Figure 14 Meshing of overall exhaust pipe of diesel locomotive

Boundary Conditions:

Input temperature of exhaust pipe of diesel locomotive is 783 kelvins.

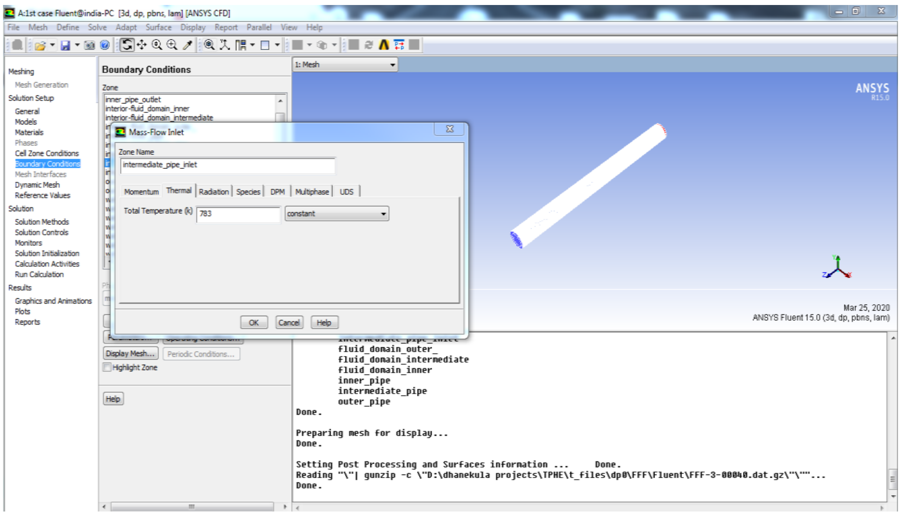

Figure 15. Boundary Conditions:

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6 .RESULTS AND DISCUSSIONS

We analyzed Crane Hook in ANSYS 15 and finding out Pressure, velocity, Temperature as show in below figures and then resulting all the max values at every load and are compared in the form of graphs.

CFD Analysis: The wire frame and volume rendering is done by using the ANSYS software. The temperature streamline, pressure streamline, and mass flow rate are obtained by using the ANSYS software. The result of the mass flow rate and pressure are shown with graph along the figures.

Case 1 Nozz

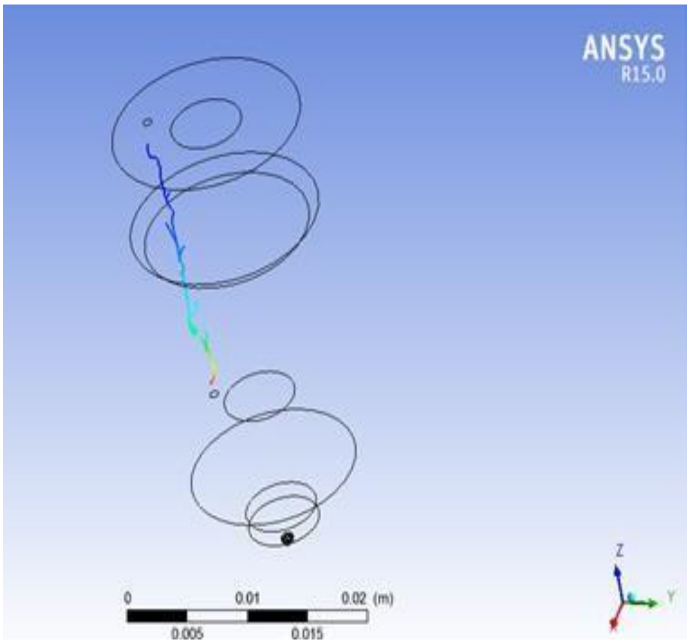


Figure 7.1 Wire Frame

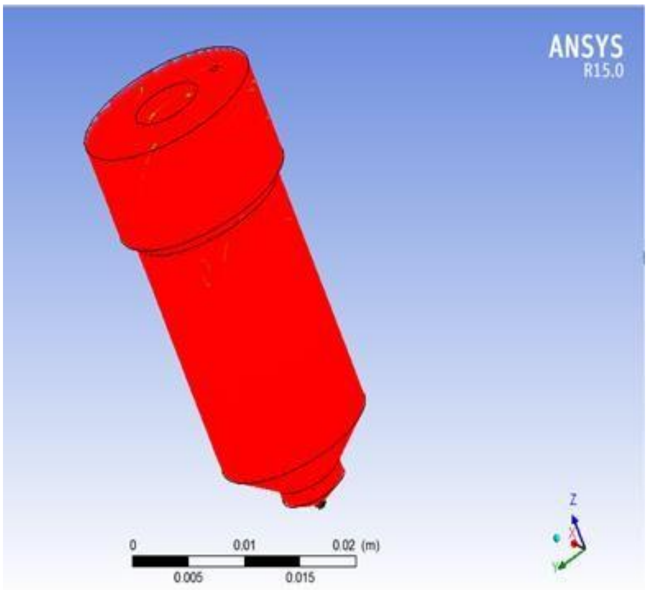


Figure 7.2 Volume Rendering

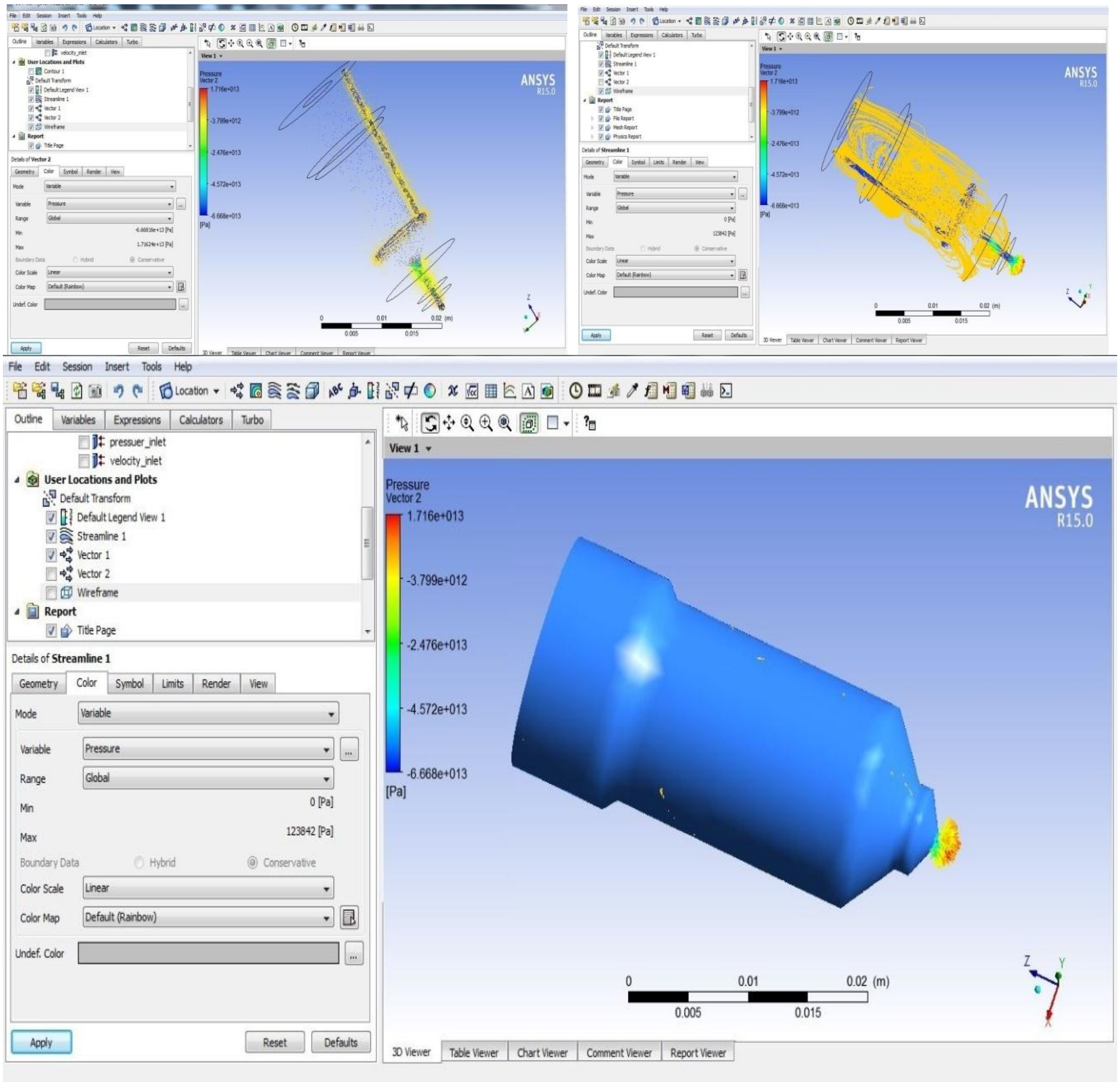
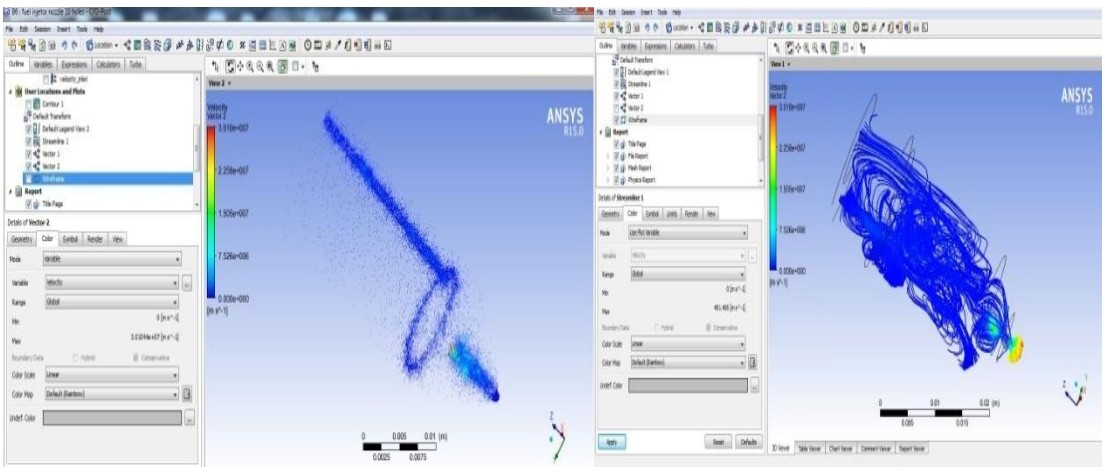


Figure 7.3 Pressure when 9 holes (0.34 dia)



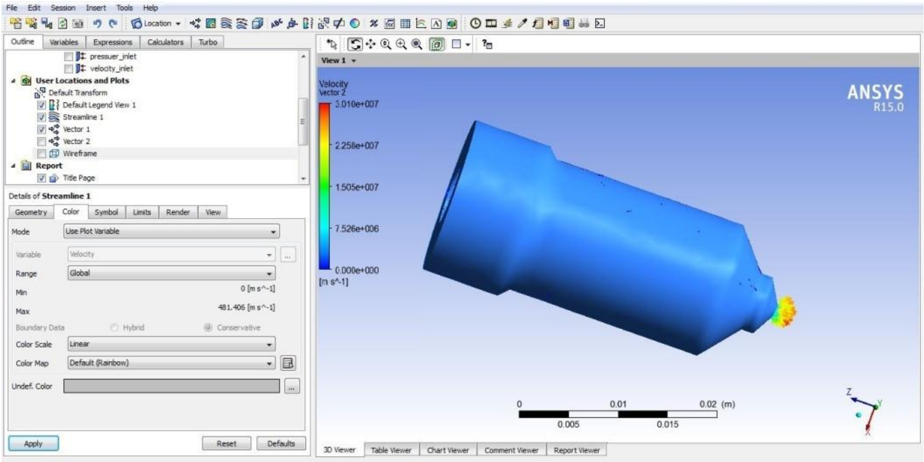


Figure 7.4 Velocity when 9 holes (0.34 dia)

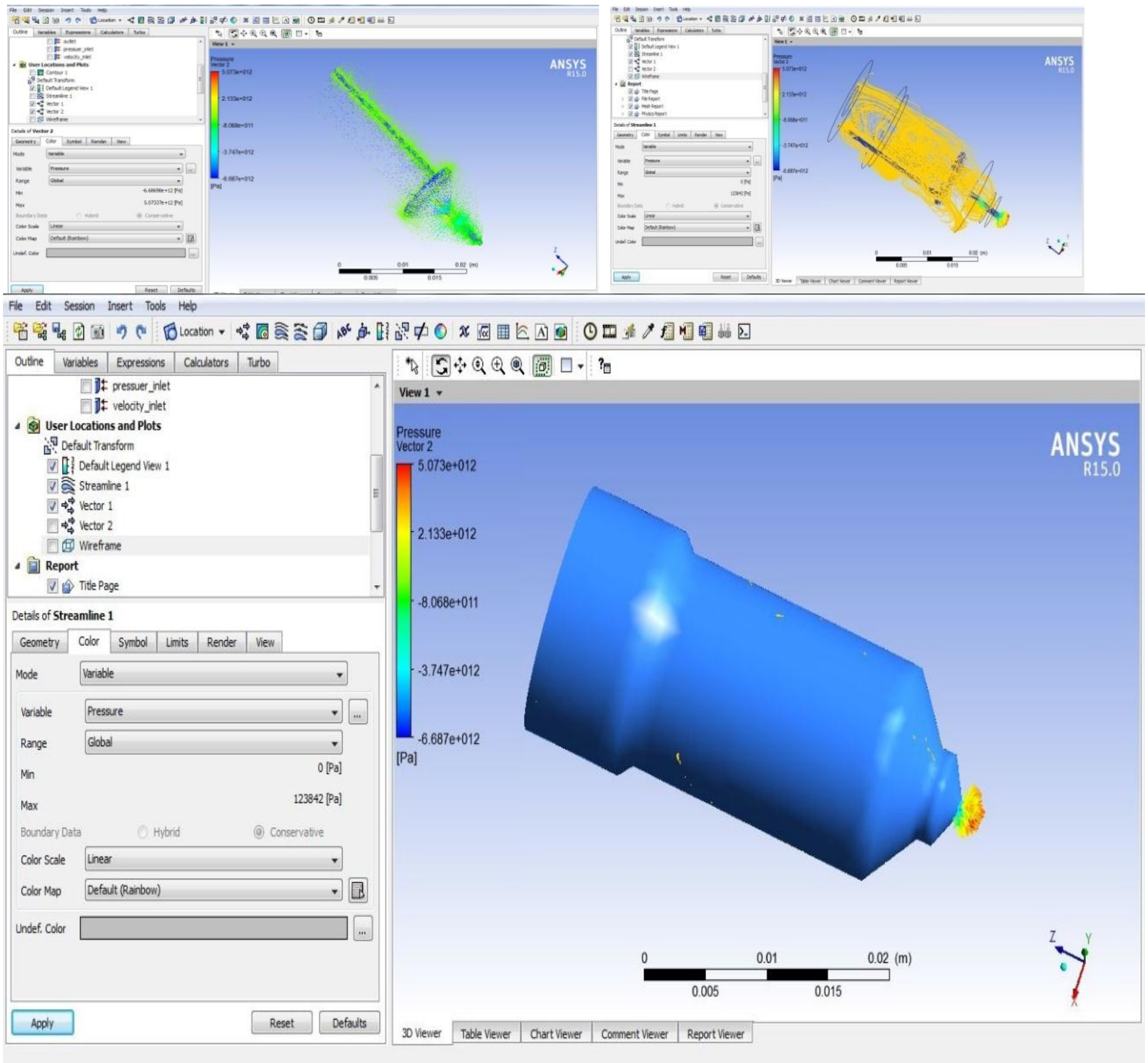


Figure 7.5 Pressure when 9 holes (0.38 dia)

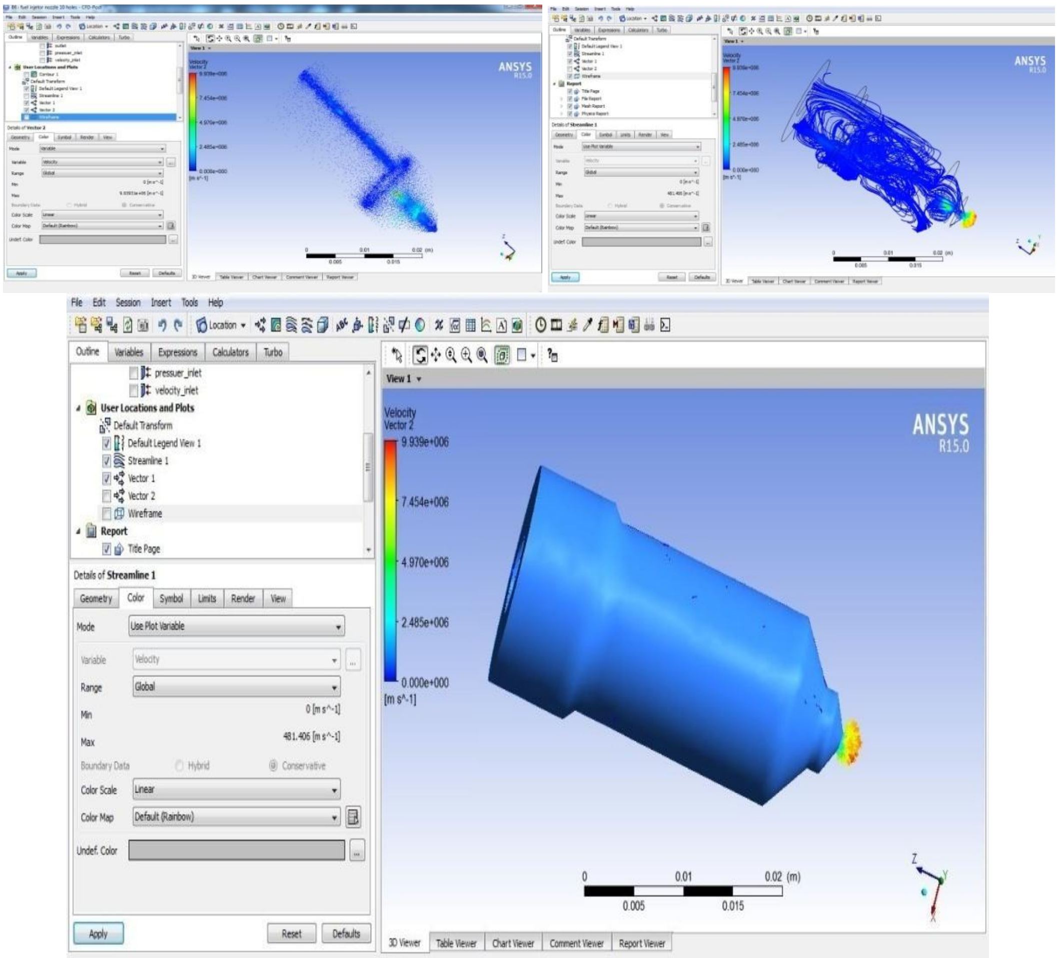


Figure 7.6 Velocity when 9 holes (0.38 dia)

A 3D steady state, incompressible answer of the Navier-Stoke equations was performed using ANSYS FLUENT style computer code. Turbulence modeling was through with the realizable k-ε model using non- equilibrium wall functions. The process results for the subsequent case was conferred and discussed:

Case 2

Case 2.1:-

There two different types of materials are provided on the exhaust pipe, top layer is polyurethane foam and intermediate layer is cellulose.

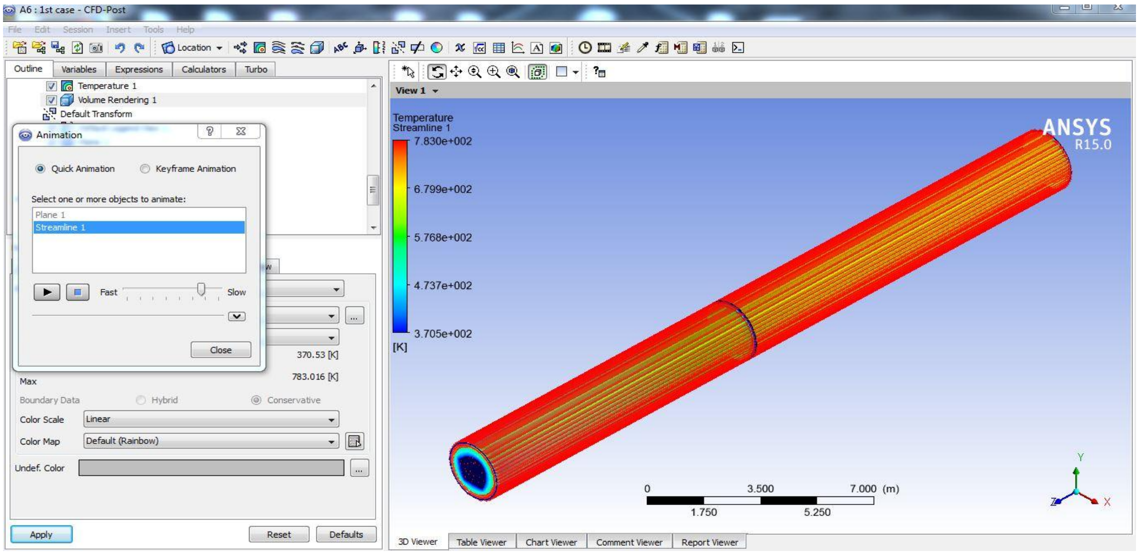


Figure 7.7 polyurethane foam and intermediate layer is cellulose.

Input temperature is 783Kelvins

Output temperature is 370Kelvins.

Case 2.2:-

There two different types of materials are provided on the exhaust pipe, top layer is cellulose and intermediate layer is polyurethane foam.

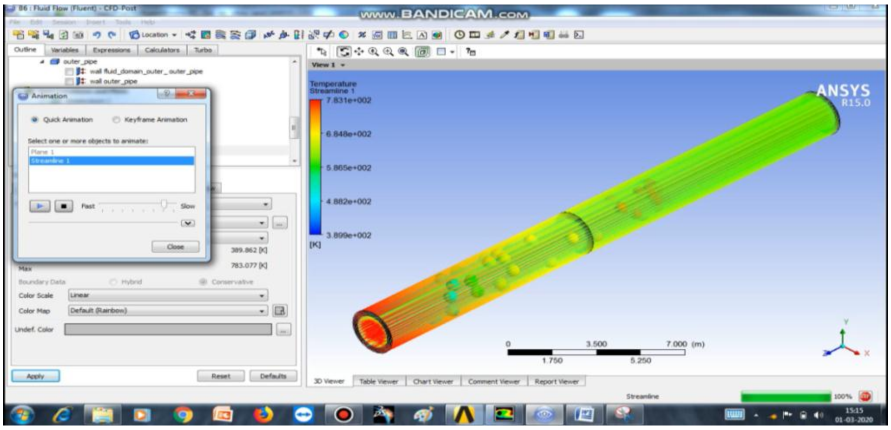


Figure 7.8 cellulose and intermediate layer is polyurethane foam.

Input temperature is 783 Kelvin

Output temperature is 389 Kelvins.

Case 2.3:-

There two different types of materials are provided on the exhaust pipe, top layer is polyurethane foam and intermediate layer is expanded polystyrene.

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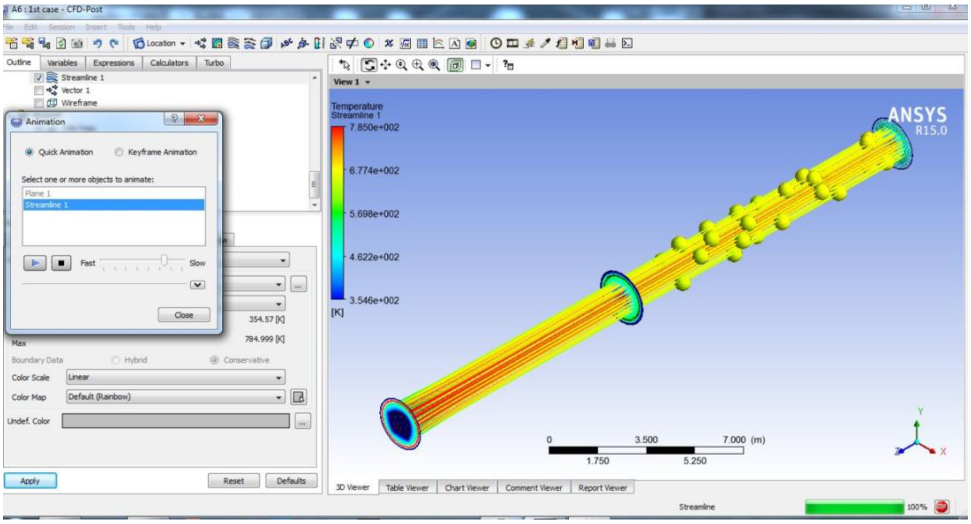

Figure 7.9 polyurethane foam and intermediate layer is expanded polystyrene.

Input temperature is 783 Kelvins.

Output temperature is 354 Kelvins.

Case 2.4:-

There two different types of materials are provided on the exhaust pipe, top layer is expanded polystyrene and intermediate layer is polyurethane foam.

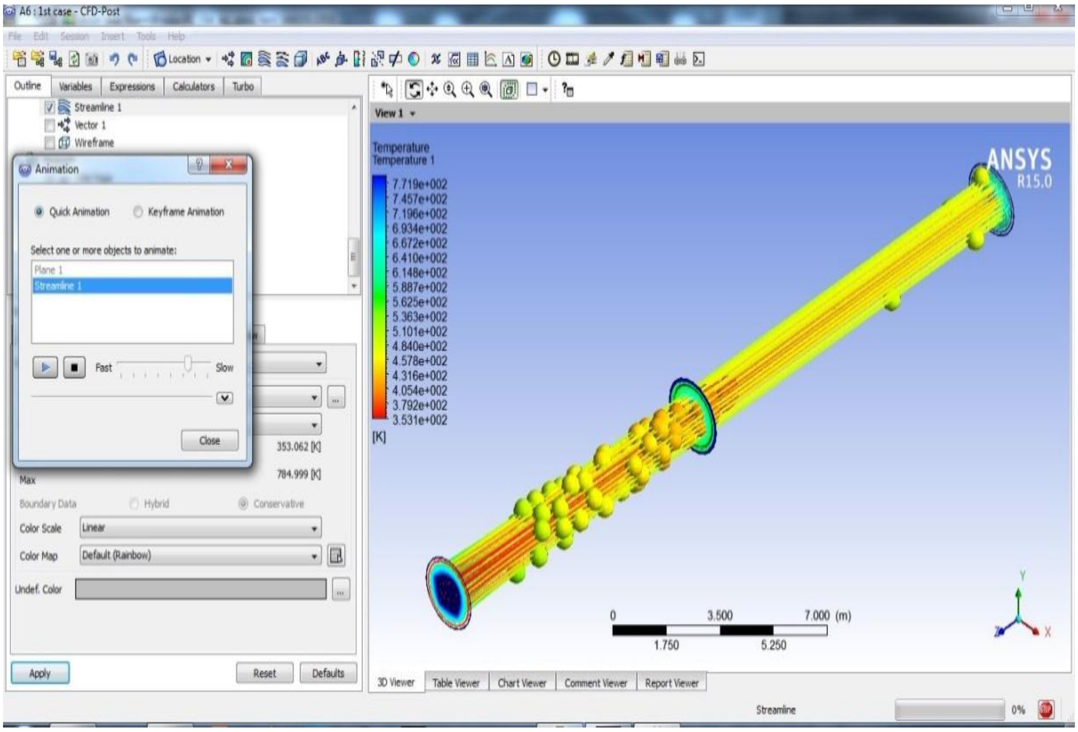

Figure 7.10 expanded polystyrene and intermediate layer is polyurethane foam.

Input temperature is 783 Kelvins.

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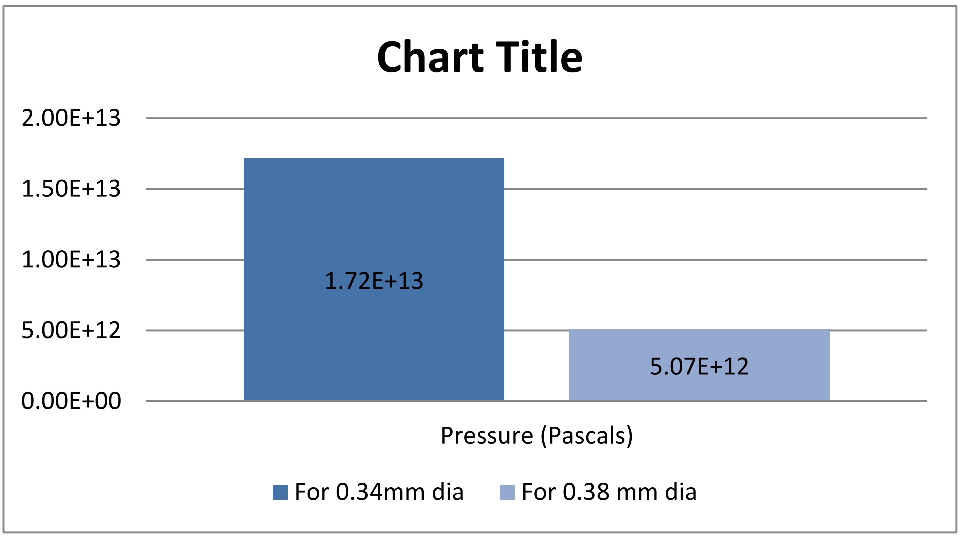
Output temperature is 353 Kelvins.

Table & Graphs:-

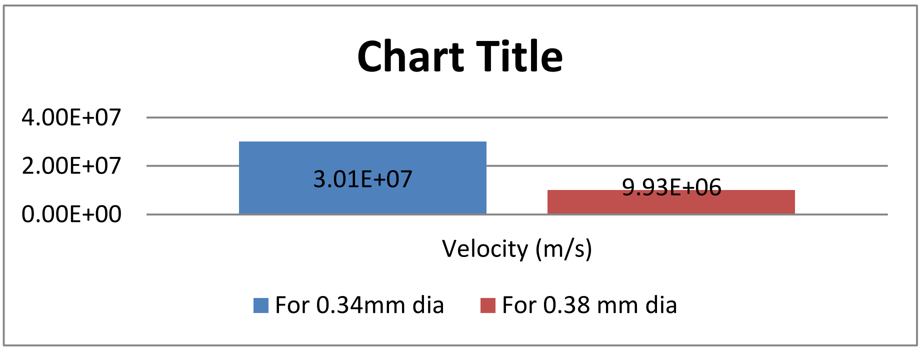
Case 1 : Nozzle

	For 0.34mm dia	For 0.38 mm dia
Pressure (Pascals)	1.716 e 13	5.073 e 12
Velocity (m/s)	3.01 e 07	9.93 e 06

Table 7.1 Cfd Results Nozzle



Graph 7.1 Pressure Results Nozzle



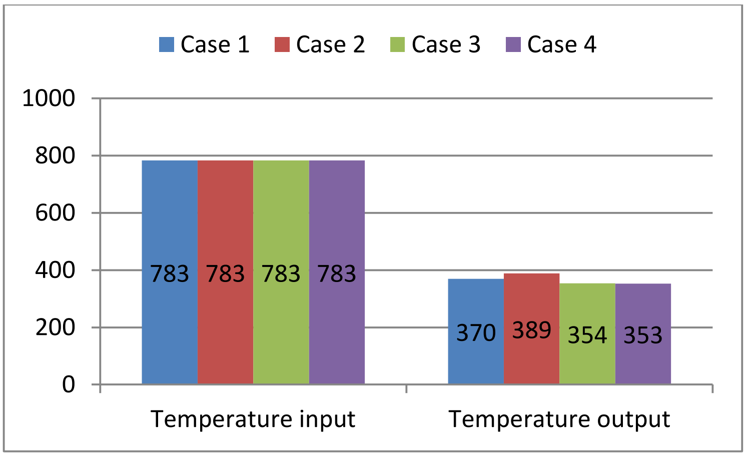
Graph 7.2 Velocity Results Nozzle

Case 2 : Exhaust pipe

Case	ombinations of materials	Input temperature	Output temperature
2.1	op layer:-polyurethane foam termediate layer:-cellulose	783k	370K
2.2	op layer:-cellulose, termediate layer:- olyurethane foam	783K	389K
2.3	op layer:-polyurethane foam, termediate layer:-expanded olystyrene.	783K	354K
2.4	op layer:-expanded olystyrene Intermediate yer:-polyurethane foam.	783K	353K

Table 7.2 : Temperature results for exhaust pipe

The below graph shows the different types of temperature output are plotted



Graph 7.3 Temperature Results Exhaust pipe

In the above all cases, fourth case has best result as it reduces the temperature from 783K to 353K and combination of materials is expanded polystyrene as a top layer and polyurethane foam as a intermediate layer on the exhaust pipe of diesel locomotive.

7. CONCLUSIONS

Case 1

The injection and the fuel spray characteristics connected with the combustion chamber geometry control the Combustion and pollutant formation processes. Therefore the engine operation characteristics could be improved by improving one of the above mentioned fuel injection systems- or engine-parts. Even though in recent years many researchers have been made considering the fuel injection systems. The fuel Injection nozzle still presents quite an un-researched area. The simulated results show that the best design for a nozzle is by using smaller holes size where turbulent flow is well developed inside the nozzle and by modifying dimensions of plunger and barrel allows to hold more volume of fuel leads to increase horse power.

Case 2

In this project, we have modeled and analysis the exhaust pipe of diesel locomotive, by considering some combination of materials. The best combination of material is expanded polystyrene and polyurethane foam which provides best results than other the combination of materials, so the internal damage to turbo charger is reduced.

- The materials like polyurethane foam, expanded polystyrene and cellulose are used.
- The combination like expanded polystyrene as a top layer and polyurethane foam as an intermediate layer has a best result as it reduces temperature from 783K to 353K.
- Thermal stress also reduced so, the lifetime of turbine blade increases

REFERENCES

- [1] Ma New Ni Tun: Design Calculation of Fuel Injection System forLight Truck Diesel Engine (Nozzle),2010.
- [2] Wikipedia: Diesel Engine,the free encyclopedia, October 2006.
- [3] Zar Chi Win, Ma: Design of Fuel Injection Nozzle for 22HpDieselEngine, 2006.
- [4] Pulkrabek, Willard W.: Engineering Fundamentals of the InternalCombustion Engine, Prentice Hall of India Private Limited, NewDelhi, 2003.
- [5] Robert L, Mott.: Applied Strength of Materials, Fourth EditionPrentice-Hall of India,2002.
- [6] Nishimuraand Assanis, D.N.: A model for Primary Diesel Fuel Atomization,University of Michigan, U.S.A, 2000.
- [7] Bernard Challen, RodicaBaranescu: Diesel Engine ReferenceBook, Second Edition,Butterworth-Heinemann, 1999.
- [8] Sein Win, U: Internal Combustion Engines,PartII,ME613,Yangon Technological University, 1999.
- [9] Heywood, J.B.: Internal Combustion Engines Fundamentals,McGraw-Hill Inc.,1988.
- [10] Toboldt, Willian K.: Diesel (Fundamental, Service, Repair), TheGoodheart- Wilcox Company, South Holland, Illinois, Inc, 1986. ws the commercial application and advantage of CATIA as compared to other

- [11] John B. Heywood, "Internal Combustion Engine Fundamentals", McGraw-Hill series in mechanical engineering.
- [12] M L Mathur, R P Sharma, "Internal Combustion Engine", II Edition, Dhanpat Rai Publications.
- [13] Willard W Pulkrabek, "Engineering Fundamentals of the Internal Combustion Engine", PHI Learning, 2012.
- [14] Frederick Remsen Hutton, "The Gas-Engine- A Treatise on the Internal- Combustion Engine Using Gas, Gasoline, Kerosene or Other Hydrocarbon as Source of Energy", Paperback, Nabu Press, 2010.
- [15] Wallace Ludwig Lind, "Internal-Combustion Engines: Their Principles and Applications to Automobile, Aircraft, and Marine Purposes", Paperback, Nabu