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Design and Analysis of Electronic Fuel Injector of Diesel Engine

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Abstract— The geometry of the diesel fuel injection nozzle and fuel flow characteristics in the nozzle significantly affects the processes of fuel atomisation, combustion and formation of pollutants emissions in a diesel engine. To describe the injector fuel flow, a three-dimensional Solidworks model is employed. The Solidworks package FlowXpress is used for 3-d flow analysis. The results represent the fuel flow characteristics for steady state flow conditions at different angular conical holes. For this purpose several three-dimensional models representing different conical angles are made in the nose region. The fuel injection pump is driven by an electric motor, the pressure control valve regulates the pressure at 100 bar and the calibration fluid is injected through the nozzle into the measuring Cylinder. For the analysis fuel is injected to the virtual conical jar made at the bottom of injector. The fuel flow profiles obtained from the Solidworks FlowXpress at steady flow conditions in the nozzle are validated with the results of the analytical calculations. The injection pressure is kept constant of 100bar and inside the cylinder the pressure is made to 20bar due to the compression ratio and then flow characteristics of all diesel fuel is simulated and observed that by increasing the angle of injection, the swirling of fuels increases and got an optimal angle beyond which it touches the cylinder which will result in more improper mixing and finally result in the Nox emissions.

Index Terms— Atomisation,Diesel,FlowXpress,Injection pump,Nox emissions,Solidworks,Swirling.

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1 Introduction

Fuel injection is a Fuel system for admitting fuel into an internal combustion engine. In olden days carburetors are used to fulfil this action. A Carburetor is a device that blends air and fuel for an Internal Combustion Engine. Carburetor works on the Bernoulli's Principle. The lower its static pressure, and the higher its dynamic pressure. The throttle (accelerator) linkage does not directly control the flow of liquid fuel. Instead, it actuates Carburetor mechanisms which meter the flow of air being pulled into the engine. The speed of this flow, and therefore its pressure, determines the amount of fuel drawn into the airstream. From the past decade these carburetors have been replaced by fuel injectors. A variety of injection systems have existed since the earliest usage of the internal combustion engine. The primary difference between carburetors and fuel injection is that fuel injection atomizes the fuel by forcibly pumping it through a small nozzle under high pressure, while a carburetor relies on suction created by intake air accelerated through a Venturi tube to draw the fuel into the airstream. The evaluation of fuel injection system is from Throttle Body Injection to Multi Point Fuel Injection to Gasoline Direct Injection. In these Fuel Injection systems Fuel Injectors are used to inject fuel. These are either cam controlled or solenoid controlled. In Solenoid controlled fuel injectors there are three stages fuel metering, fuel filtering, and fuel injection. In Multi Point Gasoline Direct Injection system fuel injector is assigned to an individual cylinder and fuel metering is also done separately in each cylinder, whereas in Throttle Body Injection one fuel injector is used for the multi cylinder arrangement and fuel metering is uneven in all the cylinders. So from the discussion the fuel injector plays a crucial role in the fuel injection systems, and in this study we are using multi hole fuel injectors with different conical angles so as to study or examine the characteristics of fuel injected into the cylinder in the prescribed path through the injector nozzle in each case.

2 PROBLEM DEFINITION:

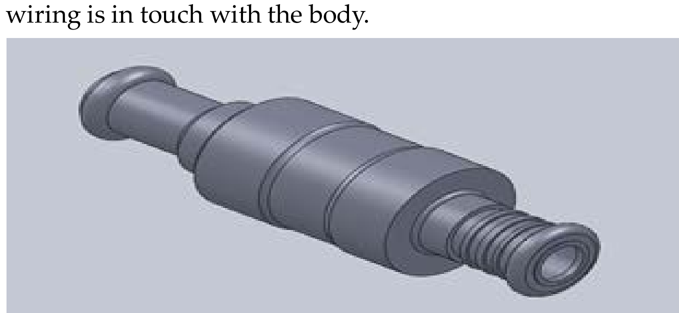
Since in the convectional fuel injectors the fuel is not mixed completely, we are making some changes in the design of fuel injectors so as to increase the fuel and air mixing. So, for this action to be done we are using multi hole fuel injector instead of single hole fuel injector because in single hole fuel injectors due to the high pressure change the flow of fuel from the fuel injector rushes to the combustion chamber following a hollow conic trace or shape as shown in the figure. Due to this shape in the hollow region of the cone trace the air and fuel are not mixed .So by using this multi hole fuel injector we can cover almost the whole area efficiently. Hence we can use these multi hole fuel injectors instead of single hole fuel injectors at different conical angle sections .

3 FUEL INJECTOR PARTS AND WORKING:

The Fuel injector consists of the following parts in order so as to complete the mechanism. .

3.1 Fuel injector body:

Fuel injector body is consisting of all the parts of the fuel injector arranged systematically inside it. The material used must be a non-conductor of electricity as the solenoid wiring is in touch with the body.



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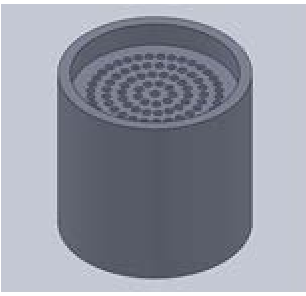
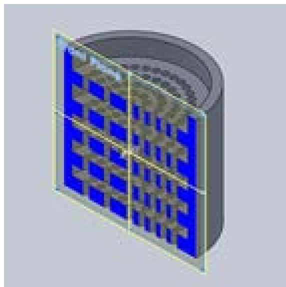
3.2 Filter:

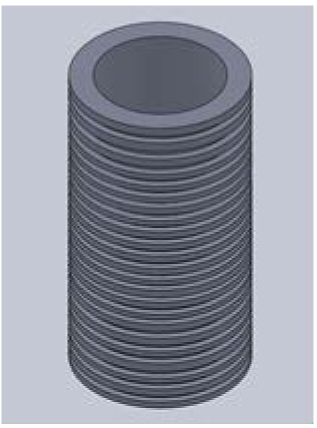
The Filter is placed in the top of the fuel injector body and its function is to filter the fuel entering inside. This action is done by keeping plates with holes.

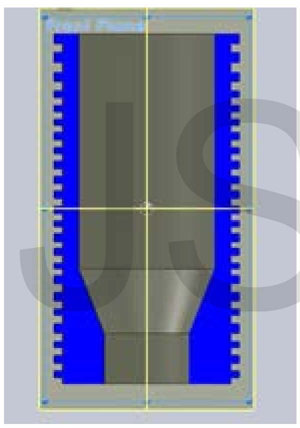




3.3 Fuel Passage:

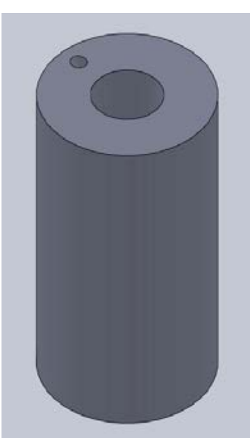
This is placed after the filter. The function of this is to send the fuel exactly in the required path and the slots at the border is to keep a rubber in it so as to maintain the grip and to reduce the leakage. This action is done by reducing the diameter to the size of the holder.

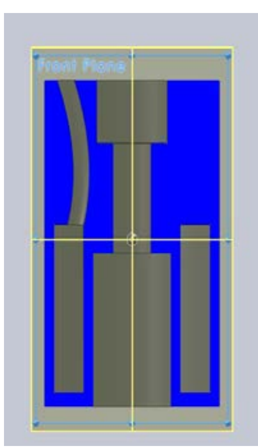




3.4 Holder:

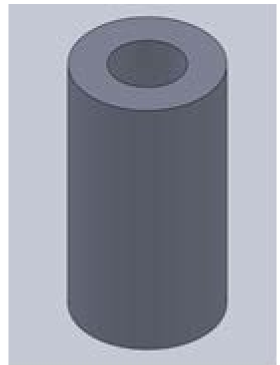
The Holder is placed after the fuel passage and its function is to hold the magnet and solenoid casing and a passage for the electrical wires is provided from this.

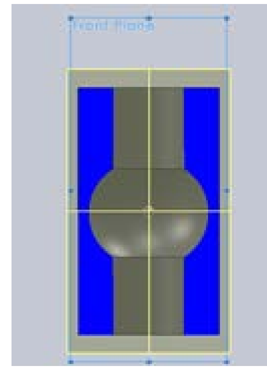




3.5 Magnet:

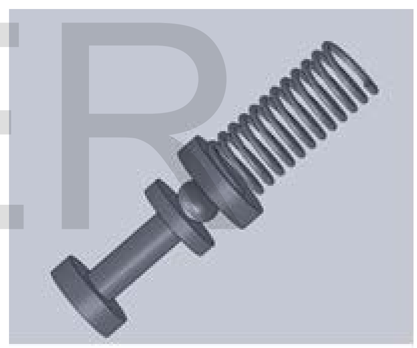
Magnet is placed inside the holder and its function is to create magnetic field and it will move the spring attaches to it downwards and hence the spring reaches the extra hollow portion and so as to allow the fuel flow through the nose region.





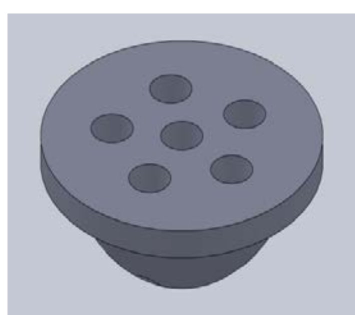
3.6 Centre Piece:

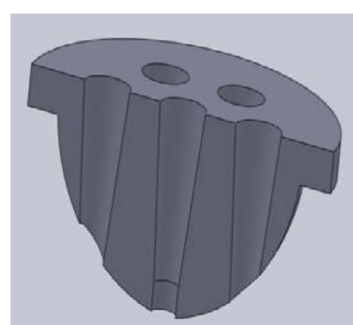
The Centre Piece is placed in between the spring and secondary magnet. The main purpose of the Centre Piece is to Support the parts and acts as the bridge between them.



3.7 Nose:

The Nose is placed at the last of the fuel injector and this is the main part of the fuel injector which is to be concentrated most. Here in this case we are using multi hole in replace to single hole and also a conical shape is used in order to create nozzle effect.





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ASSEMBLY:

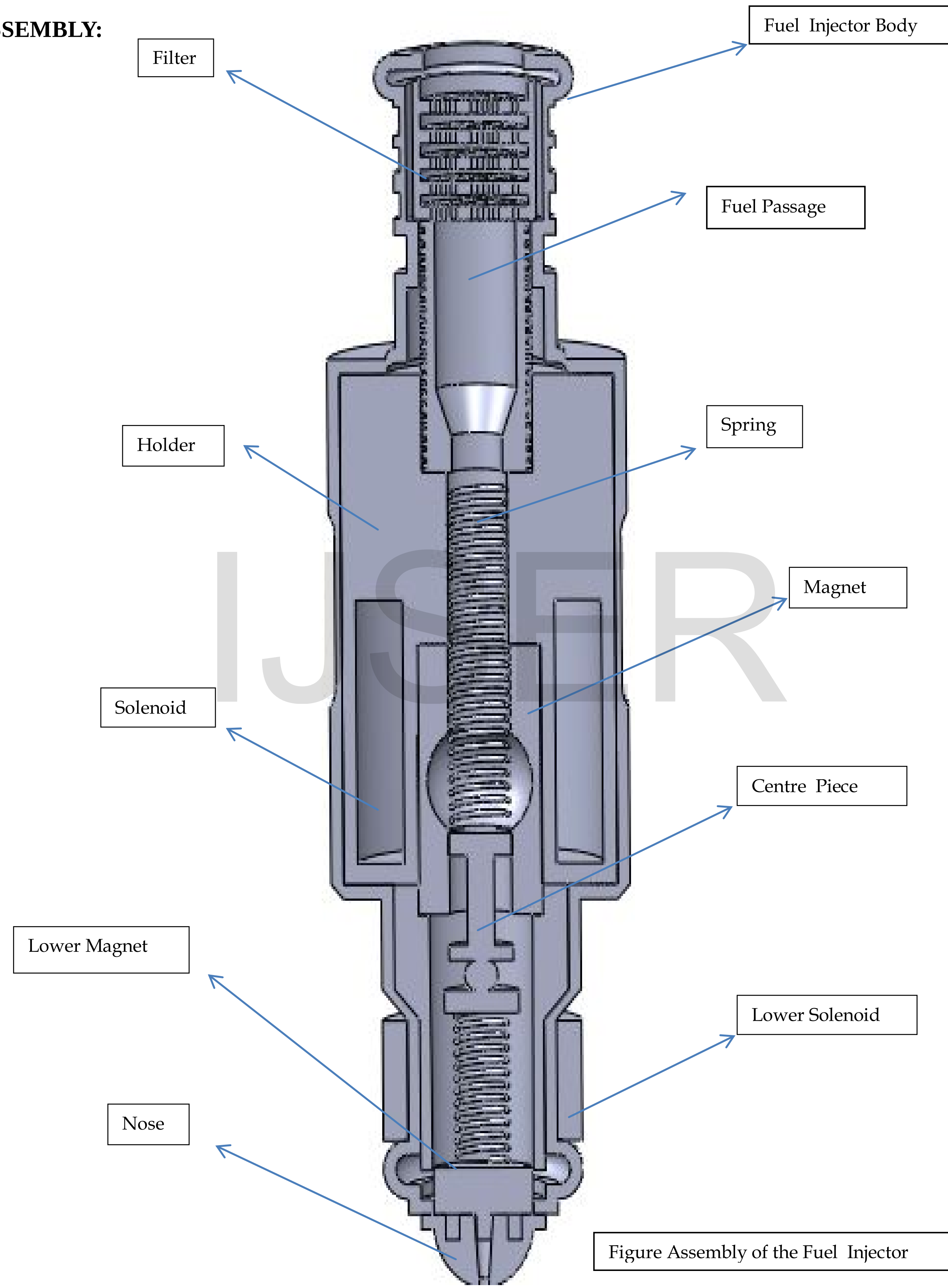

Figure Assembly of the Fuel Injector

5 Calculations:

The calculations are taken for the Land Rover V4 engine capacity-2.5 litres fuel economy gearing speed are taken from the prescribed data.
At 100 km/hr in 5th gear it is very close to 2400 rpm or 40 rev/sec.
Taken 4 stroke engine it haves 80 power strokes.
Fuel economy – 10km/litre
Total fuel burn per hour-10/3600-0.00278 litre/sec
2.78 ml is shared between 80 power strokes
For each power stroke -2.78/80 – 0.03472ml into each cylinder
Mass Flow Rate = (VOLUME OF PETROL REQUIRED FOR EACH STROKE * DENSITY OF PETROL)

(TIME TAKEN FOR 1 POWER STROKE)
m =0.0347*0.77/(1/80)=2.13752 kg/sec .

Iteration 1:

The compression ratio is 20 bar
The injector pressure is 70 bar
$P_1 /_\varrho g + v_1^2 = P_2 /_\varrho g + v_2^2$
$_\varrho = 0.77*10^3$ kg/m^3 , $V_1=0$
$P_1 - P_2 = ½ * _\varrho (v_2^2 – v_1^2)$
From the above equation we get, v_2= 45m/sec
$A_1v_1=A_2v_2$
$A_2=0.047500m^2$
$\pi/4\ d^2=0.047500$
d=0.0092969 m

Iteration 2:

Increasing the pressure difference to 100 bar
$P_1 - P_2 = ½ * \square (v_2^2 - v_1^2)$
$100*10^5=1/2\ \square v_2^2$
V_2=509.6 m/sec
$A_2=5.9920*10^{-4}m^2$
$\pi/4\ d^2=5.9920*10^{-4}m^2$
d=16mm.
Therefore holes diameter is taken as 16mm. For spraying of fuel into injector conical section is used.

6 INJECTOR FLOW SOLIDWORKS MODEL:

To analyse the flow characteristics of the in-nozzle flow six different nose models,representing nozzle lifts of 0.2mm between the angles of 0 to 70 degrees, were made, that the pressure drop in nozzle is significant only in the area of the needle seat. Some further simplifications considering the use of one outlet model of the nozzle were made according to the results of previously made analysis [3], which indicated no significant difference between the results using either a real model or an one half model of the nozzle. The mesh models at maximum needle lift of 0.2 mm with relevant number of mesh nodes and elements for this model is presented.

6.1 Initial and boundary conditions:

The boundary conditions for the given model is inlet conditions of 100 bar ,and outlet conditions of 20 bar as the outlet is inside the cylinder at the temperature of 293 K. the density 825 kg/nr' and kinematic viscosity of 2.6 mmvs. Since maximal velocities are much smaller than the speed of sound, the fluid is supposed to be uncompressible.

Some of the injector nose models:

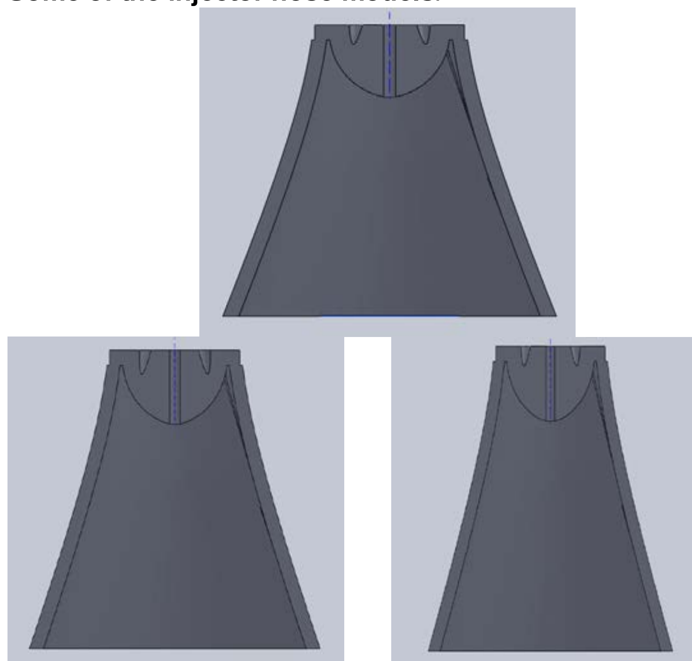

Figure 2. Noses at different injection conical angles

6.2 Results and discussions:

The thermo physical properties of the fuel i.e. diesel taken for the analysis are given in the table below giving all

FUEL PROPERTY	DIESEL
Density at 25 °C, [kgm–3]	730
Viscosity at 25 °C, [kgms–1]	0.00224
Surface tension at 25 °C, [Nm–1]	0.0020
Vapor pressure at 25 °C, [Pa]	1280

the values are

6.3 Validation:

The velocity obtained in the calculations is compared with the average velocities from the contours and shown very little variance.

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Contours Obtained Are:

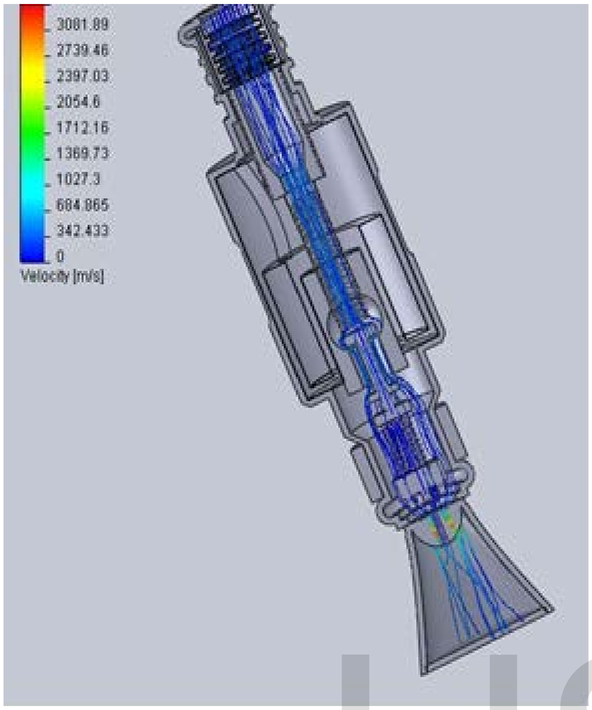


Figure 3.Flow Represented in form of balls

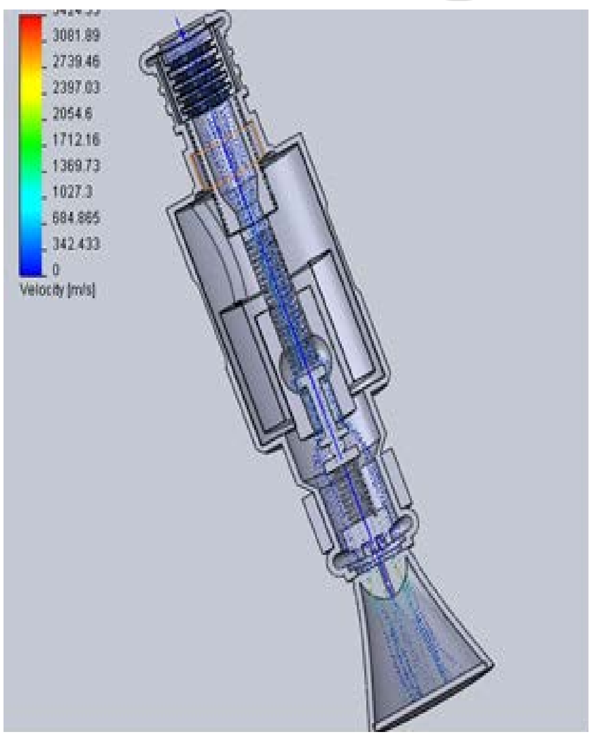


Figure 4. Flow represented in form of pipes.

The contours at the different interface regions are :

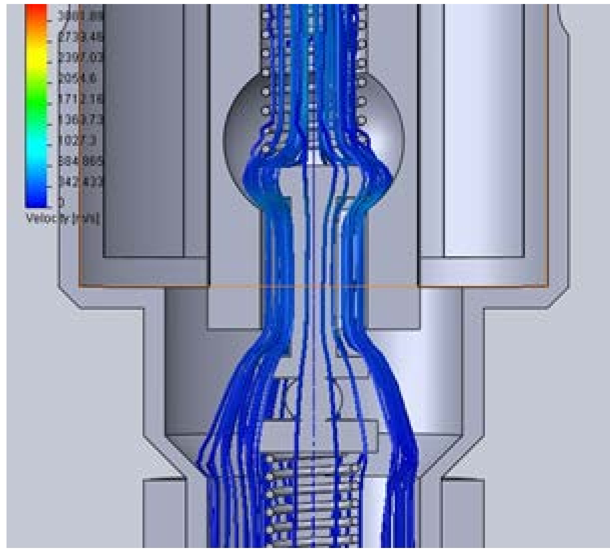


Figure 5. Flow at the opening of the centre piece

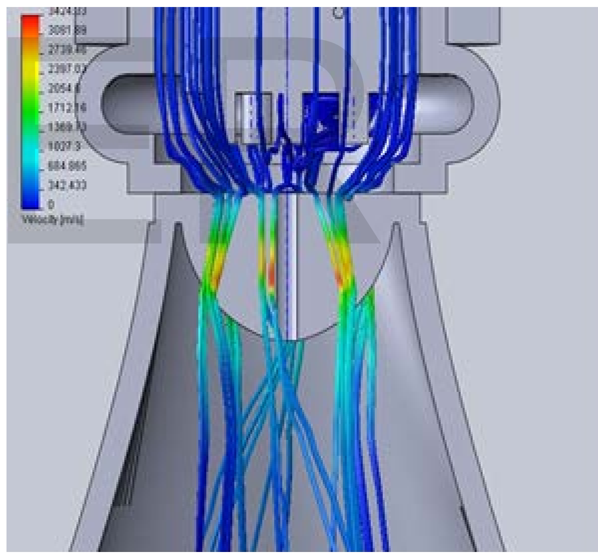
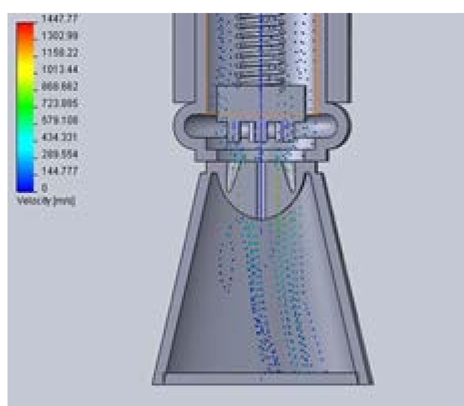


Figure 6. Flow at the nose region of injector outlet.

The contours obtained at the different conical injections:



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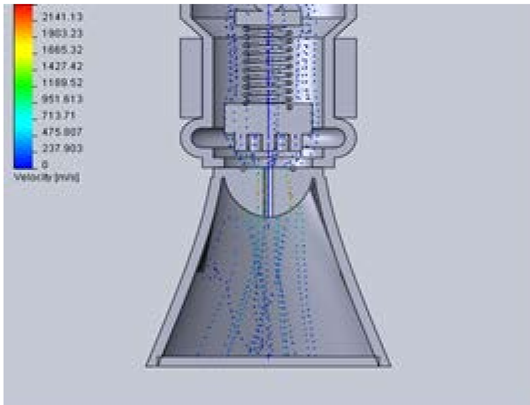
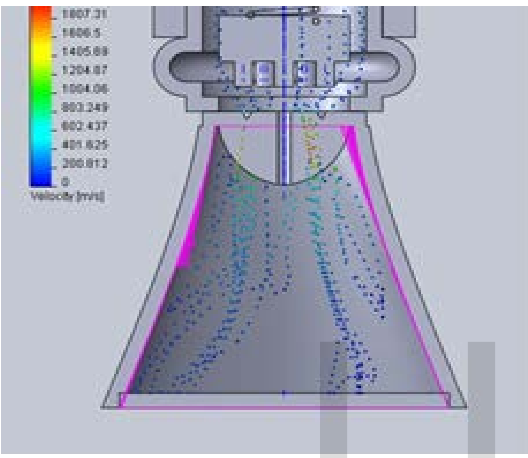
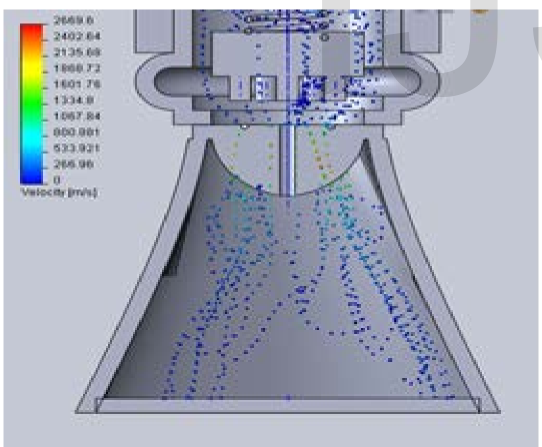
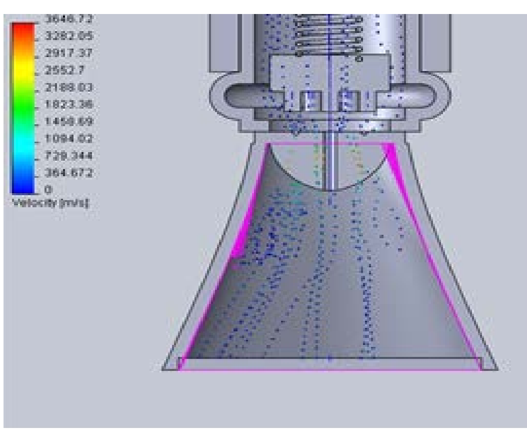
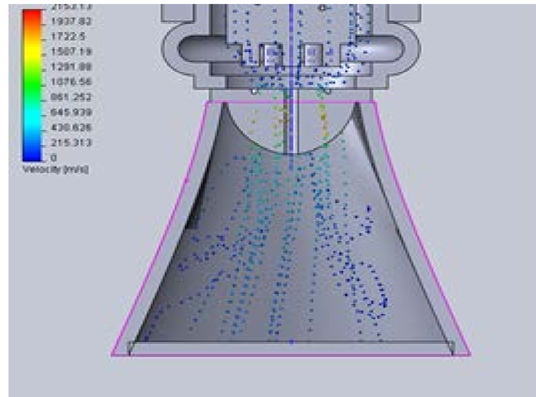


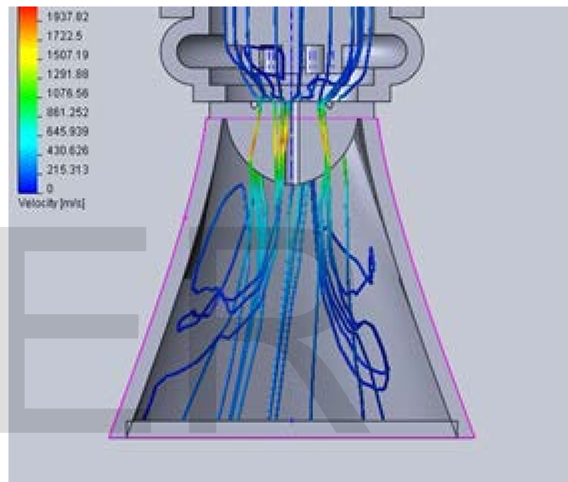


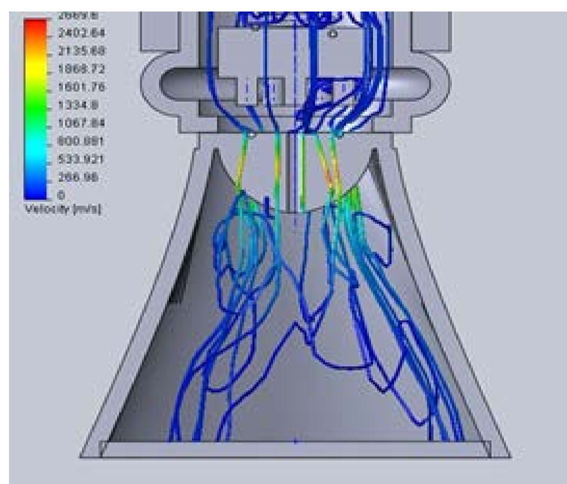






Figures. Obtained at the different injection conical angles represented in the form of balls.





Figures. Obtained at the 10 degree and the 15 degrees flow in the form of tubes.

The various different angles at the ejection of the injector of the nose region at the angles between 1 to 40 degrees interpreted that by increasing the angle the swirl component increases which means the mixing of the fuel increases in turn decreases the Nox emissions and more increment in the angle made the flow to be touching the walls which will cause the increase in Nox emissions due to improper mixing. The increased in the no of holes made the flow to mix more evenly inside the cylinder.

6.4 CONCLUSION:

The injector flow characteristics for the diesel fuel injector is done at the different conical angles at constant needle lifts of 0.2mm with the increase of the injector angles, swirl and whirl components increases. The angle shouldn't increase too much as the flow touches the walls of the cylinder The maximum optimal angle can be only formulated by both the injector angle and the angle at which the injector is placed with respect to the central axis. In the future analysis the optimal angle for different injectors placed at different angles is analysed by the 3-d spray analysis i.e. amount of nucleation occurs in the flow.`

6.5 REFERENCES:

[1] Experimental and numerical analysis of fuel flow in the diesel engine injection nozzle Martin Volmajer, Breda Kegl, Ph.D.*Research assistant*

[2] Effect of the injection pressure on the internal flow charac teristics for diethyl and dimethyl ether and diesel fuel in jectors
thulasi vijayakumar *, rajagopal thundil karuppa raj, and kasianantham nanthagopal

[3] ***, FLUENT v6.3 documentation

[4] 3D-CFD In-Nozzle Flow Simulation and Separate Row In jection Rate Measurementas preparatory steps for a de tailed Analysis of Multi-Layer Nozzles C. Menne1*, A. Janssen1, M. Lamping2, T. Körfer2, H.-J. Laumen2, M. Douch2, R. Meisenberg.

[5] M. Lamping, T. Körfer, H.-J. Laumen, H. Rohs, S. Pisching er, H. Neises, H. Busch Einfluss des hydraulischen Düsendurchflusses auf das motorische Verhalten bei Pkw-DI-Dieselmotoren 8. Tagung Motorische Verbrennung, 2008.

[6] He Zhixia and Yuan Jianping, "The diesel engine spray nozzle structural optimization numerical simulation analyzes," Internal combustion engine journal, pp. 35–41, 2006(1).

[7] Simulation of injection angles on combustion performance using multiple injection strategy in HSDI diesel engine by CFD

Konkala Bala showry1 Dr.A.V.Sita Rama Raju2

[8] Spray Pattern Recognition for Multi-Hole Gasoline Direct Injectors Using CFD Modeling
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