CFD ANALYSIS OF FLOW THROUGH VENTURI OF A CARBURETOR

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In

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By

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CERTIFICATE

This is to certify that the project entitled "**CFD Analysis of Flow Through the Venturi of a Carburetor**" submitted by '**Mr. Deepak Ranjan Bhola**' in partial fulfillments for the requirements for the award of Bachelor of Technology Degree in Mechanical Engineering at National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the report has not been submitted to any other University / Institute for the award of any Degree or Diploma.

Date:

(Prof. S.Murugan)

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ABSTRACT

Modern passenger vehicles with gasoline engines are provided with different compensating devices for fuel air mixture supply. Even then there is a high fuel consumption because of many factors. One of the important factors that affect the fuel consumption is that design of carburetor. The venturi of the carburetor is important that provides a necessary pressure drop in the carburetor device. Since different SI engine alternative fuels such as LPG, CNG are used in the present day vehicles to reduce the pollution and fuel consumption. Still for a better economy and uniform fuel air supply there is a need to design the carburetor with an effective analytical tool or software. In this work three parameters namely pressure drop and fuel discharge nozzle angle of the carburetor will be analyzed using computational fluid dynamics. For this analysis CFD will be done using 2 softwares namely GAMBIT and FLUENT. The results obtained from the softwares will be analyzed for optimum design of a carburetor.

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CHAPTER 1

1.1 Introduction: Internal Combustion Engines

Engine is a device that transforms one form of energy into another form. Heat energy is a device that transforms the chemical energy contained in a fuel to another form of energy and utilizes that energy for some useful work. Internal combustion engine is a device in which the combustion of the working fluid takes place inside the engine e.g. gasoline or diesel engine.

1.1.1 SI Engine

SI engine is known as spark ignition engine. In case of such engines the cycle is completed in 4 strokes of the piston namely suction, compression, power and exhaust.

Suction: Suction strokes starts when the piston is at the top dead center. At this time the intake valve is open where as the exhaust valve is closed. When the piston moves towards the bottom dead center, suction is created and fuel-air mixture is drawn into the cylinder.

Compression: During the return of the piston from the bottom dead center towards the top dead center, the charge sucked during the intake stroke gets compressed. During this stroke both valves are in open condition. At the end the mixture is ignited with the help of a spark plug. Due to the ignition the chemical energy of the fuel is converted into heat energy and the temperature rises to about 2000^0C.

Expansion: During this stroke both the valves remain in closed position and power is also produced.

Exhaust: During this stroke the inlet valve remains in closed position whereas the exhaust valve remains open. The piston moves from bottom dead center to the top dead center and sweeps the burnt gases out of the cylinder.

1.1.2 CI Engine

CI engine is known as compression ignition engine. In case of such engines also the cycle is completed in 4 strokes of the piston but it operates at a much higher compression ratio.

Suction: During this stroke the inlet valve opens and the exhaust valve closes. Only air is inducted into the cylinder.

Compression: The air inducted into the cylinder gets compressed due to the movement of the piston from bottom dead center to the top dead center because both the valve remains in closed position.

Expansion: Fuel is injected into the cylinder at nearly the beginning of the stroke. Both the valves are still in closed position. Heat is assumed to be added at constant pressure. When the piston moves from top dead center towards the bottom dead center the product of combustion expands.

Exhaust: Since during this stroke the inlet valve is in closed position whereas the exhaust valve is in opened position, so when the piston movers from the bottom dead center towards the top dead center the product of combustion gets expelled from the cylinder.

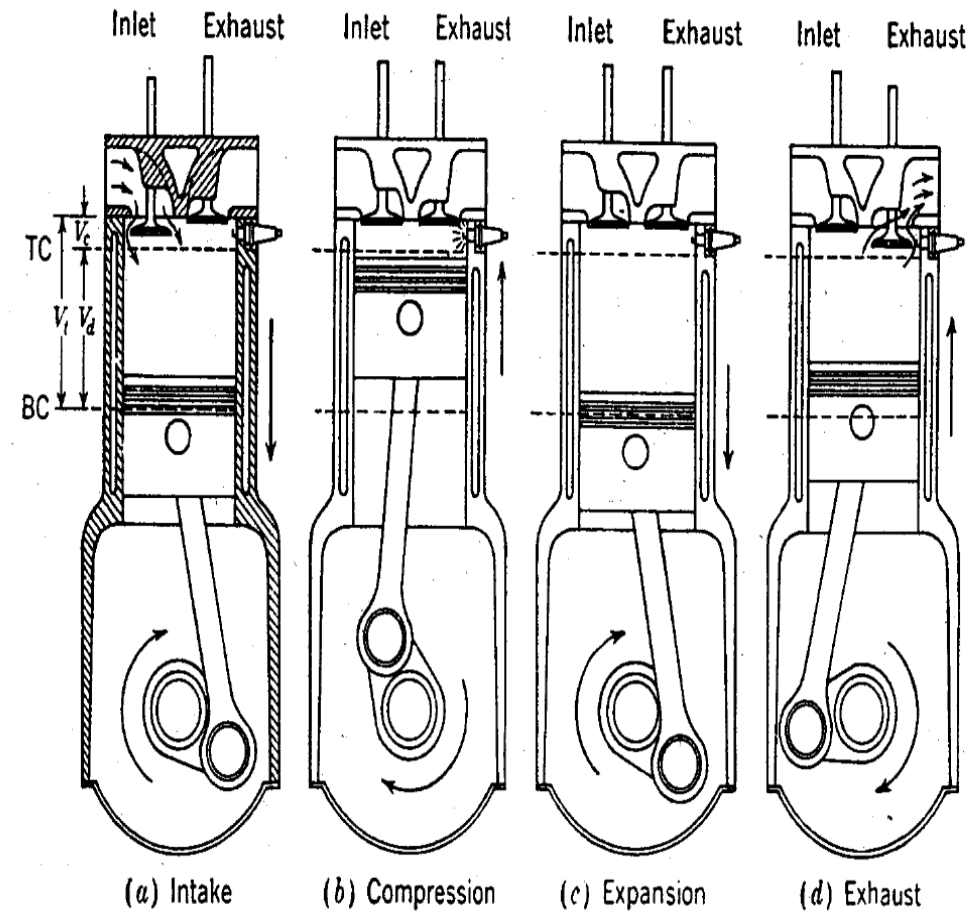


FIG 1.1: 4 Stroke operating cycle (Ref fig 1.2, IC Engines by John B. Heywood)

CHAPTER 2

2.1 Introduction

SI engines generally use volatile liquids. The preparation of the fuel-air mixture is done outside the engine cylinder. The fuel droplets that remain in suspension also continue to evaporate and mix with air during suction and compression processes also. So carburetion is required to provide a combustible mixture of fuel and air in required quantity and quality.

2.2 Definition of Carburetion

The process of forming a combustible fuel-air mixture by mixing the right amount of fuel with air before admission to the cylinder of the engine is called carburetion and the device doing this job is called carburetor.

2.3 Factors Affecting Carburetion

The various factors affecting the process of carburetion are

1. Engine speed
2. Vaporization characteristics of the fuel
3. Temperature of incoming air
4. Design of the carburetor

Since the engines are of high speed type there is very little time available for mixture preparation. So to have a high quality carburetion the velocity of the air at point of injection of fuel has to be increased. To achieve this, a venturi is provided in the path of air.

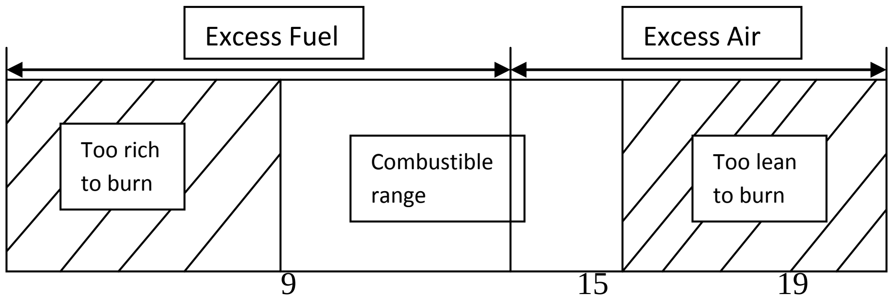
Presence of highly volatile hydrocarbons in the fuel also ensures high quality carburetion.

The pressure and temperature of the surrounding air also affects the process of carburetion. Higher atmospheric air temperature increases the vaporization of the fuel and hence a more homogeneous mixture is produced.

Design of the carburetor, its intake system and the combustion chamber also affect the uniform distribution of mixture to various cylinders of the engine.

2.4 Air-Fuel Mixtures

For proper running of the engine under different loads and speeds a proper mixture of air and fuel is required. Generally 3 types of fuel mixtures are used like lean, rich and chemically correct mixture. The mixture in which there is just enough air for the complete combustion of the fuel is called stoichiometric mixture. The mixture which contains less air than the air required for stoichiometric mixture is called rich mixture and the mixture containing more air than the stoichiometric mixture is called lean mixture. The carburetor should provide the air-fuel mixture according to engine requirement and that must be under combustible range.



ig 2.1 Useful Air-Fuel mixture range of gasoline ((Ref Fig 8.1, Ganeshan V, IC Engines, TMH, 2009)

2.5 Mixture requirements at different loads and speeds

The performance of an engine generally affected by the air-fuel ratio under which it is operating. The power output and the brake specific fuel consumption are affected by the air-fuel ratio as shown in the fig 2.2. The mixture corresponding to the maximum point on the power output curve is called best power mixture and the air-fuel ratio at this point is approximately 12:1. The mixture corresponding to the lowest point on the brake specific fuel consumption curve is called the economy mixture and the air-fuel ratio at this point is about 16:1.The best power mixture is generally richer than the stoichiometric mixture whereas the economy mixture is leaner than the stoichiometric mixture.

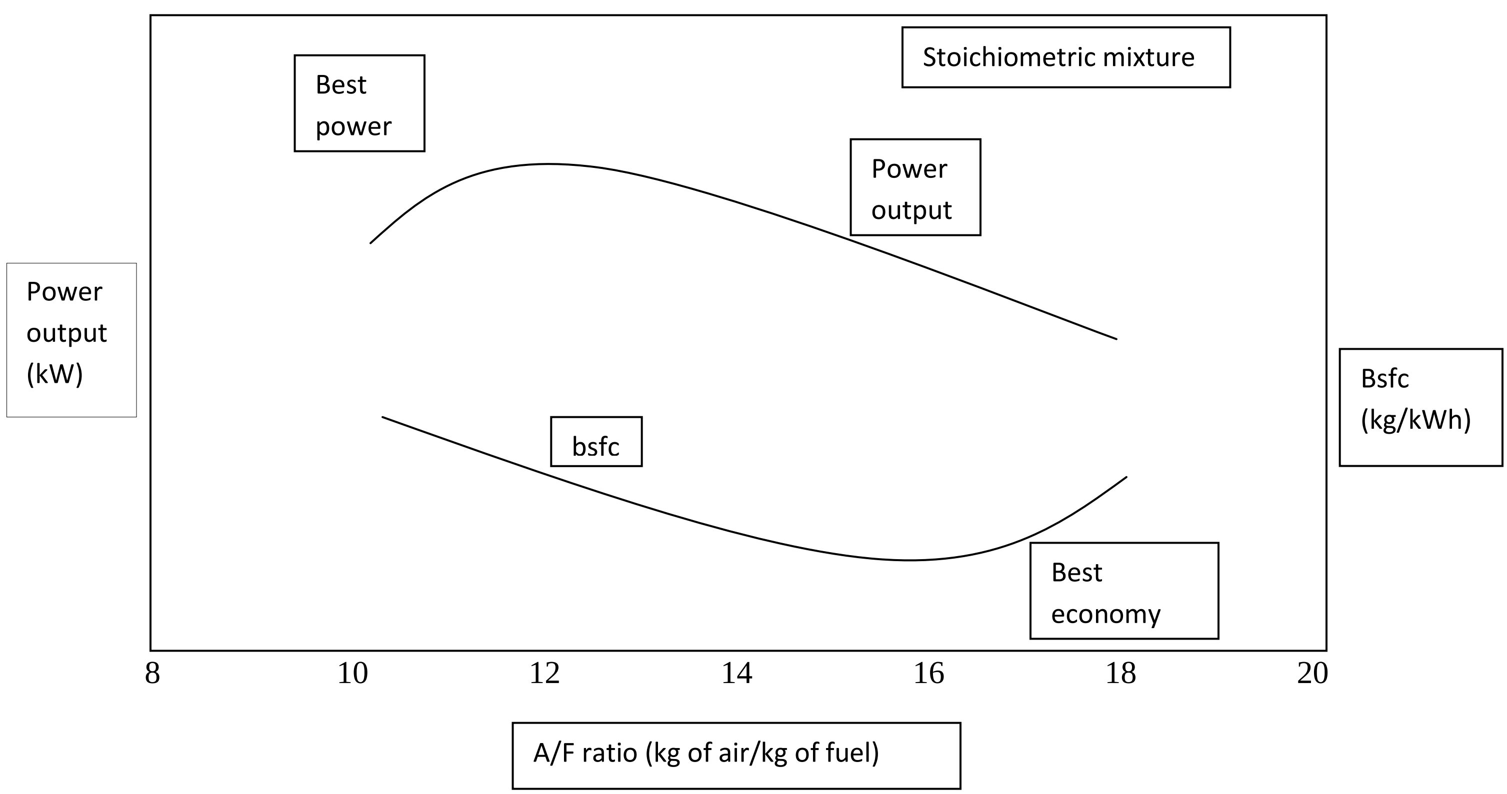


Fig 2.2 variation of power output and bsfc with A/F ratio for an SI engine(Ref Fig 8.2, Ganeshan V, IC Engines, TMH, 2009)

2.6 Automotive engine air-fuel mixture requirements

There are generally 3 ranges of throttle operation and so the carburetor must be able to deliver the required air-fuel ratio to satisfy the demands. The ranges are

1. Idling
2. Cruising
3. High Power

In idling range the mixture must be enriched as the engine operates at no load and with nearly closed throttle. It is indicated by the point A in the fig 2.3. This happens due to the existing pressure conditions inside the combustion chamber and the intake manifold that leads to exhaust gas dilution of the fresh charge. Due to constant volume of the clearance volume the mass of the exhaust gas tends to remain constant throughout the idling range. The amount of fresh charge that is drawn during the intake stroke is much less than that of during full throttle condition which tends to mixing of larger proportion of exhausts gas with the fresh charge under idling conditions. During the opening of the intake valve the pressure diffential between combustion chamber and the intake manifold results in a backward flow of the fresh charge. But as soon as the piston starts moving downwards the mixture is again sucked into the combustion chamber. Inside the combustion chamber as there is much amount of exhaust gas than the fresh charge, the exhaust gas prevents the touching of the air and fuel molecules with each other which is much necessary for the process of combustion to take place. Therefore it is necessary to provide more fuel particles by richening the air-fuel mixture. As the throttle moves from A towards B the pressure difference between the combustion chamber and the intake manifold decreases and the exhaust gas dilution of the fresh charge decreases.

In cruising range from position B to C of the throttle valve the exhaust gas dilution is insignificant. The primary aim lies to obtain a much better fuel economy. So, in this range the carburetor is required to provide the best economy mixture.

In the peak power operation the engine requires a much richer mixture as indicated in the fig 2.3 by the line CD because of

(i) During peak power operation some parts of the cylinder gets heated up. So enrichening the mixture reduces the flame temperature and the cylinder temperature and the cooling problem is solved.

(ii) Since high power is required the cruising setting must be transferred to a setting in which the mixture will deliver maximum power or to a setting in the air-fuel ration lies in the range of 12:1.

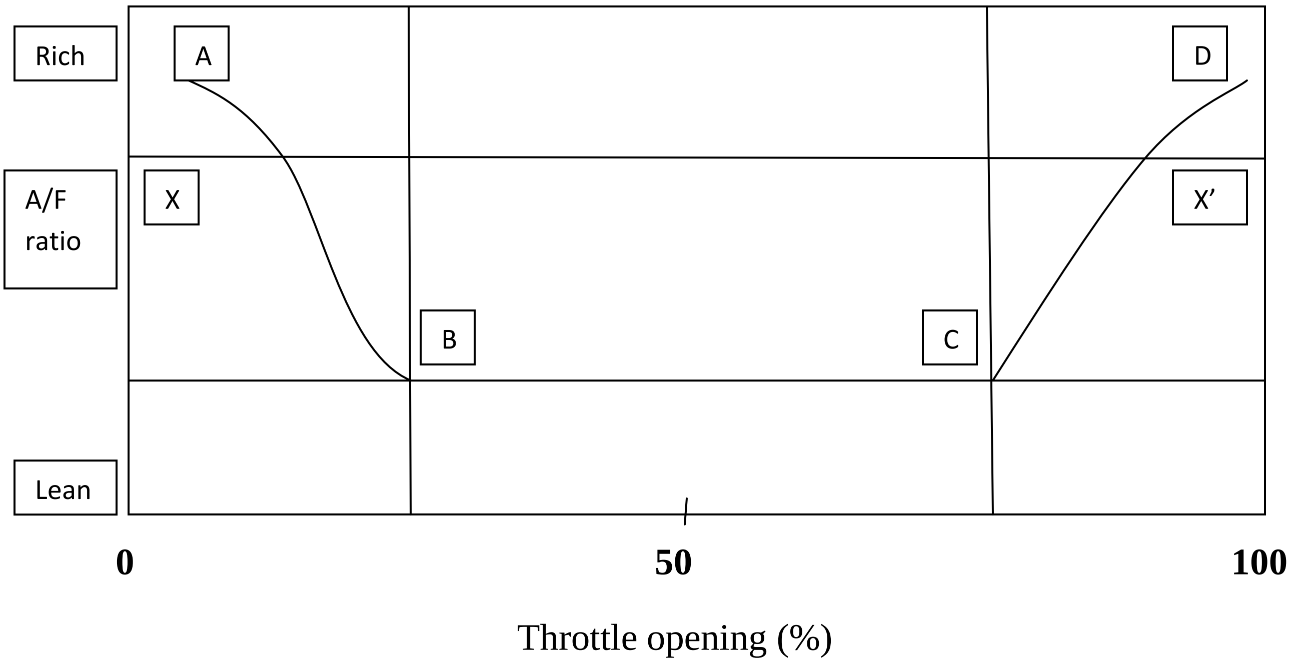


Fig 2.3 Possible carburetor performance to fulfill engine requirements(Ref Fig 8.3, Ganeshan V, IC Engines, TMH, 2009)

2.7 Principle of Carburetion

Both air and gasoline are drawn into the cylinder due to suction pressure created by the downward movement of the piston. In the carburetor, the air passing into the combustion chamber picks up the fuel discharged by a fine orifice in a tube called the carburetor jet. The rate of discharge of the fuel depends on the pressure difference between the float chamber and the throat of the venturi of the carburetor and the area of the outlet of the tube. In order that the fuel is strongly atomized the suction effect must be strong and the nozzle outlet must be comparatively small. To produce a strong suction, a restriction is generally provided in the pipe in the carburetor carrying air to the engine. This restriction is called throat. In this throat due to increase in the velocity of the air the pressure is decreased and suction is created.

The venturi tube has a narrower path at the center so that the path through air is going to travel is reduced. As same amount of air must travel must travel through the path of the tube so the velocity of the air at the venturi is increased and suction is created.

Usually the fuel discharge jet is located at the point where the suction is maximum. So this is positioned just below the throat of the venturi. The spray of the fuel from the fuel discharge jet and the air are mixed at this point of the throat and a combustible mixture is formed. Maximum amount of fuel gets atomized and some part gets vaporized. Due to increase in the velocity of the air at the throat the vaporization of the fuel becomes easier.

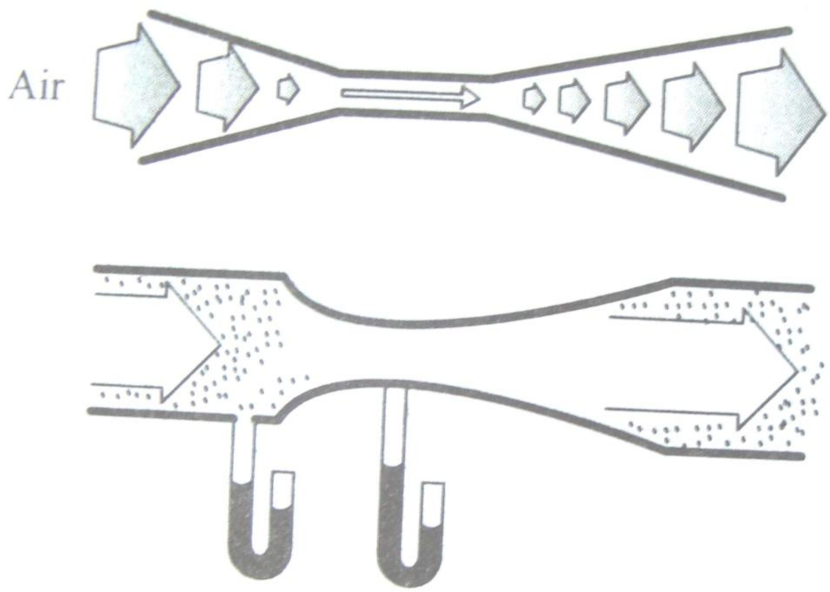


Fig 2.4 Operation of venturi tube (Ref Fig 8.6, Ganeshan V, IC Engines, TMH, 2009)

CHAPTER 3

3.1 The Simple Carburetor

The figure 3.1 shows a simple carburetor. It is the basic carburetor to describe the functions of other carburetors.

The simple carburetor consists of the following basic parts.

- Float chamber
- Venturi
- Fuel discharge nozzle
- Metering orifice
- Choke
- Throttle valve

A constant level of fuel is maintained in the float chamber by means of a float and needle valve system. If the fuel level falls below required level then the float goes down and allows the fuel supply valve to open. Then the fuel flows into the float chamber. When the designed level is reached the float again closes the fuel supply valve and the supply of fuel is stopped.

The venturi of the carburetor is a tube of decreasing cross section area. As the air flows through the venturi the velocity of the air increases and so the pressure across the venturi goes on decreasing and reaches a minimum pressure at the throat. The tip of the fuel discharge jet lies at the throat. The difference of pressure between the throat and float chamber is known as *carburetor depression.* The pressure at the throat varies from 4-5cm Hg (for fully opened throttle) and rarely reaches 8cm Hg. To avoid overflow the tip of the discharge tube lies at a height “h” above the throat.

In case of a gasoline engine in order to vary the power output at a particular speed, we have to vary the charge delivered to the cylinder. This is achieved by providing a butterfly shaped throttle valve. When the throttle is closed less amount of air flows through the venturi and the throttle goes on increasing the air flow also increases and the power output also increases.

The simple carburetor provides the required A/F ratio only at a certain opening of the throttle. As the throttle opening varies, the air flow varies and a pressure diffential is created between the float chamber and the venturi throat. Now as the pressure decreases the density of the air decreases but flow increases. So a rich mixture is produced because the density of the fuel remains unchanged.

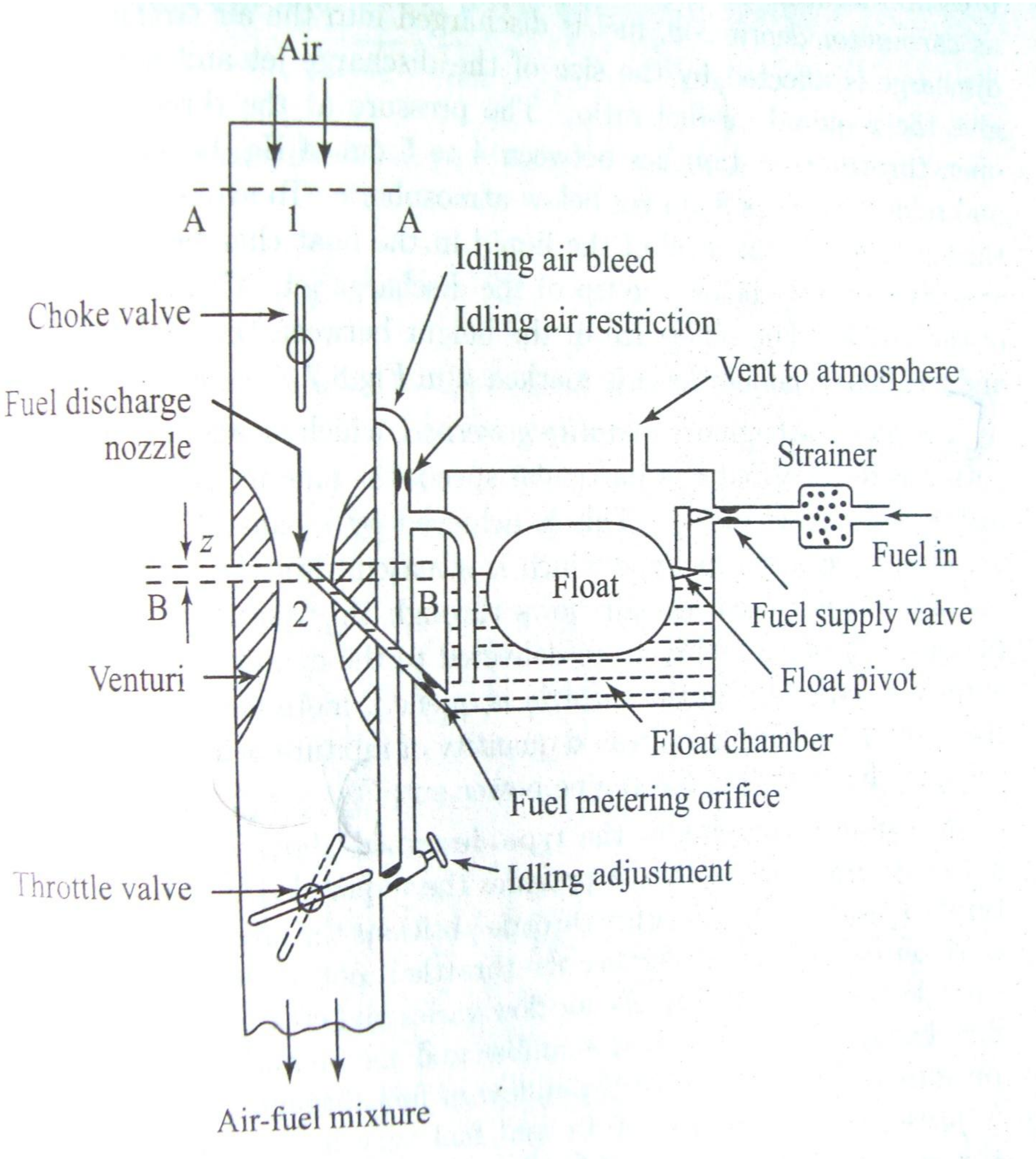


Fig 3.1: Simple Carburetor (Ref: fig 8.7, Ganeshan V, IC Engines, TMH, 2009)

3.2 Compensating Devices

The automobile has to run on different roads on different loads and conditions. The main metering system of the carburetor alone will not be able to take care of the needs of the engines. Therefore, compensating devices are provided. The important compensating devices are

a) Air-bleed jet
b) Emulsion Tube
c) Compensating jet
d) Back suction control mechanism
e) Auxiliary air port
f) Auxiliary air valve

3.2.1 Air-Bleed Jet

The air bleed jet is present in the main nozzle. The flow of air through the orifice is restricted by and orifice. Initially, when the engine is not operating both the jets are filled with fuel. When the engine starts fuel comes out from both the nozzles but gradually t5he engine picks up and after that only air comes out of the air-bleed jet and mixes with the fuel coming out from the main nozzle and forms the fuel-air emulsion.

3.2.2 Emulsion Tube

The main metering is jet is generally kept 25mm below the fuel level in the float chamber so as to avoid the overflow of the fuel. A jet is placed at the bottom of a well having holes which are connected to the atmosphere. When the throttle is opened fuel starts to flow from the well and the holes get uncovered and the air-fuel ratio increases i.e. the richness of the mixture decreases when all the holes get uncovered. The air is drawn through these holes and the fuel gets emulsified and the differential of pressure across the column of fuel is not as high as that of the simple carburetor.

3.2.3 Compensating Jet

The main purpose of the compensating jet, which is connected to a compensating well, is to make the mixture leaner as the throttle valve opens gradually. The compensating well is vented to the atmosphere and is also connected to the main fuel chamber through a restricting orifice. With the increase in air flow rate, the fuel level in the compensating well decreases so the fuel supply rate through the compensating jet also decreases. Thus the compensating jet tends to lean the mixture whereas the main jet tends to richen the mixture. So the sum of the two jets tends to keep the mixture to the required ratio.

3.2.4 Back Suction Control Mechanism

In this device, the top of the fuel float chamber is connected to the entry part of the body of the carburetor by means of a long vent line fitted with a control valve. Another vent is connected from the top of the chamber to the venturi of the throat. When the control valve is completely open then pressure at the float chamber is same as that of the air inlet. So there lies a pressure difference between the float chamber and the venturi and fuel from the float chamber flows into the venturi. But when the control valve is closed the pressure at the venturi and the float chamber are same and there is no fuel flow. Thus by proper control of the control valve a proper differential between the float chamber and the throat can be maintained and hence the quality of the mixture.

3.2.5 Auxiliary Valve

When the engine is in idle conditions the pressure at the top of the auxiliary valve is atmospheric. With increase in load, the vacuum at the throat of the venturi increases. So a pressure differential is created between the throat and the spring and this pressure difference raises the valve against the spring force. And as a result more air flows and the mixture becomes leaner.

3.2.6 Auxiliary Port

The auxiliary port connects the air entering part above the throat with the air leaving part below the throat by means of a long vent containing a butterfly valve. If the butterfly valve is opened then some additional amount of air passes through this vent and thus the flow of air across the venturi decreases.

CHAPTER 4

4.1 Alternative Fuels for SI Engines

Now a days there is enormous increase in the number of vehicles and hence there is increase in demand of fuel. As after some days the quantity of petroleum and diesel will become almost scarce and most costly. So some countries are trying to develop new technologies to use the alternative fuels in the vehicles.

Another reason of using the alternative fuels in the IC engines is the raising issue of emission problems of gasoline and diesel operated vehicles.

One more reason is that a huge percentage of crude oil imported from other oil rich countries. So it affects the economy of a country. So a development in alternative fuel technology is much necessary.

The alternative fuel is divided into three major categories

- Solid fuels
- Liquid fuels
- Gaseous Fuels

Now a days solid fuels are almost obsolete for Internal Combustion engines.

Liquid fuels are best suited and they are preferred for IC engines because they are easy to store and they have a very good calorific value. The various liquid fuels are

1. Alcohol
2. Methanol
3. Ethanol
4. Reformulated gasoline
5. Water-gasoline mixture

Out of the above listed liquid fuels alcohol is the most popular and most widely used alternative liquid fuel.

In the category of gaseous alternative fuels it is to note that gaseous fuels are best suited for IC engines because they have almost zero physical delay. There are very few gaseous fuels which are used as alternative fuels they are

1. Hydrogen
2. Natural gas
3. Liquefied petroleum gas (LPG)
4. Compressed natural gas(CNG)

4.1.1 Alcohol for SI Engines

Alcohols are most attractive and mostly used alternative fuels because they can be derived from both natural and manufactured sources. Methanol and ethanol are two widely used alcohols. There are certain advantages and disadvantages of alcohols and they are as follows

Advantages:

1. It is a high octane fuel having octane number of more than 100.
2. As compared to gasoline it produces less emission.
3. Burning of alcohols gives more amount of exhaust gases which leads to more power and high pressure in the expansion stroke.
4. Alcohols are having low sulphur content in the fuel.

Disadvantages:

1. Alcohols are having very less calorific value almost half of that of gasoline. So to produce same amount of power as that of gasoline, more than two times of the amount of gasoline is required.
2. Combustion of alcohols produces aldehydes.
3. Alcohols are having poor ignition characteristics.
4. The flames of alcohols are almost invisible. So it is difficult to handle alcohol. The addition of small amount of gasoline removes this danger.
5. The odor of alcohol is very offensive.

4.1.2 Hydrogen

A number of automobile companies have built engines or prototypes which run with hydrogen. There are certain advantages and disadvantages of using hydrogen in the engine.

Advantages:

1. As there is no carbon in the fuel so generally the exhaust contains H_2O, N_2 and NO_2. There is complete absence of CO or HC.
2. There are so many ways of making hydrogen. One of the most important ways is electrolysis of water.
3. The leakage of fuel into the environment is pollution free.
4. When hydrogen is stored as liquid, it has high energy content per volume.

Disadvantages

1. It requires very heavy and bulky storage units both in vehicles and service stations.
2. It is very difficult to refuel the hydrogen tanks.
3. It has very low volumetric efficiency.
4. Its cost is very high at present day technology and availability.
5. Because of high flame temperature it gives high NO_x emissions.

4.1.3 Natural gas

Natural gas is found at various depths below the earth surface. The gas is generally under certain pressure and comes out naturally. If the gas has to be used in the vehicle then the entrained sand must be separated from the gas. The main constituent of natural gas is methane (CH_4) and the other constituents which are present in small amounts are ethane (C_2H_5), N_2, CO_2, He and traces of other gases.

Advantages:

1. Its octane number is more than 100 and is around 110. This high value of octane number makes its flame speed higher and the engine can operate with a high compression ratio.
2. Its emission contains less aldehydes than that of emissions of methanol.
3. Natural gas is available in abundant amount worldwide.

Disadvantages:

1. Due to low energy density, it leads to low engine performance.
2. As it is a gasoline fuel, it has low engine volumetric efficiency
3. It needs a large pressurized fuel storage tank.
4. Its fuel properties are inconsistent.
5. Its refueling process is very slow.

4.1.4 Liquefied Petroleum Gas (LPG)

Propane and butane are the products of petroleum refinery process and are also obtained from oil and gas wells. Generally propane and butane are used separately for automobile use and sometimes a mixture of both of them is used.

Advantages:

1. The amount of carbon is less in LPG than that of petrol.
2. LPG can mix with air at all conditions of temperature.
3. In case of multicylinder engines, all the cylinders can be provided with a uniform mixture.
4. There is no chance of crankcase dilution as the fuel is in the form of vapour.
5. Automobile engines having higher compression ratios (10:1) can use propane.
6. LPG has high antiknock characteristics.
7. The life of the engine increases by 50% by use of LPG.
8. By using LPG, we can save the cost of about 50%.
9. LPG is having heat energy about 80% of gasoline.

4.1.5 Compressed Natural Gas (CNG)

By drilling wells petroleum and natural gas are obtained. Crude petroleum contains hydrocarbons, some amount of water, sulphur and some other impurities also. Mixing of petroleum with the natural gas gives a highly volatile liquid which is known as natural gasoline. The natural gas can be compressed and can renamed as Compressed Natural Gas. Just like LPG, CNG is also used to run the automobiles. Bothe the LPG and CNG fuel feed systems are same. Petrol driven cars can be converted into CNG driven cars by using the CNG conversion kit. The kits contain certain auxiliary parts like mixer and converter etc required for conversion.

The following table summarizes the different properties of the fuels.

Property	Gasoline	Methanol	Ethanol	Propane	Compresses Natural Gas	Hydrogen
Chemical formula	C4 to c12	CH3OH	C2H5OH	C3H8	CH4(83-99%) C2H6(1-13%)	H2
lecular Weight	100-105	32.04	46.07	44.1	16.04	2.02
Composition, Weight %						
>Carbon	85-88[12]	37.5	52.2	82	75	0
>Hydrogen	12-15[12]	12.6	13.1	18	25	100
>Oxygen	0	49.9	34.7	-	-	0
Specific gravity, 60^0F/60^0F	0.72-0.78 [12]	0.796 [16]	0.794[16]	0.508[19]	0.424	0.07[21]
Density, lb/gal@60^0F	6.0-6.5 [12]	6.63 [12]	6.61 [12]	4.22	1.07[20]	-
Boiling temperature,^{0}F	80-437 [12]	149 [16]	172[16]	-44[19]	-263.2 to -126.4[19]	-423[19]
Reis vapor pressure(100^0F) psi	8-15[13]	4.6 [17]	2.3[17]	208	2400	-
Heating value(2)						
>Lower (Btu/gal) (d)	116,090	57,250	76,330	84,250	-	-
>Lower (Btu/lb) (d)	18,676	8,637	11,585	19,900	20,263	52,217
>Higher (Btu/gal) (d)	124,340	65,200	84,530	91,420	-	-
>Higher (Btu/lb) (d)	20,004	9,837	12,830	21,594	22,449	59,806
Octane no. (1)						
>Research octane no	88-98 [13]	-	-	112	-	130+
>Motor octane no	80-88 [13]	-	-	97	-	-
Cetane no. (1)	-	-	0-54[15]	-	-	-
Freezing point, ^{0}F	-40[14]	-143.5	-173.2	-305.8[19]	-296	-435[22]
Viscosity, mm^2/s						
>@104^0F	-	-	-	-	-	-
>@68^0F	0.5-0.6 [15]	0.74[15]	1.50[15]	-	-	-
>@-4^0F	0.8-1.0 [15]	1.345 [15]	3.435[15]	-	-	-
Flash point, closed cup, ^{0}F	-45 [12]	52 [17]	55[17]	-156[19]	-300	-
Autoignition temperature, ^{0}F	495 [12]	867 [12]	793[12]	842[19]	900-1170[19]	932[19]
Latent heat of vaporization						
>Btu/gal @60^0F	~900 [12]	3340 [12]	2378[12]	775	-	-
>Btu/lb @60^0F	~150	506 [12]	396[12]	193.1	219	192.1 [22]
Specific heat, Btu/lb ^{0}F	0.48[14]	0.60 [18]	0.57[18]	-	-	-
Stoichiometric air/fuel, weight	14.7	6.45	9.00	15.7	17.2	34.3 [21]

CHAPTER 5

5.1 Literature Review

Diego Alejandro Arias [2] studied and conducted an experiment to validate the steady state model of a carburetor by measuring the fuel and air flows in a commercial (Nikki) carburetor. He used a flow-amplifier to create a low pressure zone downstream the carburetor. He compared the results obtained from the experiment and prediction of the steady state model. The uncertainty in the measurement was found to be ±2 cm^3/min. These results indicated that the model was successful in showing the effects of the pressure drop and the metering elements in the emulsion tube. He also studied the quasi steady state and dynamic model.

1. Both the steady and dynamic models were used to study the effect of different geometry and physical properties of fuel and air flow.
2. He also used the models to calculate the gravitational and frictional pressure drop across the carburetor.
3. He developed an experimental set up to access the validity of the two phase flow models for both horizontal and vertical pipes.
4. He studied the effect of various parameters on the discharge coefficient. The parameters include the mesh sizes in case of small orifices and chamfered inlet and outlet etc.
5. He studied the effect of mesh size on the velocity profile of the square edged orifices.
6. He studied the effect of inlet and outlet chamfers on the static pressure.

The results obtained from his studies are

1. For the square edged orifices the result was within 5% agreement with the experimental results. The shortest orifice gave an agreement of 1% whereas the larger orifice gave 4.6% agreement.
2. He derived the expressions for prediction of the discharge coefficient by the information obtained from the velocity and pressure fields.
3. The outlet chamfer does not seem to affect the discharge coefficient.
4. The inlet chamfer favored the attachment of velocity profile to the wall and allowed for a development of the velocity profile.
5. The comparison with the FLUENT result showed the derived expressions were simple and effective.

He also studied the CFD analysis of the compressible flow across the carburetor venturi. The steps involved in the analysis process were

1. He developed a C program with 2 scripts. First script was to create the geometry of the carburetor in GAMBIT and the second script was to instruct the analysis of the model carburetor in FLUENT.
2. GAMBIT was used to create the geometry of the carburetor, to mesh the carburetor and to define the boundary conditions.
3. He used condor to run the different geometries and flow cases.
4. Finally he analyzed the solutions obtained in FLUENT.

The results of the above analysis are

1. When he considered different obstacles in the flow path, there was a larger decrease in flow pressure after the fuel tube and throttle plate.
2. In the absence of the fuel tube the inlet obstacles reduce the discharge coefficient. But with the presence of the fuel tube, suppose it is 3 mm long, all the different geometries show the same value of discharge coefficient.

Arias A Diego and Shedd A. Timothy [4] together worked to present a mathematical model of network of complex flow which contained short metering orifices, compressible flow and two-phase flow in pipes of small diameter. They have done a detail review of pressure drop, effect of fuel well and dynamic flow in the previously developed models. The homogeneous two-phase flow model were found to be very poor in agreement with the empirical correlation derived from the experiments on small pipes. They solved the instantaneous one-dimensional Navier-Stoke equation in single phase pipes to access the dynamic flow model. This was proved successful in explaining the mixture enrichment seen under pulsating flow conditions. They also used to model the model to derive a sensitivity analysis of geometries and physical properties of air and fuel.

CHAPTER 6

6.1 Specification of the Model Carburetor

The model of the carburetor as drawn in the GAMBIT software is shown in the fig 6.1. The various dimensions of the carburetor are mentioned below.

Total length of carburetor = 122 mm

Inlet diameter = 42 mm

Throat diameter = 27 mm

Outlet diameter = 37 mm

Length of throat = 5 mm

Length of the inlet part = 51mm

Length of the outlet part = 51 mm

Nozzle inlet diameter = 2 mm

Angle of fuel discharge nozzle with the vertical axis of carburetor = ϴ

Fig 6.1 The simple carburetor

6.2 Procedure

CFD stands for computational fluid dynamics. In this project a simple carburetor as shown in fig 6.1 was taken and its various dimensions were measured. Then according to the measured dimensions a meshed structure of the carburetor was drawn with the help of GAMBIT software. Then the meshed structure was exported as the .mesh file and was analyzed with proper boundary conditions using the software FLUENT and the results of this analysis were studied.

There are so many parameters to vary but in this case only the effect of the variation of the fuel discharge nozzle angle on the flow across the carburetor is studied.

The analysis was done for $\Theta = 30^0, 35^0, 40^0, 45^0$ where Θ is the angle between the axis of the fuel discharge nozzle and the vertical axis of the body of the carburetor.

Another analysis was done to calculate the throat pressure for different angles of the throttle plate.

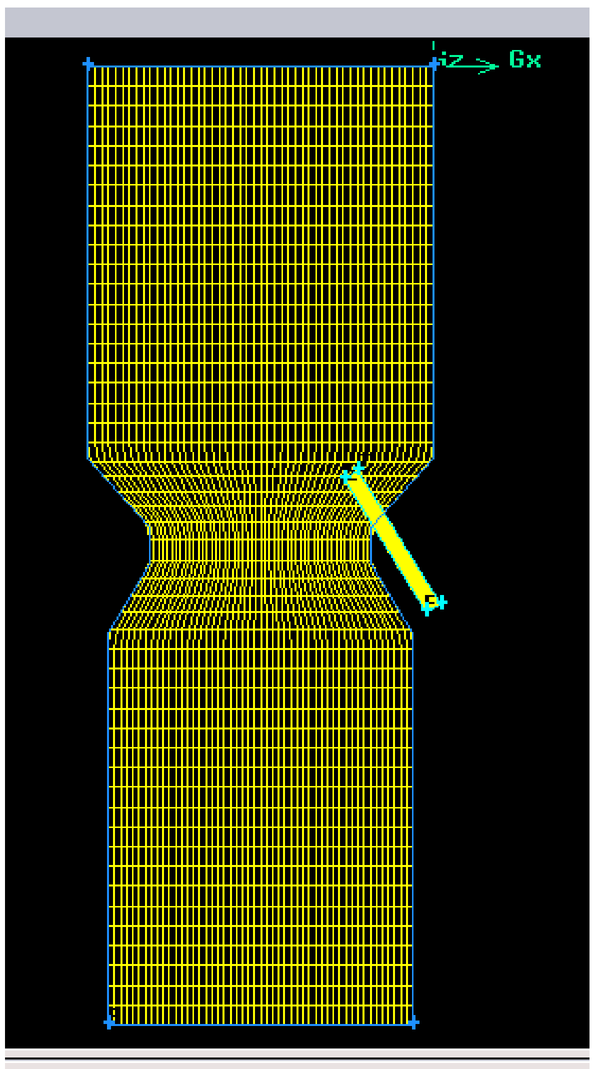
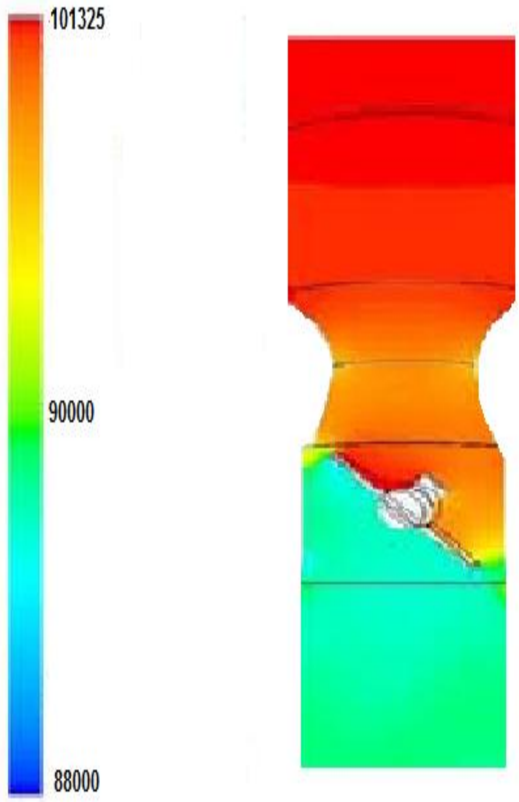


Fig 6.2 The model carburetor

6.3 Results and Discussions

The inlet air was assumed to enter the carburetor at normal temperature and the pressure was taken to be 1 atm. The following are results of the analysis of the carburetor for different angles of the throttle plate.



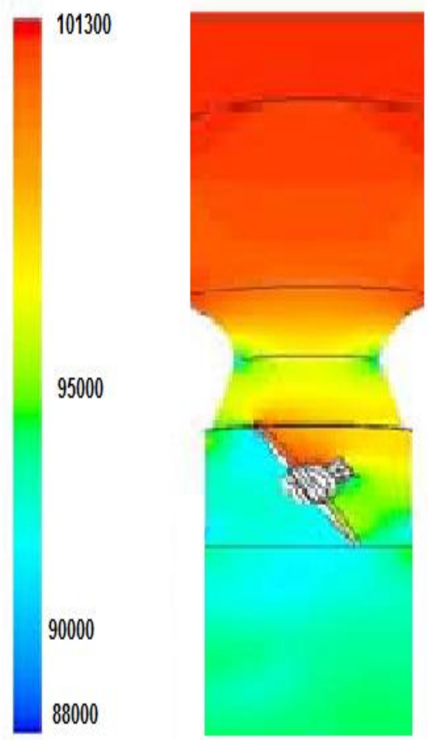


Fig 6.3

Fig 6.4

Fig 6.3 shows the statics pressure view for 45^0 throttle plate angle and fig 6.4 shows the static pressure view for 60^0 throttle plate angle.

From fig 6.3 it is clear that when the throttle plate is 45^0 open, there is less amount of air flow through the inlet valve and hence the mixture is somewhat richer than the other cases. In this case the pressure at the throat of the venturi is around 93000 Pascal.

In fig 6.4, when the throttle plate is 60^0 open, the mixture is slightly leaner than in case of 45^0 opened throttle plate condition. In this case the pressure at the throat of the venturi is found to be around 91000 Pascal.

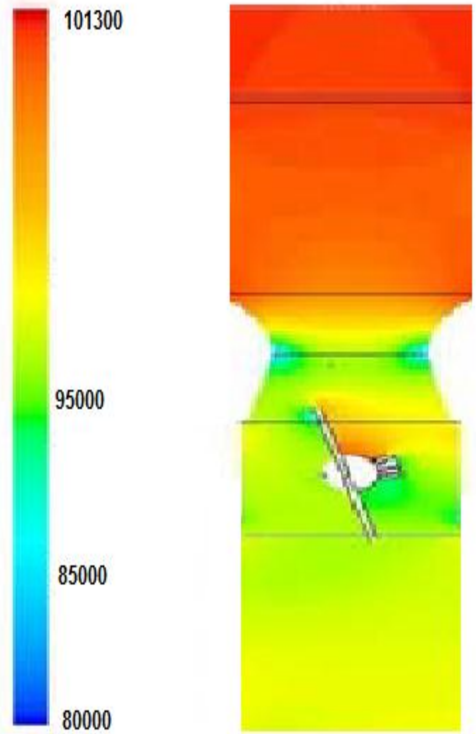


Fig 6.5

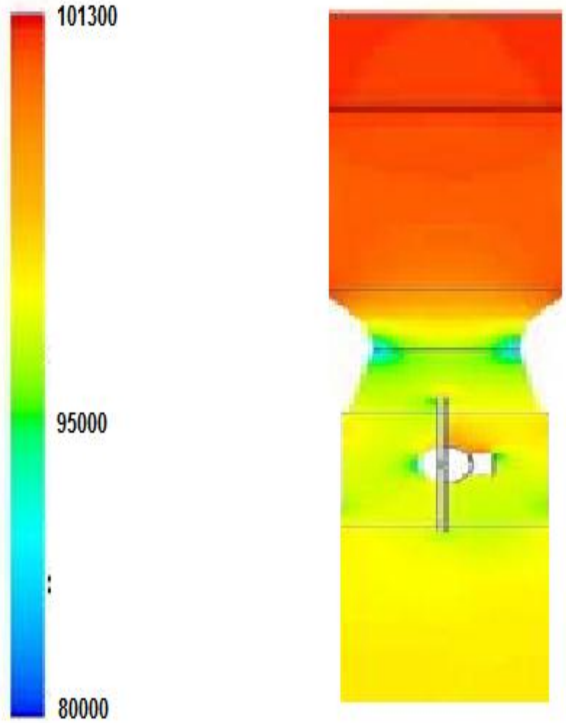


Fig 6.6

Fig 6.5 shows the static pressure view for 75^0 throttle plate angle and fig 6.6 shows the static pressure view for 90^0 throttle plate condition.

From fig 6.5, when the throttle plate is 75^0 open, there is be more amount of air flow through the inlet of the carburetor. So the mixture will be leaner. In this case the pressure at the throat is found to be 87000 Pascal.

From fig 6.6, when the throttle plate is 90^0 open, there will be maximum amount of air flow through the inlet of the carburetor but the fuel flow remains same so the mixture will be leaned in this case. In this case the pressure at the throat is found to be 85000 Pascal.

From the analysis done the throat pressure was found to be 90000 Pascal. Then by taking the previous boundary conditions and the throat pressure as 90000 Pascal, the flow of fuel through the fuel discharge nozzle as 10 m/s.

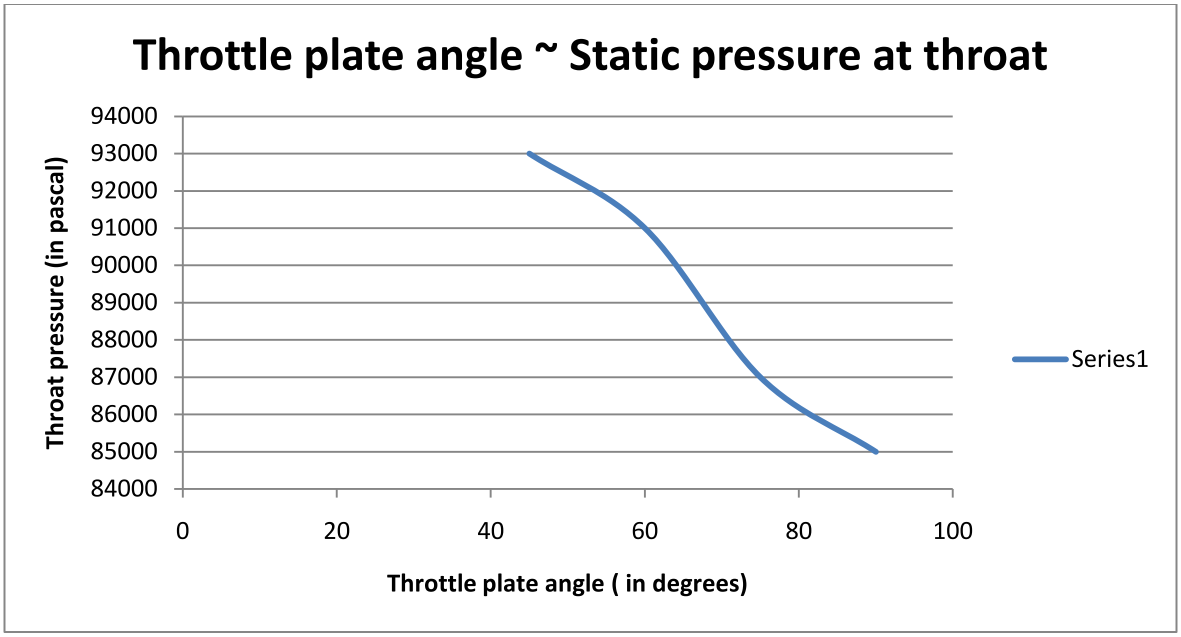


Fig 6.7 Graph showing variation of throat pressure with throttle plate opening

Density of gasoline = ρ = 737 kg/m^3

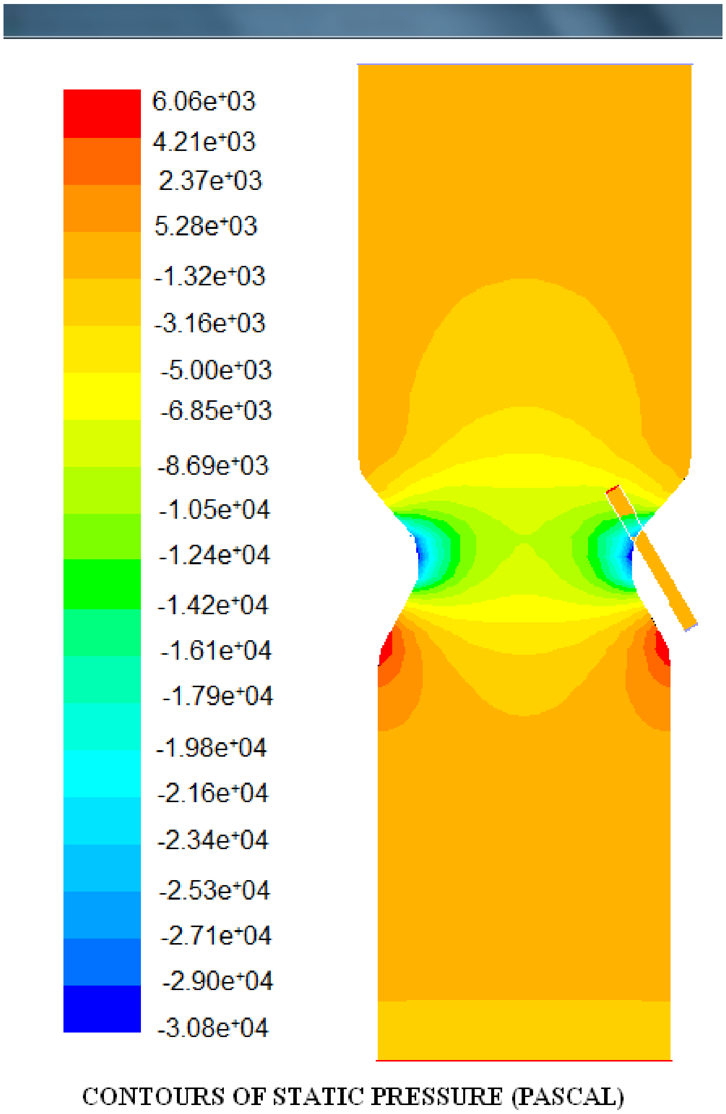
Acceleration due to gravity = g = 9.8 m/s^2

Difference between the height of tip of fuel discharge nozzle and the float chamber = h= 8mm

So the pressure at the inlet of fuel discharge nozzle = P = ρgh = 737 * 9.8*(.008)

= 147780.8 Pascal

The following pictures show the results obtained from the analysis of the carburetor with help of FLUENT.



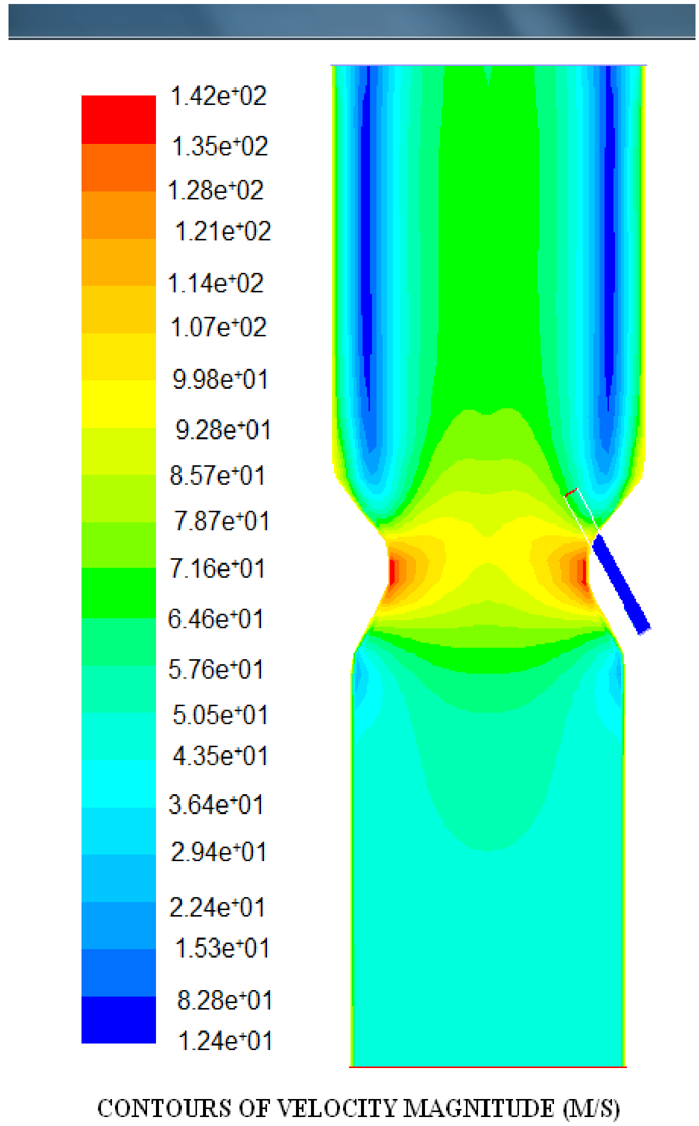
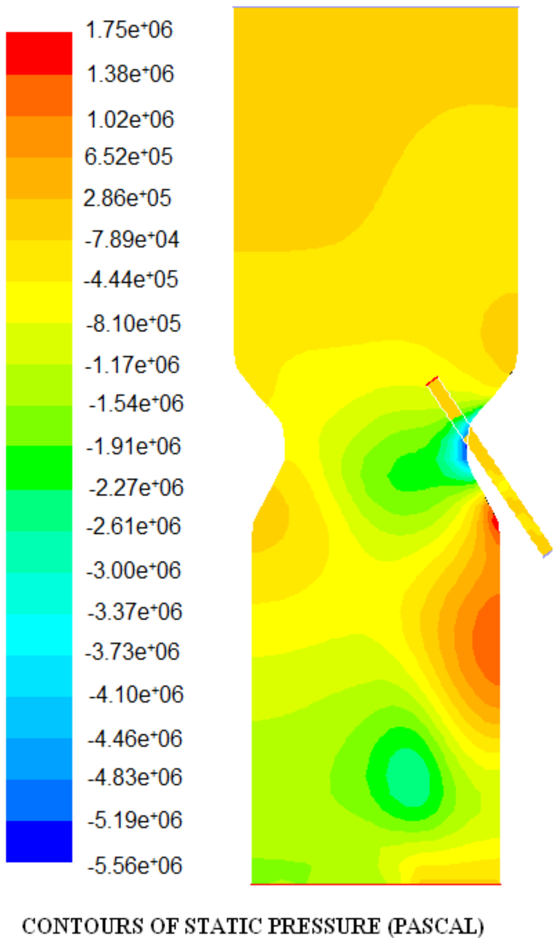


Fig 6.8

Fig 6.9

Fig 6.8 shows the static pressure contour for fuel discharge nozzle angle of 30^0 and Fig6.9 shows the velocity contour for fuel discharge nozzle angle of 30^0. It is clear from both the figures that the velocity is maximum at the throat of the venturi as shown in fig 6.9 whereas the pressure is the minimum at the venturi of the carburetor as shown in fig 6.8. Fig 6.8 shows a uniform distribution of pressure and fig 6.9 shows that the velocity also uniformly increases from the inlet of the carburetor towards the throat. Since there is uniform distribution of pressure throughout the body of the carburetor, in this case the fuel will be easily atomized and will also be properly vaporized.



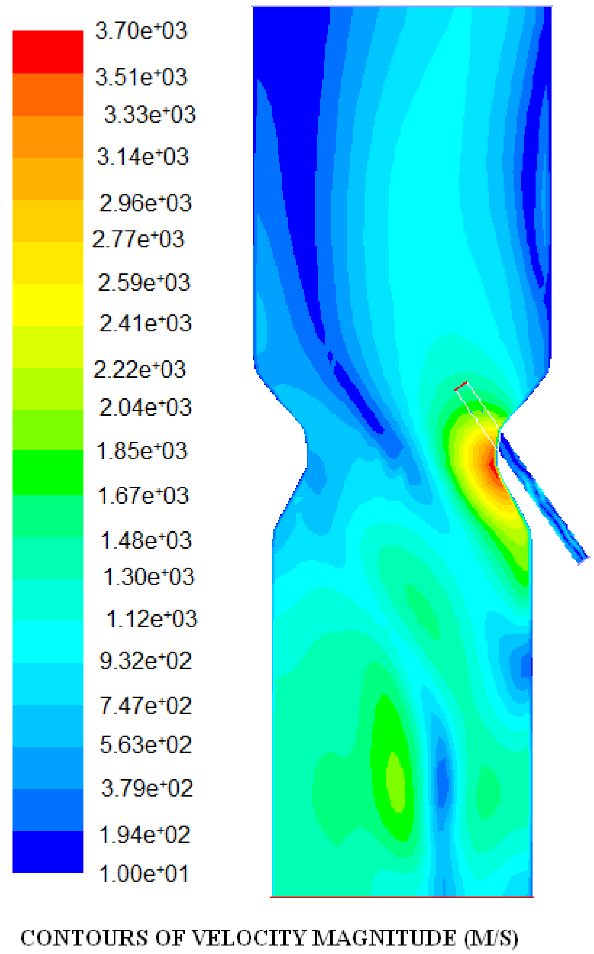
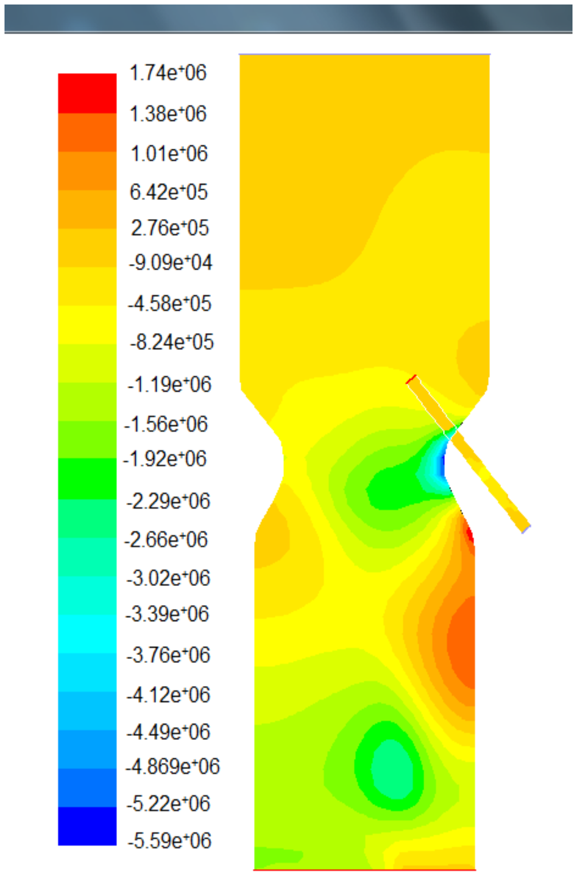
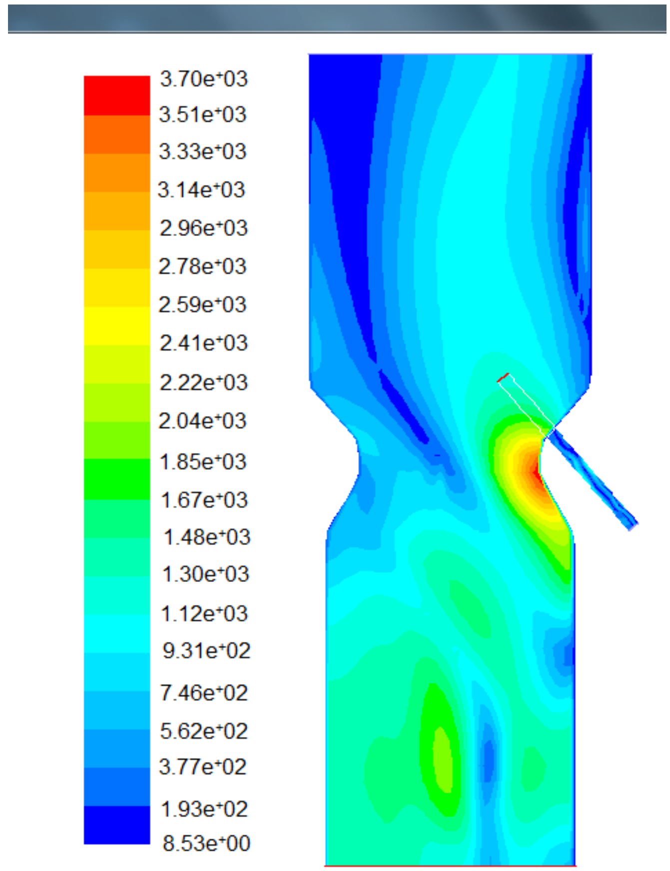


Fig6.10 6.11

Fig 6.10 shows the static pressure contour for fuel discharge nozzle angle of 35^0 and Fig6.11 shows the velocity contour for fuel discharge nozzle angle of 35^0. It is clear from both the figures that the velocity is maximum at the throat of the venturi as shown in fig 6.10 whereas the pressure is the minimum at the venturi of the carburetor as shown in fig 6.11. Fig 6.10 shows that the pressure is not distributed uniformly throughout the body of the carburetor and the distribution is also same in case of velocity as shown in fig 6.11. So, there will not be proper atomization and vaporization of fuel inside the body of the carburetor.



CONTOURS OF STATIC PRESSURE (PASCAL)



CONTOURS OF VELOCITY MAGNITUDE (M/S)

Fig 6.12

Fig 6.13

Fig 6.12 shows the static pressure contour for fuel discharge nozzle angle of 40^0 and Fig6.13 shows the velocity contour for fuel discharge nozzle angle of 40^0. It is clear from both the figures that the velocity is maximum at the throat of the venturi as shown in fig 6.12 whereas the pressure is the minimum at the venturi of the carburetor as shown in fig 6.13. Fig 6.12 shows that the pressure is not distributed uniformly throughout the body of the carburetor and the distribution is also same in case of velocity as shown in fig 6.13. So, there will not be proper atomization and vaporization of fuel inside the body of the carburetor.

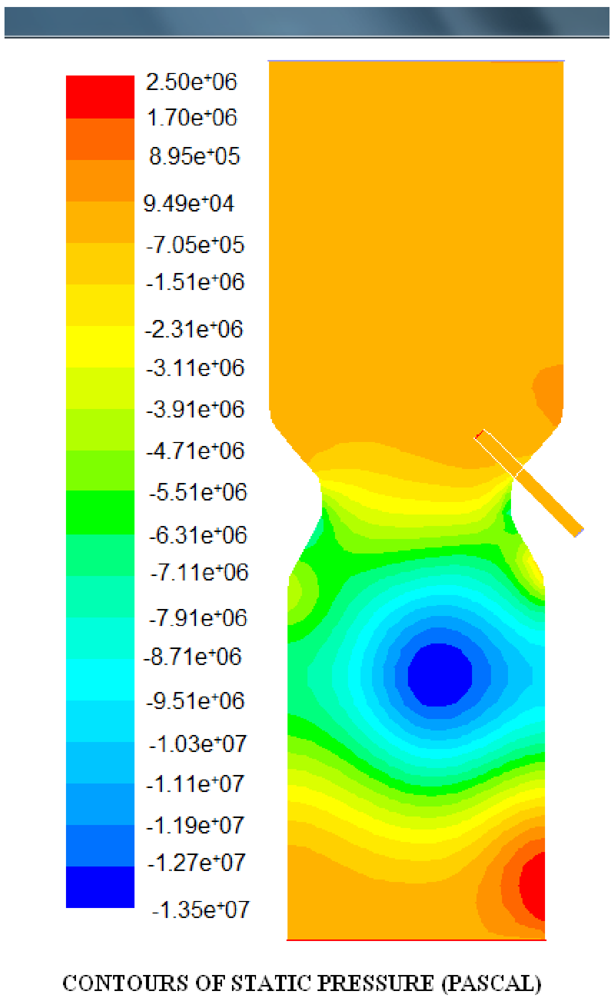


Fig 6.14

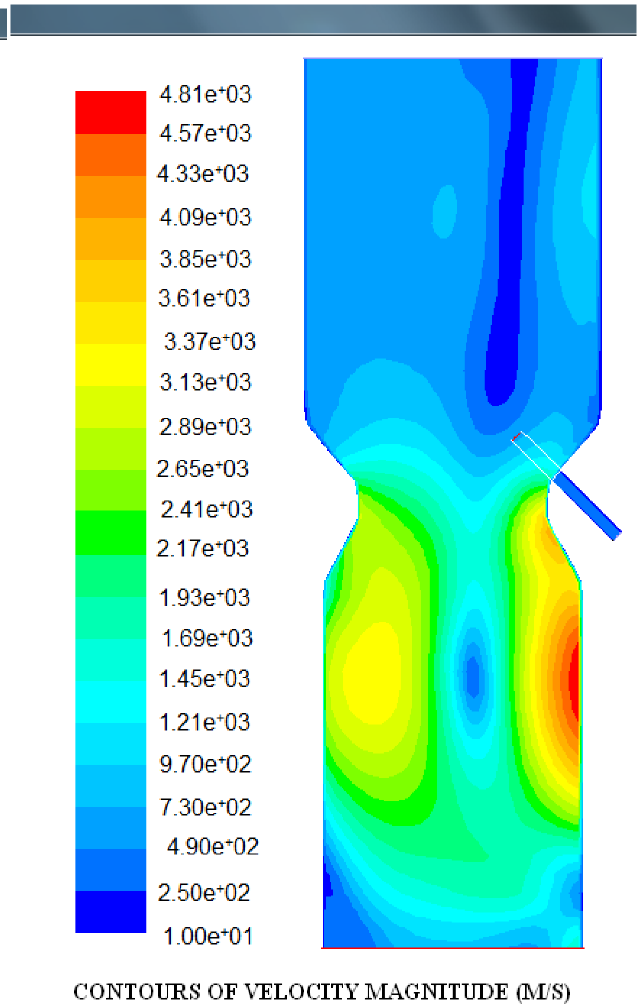


Fig 6.15

Fig 6.14 shows the static pressure contour for fuel discharge nozzle angle of 45^0 and Fig6.15 shows the velocity contour for fuel discharge nozzle angle of 45^0. It is clear from both the figures that the velocity is maximum at the throat of the venturi as shown in fig 6.14 whereas the pressure is the minimum at the venturi of the carburetor as shown in fig 6.15. Fig 6.14 shows that the pressure is not distributed uniformly throughout the body of the carburetor and the distribution is also same in case of velocity as shown in fig 6.15. So, there will not be proper atomization and vaporization of fuel inside the body of the carburetor.

6.4 Conclusion

From the above analysis the conclusions obtained are

1. When the flow inside the carburetor was analyzed for different angles of throttle plate opening, it was found that the pressure at the throat of the venturi decreased with the increase in opening of the throttle plate. Because when the throttle plate opening increases then the flow of air through the carburetor increases but the fuel flow remains constant. So the mixture becomes leaner. But as obtained from the analysis above the pressure at the throat the throat also decreases with increase in opening of the throttle plate so the flow of fuel from the float chamber into the throat increases and hence the quality of the mixture tends to remain constant.
2. When analyzed for fuel discharge nozzle angle of 30^0, it was observed that the pressure distribution inside the body of the carburetor is quite uniform which leads to a better atomization and vaporization of the fuel inside the carburetor body. But in other cases like where the fuel discharge nozzle angle was 35^0, 40^0 or 45^0, the pressure distribution is quite non-uniform inside the body of the carburetor. So it is concluded that for gasoline operated engine the optimum fuel discharge nozzle angle is 30^0.

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