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CFD Analysis Of Simple Carburetor For Different Positions Of Modified Aerodynamic Shape Throttle Valve And Fuel Nozzle Valve

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Abstract — *Carburetor plays a crucial role in SI engine performance which supplies correct mixture of fuel air at the right time. One of the important factors that affect the fuel consumption is the design of the carburetor. The throat of the carburetor provides required pressure drop in the venturi tube of the carburetor device. Currently, alternative fuels like LPG, CNG, etc. are gaining attention all over the world because of their ecofriendly nature. So the design of the carburetor is important. To get a better economy and uniform distribution of fuel air mixture, it required to design the carburetor with an effective analytical tool or software. In this work, CFD (Ansys) analysis was carried out on a simple carburetor to find pressure drop and velocity profile for different throttle valve angle and fuel discharge nozzle angle. The results obtained from the analysis are analyzed for optimum design of a carburetor.*

Keywords- *Carburetor ,throttle valve, computational fluid dynamics, Fuel Nozzle, Throttle valve*

I. INTRODUCTION

All carburetors work on the Bernoulli's Principle which states that the velocity of a fluid increases, when the pressure drops. Within a certain range of velocity and pressure, the velocity increases with the drop in pressure. However, this linear relationship only holds within a certain range. Carburetor has to accelerate from rest, to some speed. It depends upon the air flow demanded by the engine speed and the throttle butterfly valve setting. According to Bernoulli theorem, air flowing through the throat of the carburetor will be at a pressure less than atmospheric pressure, and related to the velocity.

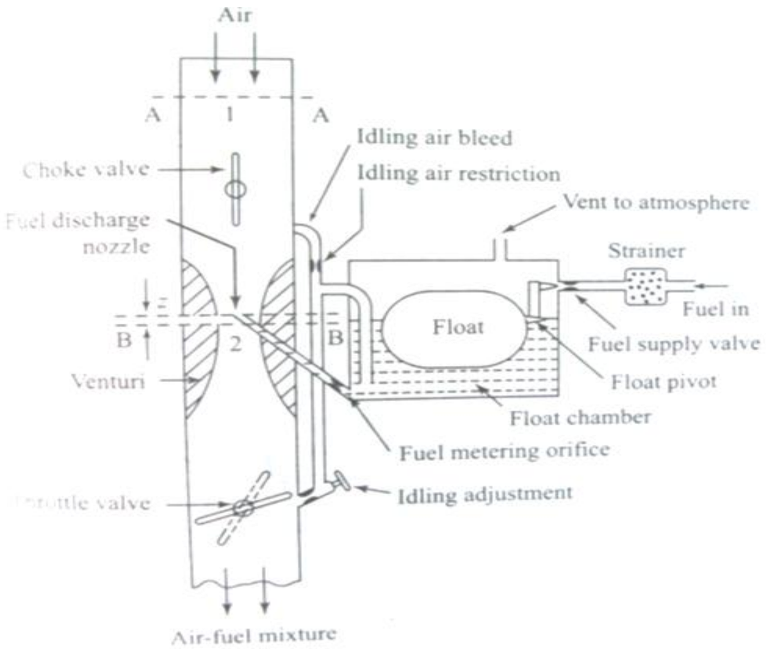

Fig.1 : The Simple Carburetor

II. LITERATURE REVIEWS

Shashwat Sharma, Prateek Jain[1] Investigate that When analyzed for fuel discharge nozzle angle of 30^0,it was observed that the pressure distribution inside the body of the carburettor is quite uniform which leads to a better Atomization and vaporization of the fuel inside the carburettor body. But in other cases like where the fuel discharge nozzle angle was 35^0 or 40^0, the pressure distribution is quite non-uniform inside the body of the carburettor. So it is concluded that for gasoline operated engine the optimum fuel discharge nozzle angle is 30^0. Rangu P, Ganesha T, M.C.Math[2] Investigate that In nozzle angles at 36^0, and 39^0, it was observed that the pressure and velocity distribution became more non-uniform. At fuel discharge nozzle angle of 33^0, it is observed that the pressure and velocity distribution is uniform which leadsto a better atomization and vaporization of the fuel inside the body of the carburetor. So, it can be concluded that optimum fuel discharge nozzle angle must be kept at 33^0. Kriti Gupta[3] Investigate that the hexagonal cross-section is the most optimal for throttle shaft, among all other analysed shapes. The hexagonal cross-section allows the most efficient flow of air with minimal velocity drop between the inlet and outlet. Also, the wake region is less for this configuration and hence, the air flow is better. Thus, valve shafts with hexagonal cross-section can be advantageously employed for use in throttle bodies of automobile engines. Nik Rosli Abdullah, Nafis Syabil Shahruddina[4] At high intake pressure, the fuel consumption is lower compared to the with lower intake pressure.

III. RESEARCH GAP

There has been plenty of research done on analysis of different positions of throttle valve and fuel discharge nozzle angles of simple carburetor. There has been also more work carried out of air intake pressure and fluid flow analysis through carburetor body to improve function and design of carburetor .Less work has been found in literature regarding the application of aerodynamic shaped throttle valve in the simple carburetor of Spark Ignition engine and its effects i.e. pressure changes and velocity of intake air and fuel mixture in throttle body of carburetor using CFD analysis.

IV. CARBURETOR MODEL

4.1Specification of Model Carburetor

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 = 38 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

Properties of air

Property	Value
Density	1.225 kg/m3
Specific Heat (Cp)	1006.43 J/kg-K
Viscosity	1.7894e-05 kg/m-s

Table 1 : Properties of Air

Boundary Conditions

At inlet

Velocity	40 m/s
Turbulent Intensity	3.7 %
Hydraulic Diameter	38mm
Temperature	294 K

At outlet

Absolute Pressure	100596.57 Pascal
Turbulent Intensity	3.7 %
Hydraulic Diameter	38 mm
Temperature	294 K

Table 2 : Boundary Conditions

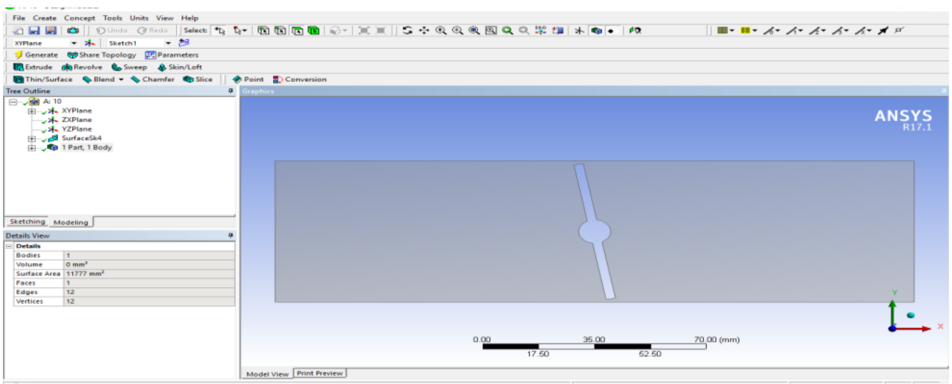

Fig 2 : Geometry of carburetor model

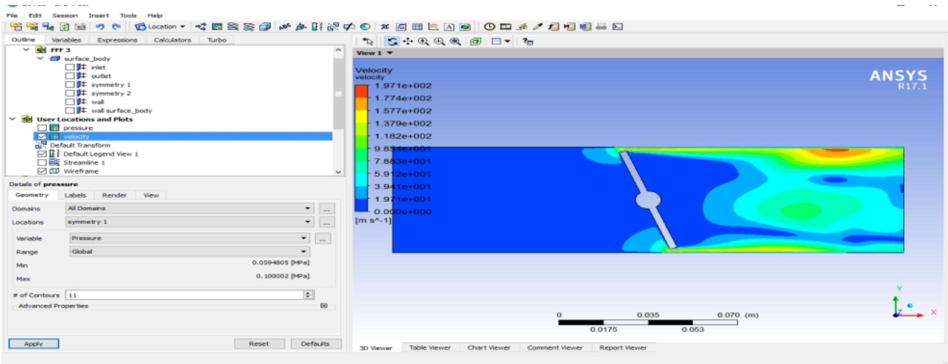

Fig. 3 : Pressure Contour at 20^0 Angle of Throttle Valve

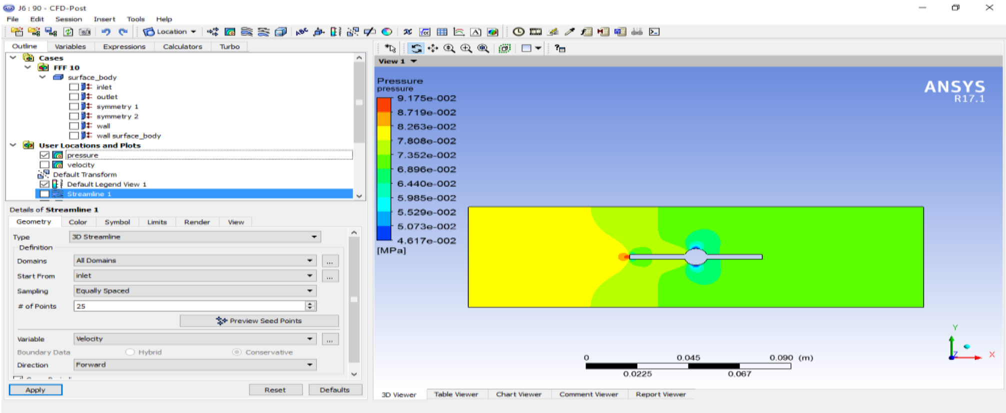

Fig. 4 : Pressure Contour at 90^0 Angle of Throttle Valve

V. METHODOLOGY

5.1 Tool to be use to increase the performance of Carburettor

The NACA airfoil series

The early NACA airfoil series, the 4-digit, 5-digit, and modified 4-/5-digit, were generated using analytical equations that describe the camber (curvature) of the mean-line of the airfoil section as well as the section's thickness distribution along the length of the airfoil. Later families, including the 6-Series, are more complicated shapes derived using theoretical rather than geometrical methods. Before the National Advisory Committee for Aeronautics (NACA) developed these series, airfoil design was rather arbitrary with nothing to guide the designer except past experience with known shapes and experimentation with modifications to those shapes. This methodology began to change in the early 1930s with the publishing of a NACA report entitled The Characteristics of 78 Related Airfoil Sections from Tests in the Variable Density Wind Tunnel.As airfoil design became more sophisticated, this basic approach was modified to include additional variables, but these two basic geometrical values remained at the heart of all NACA airfoil series.

NACA Four-Digit Series:The first family of airfoils designed using this approach became known as the NACA Four-Digit Series. The first digit specifies the maximum camber (m) in percentage of the chord (airfoil length), the second indicates the position of the maximum camber (p) in tenths of chord, and the last two numbers provide the maximum thickness (t) of the airfoil in percentage of chord. For example, the NACA 2415 airfoil has a maximum thickness of 15% with a camber of 2% located 40% back from the airfoil leading edge (or 0.4c). Utilizing these m, p, and t values, we can compute the coordinates for an entire airfoil using the following relationships:

1. Pick values of x from 0 to the maximum chord c.
2. Compute the mean camber line coordinates by plugging the values of m and p into the following equations for each of the x coordinates.

$$y_c = \frac{m}{p^2}(2px - x^2) \qquad \text{from } x = 0 \text{ to } x = p$$

$$y_c = \frac{m}{(1-p)^2}[(1-2p) + 2px - x^2] \qquad \text{form } x = p \text{ to } x = c$$

where

x = coordinates along the length of the airfoil, from 0 to c (which stands for chord, or length)

y = coordinates above and below the line extending along the length of the airfoil, these are either y_t for thickness coordinates or y_c for camber coordinates

t = maximum airfoil thickness in tenths of chord (i.e. a 15% thick airfoil would be 0.15)

m = maximum camber in tenths of the chord

p =position of the maximum camber along the chord in tenths of chord.

3. Calculate the thickness distribution above (+) and below (-) the mean line by plugging the

value of t into the following equation for each of the x coordinates.

$$\pm y_t = \frac{t}{0.2}\left(0.2969\sqrt{x} - 0.1260x - 0.3516x^2 + 0.2843x^3 - 0.1015x^4\right)$$

4. Determine the final coordinates for the airfoil upper surface (x_U, y_U) and lower surface (x_L, y_L) using the following relationships

$$x_U = x - y_t \sin\theta$$
$$y_U = y_c + y_t \cos\theta$$
$$x_L = x + y_t \sin\theta$$
$$y_L = y_c - y_t \cos\theta \quad \text{where } \theta = \arctan\left(\frac{dy_c}{dx}\right)$$

5.2 New shape of throttle valve

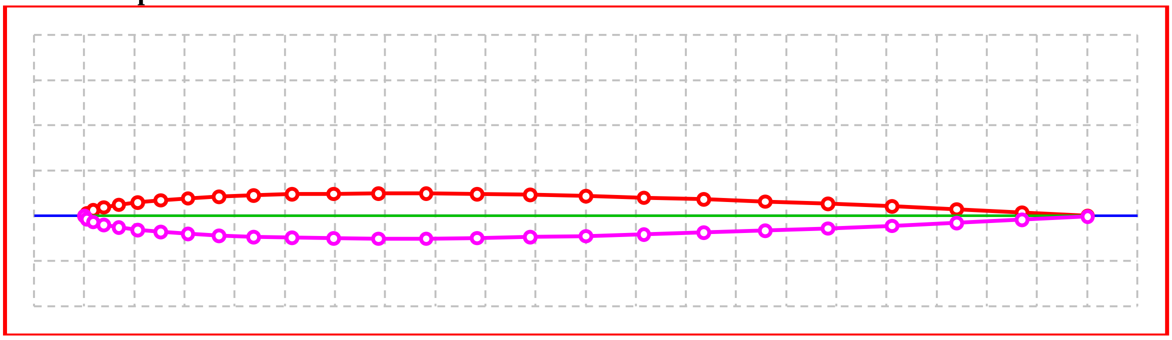

Fig. 5 : New shape of throttle valve

		NACA four-digit airfoil profile
	0%	**m**; Maximum chamber, relative to chord
	5	**p**; Position *(tenths)* of maximum chamber
	5%	**t**; Thickness, relative to chord
	25	Data points; each surface *(upper & lower)*

	x	y(t)	y(c)	x(U)	y(U)	x(L)	y(L)
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00214	0.00337	0.00000	0.00214	0.00337	0.00214	-0.00337
3	0.00856	0.00659	0.00000	0.00856	0.00659	0.00856	-0.00659
4	0.01921	0.00965	0.00000	0.01921	0.00965	0.01921	-0.00965
5	0.03407	0.01253	0.00000	0.03407	0.01253	0.03407	-0.01253
6	0.05307	0.01519	0.00000	0.05307	0.01519	0.05307	-0.01519
7	0.07612	0.01760	0.00000	0.07612	0.01760	0.07612	-0.01760
8	0.10313	0.01973	0.00000	0.10313	0.01973	0.10313	-0.01973
9	0.13397	0.02153	0.00000	0.13397	0.02153	0.13397	-0.02153
10	0.16853	0.02299	0.00000	0.16853	0.02299	0.16853	-0.02299
11	0.20665	0.02406	0.00000	0.20665	0.02406	0.20665	-0.02406
12	0.24816	0.02474	0.00000	0.24816	0.02474	0.24816	-0.02474
13	0.29289	0.02500	0.00000	0.29289	0.02500	0.29289	-0.02500
14	0.34065	0.02486	0.00000	0.34065	0.02486	0.34065	-0.02486
15	0.39124	0.02431	0.00000	0.39124	0.02431	0.39124	-0.02431
16	0.44443	0.02337	0.00000	0.44443	0.02337	0.44443	-0.02337
17	0.50000	0.02206	0.00000	0.50000	0.02206	0.50000	-0.02206
18	0.55771	0.02040	0.00000	0.55771	0.02040	0.55771	-0.02040
19	0.61732	0.01841	0.00000	0.61732	0.01841	0.61732	-0.01841
20	0.67856	0.01612	0.00000	0.67856	0.01612	0.67856	-0.01612
21	0.74118	0.01355	0.00000	0.74118	0.01355	0.74118	-0.01355
22	0.80491	0.01070	0.00000	0.80491	0.01070	0.80491	-0.01070
23	0.86947	0.00759	0.00000	0.86947	0.00759	0.86947	-0.00759
24	0.93460	0.00420	0.00000	0.93460	0.00420	0.93460	-0.00420
25	1.00000	0.00052	0.00000	1.00000	0.00052	1.00000	-0.00052

Table 3 : Coordinates of throttle valve profile

5.3 Optimization of throttle plate

During the preliminary design phase, numerical optimization starts with an existing design, and the goal is to redesign and improve performance by using numerical optimization.

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

Import Part in Ansys software

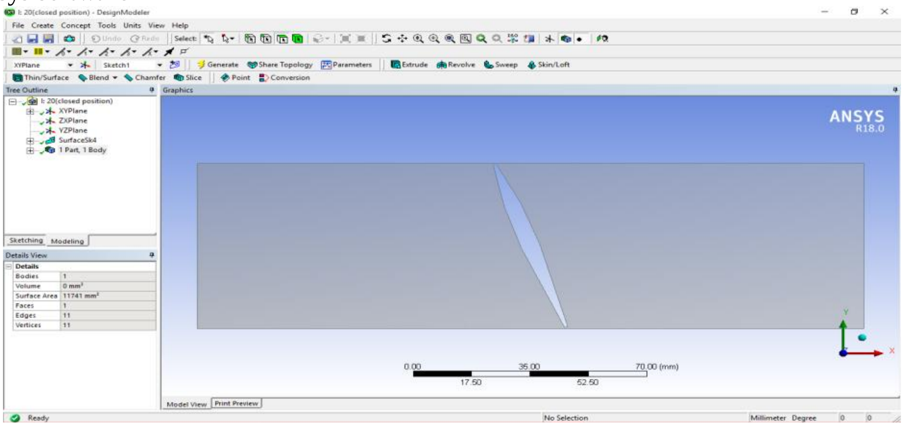

Fig. 6 : Close condition of aerodynamic shape of throttle valve

4.4 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.

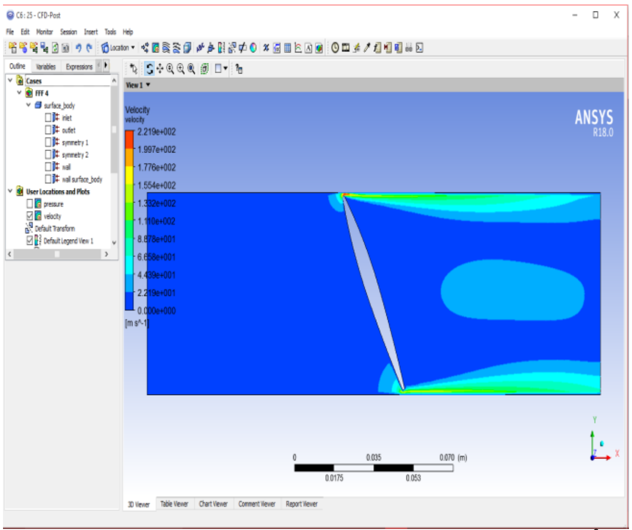

Fig.7: Pressure Distribution in throttle angel 25°

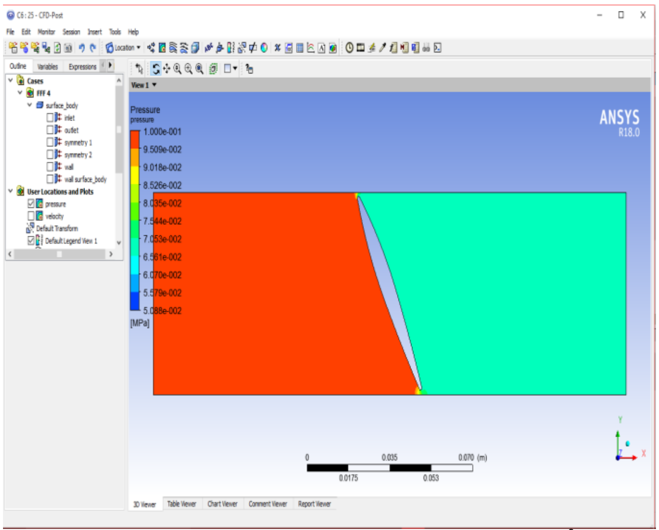

Fig. 8: Velocity Distribution in throttle angel 25°

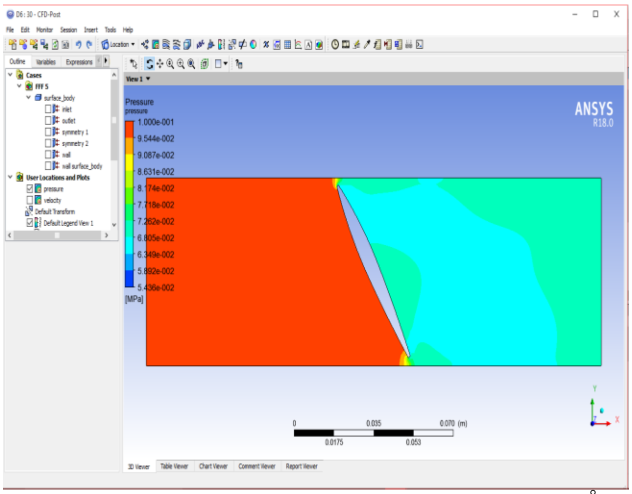

Fig. 9: Pressure Distribution in throttle angel 30°

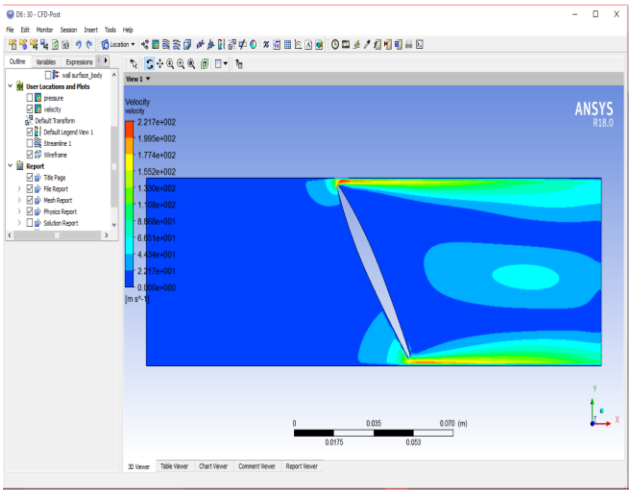

Fig. 10: Velocity Distribution in throttle angel 30°

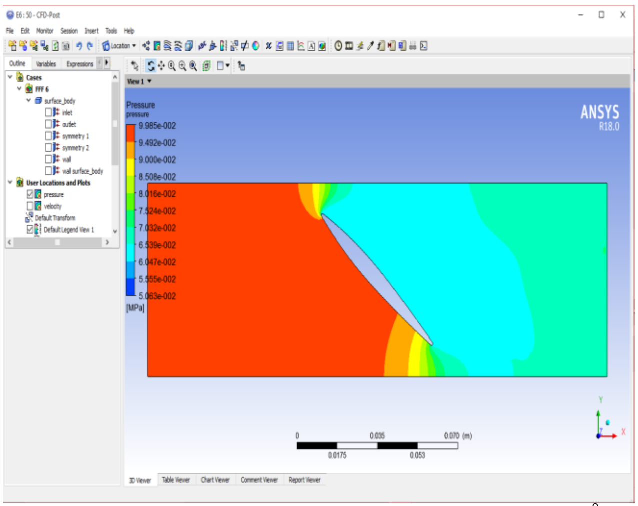

Fig. 11: Pressure Distribution in throttle angel 50°

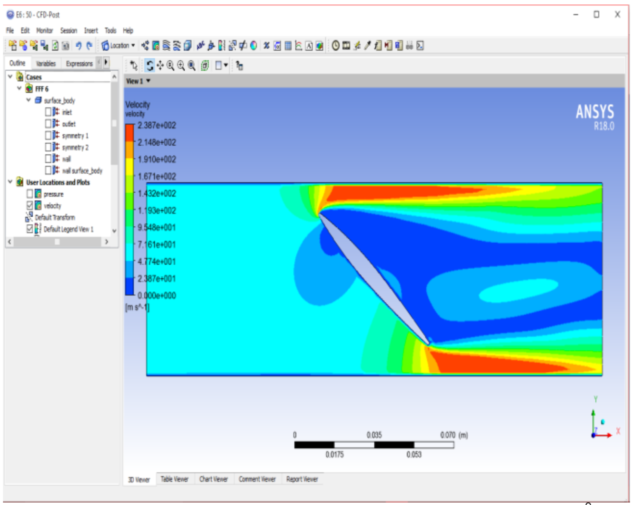

Fig. 12: Velocity Distribution in throttle angel 50°

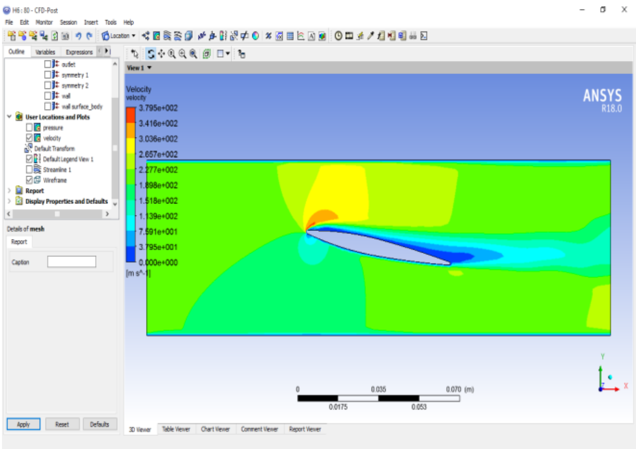

Fig. 13: Pressure Distribution in throttle angel 80°

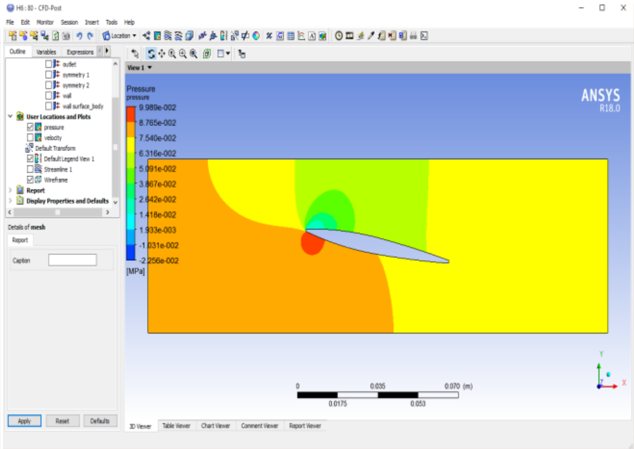

Fig. 14: Velocity Distribution in throttle angel 80°

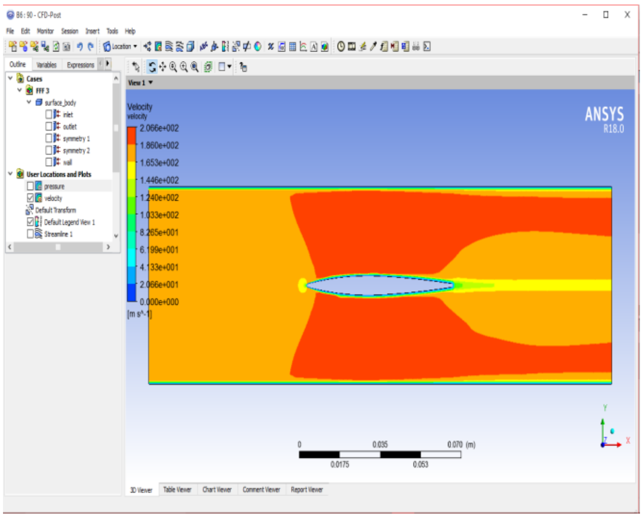

Fig. 14 : Pressure Distribution in throttle angel 90°

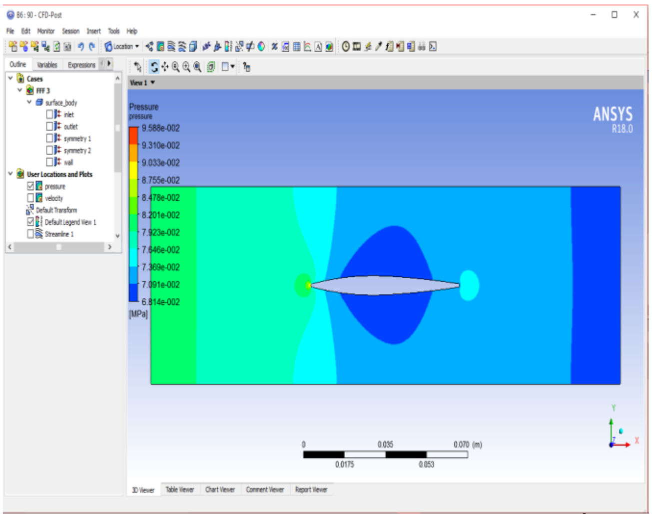

Fig. 14: Velocity Distribution in throttle angel 90°

VI CONCLUSION

When the flow inside the Carburator was analyzed for different angles, it was found that the pressure decreased with the increase in opening of the throttle plate. Because when the throttle plate opening increases then the flow of air through the venture increases. 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 air from the float chamber into the throat increases.

The pressure at the throat of the venturi when the throttle valve is30º, 40º, 50º, 60º, 70º, 80º and 90º respectively. The pressure at the throat section has decreased gradually with the increase in the throttle valve angle. It is minimum (3.867 X 10^2 Mpa) at 80º and maximum (7.718 X 10^2 Mpa) at 30º throttle valve position. With the increase in the throttle valve angle from 30º to 90º, the air velocity has increased, consequently the pressure at the throat section has decreased. This has a greater effect on the mixture strength. With the increase in pressure drop at the throat section, amount fuel entering into the throat section increases and makes the mixture progressively rich.

The Velocity streamline is uniform in aerodynamic shape by Comparing to existing flate plate throttle valve to aerodynamic throttle valve design , mixing of air fuel is also uniform, reduced unborn fuel ratio and increase the efficiency of carburator .

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