Design and Optimization of Venturi of Carburettor Using CAE Software

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Abstract- *The carburettor is one of the parts of internal combustion engine in an automobile. It is a device for mixing vaporized fuel with air to produce a combustible or explosive mixture, as for an internal-combustion driving force. Venturi plays very Important Role in a different field of engineering. Venturi has some industrial applications in which its design is a major factor. One of the important factors that affect the fuel consumption is that design of venturi of the carburettor. The venturi of the carburettor is critical that provides a necessary pressure drop in the carburettor device.*

Pressure drop in carburettor depends on the angle of venturi. The main aim of the project is to determine the optimum pressure of carburettor by optimizing the angle of venturi. To optimize the pressure in the carburettor, CFD analysis is carried out on venturi of the carburettor. In CFD analysis, parameters like velocity, pressure drop and angle of venture are determined.

Optimum pressure observed in CFD analysis is used as a static load for static structural analysis. The carburettor is optimized for different materials (i.e., zinc, aluminium and cast iron).3d model of Carburettor is designed in CAD software and flow analysis is done using CFD software, and static analysis is carried out by using CAE software. NX-CAD software is used for 3d modelling, and ANSYS software is used for flow and static analysis of carburettor.

I. INTRODUCTION

A carburettor is a device that blends air and fuel for an internal combustion engine.

The carburettor works on Bernoulli's principle. The faster air moves, 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 mobilises the carburettor 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.

When carburetors are used in aircraft with piston engines, special designs and features are needed to prevent fuel famine during inverted flight. Later engines utilised in the early form of fuel injection known as a pressure carburettor.
Carburetion:

The process of preparing a combustible fuel-air mixture outside engine cylinder in the engine is known as carburetion.

Important factors which affect the process of carburetion are given below:

- Time available for the mixture preparation, i.e. atomization, mixing and the vaporization
- Temperature of the incoming air
- Quality of the fuel supply
- Design of combustion chamber and induction system

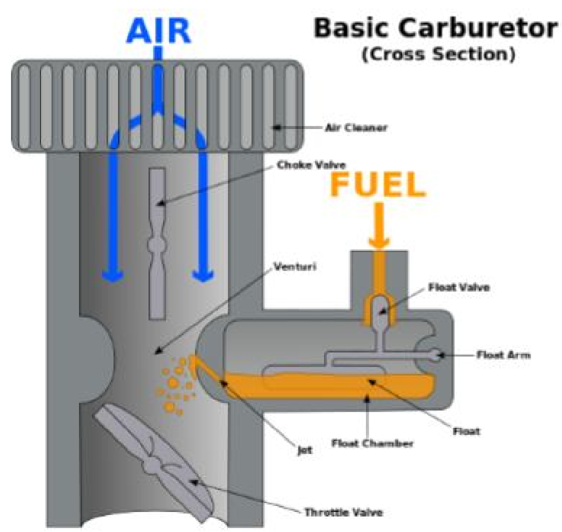

Figure 1. shows a cross-section of basic carburetor.

II. LITERATURE SURVEY

1. CFD Analysis of Flow through Venturi by Jay Kumar, Jaspreet Singh, Harsh Kansal, Gursimran Singh Narula, Prabhjot Singh. Venturi plays very Important Role in a different field of engineering. Venturi has some industrial applications in which its design is a major factor. One of

the major factors that affect the fuel consumption is that design of venture of the carburettor. The venturi of the carburettor is critical that provides a necessary pressure drop in the carburettor device. There is a need to design the Venturi with an effective analytical tool or software. In this work, there are three parameters namely pressure drop and Velocity discharge nozzle angle of the Venturi will be analysed using computational fluid dynamics. For this analysis, CFD will be done using two software's namely GAMBIT and FLUENT. The results obtained from the software's will be analysed for optimum design of a venturi.

2. CFD analysis of flow through Venturi of a carburettor by Deepak RanjanBhola.Modern passenger vehicles with gasoline engines are provided with different compensating devices for fuel air mixture supply. Even then there is huge fuel consumption because of many factors. One of the major factors that affect the fuel consumption is that design of carburettor. The venturi of the carburettor is critical that provides a necessary pressure drop in the carburettor device. Since different SI engine alternative fuels such as LPG, CNG is used in the present day vehicles for the reduction of the fuel consumption and pollution. Still, for a preferable economy and uniform fuel air supply, there is a necessity to design the carburettor with a useful analytical tool or software. In this work there are three parameters namely pressure drop and fuel discharge nozzle angle of the carburettor will be analysed using computational fluid dynamics. For this analysis, CFD will be done using two software's namely GAMBIT and FLUENT. The results obtained from the software's will be analysed for optimum design of a carburettor.

3. A study on Optimization of Flow through Venturi of a Carburettor by Shashwat Sharma, Prateek Jain, Adhar Singh. Modern passenger vehicles with gasoline engines are provided with different compensating devices for fuel air mixture supply. Even then there is a high fuel utilisation because of many factors. One of the important factors that affect the fuel consumption is that design of carburettor. The Venturi of the carburettor is important as it provides a necessary pressure drop in the carburettor device. Since different SI engine uses alternative fuels such as LPG, CNG in the present day for the reduction of the fuel consumption and pollution. Still, for a uniform fuel air supply and better economy, there is a need to design the carburettor with a useful analytical tool or software. In this work there are two parameters namely pressure drop and fuel discharge nozzle angle of the carburettor will be analysed using computational fluid dynamics.CFD analysis of the carburettor has done by solid works and results obtained are used for the optimum design of a carburettor.

III. 3D MODELLING OF CARBURETTOR

The CAD model of the carburettor is shown below

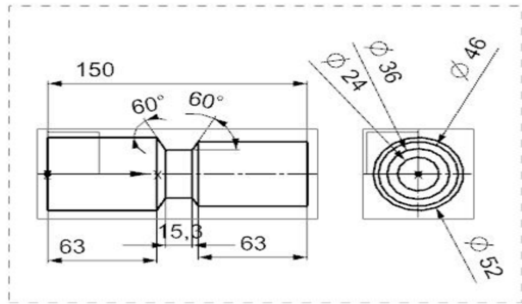

Figure 2. shows drafting of the carburetor.

Isometric view of Carburettor:

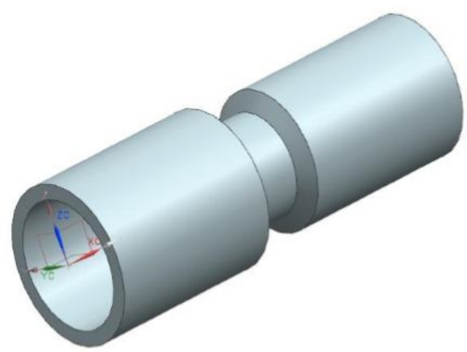

Figure 3. Shows the Isometric view of Carburettor

IV. FLOW ANALYSIS OF CARBURETOR

CFD allows virtual experimentation with and accordingly optimisation of the design parameters such as carburettor design calculations and a wide range of operating boundary conditions. It is very attractive to industry as it saves both effort and during the design process when compared alongside traditional experimental methods. However, the degree of confidence in the results is dependent on many factors and as a result.The air enters into the carburettor at environmental pressure and temperature. So, the environmental pressure of 1 atm is given as input to the inlet of the carburettor.From previous papers, the outlet pressure of carburettor was given as 94500 Pa.

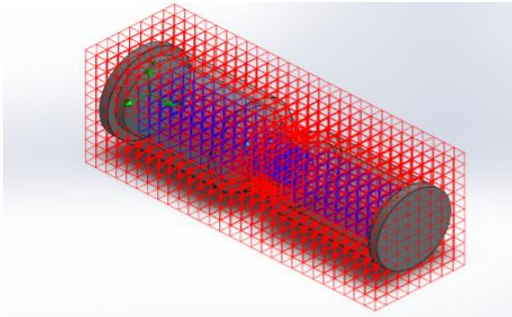

Figure 4.

From the above fig 4.1 blue colour indicates that it is fluid domain and red colour indicates solid domain of carburettor.

Table 1. MATERIAL PROPERTIES

PROPERTY	UNITS	VALUES
Density	kg/m3	1.225
Cp (Specific Heat)	j/kg-k	1006.43
Thermal Conductivity	w/m-k	0.0242
Viscosity	kg/m-s	1.79E-05
Molecular Weight	kg/kg mol	28.966
Thermal Expansion Coefficient	1/k	0
Speed of Sound	m/s	340m/s

Pressure contour:

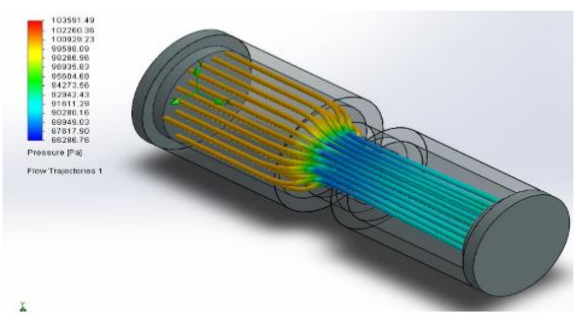

Figure 4. shows the contour of pressure in the carburettor

Velocity contour:

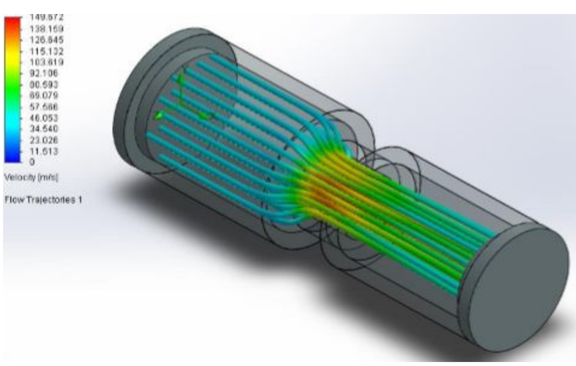

Figure 5. shows the contour of velocity in the carburettor

Table shows pressure and velocity at different locations of carburetor

Table 2. Compression of Pressure and Velocity

Location	Pressure [Pa]	Velocity [m/s]
Convergent	97729.9	68.6
Open of venturi	95048.5	94.8
End of venturi	89478.1	138.3
Divergent	89825.9	133.8

Comparison of pressure and velocity at different locations of carburetor for different angles of

Table 3. comparison of pressure and velocity at different locations of carburetor for different angles of venture

S.NO	LOCATION	VENTURI ANGLE					
		ANGLE 30^0		ANGLE 45^0		ANGLE 60^0	
		Pressure [Pa]	Velocity [m/s]	Pressure [Pa]	Velocity [m/s]	Pressure [Pa]	Velocity [m/s]
1	Convergent	97729.9	68.63	99266.4	53.0	98902.09	60.77971
2	Open of venturi	95048.5	94.88	95684.3	94.4	91577.22	126.5504
3	End of venturi	89478.1	138.3	91841.5	124.4	87947.87	150.9275
4	Divergent	89825.9	133.8	92371.8	120.1	90513.7	137.2439

From above table, the velocity and pressure in the carburettor change concerning the change in the angle of venturi of the carburettor. From the table, it is also concluded that pressure increases with a decrease in velocity. The pressure of carburettor for 600 angles of the venture is less compare to 300 and 450angles of venturi in all the locations of the carburettor. The velocity at all the locations of the carburettor is higher for 600 angles of venturi compare to 300 and 450 angles of venturi. So, the pressure load for static analysis of the carburettor is taken from results of the carburettor with 600 angles of venturi. The maximum pressure observed from results of the carburettor with 600 angles of venturi is 98.90 KPa.

Static analysis is done on carburettor with 600 angles of venturi. The carburettor is studied for a static load of 98.90 KPa. Static analysis is carried out on the carburettor for different materials (i.e. aluminium, zinc and cast iron).

V. FINITE ELEMENT ANALYSIS OF CARBURETOR

3D model of the Carburettorwas developed in UNIGRAPHICS. The model was then converted into a Parasolid to import into ANSYS. A Finite Element model was established with solid elements. The elements that are used for idealising the Carburettorwere described below. A detailed Finite Element model was built with solid elements to idealize all the components of the Carburettor. The static and Modal analysis was carried out to find the natural frequencies. Changes were also implemented to shift the fundamental natural frequency. The elements that are used for idealising the Carburettorare solid 92.The description of each element is given below.

Element Type Used:
Element type: Solid92
No. of nodes: 10
Degrees of freedom: 3 (UX, UY, UZ)
The boundary conditions and loading applied for static analysis are shown below

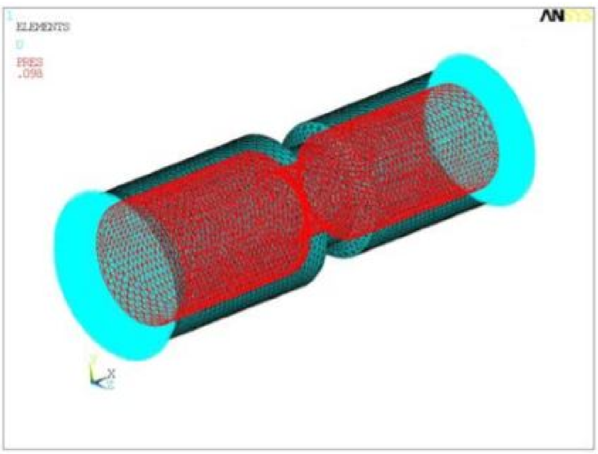

Figure 6. Shows the Boundary conditions applied on Carburettor for static analysis

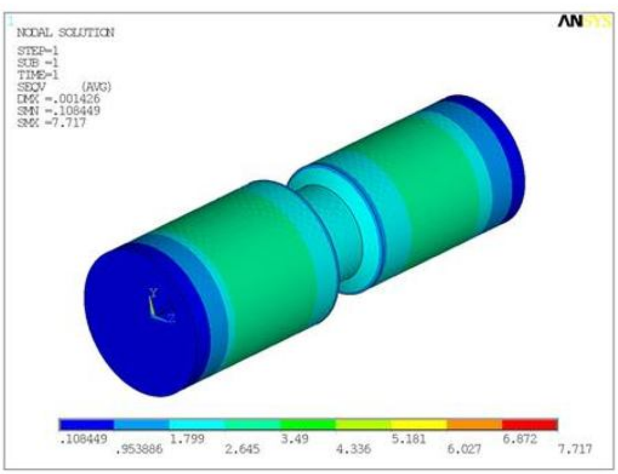

Figure 7. Shows Von Mises stress for static analysis of Carburettor

From the analysis, it is observed that the maximum deformation 0.001mm and Von Mises stress 7.71MPa observed on Carburettor. The yield strength of the material (Aluminium) used for Carburettor is 276 MPa. The FOS at most of the locations is 276/7.71 = 35. According to the Von Mises Stress Theory, the VonMises stress of Carburettor is less than the yield strength of the material. Hence the design of Carburettoris safe for the above operating loading conditions.

Table 4. Comparison of deflections and stresses of carburettor for different materials

S.NO	MATERIALS	DEFLECTION (mm)	STRESSES (Mpa)	FACTOR OF SAFETY
1	Aluminum	0.001	7.71	35
2	Zinc	0.0009	7.74	31
3	Cast Iron	0.001	7.71	31

Table 4 Comparison of deflections and stresses of carburettor for different materials

Comparison of Stress values of carburettor for different materials

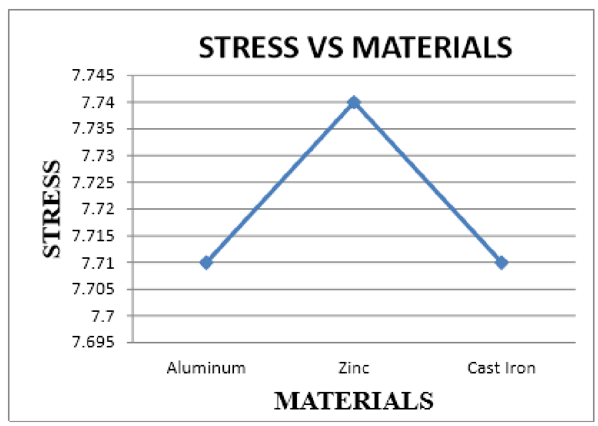

Figure 8. Comparison of Stress values of carburettor for various materials

The carburettor is studied for flow analysis and static analysis. In flow analysis, the carburettor was examined for different angles of the venture to optimise the pressure of the carburettor. In static analysis, the carburettor was analysed for various materials (i.e. Aluminium, Zinc, and Cast Iron).

VI. CONCLUSION

The carburettor was developed in UNIGRAPHICS software. Flow analysis of carburettor was done using SOLID WORKS STIMULATION. Static analysis of carburettor was done using ANSYS software. Flow analysis was done on the carburettor for different angles (i.e. 300, 450, and 600) of the venture to optimise the pressure of carburettor. From Flow analysis, Venturi with 450angle has optimised pressure value for the carburettor. The optimised pressure of 98Mpa was obtained was taken as input for Static analysis of carburettor. Static analysis was done on the carburettor for different materials (i.e. Aluminium, Zinc, and Cast Iron). From the static analysis, all materials have Von misses less than their yield strengths. So, all the materials are suitable for carburettor but, by considering Factor of safety, Aluminium has high Factor of safety value than Zinc and Cast Iron materials. Hence, it is concluded that Aluminium is Best suitable material for the carburettor.

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