ANALYSIS OF VENTURE FLOW RATE

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ABSTRACT:

Venturi plays very Important Role in different field of engineering. Venturi has a number of industrial applications in which its design is important factor. One of the important factors that affect the fuel consumption is that design of venture of carburetor. The venture of the carburetor is important that provides a necessary pressure drop in the carburetor device. There is a need to design the Venturi with an effective analytical tool or software. In this work, two types of fluids kerosene and water with two different mass flows are taken and analyzed using computational fluid dynamics. For this analysis CFD will be done using two software's namely CATIA for designing and FLUENT for CFD analysis. The results obtained from the software's will be analyzed from the design of a venture

INTRODUCTION

A venturi creates a constriction within a pipe (classically an hourglass shape) that varies the flow characteristics of a fluid (either liquid or gas) travelling through the tube. As the fluid velocity in the throat is increased there is a consequential drop in pressure. A venturi can also be used to mix a fluid with air. If a pump forces the fluid through a tube connected to a system consisting of a venturi to increase the water speed (the diameter decreases), a short piece of tube with a small hole in it, and last a venturi that decreases speed (so the pipe gets wider again), air will be sucked in through the small hole because of changes in pressure. At the end of the system, a mixture of fluid and air will appear. The Venturi effect is a special case of Bernoulli's principle, in the case of fluid or air flow through a tube or pipe with a constriction in it.

Venturi Effect

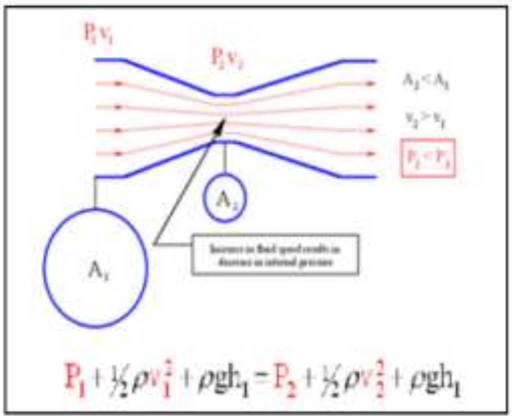
The Venturi effect is a jet effect; as with a funnel the velocity of the fluid increases as the cross sectional area decreases, with the static pressure correspondingly decreasing. According to the laws governing fluid dynamics, a fluid's velocity must increase as it passes through a constriction to satisfy the principle of continuity, while its pressure must decrease to satisfy the principle of conservation of mechanical energy. Thus any gain in kinetic energy a fluid may accrue due to its increased velocity through a constriction is negated by a drop in pressure. When a fluid such as water flows through a tube that narrows to a smaller diameter, the partial restriction causes a higher pressure at the inlet than that at the narrow end. This pressure difference causes the fluid to accelerate toward the low pressure narrow section, in which it thus maintains a higher speed. The Venturi meter uses the direct relationship between pressure difference and fluid speeds to determine the volumetric flow rate.

Bernoulli's Principle

The Venturi effect is a special case of Bernoulli's principle, in the case of fluid or air flow through a tube or pipe with a constriction in it.

Bernoulli's principle can be derived from the principle of conservation of energy. This states that, in a steady flow, the sum of all forms of mechanical energy in a fluid along a streamline is the same at all points on that streamline. This requires that the sum of kinetic energy and potential energy remain constant.

Thus an increase in the speed of the fluid occurs proportionately with an increase in both its dynamic pressure and kinetic energy, and a decrease in its static pressure and potential energy. If the fluid is flowing out of a reservoir, the sum of all forms of energy is the same on all streamlines because in a reservoir the energy per unit volume (the sum of pressure and gravitational potential ρ g h) is the same everywhere.



Venturi Tube

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.

WORK INSTRUCTIONS FOR CALIBRATION OF VENTURIMETER

This Work instructions details out the key processes, various procedure for calibration for Venturimeters up to 500mm of upstream diameter for low speed air flow applications. This work instruction also addresses the various controls exercised and the key measurement parameters involved in the calibration procedure.

Requirement of instrumentation and measurement parameters

The following pre-calibrated instruments / items are required for the calibration

- RTD with display unit.
- Micromanometer (0-2000 mmwc range with 0.1 mm resolution)
- Selector box.
- Traversing mechanism with controller.
- Three holed cylindrical / wedge probe.
- Dry and wet bulb temperature. Absolute pressure transducer (0-1200 mbar)

Calibration requirements of instrumentation

All the instruments and measuring equipment's listed in above are required to calibrated in a setup where traceability is maintained to the national or international standards.

Venturimeter Calibration set up preparation

- Venturimeter is to be inspected for any burrs or rust which will be cleaned by emery/filling.
- Checking of pressure tap nipples at the upstream and venture throat for blockage and cleaning as needed.
- Connection of Venturimeter in the ducting as detailed.
- Setting up of traversing mechanism along with aerodynamic probe for flow measurement at the upstream of venturimeter.
- Leak proof Connection of three pressure signals from the cylindrical probe and one static tap at the same traverse plane to the selector box using tubing.
- Leak proof Connection of pressure signals from venturimeter upstream and throat to the selector box using tubing.

- Leak proof Connection between selector box output port and micro manometer.
- Setting up of RTD at Venturi up stream and connection to digital display.

Venturimeter Calibration procedure

- Visual inspection of the pressure signal lines for leakage or blocks.
- Start of blower for mechanical run and for system stabilization.
- Run the blower at different speeds (at least five) by regulating the IGV and make the following measurements:
  - ➢ Ambient pressure (Barometric pressure)
  - ➢ Dry and wet bulb temperatures.
  - ➢ Wall static pressure at the probe location.
  - ➢ Three pressure signals from the probe.
  - ➢ Venturi upstream and throat pressures.
  - ➢ Venturi upstream flow temperature.
- Recording of primary data as above and data analysis
- Preparation of the detailed report.

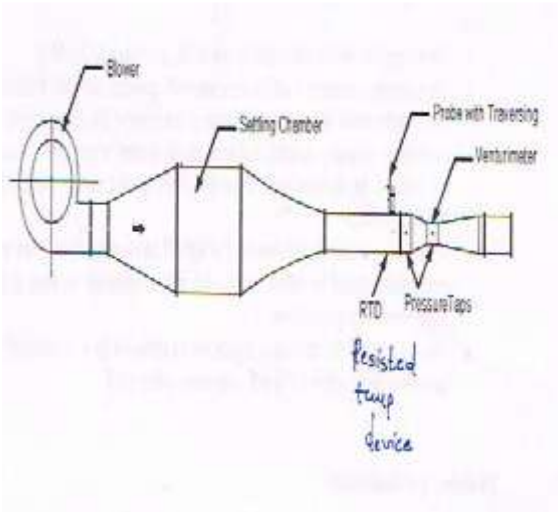
Test Verification and Validation

The following methodology will be followed to verify the correctness of the test data:

- The uncertainty will be calculated as per procedure.
- The calibration constant K will be compared with previous data, if the size of the venturimeter is same and variation of the order of 5% will be accepted considering geometry variation and uncertainty. In case of nonconformance, the test will be repeated with through checking of primary signals for leakage/blockage.
- In case of new size of venturimeter, the test will be repeated three times and repeatability should be within 2%. Nonconformance will be dealt in the same manner as given above.
- The validation of the calibration results will be achieved for a repeatability of calibration factor within 2% and uncertainty within 2%.

Measure of Completion

The measure of completion would be the submission of the calibration report to the commercial departments as per the schedule given in the work order. Internal measure of the productivity shall be as per the procedure.



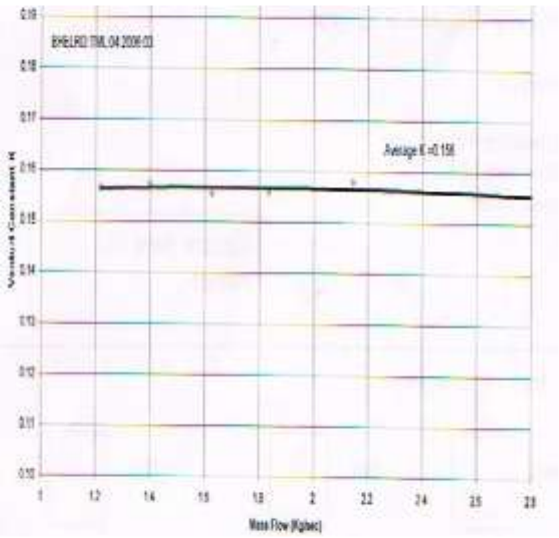
<u>Fig.Calibration of Venturimeter with traverse mechanism</u>

<u>Test Results</u>:

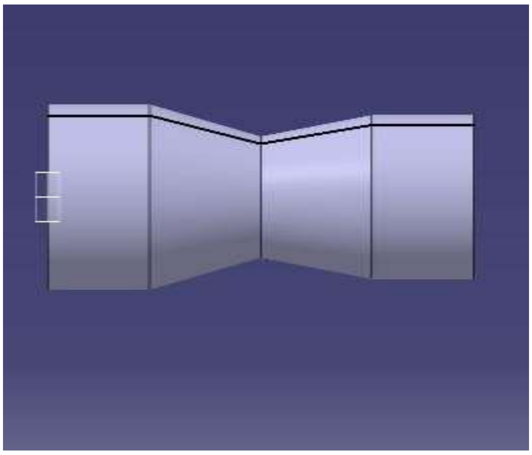
Mass Flow(m)	Venturi Constant(K)
kg/sec	K
2.918	0.155
2.145	0.158
1.834	0.156
1.626	0.155
·1.399	0.157
1.217	0.157
Average K	0.156

Venturi Constant K
=
= (Mass flow/(density*sqrt(differential Pr. of venturi /density)

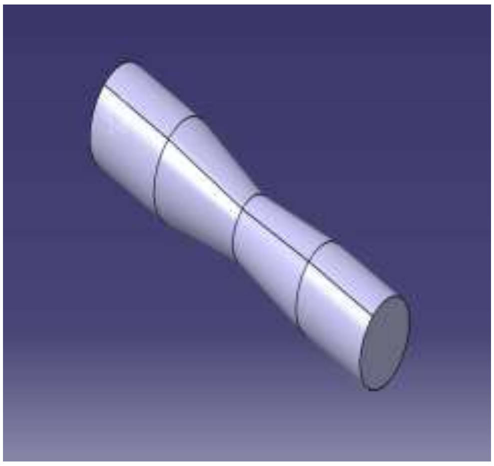
CALIBRATION OF VENTURIMETER



Designing In this a simple venturi as shown in fig was taken and its various dimensions were measured. Then according to the measured dimensions a meshed structure of the venturi was drawn with the help of CATIA 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 angle on the flow across the venturi is studied. The analysis was done for ϴ = 300, 400, 450 where ϴ is the angle between the axis of the vertical axis of the body of the venturi.



Geometry of Simple venturi in CATIA



ISOMETRIC VIEW

Results and Discussions

The inlet air was assumed to enter the venturi at normal temperature and the pressure was taken to be 0.1m/s. The following are results of the analysis of the venture for different angles of the throttle plate.

Fluid type: water
Pressure: 0.1m/s

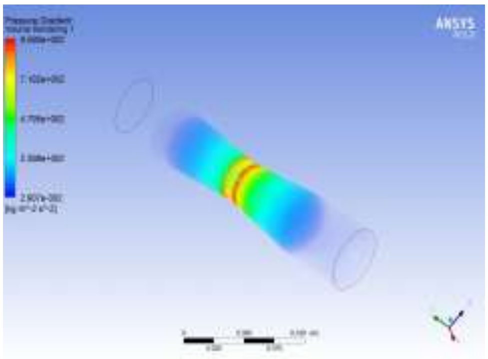
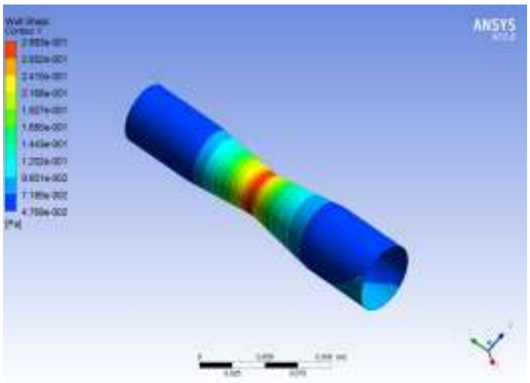
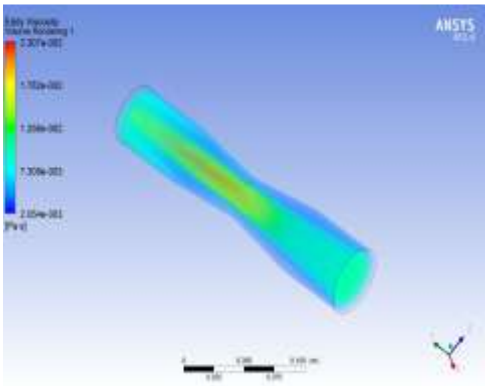


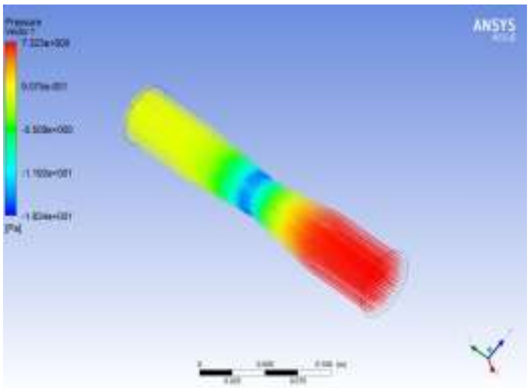
Fig shows pressure gradient



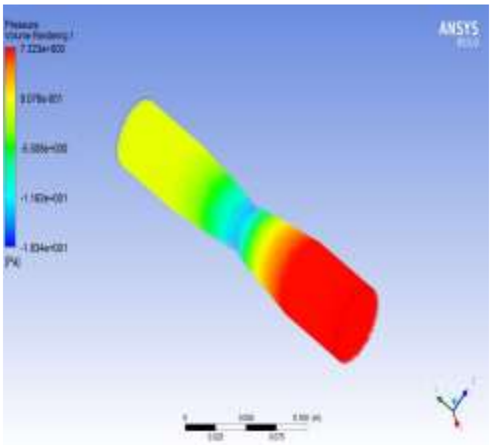
Venture wall shear stress



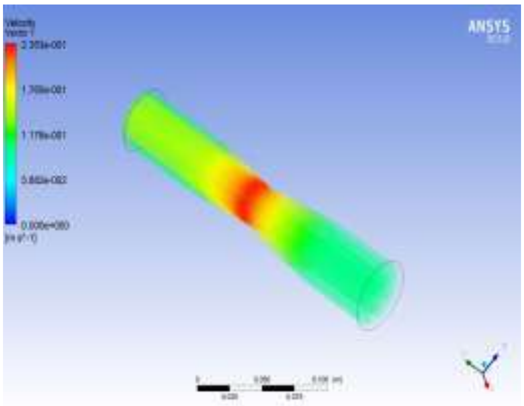
Eddy viscosity



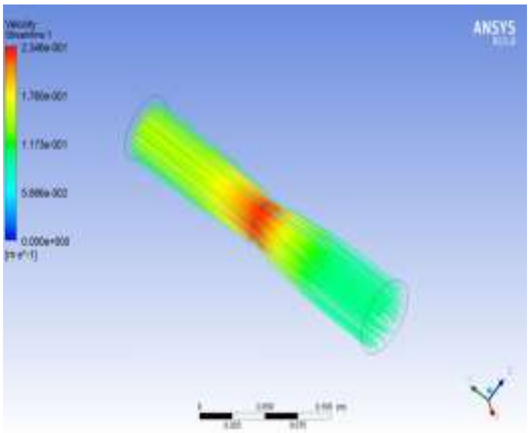
Pressure vector



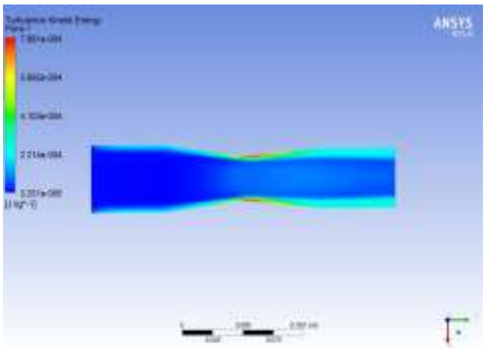
Pressure volume rendering



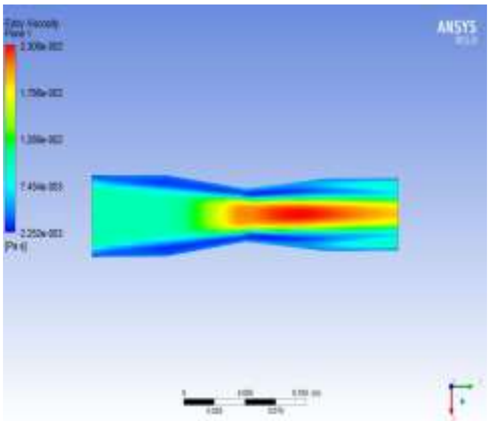
Velocity vector



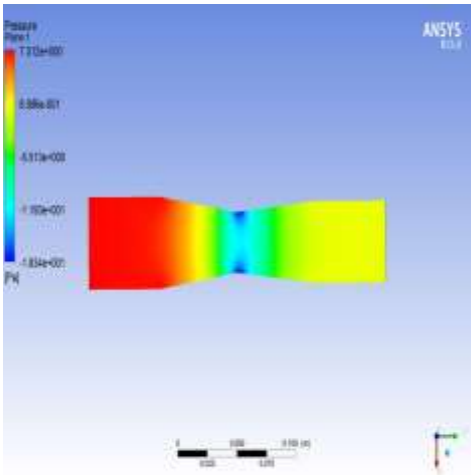
Velocity flow



Turbulence kinetic energy



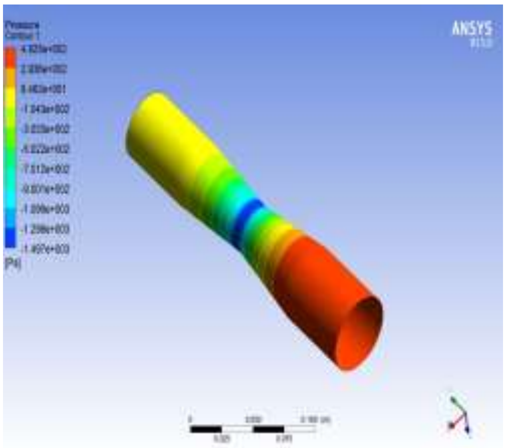
Eddy viscosity



Pressure along y-direction

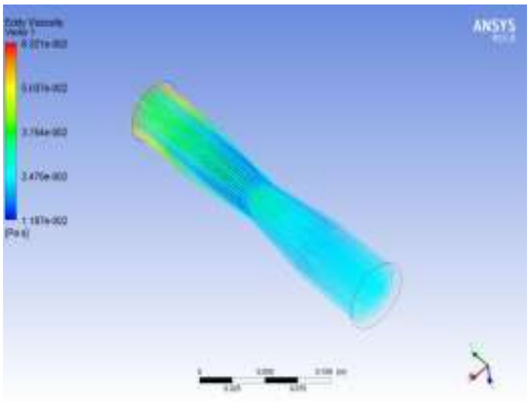
Fluid type: Kerosene

Pressure: 1m/s

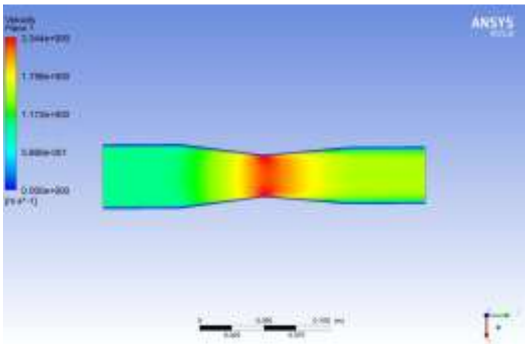


Pressure contour

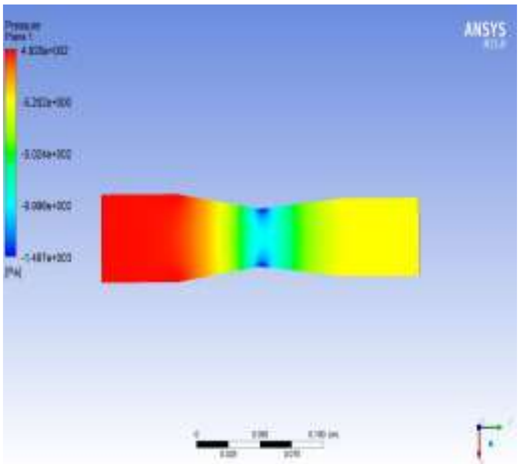
Fig. shows the statics pressure view for 450 throttle plate From fig. it is clear that when the throttle plate is 450 open, there is less amount of air flow through the inlet valve and hence the mixture is somewhat richer than the other cases. In this case the pressure at the throat of the venturi is around 4.9200 Pascal. , when the throttle plate is open, the mixture is slightly leaner than in case of 450 opened throttle plate condition. In this case the pressure at the throat of the venturi is found to be around 9.4600 Pascal.



Eddy viscosity



Velocity plane



Pressure along y-axis

CONCLUSION:

From the above analysis the conclusions obtained are

- When the flow inside the venturi was analyzed with two different fluids, in both cases 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 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 Calibration of Venturimeter has done by the traversing mechanism. In the traverse mechanism with the help of probe and micro manometer the required parameters has measured. The Dry and Wet bulb Temperatures are required in the calculation of density and volume air flow.

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