Computational Analysis of Intake System for Biogas Fuelled SI Engine

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***Abstract* - For the use of Biogas as a fuel in the SI engine some modifications are done. The improvement of flow strategy is implemented in the intake system of the engine to produce better biogas engine performance. The intake system for air-fuel mixture is studied, designed, simulated and analyzed with ANSYS-CFX and CFD-Post code. A venturi with an inlet for air at nozzle convergent section and for biogas at throat with providing an accelerating device for maintaining flow of biogas is done. In CFD analysis the effect of flow of air-fuel mixture with the contoures of pressure, velocity, kinetic energy and streamlines are studied. Form that results the effect of break power, air/fuel ratio, bsfc at the speed 1000rpm, 3000rpm, 5000rpm and 7000rpm are studied. In this study it is found that the break power at the respected speed are 0.96kW, 1.7kW, and 2.7 kW, 5.3kW resp. Whereas the specified speed of standard petrol engine comes near about same as that of biogas speed at 7000rpm.**

Keywords: CFD; Intake Syste;Venturi; Biogas

I. INTRODUCTION

As the population and economic growth increase, most of developing countries facing the increasing demand of energy. Energy saving and emission reduction are two world wild problems. In order to meet the increasing demand on the performance of internal combustion engine and satisfy the more and more restricted emission regulations, the power, reliability, life cycle, emissions and fuel economy of IC engine need to be further improved. In order to meet the energy requirements, there has been growing interest in alternative fuels like biodiesels, methyl alcohol, ethyl alcohol, biogas, hydrogen and producer gas to provide a suitable fuel substitute for internal combustion engines. Biogas has been a major source of energy and it is also a renewable source of energy. The biogas is easily developed under specific climatic and socio-economic conditions and the cost of production of biogas is very low. Also 60-80% methane gas is present in the biogas; hence we can use the biogas as a fuel in the SI engine.

The problem under study aims to improve the biogas engine performance by implementing a suitable intake system which endorses the pressurized turbulent flow of air-fuel mixture. The pressurized flow will increase volume of the fuel; hence improve the volumetric efficiency and the turbulence will increase the homogeneity of mixture; hence improve the flame speed. The problem under consideration includes computer aided design analysis of an intake system for biogas operated 4-stroke spark ignition engine. Analysis of the fuel intake system is designed by using conventional equations and analysed with a CFD code for evaluating performance.

II. NEED FOR ANALYSIS

Air/fuel ratio exerts a large influence on exhaust emission and fuel economy in IC engine. With increasing demand for high fuel efficiency and low emission, the need to supply the engine cylinders with a well-defined mixture under entire range of operation from no load to full load condition has become more essential for better engine performance. Carburettors are in general defined as devices where a flow induced pressure drop forces a fuel flow into the air stream. But the conventional carburettors are especially designed and developed for liquid fuels like gasoline. Their main functions of conventional carburettors are carburetion and mixing the fuel with air properly apart from acceleration. But biogas being a gaseous fuel requires the intake system only for mixing the fuel with air properly.

III. DESIGN OF INTAKE SYSTEM

The basic function of carburetor is to provide required air fuel ratios at all loads and speeds. To achieve this function, throat diameter and the jet diameter must be calculated with most care. Venturi type of Biogas mixer was designed and fabricated for selected Hero Honda Engine. A mixer is capable for providing a stoichiometric air fuel ratio for overall operating conditions of the engine to operate

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smoothly. The mixing device has to ensure the provision of a constant air/fuel ratio irrespective of the actual amount sucked into the engine, irrespective of the butterfly valve position. This is achieved by adequate design of the mixing device, whether a venturi mixer or a suction-pressure controlled mixing valve.

A suitable mixture for a biogas engine should be a venturi with the accelerator cone being tapered as a curve of suitable radius and the diffuser cone angle. The biogas is fed into the venturi through a single opening at throat portion. The simple slider is attached to the throat for controlling the fuel flow which is operated as the accelerating device. Venturi mixers utilize the velocity increase and subsequent pressure reduction in a flow through a tube with a contraction. The pressure at the smallest cross-section area is a function of the air velocity, hence the air volume Fuel gas enters and mixes with the airstream at the smallest cross-section (the bottleneck).

An almost constant air/ fuel ratio is thus achieved. The cross section area of biogas entrance, the diameter of the biogas entrance to be selected such that the engine performance will be optimum. With this information, an intake system or a mixer comprising of basic venturi is designed as shown in figure. The basic venturi model and the designed assembly of the intake system is given as fallows,

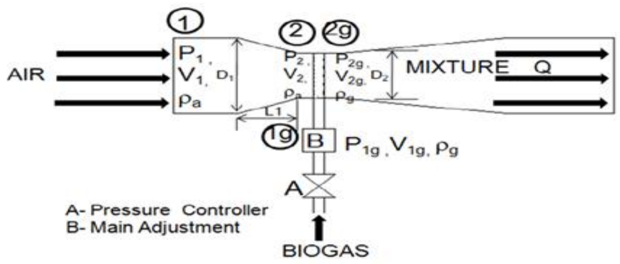

Fig 1.Basic Venturi

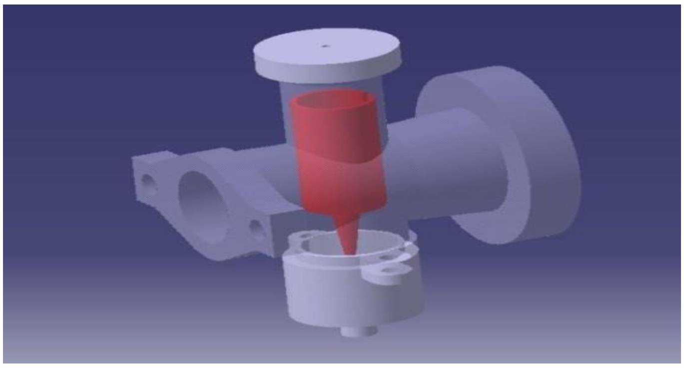

Fig2.Assembly of Intake System

Where notations and known conditions

Q- Discharge of air through venturi,

D_1 &D_2- Diameters of venturi inlet & throat resp. in mm,

A_1& A_2- Areas of venturi inlet & throat resp.,

P_1- Pressure at venturi inlet $=P_{atm}= 101337.3\ N/m^2$,

P_2- Pressure at venturi throat $=P_{2g}$,

V_1 & V_2- Velocities at venturi inlet & throat resp.,

ρ_a&ρ_g- Densities of air & biogas= 1.2629 & 1.16 resp.,

P_{1g}- Gas pressure at inlet $=P_{atm}= 101337.3\ N/m^2$,

V_{1g}-Gas velocity at inlet = 0,

V_{2g}- Gas velocity at throat,

A_g- Area of gas passage,

d_1& d_2- diameters of gas entrance in mm,

m_g& m_a- mass of gas & air resp. in kg,

The d1 is the outer diameter which is constant i. e. 6.50 mm and the value of d2 changes as per the engine speed. Due to the accelerating device the values of d2 are 5.79mm, 5.65mm, 5.51, 5.09mm, 4.82, 4.45mm, 2.68mm, 2.16mm resp. as the speed varies from 1000rpm to 8000rpm.

IV. SOFTWARE MODELLING AND ANALYSING OF VENTURI SECTION:

The software “AutoCAD2011”, “CATIA V5R16” and “ANSYS CFX and CFD-Post” are used for drafting, modeling and analyzing the intake system respectively. The model of the venturi is given as,

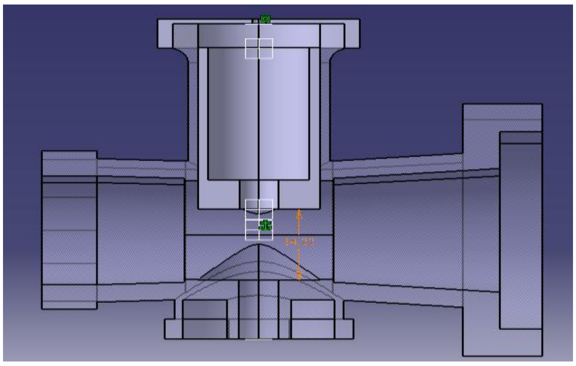

Fig. 3 a. Front view of venturi

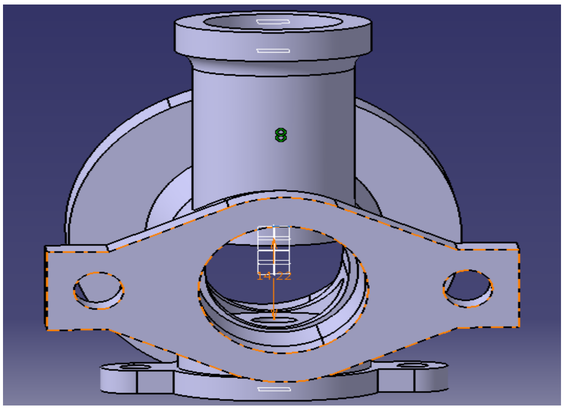

Fig 3 b.Side view of venture

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CFD Stands for Computational Fluid Dynamics. It is a numerical tool to solve the equations of Fluid Dynamics by suitable methods which can capture the essential physics of the fluid. The numerical schemes that are used for discretization of the equilibrium of equations for fluid, i.e. the Navier-Stokes equations can be one out of Finite Difference Method, Finite Volume Method or Finite Element Method. The general purpose CFD software ANSYS CFX and CFD-Post is used to analyze performance of designs. ANSYS CFX and CFD-Post are supported in Release 12.0 of ANSYS Workbench, which is built on a new framework while leveraging the strength of ANSYS core applications, solvers, and associated tools with a new workflow and simulation project management capability.

After making model for analysis the part where the fluid comes in contact of venturi only those parts have to be taken for analyzing purpose. In this paper the analysis of air and biogas mixture at different speed i.e. 1000rpm, 3000rpm, 5000rpm and 7000rpm are done. While making all the procedure of analysis for air and biogas fluid the contoures of Static pressure, Velocity, Streamlines and kinetic energy are given as fallows,

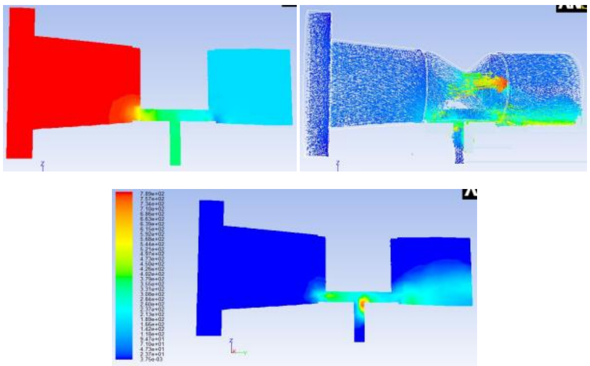

Fig 4. For 1000 rpm-Contours of Static Pressure(Pascal), Velocity Vectors Colored By Velocity Magnitude (m/s), Contours Of Turbulent Kinetic Energy (m^2/s^2)

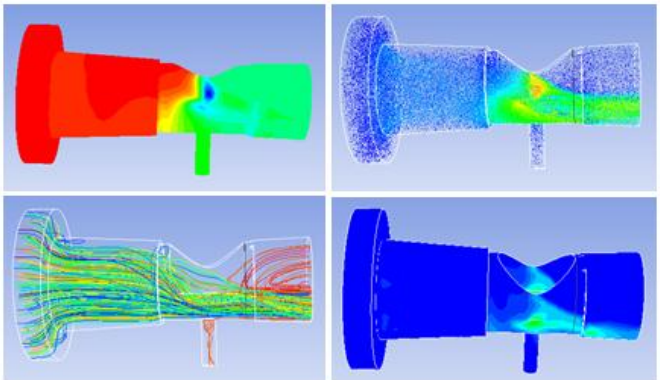

Fig 5. For 3000 rpm - Contours of Static Pressure(Pascal), Velocity Vectors Colored By Velocity Magnitude (m/s), Path lines Coloure By Particle ID, Contours Of Turbulent Kinetic Energy (m^2/s^2)

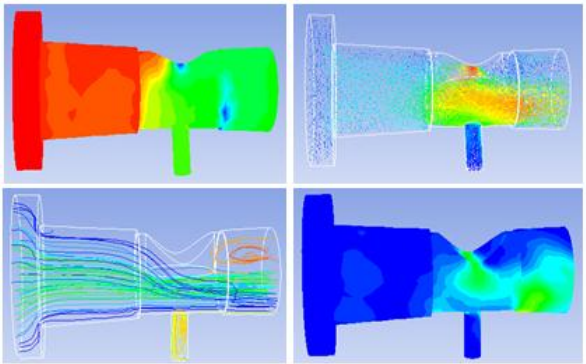

Fig 6. For 5000 rpm - Contours of Static Pressure(Pascal), Velocity Vectors Colored By Velocity Magnitude (m/s), Path lines Coloure By Particle ID, Contours Of Turbulent Kinetic Energy (m^2/s^2)

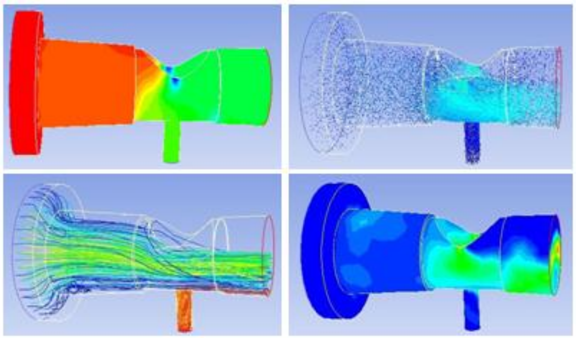

Fig 7. For 7000 rpm - Contours of Static Pressure(Pascal), Velocity Vectors Colored By Velocity Magnitude (m/s), Path lines Coloure By Particle ID, Contours Of Turbulent Kinetic Energy (m^2/s^2)

V. RESULTS

From this analysis we got the flow related values such as pressure, velocity. The results for model of the intake system which is made and manufactured for the SI Engine at N=1000rpm, 3000 rpm, 5000rpm and 7000rpm have been found in the following table,

TABLE 1. RESULTS OF INTAKE SYSTEM FOR CFD ANALYSIS

N rpm	P2-P1 N/m^2	V1 m/s	V2 m/s	V2g m/s	3 D Streamline Velocity m/s	Turbulence KE m^2/s^2
1000	-25.84	2	21.6	18	16.3	0.08
3000	-205.66	6	30.4	24	29.7	0.71
5000	-400.966	11	33.1	25	41.2	3.56
7000	-1007.76	16	34.4	25	68.7	6.34

By using above result from software and the following equations the remaining terms have been found. The sample calculations are as,

$$m_a = \rho_a \times A_a \times V_{2g}\,(act) \quad (1)$$

$$Q = A_1 \times V \quad (2)$$

$$m_a = \rho_a \times Q \quad (3)$$

$$BP = m \times \eta \times CV \quad (4)$$

$$T = BP \times 60 \times 1000/2\pi N \quad (5)$$

$$A/F = m_a/m_g \quad (6)$$

$$bsfc = m_g \times 3600/\,BP \quad (7)$$

The result table by calculating all values is given in the following table,

TABLE 2.RESULT TABLE BY CALCULATION

Sr. No.	N rpm	Q $(x10^{-3}\,m^3/s)$	m_g $(x\ 10^{-4}\ kg/s)$	m_a $(x\ 10^{-4}\ kg/s)$	BP (KW)	T (Nm)	A/F Ratio	bsfc (gm/kWhr)
1	1000	1.132	1.42	14.3	0.96	9.23	10.1:1	528.60
2	3000	3.366	2.59	42.51	1.76	5.61	16.4:1	528.64
3	5000	5.609	4.06	70.84	2.76	5.28	17.4:1	528.63
4	7000	7.853	7.83	99.18	5.33	7.27	12.7:1	528..63

From this result table the break power and the torque values are calculated and also the air/fuel ratio and bsfc calculated.

VI. CONCLUSION:

The study has demonstrated the possibility of implementation flow management strategy in improving the biogas engine performances, through a system called advanced intake system. This approach is simpler and cheaper compared to improvement on combustion chamber. The research provided an example how the flow management strategy may improve the engine performance without major modification. It is shown in the study that the intake system is capable in increasing the engine performance. The combination of venturi with accelerating device is produced well effect of engine. The break power at the speed 1000rpm, 3000rpm, 5000rpm and 7000rpm are 0.96kW, 1.7kW, and 2.7 kW, 5.3kW resp. which shows that the analysis part is concluded. Besides producing cleaner emission, the biogas operation also reduces operational cost on the vehicle. It promises a green and sustainable source of energy. In the overall, the study has provided a simpler, cheaper and effective alternative to improve the biogas engine performance by implementing a pressurized and turbulent mixture proper A/F ratio.

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REFERENCES

[1] S. J. Suryawanshi, R. B. Yarasu, “Design and Simulation of a Producer Gas Carburetor – A Review”,*International Journal of Current Engineering and Technology*, ISSN 2277 – 4106, (April 2014).

[2] S. Bari, P. J. G. Johansen, A. J. T. Alherz, “Simulation of improvements to in-cylinder mixing of biodiesel with air by incorporating guide vanes into the air intake system”, *6th BSME International Conference on Thermal Engineering* (ICTE 2014).

[3] M. S. Ali, M.A. Salim, Rosli A. Bakar, A. M. Fudhail, M.Z. Hassan, Abdul Muhaimin M. S., “Performance analysis of a spark ignition engine using compressed natural gas (CNG) as fuel”, MusthafahMohd. Tahir, *2nd International Conference on Sustainable Energy Engineering and Application,* ICSEEA 2014.

[4] N.R.Banapurmath1, V.S. Yaliwal, K. J. Noolageri, P.G. Tewari, “Development of Carburetor for Optimum Performance of Producer Gas Fueled Dual Fuel Compression Ignition Engine”

[5] AmbarishDatta, Achin Kumar Chowdhuri, Bijan Kumar Mandal, “Experimental Study on the Performances of Spark Ignition Engine with Alcohol-Gasoline Blends as Fuel”, *International Journal of Energy Engineering.*

[6] Stefan MIHIC, “Biogas Fuel for Internal Combustion Engines”, *Annals of the faculty of engineering Hunedoara*, Tome II, Fascicole 3 (2004).

[7] SuyogVIJ , “Biogas Production From Kitchen Waste”, *Department of Biotechnology and Medical Engineering National Institute of Technology, Rourkela*(2010-2011).

[8] Bui Van Ga, Tran Van Nam, Le Minh Tien, Bui Thi Minh Tu, “Combustion Analysis of Biogas Premixed Charge Diesel Dual Fuelled Engine”, *International Journal of Engineering Research & Technology (IJERT)* ISSN: 2278-0181 IJERTV3IS110159 www.ijert.org ,Vol. 3 Issue 11, November-2014

[9] Xiaolong Yang a, Cheng Liao, Jingping Liu, “Harmonic analysis and optimization of the intake system of a gasoline engine using GT-power”, *Energy Procedia* 14 756 – 762 (2012).

[10] S. D. Yadav, Dr. Bimlesh Kumar, Dr. S. S. Thipse, “Development of Advanced Intake System for Optimum Biogas-fuelled SI Engine Performances”, *International Journal of Mechanical Engineering and Technology (IJMET),* Volume 3, Issue 1, January- April (2012), pp. 64-76.