Journal of Material Science and Mechanical Engineering (JMSME)
Print ISSN: 2393-9095; Online ISSN: 2393-9109; Volume 2, Number 5; April-June, 2015 pp. 471-475

http://www.krishisanskriti.org/jmsme.html

Experimental Investigation of an Airenhancement Device on the Performance of a Compression Ignition Engine

A. Raj Kumar[1], G. Janardhana Raju [2], K. Hemachandra Reddy[3] and M. Chakrapani[4]

[1]*Guru Nanak Institute of Technical Campus (GNITC), Hyderabad.*
[2]*Nalla Narsimha Reddy Engineering College Hyderabad*
[3]*J.N.T.U Anantapur*
[4]*Guru Nanak Institute of Technical Campus (GNITC), Hyderabad*

Abstract—*The fluid motion in an internal combustion engine is induced during the induction process and later modified during the compression process. Air enhancement devices for air intake manifold systems of automotive engines have been widely available in the market with the claim that they can improve fuel-air mixing and thus bring more power to the engine performance and better fuel efficiency. The objective of this study is to investigate the ability of an air enhancement device in improving the performance of a Compression Ignition (CI) engine. The investigation is performed by an experiment on a four-stroke single-cylinder diesel engine test bed with three different types of vane profiles, were installed at the downstream of the air intake manifold. The measurements are done at constant speed of 1500 rpm. The results are compared with normal engine (without air swirl generation vanes). The results of test show an increase in performance of the engine. The brake thermal efficiency at full load was developed by four vane air swirl generating device and it was 9.24% higher than without air swirl generating device.*

Keywords: *Blade type, Diesel Engine, Air Swirl, Intake Manifold, Efficiency,*

1. INTRODUCTION

Although there is large development in the CI engine in last few decades it is still lagging in the performance in the sense of fuel economy & exhaust emission. It is due to the ineffective use of air in the engine causes improper atomization of the air-fuel mixture results in the poor combustion, which affects the engine performance characteristics in terms of fuel economy and emissions at part load conditions. So to enhance the performance of engine better utilization of intake charge is necessary, different techniques are introduced in form of modification of intake manifold, development of swirl and tumble devices, modification of piston profile for efficient combustion of charge. In this paper different swirl generating devices are analyze and their result is compared with base model without swirl device. Resistance offered by device to flow is prime factor. Since volumetric efficiency of CI engine is always a critical parameter due to numerous component in intake system. Addition of swirl generating device should not develop more resistance to flow. Requirement of swirl is also varying in engine and is not constant at all loading conditions. At cold start conditions and part load conditions engine require slightly rich mixture. Modeling of device is done taken into consideration the fact that it should be able to develop variable swirl while its operation.

In-cylinder flow field structure in an internal combustion engine has a major influence on the combustion, emission and performance characteristics. Fluid flows into the combustion chamber of an I.C engine through the intake manifold with high velocity. Then the kinetic energy of the fluid resulting in turbulence causes rapid mixing of fuel and air, if the fuel is injected directly into the cylinder. With optimal turbulence, better mixing of fuel and air is possible which leads to effective combustion. A good knowledge of the flow field inside the cylinder of an I.C engine is very much essential for optimization of the design of the combustion chamber for better performance (B. Murali Krishna,2010).Previously, Heywood (1998) has stated that generating a significant swirl and/or tumble motion inside the engine cylinder during the intake process was one of the promising ways to obtain high in-cylinder turbulent intensity. Valentino et al (1993), Reeves et al (1999),Li et al (2001), Yasar et al (2006) and Stansfield et al (2007) have conducted PIV measurements on various engines and reported that the flow structure changes substantially along the cylinder length due to the geometry of the intake valve port and the tumble motion was generated during induction process. Also, reported that the increase in the air flow rate at higher engine speed causes the vortex center to move right-upwards compared to the lower engine speeds. In general, the presence of a swirl in the cylinder of an internal combustion engine improves the homogenization of the air -fuel mixture, and consequently, enhances fuel combustion. The aim of this work is to an to analyse the effect of the swirl on the combustion and emission by modifying the inlet manifold

Swirl can be defined as rotational of intake charge about the cylinder axis. This can be done by carrying the intake charge flow with an initial angular momentum such that non uniform flow distribution will occur. At part load operating conditions it is advantageous to dilute air fuel mixture with introduction of swirl for these reasons. Geometry of device is maintained in such a way that it should allow max air to flow inside it will affect volumetric

efficiency of engine as low as possible. In case of uniform flow device the volumetric efficiency is more because resistance in the flow way is less. By considering this factor the geometry has created. The geometry has curvature like that flow gets deflected into angular momentum.

1) Expansion stroke work is increased for given expansion result as result of change in thermodynamic properties. 2) For given mean effective pressure, intake pressure increases with increase in mixture dilution, thus reduction in pumping work. 3) Heat losses to cylinder wall are reduced thus reducing the burned gas temperature and controlling exhaust emission parameters. Swirl generation method for better air fuel mixing of charge which has inducted during the suction stroke is used in both petrol & diesel engine. Because of angular momentum to the charge proper atomization of fuel takes place which results in enhancing combustion process resulting in better engine performance, fuel economy & reduced exhaust emissions. There are two ways of generating swirl in engine

2. LITERATURE SURVEY

Idris Saad & Saiful Bari has modeled the guide vane & tumble device for improving the air-fuel mixture for the highly viscous fuel in diesel engine. They have created a device with four & six number of vanes. Prime importance is given to improvement of the air flow & the effect of vane twist angle. number of vane device swirl generated is more than 4 vanes but the resistance in the flow way is increased on other hand. The vane angle is varied from 30 to 600 it is found that with 350 vane angle in-cylinder air pressure increases by 0.02%, total kinetic energy of air by 2.7% & velocity of air by 1.7% compared to the unmodified diesel engine.[1]

A.K. Mohiuddin investigates the swirl effect on the engine performance by using insert swirl adapter. The testing has carried out on the protons CAMPRO engine model of 1.6 liter. In swirl device adapter blade angle is maintained at 300 & is fitted in the intake port. Obtained results compared with the normal engine & it has found that at the full load condition the swirl generation is less but at the part load condition the swirl produce is effective. The BSFC reduces at part load condition but as the speed increases beyond 3500 rpm BSFC increases, as the speed increases beyond 3500 rpm BSFC increases.[2]

Liu Shenghua investigates the effect of new swirl system & its effect on DI engine economy. In this ring type generator with four curvilinear blades used. The generator fitted in the intake air duct & the comparison is carried out, the result found out that with 1500 rpm effective swirl is generated and with reduced emissions.[3]

Dr. Pankaj N.Shrirao, Dr. Rajeshkumar U. Sambhe [5], have worked on the air swirl created by directing the air flow in intake manifold on single cylinder 4-stroke engine performance as well as its exhaust emissions. Experiments were done with different types of internal threads, viz. acme, buttress and knuckle of constant pitch and also take the exhaust emissions of different manifolds. Finally they have found experimentally that compare to other two configurations, the inlet manifold with buttress thread has better air-fuel mixing process and hence thermal efficiency is increases and BSFC and exhaust emissions are reduced.

V.CVS Phaneendra,V.Pandurangadu & M. Chandramouli [6], have experimentally investigated that by designing and changing the orientation of the inlet manifold of a four stroke air cooled C.I engine at rated speed 1500 rpm the performance characteristics of an engine are increased and emissions levels are decreased. Experiments were done in various shaped threaded manifold of pitch 10mm, 15mm, 20mm, and 25mm, and they have proved that the performance characteristics with 10mm pitch showed better for performance as well as emission levels compared to normal manifold

S. L. V. Prasad, V. Pandurangadu [7],have experimentally investigated the effect of air swirl generated by directing the air flow in intake manifold on engine performance. They have performed experiments on single cylinder 4-stroke water cooled engine at constant speed of 1500rpm. The turbulence is achieved in the inlet manifold by grooving the inlet manifold with a helical groove of size of 1 mm width and 2 mm depth of different pitches to direct the air flow.

The tests are carried with different configurations by varying the pitch of the helical groove from 2 mm to 10 mm in steps of 2 mm inside the intake manifold. The results indicate that configuration of 8 mm pitch groove has increases the turbulence and hence better mixing of air-fuel process takes place among all configurations and the soot emissions are reduced. They have also found that the laser carbon deposits in the combustion chamber, piston crown and exhaust system due to controlled combustion. Also, more power is derived from the same charge.

P. Ramakrishna Reddy ,K. Govinda Rajulu, T. Venkata Sheshaiah Naidu [8], have performed various experiments to find the effect of swirl on the performance of the engine as well as on its emissions, by inducing swirl with different inlet manifolds having helical, spiral and helical-spiral shapes. The test were done on the 4-stroke,water cooled C.I engine. First they have made the 3D model of three manifolds and then take the observations. The analysis shows that all the three types of inlet manifolds yields much better performance and less amount of emissions in comparison with normal manifold

3.1 EXPERIMENTAL SET UP

The engine was a computerized single cylinder four stroke, naturally aspirated direct injection and water cooled diesel engine. The specifications of the test engine are given in below. In order to determine the engine torque, the shaft of the test engine was coupled to an electric dynamometer, which was loaded by an electric resistance. A strain load sensor was employed to determine the load on the dynamometer. The engine speed was measured by an electromagnetic speed sensor installed on the dynamometer. The engine was equipped with an orifice meter connected to an inclined manometer to measure mass flow rate of the intake air. The temperatures of air inlet, cooling water engine inlet, cooling water engine outlet, water exchanger inlet, water exchanger outlet, exhaust gas engine outlet and exhaust gas exchanger outlet were measured by K type thermocouples. The engine and the dynamometer were interfaced to a control panel which is connected to a computer.

ENGINE SPECIFICATIONS	
TYPE	4 - STROKE, 1 - CYLINDER DIESEL ENGINE
MAKE	KIRLOSKAR A V – 1
POWER	3.7 KW, 1500 RPM
BORE & STROKE	80MM x 110 MM
COMPRESSION RATIO	16.5:1 VARIABLE UPTO 20
CYLINDER CAPACITY	553 CC
DYNAMOMETER	ELECTRICAL AC GENERATOR
CYLINDER PRESSURE	BY PIEZO SENSOR, RANGE 200 PSI
ORFICE DIAMETR	20 MM

2.1 Specification of Diesel Engine

2.2 Different types of Swirl generating vanes

Engine Lab view Soft was used for recording the test parameters such as fuel flow rate, temperatures, air flow rate, load etc, and for calculating the engine performance characteristics such as brake power, brake thermal efficiency, brake specific fuel consumption and volumetric efficiency.

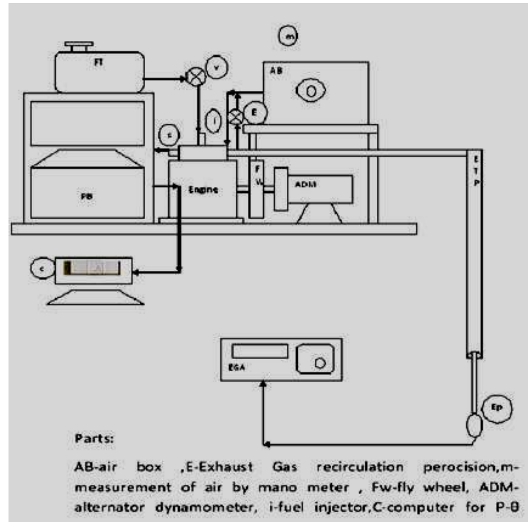

Fig. 3.2: Experimental Set Up

Engine performance parameters that are considered are thermal efficiency is investigated because it is a direct measure for fuel efficiency. Emissions are not measured in this study. To validate the predictions an experimental set-up is built and experiments are carried out.

The experimental set-up contains a of small diesel generator set, the load was done through this generator. The maximum electrical load imposed on the generator set was 4 Kw, and loaded the diesel engine with a step up 1 Kw and the reading were taken.

2.3 EXPERIMENTAL PROCEDURE

The engine was started with neat diesel as fuel at no load by pressing the inlet with decompression lever and it was released suddenly when the engine was hand cranked at sufficient speed and it was allowed to run about half an hour till the steady state conditions reached. The engine was then loaded gradually from no load to full load (i.e. 0% to 100%) in the step of 20% keeping the speed within the permissible range and the observations of different parameters were recorded. With the fuel measuring apparatus and stop watch the time elapsed for the fuel consumption for 20 ml of fuel was measured. The other observations recorded were brake load reading, engine speed. The experiments were conducted without inserting vanes and with vanes in the intake manifold.

3. RESULTS & DISCUSION

3. 1 Loads versus Brake Power: From the Fig. 4.1 it is inferred that the Brake power increases with increase of Load. For normal working conditions i.e without inserting the vanes the bake power is 3.976 Kw at full load. By inserting the different geometry of vanes it is observed that in five vanes blade the brake power is maximum and is 4 .01Kw. Due to the air swirl generation the brake power was increased 0.6% in five vanes when compared with normal working engine. It was observed that the brake power is low in 3 vane swirl generator which is 3.86.

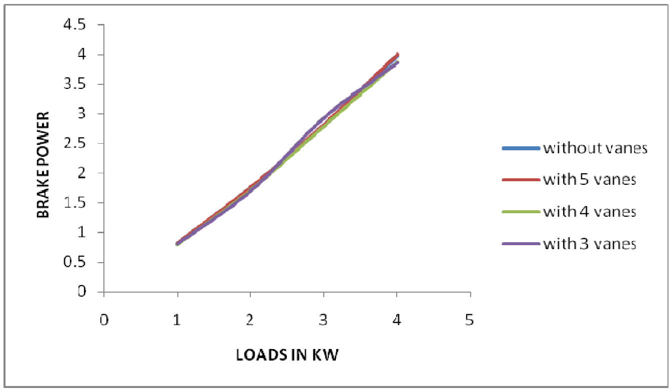

Fig. 4.1: Load versus Brake power

3.2: Load versus Brake Thermal Efficiency

From the Fig. 4.2 it is inferred that brake thermal efficiency increases with load. Without air swirl generator device the brake thermal efficiency was 23.8% at full load, and with the air swirl generator of Four vane the maximum brake thermal efficiency of 26% was observed. The brake thermal efficiency was improved by 9.24% was increased in comparison with normal working engine without air swirl generator. The brake thermal efficiency was very low at the same load for five vane device, and the value is 24.4% which is even higher than without air swirl generator.

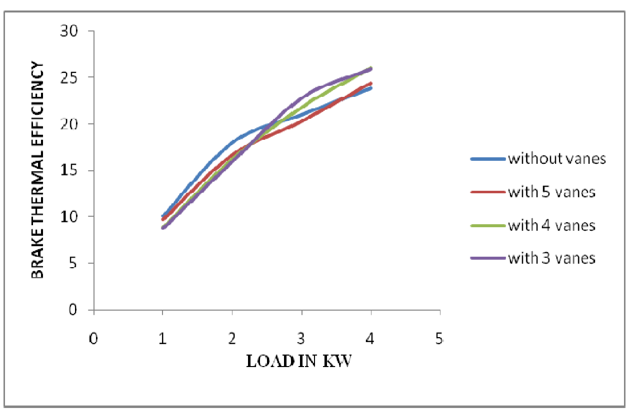

Fig. 4.2: Load versus Brake Thermal efficiency

3.3: Load versus Brake specific fuel consumption

From the Fig. 4.3 it is inferred that brake specific fuel consumption decreases with increase of load. It was observed that at full load four vane air swirl device the brake specific fuel consumption is low as compared with other type of vanes. The brake specific fuel consumption decreased to 9.14% in comparison with the normal working engine without air swirl generating device.

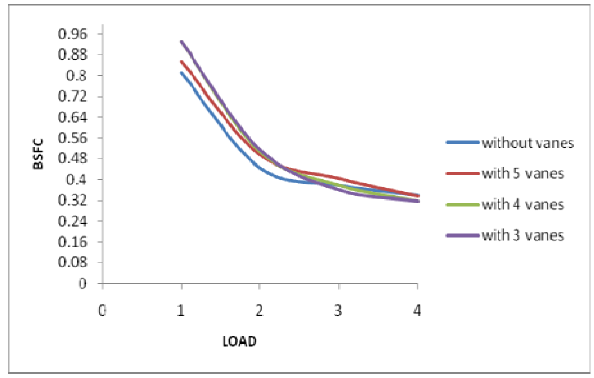

Fig. 4.3: Load versus Brake specific fuel consumption

3.4: Brake power versus Brake specific fuel consumption

From the Fig. 4.4 it is inferred that brake specific fuel consumption decreases with increase brake power. The brake specific fuel consumption is low for three vane air swirl generator compared to normal working engine without air swirl generating device at maximum brake power of 3.86 Kw.

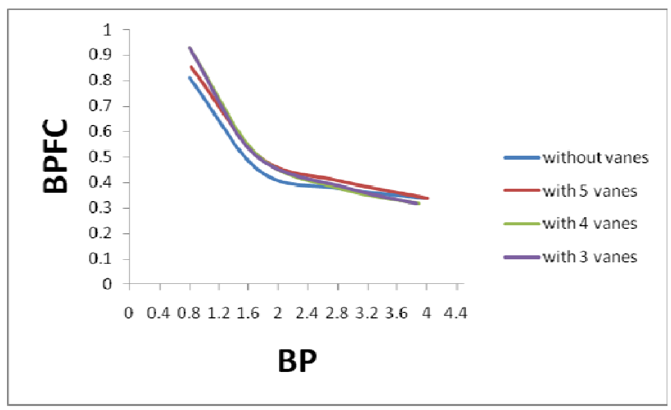

Fig. 4.4: Brake power versus Brake specific fuel consumption

4. CONCLUSIONS

To enhance the performance of engine better utilization of intake charge is necessary, different techniques are introduced in form of modification of intake manifold, development of swirl and tumble devices, modification of piston profile for efficient combustion of charge.

1. At full load the maximum brake thermal was developed by five vane air swirl generating device. By using this device overall 0.6% improvement was observed.
2. The brake thermal efficiency at full load was developed by four vane air swirl generating device and it was 9.24% higher than without air swirl generating device.

3. The brake specific fuel consumption was low at full load with four vane air swirl generating device and it was 9.14% lower than without air swirl generating device.

The final conclusion is that if four vane air swirl generating device is used the performance of the engine is good when comparing with the other devices and without air swirl generating devices.

REFERENCES

[1] Idris Saad & Saiful Bari, Improving Air-Fuel Mixing In Diesel Engine Fuelled By Higher Viscous Fuel Using Guide Vane Swirl And Tumble Device (GVSTD), SAE International 2013.
[2] A.K.M. Mohiuddin, Investigation of the Swirl Effect on Engine Using Designed Swirl Adapter, IIUM Engineering Journal 2011.
[3] Liu Shenghua, Development of New Swirl System and Its Effect on DI Diesel Engine Economy, SAE International 1999-01-2889.
[4] Sihun Lee, Kun Tong, Effects of Swirl and Tumble on Mixture Preparation during Cold Start of a Gasoline Direct-Injection Engine, SAE International 2000-01-1900.
[5] Dr. Pankaj N.Shrirao, Dr. Rajeshkumar U. Sambhe," Effect of Swirl Induction by Internally threaded Inlet Manifolds on Exhaust Emissions of Single Cylinder (DI) Diesel Engine", International Journal of Science and Research, July 2014, pp. 1718 - 1722 .
[6] V.CVS Phaneendra, V.Pandurangadu & M. Chandramouli,[6] " Performance Evaluation Of A Four Stroke compression Ignition Engine With Various Helical Threaded Intake Manifolds", International Journal of Applied Research in Mechanical Engineering, July 2012, pp. 53 - 60.
[7] S.L.V. Prasad and V. Pandurangadu," Reduction Of Emissions By Intensifying Air Swirl In A Single Cylinder Di Diesel Engine With Modified Inlet Manifold", International Journal of Applied Engineering and Technology, October - December 2011, pp. 18 - 23.
[8] Jorge MARTINS, Senhorinha TEIXEIRA & Stijn COENE," Design Of An Inlet Track Of A Small I. C. Engine For Swirl Enhancement", 20th International Congress of Mechanical Engineering, Gramado, RS, Brazil, November 2009, pp. 15 - 20.
[9] P. Ramakrishna Reddy, K. Govinda Rajulu and T. Venkata Sheshaiah Naidu," Experimental Investigation on Diesel Engines by Swirl Induction with Different Manifolds", International Journal of Current Engineering and Technology, February 2014,pp. 488 - 492.