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Experimental Investigation of Air Swirl Technique in C.I Engines

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***Abstract*- Swirl is the rotational flow of air with in the cylinder about its axis. It will ensures proper mixing of fuel-air in cylinder and increases the efficiency of combustion process, but also has a significant impact on heat transfer, combustion quality, engine raw emissions. For generating swirl efficiently, many researchers have been performed, under normal conditions, without air swirl the mixing of fuel-air is poor which leads to incomplete combustion causes the emission of un-burnt carbons. Due to these circumstances the performance of C.I engine is low, not only the performance it also effects the emissions which are polluting the environment due to un-burnt fuel, CO (Carbon-monoxides).Hydrocarbons. For overcoming these problems and generates more efficient swirl during the intake process, we design a new swirl generating device, to induce intake swirl in intake manifold of diesel engine. In this project, we designed four types of new swirl generating devices including one circular plate, Fan, cone and convergent-divergent profiles.**

By inserting the swirl generators in intake manifold, we analyzed and evaluated the performance and emissions of a C.I engine. Finally, we suggest the most appropriate model which gives the better result is cone with 8 blades.

I.INTRODUCTION

In CI engine after suction of air into the combustion chamber, the compression stroke begins and then at the end of compression stroke fuel is injected at very high velocities in one or more jets. The fuel gets atomized due to high velocity injection and vaporizes due to high temperature. The fuel reaches the self-ignition temperature and thus combustion begins. In CI engines the following combustion phases taking place in expansion stroke is divided in following phases:

- Ignition delay - This is the period between fuel injection initiation and beginning of combustion
- Premixed or rapid combustion phase - The fuel accumulated in the combustion chamber ignites as the fuel reaches its self-ignition temperature. High heat release rate is obtained during this phase.
- Mixing controlled combustion phase - The burning rate in this phase is of controlled manner and the heat release decreases in this phase.
- Late combustion phase - Heat release rate is lowest in this phase, as small amount of fuel is available for burning.

In CI engine the fuel when sprayed into the combustion chamber, the fuel droplets are larger than the diameter of nozzle at lower jet speed, called as Rayleigh regime. The break up in this regime is due to unstable growth of surface waves caused by surface tension.

As the jet velocity increases, forces due to relative motion of jet and surrounding also increase which are higher than surface tension force and thus resulting in breakup of fuel into drop size equal to jet diameter. This is called first wind induced break up regime. Further increase in jet velocity decreases the drop diameter thus atomizing it.

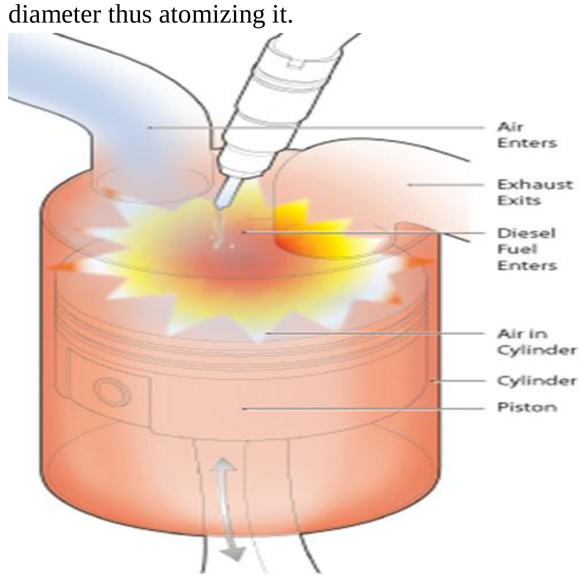

Fig.1.1Combustion Process

II LITERATURE SURVEY

A well-designed intake manifold and cylinder head will reduce the flow resistance and increases the swirl. Swirl is the rotation of charge about cylinder axis, and it is used in SI engines to speed up the combustion process, and in the diesel engines to control the air-fuel mixing [6]. Two general approaches are used to create swirl during the induction process. In the first approach, swirl is created by discharging the flow into the cylinder tangentially towards the cylinder wall (helical port) and in the second approach, the swirl is generated in the manifold runner so that the flow rotates about the valve axis before it enters the cylinder. Several research studies related to Concept for different Swirl generating devices is developed taking into consideration turbulence, behaviors of air flow through pipes these devices are modeled taking into

Consideration their installation into intake air flow duct after carburetor. Total 3 such devices are modeled and their flow performance is compared with base system (Without any swirl device).Developed swirl device can be inserted into intake duct of Engine as mentioned in Fig.1. Capability of device to produce variable swirl is also explored. On basis of device geometry devices are named as vane type, Blade type and Deflector type. The shape of the geometry is modeled like that it should give efficient angular momentum to the charge but without affecting to the volume flow rate so less resistance to the charge. Devices are shown in following Fig.

Fig. 2.2: Marked location of device on engine.

In this flow rate of charge is held constant, with known velocity and pressure conditions at inlet. With some modifications in inlet duct swirl device is introduce.

The geometry of devise is made such that it will offer minimum resistance to flow and minimum vortex are generated after air pass through device.

Resistance offered by device to flow is prime factor. Since volumetric efficiency of SI 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. 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. The combustion efficiency in the combustion chamber depends on the formation of homogeneous mixture of fuel with air. The formation of homogenous mixture depends on the amount of swirl created in the combustion chamber. This further increases the thermal efficiency of the engine. This investigation leads to improvement in performance,combustion and emission characteristics of a D.I diesel engine through methods enabling improvement in ignition characteristics of the fuel by generating turbulence in the cylinder, for the achievement of better fuel air mixing.

To enhance the efficiency of an engine it is important to optimize thermal efficiency, which is obtained at the highest possible compression ratio. However, if the compression ratio is too high, there is a chance to have knock, which should be avoided at all cost. A solution for this problem is to promote rapid combustion, to reduce the available time for the self-ignition to occur [12]. For the promotion of rapid combustion, sufficient large-scale turbulence (kinetic energy) is needed at the end of the compression stroke because it will result in a better mixing process of air and fuel and it will also enhance flame development. However, high turbulence leads to excessive heat transfer from the gases to the cylinder walls, and may create problems of flame propagation

[13, 14, and 15]. The key to efficient combustion is to have sufficient swirl in the combustion chamber prior to ignition.

The Swirl can be generated in the diesel engine by modifying three parameters in the engine, they are the cylinder head, the piston i.e. modification of combustion chamber and the inlet manifold [16]. Lin.et.al[17] has invented a multi impingement wall head is located at the center of the cylinder head to enhance the swirl and squish Somendersingh[18] has identified a method to improve turbulence in combustion chamber by making grooves on the cylinder head, to reduce the heat losses. The burn time needs to be as quick as possible. According to Al-Rousan[19] swirl is generated in the -inlet manifold by inserting a loop inside the intake manifolds to increase the swirling in the air during induction

III. EXPERIMENTATION

Fig 3.1 Four stroke 1-cylinder diesel engine Experimental test rig with computer interface

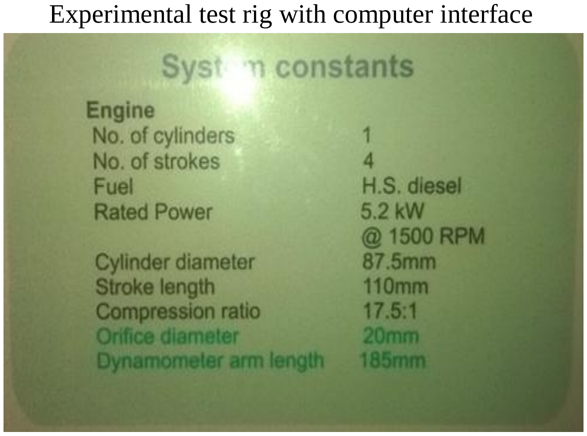

Fig.3.2Test Rig Specifications

Fig 3 Circular Plate with Holes

SPECIFICATIONS:
1. External Diameter = 45 mm
2. Outer periphery of holes Diameter = 40 mm
3. Number of holes in Outer periphery = 9
4. Inner periphery of holes Diameter = 20 mm
5. Number of holes in Inner periphery = 5
5. Center hole Diameter = 7 mm
6. Periphery holes Diameter = 4 mm
Note: All the holes are drilled at equidistance.

FAN

Fig.4.Fan

SPECIFICATIONS:
1. External Diameter of casing = 45 mm
2. Internal Diameter of rotor = 26 mm
3. Number of wings = 7

4. Angle of wing normal to plane at inlet = 300
5. Angle of wing normal to plane at exit = 700

CONICAL PROFILE

Fig Front view of the conical swirl generator

Fig 6 Top view of the conical swirl generator

SPECIFICATIONS
1. Outer Diameter of cone = 50 mm
2. Inner Diameter of cone =36 mm
3. Length of cone =65 mm
4. Number of blades=8
5. Blade angles tangent to plane=600,800

CONVERGENT DIVERGENT CONE

Fig. 7 Top view of the convergent-divergent swirl generator

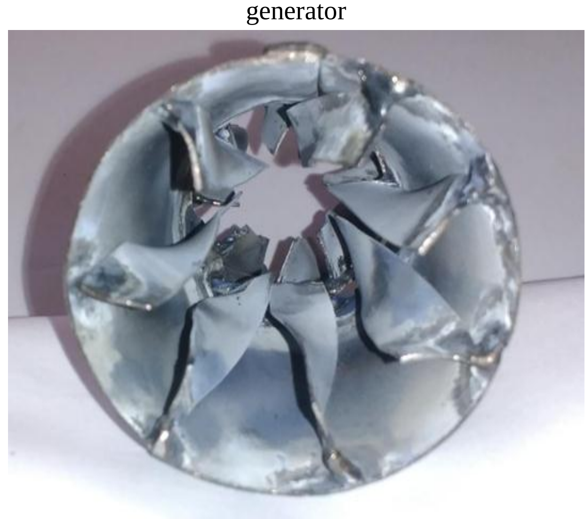

Fig.8 Front view of the convergent-divergent swirl generator

SPECIFICATIONS
1. Diameter of cone at Inlet and Exit = 50 mm
2. Throat Diameter of Convergent-Divergent =36 mm
3. Length of Convergent-Divergent =130 mm
4. Number of blades =7, 8
5. Blade angles tangent to plane = 60&80deg

IV. EXPERIMENTAL PROCEDURE

First of all the Engine test rig is connected to computer and checked out the connections.
Then we checked the water connections to dynamometer and fuel level in the tank.
The engine is started by cranking it with the help of a self-starting motor.
Run the engine in ideal no load condition for some time so as to stabilize the readings.
Then gradually increase the load by applying load on electrical dynamometer through transformer.

Run the engine in the applied condition for some time so as to stabilize. Then we can note the readings.

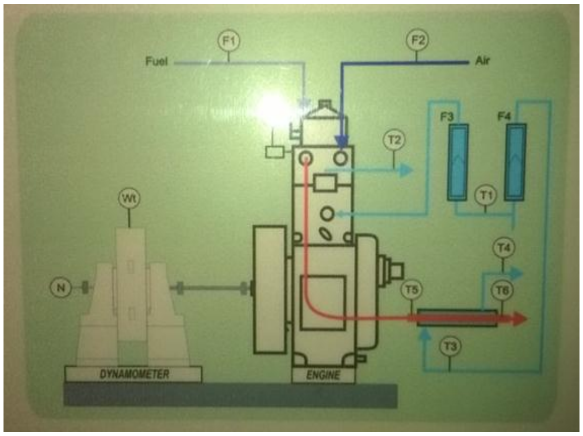

Fig.9 Operation manual guide

By following the above manual take down the readings

After noting down the results increase the load in to another level.

Repeat the same steps for noting the different values at different loads.

Take the readings for 10c.c of fuel so that specific fuel consumption may find out.

Take down the emission readings for every load.

Now, insert the swirl generators in intake manifold and repeat the experiment.

First detach the hose going to intake manifold and then insert the swirl generators in the manifold.

Reattach the hose and make the joint tight so that no air will leak from the hose pipe.

Then restart the engine and run in ideal condition for some time.

Then load the engine and take down the readings.

Similarly, not down the soot emissions at different loads.

We can directly get the operational data from the computer.

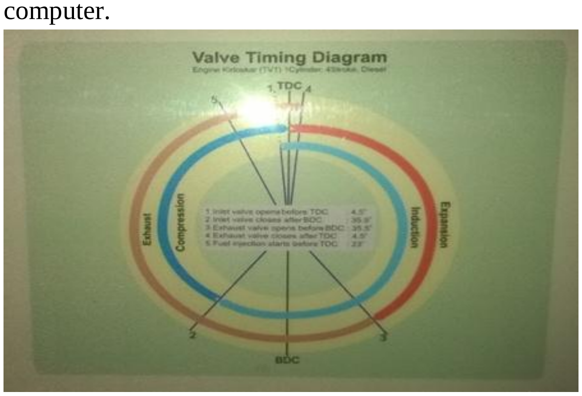

Fig.10 Valve timing diagram of test rig

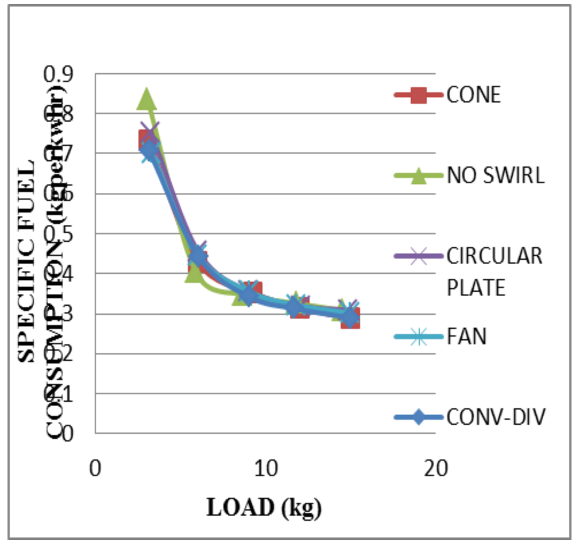

Fig 11 Load Vs Specific Fuel Consumption

V. CONCLUSION

Thus from the above figures we can conclude that Cone type geometry generates high swirl as compared to others. The performance level of cone is better in all the cases. It produces a highest Brake power value of 4.2kw at full load. Brake thermal efficiency is increased to 29.79% where without swirl Brake thermal efficiency is 26.86%. It gives 100% volumetric efficiency at full loads. We can say that it reduces the fuel consumption i.e., 0.288kg/hr which is the least value in this analysis. By using cone type swirl generator we reduced soot emissions to 45.9%.

VI. FUTURE RECOMMENDATTIONS

1. The blade angles at inlet and exit should be varied and tested.
2. The slenderness of the cone may increase the velocity of air.
3. Number of blades should be varied i.e., minimum to maximum as possible in the conical profile.
4. Note that flow area should not be restricted. As low availability of air may causes incomplete combustion and increases the emissions.
5. Circular plate design should be modified by increasing the hole diameter. Which should offer minimum flow resistance.
6. Cylindrical profile with diffuser design may also perform better.

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