A Novel Design and Computational Fluid Dynamics of Swirl Flow Enhancing Device in Intake of IC Engine

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Abstract— The present paper work is directed to a device located at the intake port at the junction of the intake manifold and the engine head. This location allows the device to be used with any type of carburetor or fuel injection system. It is the object of the present device to utilize at least three fixed, helically twisted blades to impart additional swirl mixing of the fuel/air mixture. This fuel/air mixture has already been pre-heated by its travel through the intake manifold. The "violent swirl" created by the device provides a more uniform fuel/air mixture, thereby causing a more complete and efficient combustion. The overall result of using the device is better gas mileage, increased performance, easier starting, and less pollution. The object of the project work to improve the fuel/air mixture of the fuel injected engines, preventing valves from being burned or eroded by clogged injectors. As a result of forcing the air to enter the intake port in a high velocity swirl, there is disruption of any direct fuel streams upon the head of the cylinder intake valve which occur as a result of clogged injectors. Another object of the project work is to provide a device that improves the homogeneity of the fuel/air mixture delivered by the carburetor to the cylinders of an internal combustion engine with little or no obstruction in the mixture flow resulting in no starving of the engine. Another object to deliver the fuel/air mixture to the center of the cylinder for a uniform flame front. The swirling mixture delivered by the present invention results in cleaner, more-efficient combustion.

Key words: Internal Combustion Engine, Swirl, CATIA V5, Computational Fluid Dynamics (CFD)

I. INTRODUCTION

The present paper work is directed to a device located at the intake port at the junction of the intake manifold and the engine head. This location allows the device to be used with any type of carburetor or fuel injection system. It is the object of the present device to utilize at least three fixed, helically twisted blades to impart additional swirl mixing of the fuel/air mixture. The strategic location of the device in the flow path creates the violent swirl of the fuel/air mixture immediately before and as the mixture enters the combustion cylinder. This fuel/air mixture has already been pre-heated by its travel through the intake manifold. The "violent swirl" created by the device provides a more uniform fuel/air mixture, thereby causing a more complete and efficient combustion. The overall result of using the device is better gas mileage, increased performance, easier starting, and less pollution. It is another object of the project work to improve the fuel/air mixture of the fuel injected engines, preventing valves from being burned or eroded by clogged injectors. As a result of forcing the air to enter the intake port in a high velocity swirl, there is disruption of any direct fuel streams upon the head of the cylinder intake valve which occur as a result of clogged injectors. The device requires no modification to the basic combustion engine. The configuration and size of the invention will vary according to the type of intake opening found in the various four-cycle internal combustion engines, whether one cylinder or more, whether in-line, opposed, V-type, or radial engines. In this work for design CATIA V5 and for analyzing CFD software for analyzing swirl flow.

II. GEOMETRY DESIGN

The schematic diagram of the swirl device usage is as shown in Figure1.

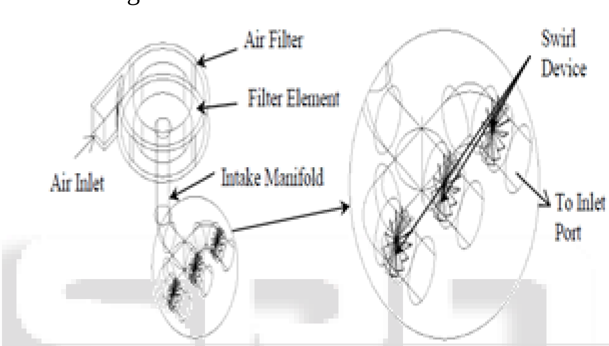

Fig. 1: Schematic Diagram of the Airflow Including the Swirl Device

Wing structure of air swirling device for internal combustion engine, which has a swirling device body mounted in the air flow system of the engine, a plurality of wings mounted slantingly and radically on said swirling device body for accelerating or increasing an airflow revolution, and one or more slits formed on prescribed positions of said plurality of wings for suppressing the formation of eddy in a negative pressure zone on the rear surface of each of said plurality of wings, said wing structure comprising: a plurality of auxiliary wings protrudly provided to the outside with reference to the surface of each of said plurality of wings, so that the airflow collided against the surface of each of said plurality of wings goes straight ahead. A wing structure of air swirling device for internal combustion engine, which has a swirling device body mounted in the air flow system of the engine, a plurality of wings mounted slantingly and radically on said swirling device body for accelerating or increasing an airflow revolution, and one or more slits formed on prescribed positions of said plurality of wings for suppressing the formation of eddy in a negative pressure zone on the rear surface of each of said plurality of wings, said wing structure comprising: one or more airflow holes formed at prescribed positions for reducing airflow resistance due to eddy generated at a negative pressure zone of each of said plurality of wings; and a plurality of auxiliary wings protrudly provided to the outside with reference to the surface of each of said plurality of wings, so that the airflow collided against the surface of each of said wings go straight ahead. A wing structure of an air swirling device used in an air cleaner or an air duct of an internal combustion engine, which induces a swirl action of air filtered through an air cleaner of a spark ignition internal combustion engine of a carburetor or fuel injection type, a diesel engine, and so on. The wing structure of the swirling device introduces airflows into a combustion chamber of the engine, which is effective in reducing resistance due to negative pressure and eddy formed on the wings in the air swirling device, thereby improving processibility of the wings and increasing the amount of air flow and the speed of air flow in the combustion chamber.

Fig. 2: Swirl Enhancing Device with Inlet Manifold

III. Equations Used

BP = (2×π×N×T)/60 Kw
TFC = (density of petrol × volume)/time in sec. Kg/hr
SFC= TFC/BP Kg/Kwhr
BTF= ((BP×3600)/ (TFC×CV) ×100 %
ITE = ((IP×3600)/ (TFC×Cv)) ×100 % (Calorific Value, Cv of petrol = 44835 KJ/Kg)
IP= BP+FP

IV. Experimental Setup

A. Test Rig Specifications:

1) Engine:

Four Cylinder Four Stroke vertical water cooled variable speed petrol engine. 'PAL' make .the engine is provided with clutch plate, cover assembly Bell housing, accelerator control, self start motor, dynamo, battery ignition switch, HT coil, cutout, solenoid switch etc.

- Bore: 73mm
- Stroke: 70mm
- Compression Ratio: 9:1
- Loading device: Froude's dynamometer
- Flow rate: 300 lpm
- Torque Arm Length: 410mm
- Fuel arrangement: 3-way clock connecting tube.
- Air intake measurement: Air intake reservoir with orifice plate and differential manometer.
- Multi-channel Digital Temperature Indicator to measure the temperature at various points.
- A sensor with digital panel: to indicate the RPM.

V. Results & Discussion

The device enhances the turbulence and hence results in better air-fuel mixing process among all the configurations of diesel engine. As a result, the thermal efficiency is increased and SFC and soot emission are reduced. It can be concluded that MM8 is the best trade-off between performance and emissions. Based on this investigation, the following conclusions are drawn: More power output is derived from the same given charge. Lesser emission due to far more complete combustion is provided and lesser carbon deposits in the combustion chamber, piston crown and exhaust system occur due to controlled complete combustion. There is no pinging or detonation or auto ignition due to reduced temperature in the combustion chamber and no residue of unburnt fuel. There is better fuel economy due to improved and complete combustion.

A. Simulation Results:

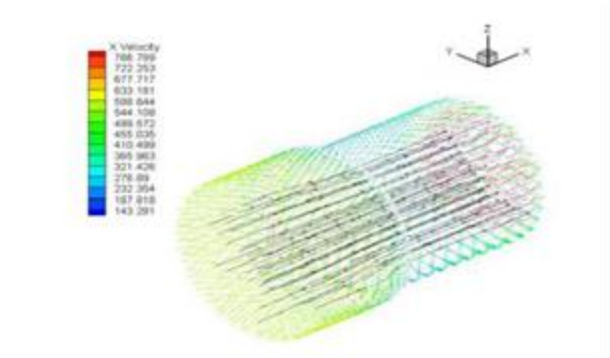

Fig. 3: Simulation Result with Out Device

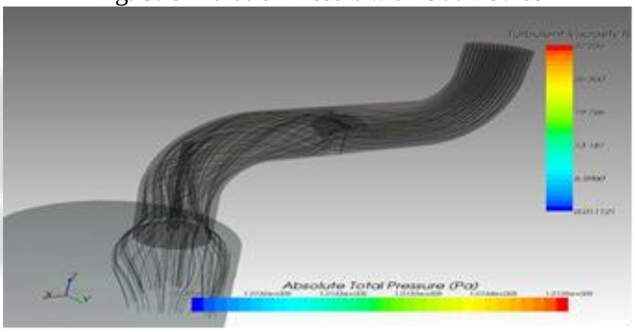

Fig. 4: Simulation Result with Device 1

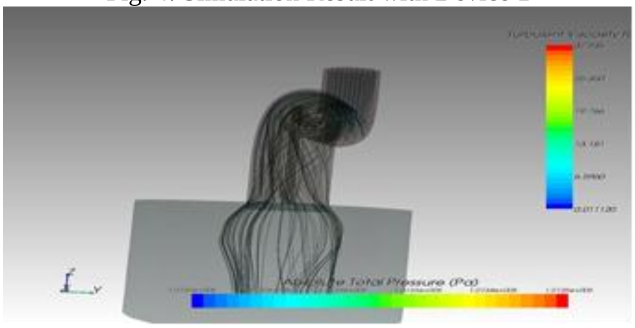

Fig. 5: Simulation Result with Device 2

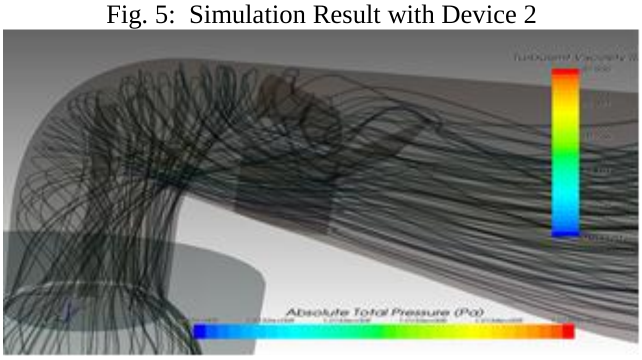

Fig. 6: Simulation Result with Device 3

Simulation with Engine Speed 1500 rpm the swirl device is simulated to detail the air flows. If the blade is taken out from the swirl device, the result shows that the intake manifold will not create a swirl flow before the mixtures enter the cylinder. The intake mixture will flow straight following the shape of the intake manifold. The simulation results of the swirl device are shown in Figure 2 shows that the air motion is straight at the inlet and change direction following the blade angle when the flow reaches the blades. It is because the blades act as guide vanes to guide the flow to change direction before flow through the blades and the swirl motion of the intake mixture created. Based on the simulation results, the following conclusions are drawn concerning the swirl created. Swirl will be generated after flow through the swirl device. The swirl device will increase significantly the swirl ratio when smaller blade angle used in the swirl device.

VI. Conclusion

Based on the simulation results, the following conclusions are drawn concerning the swirl created. Swirl will be generated after flow through the swirl device. The swirl device will increase significantly the swirl ratio when smaller blade angle used in the swirl device. And as per the experiment slight change in performance is occurred. By improving the existing design can create device without any frictional loss and By varying the design and number of blades we can reduce the eddy generation at negative pressure zone of the rear surface of the blades. Thus the carbon monoxide (CO) levels can be reduced up to about 17% at engine idle speed, the engine power can be increased up to about 11%, fuel economy can be improved to about 6%, and knocking of the engine can be reduced up to about 5%.

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Appendix

BP	Brake power
TFC	Total Fuel Consumption
SFC	Specific Fuel Consumption
IP	Indicated Power
ITF	Indicated Thermal Efficiency
BTP	Brake Thermal Efficiency