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Emission Characteristics Of Two- Stroke Si Engine With Direct Fuel Injection (Dfi)

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ABSTRACT
Emission reduction and enhanced efficiency are the prime requirement for present day automotive engines. 2-Stroke IC Engines have definite advantages when compared to 4-Stroke IC Engine in terms of weight, power, and cost. 2 stroke IC Engine has the ability to produce greater power than 4 stroke IC Engines for the same displacement volume of the cylinder. Reduction in emissions along with SFC of such engines still makes them a viable alternative for their use in light motor cycles and micro light aircrafts. Extensive review of the available literature on the subject reveals that systematic methodology for choosing the right piston chamber geometry, location of inlet and exhaust port with respect to the transfer port, intake / exhaust port, opening and closing timings could be optimised for a given operating compression ratio and fuel composition to increase the efficiency of such engines. The present paper discussus the influence of direct fuel injection instead of supplying the air fuel mixture through a carburetor, on the performance of the 2 stroke cycle SI engine. A DFI system has been incorporated into the test engine by modifying its combustion chamber and bypassing the carburetor system. The performance of the engine and the emission characteristics have been studied at various operating conditions.

Keywords - DFI, Scavenging and Emissions

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I. INTRODUCTION

The advent of the automobile engineering has transformed the entire world in almost 150 years, of the recent history of mankind. A major point of transformation came, with the advent of internal combustion engines by Carl Benz, in Germany, and contemporaries. In this century, millions and trillions of vehicles have swarmed over the entire world on land, sea and air. All were the developments of internal combustion engines of various origins. Almost all use the petroleum based hydrocarbons, ranging from crude oils to diesel, furnace oils, and automobile, gas, petrol and aviation fuels. As a result, obviously the pollution problems, global warming has engulfed the entire globe. Mankind is witnessing the great upheavals in climatic changes and the major contributors are the internal combustion engines of various types. On the other hand, the greatest and the biggest advantage of the two strokes engine over their four stroke counterparts is that they have comparatively high power/weight ratio and excellent acceleration characteristics. However, their performance is purely dictated by the process of scavenging, which is a primary factor affecting the quality of trapped conditions and hence the power output. The scavenging process is very complex and it is difficult to represent it in a comprehensive model in any accurate manner other than by the application of computational fluid dynamic (CFD) methods which also present their own difficulties in application especially with reference to the formulation of boundary conditions. Further, it is important to mention that the direct fuel injection system has emerged as an improvement over the conventional engine technology which uses carburetor based fuel injection. Thus, DFI has lead a path into new era of revival of existing 2 stroke engine and some four stroke engines. It holds the key to a major transformation from older engines to new retrofitted engines to become more fuel efficient and less polluting engines.

The automotive industry by and large, is focusing its design and research towards development of direct fuel injection engines relegating the needs of two stroke engines to certain

specific applications like small industrial and agricultural implements, micro light aeronautical power plants where power/weight ratio is of utmost significance. This aspect combined with the fact that there are no published data available that deals with the optimization of the location of inlet, exhaust and transfer ports with reference to the specific bore and stroke of the two stroke engine, have led the present investigation to focus on this aspect in the conceptual design and development of a new technology, direct fuel injection, two stroke cycle engine.

The scavenging process which is part of the thermodynamic cycle of two stroke cycle engine is expected to be fully controlled by the proper porting of the cylinder with specific relation to its bore and stroke. There is an urgent need to find an alternative path which reduces emissions and use alternative technology or modify the existing technology till we evolve better technology which is less polluting ones. In view of this, the approach followed is to go in for modification in the available engine technology and incorporate the technology which is less polluting and more fuel efficient. A comparison of the combustion characteristics, emission characteristics as well as the performance characteristics between the conceptualized engine and conventional two stroke engine is also planned to be included in this study for experimental validation.

II. LITERATURE SURVEY

Two stroke engines have definite advantages when compared to four stroke engines in terms of weight, power and cost. 2 stroke engines have the ability to produce greater power than 4 stroke for same displacement [1]. Reduction in emission and efficient fuel economy can help in increasing the utilization of these engines. The emergence of efficient engine basically depends on greater fuel economy and emissions of exhaust gases. The piston geometry profile, mixture ratios and accumulation of air fuel mixture at the spark plug are few more criteria's which decide the overall performance of the engine [2]. Shivam Kumar et al., reviewed direct injection 2 stroke engine and also analysed by using CREO and ANSYS software's. The results showed more control over combustion, improved efficiency, reduced emissions at lower speeds and enhanced power output [3]. Ajay Kumar Singh, et al have also presented a paper on direct fuel injection system for gasoline fuel. Many drawbacks encountered by carburetor system was overcome by using DFI. [4]. copious piston designs have been tried to identify the improvement either in terms of emissions or performance. Combustion surface modifications have brought about visible changes in the output, reduction in HC emission, improved IMEP and better inflow characteristics. However, NOx is noticed to increase with this design. [5] There are various methods of mixture preparation in 2 stroke engines. The conventional method by using carburetor is widely used since the conception. However, the drawbacks with this concept led to emergence of different methods to improve the fuel economy and emission reduction. Improper scavenging is one of the core reasons for increased emission in 2 stroke engine. Numerous researchers have claimed application of GDI in 2 stroke would improve scavenging and in turn reduce the emissions [6-7]. Lamas and Carlos et al., developed a numerical simulation model to simulate fluid flow and heat transfer processes inside the cylinder. The experimental and simulated results had no much variation. However, this design was developed only for the study of scavenging process [8].the studies was also conducted and concluded stating that mixing of alcohols to fuel increases the octane rating than any other additives. However, using these blends in 2 stroke engine is not viable due to overlapping port timings and inefficient scavenging [9]. Ashraf Elfasakhany et al. have studied emission analysis by mixing ethanol and methanol. It was observed to see the reduced emission with these blends. CO and UHC emissions were drastically reduced with this mixture [10]. Scavenging plays a greater role in determining the overall performance of the engine. The contamination of lubricating oil increases with improper scavenging and also the wall temperatures of the cylinder enhances due to improper scavenging. Hence, the process of scavenging plays an important role in reducing the emission and increasing the overall efficiency of the engine [11, 12, and 13].

The advancement and advantages of usage of DFI (Direct Fuel Injection) in 4 stroke engines have drastically helped in improvement of power and reduction in emission. The same concept being extended to 2 stroke engine will enhance the overall performance of 2 stroke engine. The combination of DFI with engine management system will also help in calculating the precise mixture for combustion. The change in loads can be adjusted for DFI and can precisely send lean, stoichiometric or rich mixture [14]. Ali S Faris et.al. Studied the magnetic effects on fuel consumption and exhaust emissions. The maximum level of fuel was reduced to 14%. Also the exhaust gas components like CO and HC were reduced by 30% and40% respectively. However, CO2% was increased by 10% [15]. The utilization of DFI in 2 stroke engine is being implemented in this paper and the emission characteristics with this modification are studied. The main objectives of this design include effective utilization of air fuel

mixture and enhanced scavenging with reduced pollution.

III. EXPERIMENTAL DETAILS

A standard two stroke cycle engine of small displacement 100-150 cc is selected and a test rig is set up with all the required instrumentation for obtaining cylinder pressure crank angle (p-θ) diagrams, fuel flow, engine speed and emission. The conceptualized engine is built from scratch as per the design details to facilitate direct fuel injection at the required injection timing (which is made of variable adjustable) with fully controlled scavenging process. A comparison is made with regard to the combustion characteristics; performance characteristics as well as emission characteristics of the two engines (of similar cubic capacity) as stated above for experimental validation of the new proposed design. The existing carburetor system and proposed system by DFI (direct fuel injection) is being projected in the figure 3.1 and 3.2 respectively.

The conventional 2 stroke engine works with carburetor as a main part. Figure 3.1 gives a brief block diagram explanation of conventional form. The air flow from the inlet is sprayed with evaporated fuel from the fuel jet and converts it in to proper air fuel mixture. This flows into the inlet manifold of engine. The air fuel mixture is ignited by the spark plug, with timer device. The combustion gas expands and converts heat energy in to mechanical energy by piston crank shaft combination. The timing of spark plug is controlled by timer circuit attached with crank shaft. The system works well with proper load and torque, but in idling condition, or low load, lot of unburnt fuel is lost in the process of scavenging and short circuiting of fresh air fuel mixture and combusted gasses. The valves operations of inlet and outlet valves show some problems due to which scavenging is not perfectly matched.

The present investigation is described by a schematic drawing in a simple way. The detail design of each component, circuits and parameters come under classified information. For simplicity we are referring to the block diagram representing the system. The heart of the system is engine combustion chamber head. The two stroke engine is driven by petrol, as a fuel. Where fuel is injected by fuel injector operated by fuel injection circuit which is controlled by electronic circuit and the trigger is given by a sensor. The other portion of the engine describes the spark ignition system where spark is generated by spark ignition circuit. It is operated by timer device integrated to crank mechanism. The interlinking of both the circuit namely fuel injection system and spark ignition system are done through the timer and sensor located within crankcase and a crank mechanism.

The working of conceptual design and development of fuel injected, two stroke cycle, SI-Engine with improved scavenging efficiency. The new technology dispenses with the conventional fuel supply system based on the carburetor and replaces it by an advanced fuel injection system. The fuel is injected by fuel injector operated by fuel injection circuit which is controlled by electronic circuit and the trigger is given by a sensor. The other portion of the engine describes the spark ignition system where spark is generated by spark ignition circuit. Operated by timer device integrated to the crank mechanism. The inter link of both the circuit namely fuel injection system and spark ignition system are done through the timer and sensor located within crankcase and a crank mechanism. The new engine is tested for emission characteristics.

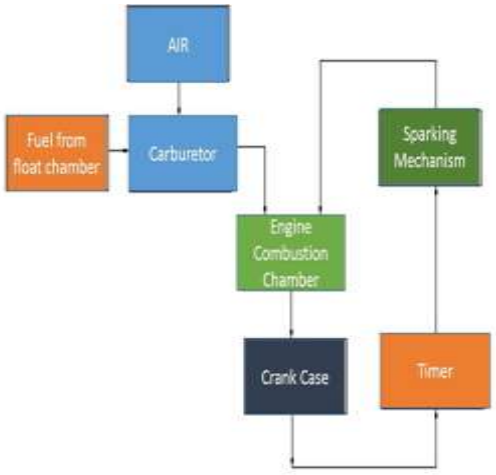

Fig 3.1: Block diagram of conventional two stroke SI-Engine.

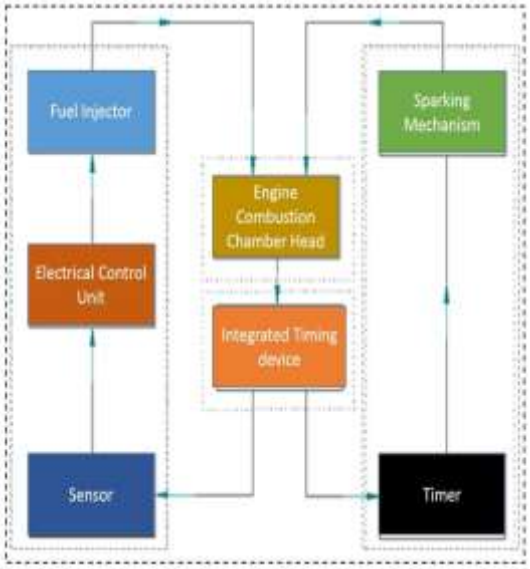

Fig 3.2: Block diagram of modified Two Stroke SI-Engine (DFI-System)

The conventional 2stroke, SI- Engine of the Bajaj Auto rickshaw is modified to incorporate the fuel injector. The fins of the head are partially cut with minimum disturbance, to accommodate the direct fuel injector and a clamping stud bolt. The hole is fitted with proper sleeve, press fitted and tightly bolted to hold the fuel injector and mounting. The joint is tightly fit so that it takes care of high pressure inside the head, shock waves, knocking if any and larger temperature variation if any. Figure 3.3 and 3.4 depicts the conventional and modified engines designs respectively.

Fig 3.3: Conventional 2 stroke engine

Fig 3.4 Modified DFI 2 stroke engine

IV. RESULTS AND DISCUSSION

Figure 4.1, 4.2, 4.3 shows graphical representation of variation of CO, CO2 and HC emissions respectively recorded with respect to speed in a modified 2 stroke engine attached with and without direct fuel injection system. From the graph it is clear that there exist a clear variation with the use of injector for CO, CO2 and HC emissions studied. Usage of direct fuel injection system has significantly reduced emissions for all the three cases studied. It is observed from the graph that CO, CO2 and HC emissions have been drastically reduced with direct fuel injector. The placement of DFI and injection timing plays a great role in reducing these losses from 2 stroke engine. Complete combustion and efficient temperature at the power stroke clubbed with improved scavenging have helped in achieving the reduction in losses.

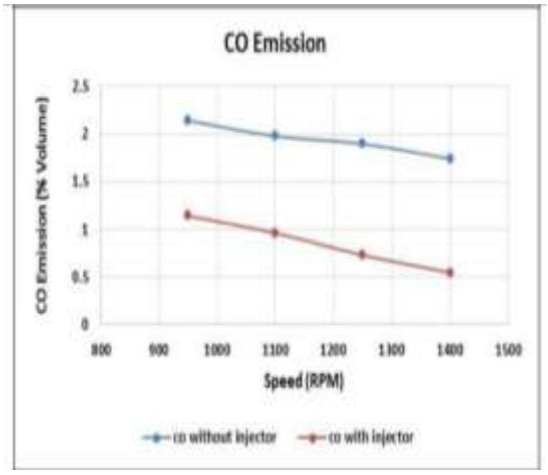

Fig 4.1: Speed v/s CO Emission

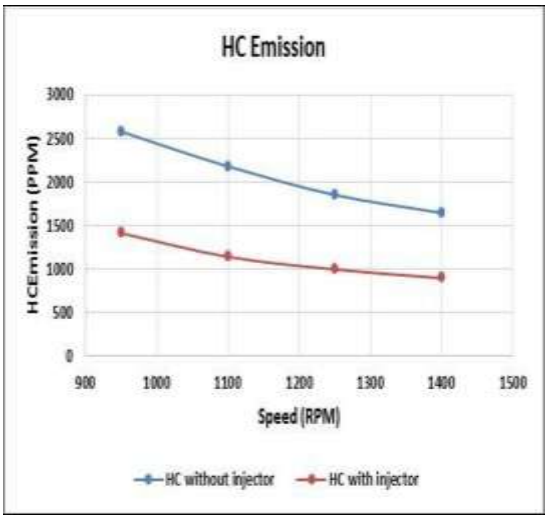

Fig 4.2: Speed v/s HC Emission

As the speed increases, it is observed that there is a marginal decrease in the emission of all the three gases CO, CO2 and unburnt HC. CO emissions have dropped down from 1.8gm/km to 0.5gm/km, which shows 46% reduction in the CO emissions. Owing to complete combustion by inducing stoichiometric quantity of fuel to air, reduces CO to CO2. The reduction is observed from idling rpm to

higher rpm. 43% reduction of HC and reduction of CO2 by 21% can be observed with results.

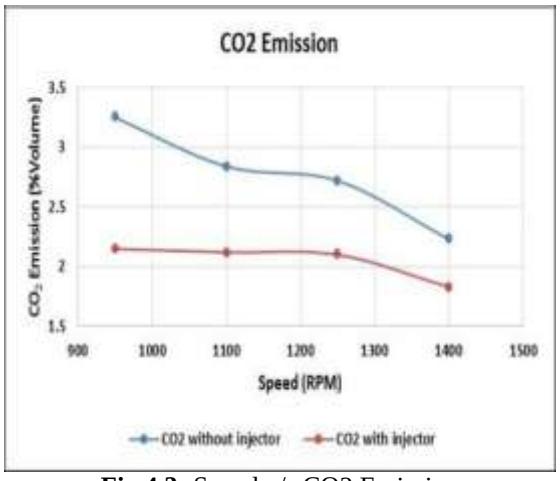

Fig 4.3: Speed v/s CO2 Emission

The emergence of HC emission basically arises due to improper air fuel mixture and patchy combustion process. The accumulation of uneven mixture at various positions in the cylinder will also enhance the HC emissions. Figure 4.2 indicates the reduction of HC with increased speed. 43% reduction of HC and reduction of CO2 by 21% can be predicted with above results.

V. CONCLUSION

The scope of using DFI in the two stroke engine as proven to be viable for its commercial use on all two stroke petrol engines with appropriate change in the fuel induction system. Significant reductions in CO, CO2 and HC have been observed with usage of direct fuel injection system. With implementation of fuel injector in the experimental engine a maximum of 46%, 21% and 43% reduction in CO, CO2 and HC have been recorded.

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