EXPERIMENTAL INVESTIGATION ON EXTERNALLY SCAVENGED S. I. ENGINE

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ABSTRACT

Two stroke crank-cased spark ignition engines have high exhaust emissions and low brake thermal efficiency due to the short-circuiting losses and incomplete combustion, which occur during idling and at part load operating condition. During short-circuiting, fuel air mixture may be lost directly to the exhaust port resulting in increase in the raw pollutant emission with increase in fuel consumption. Externally scavenged engine is developed to eliminate the short-circuiting losses. In this research study, an attempt has been made to improve scavenging characteristics of two stroke engine. Experimental investigations have been carried out at various valve openings. Externally scavenged engine gives superior performance as compared with crank-cased engine. Performance parameters like BP, BSFC, delivery ratio, scavenging efficiency are also improved.

KEYWORDS: Brake Power, Externally Scavenged Engine & Emission Analysis

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1. INTRODUCTION

The two-stroke engine is relatively small in size and has higher power to weight ratio, simplicity of operation with less cost. However, these engines have high exhaust emission and low brake thermal efficiency due to short-circuiting losses and incomplete combustion. Many researchers have worked on the improvement of scavenging systems for improving performance and reducing exhaust emission.

The concept of providing hole in transfer port for aspiration of air is an attractive proposition for eliminating drawbacks of two-stroke engine. This system needs detail investigation in terms of its performance evaluation, exhaust analysis, formulation of models and its simulation.

Scavenging process has direct impact on the performance and exhaust emissions of two stroke engine. Poor scavenging leads to decrease in the power developed and increase in the exhaust emissions. Therefore, it is necessary to develop an effective scavenging technique, so as to avoid dead loss and improve the performance.

2. LITERATURE REVIEW

The development in the field of two stroke SI engine with comparison of various scavenging process have been reviewed. Literature survey was carried out as per the following categories.

- Design, Modification and Performance improvement. This comprises of
 - Effect of direct fuel injection on engine performance.

- Feasibility of supercharger for scavenging purpose.
- Performance improvement by direct CNG injection.
- Numerical and computational study

The research work carried out by various researchers supported by experimental setup was reviewed. This review justifies the importance of the current research work.

Direct CNG injection is carried out to eliminate the loss of fresh charges due to short-circuiting phenomenon. It was observed that there was improvement in brake thermal efficiency from 15.2% to 24%. Also, the pollution levels of HC and CO were reduced by 20% and 22% respectively, compared to a conventional carbureted engine.

Few researchers focused on the optimization of inlet ports and combustion chamber geometry to reduce raw pollutant emissions of fuel-air mixture during scavenging. Researchers also analyzed the effect of direct fuel injection on the performance and exhaust emissions.

Research was carried out on numerical and computational study of two-stroke engine. In-cylinder flow was analyzed to predict temperature and pressure distribution inside combustion chamber. The pressure inside cylinder and intake port were collected and applied for validation with numerical results. It was observed that higher rpm mode produced higher cylinder pressure than lower rpm. Relative error between experimental and numerical results was found to be less than 2%.

From the literature review, it was found that higher exhaust emissions due to short-circuiting phenomenon are the major problem associated with the two-stroke engine. External air aided scavenging is one of the possible alternatives to avoid short-circuiting phenomenon.

3. PROBLEM FORMULATION

In two stroke engine, short-circuiting is the major cause for poor performance and high exhaust emissions. In this research work, an additional provision was provided to regulate the flow of extra air into the combustion chamber. This modification pushes the un-burnt gases outside the combustion chamber, thereby improving the performance of the engine.

4. EXPERIMENTATION

The experimental trials were conducted on single cylinder two-stroke SI engine using a standard test rig with eddy current dynamometer. The main specification of the engine is shown in table 1.

Table 1: Technical Specification of the Engine

Performance		
Peak Power	8.0 hp at 5500 rpm	Highest power amongst 2-stroke scooters
Peak Torque	1.35 Kg at 3500 rpm	Instantaneous pick-up
Engine		
Type	5-port single cylinder, 2-stroke with reed valve	Advanced engine for superior performance
Transmission	4-speed gear box	Smooth easy shifting
Operating cycle	Two-stroke spark ignition, 150 cc engine	
Compression ratio	6-10	

Table 1: Contd.,	
Bore	0.05-0.085 m
Stroke/bore ratio	1.2-0.9
Max rated BMEP	4-10 Atm.
Wt/power ratio	5.5-2.5
Approx. Best BSFC	350 (gm/kW hr)

5. RESULTS AND DISCUSSIONS

Performance and exhaust analysis of externally scavenged engine was evaluated and results were compared with the normal engine. The outcome of the investigations is discussed as under:

5.1 Analysis of Performance Parameters at different Valve Openings

Trials were conducted on modified engine at various valve openings. Performance of modified engine was compared with base engine. Objective of investigation is to find out the effect of variable air flow on performance and exhaust emissions of modified and base engine. This section describes variation of various engine operating parameters at different valve openings.

5.1.1 Variation of Brake Power with Engine Speed

The variation of BP with speed for base engine and modified engine is shown in Figure 1. At low speed, a greater length of time is available for heat transfer to the cylinder wall, and therefore a greater proportion of heat loss occurs, thereby decreasing BP. Higher speed produces greater air consumption and reduces time for heat transfer, which consequently increases the BP with increase in fuel consumption.

There is certain speed, at which charge inducted/cylinder/cycle will be maximum. At this point, maximum force will be exerted on piston, and BP will be at maximum.

As the speed of the engine is increased, the quantity of the indicated charge will decrease. However, the power output of the engine increases with speed due to more numbers of cycles is executed per unit time. Air consumption will continue to increase with increase in engine speed until some point is reached, where the charge per cylinder per stroke decreases very rapidly than the number of strokes per unit time is increasing.

From the graph, it is clear that at speed of 3680 rpm, charge inducted/cylinder/cycle is maximum. At this speed, brake power will be at maximum. Beyond this limit, there is decrease in brake power with increase in engine speed. When the speed of the engine is increased above 3680 rpm, the quantity of the indicated charge decreases

Figure 1: Variation of Brake Power with Engine speed

5.2 Analysis of Scavenging Parameters at Different Valve Openings

Performance of two-stroke engine depends on the process of removing the exhaust gases from the engine cylinder. In externally scavenged engine, scavenging process takes place by the extra air supplied through scavenging port. Objective of present analysis is to find out the effect of variable air flow on scavenging parameters of modified and base engine at different valve openings.

5.2.1 Variation of Delivery Ratio with Engine Speed

Figure 2 represents variation of delivery ratio with speed for different valve openings. Delivery ratio is defined as the ratio of the mass delivered to the mass the displaced volume of air has at ambient conditions, Delivery ratio is the measure of air supplied for scavenging to the cylinder content. It is mass of fresh air delivered to the cylinder to the reference mass.

From the graphs, it has been observed that there is increase in the delivery ratio for the modified engine compared with base engine for different valve openings. Delivery ratio increases with increase in percentage of valve opening. It is due to supply of extra air for the purpose of scavenging through scavenging port. Extra air increases the quantity of fresh air delivered to engine cylinder compared with reference mass.

Figure 2: Variation of Delivery Ratio with Engine Speed

5.2.2 Variation of Scavenging Efficiency with Engine Speed

Scavenging efficiency indicates to what extent the residual gases in the cylinder are replaced with fresh charges. Figure 3 represents variation of scavenging efficiency with speed for different valve openings.

From the graphs, it is clear that there is improvement in the scavenging efficiency for modified engine compared with base engine. This increase in scavenging efficiency for modified engine is attributed to higher oxygen content in the combustion chamber due to extra air aspirated by engine. This air aspiration improves combustion process, which leads to higher scavenging efficiency. It is also examined that scavenging efficiency of modified engine increases with increase in percentage of valve openings. Maximum value of scavenging efficiency is 76% at 4600 rpm at 100% valve opening, whereas minimum value is 22% at 25% valve opening at the speed of 600 rpm

Figure 3: Variation of Scavenging Efficiency with Engine Speed

5.2.3 Variation of Trapping Efficiency with Engine Speed

Figure 4 shows variation of trapping efficiency with speed for different valve openings. Trapping efficiency indicates the ability of cylinder to retain the fresh charges. It indicates what percentage of fresh charges supplied to the cylinder is retained in the cylinder.

From the graphs, it has been observed that there is increase in trapping efficiency for modified engine compared with base engine. It is due to supply of extra air for scavenging purpose. Extra air supplied to the engine provides a barrier between fresh charges and exhaust gases thereby reduces short circuiting of fresh charges. From the figure, it is also clear that trapping efficiency for modified (novel) engine increases with increase in percentage of valve opening. Maximum value of trapping efficiency is obtained at 100% valve opening. The value of trapping efficiency is 78% at 100% valve opening at 4600 rpm for modified engine compared with 50% for normal engine at the same speed.

Figure 4: Variation of Trapping Efficiency with Engine Speed

6. CONCLUSIONS

The results concluded that the performance of externally scavenged engine is superior compared with the base engine. Performance parameters like brake power, mass of fuel consumed and air- fuel ratio are improved. It was also examined that exhaust emissions like CO and HC are reduced due to supply of lean mixture and better scavenging. Delivery ratio, scavenging efficiency and trapping efficiency of modified engine are improved compared with base engine.

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