Experimental Study on Four Stroke Single Cylinder Engine for Estimation of Friction Power Contribution of Piston rings

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Abstract: **The tribological consideration in the contacts formed by piston ring assembly has attracted more attention over several decades. About 13-17% of total frictional losses observed in I.C. engine and 35-50% of total friction losses are due to PRA(Piston Ring Assembly).**

This project is a set of experiments were carried out on developed experimental setup at laboratory scale to measure PRA friction of single cylinder engine system indirectly by measurement of power consumption by motorized down method. In experiment the fabricated test rig of single cylinder engine of splendor with crank mechanism and without gear box is used. Crank shaft is coupled with induction motor to drive the engine. A.C. motor is used to drive engine. The experimental results and observations are carried out under different operating conditions in speed ranges from 600 rpm to 1400 rpm. The performance parameters which reduce the efficiency of an I.C. engine are different mechanical losses, like direct friction losses, pumping loss, blow losses, valve throttling losses. These are many geometrical parameters and physical parameters which are responsible for the frictional losses, like stroke to bore ratio, cylinder size and number of cylinders, compression ratio, engine speed, engine load, cooling water temperature, oil viscosity, and number of piston rings. It is understood that the piston ring assembly accounts for the larger part of the mechanical losses in the form of friction in the engine. There are various techniques of measuring piston ring assembly friction. In experiment, motorized test rig is used for non fired engine system of single cylinder engine of splendor and strip method is used to measure friction in terms of power consumption but in this method the effect of cylinder pressure are not measured and test will not be operating at realistic temperatures. Also, power consumption in different operating conditions is measured by dynamometer set up. The dynamometer used is a simple rope brake type dynamometer, which is used to measure the brake power of engine.

Index Terms - **Piston Ring Assembly, Friction Losses, Power Consumption**

I.INTRODUCTION

The performance parameters which reduce the efficiency of an I.C. engine are different mechanical losses, like direct friction losses, pumping loss, blow losses, valve throttling losses. These are many geometrical parameters and physical parameters which are responsible for the frictional losses, like stroke to bore ratio, cylinder size and number of cylinders, compression ratio, engine speed, engine load, cooling water temperature, oil viscosity, and number of piston rings. It is understood that the piston ring assembly accounts for the larger part of the mechanical losses in the form of friction in the engine. There are various techniques of measuring piston ring assembly friction. In experiment, motorised test rig is used for non fired engine system of single cylinder 110 cc engine and strip method is used to measure friction in terms of power consumption but in this method the effect of cylinder pressure are not measured and test will not be operating at realistic temperatures. Also, power consumption in different operating conditions are measured by running the PRA system with different operating speed and test run with independent piston ring assembly simultaneously.

II.LITERATURE SURVEY

2.1 Previous Research:

Mufti and Priest [1] have measured the piston assembly friction losses under fired condition on a single cylinder Ricardo Hydra Gasoline car engine using the IMEP method and found that piston assembly friction found approximately double during power stroke and compression stroke in comparison to suction and exhaust stroke in an engine cycle at different all speeds. Also, they observed that power loss by first compression ring is always found approximately 33% higher than that of second ring at different operating conditions and piston assembly friction losses by both rings also observed about 30-35% of total power losses at all different operating speeds. Hamatake et. al.[2] studied the frictional behaviour of piston ring assembly by varying no. of piston rings and concluded that to reduce the friction losses, decrease the number of rings. Hoshi [3] has experimented on 1300CC 4-cylinder petrol engine at speeds 2000 rpm without load and at 5000rpm with full load by using lubricating oil as SAE 10W30 at constant temperature of 800 0C and concluded that by changing the piston shape and reducing cross section, friction losses in piston assembly system were reduced by 23% that amounted to 9-11.5% of total friction losses. 3% of total frictional losses reduced by reducing slightly diameters and width of bearing on crankshaft and connecting rod. Estimated total % frictional losses were observed at 2000rpm and at 5000rpm were 21%and 17% respectively. Tateishi [4] has experimented to reduce piston ring friction losses by applying two-ring package instead of the standard three ring packages and by developing low viscosity engine oil, reduction in piston mass, piston ring width and piston ring tension. Reduction of piston ring tension and using two ring packages are effective in reducing piston ring friction and reduction of piston ring friction can contribute to reducing the fuel consumption by several percentages. Wong [5] have done experiments and found that the PRA friction force was found to increase linearly with piston speed, decrease with increasing oil film temperature and slightly increase with gas pressure. Bolander et al.,[6] have developed the numerical model to investigate the effects of surface modifications on the lubrication condition and frictional loss at the interface between a piston ring and cylinder liner and observed that the modified cylinder liner was shown to reduce the cycle-average friction coefficient by 55-65%, while total energy loss per cycle was reduced by 20-40%.

2.2 Friction of piston rings and skirt against cylinder liner

This section covers various aspects of the presence of a coefficient of friction between piston ring and cylinder liner on the one hand, and piston skirt and cylinder liner on the other hand. The issue of friction is highly relevant, as the brake thermal efficiency (η_e) of an internal combustion engine can be expressed as,

$$\eta_e = \eta_i * \eta_m = \eta_t * \eta_r * \eta_m \quad (1)$$

Where,

η_i is the indicated efficiency,

η_m the mechanical efficiency,

ηt the cycle efficiency and ηr the relative efficiency (Maass, 1979).

As the frictional work losses form a significant proportion of the total mechanical losses, the frictional losses can be regarded as highly important for the brake thermal efficiency of an engine. Expressed in terms of the cylinder pressure of the engine, the frictional losses (friction pressure, p_f) can be expressed as the difference between the indicated mean effective pressure (p_i) and the brake mean effective pressure (p_e) of the engine, as follows:

$$pi - pf = pe \quad (2)$$

III. EQUIPMENT AND EXPERIMENTAL METHODS

3.1. Test Rig Specifications

The fabricated test rig of 'Hero Honda Splendor' single cylinder S.I. engine system with crank mechanism, piston cylinder head, with engine cooling system, without gear box is used. Crank shaft is coupled with induction motor to drive the engine. A.C. motor with speed regulator is used to vary the motor speed which results into engine speed variation. A multi-meter is also used to measure the power consumption of A.C. Motor. The performance variation is measured in terms of power consumption of A.C.Motor.

3.2. Lubricant

Lubricating oil –Hero Honda Genuine Oil

3.3. Engine Specifications:

Table 3.1: Engine Specifications

Engine	4-Stroke OHC, Single Cylinder, Air Cooled
Bore x Stroke	52.4 x 57.8 mm
Displacement	124.7 cc
Compression Ratio	9.1: 1

3.4. Motor Specifications:

Table 3.2: Motor Specifications

Electrical Supply	Single Phase A.C
Power	½ Hp
RPM	1440

3.4. Experimental methodology

The experimental work is carried out on developed single cylinder S.I.engine test rig under different variables. i.e., speed, ring geometry. The test carried out to calculate the frictional losses of single cylinder engine (unfired) and also the frictional losses of various components.

a. First of check the complete set-up of test rig and prepare it for selected operating condition.
b. Check the foundation of test rig.

c. Check all ht electrical connections of test rig including A.C. Motor, Speed Regulator etc.
d. Switch on the power supply and adjust the rpm at desired value.
e. Then measure the power consumption by using multi-meter or any other similar indicator.
f. Note down the power consumed by A.C. Motor for the complete assembly
g. Then take the reading and cut the power supply.
h. Now remove the first piston ring from the engine and repeat the steps 4-8.
i. Now remove the 2nd piston ring and repeat the steps 4-8.
j. Now remove the last piston ring and repeat the steps 4-8.
k. Now remove the complete PRA & Connecting Rod then repeat steps 4-8.
l. Now the difference between the power consumption of A.C. Motor when the complete assembly is present and after removing first ring is nothing but the frictional power consumed by first ring. Make the calculations for all the rings.

IV.RESULTS AND DISCUSSION

The power consumed by the engine was recorded for different operating conditions at different engine speed are plotted in graphical way.

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1. At 80 Volt Power supply to motor:

Table 4.1: Results for Frictional Power Contribution

Trial	**Power Supply 80V**		**Power Supply 100V**		**Power Supply 120V**		**Power Supply 120V**	
	Power Consumption of Motor (Watt)	**FP Contribution of Ring (%)**	**Power Consumption of Motor (Watt)**	**FP Contribution of Ring (%)**	**Power Consumption of Motor (Watt)**	**FP Contribution of Ring (%)**	**Power Consumption of Motor (Watt)**	**FP Contribution of Ring (%)**
With Complete Assembly	120	100	120	100	120	100	120	100
When 1st ring removed	20	16.67	10	8.33	5	3.85	5	3.57
When 2nd ring removed	35	29.17	30	25	30	23.08	23	16.43
When 3rd ring removed	65	54.17	80	66.67	70	53.85	83	59.29

PRA System without 1st piston ring:
- Power consumption is less as compared to PRA system with all rings at observed speed (about 17%).

PRA System without 2nd piston ring:
- Power consumption is less as compared to PRA system with all rings at observed speed (about 30%).

PRA System with oil ring only:
- Power consumption is less as compared to PRA system with all rings at observed speed (about 53%).

V.CONCLUSION

Referring all the results for the experiment carried out under different operating condition it can be concluded that frictional power loss contribution by individual piston ring varies under different speed.

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