Experimental Investigation on Exhaust Emission with & Without MOLY Coated Piston Ring in C. I. Engine

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Abstract— Now a day’s various surface treatment methods are used on cylinder piston group (CPG) components to reduce exhaust gases. The wear resistance of thermal sprayed molybdenum coatings applicable to the piston ring was investigated in this study. Among thermal spraying methods, plasma spraying is most widely applied in the automotive industries, because it has a high spray rate and deposition, the process consumes fuel gases which are inexpensive and easily obtainable. Wear resistance of the moly coated piston ring is very high as compare to the ordinary cast-iron ring. So less wear of the moly coated ring, which improve compression characteristics and reduce leakage of engine oil in the combustion chamber from the ring gap or looseness of the ring. Experimental results shows that, by using Moly coated piston ring in the 4-stroke single cylinder C.I. Engine, HC reduces by 7.7%, NO$\text{x}$ reduces by 2.29%, CO reduces by 3.73% and CO$\text{2}$ reduces by 7.73% after 100hr running cycle of the engine with compare to the cast-iron piston ring. It is therefore concluded that development of Moly coated piston ring is feasible since it gave satisfactory results for given operating conditions and reduction of HC, NO$\text{x}$, CO and CO$\text{2}$ emissions.

Keywords: Significance of piston rings, Plasma spraying, Moly coating, Exhaust gases(HC, NO$\text{x}$, CO, CO$\text{2}$)

I. INTRODUCTION

The requirement placed on the internal combustion engine is continuously change throughout the history of its development. To reduce the exhaust emission of the engine one way is to improve the wear resistant of the piston ring. In engine 30% energy of total energy is lost due to the friction between piston ring and cylinder liner. For this purpose material use for these components is more important. Today, the most commonly used piston rings are coated with electroplated chromium layers. In recent years, much development work has been performed to replace chromium platting by chromium nitride and molybdenum alternatives.

Among thermal spraying methods, plasma spraying is most widely applied in the automotive industries because (a) it has a high spray rate and deposition, (b) the process consumes fuel gases which are inexpensive and easily obtainable, (c) the process requires minimum preheating and cooling during spraying, (d) the technical reliability of plasma systems is well established in industrial applications, and (e) spraying conditions can be easily controlled upon various applications. In particular, molybdenum coatings fabricated by atmospheric plasma spraying have enhanced resistance to wear and heat and thus this coating technology was commercialized for application to the automotive industry.

II. PLASMA SPRAYING

In plasma spraying process, the material to be deposited (feedstock) is typically as a powder, sometimes as a liquid, wire is introduced into the plasma jet, emanating from a plasma torch.

In the jet, where the temperature is on the order of 10,000 K, the material is melted and propelled towards a substrate. There, the molten droplets flatten, rapidly solidify and form a deposit. Commonly, the deposits remain adherent to the substrate as coatings; free-standing parts can also be produced by removing the substrate. There are a large number of technological parameters that influence the interaction of the particles with the plasma jet and the substrate and therefore the deposit properties. These parameters include feedstock type, plasma gas composition and flow rate, energy input, torch offset distance, substrate cooling, etc.

III. PLASMA SPRAYED MOLYBDENUM COATING

Molybdenum is coated on the ordinary cast-iron piston ring by the plasma spray technique. After coating honing process is done on the ring to improve surface finish of the ring to improve the friction properties. Ordinary and plasma sprayed molybdenum coated piston rings are shown below.

Fig. 1: Ordinary piston rings
IV. EXPERIMENTAL

- List of instrument:
  1) Single cylinder four stroke diesel engine
  2) Rope brake dynamometer
  3) Burette
  4) Tachometer
  5) Temperature sensor
  6) Exhaust gas analyzer (5-Gas)

- Experiment was conducted on four stroke single cylinder diesel engine; Specification of engine is given in below table.

<table>
<thead>
<tr>
<th>Make</th>
<th>Capton diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Single Cylinder, Four Stroke, vertical, water-cooled, cold start, compression ignition, high speed Diesel Engine</td>
</tr>
<tr>
<td>Bore</td>
<td>80mm</td>
</tr>
<tr>
<td>Stroke</td>
<td>110mm</td>
</tr>
<tr>
<td>Speed</td>
<td>1500rpm</td>
</tr>
<tr>
<td>Power</td>
<td>5 HP or 3.7 kW</td>
</tr>
<tr>
<td>Compression Ratio</td>
<td>16.5:1</td>
</tr>
<tr>
<td>Fuel</td>
<td>Diesel</td>
</tr>
</tbody>
</table>

Engine setup is shown below in fig.3

Experiment was conducted on the above four stroke single cylinder diesel engine for the running cycle of the 100hr using Moly coated and without Moly coated piston ring. The exhaust gas emission can be measured by the 5-gas analyser.

The 5-gas analyser and its specification can be shown in fig.4 &5:

V. RESULTS & DISCUSSION

From experimental data following analysis can be carried out when ordinary and Moly coated piston ring is used in the engine.

1) It can be seen from fig. that during no load, 25% load, 50% load, full load and over load(110%) condition of engine HC (%) contents are highest in the exhaust during over load condition. In the above result we show that at the full load conditions HC (%) decreases.
3.73% by using the moly coated piston ring with compare to the ordinary piston ring after 100hr running test of the single cylinder 4-stroke C.I. Engine.

2) It can be seen from fig. that during no load, 25% load, 50% load, full load and over load(110%) condition of engine NO, contents are highest in the exhaust during over load condition. In the above result we show that at the full load conditions NO decreases 2.29% by using the moly coated piston ring with compare to the ordinary piston ring after 100hr running test of the single cylinder 4-stroke C.I. Engine.

3) It can be seen from fig. that during no load, 25% load, 50% load, full load and over load(110%) condition of engine CO contents are highest in the exhaust during over load condition. In the above result we show that at the full load conditions CO decreases 7.7% by using the moly coated piston ring with compare to the ordinary piston ring after 100hr running test of the single cylinder 4-stroke C.I. Engine.

4) It can be seen from fig. that during no load, 25% load, 50% load, full load and over load(110%) condition of engine carbon monoxide contents are highest in the exhaust during over load condition. In the above result we show that at the full load conditions carbon monoxide decreases 7.7% by using the moly coated piston ring with compare to the ordinary piston ring after 100hr running test of the single cylinder 4-stroke C.I. Engine.

VI. CONCLUSION

Experimental results shows that, by using Moly coated piston ring in the 4-stroke single cylinder C.I. Engine, HC reduces by 7.7%, NO\textsubscript{x} reduces by 2.29%, CO reduces by 3.73% and CO\textsubscript{2} reduces by 7.73% after 100hr running cycle of the engine with compare to the cast-iron piston ring. If experiment can be done for more time we can get the better result in reducing exhaust emission. It is therefore concluded that development of Moly coated piston ring is feasible since it gave satisfactory results for given operating conditions and reduction of HC, NO\textsubscript{x}, CO and CO\textsubscript{2} emissions.

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