TRIBOLOGICAL PERFORMANCES OF SOME PISTON RING MATERIALS LUBRICATED WITH LOW ACIDITY FUEL ALCOHOL

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ABSTRACT

The tribological performances of some current or candidate piston ring material/coatings named as CrN, WS2, nitroded iron and B4C against cast iron cylinder bores which were lubricated by the current Chinese fuel alcohol with low acidity which measured up GB18350-2001 for the Denatured Fuel Ethanol were researched by the SRV tester, SEM and EDX were used to observe the wear trace of the specimen surface, the width and depth of the specimen surface was measured also, the results of the experiments show that, alcohol with low acid can lubricate the materials some well while the adherence wear mainly take place. To the materials under the research, CrN shows the best tribological performance.

Key words: fuel alcohol, CrN, WS2, B4C, nitroded iron, tribological performance

1 Experiment Materials

1.1 Upper specimen

Four piston ring materials were tested with the contents shows below (from substrate to above): Nitrided: nitrided iron, CrN: nitrided iron–CrN, B4C: nitrided iron–CrN–B4C, WS2: nitrided iron–CrN–B4C–WS2.

1.2 Lower specimen

The lower specimen is made of the cast iron which is used to make the current cylinder bore, the surface structures of the lower specimen include pearlite, ferrite and graphite, the microhardness (Hv) of the specimen is 451.

2 Results and discussion

2.1 SRV results

The Friction Coefficient- time curve of CrN-cast iron pair, WS2-cast iron pair, B4C-cast iron pair and Nitrided-cast iron pair on the SRV tester is shown in figure 1.

It can be easily found that at the beginning of the test, the friction coefficient of the 4 tested tribo-pairs are similarly around 0.15, suggested that the friction coefficient of the ethanol lubricant may around 0.15.
the end of the experiment which suggested happening of lubrication fail.

The surfaces of the lower specimens were measured by the Talyurf 5P-120 Surface topographical tester and the compare of the tribological performances of the 4 tribo-pairs lubricated by the fuel ethanol and under dry lubrication is shown in table 1.

The Rate of the wear of different tribo-pairs is listed by the sequence from high to low as: B4C/cylinder bore> WS2/cylinder bore> Nitrided/cylinder bore> CrN/cylinder bore, suggested that CrN pair shows the most excellent tribological performance while the B4C pair shows the worst.

Table 1 Friction Coefficients and wears of 4 tribo-pairs under different Lubrication

<table>
<thead>
<tr>
<th>Lubricant</th>
<th>Tribo-pair</th>
<th>Friction Coefficient</th>
<th>Wear Area, μm²</th>
<th>Wear Rate, μm²/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>dry</td>
<td>CrN</td>
<td>&gt;0.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B4C</td>
<td>&gt;0.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WS2</td>
<td>0.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CrN</td>
<td>0.08</td>
<td>10039</td>
<td>147.6</td>
</tr>
<tr>
<td>fuel ethanol</td>
<td>B4C</td>
<td>0.15</td>
<td>59290</td>
<td>2280.4</td>
</tr>
<tr>
<td></td>
<td>WS2</td>
<td>0.15</td>
<td>18117</td>
<td>545.2</td>
</tr>
<tr>
<td></td>
<td>Nitrided</td>
<td>0.175</td>
<td>19227</td>
<td>534.1</td>
</tr>
</tbody>
</table>

2.2 Discussion

Both of surfaces of the CrN-cast iron tribo-pair tested are observed by the SEM after the SRV test mentioned above, and 500× and backscatter results of SEM are showed below.

Figure 2 500× image of the lower specimen surface ground with CrN by SEM

Figure 3 Elements contents of the lower specimen surface ground with CrN by EDX

It can be easily found that the surface of the lower specimen which ground with CrN is smooth with little trace of wear while adhesive wear and plastic deformation could be found, no existence of corrosive is found. The EDX result shows existence of oxygen content which may be formed by the cast iron during the grinding which suggests that there was not enough tribological reaction film covering the surface of the lower specimen resulted that Fe supposed to the air environment and oxidized. No existence of CrN is found. C element is found on the surface which may be the react product of fuel ethanol under the ground condition.

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3 Conclusion

(1) The current fuel ethanol has some lubrication and the friction coefficient of the fuel ethanol is around 0.15 under the tested condition.

(2) Under the tested condition, CrN shows the most excellent tribological performance.

(3) When lubricated by the current fuel ethanol, adhesive wear is the main reason of wear, while the material of the softer cast iron transported to the surface of the harder specimen.

(4) When lubricated by the current fuel ethanol, C, which may be the tribological reaction product formed during grinding, is found on the surface of the cast iron ground with CrN.