STUDIES ON WEAR CHARACTERISTICS OF GRAY CAST IRON CYLINDER LINERS TREATED WITH SALT BATH NITRIDING PROCESSES

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ABSTRACT: The gray cast iron specimens cut from the cylinder liners have been hardened by salt bath nitriding processes. The wear characteristics have been evaluated in a ring and block wear test apparatus. The relative ranking of as-cast and nitrided liners was found to be dependent upon the presence of residual contaminants on the nitrided materials. Removal of these contaminants by polishing significantly improved the wear resistance.

Keywords: *gray cast iron, cylinder liners, nitriding*

1. INTRODUCTION

The problem of cylinder wear in the engines is a very acute one. The solution to this has been found in the use of cylinder liners as shown in Fig-1, which can be replaced when these are worn out. They are made in the form of barrels from special alloy iron containing silicon, manganese, nickel and chromium. These are cast centrifugally [1].

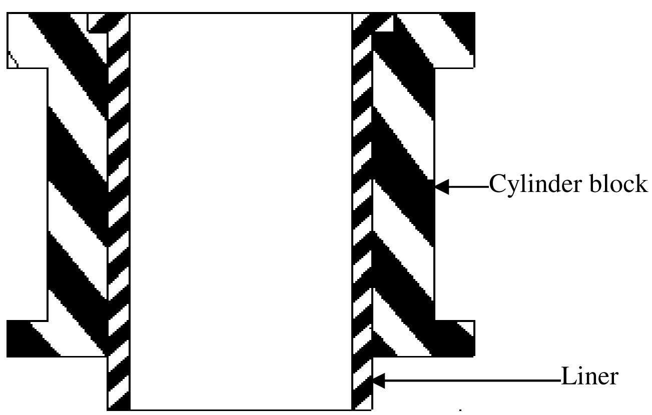

Fig-1 Cylinder block with liner

The wear rate of these liners can be improved by transforming the matrix material to martensite by conventional heat treatment procedures. Although this approach reduces wear rate engine tests indicate that it does not eliminate the problem of flange breakage encountered by heavy loaded engines. The liners may be further hardened by nitriding or chromium plating. For nitriding, liners are exposed to ammonia vapor at about 500^0C and then quenched. Chromium plating improves their resistance to wear and corrosion [2,3].

This paper presents the comparative laboratory tests on gray cast iron, which has been case hardened by two different salt bath nitriding processes:

- The Process –1: In this process, the case hardening was performed in a reducing salt bath composed primarily of cyanide and cyanate compounds.

- The Process-2: This process employs an oxidizing bath that is aerated to replenish the oxygen constituent, thus alleviating cyanide disposal problems.

2. EXPERIMENTAL PROCEDURE

A commercially available wear test apparatus [4] as shown in Fig-2 was used in this study. The specimen blocks were machined from finish machined cylinder liners such that rubbing contact occurred on the honed bore surface. Test rings were selected to simulate the surface characteristics of chrome plated piston rings, which are often used in heavy-duty diesel engine applications. The test load and duration was selected to obtain a measurable amount of wear on all materials tested without the wear depth exceeding the depth of the compound layer on nitrided specimens. All specimens were cleaned in trichlorethylene prior to each test. An optical micrometer was used to measure the wear of each specimen block. An optical microscope was used to study the metallographic characteristics of the specimens.

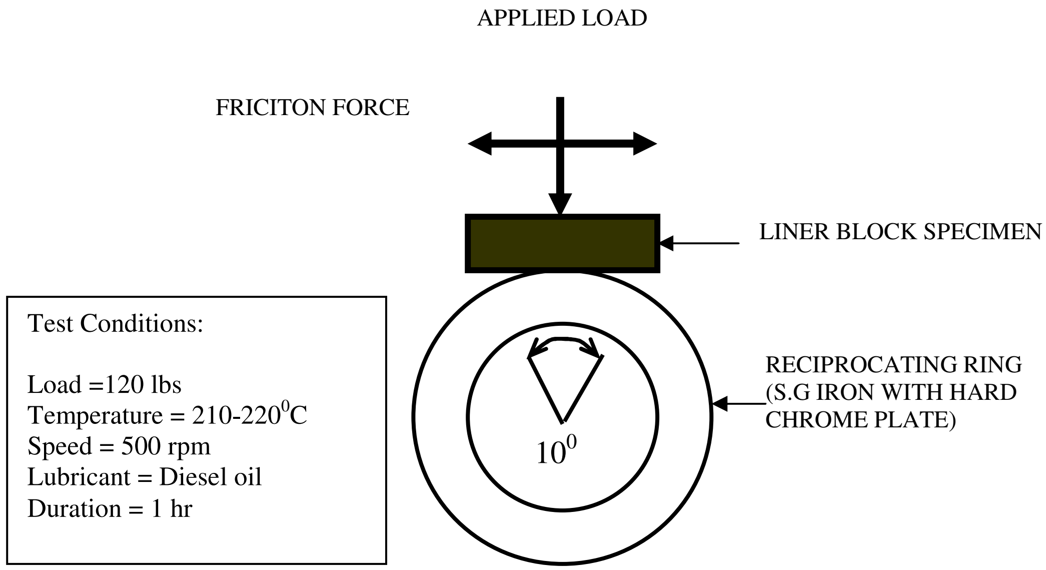

Fig-2 Wear test conditions

3. RESULTS AND DISCUSSION

The surface morphologies of the as-treated components are shown in Fig-3. Both processes produce a hard (HRC 55-60) surface layer consisting of epsilon iron nitride. The liner surface treated by salt bath nitriding process-2 is covered with rough, loosely adhering particles, which may break during service, thus adhering abrasive debris. These particles may consist of complex iron oxides formed during the salt bath treatment. Polishing this surface with 325 grit emery cloth removes the potentially abrasive material without significant loss of compound layer thickness. The surfaces of polished specimens are shown in Fig-4.

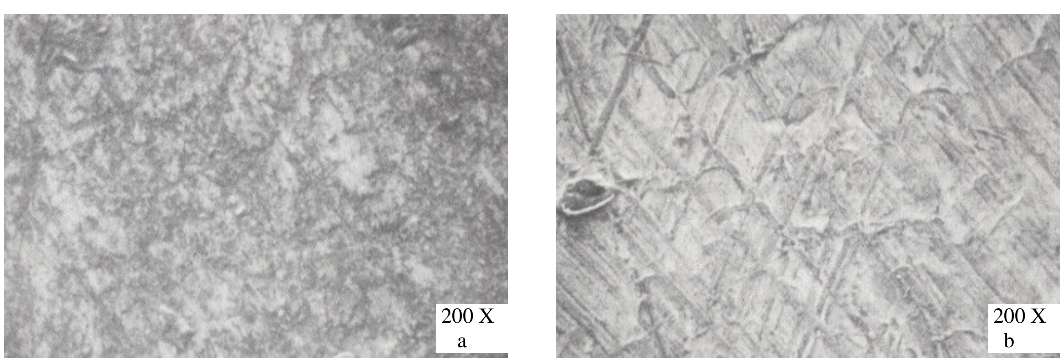

Fig-3 The surface morphologies of the as-treated components (a) Process-1 (b) Process-2

The results of comparative wear tests are shown in Fig-5. The data indicates that the martensitic through hardened liner exhibited the best wear resistance of all materials tested. It also emphasizes the significance of polishing the surfaces of salt bath nitrided specimens before testing. When polishing is used to remove residual contaminants on the porous layer, the wear performance of the treated samples exceeds that of the as-cast material. The SEM microscopy of the as-treated nitrided sample is shown in Fig-6. The micrograph shows that abrasive debris is resulted by removal of friable particles from the as-treated surface. The plowed furrows in the wear scar are evidence that these particles are dragged into the rubbing interface, thus aggregating wear character.

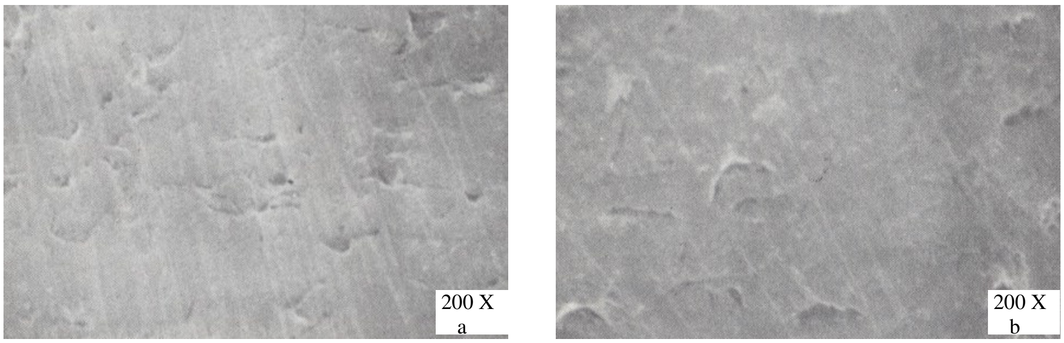

Fig-4 The surface morphologies of the as-treated components and polished (a) Process-1 (b) Process-2

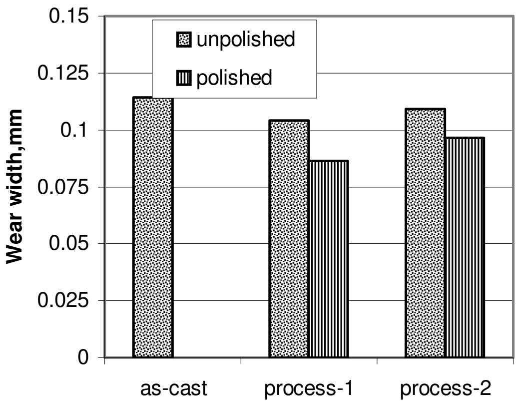

Fig-5 Comparative wear results

Fig-6 SEM micrograph of wear surface

CONCLUSIONS

The significant improvements in wear material provided that residual contaminants are removed prior to service by polishing. If surface cleaning is not performed, the wear rate of treated liners may actually be higher than that of the as-cast form.

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