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Tribochemistry of Sugar Mill Roller Shaft Materials

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Abstract

Study of laboratory simulated conditions of tribological behavior of sugar mill roller shaft has shown that the cracks initiated on the surface were consequences from the tribological phenomenon at the sliding interface. The contaminated interface with sugar cane juice and dried waste called bagasse resulted in a tribofilm which played important role in the sliding behavior. The work was undertaken to characterize wear debris formed and study the tribochemical reactions during sliding wear of shaft material EN8 against E52100 steel under different sliding conditions. Fourier transform infrared (FTIR) and Thermo gravimetric analysis (TGA) was used for understanding of physical and chemical changes of shaft material caused by friction. Debris analysis suggests that the compositional changes within the wear particles accelerate the wear.

Keywords:wear debris, tribochemistry, friction, interface reactions, FTIR, TGA

1 Introduction

Tribochemistry is defined [1]as the chemical reactions between the surface and lubricant/ environment molecules inside the sliding contact under lubricated conditions. Tribochemistry is of particular importance for fundamental research and tribological engineering practice. It comprises physical and chemical phenomenon leading to initiation of chemical reactions due to mechanical action. Tribochemistry is interdisciplinary and relates with mechanical engineering, surface chemistry, physics, mechanics and biomedical. The path of chemical reactions is strongly influenced by the simultaneous occurrences of friction and mechanical impact. The reaction products influence the tribological processes at the interface.

Considerable researches have been carried out by R. Keshavamurthy [2] and Himanshula kala [3] to study the tribological characterization of different materials.In the previous work [4] we have reported effects of operating conditions on the tribological behavior of sugar mill roller shaft

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material in laboratory test conditionsSugar cane juice, bagasse, and water were used to simulate the contaminated lubricated and unlubricated service conditions. It was concluded that the cracks initiated on the surface are consequences from the tribological phenomenon at the sliding interface. The interface is contaminated with sugar cane juice and dried waste called bagasse. Under these sliding conditions, [5] components from the specimen material, the counterface and contaminated particles can mechanically mix to produce patches or a layer of tribomaterial from which typical wear debris is generated. This tribomaterial has structure, composition and properties that are different from those of the original pair of contacting materials. The tribolayer and/or the debris are sometimes referred to as a third body to emphasize these differences and to highlight the roles they play in sliding behavior. The tribomaterial prevents direct contact between the original materials. Further, since typical wear debris particles are generated from the tribomaterial,

An understanding of the nature [6] of the wear debris and the mixed layer from which the debris is formed, especially composition, could provide important insight into the wear mechanisms of these materials. The present work aims at providing a better understanding of sugar cane mill shaft tribology, especially by accounting for the mechanisms of its real tribo-chemistry.

2 Experimental details

2.1 Characterization Methods

2.1.1 *FourierTransform Infrared Spectroscopy*

The principle of FTIR is based [7] on the fact that bonds and groups of bonds vibrate at characteristic frequencies. During FTIR analysis, a spot on the specimen is subjected to a modulated IR beam. The specimen's transmittance and reflectance of the infrared rays at different frequencies is translated into an IR absorption plot consisting of reverse peaks. The resulting FTIR spectral pattern is then analyzed and matched with known signatures of identified materials in the FTIR library. Chemical identification is also carrying out by Fourier Transformed Infra-Red Spectroscopy (FTIR). The chemical structure of wear debris was analyzed using Fourier Transform Infrared Spectroscopy Perkin-Elmer Spectrum Spotlight Spectrometer. The spectra were collected over the 4000-450cm^{-1} wave number range.

In the present work there is need to do FTIR analysis to confirm different functional groups which are present within wear particles.

2.1.2 Thermo **gravimetric analysis**

The principle of the TGA [8] states that, the sample is heated under nitrogen or synthetic air with constant heat rate while the difference of the mass during this process is measured. Thermogravimetric analysis or thermal gravimetric analysis (TGA) is a method of thermal analysis changes in physical and chemical properties of materials are measured as a function of increasing temperature. TGA is commonly used to determine selected characteristics of materials that exhibit either mass loss or gain due to decomposition, oxidation, or loss of volatiles (such as moisture).Thermo gravimetric analysis was carried out on wear debris, which was collected from specimens tested at different sliding conditions using Perkin-Elmer Pyris 6 TGA. The wear debris was heated up to 900°C at 10°C/min. The changes in weight were measured and plotted as a function of temperature. The present investigation needs to verify the thermal stability of wear debris, thermo gravimetric analysis was carried out.

3 Results and Discussions

3.1 Infrared Spectroscopy

Fig.1-4 shows the FTIR spectra of the wear debris in dry, lubricated, contaminated and lubricated with contaminated sliding conditions.

In dry sliding condition, E52100 steel slides against EN8 steel specimen. This sliding test was conducted without lubricant oil. Under dry sliding condition large amount of wear debris were