Evolution of Chemical and Physical Properties of Steel Contacts During Scuffing Wear – WTC 2022, Lyon

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Fuel pump materials must resist wear when lubricated upon operation in hydrocarbons under conditions of dynamic fluid pressure and flow to expand fuel compatibility. Determination of new materials to implement in such systems is impeded without a thorough understanding of scuffing initiation on currently used hardened steel surfaces. In this work, a pin-on-flat high-frequency reciprocating tribometer was used to establish an experimental method that repeatably produces scuffing events on self-mated AISI 52100 steel. Optical microscopy, scanning electron microscopy, energy dispersive spectroscopy, profilometry, Raman spectroscopy, and Fourier transform infrared spectroscopy were used to characterize the evolution of sliding interfaces during scuffing.

Keywords (from 3 to 5 max): wear fundamentals, space and aerospace, mechanical properties of surfaces

1. Introduction

In order to expand the fuel compatibility of fuel injection systems, these fuel pump materials must resist wear under non-optimal lubrication conditions during dynamic fluid pressure and flow. This study aims to develop a better understanding of the evolution of steel surfaces during the scuffing process in order to determine selection criteria for scuffing-resistant materials.

2. Methods

In order to study the evolution of steel interfaces during scuffing, an experimental procedure that consistently produced scuffing events was developed. The scuffed surfaces used in this study were produced by two different tribological experiment procedures, as displayed in Table 1. Detailed surface analysis of the surfaces after tribological experimentation were performed with optical microscopy and Fourier transform infrared spectroscopy.

Table 1: Parameters for tribological experiments

Experimental Procedure	A	B
Surface	Through-Hardened AISI 52100 Steel	
Counter Body	6.35 mm diameter AISI 52100 Steel ball	10 mm diameter AISI 52100 Steel ball
Lubricant	Dodecane, Ethanol, F-24	
Sliding Velocity	Reciprocating, 250 mm/s	Reciprocating, 100 mm/s
Load Progression Details	2 – 100 N, 14 N increase per step, 5 min per step	5 – 300 N, 15 N increase per step, 5 min per step
Temperature	40 °C	
Initial Contact Pressure	~0.5 GPa	

2.1. Results

The optical images of the flat and counter body surfaces generated with experimental protocol A are shown in Figure 1.

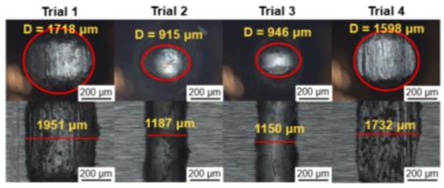

Figure 1: Optical images of flat and counter body worn surfaces generated with experimental protocol A.

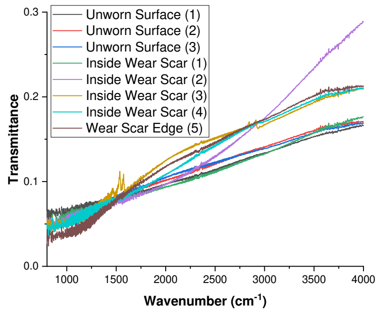

Figure 2: FTIR analysis of flat AISI 52100 steel surface worn in F-24 fuel.

3. Discussion

The optical microscopy of the worn steel surfaces revealed that surfaces that experienced scuffing produce a larger amount of wear material, as evidenced by the larger dimensions of the wear scars produced during scuffing events. In addition, FTIR analysis of a unworn and worn steel surface exposed to F-24 fuel indicate that the dynamic sliding conditions during experiments promote adsorption of the fuel molecules to the steel surface. This highlights the role that the fuel itself takes in protecting metallic surfaces during sliding.

4. References

[1] Bowman, W. F. et al., "A Review of Scuffing Models," Tribology Letters, 2(2), 113-131.