Session 2G, Wind Turbine Tribology II on **Monday, May 20, 2019** from **2:30 – 3:00 pm**

Effect of Lubricant Stability on White Etching Area Evolution under Severe Dynamic Load Sliding Contact

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Introduction

The modernization in the mechanical drive train systems urge to meet increasing power density requirement with severe transient loading profile such as modern wind turbines gearbox (WTG). WTG are often exposed to gusty nature of wind, grid interactions and severe environmental conditions. Consequently, WTG bearing undergo premature failure mode called white etching area (WEA) and associated cracking[1,2]. Tribologist and lubrication engineers unanimously approved that the cause of bearing premature failure in WTG has multiple dimensions. Preceding investigations debated influence of multiple factors such as mechanical operational parameters, material and lubrication associated issues. Out of these, lubricant formulation associated problems are still not fully understood. Debate within researchers indicate that hydrogen ingress from lubricant decomposition is one of the major root cause of white etching area (WEA) formation and associated cracking in bearings.

Kohara et al. investigated the hydrogen generation from certain base oil such as mineral oil, poly-alpha-olefins (PAO) and ester etc. under very high vacuum condition [3]. Since, one of the primary H source is oxidative decomposition of lubricant on nascent metal surface, experiments in high vacuum is not effectively simulating the service conditions in WTG [4]. Moreover, the results were interpreted with surface initiated sliding wear. The tribologist proposed two sources on origin of H atom from lubricants i) presence of water contamination in lubricant ii) lubricant molecule decomposition at tribo-contact. The exact mechanism relating lubricant molecular decomposition and associated WEA formation is not identified yet. Therefore, the individual role of base oil/additives decomposition and hydrogen ingress in steel to form WEA yet to be established. Therefore, as a part of

preliminary study, the current work focus on the stability of lubricant base oil against WEA evolution under severe dynamic load sliding contact condition.

Experimental Methodology

Recently, a new methodology was proposed to replicate WEA in laboratory in level using dynamic load Pin-on-Disc (PoD) tribometer with in shorter duration[5]. Therefore, all the experiments for this study was carried out on dynamic load PoD tribometer under severe boundary condition with lambda ratio of 0.1 with 1.45GPa contact pressure. The effect of base oil chemistry on WEA formation is studied by conducting experiments on three different lubricants such as mineral oil, PAO and PAG (polyalkylene glycol) synthetic base oils with 270 loading cycle per minute. Both ball and disc configuration in dynamic load PoD arrangement is made up of AISI 52100 bearing steel. The metallographic instigation for WEA formation is restricted to bearing ball sample.

Summary

The test duration of the each experiment is fixed based on the microstructure investigation and until the WEA formation is observed in the sample. The summery of test results of three lubricants is given in Table 1. Metallographic inspection of the samples tested in three different oil is illustrated in Figure 1. Several irregular shaped WEA formations observed in mineral oil sample is shown in Figure 1 (a). Long linear cementite formation in PAO sample shown in Figure 1(b) indicate the precursor of long WEA formation in samples. Similarly, one butterfly shaped WEA formation observed in PAG sample is shown in Figure 1 (c).

Table 1. Summary of test results.

Lubricants	Mineral oil	PAO	PAG
Viscosity (cSt)	71	32	68
Density (Kg/m^3)	852	830	981
Lambda	0.1	0.1	0.1
Duration (hrs)	10	13.3	30
Total load cycles	1.62×10^5	2.62×10^5	4.86×10^5
Remark	WEA formation	WEA formation	Faint WEA formation

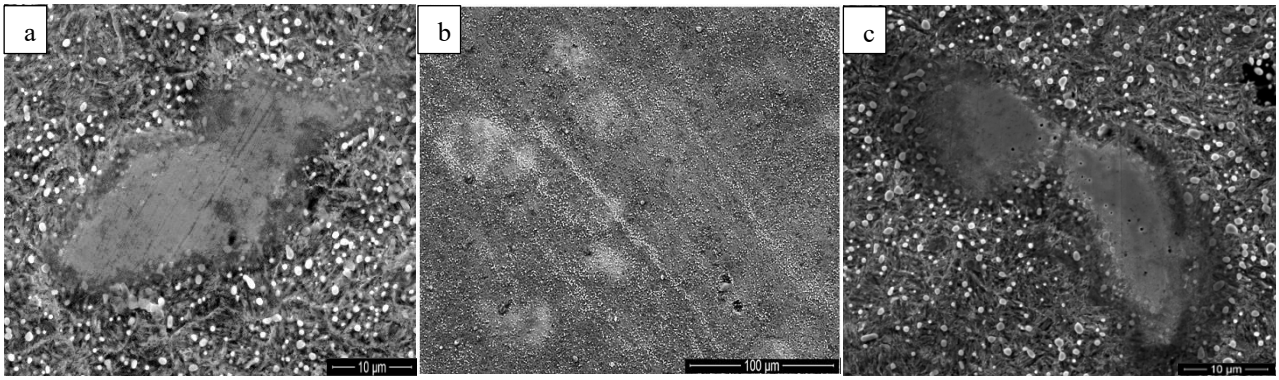

Figure 1. SEM image of (a) Irregular shaped WEA formation in samples tested in mineral oil (b) Long range clustering of cementites observed in samples tested in PAO (c) butterfly formation in PAG 30hr test.

References

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Keywords

Bearing steel; Gear oil; Severe sliding; White etching area