Wear Scars do not represent Wear Loss – A Fretting Corrosion Example

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After tribological experiments the wear scars are analyzed as to their volume or depth, which is considered being the material loss. Still, such analyses are carried out after cleaning. Thus, the material loss has taken place during cleaning instead of during tribological loading. A fretting corrosion test was carried out and analyzed as to the usual characteristics. This brought about that the average depth or volume of the wear scars do not represent the wear loss as would the ICP analyses of the lubricant. Thus, such wear scar quantities could be seen as a portion of the 3rd-bodies generated, but not as wear loss.

Keywords: gross-slip fretting, CoCr29Mo6, TiAl6V4, ultra-mild wear, mechanisms, submechanisms

1. Introduction

Modular hip joints might undergo fretting corrosion. The proteinaceous tribomaterial (3rd-bodies) within such contact appeared beneficial by acting as boundary lubricant and hindering corrosive attack. Still is could be shown that a low-carbon CoCrMo sacrifices because of the detrimental tribological characteristics of Ti [1, 2]. In this contribution a high-carbon CoCr29Mo6-alloy was tested against TiAl6V4 under fretting motion. Wear loss as well as wear mechanisms and submechanisms were investigated and compared to that of the low-carbon alloy

2. Methods

Gross slip fretting tests were carried out in bovine calf serum (BCS) at 37°C with two types of CoCrMo (CoCr29M6C0.25, CoCr29Mo6C0.03) against TiAl6V4. The appearance and depth of each wear scar were analyzed by light and scanning-electron microscopy [3]. The concentration of metal ions within the BCS lubricant (representing the wear loss) and of the enzymatic soap (representing the tribomaterial) was determined by means of ICP-MS.

3. Results

Figure 1 shows that the average depth of the wear scar per length of wear path develops faster for the high-carbon alloy during run-in; but it levels out to that of the low-carbon alloy at steady-state. The wear loss was

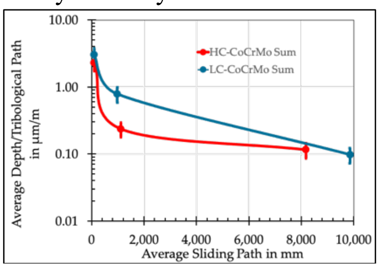

Figure 1: Ratio of the Average Depth of the Wear Scar per Sliding Path in µm/m.

measured by the metal ion concentration within the BCS related to the length of the wear path (Table 1). The same procedure rendered a 1st and rough approach towards a 3rd-body generation rate (Table 2). Wear particles were not analyzed as to type, size and quantity.

Table 1: Wear Rates of both Bodies derived from ICP-MS Analyses of BCS in ng/m Sliding Path

	Co in ng/m	Ti in ng/m
CoCr29Mo6C0.03 (low-carbon)		
run-in	1.4±0.7	0.8±0.2
steady-state	0.8±0.4	0.08±0.02
CoCr29Mo6C0.25 (high-carbon)		
run-in	0.8±0.3	0.5±0.05
steady-state	0.7±0.4	0.1±0.02

Table 2: 3rd-Body Generation Rates of both Bodies derived from ICP-MS Analyses of an Enzymatic Soap in ng/m Sliding Path

	Co in ng/m	Ti in ng/m
CoCr29Mo6C0.03		
run-in	0.3±0.05	5.6±3.2
steady-state	0.06±0.01	0.4±0.03
CoCr29Mo6C0.25		
run-in	-	-
steady-state	0.2±0.03	0.8±0.03

4. Discussion

The wear behavior was characterized by microcutting and -ploughing (submechanisms of abrasion) on both bodies while tribocorrosion (submechanism of tribochemical reactions), and materials transfer (submechanism of adhesion) was limited to the CoCrMo-side [3]. The ultra-mild wear rates of some ng/m could not be related to the µm/m of the wear scars. There was more tribomaterial generated than ejected, which proofs the protecting nature of such 3rd-bodies. Despite the fact that hard phases of CoCr29Mo6C0.25 brought about higher frictional work, it had no influence on the steady state material loss [3]. Again, reaction products of TiAl6V4 bring about the markedly bigger fraction within the tribomaterial and it wears less than either CoCr29Mo6 alloys.

5. References

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