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Tribocorrosion: A novel design and approach

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ABSTRACT – Offshore industries commonly experience wear due to abrasive particles in corrosive environments. The synergy on account of the combined effect of abrasive particles and corrosive environments on material degradation cannot be quantified with the test rigs currently available. Therefore, a novel test rig design has been envisioned, which could aid in obtaining the synergy between abrasive wear and corrosion of steels. The present article explains in detail the design and construction of the novel tribocorrosion test rig.

1. INTRODUCTION

Offshore industrial sectors such as dredging, wind turbine structures, slurry transporting pipelines, drilling etc., commonly experience the simultaneous action of abrasion and corrosion referred to as abrasion-corrosion or 'tribocorrosion'. Tribocorrosion can be defined as the chemical – electrochemical – mechanical process leading to a degradation of materials in sliding or rolling contacts immersed in a corrosive environment [1]. The degradation of materials due to tribocorrosion was recognized by Zelders [2]. Tribocorrosion is of significant economic importance, especially in the offshore industry [3,4]. The mechanism of degradation due to tribocorrosion, however, is not yet fully understood due to the intertwined nature of the different processes (chemical, electrochemical, physical, and mechanical) involved [5].

2. METHODOLOGY

Synergy is the term used to describe the interaction or cooperation of two or more individual elements to produce a total effect which is greater than the sum of individual elements (Angus). In the present context the combined effect is the loss of material due to the interaction of wear and corrosion. Wear leads to the loss of material due to mechanical processes and corrosion leads to the loss of material due to chemical reactions. The combined interaction of these two mechanisms leads to a material loss greater than the individual contribution. ASTM G 119 standard has been developed as a guideline to perform testing in the coupled conditions of wear and corrosion. It explains the procedure to obtain the effect of synergy due to the combined action of wear and corrosion [6]. The total material loss, T, is related to the individual contributions due to wear W_O, corrosion C_O and synergy S by the following equations:

$$T = W_0 + C_0 + S \quad (1)$$
$$T = W_0 + C_0 + \Delta C_w + \Delta W_c \quad (2)$$
$$W_c = W_0 + \Delta W_c \quad (3)$$
$$C_w = C_0 + \Delta C_w \quad (4)$$
$$T = W_c + C_w \quad (5)$$

Where ΔC_w is the change in corrosion due to wear and ΔW_c is the change in wear due to corrosion and C_w is the total corrosion component which can be obtained by electrochemical measurements and W_c is the total wear component [3].

3. TEST RIG DESIGN AND CONSTRUCTION

Tribocorrosion test rigs usually work on the basic principle of combining the simultaneous action of wear and corrosion [6-8]. The general schematic of the working principle of a tribocorrosion test rig is shown in Figure 1. The test set combines the principles of abrasion (pin on abrasive paper) and corrosion testing. To explain further, the wear is created due to the abrasive action between the sample and the abrasive paper whereas the controlled corrosion environment is achieved by a three-electrode system. In the three-electrode system, it is possible to isolate and monitor the performance of the working electrode (sample). This is the ideal requirement as the behaviour of the working electrode which in this case is the steel sample can be isolated in the presence of a corrosive environment.

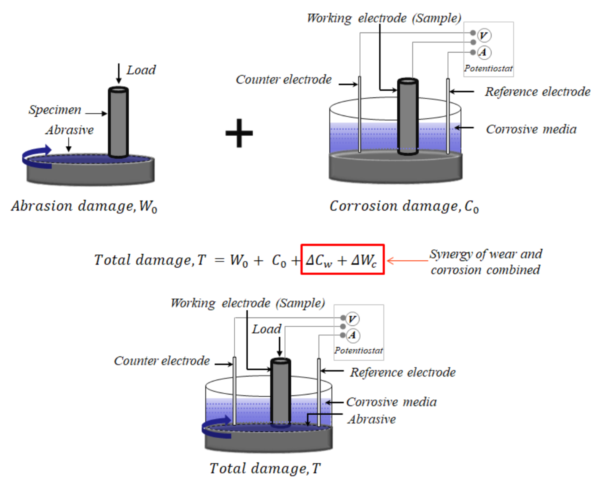

Figure 1 Schematic representation of synergy in the novel abrasion-corrosion test rig.

4. RESULTS AND DISCUSSION

The 3D model of the machine designed is shown in Figure 2. Two modules of the machine are developed one to test multiple asperity two-body abrasion testing coupled with corrosion and the second single-asperity abrasion coupled with corrosion. Two modules are required to study two different contact conditions and material wear responses. First module, the multiple asperity two-body abrasion coupled with corrosion, aids in studying the bulk wear response of the material to multiple abrasives in corrosive environments. The second module, the single asperity abrasion coupled with corrosion, helps in understanding the one-to-one interaction of the abrasive particle and the material in corrosive environments. The mechanism of material removal can be studied in detail in the second module. The preliminary experiments will be carried out in the future.

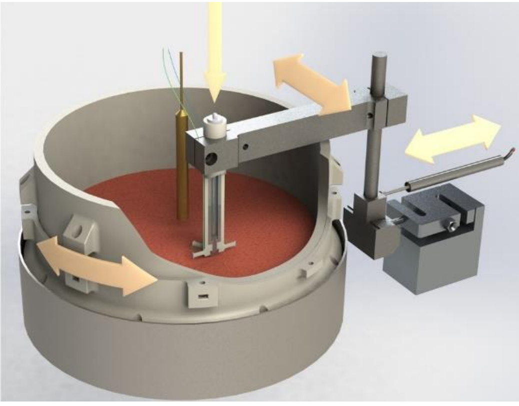

Figure 2 3D drawing the tribocorrosion test rig for multiple asperity abrasion-corrosion.

5. CONCLUSION

A novel test rig has been designed to study the influence of tribocorrosion on steels. The test rig can be used to conduct experiments in two different test configurations, i.e., single and multiple asperity abrasion.

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