STUDIES REGARDING SEVERAL ASPECTS IN FRETTING WEAR

Adriana Urs (Zara), M. Benta , R. Oprisan (Stoica) & E. Ene, B. Novac

"Transilvania" University of Brasov-Romania, Blvd. Eroilor No. 29 Brasov, Romania

Corresponding author: Adriana Urs (Zara), adrz2007@yahoo.com

Abstract: Fretting emergence is accelerated by the presence of surface chemical reactions between constituents and the environment, but not exclusive. Fretting usually takes place in tight assemblies where vibrations are likely to happen. The objective of this paper is to identify the areas of appearance of fretting, the removal of surface superficial films formed on carbon steels used in thermal power and the fretting on assembly by groove.
Key words: fretting, surface superficial films, thick film depositions of corrosion

1. INTRODUCTION

It is known that it was first mentioned by Eden and collaborators in 1911 along with the discovery of the presence of wear debris (red powder) on the fatigue testing machines at two steel surfaces in contact, as "Fretting Corrosion ".

Over time, fretting site received several names and interpretations, not currently being used by a single term with a single meaning. Thus, most appropriate and acceptable definition states that fretting could be considered as surface damage produced by a small amplitude oscillatory sliding between two solids in contact. This deterioration involves notions of the fretting wear and fretting fatigue.

Fretting wear is understood as the removal of material on contact surfaces due to fretting action, while the fretting fatigue represents reduced of life due to cracks caused by fretting. Areas of appearance include:Thermal power station where various stainless steel metal structures are exploited regime of strong vibration or variable load, in conditions of high temperature and sometimes a powerful oxidizing atmosphere;large diesel engines, the fretting damage occurring in the area sealing between cylinder and engine block shirt, the bearings and housing as they are assembled; various machine parts, as bearings with rolling, feathers, couplings, gearing; specific electrical connectors, electrical contacts, there is strong negative effects fretting site mainly by increased contact resistance [1].

Recent studies efectuated emphasizes the fact that during operation of thermal power, the processes of corrosion of carbon steel interface / environment aqueous lead to the formation of layers while becoming thicker corrosion product, containing mainly iron oxides or inorganic nature films [2,3]. These thick deposits affect heat transfer through pipe walls and therefore it was necessary to remove these thick film deposits of corrosion product formed, in particular, on the inner surfaces of pipes [4].

2. MATERIALS

Inside thermal power pipes there are existing deposits consist of two substrates: the first one is located nearest of the metal, being adherent and compact with good hardness; the second one is in outward, porous, less hard.

For doing this, to remove the corrosion product deposition, there have been used some acid solutions. There are several requirements regarding these acid solutions used to remove these thick film depositions of corrosion. Among them, the main requirements imposed on these solutions are as follows: they must dissolve most of the deposit and attack as little metal basis; chemical residuals ultimately should not produce a subsequent corrosion of the installation where they were not completely removed.Usually, the acid solutions embrace: one or a mix of organic acids; one complexing agent and one or more inhibitors used for reducing the solution attack on the base metal . What happens when it has been used acid solution less inhibitors (A), acid solution with diferent inhibitors (B) .

For investigations there have been used test tube of OLT 35. A metallographic microscope NEOPHOT it has been used to emphasize the initial and final appearance, as thickness, uniformity and morphology film surface of OLT 35 samples. In fig.1 is presented the aspect of interior depositions layout existing initially on OLT 35 pipes samples. The presence of magnetite was observed in a thicker or thinner film OLT 35 pipes samples regardless the kind of acid solution (A), or (B) used on. Following studies concluded that to remove deposits formed on the inner walls of carbon steel pipes over exploitation of thermal power station, there should be applied successive acid solutions. Another conclusion that appears is regarding of acid solution componency in order to increase it's efficiency and in the same time to protect the base metal left uncovered.

For this in the solutions must be added various inhibitors in variable concentrations [5].

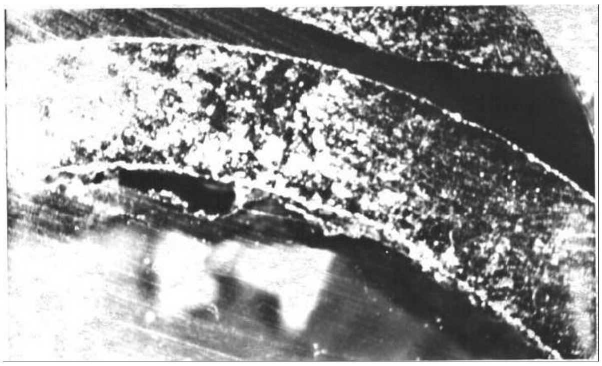

Fig. 1. Initial appearance of a test tube of OLT 35

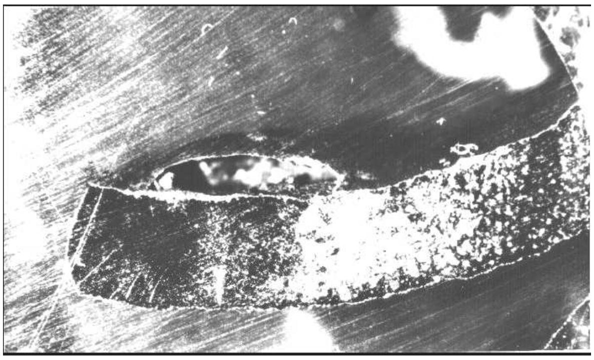

Fig. 2. OLT 35 after the action of the acid solution(B)

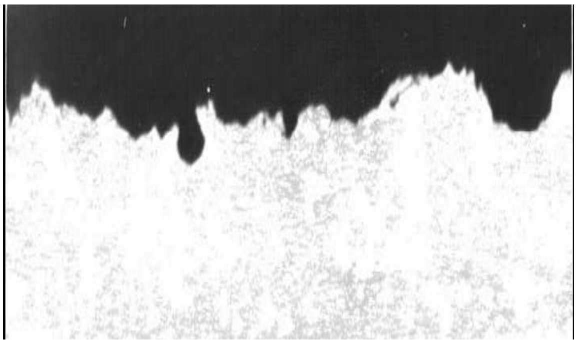

Fig. 3. OLT 35 after acid solution less inhibitors (A)

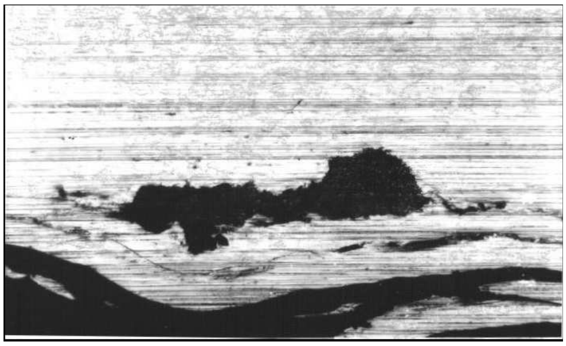

Fig. 4. Oxides remained on test tube OLT 35 after the action of acid solution (B)

Another important aspect regarding fretting is the analysis or fretting contact.Studies effectuated reveals that the phenomenon of fretting is installed just after the first round of cycle solicitation.

Representative study identifies three possibilities of fretting regimes namely: undeterioration condition, regime induced by fretting wear, regime cracking induced by fretting [6, 7].

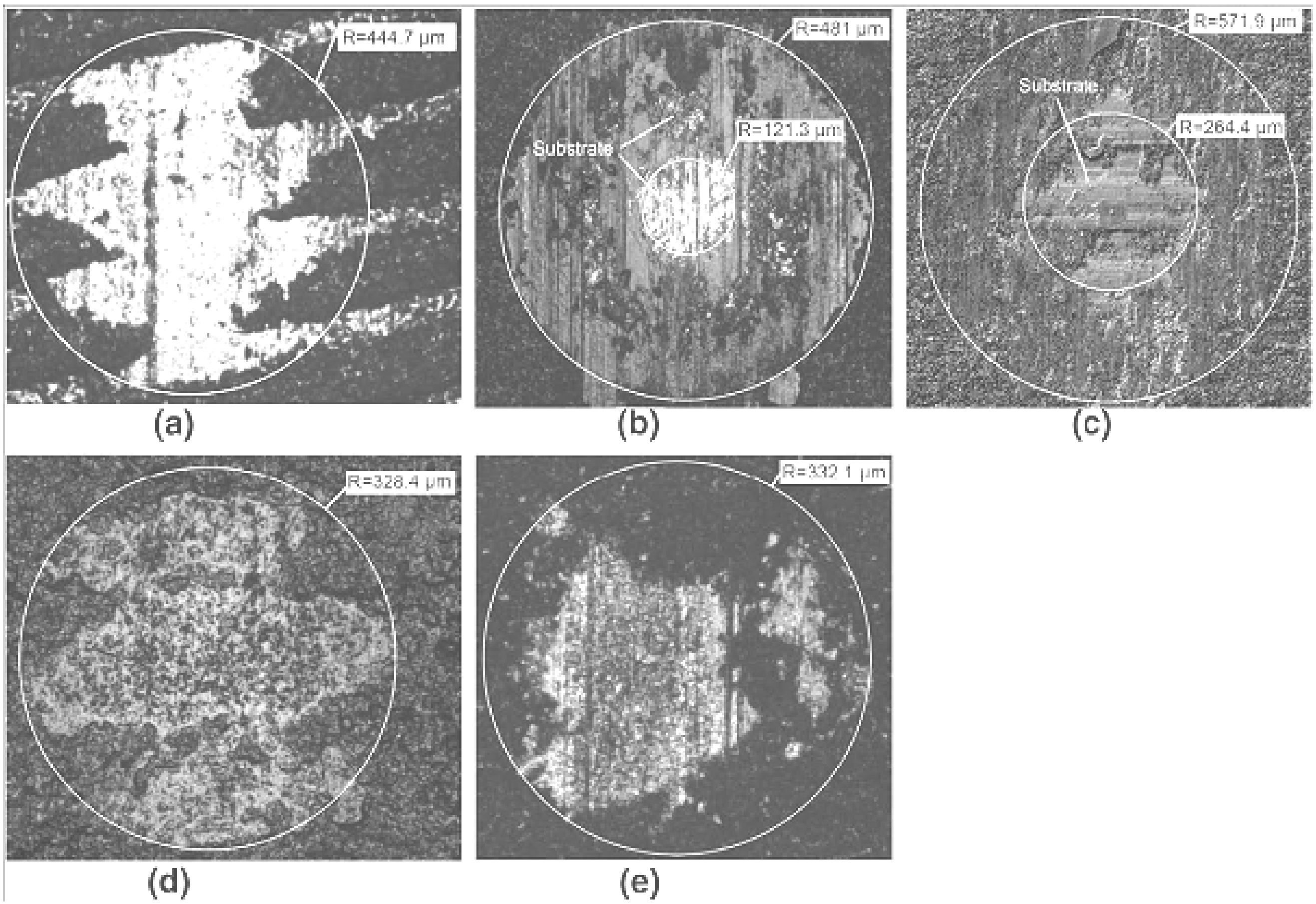

Fig. 5. Micrographs of the craters under 1N and 60 rpm after a 30 minute test

In this figure above it is shown the craters of the 5 coatings (a), (b), (c), (d) and (e) after 30 minute test, under the condition of 1N and 60 rpm.

a) b) c)

Fig. 6. a) Fretting scar; b) Wear particles formed in laboratory air; c) Wear particles under argon atmosphere

In figure 6a it is shown a typical fretting scar in which wear particles were found irregularly distributed. The shape and size of these particles depend on the environment in which the tests were conducted.

When the test is run in laboratory air (figure 6b) the oxygen reacts with the delaminated particles, which are broken in brittle form, leading to the oxide debris formation. The scars formed under argon atmosphere have a less rough surface (figure 6c), [12].

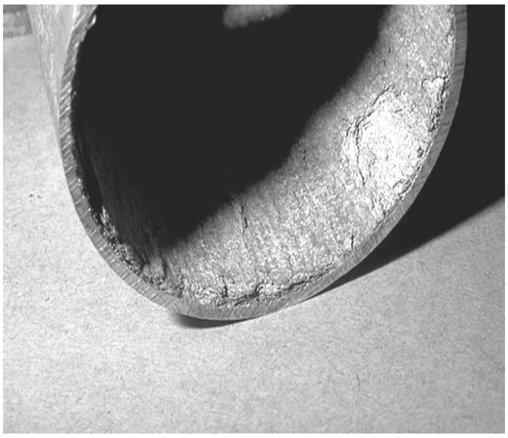

Fig. 7. Exfoliation corrosion morphology inside of formation of grooves, holes etc

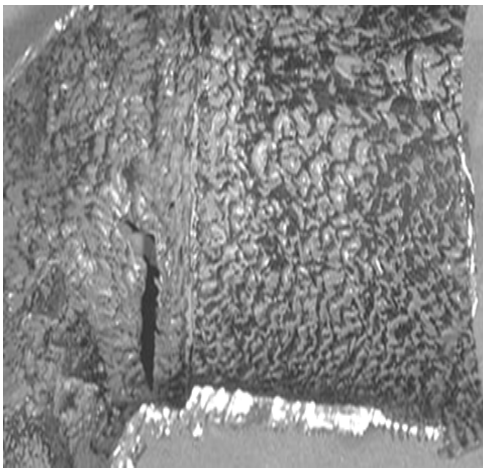

Fig. 8. Characteristic directional appearance in the process a water pipeline

In this case, it is shown the exfoliation corrosion inside a pipeline and the formation of blister on the slivers of uncorroded metal, [8, 9]. It occurs essentially when the interface is subjected to vibrations (repeated relative movement of the two contacting surfaces) and to compressive loads, [10].

The amplitude of the relative movement is very small, typically of the order of a few microns. When the frictional movement in a corrosive medium is continuous, the resulting process is termed tribocorrosion. This process leads to the formation of grooves, valleys, wavy surfaces, holes etc., with a characteristic directional appearance (comet tails, horseshoe marks etc.).

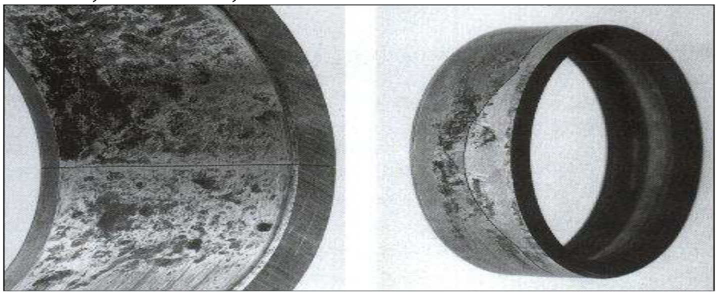
a) b)

Fig. 9. a) The fretting corrosion has caused the cracking of spherical roler bearing inner ring; b) fretting corrosion has caused longitudinal crack in a deep groove ball bearing outer ring.

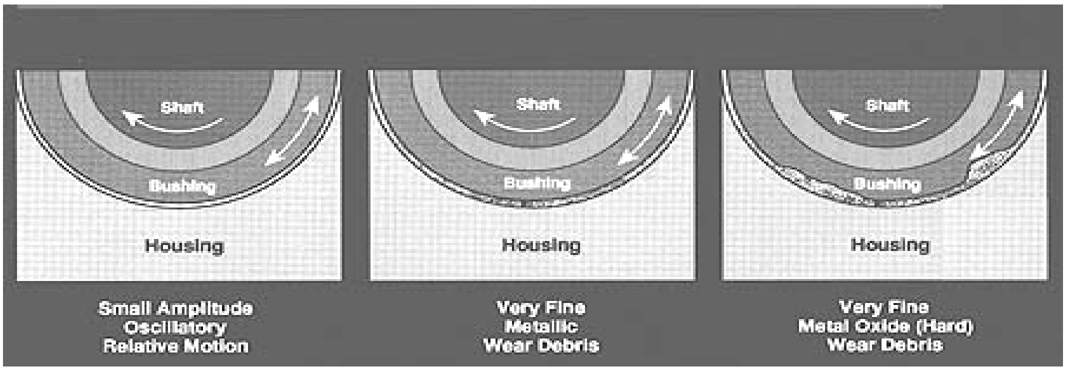

Fig. 10. The mechanism of fretting corrosion

Fretting wear occurs where there is oscillatory motion with a small displacement (~1 micron) of the contacting surfaces under load, [11].
Small wear particles are formed through the mechanism of adhesive wear. Because of the small amplitude of motion the wear particles are not carried out of the contact area and removed from the system.
The particles produced contribute to the wear through abrasive action. Where the material is steel, which is usually the case, corrosive wear most definetly appears.
The wear particles oxidize and generally, being harder than the base metal, expose clean metal to further oxidation. Under fretting conditions, fatigue strength or endurance limits can be reduced by as much as 50 to 70% during fatigue testing, [13].

3. CONCLUSION

Following studies concluded that to remove deposits formed on the inner walls of carbon steel pipes over exploitation of thermal power station, there should be applied successive acid solutions.
The size and shape of the wear debris particles is strongly affected by the environment. Traces of wear are strongly related to the number of cycles of application.
It has been observed that the increase of trace wear is influenced by the increased of normal force of pressing.

4. REFERENCES

1. Cotton, J., (2001) *Material Performance 50*, No.9, pp.50.
2. Jonas, O., (2001).*Material Performance 50*, No.12, pp.42.
3. Jonas, O. (2001), *Safety Issues in Fossil Utility and Industrial Steam Systems*, Material Performance 40, No.5 pp. 8.
4. Jonas, O. (2001), *Current Water Treatment Practices - Utility and Industrial Steam Systems* Material Performance 39, No.10 pp.48.
5. Lukovits, I. et. al. (2003). *Corrosion inhibitors: quantitative structure – activity relationships*. Russ.Journal of Electrochemistry 39 No.2, pp.177
6. Li, P., (1997), *T.C.Tan Corrosion, NACE 53*, No.3 pp.186
7. D.B. Luo, et al., (2009), *Surf. Coat. Technol*. PP. 33-36.
8. Zhou, Z.R., Vincent L., (1999), *Wear 225–229* pp. 962.
9. *** Laboratoire de Physicochimie Industrielle, Multimedia corrosion Guide 2nd Edition, ww.cdcorrosion.com : corrosion_fretting .html, Accesed: 23.11.1009.
10. *** www.vibanalysis.co.uk/.../cracks/cracks.html STLE Society of Tribologists and Lubrication Engineers, Accesed: 06.02.2010.
11. *** www.stle.org/.../lubelearn/wear/default.aspx
12. Castro, D.B.V., Rossino, L.S., Baptista, C.A.R.P., Rodrigues JR., D., (2003), *A Study on the Fretting Fatigue Behavior of Titanium*, In: Brazilian congress of mechanical engineering, 17th COBEM, 2003, São Paulo, Brazil. Proceedings, (in cd-ROM)
13. *** ASM (1995), International, Corrosion of Aluminum and Aluminum Alloys.

Received: 26 January 2010 / Accepted: 10 may 2010 / Abstract published online: 18 May 2010