Proceedings of Malaysian International Tribology Conference 2015, pp. 104-105, November 2015

The characteristics of the fretting wear of Inconel738LC and CM247LC according to the roughness change

Kyoung-Sup Kum, Young-Ze Lee*

School of Mechanical Engineering, Sungkyunkwan University, Suwon, Gyeonggi-do, Korea.

*Corresponding e-mail: yzlee@skku.edu

Keywords: Fretting; superalloy, roughness

ABSTRACT – Especially, in the gas turbine blades, Inconel 738 LC and CM 247 LC have been mainly used as the substrate of blade's components. Since the gas turbine blades are rotating to generate the power, this makes the vibration between blades and blade wheel, so called "dovetails". This induced vibration acts the fretting wear. The damage level of fretting wear is related with the surface shape such as the roughness. Therefore, we can reduce the damage level of fretting wear by control the roughness. In this paper, the fretting test was conducted under the 3 steps-roughness (Ra 2.5um, 0.7um, 0.02um) to verify the characteristics of the fretting wear depending on the roughness changes. The results show that the friction coefficient of fretting was decreasing as the roughness was increasing. Therefore, the main wear mechanism is adhesive wear since the friction coefficient shows higher in smoother surface. The fretting wear of CM247LC is less affected by the roughness change than Inconel738LC. However, the Inconel 738 LC may have better performance than CM247LC in 2.5um of Ra.

1. INTRODUCTION

In gas turbine plants and aero-engine industries, the super alloy has been used as the hot section components such as turbine blades and turbine wheel because the super alloy has the high thermal resistance. In the gas turbine blades, Inconel 738 LC and CM 247 LC have been mainly used as the substrate of blade's components [1,2]. Since the gas turbine blades are rotating to generate the power, this makes the vibration between blades and blade wheels, so called "dovetails" [3]. This induced vibration acts the fretting wear so that the crack initiation arises and finally the fracture breaks out on the blades. The damage level of fretting wear is related with the surface shape such as the roughness [4]. Therefore, we can reduce the damage level of fretting wear by control the roughness. In this paper, the fretting test was conducted under the 3 steps-roughness to verify the characteristics of the fretting wear depending on the roughness changes.

2. METHODOLOGY

A fretting wear test rig was used to test the fretting wear behaviours under a contact configuration of flat-on-flat. As shown in Fig. 1, the coin specimen was fixed at the upper holder, and moved with the piston of the hydraulic system. The flat specimen was fixed on the lower holder, which was mounted on the specimen chamber. The friction force was measured by sensor of load cell. The normal load (*F*n) was applied on the clamp of the upper specimen by a weight set controller. During the fretting test, the coefficient of friction was measured by DAQ board and Labview program.

Two kinds of superalloy, Inconel738LC and CM247LC was used in this experiment. Table 1 shows the material chemical composition of Inconel738LC and CM247LC. The specimen of Inconel 738LC is coin type, with diameter 25mm and thickness 3mm. And the specimen of CM247LC is also coin type with diameter 17mm and thickness 3mm. Each counterpart is also same shape (coin type). The roughness of upper specimen is keeping Ra 0.08um. The roughness of lower specimen is Ra 2.5um, 0.7um, and 0.02um. Table 2 shows the condition of the fretting experiment.

Table 1 The Chemical composition: Inconel 738LC and CM 247 LC.

Material	Composition (unit: wt.%)
Inconel 738 LC	0.11C, 15.84Cr, 8.5Co, 2.48W, 1.88Mo, 0.07Fe 0.92Nb, 3.46Al, 3.47Ti 1.69Ta, 0.001S, 0.04Zr 0.012B, balance Ni
CM 247 LC	0.07C, 8.1Cr, 9.2Co, 8.5W, 0.5Mo 3.2Ta, 5.6Al, 1.4Hf, 0.7Ti, 0.15B, 0.015Z, balance Ni

Table 2 Fretting condition: Inconel738LC and CM247 LC.

Load	Amplitude	Time	Frequency
9.8N	2mm	30 min	120 rpm

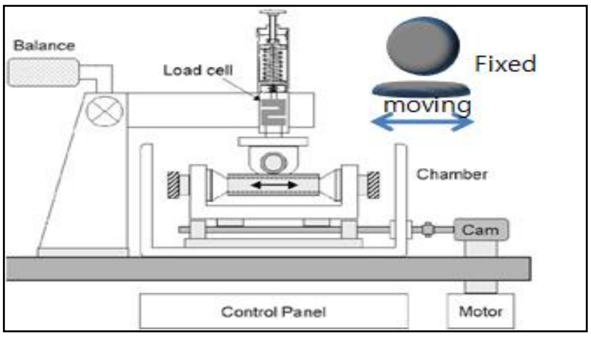
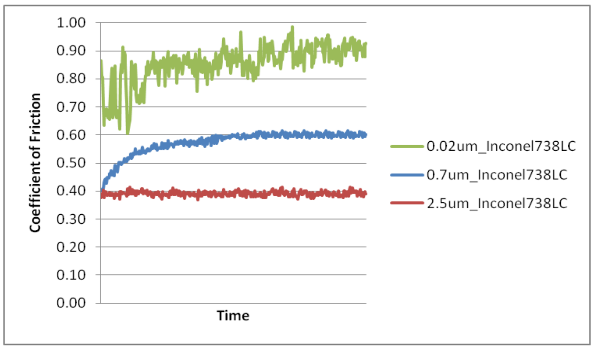


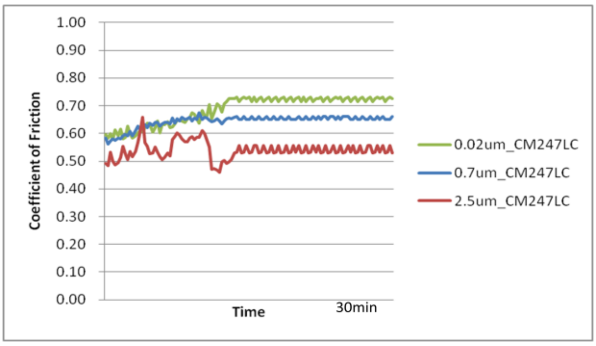
Figure 1 Fretting machine structure.

3. RESULTS AND DISCUSSION

Figure2. Show that the friction coefficient of fretting at the different conditions. In case of Inconel738LC, when the roughness was each Ra 0.02um, 0.7um and 2.5um, COF was each about 0.9, 0.6 and 0.4. Also, in case of CM247, when the roughness was each 0.02um, 0.7um and 2.5um, COF was each about 0.7, 0.65 and 0.55. In short, as the roughness was increasing, the friction coefficient of fretting was decreasing. Therefore, the main wear mechanism is adhesive wear since the friction coefficient shows higher in smoother surface. When the surface is smoother, the real contact area will be increased so that the COF and wear is increased [5]. In addition, the difference of COF is smaller in CM247LC than that of Inconel738LC. That means the CM245LC is less affected by the roughness than Inconel738LC. However, when the roughness is 2.5um the COF of Inconel738LC is smaller than that of CM247LC. That means the Inconel738LC with Ra of 2.5um will be good performance under fretting condition.



(a)



(b)

Figure 2 The coefficient of friction; (a) Inconel 738 LC (b) CM 247 LC.

4. CONCLUSIONS

Inconel 738LC and CM 247LC have been mainly used as the substrate of blades' components in gas turbine. Since the turbine blades are rotating, this makes vibrations which induce the fretting wear. In this paper, we researched the characteristics of Inconel738LC and CM247LC depending on the roughness.

a) Both materials have the tendency that as the roughness is increasing, the COF is decreasing.
b) According to this tendency, the fretting wear mechanism under this experiment conditions will be explained by adhesive wear mechanism.
c) The fretting wear of CM247LC is less affected by the roughness change than Inconel738LC.
d) However, the Inconel 738 LC may have better performance than CM247LC in 2.5um of Ra.

5. ACKNOWLEDGEMENT

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (no.2011-0020024).

6. REFERENCES

[1] Hsin-Erh .H and Chun-Hao .K "Characteristics and Mechanical Properties of Polycrystalline" Materials Transactions, Vol. 45, no. 2, pp. 562-568, 2004

[2] Z. Mazur , A. Luna-Ramırez , J.A. Juarez-Islas , A. Campos-Amezcua , "The Failure analysis of a gas turbine blade made of Inconel 738LC" Engineering Failure Analysis ,Vol. 45, pp. 474–486, 2005

[3] Patrick J. Golden "Development of a dovetail fretting fatigue fixture for turbine engine materials" International Journal of Fatigue, Vol.31, pp.620–628, 2009

[4] M. Ashafi'e, M.F.B. Abdollah, N. Ismail, and H. Amiruddin, "Pre-materials selection for eco-aware lightweight friction material," in 9^{th} *International Materials Technology Conference and Exhibition*, 2014, pp. 1–4.

[5] Ernest Rabinowicz, *Friction and Wear of Matertial*, 2^{nd} ed. pp66-74, New York; Wiley-Interscience, 1995.