Proceedings of Malaysian International Tribology Conference 2015, pp. 42-43, November 2015

Problems of rolling bearing life in small turbojet engines

Boleslaw Giemza[1,*], Pawel Jozwik[2]

[1)] Division for Fuels and Lubricants, Air Force Institute of Technology,
Ksiecia Boleslawa Street 6, 01-494 Warsaw, Poland.
[2)] Department of Advanced Materials and Technology, Military Universtity of Technology,
Kaliskiego Street 2, 00-908 Warsaw, Poland.

[*]Corresponding e-mail: boleslaw.giemza@itwl.pl

Keywords: Hybrid rolling bearings; Si_3N_4 ball; small turbojet engines

ABSTRACT – This paper presents investigations results of several worn rolling hybrid bearings with ceramic Si_3N_4 balls and steel raceways – 608 type. Bearings were acquired from small turbojet engines, used in aircraft models, after its have reached the service life. Authors used scanning electron microscopy, light optical microscopy and non-contact profilometry techniques for bearing elements examination.

1. INTRODUCTION

In modern turbojets rolling bearing are used for rotors supporting. The life of this bearings limited by rolling contact fatigue (RCF) and wear depends strongly on hard working condition like:

a) vibratory stresses,
b) bending moments,
c) high rotation speed,
d) elevated temperature,
e) insufficient lubrication.

Using new technologies in high-speed rolling bearing system, as the use of ceramic balls, improves load bearing capacity, durability, and resistance to temperature etc. However, this results in service the problems associated with the properties of used ceramic materials – particularly high hardness and brittleness.

This paper present results of fatigue and wear investigation of bearings with ceramic balls applied in small turbojet engines.

2. METHODOLOGY

Investigations concern several 608 type hybrid bearings – ceramic Si_3N_4 balls and steel raceways. Worn, examined bearings were acquired from small turbojet engines, used in aircraft models, after its have reached the service life.

The following research techniques were used for bearing elements (ceramic balls and inner raceways) test:

a) scanning electron microscopy (SEM),
b) light optical microscopy (LOM),
c) non-contact profilometry.

3. RESULTS AND DISCUSSION

Research results contain information concerning:

1. LOM and SEM research:
   a) quality and quantity description of detected objects,
   b) distribution of the chemical composition (SEM),
   c) identification of impurities and fractures and microfractures,
   d) identification of fatigue and wear effects.
2. Non-contact profilometry (NCP) research:
   a) identification of fatigue and wear effects,
   b) microsurface topography of worn parts,
   c) microprofiles of worn sufraces.

Typical SEM results are shown on Figure 1 and 2.

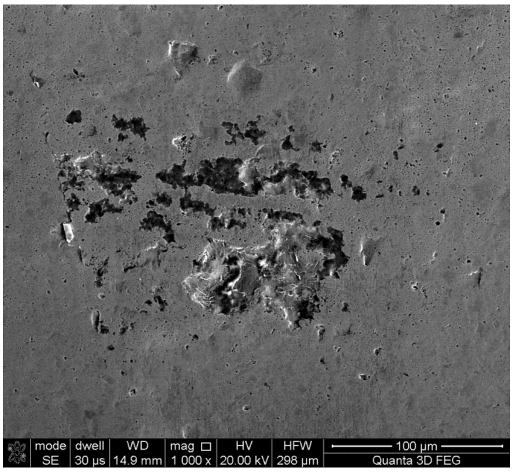

Figure 1 Fatigue symptoms – microspalling and micropitting – on inner raceway of tested ball bearing.

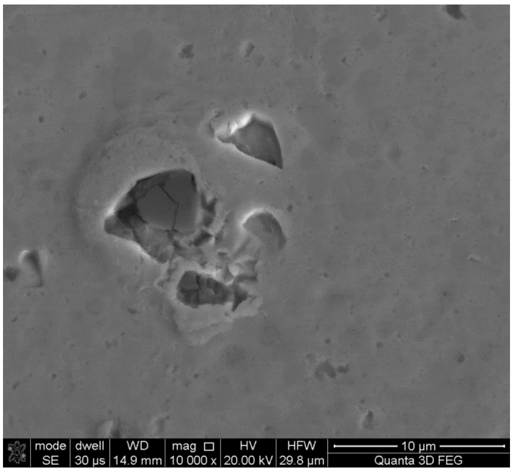

Figure 2 Delaminated debris of ceramic ball embedded in the surface of the inner raceway.

Typical LOM results are shown on Figure 3 and 4.

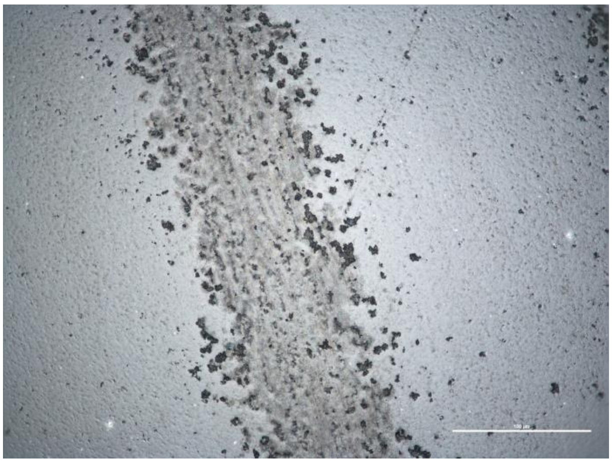

Figure 3 Worn surface of worn Si_3N_4 ball – bright field, 100µm scale (10x20).

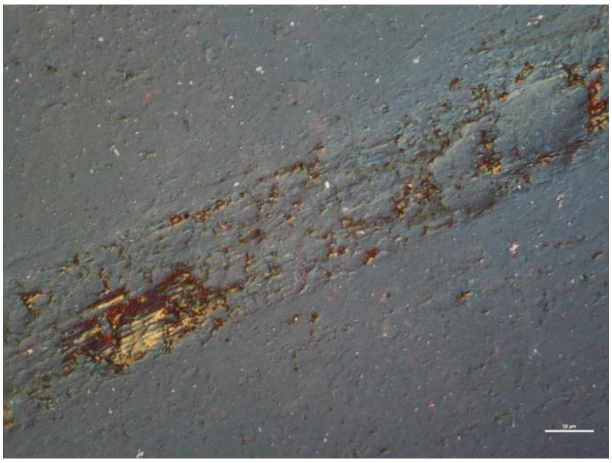

Figure 4 Worn surface of worn Si_3N_4 ball – bright field DIC, 10µm scale (10x100).

Typical NCP results are shown on Figure 5 and 6.

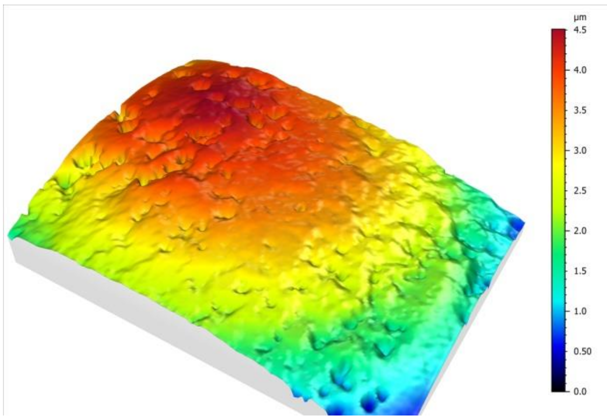

Figure 5 General 3D view of worn ball spherical surface – pseudocolour map.

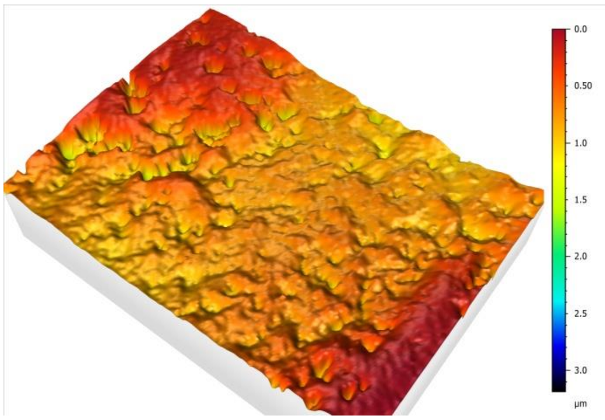

Figure 6 General 3D view of worn ball surface with substracted sphere – pseudocolour map.

4. CONCLUSIONS

Main types of tribological wear of examined bearings were as following:

a) micropitting and microspalling – on balls and inner raceways surface,
b) embedding of hard particles in the surface of the inner raceway,

These processes resulted in a reduced service-life of examined bearings in minijets.

5. ACKNOWLEDGEMENT

Authors are grateful to Thomas Sykuła and OPTOTOM for sharing Confovis non-contact profilometer.

6. REFERENCES

[1] H. K. D. H. Bhadeshia, "Steels for bearings", *Progress in Materials Science*, vol. 57 pp. 268-435, 2012.

[2] A. K. Rai, H. K. Trivedi, R. S. Bhattacharya, C. J. Klenke, N. H. Forster: "An Approach to Evaluate the Abrasive Land Wear of High-Speed Bearings", *Tribology Letters*, vol. 39: pp. 143-149, 2010.

[3] L. Wang, R. W. Snidle, L. Gu, "Rolling contact silicon nitride bearing technology: a review of recent research", *Wear*, vol. 246 159-173, 2000.

[4] Ebert Franz-Josef, "An Overview of Performance Characteristics, Experiences and Trends of Aerospace Engine Bearings Technologies", *Chinese Journal of Aeronautic*, vol. 20, pp. 378-384, 2007.

[5] A. Sottomayor, A. Campos, J. Seabra, "Traction coefficient in roller-inner ring EHD contact in e jet engine roller bearing", *Wear*, vol. 209, pp. 274-283, 1997.

[6] G. Donzella, M. Faccoli, A. Mazzù, C. Petrogalli, H. Desimone, "Influence of inclusion content on rolling contact fatigue in a gear steel: Experimental analysis and predictive modeling", *Engineering Fracture Mechanics*, vol. 78, pp. 2761-2774, 2011.