

# Problems of rolling bearing life in small turbojet engines

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**ABSTRACT** – This paper presents investigations results of several worn rolling hybrid bearings with ceramic Si<sub>3</sub>N<sub>4</sub> 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<sub>3</sub>N<sub>4</sub> 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.

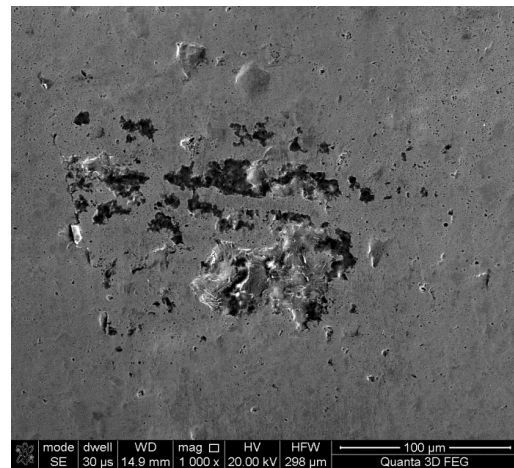


Figure 1 Fatigue symptoms – microspalling and micropitting – on inner raceway of tested ball bearing.

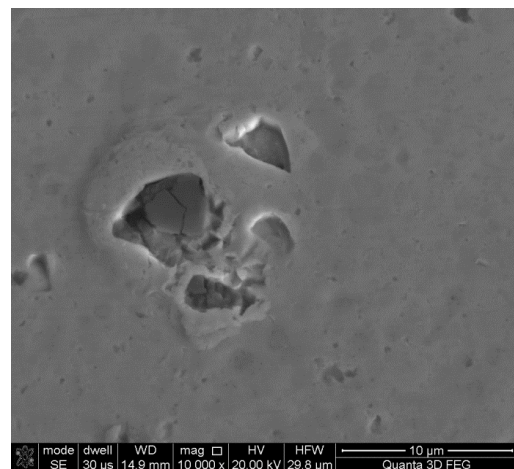


Figure 2 Delaminated debris of ceramic ball embedded in the surface of the inner raceway.

Typical LOM results are shown on Figure 3 and 4.

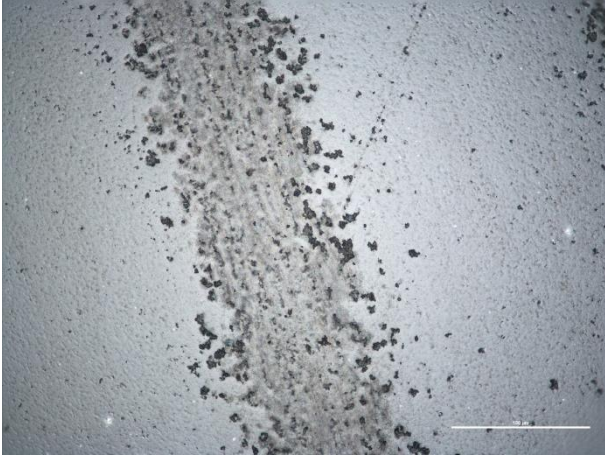


Figure 3 Worn surface of worn  $\text{Si}_3\text{N}_4$  ball – bright field, 100 $\mu\text{m}$  scale (10x20).



Figure 4 Worn surface of worn  $\text{Si}_3\text{N}_4$  ball – bright field DIC, 10 $\mu\text{m}$  scale (10x100).

Typical NCP results are shown on Figure 5 and 6.

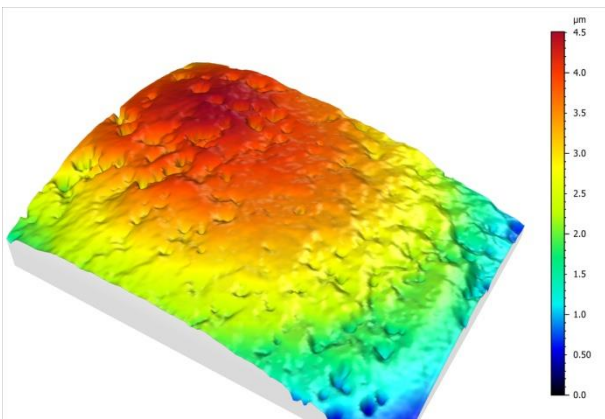


Figure 5 General 3D view of worn ball spherical surface – pseudocolour map.

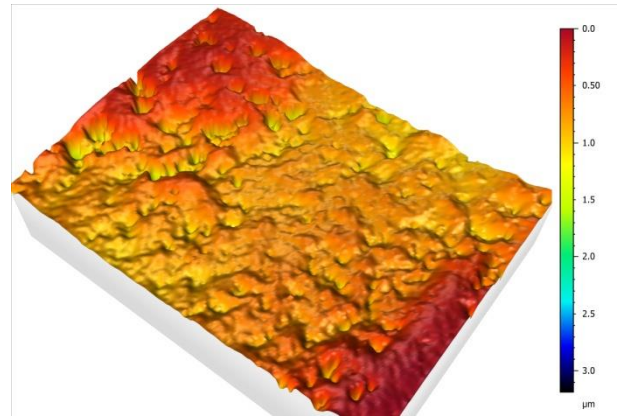


Figure 6 General 3D view of worn ball surface with subtracted sphere – pseudocolour map.

#### 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

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