APPLIED EXAMPLE FOR REM USAGE AS A TOOL FOR QUICK AND OPERATIVE ANALYSIS OF DEFECTIVE COMPONENT

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Abstrakt
Nowadays, promptness and operative delivery of preliminary but objective results of component failure during its exploitation are needed. For complex material analyses are required to perform several material tests as are chemical composition determination, test of mechanical properties, micropurity and microstructure evaluation, RTG phase analysis, fractography analysis and other. These tests are too expensive in costs and spent time. Application of needed corrective arrangements and restoration of continual production depend on quick and in-time delivery of test results to the producer or user. Application of reflection electron microscope (REM) in evaluation of fracture plane for the real case of damaged component after few load cycles is described in the paper including advantages and disadvantages of REM. Fractography analysis was used to determine of the surface carbonization at standard quenching and tempering. This was consequently confirmed by optic metalography. Main advantage of REM is minimal requirements for test sample surface preparation what are cutting to the dimensions and cleaning. Only disadvantage of this method are qualification requirements and experiences of operator.

Key words: damage, REM, carburizing layer, intergranular fracture

1 Introduction

Nowadays, the time is most important factor in all fields of industry. Any production layoff and long devices repair periods brings high economical losses. Therefore the promptness and operative delivery of preliminary test results is primary goal to allow apply adequate corrective arrangements. The results must be also enough fair and objective and further detail about failure causes may be delivered later. For complex material analyses are required to perform several material tests as are chemical composition determination, test of mechanical properties, micropurity and microstructure evaluation, RTG phase analysis, fractography analysis and other. These tests are too expensive in costs and spent time. Therefore, main factor and main reason why customer chooses the material analyses is the Time. The paper deals with real practic case of failure cause considering for selected component during its exploitation.

2 Description of defective components

The fraction of "Bearing" component was delivered for expertise by customer. It was made by 30CHRA steel with basic chemical composition: C=0,30 %; Si=0,25 %; Mn=0,70 %; Cr=1,20 %; B=0,003 %. The component was quenched and tempered in protective atmosphere (C-potential = 0,4) to prescribed hardness 42÷48 HRC and its rupture occurred at dynamic impact load [1]. More input information was not provided by customer due to protection of confidential company information protection. Defective component with places of assumed crack initiations is documented in fig. 1. Laboratory fracture (fig. 2) was prepared by break with using impact load.

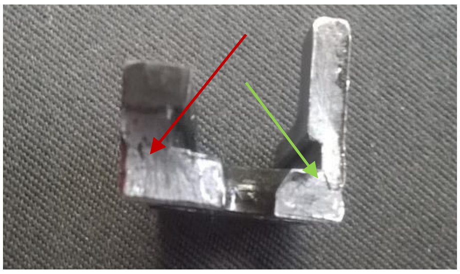

Fig. 1 *Broke component with places of fracture initiation*

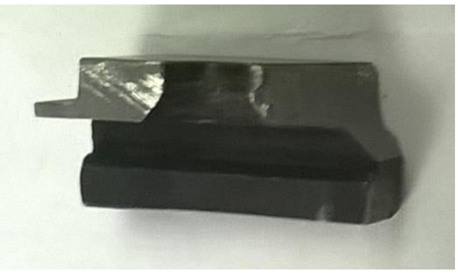

Fig. 2 *Laboratory fracture*

3 Achieved results

Efective and operative methods for components defect reason determination is micro fractographic evaluation of fracture surface by reflection electron microscopy – REM (fig. 3). REM uses excited electrons as a emission source what allow to achieve very high magnifications (about 150 000 x) at high resolving ability (about 2 nm) and depth of focus. These specifications are very suitable for studying of surface reliefs as are fractures. Several types of signals are generates in electron beam interaction with material (fig. 4). For practical usage are important secondary electrons used for topographic contrast adjusting and characteristic RTG emission used for local analysis of chemical composition [2].

Fig. 3 *REM microscope*

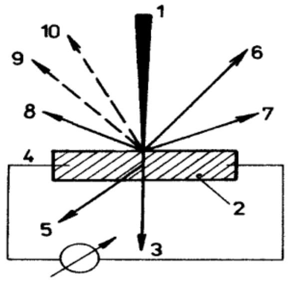

Fig. 4 *Signals in REM – 1 – primary electron beam, 2 – sample, Electrons: 3 – passing, 4 – absorbed, 5 – diffused, 6 – reflected, 7 – secondary, 8 – Auger's, 9 – characteristic RTG emission, 10 - continuous RTG emission*

Two fracture surfaces of two samples cut from operational fracture in assumed places of break initiation and one laboratory fracture surface were evaluated in fractographic analysis. Micro morphology of laboratory mostly consists of transgranular quasi fissible (TKQ) and partially of transgranular foveal fracture (TKJ). The presence of brittle intergranular foveal facettes was not observed. (fig. 5 and 6). Observed fracture micro morphology is typical for fracturing of bainite or low tempered martensite.

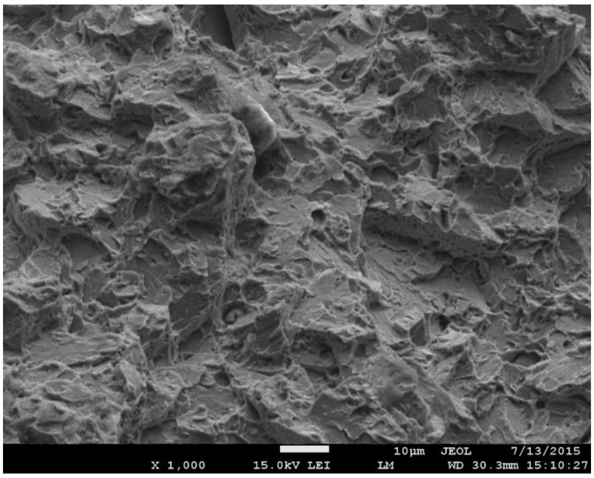

Fig. 5 *TKQ fracture*

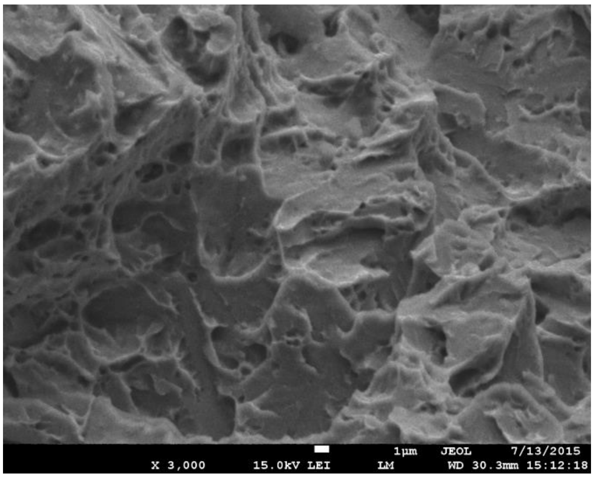

Fig. 6 *TKQ fracture*

Macro morphology of the samples is documented in fig. 7. There is observed morphological different "strip" in upper part of the sample with depth about 0,1 mm copying whole profile of gouge (fig. 8). The place of fracture initiation is pointed with arrow. More detailed control of fracture micro morphology is shown brittle IKS facettes (fig 9. and fig. 10). There were observed TKQ and TKJ mechanisms similar to laboratory fracture in remaining areas of the sample (fig. 11 and fig. 12).

Micro morphology of fracture on sample 2 was similar to sample 1 and is documented on fig. 13, fig. 14 and fig. 15.

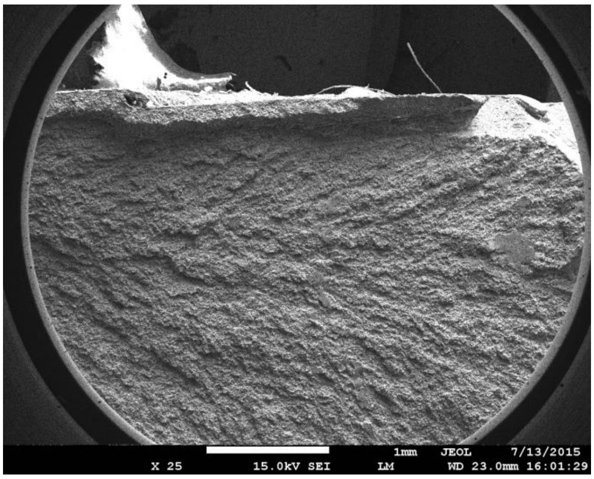

Fig. 7 *Macro morphology*

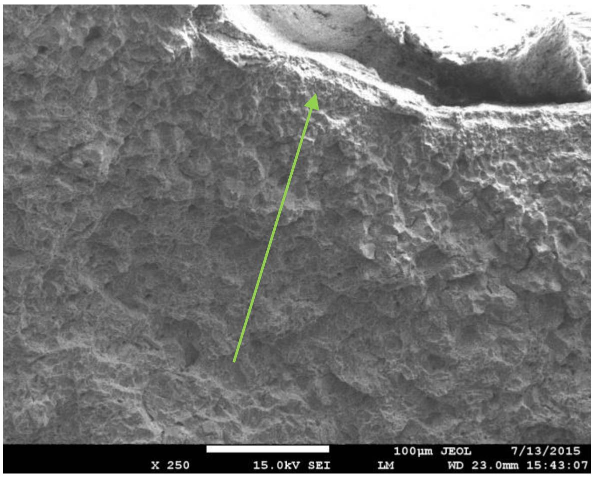

Fig. 8 *IKS fracture*

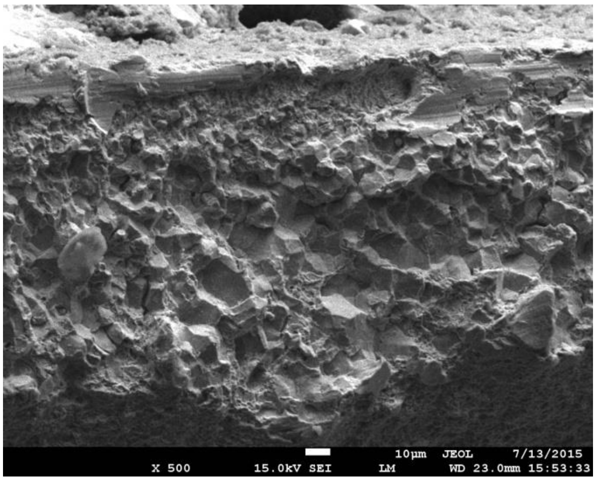

Fig. 9 *IKS fracture*

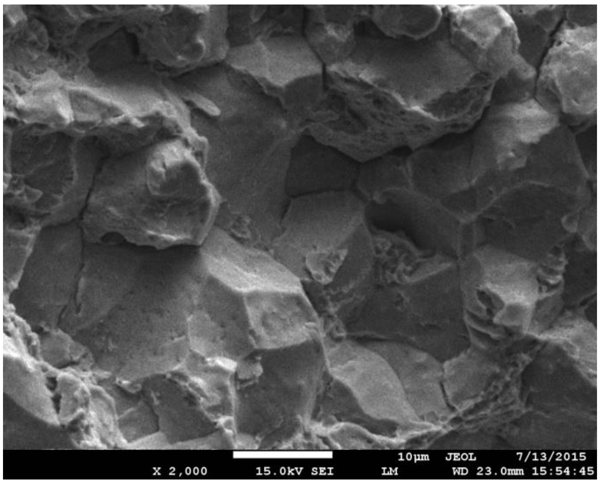

Fig. 10 *Detail from figure*

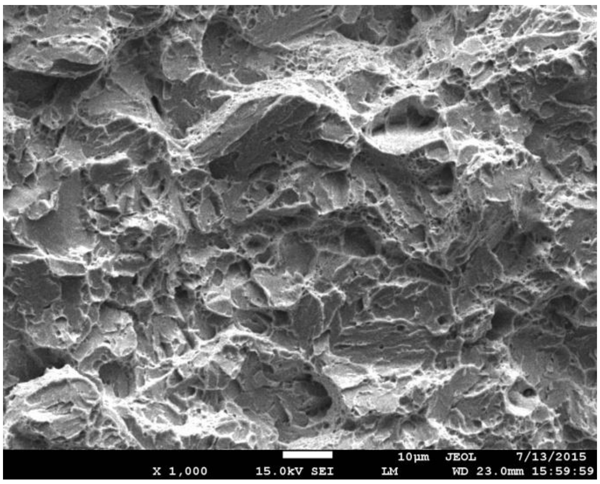

Fig. 11 *TKQ + TKJ fracture*

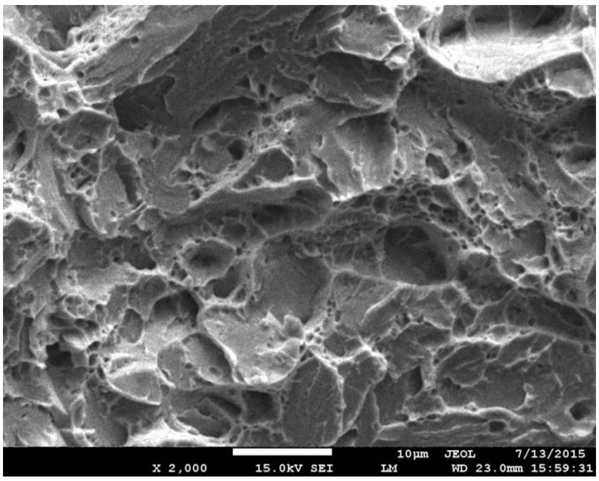

Fig. 12 *TKQ + TKJ fracture*

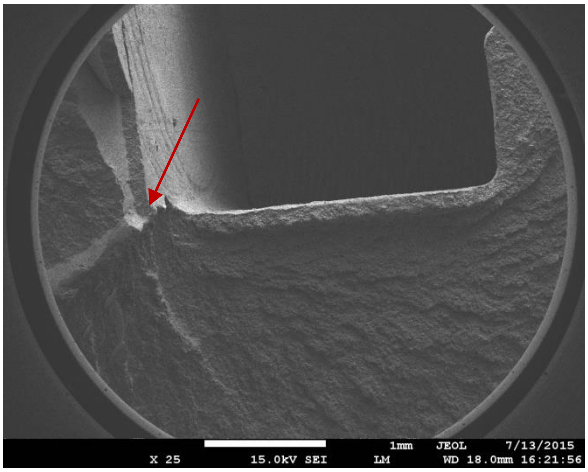

Fig. 13 *Macro morphology*

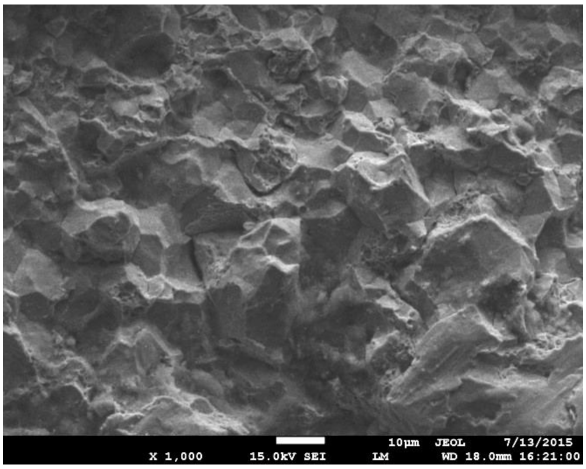

Fig. 14 *IKS fracture*

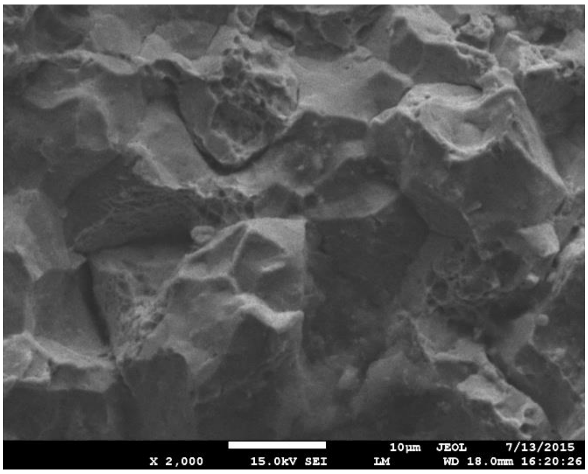

Fig. 15 *IKS Fracture*

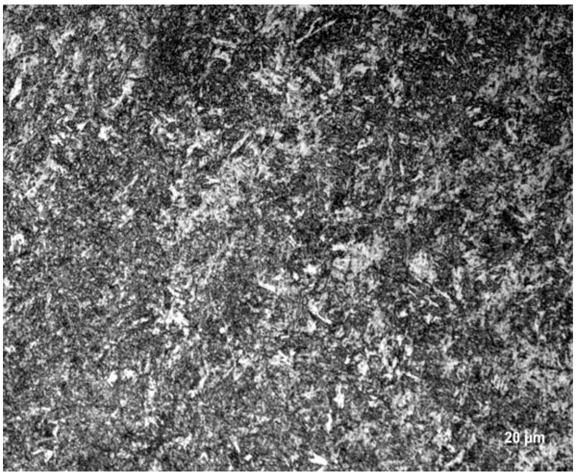

Fig. 16 *Microstructure of sample core*

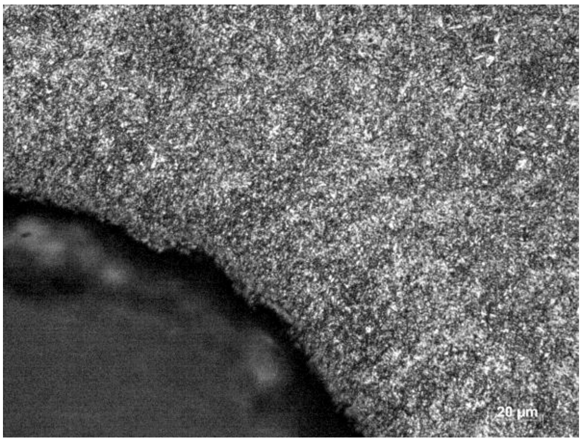

Fig. 17 *Microstructure of carbonizated layer*

4 Conclusions

Following acknowledgements based on observed results could be summarized:

- Primary cause of “Bearing” component failure is embrittlement of surface areas,
- Most probably reason of the ebrittlement is the carbonization of surface areas during heat treatment,
- Fracture micro morphology of other areas correspond with the state after quenching and tempering and intergranular ebrittlement was not observed,
- Fracture of the component was initiated from the gauge, assumed initiation places are pointed with arrows,
- Fracture of the component has not fatigue character

Additional metallographic analysis proves carbonization of surface layers (fig.16) and its mostly bainitic structure in the core (fig. 17).

The reason of the component defect was identified very quickly with help of experiences about morphology of fracture in carburizing layer is inter granular fissible [3, 4], with determination of the shape and localization of that layer and considering the influence of carbon potential of protective atmosphere to microstructure change [4].

Stated factors and investigations allowed to the customer to make appropriate corrective arrangements.

References

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