Ročník 2020 electroscope Číslo I

# Detection of pollutants in the grease of a bearing by EDS and SEM: A case study

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**Abstract**:
The most common cause of mechanical failure of brushed electric motors is the damage to the commutator and brushes but in harsh environments also mechanical damage to the bearings occurs. One of the main grounds of bearing damage is an unsuitable lubricant, various microparticles entering the lubricant on grinding poor quality bearing parts or inclusions related to the mechanical wear of the commutator. We examined the foreign substances or particles in the grease (petroleum jelly) of the bearing by Energy Dispersive X-ray Spectroscopy (EDS) of the components of a used commutator and of a new one. After disassembling the bearing, we analysed the cage, balls, grease and inner ring of the bearing. The obtained results indicate that the undesirable properties of the studied bearing are related to defects in the metallic components of the bearing and to the content of impurities in the lubricant.

## INTRODUCTION

The commutator is a mechanically and electrically highly stressed rotary switch in certain types of electric motors and generators. Due to the gaps between the commutator bars, not quite accurate mounting of the collectors to the bars, friction and sparking it is often a source of malfunctions. The user of the electric motor assumed that the undesirable properties of the bearing on the common engine shaft were caused by mica used as an insulator between the commutator bars. The objective of the presented study is to identify the real ground of commutator failure.

## EXPERIMENT

Our study examined the foreign substances and particles in the grease (petroleum jelly) of the bearing. Unlike other authors employing modern analytical methods such as laser induced breakdown spectroscopy [1] and acoustic emission technique [2] to detect impurities in the lubricants, we performed EDS (energy dispersive X-ray spectroscopy) elemental analysis of the components of a used commutator and of a new one. After disassembling the bearing, we performed analyses of the cage, balls, grease and inner ring of the bearing. Each spot of analysis was visualized by a field emission scanning

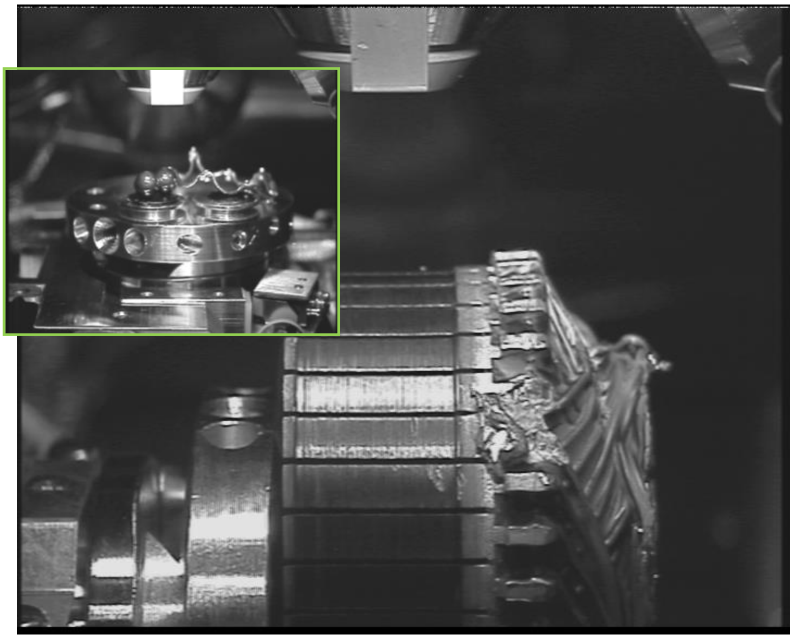
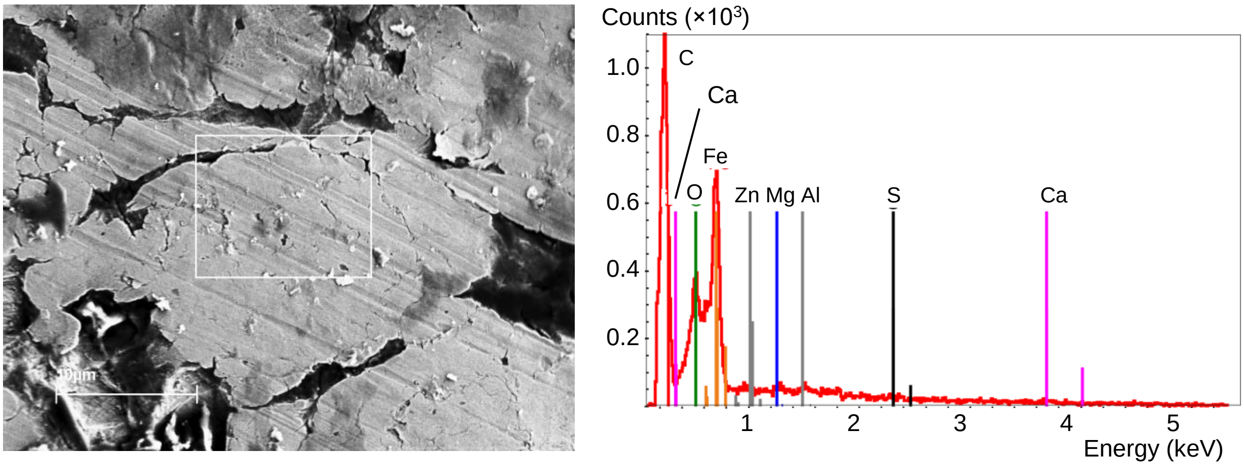


Fig. 1: The commutator placed in the specimen chamber of the scanning electron microscope. In EDS analysis, the electron gun was directed into the commutator groove. The inset is a view into the specimen chamber, showing the balls and the bearing cage.




**(a)** **(b)**

Fig 2: (a) Morphology of the bearing cage material. (b) The detail in the frame was analyzed by EDS. The dominant elements of the cage material are iron, carbon and oxygen. Other elements in the EDS spectrum – zinc, magnesium, aluminum, sulfur and calcium – are elements of embedded or surface impurities.

electron microscope LEO 1550. Figure 1 shows the commutator in the chamber of the scanning electron microscope.

The study revealed that the metallic parts of the bearing, thus the cage, the balls and the inner ring were morphologically defective, see Figs. 2 and 3. Cracks, grooves and holes on the surface of the components are microscopic in size. The steel cage of the bearing contains metallic admixtures of Cu and Zn, the contain Ni, and the inner ring contains Mn, Cr and Zn. Non-metallic elements such as sulphur may be a trace element of steel in phosphorus, nitrogen and silicon are usually present or come from the outside. Non-metallic bearing steel elements create microscopic reaction centres and undergo chemical reactions under the influence of moisture, heat and oxygen. This creates inhomogeneities in the material, gradually disrupting the bearing surface and integrity and changes the mechanical (*eg* friction) and physicochemical (*eg* corrosion) properties of the bearing components.

The presence of mica in the two commutators was detected by the Al:Si ratio of approximately 1:1. EDS analyses of the new and old commutators show that different kinds of mica (probably from different locations) were used in their construction. Sodium and potassium were detected in the new commutator, while only potassium was detected in the old one, see Fig. 4.

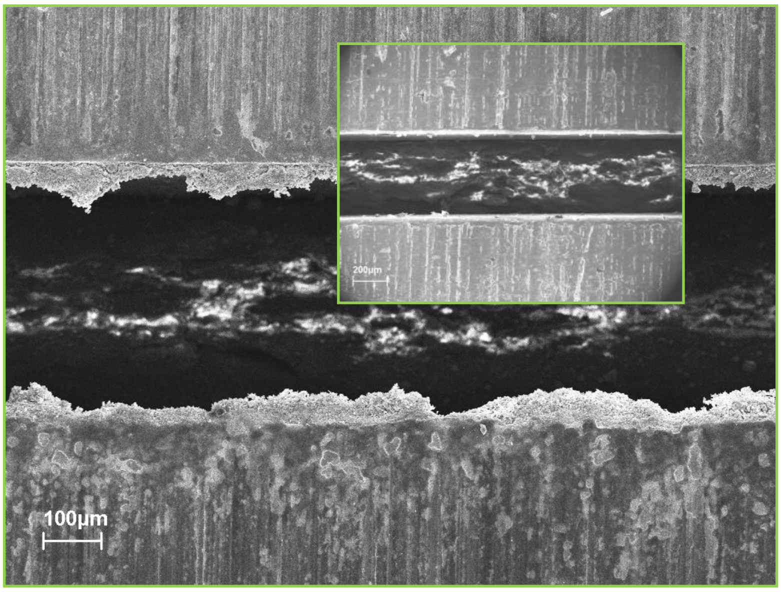



Fig. 3: Morphology of the surface of the bar insulation material and of the bar edges of the commutator. At the edges of the bar, a layer of coating can be seen. Inset: Morphology of the surface of the bar insulation material and of the bar edge of the new commutator.

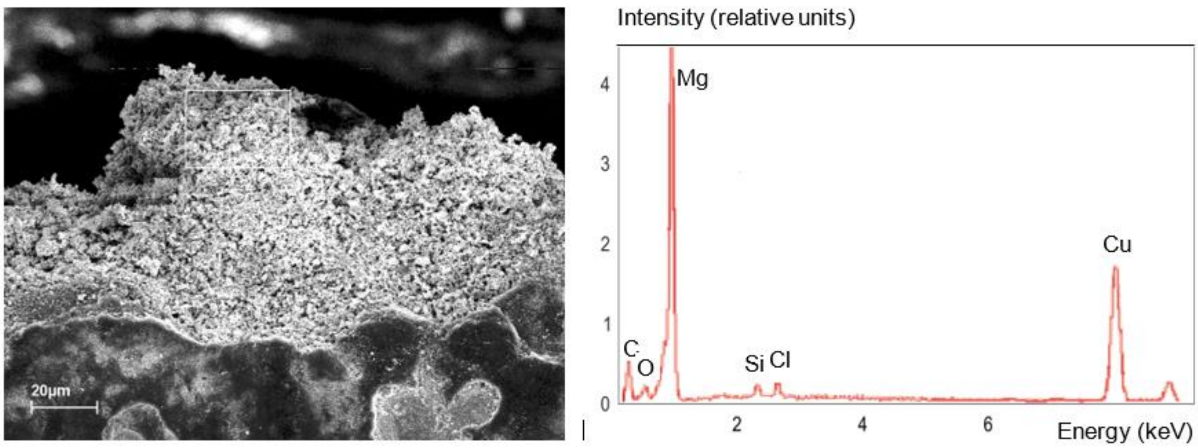



Fig. 4: (a) Detail SEM image of the deposits on the commutator bar. (b) EDS analysis of the framed area in the detail image of the bar coating. Elemental analysis shows the presence of copper, undoubtedly due to the abrasion of the bars, and carbon. Traces of oxygen, sulfur and chlorine are of atmospheric origin.

EDS analysis of the lubricant shown in Fig. 5 reveals that it contains solid particles of inorganic nature. The solid particles are grains (crystals, crystal fragments) of alkali metals and alkaline earth silicates as well as sulphates. The presence of rust, *ie* iron oxide, but also of magnesium, calcium, sodium, potassium, copper, zinc and tin, was noted in the lubricant. Occasionally, we found the presence of mica mineral in the lubricant, the torn scales had a size of several hundred nanometres to 40 micrometres. In all observed lubricant samples, mica in the EDS spectra was manifested by two identical profiles and heights of the aluminium and silicon peaks, with the addition of mica impurity elements such as sodium, potassium and magnesium.

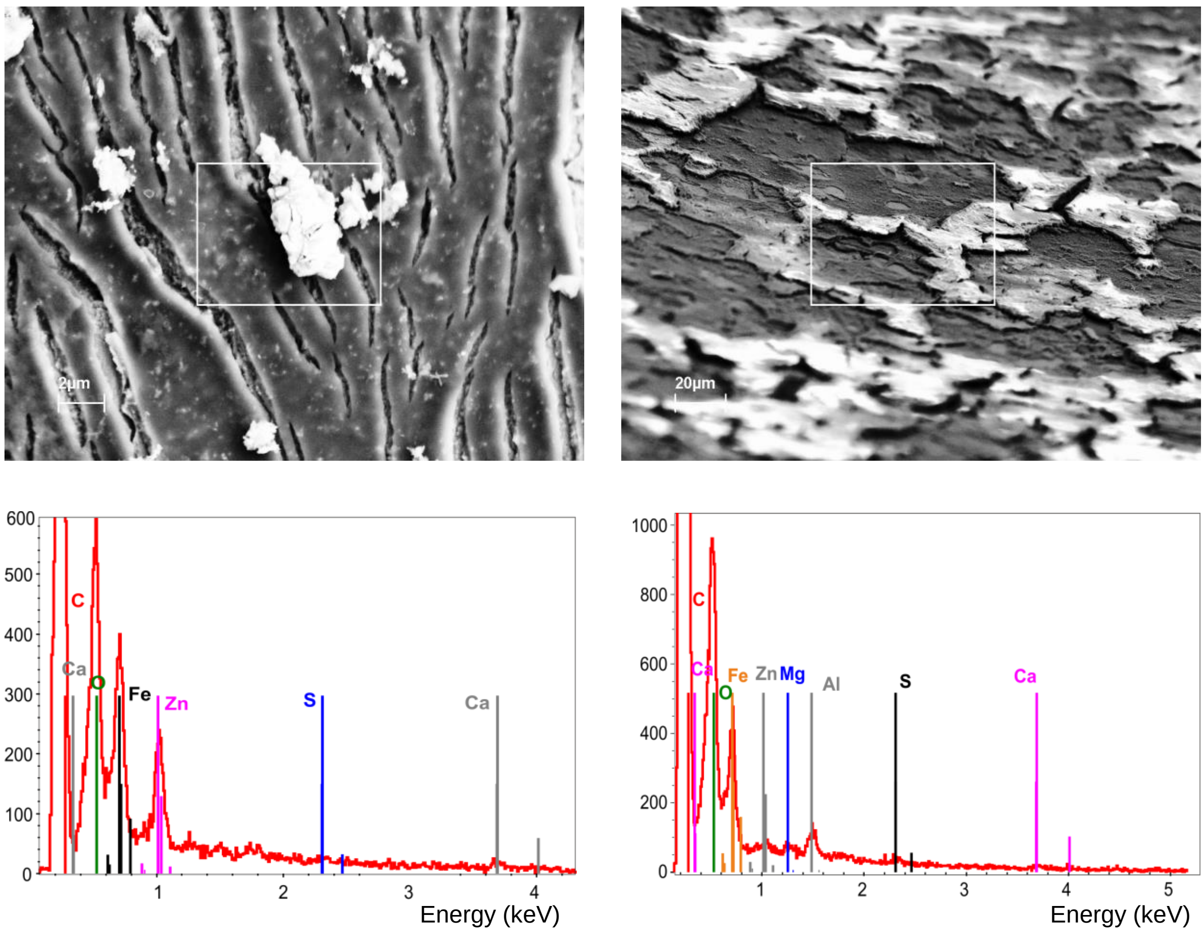



Fig. 5: SEM micrographs of the lubricant morphology. The framed spots were analyzed by EDS.

## CONCLUSION

The lubricant is a petroleum fraction from petroleum distillation with different chemical composition and physical properties (*eg* density, viscosity, boiling point, freezing point) depending on the type of oil used. For the purpose used, the chemical composition of the lubricant is not decisive and is not even indicated by the bearing manufacturer. Physical properties are critical.

The experimentally obtained results indicate that the undesirable properties of the bearing are related to defects in the metallic components of the bearing and to the content of impurities in the lubricant. Dirt enters the grease during the bearing duty cycle. The foreign substances in the lubricant were shown to be metallic fragments (iron and copper), as well as copper sulphide produced by tanning from the bars during sparking. Aluminium was also found in the lubricant samples. A full range of aluminosilicates were present, such as sand, clay and dust from the outside. The metal oxides are the product of chemical processes associated with the penetration of moisture into the bearing. Thus, the experiments did not confirm mica as a root cause of the bearing destruction.

## REFERENCES

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## ACKNOWLEDGEMENT

We are grateful to the scientific grant agency VEGA of the Ministry of Education, Science, Research and Sport of the Slovak Republic for financial support of project No. 1/0532/19, and to the Slovak Research and Development Agency, contract No. APVV-17-0169.