USAGE OF TECHNICAL EQUIPMENT IN TEACHING TECHNICAL SUBJECTS

Sylvia Kusmierczak
Jan Evangelista Purkyně University in Ústí nad Labem, Czech Republic
kusmierczak@fvtm.ujep.cz

Abstract. Teaching technical subjects is generally based on theory. But for the manufacturing sector practical knowledge is important. Therefore, it is important to give students the opportunity to work on solving specific technical problems. According to these solutions students should be allowed to work on modern devices. This will increase their competencies, thus opening the way to the labour market. The article presents an example of the use of modern technical equipment for finding the causes of degradation of specific technical parts during the seminar work of "Construction materials and limit states".

Keywords: technical subjects, technical equipment, teaching, analyses.

Introduction

The training of technician students that are educated by technical faculties is not possible without practical training and experiments. Practical exercises should be carried out on such equipment, which is in production companies commonly available. Technical faculty must prepare students so that students are able to solve real engineering problems [1-3]. Students therefore attend subjects such as Construction materials and limit states, Metallography and fractography, Corrosion and protection materials, Heat treatment, Degradation of materials and others.

One of the ways to increase the quality of teaching is the practical experience that students gain during the study. Engineering practice requires practical experience in macro and microscopic analysis, ability to process the obtained results in the form of reports, database creation and archiving of the results and statistical evaluation of the results, analyse the results and look for the causes of degradation and failure of materials [4-5].

Study and evaluation of the structure of materials belongs to basic knowledge students with technical orientation, which is related with information about the materials and also production technologies. In the long term the emphasis is on improving the quality and life of the machine parts, which are working under severe operating conditions. The material is often due to the states loaded to the extent that there are changes in the structure, which can result in changes to the declared values of mechanical, eventually physical properties. The material properties are affected by manufacturing technologies, for example, by casting, forging or welding [6-9]. Any change of the properties can be monitored using the input and output control. The most common and fastest method that leads to describe the changes in the properties is the hardness test of the material and subsequently evaluation of the structural characteristics of materials by using the methods of microscopy, which include in particular the quantitative and qualitative methods of light and electron, microscopy. Students in practical lessons can carry out different types of analysis such as:

- microstructural analysis of various materials and their surface and subsurface layers;
- identification of the structural phase (intermetallic phases, inclusions, etc.);
- evaluation of structural changes after heat treatment, surface treatment and technological processes;
- analysis of the causes of limit states and degradation of materials [10-11];
- evaluation of fracture surfaces, and others.

General procedure that leads students to find out the real causes of damage of materials:

- analysis and identification of internal and external factors, which affect material properties;
- macroscopic analysis – preparation of metallographic specimens - microscopic analysis;
- further analysis: spectroscopic analysis of chemical composition, hardness test, static tensile test, etc [12].

This article aims to show the use of technical equipment by students, which are looking for causes of degradation of specific parts in the framework of practical lessons in the subject Construction materials and limit states.

Technical equipment

The accuracy of the performed analyses influences the level of technical equipment. Therefore, in practical lessons students have the opportunity to use modern equipment. The most frequently used equipment will be further described. For macroscopic evaluation there are available: a digital camera with lighting and a microscope that works with magnification max. 50x, it is connected to the PC with software for processing the obtained image.

For metallographic sample preparation a metallographic saw, metallographic press, grinding and polishing machine are used. After polishing the sample is often etched with etchants selected, the sample can be monitored by light microscopy. Of course, if necessary, the sample can be observed in the non-etched state. The students most often carried out microstructure analysis on the confocal laser microscope Lext OLS 3100 or optical microscope Olympus BX51M. This equipment belongs to the most used during practical lessons, Fig. 1-8.

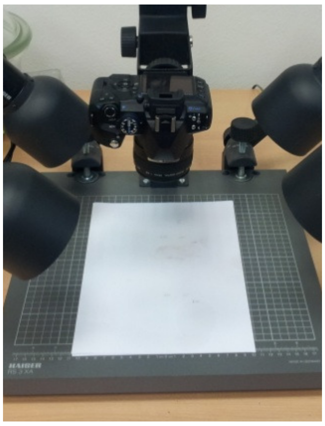


Fig. 1. **Camera Olympus E 520**

Fig. 2. **Optical microscope Olympus SZX10**

Fig. 3. **Metallographic saw MTH Mikron 110**

Fig. 4. **Press MTH Standart 30**

Fig. 5. **Grinding and polishing machine MTH Kompakt 1031**

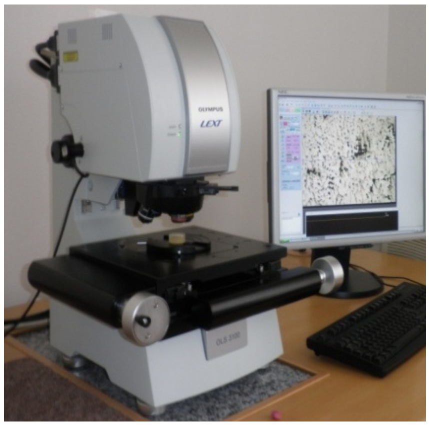


Fig. 6. **Olympus Lext OLS 3100**

Fig.7. **Electron microscope Tescan Vega 3**

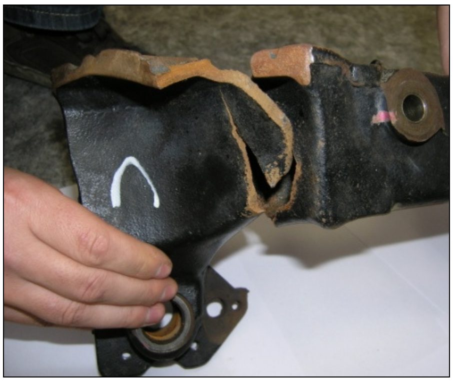
Fig. 8. **Spectrometer BRUKER Q4 TASMAN**

All this equipment is available to students not only in the practical teaching of the selected subjects, but also in solving bachelor, master and PhD thesis.

Students in solving their projects work either independently or in small groups (two or three students maximum), so that each student can get practical skills in the use of the equipment.

Use of technical equipment in practical training

In the subject "Construction materials and limit states" students carried out analyses of the causes of limit states and degradation in different elements of design, Fig. 9.

a) 

b) 

Fig. 9. **Examples of the analysed components:** a – part of the car chassis, fracture; b – valves, creep

Example analysis of students

Students decided to analyse the damaged articulated bearing, specifically the tiller, which served to connect the truck to the universal milling machine. The analysed part was damaged at the point where a section was weakened by drilling. As the first step, students documented the current status of the component, Fig. 10.

Fig. 10. **Documentation of the degraded part**

The second step was to make a macroscopic analysis in the area of the fracture and on the surface of the component, Fig. 11.

Fig. 11. **Macroscopic observation**

Next metallographic preparation of the sample in order to observe the microstructure of the material followed. The first operation was cutting the component, using a circular saw MTH. After creating a sufficiently small portion the press was used. The following operation was grinding by the laboratory horizontal grinder MTH 1031 COMPACT. Students used abrasive papers with different grain sizes. Polishing with abrasive pastes with different roughness followed. The final operation was etching the sample.

Microscopic analysis was carried out on a confocal microscope LEXT OLS 3100. It has been shown that the basic material in the area of the fracture has a high concentration of inclusions (Fig. 12), which worsen the properties of the material. In fracture profile oxide membranes occur, Fig. 13, which are formed in the material during casting.

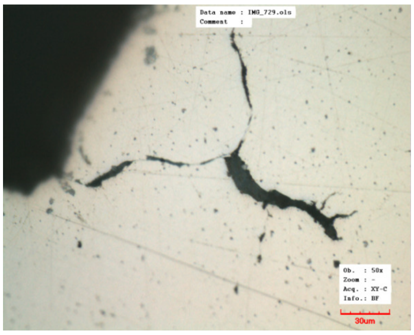


Fig. 12. **Oxide membranes, inclusions**

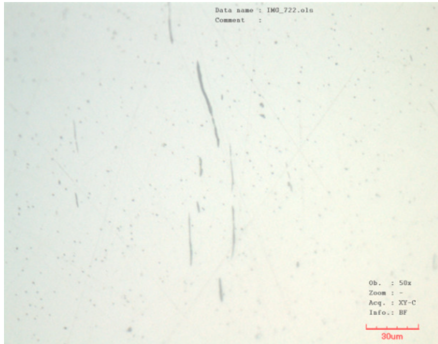


Fig. 13. **Sulphide inclusions**

Sulphide inclusions formed bands, which relate to the method for manufacturing. Such oriented inclusions substantially reduce the plastic properties of the material.

After etching the components were observed using the confocal laser microscope Lext OLS 3100. The material has degraded parts of the ferrite-pearlite structure, Fig. 14, 15, consisting of polyedral grains. Locally it can be observed that the material was cold-rolled, the structure was heterogeneous.

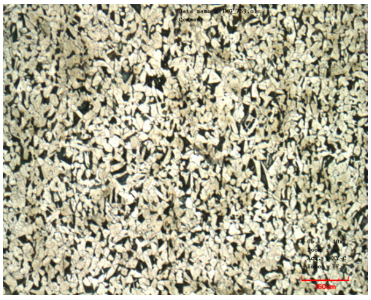


Fig. 14. **Structure of the material**

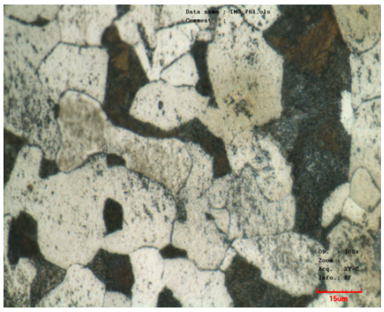


Fig. 15. **Detail of the material**

The last step was the fractographic analysis of the fracture surface (Fig. 16) with an electron microscope Tescan Vega of 3. This allowed the students to view the fracture surface with a large depth of field.

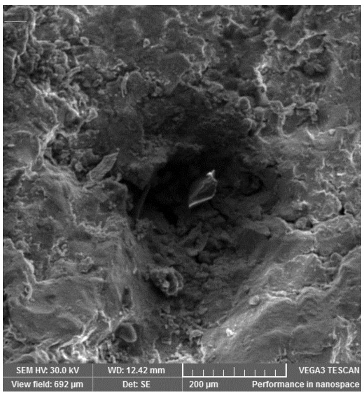


Fig. 16. **Fracture surface**

This allows describing the morphology of the fracture surface, carrying out chemical analysis of the selected phases using EDX. The analysis confirmed the assumption of the microscopic analysis that the inclusions on the fracture surface are sulfides on the basis of MnS.

Based on the results, the students were able to present conclusions about the causes of degradation and subsequent fracture component.

Conclusions

The aim of the article was to show the importance of the use of technical equipment for teaching technical subjects. In a definite example the procedure during practical training was demonstrated, which most often leads students to discover the causes of degradation processes.

The possibility of individual students to work on modern technical equipment has resulted in the following.

1. Identification of real causes of damage to components.
2. Practically getting acquainted with modern equipment.
3. Simulation of the processes of manufacturing practices.
4. Extending the knowledge of the students and it opens up new possibilities in the labour market.

Each of these points is important for technical education, because it leads to improving the quality of the teaching process. And it has to be the effort of each educational institution.

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