CREATION STUDY AIDS WITHIN THE STUDENTS WORKS

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Abstract. Department of Technology and Material Engineering, FPTM in J. E. Purkyně University in Ústí nad Labem addresses in their students' work in particular technical problems in close contact with technical practice. This paper is devoted to work, which aimed to create teaching aids that are applied in teaching of technical subjects such as Technical Materials and Welding.

Keywords: didactic aid, students' work, microstructures, heat treating, technical subjects.

Introduction

Training students in technical fields is challenging not only for students but also for teachers and especially for their performance in the field of technical security training. An effort of the Department of Technology and Material Engineering of the Faculty of Production Technology and Management is to show in the courses much experience by fully using teaching aids. Since students have a number of technical subjects in terms not only theoretical but also practical, it is necessary to support the teaching aids to approach the subject taught as closely as possible to the facts.

Metals are a material that is found in everyday life, their presence and importance are often not even realized. A large variety of requirements for steel and iron products will require a very wide range of alloys with different combinations of elements, trying to improve certain properties such as physical characteristics, chemical, mechanical and technological properties [1, 2], which determine the suitability of the material for cutting and non-cutting processing.

This contribution has developed teaching materials that were created in the final work of bachelor students. Specifically, the creation of the atlas structures after heat treatment of steel, which are used in teaching the course materials Technical I and Welding.

Materials and methods

The paper deals with monitoring the impact of heat treatment on the mechanical properties and structure of selected steels. When processing the documents and experiments the following steps were chosen:

- choice of material specimens, preparation of experimental samples;
- design heat treatment, heat treatment prepared samples;
- mechanical tests, evaluation of mechanical properties of heat-processed samples;
- metallographic sample preparation;
- analysis of the microstructure before and after heat treatment;
- processing the measurement results in the form Atlas of steel microstructures on CD.

Steels ČSN 41 1600 (EN 10025-94) and ČSN 41 4220 (EN 10084-94) where chosen as experimental material.

On the basis of the material sheets, calculations, literature and empirical experience, it was necessary to determine the parameters of the selected steels for different heat treatment: annealing temperature, heating time, length of stay on the temperature, cooling environment.

- Steel ČSN 41 1600 (EN 10025-94) with a usual quality higher carbon content.
    - Chemical composition [%]: C – 0.50, P – 0.045 max, S – 0.04 max, N – max 0.009.
    - Application: suitable for machine components statically and dynamically stressed, do not require weld ability; components exposed to high pressure; shafts, axes, gears, sprockets, levers, pins, piston rods, pins, supports, holders, clamps, screws and bolts, wedges, pens, sliding blocks, racks, pulleys, couplings, insert segments and axial bearings, spacers, various clamping elements, body belts and cutters, etc. for forming bands bend.

  - Heat treatment: normalization, soft annealing, hardening.
  - Soft annealing: annealing temperature – 700 ˚C; heating time – 45 min => 16 ˚C·min^{-1}; remain on the temperature – 5 minutes (1 min/∅1mm); cooling – furnace.
  - Hardening: hardening temperature – 830 ˚C; heating time – 50 min => 17 ˚C·min^{-1}); remain on the temperature – 5 minutes (1 min/∅1mm); cooling – oil.
- Steel ČSN 41 4220 (EN 10084-94) manganese-chrome hardening steel.
  - Chemical composition [%]: C – 0.14-0.19, Mn 1.10-1.4, Si – 0.17-0.37, Cr – 0.80-1.10, P – 0.035 max, S – max 0.035.
  - Application: suitable for machine parts for upgrading to a diameter of 35 mm, hardening with great strength in the core, such as shafts, gears, camshafts, valve lifters, piston pins, gear couplings.
  - Heat treatment: normalization, soft annealing, thermal refinement, double tempering.
  - Normalization: annealing temperature – 900 ˚C; heating time – 39 min => 18 ˚C·min^{-1}; remain on the temperature – 5 min (1 min/∅1mm); cooling – air.
  - Soft annealing: annealing temperature – 700 ˚C; heating time – 45 min => 16 ˚C·min^{-1}; remain on the temperature – 5 minutes (1 min/∅1mm); cooling – furnace.
  - Thermal refinement: hardening temperature – 860 ˚C; heating time – 48 min => ∅18 ˚C·min^{-1}; remain on the temperature – 5 minutes (1 min/∅1mm); cooling – oil, tempering temperature – 180 ˚C; heating time – 10 min => 18 ˚C·min^{-1}, remain on the temperature – 5 minutes (1 min/∅1mm); cooling – air.
  - Dual hardening: hardening temperature – 860 ˚C; heating time – 50 min; remain on the temperature – 5 minutes (1 min/∅1mm); cooling – oil; hardening temperature – 820 ˚C; heating time – 48 min; remain on the temperature – 5 minutes (1 min/∅1mm); cooling – oil.

Mechanical tests

Mechanical tests to determine the mechanical properties of samples were used for such destructive tests:

- Static tensile test EN 10002-1
- Impact bend test EN 10045-1
- Rockwell hardness tests.

Examples of the results of the static tensile tests for material ČSN 41 1600 are shown in Table 1. Other mechanical values were then used to create a catalogue and proceeded the same way with the material ČSN 41 4220.

Table 1

The results of mechanical tests, mat. ČSN 41 1600

Heat treatment	R_e [MPa]	R_m [MPa]	A [%]	Z [%]
Thermally unprocessed	335	600	16	40
Normalization	326	519	16	59
Soft annealing	350	413	21	64
Hardening	841	1059	5	10

The heat-treated samples that were metallographically prepared by means of pressing, cutting and polishing, etched of the original mechanical tests were metallographically analyzed. Analysis has served to describe the structures created after heat treatment, Figure 1, and were again entered into the Atlas structures.

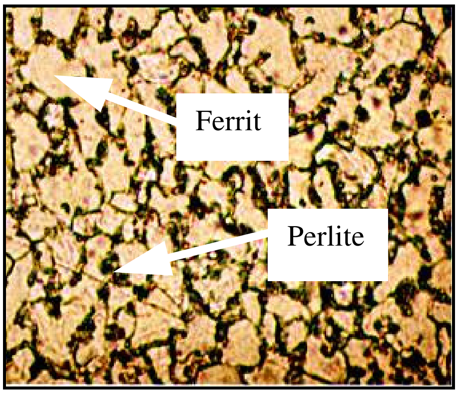
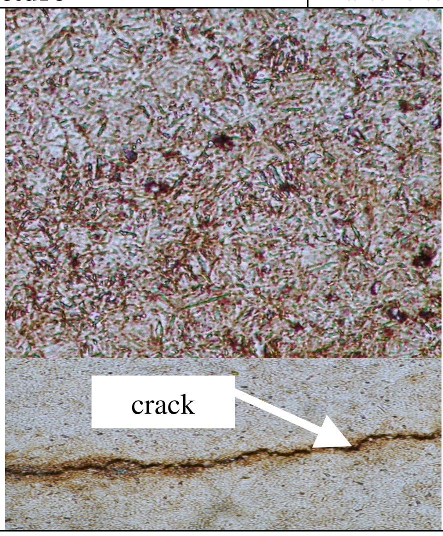
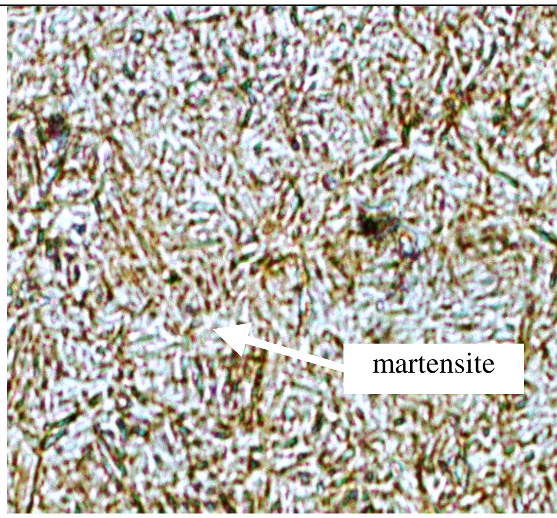


Fig. 1. **Steel ČSN 41 4220.0, etching. Nital 1%, mag. 500x**

Next is a sample of one page form "Atlas of microstructures of steels", Table 2.

Table 2

Microstructures after heat treatment, steel ČSN 41 600.7

Material	steel, ČSN 41 600.7
Heat treatment	hardening
Chemical composition (%)	C – 0.5; P – max. 0.045; S – max. 0.04; N – max. 0.009
Mechanical properties	R_e = 841 MPa R_m = 1059 MPa A = 5 % Z = 10 % HRC 48 KCU2 = 49 J·cm^{-2}
Structure	martensite and residual austenite
	
Mag. 200x	Mag. 500x

Conclusion

This contribution provides a procedure for drawing up the atlas of microstructures of selected steels. Documents for the creation of the atlas were prepared by students in their works. The atlas is for each heat treatment the result of mechanical tests, a description of microstructures with links (to compare two magnifications), and the heating process. This atlas serves students as a teaching aid for teaching technical subjects at DTME such as the Technical Materials I, II, Welding and so on.

References

1. Jech J. Tepelné zpracování kovů, SNTL, 1983. (In Czech).
2. Ptáček, L. Nauka o materiálu II, CERM, 2002, ISBN 80-7204-248-3. (In Czech).