INFLUENCE OF THE DOUBLE TEMPERING IN THE MECHANICAL PROPERTIES OF STEEL SAE D2 TOOL USED IN COLD CUT WORKING

Tamara de Oliveira Barros[1], Aryadne de Jesus Picoli[1]
[1]*Centro Universitário do Espírito Santo – UNESC*

1. Introduction

Steel SAE D2 has features that makes it one of the most used steels in the metalworking industry, especially in shaping industry and cold cut working. This is due to its excellent dimensional stability by having hard carbides chromium in its structure. It can be treated in a thermal way for high hardness maintaining good resistance to fracture and wear [1].

Quenching is a heat treatment which increases the strength and hardness of steels, however, it decreases the toughness thereof. To delay and reduce this effect is used as a tempering treatment subsequent to quenching. This treatment in turn aims to reduce internal stresses that cause the hardening material. The important element in the transformation process during the heat treatment is chromium carbide that have coarse grains, anisotropic and are integrated into the surface of a metal forming a network connecting the cells. These characteristics after production tooling has great importance in the performance improves wear resistance, corrosion resistance and also retains these properties at elevated temperatures and also influence the behavior of the heat treatment [2].

According to SILVA and MEI (2010), the tools and high hardenability steels should receive a double tempering. The first must start with the workpiece at temperatures between 60 and 90°C, this temperature the reliefs voltage occur, tempering of martensite and carbide precipitation in austenite crosslinked. The lower carbon content increases the temperature of the retained austenite, thereby hardening occurs during cooling, forming more martensite. The second tempering has the function of tempering the martensite formed new. This treatment is often used for dimensional stabilization tools and gauge which may be annealed to over twice [3].

2. Experimental

The specimens of the SAE D2 steel were separated by numbering into three distinct groups. A group of samples that were annealed once (1, 2, 3), a group with twin tempered samples (4, 5, 6) and standard samples (7, 8, 9). They were held in rejoinders so that there was an average of the results.

The samples were annealed at 1020ºC for one hour, with preheating of 750°C. They were cooled in oil with a cooling rate of 8°C/s. The samples were heated to 200°C, and then annealed again at a 500ºC temperature range and remained for two hours. The samples passed the Vickers hardness tests and Charpy impact type. The metallographic analysis was performed using as a chemical reagent Nital 4% for the attack, revealing the changes generated in the final microstructure.

3. Results and Discussions

The test with double tempering obtained a significant increase around 27% in its impact resistance. Quenching greatly reduces the toughness of steel, tempering conducted yet brings a part of impact resistance that was lost.

The results of Vickers hardness (HV) made in standard samples with one and with a double tempering and quenching added showed an increase considerably the steel hardness and toughness twice double tempering, an increase of 63.9%.

Table 1 shows all the means of the results of hardness and impact for verification of the data collected in this research.

Table 1: Average of all samples of hardness and impact

Sample	Impact (J)	Hardness (HV)
Pattern	3.93	234
Tempered at 200°C	1.73	744
Double tempered at 500°C	2.36	648.91

The images shown in figures 2, 3 and 4 show the microstructure obtained before and after tempering. It is observed in Figure 2 further steel without heat treatment. The microstructure features carbide grains formed by alloying elements. In figure 3 you can see that there is a reduction in the width of grains of martensite - forming characteristic due to internal compression suffered by them. Keeping carbides containing alloying elements, which makes the mechanical properties of the steel. In Figure 4, the steel has a uniform microstructure. This is due to the formation of tempered martensite, forming a more homogeneous and less internal stress structure, thus the material becomes more flexible and tenacious.

*Corresponding author: tamara.barrosoliveira@gmail.com

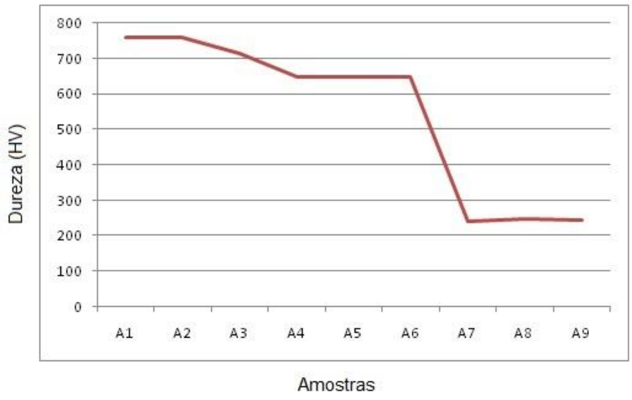

Fig. 1. *Samples x Toughness (HV).*

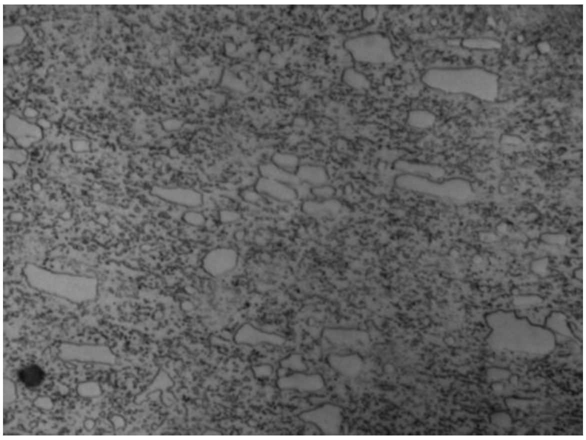

Fig. 2. *Steel sample metalography SAE D2 increased by 800X.*

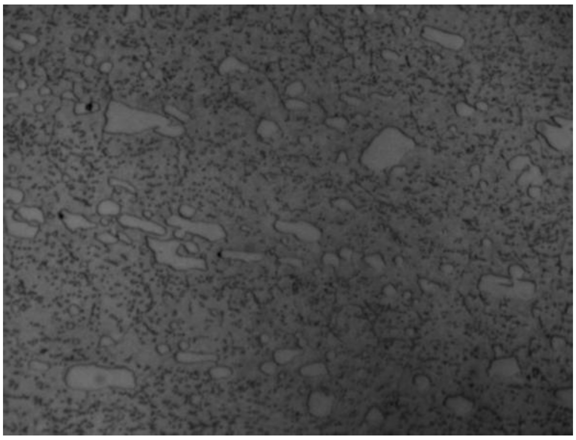

Fig. 3. *Steel metallography SAE D2 with a tempering increased 800X.*

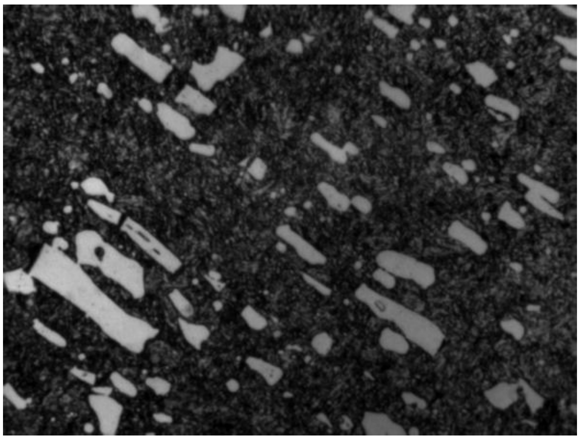

Fig. 4. *Steel metallography SAE D2 double tempering increased 800X.*

The mechanical tests have proven that the heat treatment gave the largest steel SAE D2 organization and coarsening of the grains. The influence of the double tempering, with the same hardness reduction is compensated by the higher percentage toughness. It is possible that parts with just one tempering do not support the efforts that are exerted in cold working.

The use of double tempering substantially increases the toughness compared to single tempering, besides promoting a difference of minimum hardness. Furthermore, the double tempering provides intermediate characteristics between toughness and hardness. Samples with only one tempering showed increased hardness of 68.5% and a decrease of about 56% in stiffness, while the sample dual tempering had a 63.8% increase in hardness and a 40% reduction in toughness. Another important factor is the maintenance of alloying elements, which have been shown in metallography even after the completion of quenching and tempered, showing that its solubility should occur at temperatures above 1020ºC. This is important because despite being a tool steel for cold working its characteristics are retained even at high temperatures. The results of this study are in agreement with other studies where the double tempered steel was used for the SAE D2.

4. References

[1] - RAUTER, Raul Oscar. Steel tools: selection, heat treatment, troubleshooting. Rio de Janeiro: LTC (1974).

[2] - Mendanha, Adriano et al. Main metallurgical parameters and their influence on quality and performance steel for cold working AISI D2. In: 6th Seminar tools chain, molds and dies - ABM, 2008 São Paulo.

[3] - SILVA, André Luiz V. da Costa; MEI, Paulo Roberto. Steels and special alloys. 3. ed. São Paulo: Edgar Blucher (2010).

Acknowledgments

Laboratories of the Centro Universitário do Espírito Santo – UNESC

*Corresponding author: tamara.barrosoliveira@gmail.com