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THE PROPERTIES OF BÖHLER K340 STEEL DEPENDING ON THE APPLIED HEAT TREATMENT

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Abstract

In the mass production of automotive parts, the tool life of the manufacturing tool is very important from an economic site. The tool life is determined by the material quality and the properties of the tool achieved by heat treatment. Böhler K340 Isodur grade tool steel is considered one of the best cold forming tool steels due to its chemical composition and its electro-slag remelting manufacturing. In our experiments, samples made from this steel were subjected to two different heat treatment technologies. The first one (CT-conventional treatment) was tempered three times at high temperature after high temperature hardening, and the second one (DCT-deep cryogenic treatment) was deep frozen – with nitrogen – after high temperature hardening and then tempered three times at high temperature. After the heat treatment, the pieces were subjected to microscopic, toughness, hardness and wear tests. The results of the measurements showed that the structure of the DCT steel is much finer and more homogeneous than the CT steel, the impact strength is higher, there is no difference in hardness, but the wear resistance of the CDP specimen is better than the CT specimen.

Keywords: *tool steel, deep cryogenic treatment, wear resistance.*

Introduction

The high requirements for the properties of the tools make it important to choose the right tool steel quality and their heat treatment technologies. Böhler K340 Isodur is a universal cold work tool steel with high toughness and compressive strength, excellent adhesive wear resistance, high abrasive resistance, very good resistance to tempering. It is a secondary-hardening steel with good dimensional stability suitable to vacuum hardening, plasma nitriding, PVD coating and EDM machining. This steel has fine distributed carbides and a homogeneous clean microstructure thanks to its electroslag remelting manufacturing technology. It is a raw material for many cold forming technology like forming, punching, deep drawing, extrusion, coining , bending, and threat rolling.

The purpose of the heat treatment of the tool is to achieve appropriate properties such as wear abrasion resistance, toughness and strength.

Optimizing the heat treatments parameters tool steel properties and its wear resistance can be enhanced [1]. It is well-known that the application of cryogenic treatments is a good method to reduce the retained austenite content. Minimising the retained austenite we can improve the performance of tool steels. The retained austenite in steels reduce the life of the tools and, when tools are working this phase can be transformed into martensite. Martensite is very brittle and causes internal stresses in the material. Reducing the retained austenite we can increase the dimensional stability of the tools and extend the service lifetimes [2].

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Some studies have shown that cryogenic treatment improve the fracture toughness and wear resistance of the cold work tool steels [3].

The properties like ductility and impact toughness have important effect on wear behaviour and load-carrying capacity of the surfaces [4].

Another advantage of cryogenic treatments is that modifying the carbide distribution could be a positive effect on hardness, mechanical strength, fracture toughness and structure homogeneity. The structures leads to a finer and more homogeneous carbide precipitation and to an increase in the volume fraction of fine carbides [5]. Regarding the economic site it is well known that the life of cutting tools get extended substantially due to cryogenic treatment, and it is an inexpensive one time permanent treatment affecting the entire section of the pieces [6]. The greatest improvement in properties is obtained by carrying out the deep cryogenic treatment between quenching and tempering [7,8]. In cryogenic treatment after quenching to room temperature the specimens are cooled to minus degree Celsius and soaked at that temperature some time. This step is followed by heating to the tempering temperature.

In this work deep cryogenic treatment was applied to the Böhler K340 Isodur cold work tool steel to investigate its effect on hardness, microstructure and wear resistance. The aim of this paper is to compare the mechanical properties after the two different type of treatments (CT= conventional treatment and DCT= deep cryogenic treatment) and to determine the optimal heat treatment parameters based on them.

Materials and experiments

The chemical composition of studied specimens is given in Table 1. Each specimen was cut and machined from rolled raw material annealed to 225HB.

Table 1. Chemical composition of the Böhler K340 Isodur cold work tool steel (mass%)

C	Si	Mn	Cr	Mo	V	Al	Nb
1.11	0.88	0.41	8.39	2.12	0.52	1.10	0.14

The specimens were cleaned in an ultrasonic washer type Elmasonic S before starting the heat treatment (Fig 1.).

Fig.1. Specimens in the ultrasonic washer

The heat treatment was performed in a vacuum furnace type IVA Schmetz IU72 and a nitrogen atmosphere tempering furnace type Muhel 240 (Fig. 2.).

Fig.2. IVA Schmetz vacuum furnace and Muhel nitrogen atmosphere tempering furnace

The heat treatment diagram of the DCT treated specimens is shown inFig. 3.

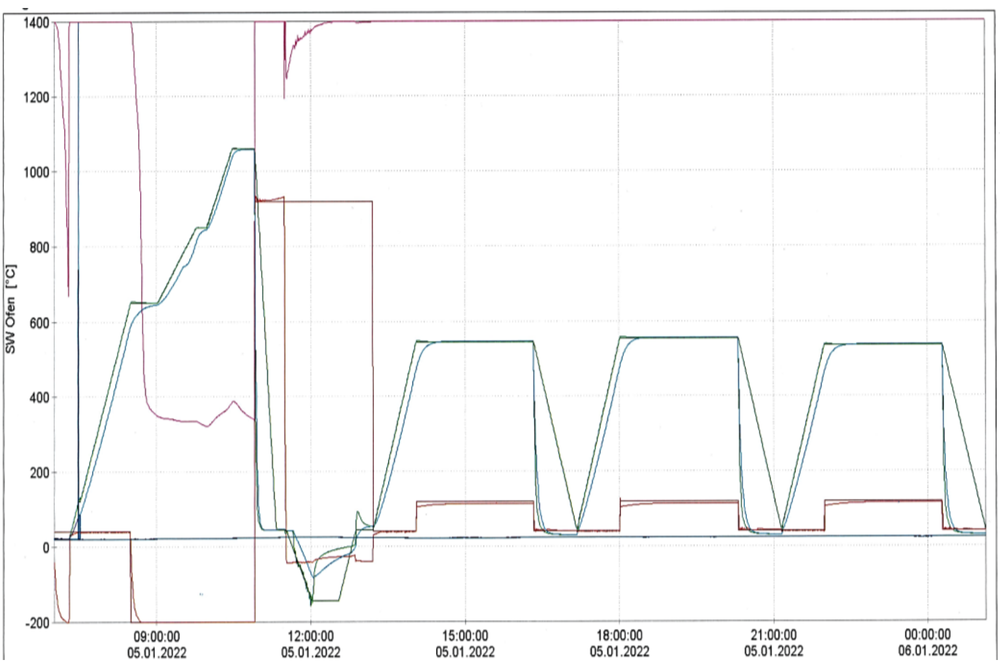


Fig. 3. The heat treatment diagram of DCT treated Böhler K340 steel

The austenization of the samples were performed in vacuum in a IVA Schmetz IU72 600x600x400mm 10bar furnace at 1060°C, with two-stage heating 650°C respectively 850°C for temperature equalization between the core and middle of the specimens.

The cooling was performed with 9 bar nitrogen gas till 45°C, than the CT specimens was moved to tempering in the Muhel nitrogen atmophare furnace and the DCT specimens was further cooled to -145°C with the liquid nitrogen and after it was tempered.

After the heat treatments , the hardness of the specimens was measured with an universal hardness tester type Ernst AT 130 D (Fig. 4.).

Fig.4. Hardness tester

Fig. 5. Charpy impact test machine

For the fracture impact test we are used the Charpy impact test machine (Fig. 5.).

A ball wear equipement was used for abrasive wear testing (Fig.6.), and for the microstructure investigation an optical microscop type Olympus DSX100 (Fig.7.).

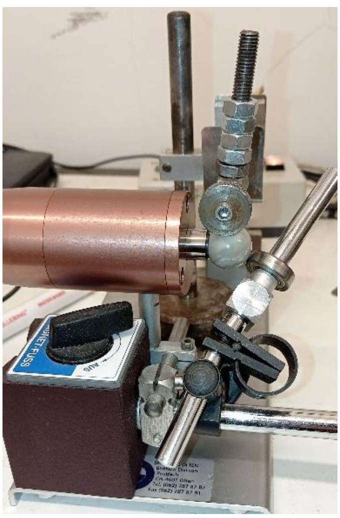


Fig.6. Ball wear equipement

Fig. 7. Olympos DSX microscope

Test results

After the heat treatments Rockwell C hardness measurements were performed according to tandard practice.

The wear abrasion factor (K) was calculated based on the equation (1), which is calculated from the abrasion volume (Vv), the abrasion path length (S) and the load force (N):

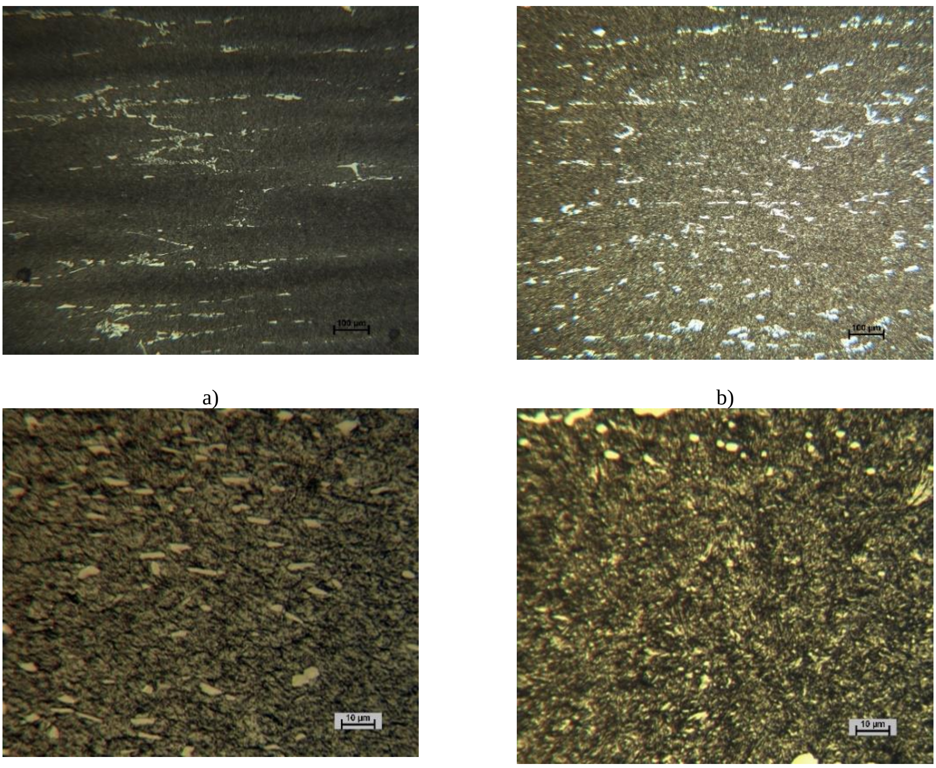
$$K=\frac{Vv}{SN}, \quad [mm^3/Nm] \tag{1}$$

The averige hardness, the results of the impact test and the wear abrasion factor for the examinad samples are presented on Table 2.

Table 2. Results after the hardness, impact toughness and wear abrasion examinations

Samples	**Hardness (HRC)**	**Impact energy (J)**	**Abrasion factor K (mm^3/Nm)**
K340 CT	60	4	$4.49x10^{-8}$
K340 DCT	59	8	$4.40x10^{-8}$

The microstructures of the samples are shown in Fig.8 a, b, c, d. The micrograph Fig 8 a. and Fig. 8 c. represint the microstructures of the conventional treated specimens from the Fig. 8 b. and Fig 8. d. the microstructures of the specimens with cryogenic treatment on different resolution.



a) b)

c) d)

Fig. 8. Microstructural analysis at 100X: a) K340 CT; b) K340 DCT; c) K340 CT; d) K340 DCT

Conclusion

Based on microscopic examination it can be observed that after the DCT treatment the retained austenite is completely dissapeared. This explains the impact toughness and the abrasion wear resistance improuvement. The removal of reatined austenite ensures dimensional stability of the tool after the heat treatment.

The microstructures clearly shows that the matrix of the DCT treated samples displays more homogeneous structure and finer carbide distribution that CT samples resulting better wear abrasion resistance.

On Rockwell C hardness there is neglijible differences between the conventionally treated and deep cryogenic treated specimens.

Acknowledgement

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