METABK 54(1) 191-193 (2015)
UDC – UDK 669.15:621.78:620.178.1:66.095.81=111

THE INFLUENCE OF HEAT TREATNEMNT ON THE ABRASIVE WEAR RESISTNACE OF A CONSTRUCTION AND A TOOL STEEL

Received – Prispjelo: 2014-04-25
Accepted – Prihvaćeno: 2014-09-30
Preliminary Note – Prethodno priopćenje

The paper deals about the influence of heat and chemical-heat treatment of construction steel 100Cr6 and alloy steel X210Cr12, which were treated according to their corresponding norms. The steel X210Cr12 was also treated in an unconventional way. The influence of the material structures and hardness on the abrasion wear resistance was studied. The influence of nitridation was considered in a way how to increase the abrasion wear resistance and how the heat treatment affects the hardness and the quality of the nitrided layer. The nitridation with diffusion annealing of the tested materials caused a decrease and also an increase of the materials wear resistances.

Key words: alloy steel, heat treatment, abrasion, nitridation, wear resistance

INTRODUCTION

In the present the companies all over the world try to increase their productivity, the quality of their products and their durability. This requires a high consumption of energies which need to be delivered to the companies. This requires using alternative fuels or renewable fuels made from agricultural waste, wooden waste, wooden saw dust. Fuels made from agricultural waste or saw dust are made in specific forms, like wooden pellets made from harvested wooden waste, briquettes made from wooden saw dust or straw briquettes. Briquettes from wood, saw dust agricultural waste, wooden pellets are made from waste, therefore it is clear that it will be contain dirt, sand, small rocks. To achieve the right quality and shape of the pellets, briquettes it is necessary to secure the right working conditions of the tools, such as the temperature, pressure, velocity which are in details presented in [1]. From the point of pressing the briquettes the small particles like sand and rocks cause enormous abrasion wear to occur, which reduces the lifespan of the pressing tools. These small particles affect like small abrasion particles which damage the tool surface by various types of mechanisms [2-4]. In these cases the abrasion wear is so intense that the tools have to be removed after short periods of time, due to the change in the tools shape [5]. The increase of the pressing temperature leads to higher briquette qualities. Therefore it is necessary to chose the right materials of the pressing tools and their heat treatment like is documented for various materials used in practice [6].

M. Orečný, M. Buršák, J. Viňáš,, Technical University of Košice, Slovakia

MATERIALS AND EXPERIMENTAL METHODS

The tested materials were a 100Cr6 steel used for bearings, and a chromium tool steel X210Cr12, which was heat treated by two different methods. From the materials cylinder test samples were made, the dimensions were: diameter ø 6 mm and length 15 mm. A part of the samples was only hardened and tempered, the other part was also nitrided and diffusion annealed. The chemical compositions of the tested materials are shown in Table 1 and the applied heat treatment is in Table 2.

Table 1 **Chemical compositions of the tested materials / wt. %**

Material	C	Mn	Si	Cr
100Cr6	1,1	0,5	0,35	1,5
X210Cr12	2	0,5	0,4	12

Table 2 **Materials heat treatment**

	Material		
	100Cr6 (case A)	X210Cr12 (case B)	X210Cr12 (case C)
Hardening	820 °C	960 °C	1 100 °C
Tempering	170 °C/ 2 h	180 °C/ 2 h	550 °C/ 2 h
	(case D)	(case E)	(case F)
Nitriding	520 °C/ 14 h	520 °C/ 4 h	520 °C/ 4 h
Diffusion annealing	520 °C/ 10 h	520 °C/ 30 h	520 °C/ 3 h

RESULTS AND DISCUSION

For gaining information of the materials after the chosen heat treatment methods like light microscopy, measuring of hardness HRC and microhardness HV0,05 were used. The microstructure of the material 100Cr6 after hardening and tempering is illustrated in Figure 1. The hardness of the material was 60 HRC (case A).

On a part of the cylinders the nitridation with diffusion annealing was applied to increase the surface hard-

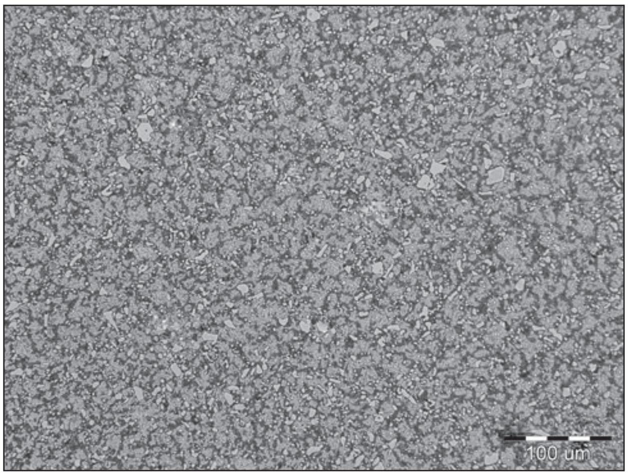

Figure 1 Structure of steel 100Cr6 (A)

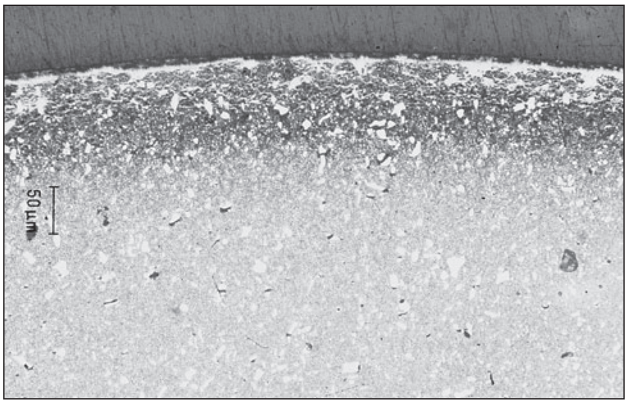

Figure 2 Steel 100Cr6 nitrided layer (D)

ness (case D). The nitrided layer hardness was 641 HV0,05. The depth of the layer was 0,15 mm as it can be seen in Figure 2.

From the material X210Cr12 samples were treated according the corresponding norm (case B). The maximal hardness of the samples was 60 HRC. The structure of the material is almost the same as the structure of steel 100Cr6. The only difference is in the higher carbon content of steel X210Cr12.

Samples of this material after the heat treatment were nitrided and diffusion annealed. The nitrided layer of steel X210Cr12 is documented in Figure 3.

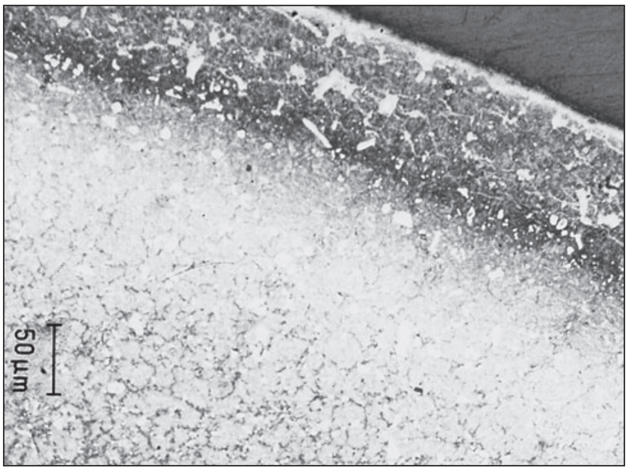

Figure 3 Steel X210Cr12 nitrided layer (E)

Figure 4 Steel 100Cr6 nitrided layer (D)

The higher amount of chromium caused that the hardness of the layer increased to a value of 853 HV0,05. The depth of the nitrided layer was 0,15 mm and in the depth 0,17 mm. From steel X210Cr12 another part of the samples was hardened from 1 100 °C in to oil, and then tempered at 550 °C for two hours (C). The hardness after hardening was 55 HRC and after tempering in increased to 58 HRC. The structure of this material is a typical high tempered martensite. The cylinder samples were nitrided and diffusion annealed. The maximal depth of the layer was 0,18 mm and its hardness reached 1 417 HV0,05. In the depth of 0,25 mm the hardness was 570 HV0,05. The detail of the nitride layer is documented in Figure 4.

The dependence of the layers hardness over the layer depth of materials 100Cr6 (D), X210Cr12 (E) and X210Cr12 (F) are documented in Figure 5.

The measurement of the tested samples was focused on the materials weight loss after all heat treatments. The relative abrasion wear resistance was set according the steel 100Cr6 in case A, with the hardness of 60 HRC and its value was set to ‘’1’’. The abrasion coated paper of grain P 120 was put on a cylinder of diameter D = 150 mm, and the samples were fixed in a fixation device. The pressure force was F = 5 N, the trajectory

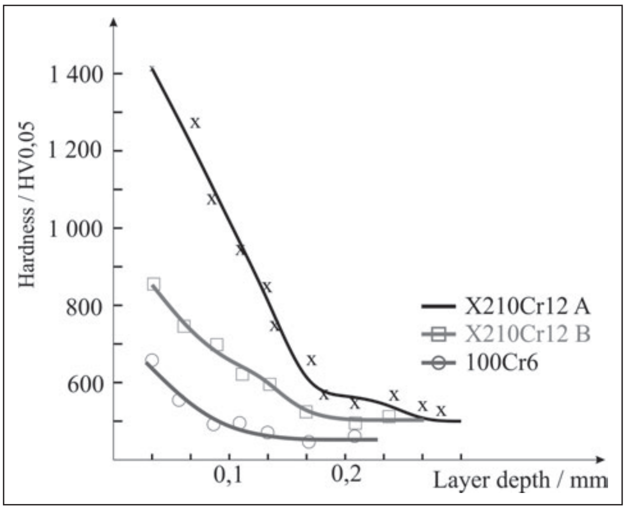

Figure 5 Nitrided layers hardness over the layer depth

was s = 40 m. The samples were weighted with a tolerance ± 0,0001 g. The materials weigh losses are shown in Tables 3 and 4.

Table 3 **Hardened materials weight loss**

Hardened and tempered	
Material	Average weight loss / g
100Cr6 (A)	0,02388
X210Cr12(B)	0,01654
X210Cr12(C)	0,01332

Table 4 **Nitrided and diffusion annealed materials weight loss**

Nitrided with diffusion annealing	
Material	Average weight loss / g
100Cr6 (D)	0,03248
X210Cr12(E)	0,01700
X210Cr12(F)	0,01060

From the obtained information it can be seen that the steel 100Cr6 has a higher abrasive wear resistance compared to its nitride state. The reduction in the resistance is caused by the fact that the ε phase occur around the carbides. The ε phase creates nitride nets, which reduce the layer unity. The same phenomenon occurred in the steel X210Cr12 after its norm heat treatment. The X210Cr12 steel had the same hardness like 100Cr6 after hardening and tempering, but the steel X120Cr12 had more special carbides in its matrix which affected the abrasion wear resistance positively. In both cases after nitridation the abrasive wear resistance was decreased. The comparison of the materials abrasion relative wear resistance is documented in Figure 6.

The decrease of the materials abrasion wear resistance after nitridation was caused because the nitride ε phase occurred, which caused the layer to crack and remove the carbides from the soft matrix. In the case of the unconventional heat treatment of the X210Cr12 steel the abrasion wear resistance rise compared to the norm heat treatment. It was caused by the fact that the high hardening temperature enabled the carbides and carbon to melt and the austenite could saturated to its maximal capacities. After the hardening and tempering the steel hardness was 58 HRC. Due the lower hardness of the material it showed the highest abrasion wear resistance after hardening and tempering. The applied nitridation was very gainful. The high degree of the austenite saturation and its homogeneous chemical composition enabled to create complex nitrides and carbonitrides in the nitrided layer which lead to a high increase of the material abrasion wear resistance.

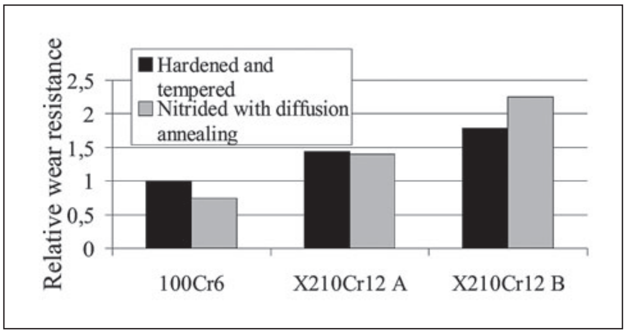

Figure 6 Materials relative abrasion wear resistance

CONCLUSIONS

The aim of this experiment was to demonstrate the influence of the heat treatment of materials used for working in abrasion wear conditions. From the results it is clear that the hardness of the material and the amount of carbides cannot be the main criterions for the application for materials working in these conditions. These materials should have proper chemical composition, heat treatment, structure and hardness. The best properties of the tested materials were obtained for steel X210Cr12 with a martensitic structure with precipitated carbides. The layer after nitridation was without the unwanted ε phase, it was thicker and harder compared to the norm treated material.

Acknowledgements

This study was supported by the grant project VEGA 1/0130/14.

REFERENCES

[1] Križan, P., Matúš, M.: Dôležitosť druhu lisovaného materiálu pri briketovaní a peletovaní. Energie z biomasy X. - odborný seminár, Brno 2009.

[2] Gee, M.G., Gant, A., Roebuck, B.: Wear mechanisms in abrasion and erosion of WC/Co and related hardmetals. Wear, 263 (2007) 1-6, 137-148.

[3] Zdravecká, E., Smetana, Š., Suchánek, J.: Abrazívne a erozívne opotrebenie. Technická univerzita v Košiciach: Edícia študijnej literatúry, Košice 2012.

[4] Matúš, M., Križan, P., Kováčová, M.: Analýza konštrukčných parametrov vyplývajúcich na výslednú kvalitu výlisku. Energie z biomasy X. - odborný seminár, Brno 2009.

[5] Totten G. E.: Steel Heat Treatment: Metallurgy and Technologies, Taylor & Francis Group, USA 2007.

[6] Rowe, W. B.: Mechanics of Abrasion and Wear. Principles of Modern Grinding Technology, 17 (2014), 349-379.

Note: The responsible translator for English language is Andrea Horvath, Prievidza, Slovakia