

ANALYZE AND RESEARCH OF CARBIDES BY OPTICAL AND SCANNING ELECTRONIC MICROSCOPES FOR 100Cr6 STEEL

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ABSTRACT

Steel 100Cr6 belongs to a group of hardened steels, which are applicable for production of rolling elements and rings. Because of specific working conditions, the material is exposed to high specific compression as well as wearing. Because of these reasons, a high hardness and its uniformity is required for the steel 100Cr6. In this paper, the research results of the carbide particles are presented for the steel produced in vacuum and open induction electric furnace as well as their influence on the properties described by a standard for the steel 100Cr6. The optical and scanning electronic microscope are used to identify presence of the carbides.

Key words: steel 100Cr6, carbides, optical microscope, scanning electronic microscope, vacuum induction electrical furnace, open induction electrical furnace

1. INTRODUCTION

During the steel production, some alloying elements like Cr, V, W and Mo could form the special phases that is the carbides in the determined conditions. The carbides have the special properties like the high hardness, high melting temperature, special electrical and magnetic properties. The mechanical properties (wear resistance for example) depends from type and quantity of the presented carbides. The wear resistance increases with increasing of the carbide quantity and its hardness. However, the high carbide quantity could decrease machinability and toughness. In the case of 100Cr6 steel, the main alloying element is chrome. The chrome is strong carbide forming element and together with carbon forms different carbides. These carbides are more resistant and stabile than cementite. For 100Cr6 steel is characteristic a presence of (FeCr)₃C carbides according to the chemical composition. For production bearings from 100Cr6 steel, the uniform carbide distribution, the microstructure with spheroidized carbides of medium size without a rest of lamelar carbides is necessary. Steel production method and heat treatment have very important influence on the carbide shape and distribution [1-4].

2. EXPERIMENTAL PROCEDURE

2.1. Production of 100Cr6 steel

Experimental melts of 100Cr6 steel are produced in open and vacuum induction electrical furnaces at Metallurgical Institute „Kemal Kapetanović“ in Zenica. The chemical composition of melts is given in Table 1.

Table 1. The chemical composition of 100Cr6 steel [5]

Method of production	Melts	Chemical composition [%]								
		C	Si	Mn	P	S	Cr	Ni	Mo	Cu
Open induction furnace	B7611	0,98	0,29	0,41	0,013	0,029	1,52	0,20	0,03	0,23
Vacuum induction furnace	C1302	0,95	0,35	0,43	0,007	0,016	1,60	0,22	0,03	0,19

2.2. Plastic processing

- Hammering with dimension 120x120 mm on 34 x 34 mm
- Rolling with dimension 34 x 34 mm on \varnothing 26 mm.

2.3. Heat treatment

The samples of the steel 100Cr6 are heat treated as follows:

- heating to a temperature 800 °C in the furnace without protection atmosphere
- holding at that temperature for about 4 hours
- cooling in the furnace
- heating to a temperature 820 °C in the furnace without protection atmosphere
- holding at that temperature for about 20 minutes
- quenching in water
- heating to a temperature 180 °C in the furnace without protection atmosphere
- holding at that temperature for about 1 hour and 30 minutes
- cooling in air

2.4. Metallographical investigation

The samples from 100Cr6 steel observed by the optical (Figure 1) and scanning electronic microscope (Figure 2.) at the Institute for materials and technology in Ljubljana-Slovenia.

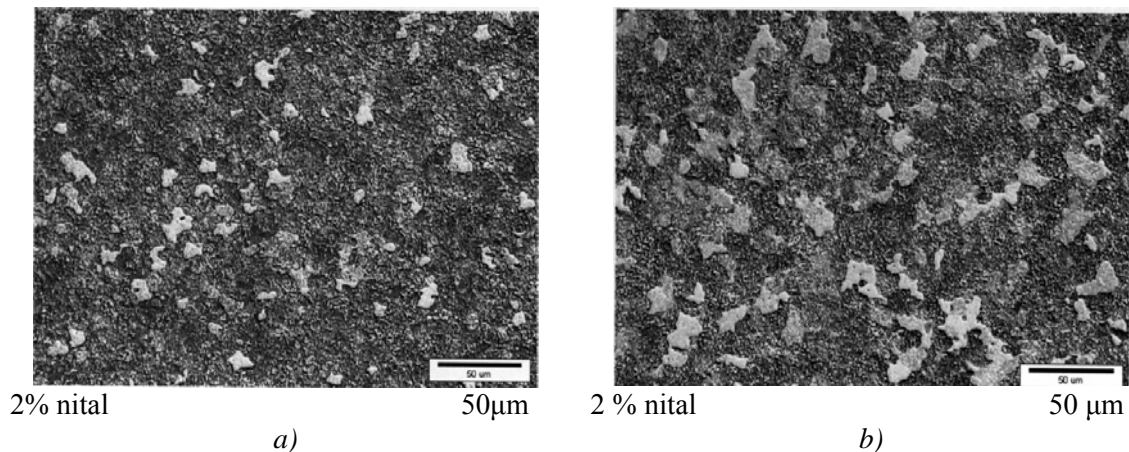


Figure 1. The carbide distribution for samples in annealed condition a) the melt produced in open electrical furnace and b) the melt produced in vacuum induction electrical furnace [5]

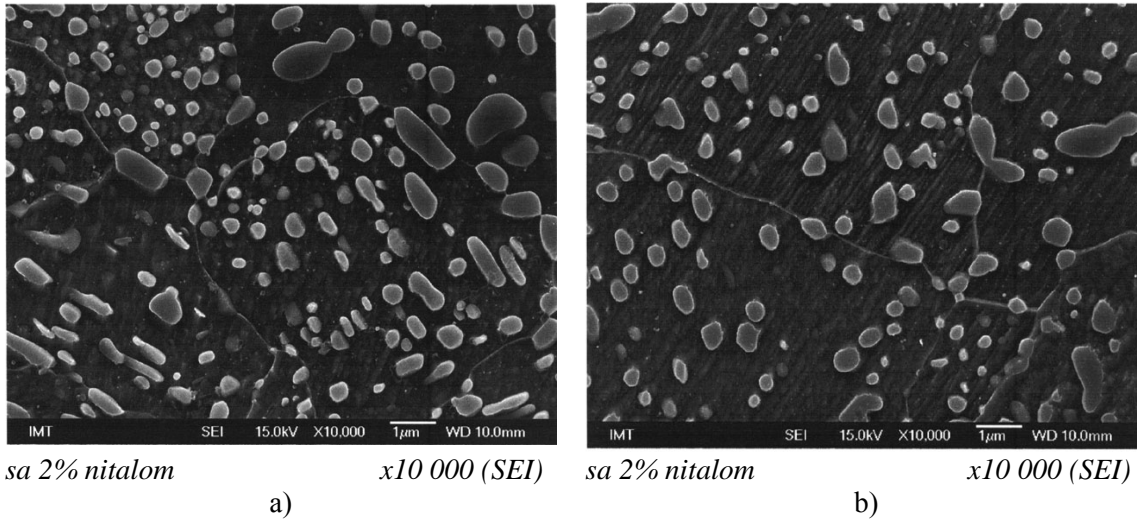


Figure 2. The carbide distribution for samples in annealed condition a) the melt produced in open electrical furnace and b) the melt produced in vacuum induction electrical furnace [5]

The carbide distribution analyzed for samples taken from bars with diameter of 26 mm in annealed, quenched and tempered condition. The rolled bars produced from the 100Cr6 steel who melted in the open and vacuum induction electrical furnace. The results of observation are presented in Table 2, according to the standard BAS ISO 5949.

Table 2. Assessment of the carbide distribution according to the standard BAS ISO 5949 [5, 6]

Melt	No. sample	Assessment of the carbide distribution			
		NA	NH	LE	LD
B 7611	1.	4,0	5,1	6,4	7,3
	2.	4,0	5,1	6,4	7,3
	3.	4,0	5,1	6,5	7,3
	4.	4,0	5,1	6,5	7,3
	5.	4,0	5,1	6,5	7,3
	6.	4,0	5,1	6,4	7,3
	7.	4,0	5,1	6,5	7,3
	8.	4,0	5,1	6,5	7,3
	9.	4,0	5,1	6,2	7,2
	10.	4,0	5,1	6,5	7,2
C 1302	1.	4,0	5,0	6,2	7,3
	2.	4,0	5,0	6,2	7,3
	3.	4,0	5,0	6,2	7,2
	4.	4,0	5,0	6,1	7,2
	5.	4,0	5,0	6,1	7,3
	6.	4,0	5,0	6,2	7,3
	7.	4,0	5,0	6,1	7,3
	8.	4,0	5,0	6,2	7,2
	9.	4,0	5,1	6,2	7,3
	10.	4,0	5,0	6,2	7,2

The distribution of carbides is assessed by comparison with the reference photomicrographs given in the above mentioned standard. The reference photomicrographs are divided into four series according to shape, dimensions and the distribution of carbides [6]:

- series NA-relating to the distribution of carbides at grain boundaries in the annealed condition

- series NH- relating to the distribution of carbides at grain boundaries in the quenched and tempered condition
- series LE- relating to carbide streaking of enclosed shape. Only heavy carbide streaking is taken into consideration
- series LD relating to carbide streaking of diffused shape.

According to the guidelines FAG PL1.203 (FAG Kugelfischer plant Schweinfurt) the limiting values of series are: NH=5,7, LE=6,3 and LD=7,4 [7].

3. ANALYSE OF RESULTS

The analyse of the carbide distribution showed that the values of series NH, LE and LD do not cross the required values according to guidelines FAG PL1.203 for the melt produced in the vacuum induction electrical furnaces.

The values of the series LE is higher from the required values for the melt produced in open induction electrical furnace.

As shown in Table 2. the values of series NA are the same for both melts. The observation of the carbide shape by the scanning electronic microscope showed that there is difference in carbide shape for the melts produced in open and vacuum induction electrical furnaces. The carbides are more spherical, smaller and the distribution is more uniform for the melts from the vacuum induction furnace [5].

4. CONCLUSIONS

The analysis of carbides for 100Cr6 steel by the optical microscope showed that the carbide distribution is more uniform and do not cross the limiting values (according to the guidelines FAG PL1.203) for melt from the vacuum induction electrical furnace compared to the melt from the open electrical furnace. The SEM analyse indicated a presence of the elongated carbides in the melts from open induction electrical furnace. It could have harmful effects on mechanical properties. Generally, from the carbide distribution results it could say there is not significant difference between the melts produced in the open and vacuum induction electrical furnace [5].

5. REFERENCE

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