Crack Analysis of W6Mo5Cr4V2 Thread Rolling Roll

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Abstract. Microstructure and facture morphology of the W6Mo5Cr4V2 steel were investigated by optical microscope (OM), scanning electron microscope(SEM) and Rockwell hardness tester , in order to figure out the reasons of brittle fracture and crack. They show that the carbides inhomogeneity is very serious and the carbides distributed together in the both samples. The microstructure of the both samples are composed of tempered martensite and carbides. However, due to overheating, serious carbides network, angular carbides and other eutectic structure grow. The results show there is overheating phenomenon during the heat treatment process. Crack formed under the action of thermal stress， W6Mo5Cr4V2 thread rolling rolls result in brittle fracture. They extend under the action of thermal stress and finally. S1 break up into three parts caused by external stress.

Introduction

In 1937, Breelor in the United States invented the W6Mo5Cr4V2 high speed tool steels [1]. High speed tool steel is a kind of tool steel with high heat resistance, high hardness and high wear resistance. Because of high performance and moderate price, W6Mo5Cr4V2 steel is often used in high temperature alloy, ultra high strength steel, stainless steel and other materials producing [2]. But crack failure often happens in the process of production and applying. Recently, many scientific researches on the optimization of W6Mo5Cr4V2 steel production process and performance improvement is still under way [3, 4].

Experimental methods

In this paper, two dimension of Φ23mm and Φ40mm of W6Mo5Cr4V2 thread rolling rolls after heat treatment by quenching and tempering were provided by Foda special steel co.,LTD, For Φ23mm sample, brittle fracture and for Φ40mm surface cracks happened in the process of using. In order to find out the reasons of brittle fracture, Chemical composition analysis(ICAP-7400 ICP-OES),hardness test(TH-300 Rockwell apparatus)， metallographic examination （HITACHI-4300），carbide analysis(Zeiss 40MAT Digital metallographic microscope) were used to investigated these samples.

Results and analysis

Visual inspection


Fig.1 Appearance of the two samples

The Φ23mm and Φ40mm samples were named by S1 and S2 respectively. Fig.1 showed two failure samples. For the S1 it was broken into three parts caused by external stress, forming two matching fracture. S2 cracked spread the whole roll, with random direction. There was no plastic deformation around the fracture and the crack. So all the cracks were typical brittle fracture.

Chemical composition analysis

We sampled from S1 and S2, and done the chemical analysis. The composition of S1 and S2 was shown in the table 1.The results in table 1 showed that S1 and S2 met the GB/T 9943-2008 in W6Mo5Cr4V2 toughened learn composition.

Table 1 Chemical compositions of S1 and S2(wt/%)

	GB/T 9943-2008	S1	S2
C	0.80-0.90	0.83	0.87
Si	0.2-0.45	0.35	0.31
Mn	0.15-0.40	0.31	0.32
P	≤0.03	0.024	0.026
S	≤0.03	0.008	0.006
Cr	3.80-4.44	4.08	4.09
V	1.75-2.20	1.93	1.98
W	5.50-6.75	5.86	5.94
Mo	4.50-5.50	4.66	4.81
Cu	≤0.25	0.063	0.064
Ni	≤0.30	0.059	0.073

Hardness test

The hardness of S1 and S2 were shown in table 2.The results showed that the hardness of samples met the requirement of GB/T 9943-2008.

Table 2 Hardness test of S1 and S2

	HRC			
	Point 1	Point 2	Point 3	AVG.
S1	66.1	66.1	66.1	66
S2	65.3	65.1	65.0	65
GB/T 9943-2008	≥ 64			

Metallographic examination

Microscopic structure

The microstructure observation for the cross section from both samples was done, the results were shown from Fig.2 to Fig.5.

Both of the samples were composed of tempered martensite and carbides microstructure. Fig.2 and Fig.3 of the S1 sample could be clearly observerd serious carbide network, angular carbide and other overheated structures.Fig.4 and Fig.5 of the S2 sample was shown the carbide had high dispersion degree, and some carbide networks were be found in the partial area caused of overheating.

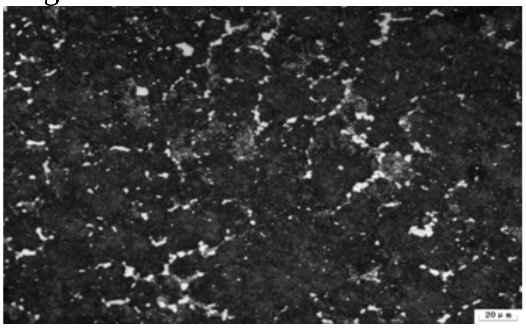

Fig.2 Microstructure of S1 (50X)

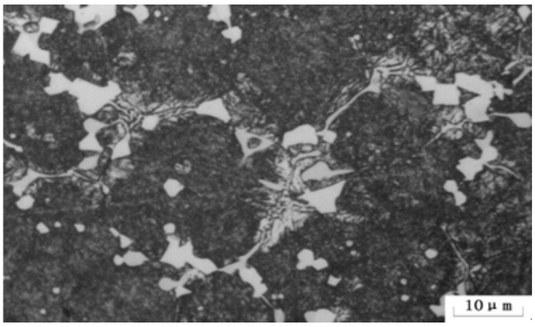

Fig.3 Microstructure of S1 (100X)

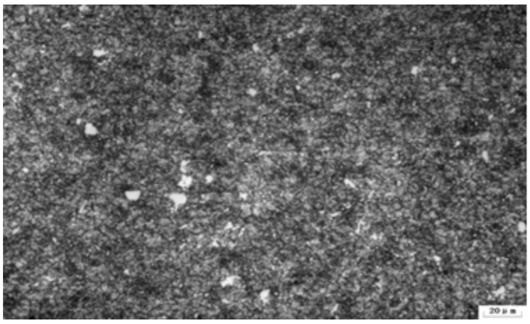

Fig.4 Microstructure of S2 (50X)

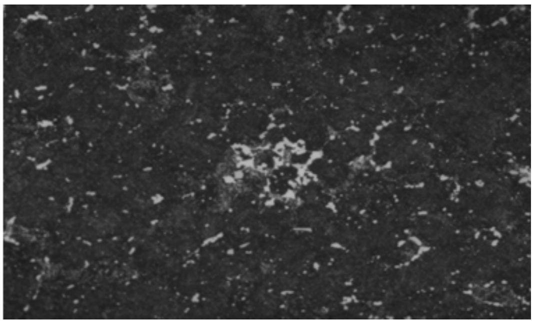

Fig.5 Microstructure of S2 (100X)

Microscopic fracture analysis

Scanning electron microscopy (SEM) analysis was carried out on the fracture surface of S1 and S2, as shown in Fig.6 and Fig.7. According to the microscopic fracture analysis, we could see the fracture characteristics were quasi-cleavage-like fracture characteristic.

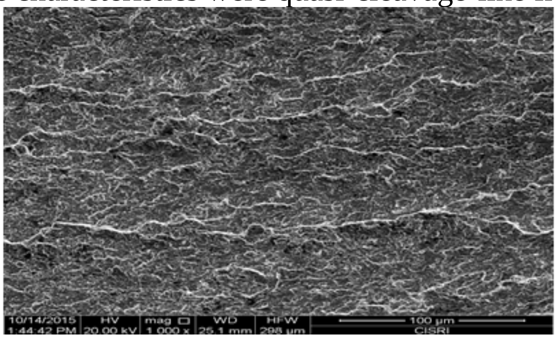

Fig.6 SEM of S1 fracture surface

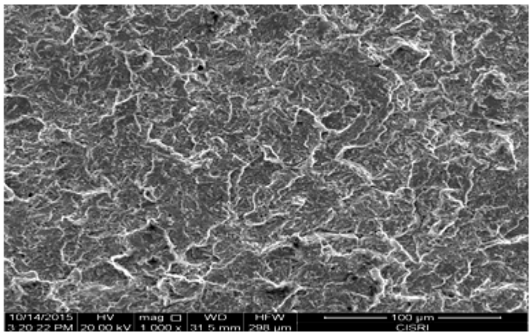

Fig.7 SEM of S2 fracture surface

Fracture section metallographic

Taking the fracture adjacent ares of S1 and S2 to do the metallographic structure observation, as shown in fig.8 and fig.9.The results showed that both fracture section organization were tempered martensite plus carbide, the same with the matrix, and no other abnormal defects were found.

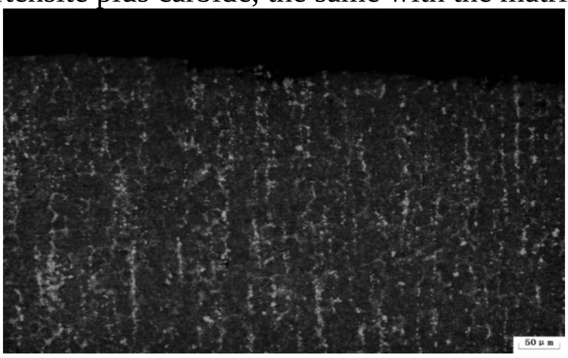

Fig.8 Microstructure of S1 fracture surface(20X）

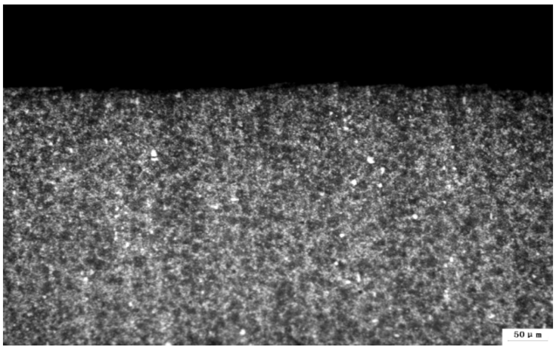

Fig.9 Microstructure of S2 fracture surface (20X)

Carbide analysis

According to GB/T 14979-1994, the longitudinal section of the S1 and S2 samples were taken to evaluate the inhomogeneity of carbide. Carbide analysis results were shown in table 3, Fig. 10 and Fig.11. Carbide inhomogeneity of the two samples did not meet the requirement of GB/T 9943-9943, and the carbide inhomogeneity level was higher than 3 grade.

Table 3 Carbide Inhomogeneity level

	Degree of inhomogeneity of carbides
S1	5
S2	4
GB/T 9943-2008	≤ 3

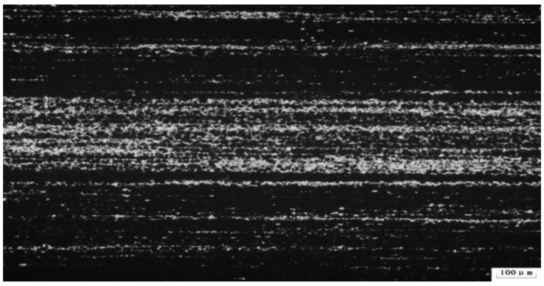
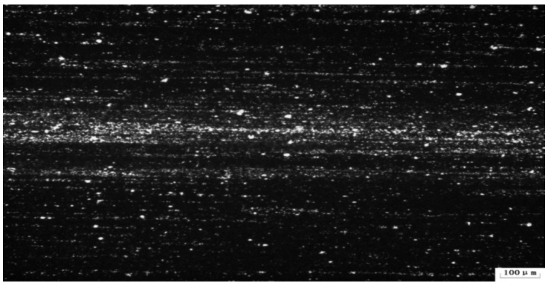

Fig.10 Inhomogeneity of carbides of S1 (10X) Fig.11 Inhomogeneity of carbides of S2 (10X)

Conclusions

Base on the chemical analysis, the composition of the W6Mo5Cr4V2 thread rolling roll meet the standard stipulations of GB/T 9943-2008.

The results of carbide inhomogeneity analysis shows that carbide inhomogeneity of two W6Mo5Cr4V2 thread rolling rolls are not meet the standard. So it can be concluded that melting process quality is poor.

According to metallographic examination, the microstructure of the two samples were tempered martensite plus carbides. However, partially there are serious carbide network, angular carbide and other eutectic structure caused by overheated. Therefore, it can be concluded that there is a case of overheating during the heat treatment process. Crack formed under the action of thermal stress， W6Mo5Cr4V2 thread rolling rolls finally result in brittle fracture. They extend under the action of thermal stress and finally. S1 broken into three parts caused by external stress.

Acknowledgements

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