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Effect of microstructure of superalloy guide plate on its surface wear resistance

Jianbo Zhou^{1,a}, Xizhen Zhang^{2,b}

¹School of Mechanical & Electrical Engineering and Automation , Tianjin Vocational Institute, Tianjin 300410, China;

²Technology Development Department, Tianjin JL Railway Transport Equipment Co., Ltd, Tianjin 300232, China

^ajzhouianbo@163.com, ^b13502017569@139.com

Abstract. The microstructure had been observed for guide plate, the guide plate be made of casting for groove controlling of hot rolled seamless tube , be produced for the production of 1600 seamless steel pipe, which cause obvious surface deformation and can not be normally produced. The alloy elements in matrix and precipitate phase of the guide plate were analyzed with the help of EDS. The results show that the wear resistance of the guide plate is directly affected by the fact that the guide plate is unable to form typical carbides, it shows that the formation of typical carbide strengthening plays an important role in improving the surface wear resistance of the guide plate.

1. Introduction

Hot-rolled seamless steel pipe, the working environment of the guide plate is very bad, its working surface temperature up to 1100 °C or so, but also bear the billet thermal shock, friction, extrusion and cooling water cooling[1]. Once the failure of the guide plate, seamless steel pipe production will be interrupted, seriously affecting the production of seamless steel pipe production and quality; Each guide unit cost of nearly ten thousand yuan, the guide plate failure to repair more difficult to bring great economic losses to the enterprise[2].

In general, the guide plate in the pipe more than 2,600 failures are normal quality level. This article on the seamless steel pipe of 1600 that is a significant deformation of the surface, leading to the production of hot-rolled seamless steel pipe can not control by the guide plate. The effects of microstructure on the surface abrasion resistance were studied.

2. Test Materials and Methods

The chemical composition of the test guide is shown in Table 1. The actual production test of the guide plate in the seamless steel pipe production line. When the pipe when the 1600, the surface of the guide that was a significant deformation, resulting in the production can not continue, and then removed the guide, the organization analysis and energy spectrum analysis was carried out.



3. Test Results and Analysis

3.1 Analysis of Metallographic Microstructure of Guide Plate

The microstructure of the guide is shown in Figure 1. It is not difficult to see from Figure 1, the guide plate microstructure is distributed in the matrix of some particles precipitated phase. As the alloy is high nickel chromium composition and as-cast, the matrix phase is austenitic structure[3]. Precipitation may be a solid solution, there may be carbide, Whether solid solution or carbide, the strengthening effect mainly from these particles[1]. If the precipitated phase is a carbide, as the carbide has a higher hardness, the strengthening effect for the alloy is more obvious, will be significantly improve the hardness and wear resistance of the alloy. And if the precipitated phase is a solid solution, its crystal structure is generally the same with the solvent element, its hardness will be improved, but the increase is limited, so the alloy hardness and wear resistance of the increase is also limited.

Table1 The chemical composition of guide plate material (wt.%)

No.	C	P	S	Si	Mn	Cr	Ni	W	Fe
1	1.02	0.016	0.010	0.71	0.30	29.80	50.21	3.67	Bal.

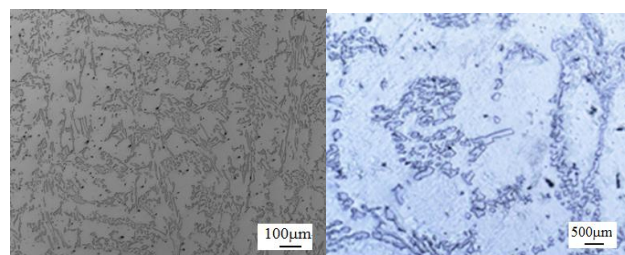


Fig.1. Microstructure of as-cast alloy

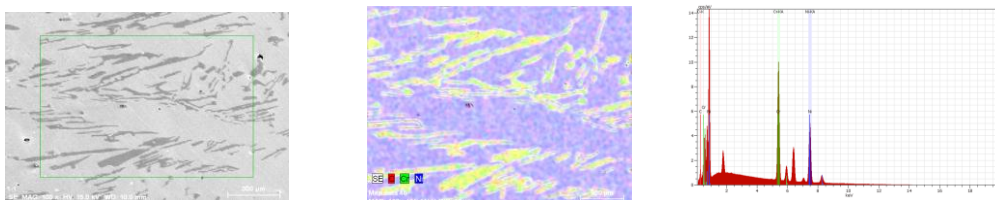


Fig.2. EDS analysis result of guide plate

3.2 EDS Analysis of Precipitates of Guide Plate

The EDS site of the precipitated phase of the guide plate is shown in Figure 2. From the X-ray spectrum of Fig. 2, it is not difficult to find: The diffraction is mainly C, Cr, Ni elements, the main constituents of the precipitated phase are C, Cr and Ni. The precipitated phase in Fig. 2 was subjected to a fixed-point composition, the results of the analysis are shown in Table 2. As can be seen from the results in Table 2: In the case of comparative weight percentage, the sum of Cr and C is 92.50%, and the content of other elements is very small, indicating that the main components in the precipitated phase are composed of C and Cr elements. From the corresponding atomic weight, in addition to Cr, C, the other elements are not enough to 1 atom. If the precipitation phase is considered to be carbide, it is $\text{Cr}_{1.584038}\text{C}_{0.844167}$, which is simplified to $\text{Cr}_{1.8764}\text{C}$ according to the absolute content. According to the relative content of the calculation, the following: $\text{Cr}_{0.652682}\text{C}_{0.347318}$, simplified to $\text{Cr}_{1.879207}\text{C}$; So this is

not a typical Cr carbide. The results are similar in both cases, indicating that the precipitates are composed mainly of Cr and C, but are not a typical Cr carbide, which should belong to the solid solution, and thus the reinforcement effect is limited, and it is not difficult to understand why the guide is premature cause of wear failure.

3.3 EDS Analysis of Matrix of Guide Plate

The matrix of the guide plate was analyzed by spectroscopy. The results are shown in Table 3. From the results of Table 2 and 3 is not difficult to find: The Cr content of the guide plate is calculated according to the precipitation phase / matrix: 3.55 (calculated as wt.%), 2.73 (calculated as at.%). Similarly, the C content can be further confirmed from the C content of the C partial segregation coefficient according to the precipitation phase / matrix calculation were: 3.38 (calculated as wt.%), 2.59 (calculated as at.%). From the two elements of the precipitation phase / matrix segregation coefficient of the two elements of the degree of similarity, further shows that the precipitation phase is mainly composed of Cr and C. At the same time, it was found that the Ni content of the guide was 50.21 (wt%), the Ni content in the matrix was 54.79 (wt.%), 47.94 (at. %), and the Ni content in the precipitated phase is 1.61 (wt.%), 1.09 (at.%). Indicating that Ni is mainly distributed in the matrix, the amount of segregation in the precipitation phase is very small, in line with the basic characteristics of the alloy.

Table2 The chemical composition of precipitate phase of guide plate material (wt.%)

EL	A.N.	A.W.	Series	Unn.C (wt.%)	norm.C (wt.%)	Atom.C (at.%)
Cr	24	52	K	60.57	81.73	61.44
				66.89	83.01	63.63
				63.73	82.37	62.54
C	6	12	K	7.88	10.63	34.59
				7.76	9.63	31.97
				7.82	10.13	33.28
Fe	26	56	K	2.66	3.59	2.51
				3.10	3.85	2.75
				2.88	3.72	2.63
W	74	184	L	2.05	2.76	0.59
				1.27	1.58	0.34
				1.66	2.17	0.47
Ni	28	58	K	0.96	1.30	0.86
				1.55	1.92	1.31
				1.26	1.61	1.09

Note: The above results, the first and second acts of two test results, the third line of the weighted average. The results of the following analysis are based on the average.

3.4 Analysis of Surface Scan Results of Guide Plate

The panel was subjected to surface scanning analysis, the results shown in Figure 3. It can be seen that the results of the elemental distribution from the micro-area scan are consistent with the

previous test results. The content of C in the precipitates is significantly higher than that in the matrix, Cr is mainly distributed in the precipitated phase, Ni is mainly distributed in the matrix, which further shows that the precipitated phase is a solid solution composed of Cr and C elements.

Table3 EDS analysis results of guide plate matrixes (%)

EL	A.N.	A.W.	Series	Unn.C (wt.%)	norm.C (wt.%)	Atom.C (at.%)	Original.C (wt.%)
Cr	24	52	K	19.96	23.21	22.93	29.8
C	6	12	K	2.58	3.00	12.85	1.02
Fe	26	56	K	14.74	17.14	15.76	
Ni	28	58	K	47.10	54.79	47.94	50.21
W	74	184	L	1.59	1.85	0.52	3.67
Total				85.97	99.99	100	

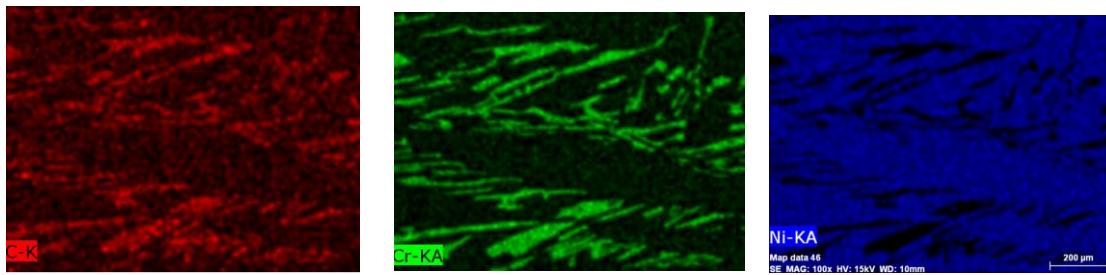


Fig.3. EDS analysis result of guide plate

4. Conclusion

The precipitation phase on the matrix of direct casting of the guide plate is the solid solution of Cr and C composition, the strengthening effect of the solid solution is far less typical of Cr carbide, is the main reason leading to poor wear resistance of the guide plate.

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