

Effect of Vanadium on the Strength and Toughness of Wheel Steel at Different Reheat Temperatures

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Abstract: Microalloy element vanadium has different effects on the strength and toughness of wheel steel at different normalization temperatures. At lower reheat temperature, vanadium increases the low-temperature impact toughness notably. On the contrary, when reheated at higher temperature, V-bearing steel obtains a remarkably-improved strength. Therefore, for wheel steel, there exists a suitable temperature, at which vanadium addition improves strength and toughness at the same time, and accordingly an excellent combination property is reached. The phenomena above are closely connected with the dissolution and precipitation of V(C, N) in the steel.

Key words: wheel steel; V(C, N); strength and toughness; reheat temperature

1 Introduction

It is well established that strength and toughness are fundamental properties of structural materials, but it is generally difficult to improve both of them at the same time. The situation happens in wheel steel as well. For a long time, low-temperature impact toughness of wheel steel used to fail the property requirement when strength and hardness was eligible. However, toughness improvement by lowering carbon content often reduced strength too much. In order to improve the combination properties of wheel steel, it is an often-used method in chemistry design to add microalloy element whilst lowering carbon content. But when Vanadium microalloying of wheel steel is concerned, there are many different and even reverse research results. Some show that V addition improves impact toughness while keeps tensile strength unchanged^[1], some tend to give a conclusion that small amount of V make little difference in wheel steel^[2] and others researchers believed that V mainly play a role of increasing strength^[3]. In this study we have systematically investigated the role of Vanadium microalloying at different reheat temperatures and tried to explain its strengthening and toughening mechanism of V in wheel steel.

2 Experimental

Two heats of steels with similar chemical content except for microalloy element vanadium were made in laboratory vacuum induction furnace, as shown in Table 1, where the No.2 steel bore small amount of vanadium. The steels were forged, rolled and then machined into samples for experiments.

Table 1 Chemical composition of experimental steels, wt%

S.N.	C	Mn	Si	Cr	S	P	V
1	0.47	0.70	0.41	0.27	0.007	0.010	---
2	0.46	0.70	0.43	0.27	0.007	0.009	0.082

The experimental steels were normalized respectively at 820, 860, 880, 900 and 950°C, and in succession tempered at 500°C for 3 hr. Then tensile and impact tests were conducted for the treated steels. For light microscopy and scanning electron microscopy sections were mounted and mechanically polished and then etched in 2% Nital. Thin foil specimens were prepared for transmission electron microscopy with twin-jet electropolishing unit. Chemical phase analysis was conducted for vanadium precipitates.

3 Results

3.1 Mechanical properties

The mechanical properties of experimental steels are shown in figure 1. The results show that tensile

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