

THE DEVELOPMENT OF HIGH STRENGTH STEELS FOR THIN SLAB CASTING

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Abstract:

Some of the factors that need to be taken into consideration when developing high strength steels suitable for thin slab casting are briefly discussed. These include the effect of titanium on high temperature precipitation and properties, ductility at temperatures below the solidus, the potential for precipitation of VN and AlN during equalisation, the effect of equalisation temperature on properties, factors affecting recrystallisation during rolling, the effects of end water cool temperature and coiling temperature on properties and an indication of the levels of V, N and other alloying elements required to achieve yield strengths in the range 50-100ksi.

1. INTRODUCTION

When the process of thin slab casting was first introduced over a decade ago it was envisaged that, because the casters were, in the main, associated with electric furnace steelmaking, using scrap as a feedstock and casting speeds were very high, the steel produced would be of low quality suitable only for manufacture of purlings and other items with no particularly demanding requirements for quality or strength. Since that time, however, both the process and the steel produced have undergone continuous development and improvement until today thin slab casters regularly produce HSLA of up to 550 (80ksi) yield strength and higher. It is the purpose of this paper to briefly examine some of the factors that require consideration when developing such high strength steels, especially vanadium containing HSLA steels.

2. CASTING AND SOLIDIFICATION

2.1 Effect of Titanium

Initially it was envisaged that the addition of titanium would have the doubly beneficial effect of reducing the soluble nitrogen content and result in precipitation of relatively fine TiN at high temperature, refinement of the nitride particle size being assisted by the relatively fast cooling rate⁽¹⁾ observed during casting. The first of these envisaged benefits was expected to lead to improved surface quality, while the second was expected to control the recrystallised austenite grain size and lead to a beneficial improvement in the ferrite grain size⁽²⁾.

What were not fully appreciated was that the addition of titanium would lead to an increase in the equilibrium dissolution temperature of VN and that the cooling rate during casting was too slow to fully suppress segregation and the formation of coarse titanium containing compounds.

Figure 1 shows the effect of titanium on the equilibrium dissolution temperature for a steel containing 0.05%V and 0.01%N. As can be seen, the dissolution temperature increases rapidly from 996°C at 0.0%Ti to 1360°C at 0.005%Ti to 1462°C at 0.02%Ti. Figure 1. also indicates that at a typical equalisation temperature of 1100°C, well above the dissolution temperature of the simple binary, some vanadium remains out of solution. This behaviour, in conjunction with interdendritic segregation, leads to the formation at high temperature of relatively large, frequently complex, titanium containing particles.