The Influence of Composition, Equalisation Temperature and Slab Thickness on the Properties of Vanadium Containing Strip Rolled from Thin Slab

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ABSTRACT

A laboratory technique has been developed to simulate the thin slab casting and hot charging process for slabs in the thickness range 30 to 80 mm (1.2 to 3.1"). Following temperature equalisation, the slabs were rolled to a thickness of 7 mm (0.27"), and cooled to simulate the run out table cooling and slow coil cooling of strip. All the steels investigated were low carbon microalloyed steels containing vanadium, and the effects on properties of varying levels of titanium, niobium and nitrogen were studied. The steels containing microalloying additions of vanadium accompanied by enhanced nitrogen contents achieved yield strengths in excess of 550 MPa (80 ksi), with good levels of Charpy toughness. Additions of titanium reduced strength, but improved Charpy toughness, due to a combination of ferrite grain refinement and reduced precipitation strengthening. Additions of niobium to the vanadium steels, and nitrogen to the vanadium-niobium steels, had a relatively minor influence on mechanical properties. An increase in equalisation temperature from 1130 to 1200°C (2066-2192°F) increased strength due to more complete solution of microalloying elements. Increasing slab thickness from 30 to 80 mm (1.2 to 3.1") was found to refine the final ferrite grain size, due to the greater total rolling reduction for the thicker slabs and as a result Charpy toughness was improved. There was little change in yield strength as slab thickness increased, despite the refinement in ferrite grain size, probably as a result of reduced precipitation strengthening. In a hot bend test to assess the likelihood of slab cracking during thin slab casting, it was demonstrated that a vanadium steel showed less evidence of surface cracking than a niobium steel. Overall, the results demonstrated that combinations of high strength and good Charpy toughness can be achieved in vanadium containing steels produced from thin slabs of varying thickness, provided that appropriate equalisation temperature and combinations of microalloying elements are used.

1. INTRODUCTION

The last ten years have seen the development and commercial application of continuous casters capable of producing slab with cast thickness as low as 50 mm (2"), compared with a thickness normally in excess of 200 mm (7.9") for conventional continuous casters. The relatively low capital cost of thin slab casters and their associated electric arc furnaces and rolling mills, together with the reduced production costs, have helped to stimulate a continuing wave of steel plant construction, mostly in the USA, but also in other countries throughout the world. Several different designs of thin slab casting machines are in operation, and some of the differences between the various machine types are the slab thickness on exit from the mould, and the slab thickness immediately prior to rolling. The SMS design, the Compact Strip Production (CSP) normally has a slab thickness of approximately 50 mm (2") on exit from the mould and prior to rolling[1]. The Inline Strip Production (ISP) system casts a 60 mm (2.4") slab, which is then reduced to between 25 and 15 mm (1 and 0.6") before entering a Cremona furnace immediately prior to rolling[2]. The VAI Conroll process can produce slabs in the thickness range 75-125 mm (3-5")[3]. The Danieli Flexible Thin Slab Casting