8306-068

THE EFFECTS OF ACCELERATED PROCESSING ON THE MICROSTRUCTURE AND MECHANICAL PROPERTIES OF V— AND V+ Cb HSLA STEELS

D. M. Fegredo and J. D. Boyd
CANMET, Physical Metallurgy Research Laboratories
Ottawa, Canada

M. J. Stewart
Dominion Engineering Ltd.
Vancouver, Canada

THE EFFECTS OF HOLD-PERIOD accelerated cooling on microstructure and mechanical properties are investigated for a series of vanadium- and vanadium-columbium microalloy plate steels.

Water-spray cooling vanadium-columbium steels decreases the hold period by a factor of 2-3, and results in a smaller ferrite grain size and improved strength and toughness compared with the normally processed plate. However, this treatment also produces a layer of hard, pancaked grains approximately 500 µm thick at the plate surfaces. The pancaked grains are deformed, unrecrystallized ferrite which occur because of enhanced Cb(C,N) precipitation and an elevated Ar_3 temperature in the surface region during the hold period.

Pancaked grains can be avoided in vanadium-columbium steels by cooling during the hold period with a compressed air-water mixture. By using this treatment the plate surfaces remain above Ar_3, the hold-period is shortened by a factor of two and there is still some improvement in strength and toughness of the rolled plate.

For the vanadium steels, water-spray cooling can be used to shorten the hold period, no pancaked grains occur and there is no change in the mechanical properties of the rolled plate. In this case, V(C,N) precipitates that form in the surface region during the hold period cooling redissolve when the plate is thermally equilibrated prior to final rolling.

INTRODUCTION

The effects of rapidly cooling controlled-rolled plate following the final rolling pass have been studied in some detail. Direct quenching (DQ) at cooling rates of 50-70°C.s^{-1} (1-7), and on-line accelerated cooling (OLAC) at cooling rates of 5-10°C.s^{-1} (8,9) have been investigated. These studies are directed primarily at optimizing strength/toughness/weldability properties and alloy-mix costs. In addition to rapid cooling following rolling, it is possible to accelerate the cooling rate during the intermediate hold period in a 2-stage controlled-rolling schedule (2,10,11). Accelerated cooling during the hold period increases the process efficiency by reducing the total rolling time, and in some cases it can effect an improvement in mechanical properties.

It was shown in earlier work on 0.08 Cb- and 0.09 Ti-HSLA steels (10) that accelerated cooling by water spraying in the hold period considerably shortens the total rolling time without changing the mechanical properties of the steels. However, this treatment results in a layer of elongated ('pancaked') ferrite grains at the surfaces of the rolled plate. It was suggested that the pancaked grains are a consequence of Cb(C,N) and TiC precipitates that form in the surface regions of the plate cooled below the Ar_3 temperature during the water spray treatment, and do not dissolve when the plate is re-austenitized prior to finish rolling. Consistent with this view, it is known that similar accelerated cooling in the hold period does not produce pancaked grains in plain carbon-manganese steels (11).

It was also shown in the earlier work by Fegredo (10) that pancaked surface layers can be avoided in the columbium and titanium steels by less severe hold-period cooling treatment, in which the plate surfaces remain austenitic during the hold period. However, a smaller reduction in total rolling time occurs with the gentler hold-period cooling treatment than with water-spray cooling. Clearly, the applicability of hold-period accelerated cooling is limited by the temperature gradients that occur through the plate thickness and it is a function of the microalloy content.