Vanadium in Interstitial Free Steels

by

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SYNOPSIS

Interstitial free steels containing vanadium have been studied. Hot rolled steels showing discontinuous yielding can be processed to give a range of strengths from 220 MPa to 250 MPa (depending on the vanadium addition) in the cold rolled and continuously annealed condition. Batch annealing of the hot band gives an interstitial free condition and allows the development of high levels of plastic anisotropy after cold rolling and continuous annealing. High levels of plastic anisotropy can also be obtained by controlling the hot rolling schedules, particularly the cooling rate after hot rolling. Cooling rates less than 30°C/hr give an interstitial free condition which allows texture development and attendant high levels of plastic anisotropy in cold rolled and continuously annealed materials. Vanadium retards strain ageing, but selection of a suitable annealing temperature can induce a bake hardening response of some 50-60 MPa.

Vanadium can be added to these ultra-low carbon steels either with or without titanium. Cold worked vanadium steels recrystallise at lower temperatures than do titanium steels, and titanium-vanadium steels recrystallise at lower temperatures than do titanium-niobium steels.

These results are discussed in terms of the solubility of vanadium carbide or other carbo-nitrides in ferrite. Vanadium additions were made to steels containing sub-stoichiometric titanium levels in order to maintain a low titanium content thereby avoiding the white powder defects seen in galvannealed steels.

1. INTRODUCTION

Interstitial free steels have found application in the form of sheet in automobile body manufacture where particularly demanding levels of formability are required. The desired properties of these interstitial free steels include

(i) a low yield strength
(ii) a high level of plastic anisotropy
and (iii) a moderate degree of bake hardening.

The low yield strength and, more particularly, a low level of flow stress is conducive to a high level of uniform elongation, and is favoured by a coarse ferrite grain size and an absence of significant strengthening by solutes and precipitate dispersions. The absence of carbon and nitrogen is particularly effective in eliminating the yield point, reducing the flow stress, and decreasing the strengthening coefficient of grain refinement. A high level of plastic anisotropy is attained by control of the crystallographic texture, the presence of significant levels of [111] and [112] orientations in the rolling plane being especially advantageous. The development of these texture components is influenced by the steel processing parameters associated with hot rolling, cold rolling and annealing processes, but an important aspect of the successful development of high levels of plastic anisotropy is an absence of the interstitial carbon and nitrogen in the hot rolled strip prior to cold rolling and annealing.