THE EFFECTS OF VANADIUM ON THE PARENT PLATE AND WELDMENT PROPERTIES OF API 5LX-80 LINEPIPE STEELS

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SUMMARY

The effects of vanadium, nitrogen and titanium levels and cooling rate through the transformation on the parent plate and weldment properties of laboratory cast, controlled rolled and accelerated cooled API 5LX-80 linepipe steels have been investigated. Parent plate yield strengths >600MPa have been achieved by control of processing conditions and chemical composition.

Superior transverse Charpy toughness, (>90J @ -100°C), has also been obtained in steels which contained a small (0.01%) titanium addition.

The steels examined all had very fine ferrite grain sizes (2-3μm) and the mechanical properties, particularly the yield strength, have been shown to depend on grain size, substitutional strengthening and precipitation strengthening. In addition, the titanium-treated steels have been shown to contain a lower volume fraction of M-A phase and this reduction has had a significant beneficial influence on the impact properties.

In two-pass welds, in which the second pass was carried out at 3.9kJ/mm, acceptable levels of both weld metal and heat affected zone impact properties, weldment hardness levels and crossweld tensile performance have been achieved. The addition of titanium resulted in refinement of the HAZ microstructure. The levels of weld metal and HAZ toughness have been compared with published information and have been shown to be broadly typical of such steels.

INTRODUCTION

Linepipe producers are responding to the increasingly severe demands which are being placed on pipelines. The need for higher strength, from an economic standpoint, and high toughness, for safety, are challenges that the linepipe producers are addressing in the production of API 5LX-80 grade steel. Arctic grade X-70 linepipe properties have been achieved in steels with polygonal ferrite-pearlite structures, in which strength is derived from the combination of a fine ferrite grain size, precipitation of vanadium and to a lesser extent niobium carbonitrides in ferrite, plus some strengthening from dislocations. A relatively small contribution to the strength also comes from manganese, silicon and other elements in solid solution. In these steels, the fine ferrite grain size has been achieved by additions of niobium, typically in the range 0.02 - 0.05wt%. This forms precipitates of niobium carbide which prevents recrystallization of austenite and, during the heavy controlled rolling schedule just above Ar_3, results in a heavily deformed pancaked austenite which transforms to fine polygonal ferrite grains. In some cases the processing technique involves rolling into the ferrite and austenite field in which a substantial contribution to strengthening is produced from dislocations in ferrite. Rolling into the $\alpha + \gamma$ phase field has been examined in the production of API 5LX-80 grade steels [1-4] and application of this process has resulted in commercial production.