

# EFFECT OF VANADIUM ON THE TOUGHNESS OF WELDS IN STRUCTURAL AND PIPELINE STEELS

## ABSTRACT

There are few data in the literature on a systematic study of the influence of vanadium on HAZ toughness of structural and line pipe steels. An extensive programme of work on a series of steels containing up to 0.20% vanadium, with nitrogen in the range 0.005 - 0.018% and niobium additions of up to 0.05% was therefore carried out to evaluate the influence of vanadium additions on HAZ toughness and the results now presented.

Two pass welds, representative of the line pipe seam welds, made at a heat input of 4.9kJ/mm and multipass butt welds, representative of welds in structural steels, made at 2 and 5kJ/mm were made in plate produced from laboratory heats of steel. The HAZ toughness was assessed, in both the as welded and post weld heat treatment conditions, using both Charpy and CTOD transition curves for specimens notched at the fusion boundary. In addition relevant hardness data was produced and accompanying metallographic examination was carried out to observe microstructural changes.

It was found that, particularly in the as-welded condition, substantial additions of vanadium could be tolerated with no adverse effect on the HAZ toughness despite an increase in hardness, indeed, in some instances HAZ toughness was observed to significantly improve with vanadium additions up to 0.15%. It was seen that the vanadium additions promoted the development of a finer transformed microstructure in the HAZ. This beneficial change in the microstructure is believed to be the principal reason for the observed good HAZ toughness behaviour.

## INTRODUCTION

Although both vanadium and niobium are used as microalloying elements in the production of linepipe steels, niobium is perhaps the more common microalloying element to be found in structural and pressure vessel steels. Partly this arises because some manufacturing<sup>(1,2)</sup> specifications apply quite low maximum limits to the vanadium content. It would seem that the origin of these low maximum contents stems from experience of the behaviour of older higher carbon, high nitrogen steels untypical of modern day concentrations of these elements. Since there is an extreme lack of relevant data on the influence of vanadium on HAZ toughness in modern lower carbon, lower nitrogen steels, a programme of work has been carried out at TWI on the HAZ properties of welds in current vanadium containing steels. This paper presents and summarises the considerable body of data which has been obtained from two pass welds representative of pipe production and from multipass welds representative of structural and pressure vessel welding.

## EXPERIMENTAL PROCEDURE

### Materials

All the steels studied were produced as small scale (50kg) laboratory heats and rolled to approximately 25mm (1 in) plate. Although most of the study was carried out on steels with 0.12% carbon, some two pass welds were made on higher (0.22%) carbon steels and some two and multipass welds were made on lower (~0.07%) carbon steels to help study the influence of this element. They were supplied in the hot rolled condition which was considered acceptable since the parent plate microstructure does not exert a significant influence on the high temperature HAZ microstructure. The compositions of these steels are given in Table 1 for two pass pipe welds and in Tables 2 and 3 for the multipass weld