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The Effect of Inclusions on the Morphology of Fe-Ti Based Simulated Weld Metals

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The effect of Ti in steel has been the centre of research due especially to its effect on the final microstructure, which is usually associated with acicular ferrite. For its formation, various mechanisms have been put forward by researchers [1-3] and, some concluded that its formation is related to the presence of inclusions [4] and they only act as passive nucleation sites to assist the heterogeneous nucleation of ferrite in undercooled welds. To date, some of the more favourable inclusions types are TiO and TiN [4] which are believed to influence the nucleation characteristics of ferrite in favour of epitaxial nucleation mechanism. Nevertheless, the effects of elements are not fully understood because of complex production methods. For example, the use of Si and Al to reduce O levels in steels may lead to confusion in understanding the effect of desired elements due to interaction between each element.

High purity Fe powder based alloys were re-melted using a modified TIG welding source in a closed Ar environment at constant cooling rate. Specimens were examined by SEM operated under 20kV fitted with Oxford Link EDS. By controlling the powder processing and melting time the O and Ti contents of the alloys could be varied independent of each other as shown in Table 1. No additions of Al or Si were made to ensure that only deoxidation reactions by Ti occurred. Duplication of an arbitrary submerged arc weld composition, FeCMnTi, gave microstructures indistinguishable from that of conventional weld; C and Mn additions also mimicked the known behaviour in welding. With increasing Ti additions to the Fe-Mn-C-Ti alloy, a range of microstructures from coarse to fine acicular ferrite was obtained as in the work by Evans [4]. The elimination of C and Mn, FeTi50, however, led to the formation of a structure analogous to that of acicular ferrite when sufficient Ti was added. SEM image in Figure 1 shows ferrite laths formed within the grain, which apparently shows intragranular formation of acicular laths, which may have been subjected to a recovery process on cooling. Further elimination of O caused the structural feature to disappear and it was replaced by an entirely polygonal ferrite microstructure (Figure 2). The inclusion type did not change markedly during this process but the number, density (and size) changed dramatically. In Figure 2, also fast moving solidification front led to the formation of some substructures which were probably affected by the presence of structural defects, such as inclusions. The implication of this study is that both inclusions and Ti in solution in austenite prior to transformation are essential prerequisites for the formation of acicular ferrite.

References

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Table 1. Compositions of specimens produced (in wt%) (P:Purified)

Code	C	Mn	Ti	O
FeCMnTi	0.06	1.4	0.02-0.084	0.02-0.006
FeTi50	-	-	0.085	N/A
FeTi50P	-	-	0.09	N/A

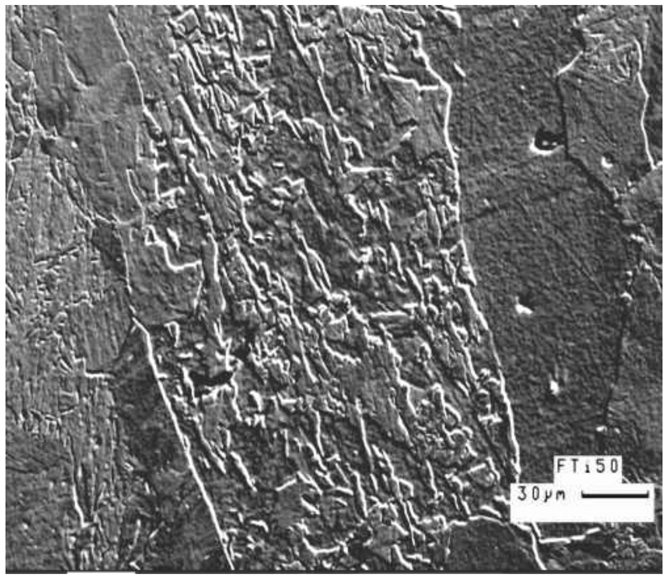

Figure 1. FeTi50 showing slightly recovered acicular ferrite laths inside a grain

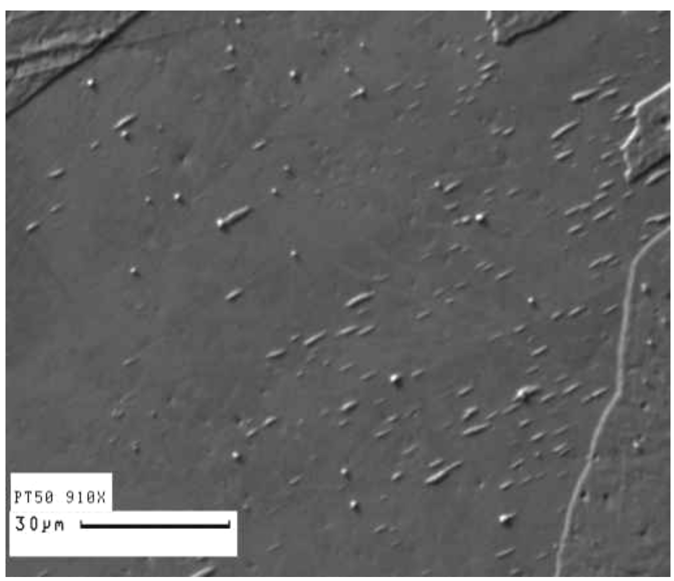

Figure 2. Purified FeTi50 SEM image showing substructures formed due probably to fast moving solidification front

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