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The influence of impurity and alloy content on stress relief cracking in CrMoV steels*

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Low alloy CrMoV steels are used almost exclusively for main steam piping and turbine components in conventional power stations of the Central Electricity Generating Board. Welds joining these components are highly restrained and relaxation of residual stresses during post weld heat treatment or subsequent high temperature service may induce cavities or crack networks in the creep embrittled, coarse grained structure immediately adjacent to the weld fusion boundary (h.a.z.). Stress relief cracking has been the cause of many costly outages in C.E.G.B. plant and has on various occasions been attributed to poor welding practice and undesirable parent compositions (Toft & Yeldham 1972). Impurities on the one hand (Myers 1972; Harris & Jones 1972) and alloy additions on the other (Nakamura *et al.* 1970) were both known to impair the resistance of CrMoV steels to stress relief cracking, but the extent to which each separately contributed was uncertain.

The reheat cracking resistances of several commercial CrMoV steels, known to be of differing susceptibility, have been examined by means of a modified stress rupture test on specimens containing either h.a.z. or parent structures. The h.a.z. structures all failed with low ductility, but the h.a.z. strengths were either greater or less than that of the parent material so that the 1 h at 690°C h.a.z.: parent strength ratios varied from 0.5 to 1.45 for the different steels examined. Previous work showed that this ratio decreased with increasing susceptibility (Myers & Price 1977) and this has been confirmed in the present tests.

Analysis of the results has indicated that vanadium is the principal variable affecting the cracking susceptibility of CrMoV steels of commercial purity; because changes in impurity levels are generally small in comparison, they can be shown from earlier work (Myers 1972; Myers & Price 1977) to be less significant. The potency of vanadium is enhanced because of its cumulative effect in depressing the h.a.z. strength and also in raising the parent strength, a feature not shared by impurities that do not significantly affect parent strength during stress relief (Myers & Price 1977).

The results suggest that h.a.z. structures in high vanadium steels have a much lower tolerance to impurity elements than in steels of lower vanadium content. Consequently, commercial levels of impurity are acceptable in power station components only if the vanadium is restricted to approximately 0.27 %. Vanadium is particularly harmful because of its strong influence on secondary hardening, but other elements such as chromium, manganese and nickel, which increase the initial hardness, and molybdenum, which may also contribute to secondary hardening, must also be restricted.

If CrMoV steels containing high vanadium and high alloy additions are used, very low impurity levels must be maintained if reheat cracking is to be avoided. Such steels are costly

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and since they may suffer excessive grain growth in the h.a.z. (Myers 1977) they introduce additional welding problems.

References (Myers)

Harris, P. & Jones, K. E. 1972 Presented at C.E.G.B. International Conference on Welding Research Related to Power Plant, Southampton, paper 26.

Myers, J. 1972 Presented at C.E.G.B. International Conference on Welding Research Related to Power Plant, Southampton, paper 25.

Myers, J. 1977 *Metals Technol.* **4**, 411.

Myers, J. & Price, A. T. 1977 *Metals Technol.* **4**, 406.

Nakamura, H., Naiki, T. & Okobayashi, H. 1970 *Trans. Japan Weld. Soc.*, p. 60.

Toft, L. H. & Yeldham, D. E. 1972 Presented at C.E.G.B. International Conference on Welding Research Related to Power Plant, Southampton, paper 1.

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