THE EFFECTS OF V, Mo, Ni AND Cu ON THE STRENGTH AND THERMAL FATIGUE RESISTANCE OF GREY IRONS SUITABLE FOR HIGH DUTY APPLICATIONS

EXECUTIVE SUMMARY

The effects of adding up to 0.5% vanadium and 0.5% molybdenum, both singly and in combination, on the tensile properties, hardness, relative thermal fatigue resistance and microstructure of grey cast irons, containing 3.2 - 3.6%C (CEV 4.0 - 4.6) have been determined. The additional effect of adding copper and nickel to some of these irons has also been examined.

It has been shown that, at the same level of addition, the effect of vanadium on tensile strength and hardness is approximately twice that of molybdenum and that the effect of a combined addition is, broadly, additive. As a consequence, it is proposed that it should be possible to produce a range of grey cast irons which, at a CEV of 4.4, would have a minimum tensile strength of 230 N/mm^2 and a minimum hardness of 200 H_B, when alloyed with 0.5% vanadium, alone. When alloyed with 0.5% vanadium plus 0.5% molybdenum, it is predicted that these properties would increase to 270 N/mm^2 min and 210 H_B min, respectively. Reducing the CEV to 4.0 should result in an increase in tensile strength of 100 N/mm^2 and in hardness of 40 - 45 H_B, irrespective of the level of alloying.

The above properties can be achieved with no reduction in relative thermal fatigue resistance, as measured by a special test developed at BCIRA, in the U.K. Indeed, at 4.4 CEV, additions of up to 0.5% vanadium or 0.5% molybdenum, appear to have resulted in a 30% improvement in average relative thermal fatigue resistance when compared with unalloyed iron, albeit with a relatively wide scatter. With an alloying addition of 0.5% vanadium plus 0.5% molybdenum, the average level of improvement was around 90%, again within a wide scatter. Reducing the CEV reduced the relative thermal fatigue resistance, but it was still possible to produce the same or slightly better level of performance in an iron of CEV = 4.0, which contained 0.5% vanadium plus 0.5% molybdenum, as was achieved in an unalloyed iron of CEV = 4.4. As noted above, this lower CEV iron was significantly stronger and harder.

Copper and nickel additions had no significant effect on properties, within the relatively limited examination carried out.

For the moderate to high CEV irons examined it was found that any tendency to chill could be controlled and virtually eliminated by inoculating with standard ferro-silicon or, preferably, strontium ferro-silicon, prior to casting.

Microstructural examination of the irons indicated that vanadium gave rise to a reduction in the eutectic cell size and both refined and compacted the graphite flakes. The addition of molybdenum to vanadium containing irons resulted in further compaction. Vanadium also resulted in refinement of the pearlitic matrix and it can be inferred that it resulted in precipitation strengthening, similar to that found in pearlitic rod and rail steels.

The range of properties obtained indicates that irons alloyed with vanadium, or vanadium plus molybdenum, should be able to meet the tensile and hardness requirements of ASTM A159, DIN1691 and BS1452. This renders them particularly suitable for consideration for use as brake drums, clutch plates, camshafts and other high duty applications where high strength and/or thermal fatigue resistance are required.