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W. J. Jackson and D. M. Southall

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The effect of trace elements (Cu and Sn) on mechanical properties of steel castings*

By W. J. Jackson and D. M. Southall
Steel Castings Research and Trade Association, Sheffield, U.K.

Because of the increase in the levels of residual elements in steel, a programme of work was initiated to determine the limits of copper and tin impurities that were tolerable in steel castings. A 1.5 % Mn–Mo steel was chosen as a base, since any effect of trace elements would be readily apparent in terms of mechanical performance in this medium–high strength steel. The effect of copper was investigated within the range < 0.01–0.5 %, and tin within the range < 0.01–0.26 %. The results were analysed by using factorial analysis in the first instance and later, as the amount of experimental work expanded and more results became available, a regression analysis was used.

The conclusions from the regression analysis were as follows.

1. The strongest effect of copper was on strength, increasing proof stress and tensile strength by 55 and 60 MPa respectively, when copper content was raised from 0.01 to 0.49 %. Copper had no effect on low temperature impact properties, although increasing copper content slightly lowered the upper shelf (room temperature) impact energy.

2. The strongest effect of tin was on low temperature impact properties, causing a shift of transition temperature from approximately −50 to −10 °C when tin content was raised from 0.01 to 0.26 %. Increasing tin content slightly lowered tensile ductility and slightly increased tensile strength; it also lowered room temperature c.o.d. fracture toughness.

3. There were no well defined levels at which copper and tin residuals became unacceptable with respect to room temperature mechanical properties; the regression equations give orders of magnitude of changes to be expected. In general, the highest toughness and ductility values were associated with the lowest copper and tin contents, but these also showed the lowest strength properties.

4. With regard to low temperature impact properties, the effect of copper was small enough to be ignored. Increasing the tin content from 0.05 to 0.10 % markedly raised transition temperature and 0.05 % tin would appear to be the upper acceptable limit.

5. No copper or tin rich phases were detected, even after very slow solidification rates, neither was any correlation found between copper and tin contents and hot tearing propensity.

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