Using Cooling Curves to Check the Composition of Cupola Metal

QUALITY CONTROL IN THE GREY IRON FOUNDRY

Apart from iron itself, carbon, silicon and phosphorus are the principal constituents of grey cast iron and the amounts present affect both the point at which freezing begins (the liquidus temperature) and that at which it ends (the eutectic temperature). It is possible to explain in terms of the carbon content the effect that silicon and phosphorus have on both these points and the "carbon equivalent" is widely used to control the structure and quality of grey iron castings.

Two papers recently published by the British Cast Iron Research Association have carried this concept considerably further and have provided the grey iron founder with a simple and rapid means of controlling composition. The first of these papers (*BCIRA Journal*, 1961, **9**, (5), 609) by Dr J. G. Humphreys, of the Association staff, gives details of work to determine more exactly the relationship between carbon, silicon and phosphorus which makes up the carbon equivalent, and have shown how, if the silicon and phosphorus contents are approximately known, the carbon content of the melt can be directly obtained from a cooling curve produced by simple apparatus sited on the foundry floor. The second paper, by R. Jelley of Morris Motors and Dr Humphreys, (*ibid.*, 622) describes the simple procedure for using freezing point determinations as a means of composition control. The method makes possible a rapid assessment of the composition of the liquid metal before castings are actually poured, so giving an opportunity for any necessary corrections to be made. It has been in use for some time in the foundries of Qualcast Ltd and of Morris Motors Ltd.

It was first established that if the liquidus temperature of a range of hypo-eutectic irons was plotted against the expression

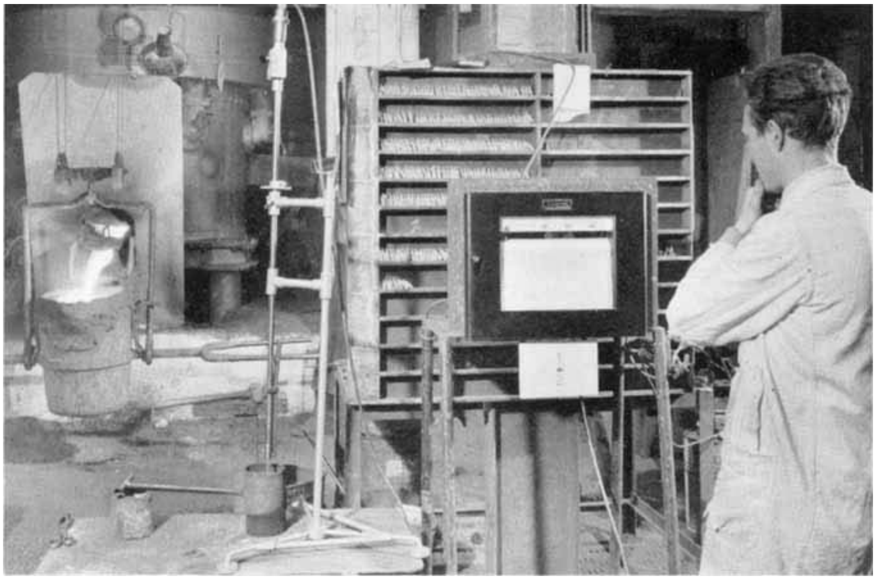
$$C\% + \frac{P\%}{2} + \frac{Si\%}{4} \qquad (1)$$

a straight line graph was obtained. It was also established that if the difference between the liquidus and eutectic temperatures was plotted against

$$C\% + 0.3\ Si\% + 0.33\%\ P \qquad (2)$$

again a straight line graph resulted.

The apparatus for the rapid determination of cooling curves on the foundry floor. A platinum: rhodium-platinum thermocouple measures the temperature of the metal during cooling



The BCIRA method in use in an automobile foundry, with a Honeywell temperature recorder directly calibrated in terms of the carbon equivalent. Results can be obtained in less than two minutes before castings are poured, so that corrective measures can be taken rapidly. The pyrometer and stand were designed by Amalgams Limited

The apparatus required for the control test is quite simple and is illustrated here. A platinum : 13 per cent rhodium-platinum thermocouple is placed centrally in a cavity 2¼ inches in diameter by 3 inches high formed by a coresand mould. The thermocouple is insulated in alumina refractory and sheathed in a ¼ inch diameter silica tube, giving a robust assembly entirely suitable for foundry use. Although a hand-operated potentiometer can be used, the thermocouple is preferably connected to an automatic recorder for which scales and charts directly calibrated in terms of the expression (1) are commercially available.

In the average foundry phosphorus contents vary little from tap to tap. More variation may occur in the silicon content, but a variation of 0.2 per cent would give an error of only 0.05 per cent in the carbon content determined by this method.

The method therefore consists in obtaining the liquidus arrest from the cooling curve, reading from the straight line graph already prepared (or directly from the chart) the value of expression (1) and from a knowledge of the approximate phosphorus and silicon contents, determining the carbon content. By a variant of the method described, it is possible to use the difference between the liquidus and eutectic arrests to determine the "carbon equivalent", an important means of controlling the mechanical properties and the susceptibility to chilling of a given section thickness. The eutectic of the iron-carbon system occurs at 4.3 per cent carbon, but phosphorus and silicon reduce this figure in such a way that the "carbon equivalent" is given by expression (2) above.

As stated earlier, plotting the interval between the start and end of freezing against this expression gives a straight line and the use of a prepared graph enables the carbon equivalent of the liquid metal to be read off directly. It should be noted, though, that the freezing range is also affected by the degree of inoculation so that the variant is normally recommended only for uninoculated hypo-eutectic irons.

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