THE SELECTION AND TESTING OF FOUNDRY IRONS.*

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WHEN it is remembered that about one million tons of pig iron are consumed annually in Great Britain for foundry work, some idea may be formed of the importance of this branch of the iron industry.

Until a comparatively recent date, the methods adopted in the selection of foundry irons for different classes of work were not such as to commend themselves to scientific minds, and it must be admitted that even at the present time the rule of thumb method largely prevails. Happily for the trade and prestige of the country, however, this state of things is gradually giving place to better methods, and it is becoming more generally recognised that the best results in foundry practice can only be achieved by the combination of scientific and practical knowledge.

Selection of Pig Iron.—In dealing with the question of selecting pig irons for foundry work there are always commercial as well as practical considerations. Obviously locality has a great bearing on the matter. Consumers in the South of England or the Midlands, for example, could not, except in special circumstances, profitably employ say Scotch pig iron, simply because of the heavy freight charges making the cost prohibitive, and this is typically a case where scientific knowledge can be applied with commercial advantage.

Judging by Fracture.—It is quite true that in certain instances, where the tests required are not too exacting, the pig iron may be judged by fracture, but it is also well known that pig irons showing apparently the same fracture to the eye may differ widely in chemical composition. Openness or closeness of grain does not necessarily depend upon any single element, not even silicon, but on the general composition of the iron, the size of the pigs, methods of casting and rate of cooling. Take for example "Lorne" pig iron containing GC 3·35 per cent., CC ·88 per cent., Si ·84 per cent., S ·015 per cent., P ·08 per cent., and Mn ·12 per cent., which is quite grey although the content of silicon is less than 1 per cent. In this case the greyness is due to the low content of manganese and sulphur and the high percentage of total carbon.

On the other hand it is possible to get a hard mottled iron with 1 per cent. silicon, if sulphur and manganese are present in appreciable quantities.

The following analysis represents an admirable "Chilling" iron, tough and strong and capable of taking a deep chill, except when cast in sand: Carbon 3·25 per cent., Si 1 per cent., S ·08 per cent., P ·4 per cent., Mn ·75 per cent. When fractured this pig iron, although containing 1 per cent. of silicon, showed a silvery fringe round the edge of the fractured surface.

It follows, therefore, that much of the trouble experienced in foundries working on the "judging by fracture" method, could be obviated if greater regard were paid to the chemical and physical properties of the iron as revealed by chemical analysis and mechanical tests.

Classification of Foundry Irons.—The irons most generally used for foundry work may be classified as follows: All-mine foundry iron, part-mine foundry iron, hematite foundry iron, and for common mixtures cinder pig iron. All these are made with hot blast, but for certain purposes it is desirable to use cold-blast pig iron, or special refined irons.

All-mine pig iron, as its name implies, is made wholly from raw ironstone, whilst part-mine pig iron is made from a mixture of ore and forge cinders.

Cinder pig is the commonest of all irons. It is made by smelting calcined tap cinders in the blast furnace. Consequently, it contains a high proportion of phosphorus and sulphur and is usually white, hard and brittle. Staffordshire cinder pig is supposed to be of better quality than that from other districts owing to the quantity of manganese present, which tends to remove the sulphur, thereby improving the quality of the iron.

In this country it is usual to classify pig iron in numbers from 1 to 6. Nos. 1, 2, and 3 are all foundry qualities, but there is a wider range than these numbers imply; *e.g.*, soft No. 1 and ordinary No. 1, or open No. 3 and close No. 3, and so on may be purchased. No. 4 pig iron is made in two qualities, viz., No 4 foundry, for chilled rolls and hydraulic castings, and No. 4 forge, for puddling. Nos. 5 and 6 are very close-grained hard irons, usually ranging from grey mottled to almost white—indeed some makers cease numbering at No. 5 and designate the harder kinds as soft or hard mottled, spotted white, or white.

Hematite iron contains about the same proportion of sulphur, but much less phosphorus than other brands of ordinary foundry iron. It is soft and tough, and is used in mixtures to impart strength and prevent contraction.

Swedish and charcoal pig irons are the purest and strongest irons made. They are produced in very small furnaces using cold blast. Special qualities of Swedish charcoal, cold-blast, grey foundry pig irons have a tensile strength of 16 to 18 tons per sq. inch, and transverse strength of 42 to 44 cwts. on a 2in. by 1in. bar 3ft. between supports. Typical analysis GC 2·8 per cent., CC ·5 per cent., Si 2·0 per cent., S ·03 per cent., P ·08 per cent., Mn ·6 per cent. Some pig irons are much cleaner (*i.e.* more free from sand and slag) than others and, consequently, besides giving a greater yield per ton require less flux and fuel to melt them. Machine-cast pigs being made in iron moulds are much cleaner than sand-cast pigs, and also possess the further advantage of being more uniform in quality, due to the mixing of the iron in large ladles before casting into the ingot pig moulds. The disadvantage, however, of using machine-cast pigs is that the moulds tend to produce a chill, rendering the iron rather harder than that cast in sand beds and, therefore, not so useful as a softer iron in foundries where it is necessary to work up a large quantity of scrap.

Refined Pig Irons.—Special or "refined" irons are made by remelting selected brands of pig iron mixed with various kinds of scrap materials, such as old ingot moulds, &c. Refined pig irons are especially useful in the production of locomotive and marine engine cylinders, or for other castings requiring a hard close grain of great density, capable of machining up to a highly finished surface and possessing good wear-resisting properties.

The analysis of such an iron should be within the following limits:—

GC	2·25 to 2·50%
CC	·6 to ·8%
Si	·75 to 1·25% (preferably about 1%)
S	·05 to ·08%
P	·15 to ·4% (not to exceed ·4%)
Mn	·45 to ·75%

Iron of this description, when mixed with suitable proportions of grey foundry pig of proper chemical composition and a quantity of cylinder scrap from a previous cast, gives the following tests:

Tensile test: 14 to 16 tons per square inch.

Transverse test: 30 to 35 cwts. on a 2in. by 1in. bar 3ft. between supports.

Cold-blast Pig Irons.—The fact that originally all pig iron was made with cold blast accounts in a large measure for the excellent quality of the castings made many years ago. In certain districts iron is still made with perfectly cold blast and is the best iron for chilled and grained rolls, cylinders, hydraulic presses and other purposes where great strength and closeness of grain or chilling properties are required.

Ores of pure quality, low in phosphorus, are generally employed, and owing to the quality of the materials and the greater consumption of fuel used in its production cold-blast iron is much more expensive than hot-blast. Cold-blast pig iron is chemically purer than hot-blast, and apart from the purity of the ores used contains much less silicon than the corresponding number of hot-blast iron. Moreover, notwithstanding the lower content of silicon, the graphitic carbon chiefly exists in the finely divided state.

At the comparatively low temperature of a furnace working with cold blast a much less quantity of impurities are reduced and taken up by the iron, and this, combined with the close molecular structure, accounts for the superior strength of cold-blast pig irons. The following analyses

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