MINING.

THE REDUCTION OF PHOSPHORUS IN PIG IRON.

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No metallurgical question that has arisen within the last 40 years has demanded and received a greater share of scientific interest than that of the relations of phosphorus to iron. Not only have metallurgical chemists the world over spent years of labor over the problems involved, but capitalists, as well, have contributed freely with their wealth to bring the matter within range of commercial possibilities.

For the manufacture of steel, ores are divided into high-phosphorus and low-phosphorus, or non-Bessemer and Bessemer, the limitations of the ordinary processes being circumscribed by the amount of this element present in the ore. Of the 12,000,000 tons of steel now annually produced in the world certainly not less than three-fourths, or 9,000,000 tons, are made of ores that contain, per 100 parts of metallic iron, not more than 0·07 part of phosphorus, so that the steel resulting from the conversion of the pig iron made from such ores does not contain more than 0·10 per cent. of phosphorus. Of the other 3,000,000 tons, 2,000,000 are made by the Thomas process from ores that contain from 1·50 per cent. to 2·25 per cent. of phosphorus per 100 parts of iron, and 1,000,000 from ores that contain from 0·10 to 1·50 per cent. of phosphorus per 100 of metallic iron.

All steel making processes of whatever nature, whether Bessemer, Thomas, open-hearth and crucible, as at present carried out, are based upon the assumption that all of the phosphorus in the ore goes into the pig iron, if there is but a trace or a very small amount present the iron may go to the Bessemer converter, or the acid open-hearth, or if above 1·50 per cent to the Thomas converter.

The principle common to all of these processes is that there is no opportunity of diminishing the content of phosphorus in the pig iron, as such, that whatever amount of phosphorus goes into the blast furnace in the burden of ore, flux and fuel comes out of the blast furnace in the pig iron, none of it going into the slag. This assumption is so far true that for all practical purposes it may be accepted as entirely reliable under present conditions of blast furnace practice. But that it is not true under all conditions is equally indisputable.

In the article referred to, Mr. Kjellberg, who is a laborious experimenter, has gone over the ground very thoroughly, considering the difficulties attending such work. He set before himself the question of determining whether the temperature or the basicity and acidity of the burden would influence the phosphorus content of the pig iron, whether, in other words, the blast furnace practice itself might not throw some light upon the affinity between molten iron and phosphorus. He employed a small blast furnace in which, however, the temperature of the blast did not exceed 225° C. (= 437° F.), about the melting point of tin, and used five different kinds of ore. The first was hematite with 60 per cent. iron and 0·2 per cent. phosphorus; the second magnetite with 69 per cent. iron and 0·7 per cent. phosphorus; the third hematite with 65 per cent. iron and 1·2 per cent. phosphorus; the fourth magnetite, with 58 per cent. iron, and 2·6 per cent. phosphorus; and the fifth magnetite, with 51 per cent. iron and 3·6 per cent phosphorus;

His conclusions are as follows: 1. When the phosphorus content of the ore is not above 1·25 p.c., the temperatures, under which he worked, do not influence the phosphorus-content of the pig iron, nor does the amount of silica in the slag. The greater part of the phosphorus of the ore is combined with the iron, only a small portion, 5 to 10 per cent., going into the slag.

2. When the phosphorus in the ore is above 1·25° it begins to enter the slag, and this slagging process increases in intensity with the increasing percentage of phosphorus. Both the temperature of the furnace and the acidity of the slag commence to influence the reduction of the phosphorus, and this action also increases with the amount of phosphorus up to 3·5 per cent. If the ore contains as much as 3·5 per cent. of phosphorus, the greater part of this element combines, under all circumstances, with the iron. If, however, the ore charge be increased and the burden made basic the phosphorus content of the ore may rise to 3·5 per cent, and still 40 to 50 per cent. of it be slagged off. With a higher temperature and an acid burden 95 per cent. of the phosphorus, already slagged, can be made to enter the iron.

3. No volatalization took place in the blast furnace even with ore containing 3·6 per cent.

4. The carbon-content of the pig iron diminishes with the increase of phosphorus, but is not manifest until the phosphorus rises to about 3 per cent. The pig iron obtained from the ores richest in phosphorus contained only a small amount of graphite and was white, with mirror-like planes on the surface of the fracture.

5. The content of silicon varies with that of phosphorus; a sample of charcoal iron with 4 per cent. of phosphorus contained no more silicon than steel does. Pig iron containing upward of 4 per cent of phosphorus can be made to take up a few tenths of one per cent. of silicon only by urging the blast and using an acid slag. The pig iron of the highest phosphurus was quite brittle, a slight blow of a hammer serving to break a bar into many pieces.

Mr. Kjellberg makes the following practical suggestions: To make basic open-hearth stock with not over 0·6 per cent. phosphorus, it is advisable to use 60 per cent ore containing not over 0·4 per cent. phosphorus. For cast irons, with phosphorus up to 1 per cent., ore with 60 per cent. iron and not over 0·6 per cent phosphorus should be used.

For Thomas iron, with at least 2 per cent. phosphorus, the ore must contain at least 1.6 per cent phosphorus, and 60 per cent iron, as only ¾ of the phosphorus is reduced and enters the pig.

Does all of the phosphorus of the burden under all circumstances enter