DEVELOPMENT OF THE ROE PUDDLING PROCESS *

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In order to understand fully the object of the various steps which have been taken, as outlined in the history of the development of this process, it is desirable to have a fairly clear conception of what takes place in the ordinary puddling furnace, and a general idea of the different types of mechanical puddlers which have been tried or suggested by others.

The puddling furnace of to-day is a direct descendant of that built by Joseph Hall about 1830, with practically no change in its design or mode of operation. The furnace is simple in construction, consisting of a fire chamber, a chimney and a working hearth, the sides and bottom of the latter being formed of oxides of iron.

The puddling process consists of the following steps: first, making bottom and fixing, or fettling, the sides; second, charging the pig iron; third, melting; fourth, adding scale or ore to the bath, that is, making oxiding additions; fifth, agitating the bath by means of rabbles—the puddling proper; sixth, balling; seventh, drawing; eighth, and possibly the most important of all, firing, which is continuous throughout all the other steps. Without entering into full details of all of these steps, it is necessary to dwell more fully upon some of their important features.

A skilful puddler, one who does his work with relative ease, is always a good fireman and one who recognizes the importance of this period.

It is very important to fuse the whole charge as nearly at one time and at as low a temperature as possible. This is accomplished by moving the pigs about with a paddle, as they approach the fusion point, thus exposing fresh surfaces to the flame and to the dissolving influence of the bath. It also has the additional object and effect of preserving the bottom and keeping it smooth for the subsequent manipulations. The early and thorough disiliconization of the metal facilitates the working, and reduces the time of the operation, and this is usually brought about by means of the relatively pure oxide of iron remaining in the furnace from the previous heat.

Practice varies as to the period of charging the oxidising agents, some charging them prior to the pig iron while others do so after the iron is melted. When "bleeding" is practiced the latter is the better plan, and also when large furnaces are being used. Usually, however, the choice is largely a matter of personal preference on the part of the management. A large part of the silicon and some of the manganese is oxidised during the melting. The elimination of the manganese follows closely upon that of the silicon and is continuous until complete. The elimination of the silicon, however, is checked as the temperature of the bath becomes higher.

During the puddling proper nearly all of the carbon, together with most of the phosphorus and sulphur are removed from the metal by oxidation. This is accomplished by agitating or stirring the bath in the presence of suitable cinder and gases of the right composition and temperature. During the first part of this period the bath is agitated wholly by means of energetic stirring with rabbles, the object being to produce as uniform conditions as possible throughout the bath and to bring the iron and cinder into intimate contact. It also prevents the iron from sinking to the bottom, and the cinder from rising to the top.

The "high boil," which may be termed the second part of this period, begins upon the accession of sufficient temperature for the rapid combination of the carbon of the iron and the oxygen of the cinder. The carbonic oxide escapes in bubbles all over the bath and very materially increases its volume. The evolution of this gas is a most efficient agitator, provided the earlier steps of the process have been skilfully taken, but the use of rabbles is still required, although their principal function at this period is to prevent the iron from settling to the relatively cold bottom in a partly refined condition. During this period grains of iron may be seen carried about by the ebullition of the bath. They start to form when comparatively little carbon has been eliminated, enough, however, to cause solidification at the then existing temperature. As the temperature rises they are remelted, more carbon is eliminated, and they again solidify and so on, in a continuing cycle, to the end; some grains being formed while others are being fused, otherwise the action would be an explosive one. The operation is completed when the carbon has been so reduced in amount that the heat is not great enough to maintain the iron in a fused, or partly fused, condition. The evolution of gas has by that time almost entirely ceased, causing the "drop" of the bath, and the grains of iron rest on the bottom in irregular clusters, with the free cinder spread tranquilly between them. Besides the cinder enveloping each grain of iron, a considerable volume is contained in pockets in the clusters: the bulk of which is subsequently removed by squeezing and rolling. If the process has been skilfully carried out, all of the iron is now uniformly ready, except that resting directly on the bottom. The mass only needs to be turned once and is then ready for balling.

I wish to emphasise the desirability of a free "high boil," as, in its absence, undue physical exertion is demanded of the puddler; that is, the bath must be thoroughly agitated by one means or the other and maintained in an open, well-mixed condition. If this is not done, clusters of iron which are "ready" are apt to form about cores of partly refined iron which cannot be subsequently acted upon efficiently, thus furnishing a prolific cause of blisters in the finished product.

Proper cinder is vital during all of the periods. Its composition is controlled by additions, the temperature and character of the gases (these being regulated by the condition of the fire and the position of the damper) and by the absorption of some of the bottom and fettling, which adjusts itself automatically to a great extent. This feature of drawing upon the fettling for correction of the cinder, together with its capacity for self-regulation, is a very important one and saves a large percentage of the iron made, since the process is not infrequently carried out in a very haphazard manner.

In the process as conducted at the present time, the weight of the iron reduced from the oxides in the bath is greater than that of the metalloids oxidised. This should give a gain in puddle bar over the pig iron charged, but, from the period of the drop to the end, oxidation of the iron occurs by reason of its immersion in the cinder and from the air drawn into the furnace through the door or other openings. This commonly results in a net loss.

It is desirable to retrace some of the steps noted, and observe what takes place when the process has been unskillfully carried out. In so called hot melting, when the pigs are not moved about, one of two things happens and sometimes both. A portion of some of the pigs that is exposed to the greatest heat drips down at too high a temperature, and, being allowed to rest, cuts holes of various sizes and depths in the bottom. This is always disastrous and frequently results in "aproning," that is, a slight reaction starts but is checked by the chilling of the iron, which sticks fast to the bottom. Later, as the process progresses, the "ready" iron fastens itself to this "apron" of raw or partly refined iron, causing serious loss in quality and weight of iron and a sacrifice of time. Again, much of the iron may be fused and some pieces of pig remain unmelted. Then, while these are being melted, the portion already fused becomes unduly hot and the cinder rises to the top with a rapidity and persistency impossible to prevent with rabbles, so small in proportion to the size of the bath and applied by manual power. This excess temperature results in slow disiliconisation, which, in turn delays the elimination of the carbon, makes a slow and arduous heat in the absence of a free "high boil," and leaves too much to be done in the period of turning and balling.

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