

The Manufacture of Silica Brick*

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Silica brick are indispensable in the manufacture of steel because they alone are able to withstand the high temperature of regenerative furnaces. All attempts to replace silica brick by other refractory materials for this purpose have failed.

Before the war, silica brick employed in France came principally from abroad, for which reason, since the beginning of hostilities, certain French steel works have been seriously handicapped. Our attention was first directed to the question by Mr. Bied, Engineer of the Teil Works. With him, we began certain investigations, at first using our laboratory and the furnaces of neighboring steel works. The larger part of our experiments, however, have been made in the laboratory of the Faculty of Sciences at Sorbonne. For the heating of our samples, we are deeply obliged to MM. Charpy, Yeatmann and Guerieau. In undertaking these studies, our first aim has been to render assistance to French industry, by indicating, as precisely as possible, the necessary conditions for the manufacture of high-grade brick but at the same time we have intended to give an example of the manner in which scientific methods may be put to practical application in the solution of industrial problems. Although our work has been confined to samples of only a few grams, we are nevertheless convinced that our information can be directly utilized by brick works of which the output is measured in thousands of tons.

As to what are most important and necessary qualities of silica brick, if one were to ask the steel metallurgists, they would almost unanimously reply that there was only one, namely, that the brick should permit the greatest possible number of runs without necessity for repairing the furnace roofs; they might suggest 400 runs as a satisfactory figure. Durability, however, is not the only factor. The brick have to be transported from the factory to the steel works without being injured by the jar or by freezing; many otherwise satisfactory bricks will not satisfy this last condition. It is further necessary that the brick shall not be too expensive, in order not to add unnecessarily to the price of the manufactured steel. The fundamental requirements, therefore, are the following: (1) durability of the furnace; (2) durability in transport; (3) moderate price.

Considering first the subject of durability of furnaces, the processes by which furnace roofs are destroyed can be answered by the direct observation of those in charge of furnaces. Our inquiries along this line did not meet with great success; only two steel works, the Ruelle Foundry, and the Chaussade Works, have been able to give us precise information, but, unfortunately, contradictory. One of these works has assured us that the roofs of Martin furnaces are almost invariably destroyed by progressive decrepitation under the action of heat. The other works, on the contrary, has assured us that similar furnaces are destroyed almost exclusively by melting. The brick manufacturers, on the other hand, have given us still a third reason, the ignorance or negligence of those in charge of the construction and operation of the furnaces. The engineer may have designed the profile of the furnace badly, not placing his burners in the most desirable place, or applying the first heat of the furnace too abruptly. The builder may have erred in shaping his bricks care-

lessly and laying them irregularly, so as to produce local pressure sufficient to occasion rupture. Above all, the heat may melt the roof of the best furnace, sometimes in a few hours, if the gas is badly regulated or if the reversals of flame are at too long intervals. From the discussion of this contradictory information and from suggestions found in different foreign publications, we have arrived at the provisional conclusion that the destruction of the roofs of steel furnaces may arise from five possible different causes, ranking in the following order of diminishing importance:

Causes of Failure of Furnace Roofs.

1. Superficial spalling of the brick under the influence of the highest temperatures developed in the furnace. This phenomenon is often noticed in the form of a continuous rain of little fragments, the falling of which may, after a few days, lead to the entire disappearance of the brick. This phenomenon depends upon two properties of the brick: Expansion of silica under high temperatures, and lack of mechanical strength at high temperature.

2. Superficial melting of the brick. Brick always melts superficially and continuously under the action of the spattering slag; this normal destruction of brick may continue for several months before leading to an actual cavity in the roof. Often, however, the brick will melt at once for a considerable width, several centimetres at a time, by which means the normal destruction of the brick may be multiplied by ten or more. This phenomenon depends upon the fusibility of the brick itself and upon its permeability, which facilitates the absorption of slag.

3. Flaking or shelling of the brick in the less intensely heated region. This begins to occur during the warming of the masonry, and below red temperature, and continues in the more remote parts after the furnace as a whole is considerably hotter. The brick, thus fractured, may then become detached and fall from the roof. This phenomenon is caused by the excessive dilation which is shown by all crystalline silicas at their temperatures of reversible transformation. Quartzose rocks decrepitate at a temperature of about 570 deg.; cristobalite, around 230 deg., undergoes an abrupt change in dimensions, of very important character; tridymite, finally, at about 150 deg. undergoes a change of slight importance. This tendency to rupture is offset by mechanical resistance of the brick and by its structure, that is to say, by the size of its grain and its amount of porosity.

4. Dislocation of the roof by excessive expansion. In furnaces made of silica brick, the roof always rises more or less when the furnace is first put into operation; this rising often becomes excessive and very irregular from point to point, which then leads to the falling in of the roof. This dislocation results, the same as spalling, from expansion of silica. If the brick is sufficiently resistant, and is heated over a considerable width all at once, it does not spall, but causes the roof to rise.

5. Collapse of the roof. The frequency of this accident with clay, magnesia, and alumina brick, makes it impossible to use these materials for the construction of the roofs of furnaces intended to maintain very high temperatures. Collapse will also occur, but very rarely, in furnaces made of silica brick. Collapsing results

*A paper to be presented at the Milwaukee meeting, A.I.M.E. It was published in the French language in the Bulletin de la Société de l'Industrie Minière, 1917