Electric Furnace Roof Refractories

by T. A. Blackwell

SINCE the electric arc furnace supplanted the old crucible process for tool steel production, furnace construction and design has gone through many changes, until today the majority of these furnaces are 3-phase circular furnaces with capacities ranging from 1 ton to 100 tons.

Any refractory used in roof construction is to confine heat, but also it must withstand stresses, slagging, thermal shock, and disintegration. Therefore, roofs have been made up of many different types, shapes, and sizes of refractories. Throughout all these trials, regular silica brick was the most popular and economical refractory for general roof applications. With latest advances in steelmaking, such as the use of oxygen and the attainment of very high temperatures, considerable experimental work is being done with the more refractory types of brick, such as sillimanite.

A number of years ago when Atlas was operating only 5 ton and 10 ton furnaces, block shape silica brick was used for roof construction. Since installing the 35 and 50 ton furnaces, all roofs have been constructed with 9 in. or 12 in. straights, side arches, and wedges. The regular use of the block shape brick was discontinued after the installation of the larger furnaces, primarily because of the spalling on the larger sizes.

At the present time all roofs are constructed in the same manner for all furnace sizes. First, an expansion strip of corrugated paper ⅛ in. thick is placed next to the water-cooled ring. Then two courses of Hi-Duty fire brick are installed, and the balance is made up of 9 in. silica straights, side arches, and wedges, with a 13½ in. brick for the electrode rings. A transverse expansion allowance of 1/16 in. per ft and a circumferential expansion of ⅛ in. per ft have been found to be most desirable for continuous furnace operation. This expansion allowance is made by using combustion expansion strips of corrugated paper. This corrugated paper is placed transversely at every tenth brick and circumferentially between every third course. All bricks except those at the expansion joints are laid after dipping in a silica cement.

The brick forming the first course next to the electrode ring brick are laid with a buttered joint using the same silica cement. No expansion joints are made in the center section. Around the 13½ in. brick at the electrode opening, a circular steel band approximately 1½ in. wide x ¼ in. thick is used. When tightened slightly by bolts the band forms a clamp to provide added support to the electrode ring brick. Before using these circular steel bands, trouble was encountered with complete rings dropping into the furnace. This was believed to be caused by the water-cooled electrode coolers sliding back and forth on top of these ring brick when furnace was being tilted. During this time, full average life on the rest of the roof was being obtained, but sometimes it was necessary to install one or two sets of rings. Since using these steel bands, the problem of rings dropping into the furnace has been eliminated, but more spalling of the ring brick on the hot face has been encountered. This, it is felt, is caused by the clamp forcing the brick slightly apart at the hot face. Therefore, while this problem is not nearly as serious, it is necessary sometimes to install an extra ring during the life of the roof because of this spalling. After the roofs are built, they are placed on a drying floor, which consists of a low temperature electrical heating element installed in the floor at roof center. Another drying floor consisting of steam pipes laid under steel plates is also available.

With present construction, using 9 in. silica brick and using the ring clamps, roof life is believed quite good. At the present time, life is 80 heats on the 50-ton furnaces, 70 heats on the 35-ton furnaces and 50 heats on the 10-ton furnace. This difference in average roof life on the various size furnaces can be explained mainly by the different grades of steel melted and melting methods used. All the tonnage grades with short refining periods are melted in the 50 ton furnaces; grades such as bearing steels, high carbon-high alloy tool steels; some stainless grades are melted in the 35 ton furnaces; and all stainless and valve steels are melted in the 10 ton furnace. Another reason for the lower life on the 10 ton furnace roofs is that this furnace is a top-charge furnace, with sharp temperature gradients.

In 1944 and 1945, two mullite roofs were installed on the 10 ton furnace, used for melting stainless, high speed, and regular tool steels. Roof life was 59 and 82 heats with these roofs.

In 1946, while running with intermittent operation on this same furnace, the mullite roof was tried with this method of operation. Four roofs were tried and life was 63, 84, 71, and 48 heats. This last roof with only 48 heats suffered an accident.

The average life of the first five roofs (disregarding the last 48-heat roof) was 72 heats. This was only 2½ times better than with the silica roof, and consequently further use was discontinued.

Regarding the use of mullite roofs the following observations were made: 1—Each roof failed because it burned out above the tap hole. 2—Spalling was negligible, i.e., there was practically no spalling visible. 3—The roofs did not appear subject to thermal shock. 4—There was no dripping of the roof, i.e., no icicles formed. 5—Roof changes are saved, but with intermittent operation, roof changes were no problem. 6—It must be considered that furnace roofs are subject to accidents and this is a definite disadvantage with mullite roofs where so much extra cost is involved.

Sufficient super-duty silica brick has been received to try four or five complete roofs, using exactly the same size and shape brick and the same method of construction. The first roof has been just built, so that no figures are yet available. If this is not found economical, it is proposed to try the main roof constructed of the regular silica brick with only the electrode ring brick being of the super-duty type. When these experiments are completed rammed monolithic center sections and roofs will be tried.

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