Present trend on refractory uses for reheating furnaces

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The function and service conditions of reheating furnaces have been described in a nut shell. The operating parameters to be withstood by the refractories are also given. Besides the temperature, the attack due to furnace atmosphere, slag or mill scale, abrasion and thermal shock are the main important factors. The types of refractories in common use for reheating furnaces have been mentioned along with their typical properties. Lastly the present trend of the use of monolithic refractories has been pointed out. The specic characteristics of such monolithics to be used in different parts of the reheating furnaces have also been illustrated.

The Reheating Furnaces play an important role in processing steel and its alloys for the production of finished products. The steel ingots, slabs or bars are heated in these furnaces to an even temperature throughout their body so that they can be properly rolled or pressed into strip, plate, rod, angle or any other shape as required. The temperature generally varies from 1130° to 1425°C, depending upon the quality of the steel, size of the product, etc Although the consumption of refractories per tonne of steel for the reheating furnaces is not much, the object for the consumers is to have better and better refractories for getting longer life with less number of shutdowns for intermediate repairs. This will ultimately lead to reduced cost for refractories.

The Reheating Furnaces may be broadly divided into batch and continuous type. Although soaking pit is a type of reheating furnace, it is not normally considered under reheating furnaces. The batch type reheating furnaces generally consist of bogie or carbottom type of furnaces. There are various designs of continuous type reheating furnaces such as Walking beam furnace, Continuous pusher furnace and so on. The size and shape of the reheating furnaces are different for different products depending upon its design with an ultimate object of getting uniform temperature in the stock without much surface defect and maximum heat efficiency. There may be both electrically heated as well as fuel fired furnaces.

The service conditions[1] for the refractories are the operating temperature, furnace atmosphere, abrasion resistance, thermal shock resistance and the attack by the slag or mill-scale. The temperature as already mentioned may be as high as 1425°C, with rarely exceeding 1500°C. Generally, the roof temperature of the reheating furnaces are about 40-50°C higher than the temperature required for heating up the stock. The desirable furnace atmosphere is slightly on the oxidising side, but sometimes, reducing atmosphere occur as a result of poor combustion air distribution or failure of automatic control. The slag attack in the reheating furnace is actually due to mill-scale or iron oxide fumes. The hearth of the furnace and the lower portion of the side walls are normally attacked by the mill-scale and the roof is attacked by iron oxide dust or fumes. The hearth, the lower portion of the wall and particularly the refractory skids are to withstand high resistance to abrasion at the operating temperature. The resistance to thermal shock is important for the batch type furnaces. The spalling is, however, present in all ahe types of furnaces due to reaction with mill-scale and iron oxide. The strain developed at the interface of the reacted portion and the unreacted portion, produces cracks leading to spalling.

The important factors[1] for the choice of proper refractories are

1) Operating temperature
2) Heating cycle
3) Impingement of flame
4) Contact with the stock

The refractories used for the construction of reheating furnaces are more or less similar to those required for the soaking pits. In this paper, mostly the refractories for reheating furnace would be dealt with. The most important portions of the reheating furnaces are the hearth and roof. The hearth is the only portion in contact with the stock or charge and the roof is affected by the atmosphere and iron oxide in particular.

The hearth is constructed with high alumina refractories containing about 85% alumina as given in table I. It may be pointed out that in our country excepting the skids, the hearth is not generally constructed with such a high alumina content refractory. High alumina plastics with and without phosphate bond have also been recommended for use in the hearth. Skids are often made of electrocast high alumina refractory. Besides high alumina, chrome plastic has also been used successfully in the hearth construction. In case of chrome plastic, special care is necessary to avoid lime in chrome plastic, because even a small percentage of lime produces low fusable compound.

The side wall does not pose any problem except in the lower portion where sometimes the wall touches the charge. This lower portion is constructed of high alumina products, either brick or plastics but the upper portion of the wall is normally made from 35-40% alumina firebricks. This firebrick wall is being backed by insulating bricks for reducing the heat losses through the wall. The properties of the firebricks are given in table I.

The refractories containing 35 65% alumina have been used in the roofs depending on the condition of the furnace. The main problem is the reheat shrinkage and spalling resistance. This spalling resistance must be both due to pure thermal effect and also due to chemical reaction with iron oxide. Use of castables and plastics has also come into vogue for roof construction. Properties of the refractories used in roof are also given in table I.

Properties of some of the indigenous refractories used for reheating furnaces are stated in table II.

The recuperator chamber, flue and stack are being made of plastics, castables and firebricks. The recuperator tubes are either silicon carbide or sillimanite in order to have high thermal conductivity. The life of these areas is fairly long and many extend upto 15 years.

The monolithic refractories particularly plastics are coming into use in place of bricks for various advantages as noted below :—

1). Provides flexibility of design for maximum fuel efficiency.

2) Gives jointless construction which is desirable for lower heat loss through the construction.

3) Reported to give longer life.

4) Takes shorter time for construction as well as repair, which means less downtime.

5) Has less thermal conductivity compared to bricks, which also adds to fuel efficiency.

6) Reduces inventory for the consumers.

Plastic refractories containing 50 to 90% alumina have been reported to be used in almost all the parts of the reheating furnaces. The side walls and roofs consumed mostly plastic refractories containing lower alumina content in the range of 50 to 60% alumina giving a life of 4 to 8 years. The burner ports are made from 70 to 80% alumina plastic refractories whereas the hearth of the furnaces is made out of higher alumina content plastics even upto 90%. Even then the life of the hearth is not more than 18 months. This high alumina plastic was specially used to resist the reaction with millscale and iron oxide. The plastic refractory for hearth construction was sometimes made with phosphate bonding for higher strength. As mentioned earlier, chrome plastic was also used for hearth construction with better performances. Some of the characteristics of the plastic refractories have been shown in table III.

It may be pointed out at the end that the bricks or monolithic refractories required for hearth should be such that the reaction with the millscale and iron oxide should be minimum. Similarly, the roof bricks should also have good thermal shock as well as resistance to reaction with iron oxide. In order to achieve this characteristic it has been observed that the refractories used for hearth and roof are comparatively of higher alumina content with low Fe_2O_3. No such special care is required for wide wall construction

References

J. H. CHESTERS—"Refractories for Iron and Steel Making" The Metal Society, London, 1974.

G. M. VORKMAN—"High-alumina bricks in the roofs of continuous slab reheating furnaces" Trans Brit Ceram Soc., 61, 11, 753-772, 1962.

TABLE—I

Properties of Refractories for Reheating Furnaces[1,2]

Properties	Medium to HHD Fire-brick	Super Duty Firebrick	Sillimanite Brick	Mullite Brick	High Alumina Brick
PCE (Orton)	31-31½	33-35	36	38	40
Al_2O_3, %	35-38	42-45	58-60	70-74	80-90
Fe_2O_2, %	1.5-2.4	1.5-2.0	1.0-1.5	1.0-1.5	2.5-3.0
AP, %	20-25	16-20	20-24	14-18	17-21
BD, gm/cc	1.95-1.98	2.0-2.2	2.2-2.4	2.45-2.55	2.8-3.0
CCS, Kg/cm^2	200-250	300-350	500-700	600-800	500-600
PLC, %	-0.5 1450°C, 2 hrs	-0.5 1500°C, 2 hrs	-0.5 1500°C, 2 hrs	-1.0 1700°C, 5 hrs	-0.7 1500°C, 2 hrs
Thermal Shock	Good	Good	Excellent	Excellent	Excellent

TABLE—II

Properties of some Indigenous Refractories in use for Reheating Furnaces

Properties	H H D Firebrick	Super Duty Firebrick I	Super Duty Firebrick II	Sillimanite Brick	High Alumina Brick I	High Alumina Brick II
PCE (Orten)	31½-32	32½-33	33-34	36	36	40
Al_2O_3, %	38-40	40-43	42-45	58-60	61-63	80-85
Fe_2O_3, %	2.0-2.5	1.5-2.0	1.5-2.0	0.5-1.0	0.5-1.0	0.5-1
AP; %	23-26	18-23	18-20	22-25	22-25	14-16
BD, gm/cc	2.0-2.1	2.1-2.15	2.1-2.2	2.2-2.4	2.3-2.4	3.0-36
CCS, kg/cm²	170-230	200-250	250-300	300-400	220-270	800-1000
PLC, %	-0.5 1400°C, 2 hrs	-0.5 1450°C, 2 hrs	-0.5 1450°C 2 hrs	-0.5 1500°C, 2 hrs	-0.5 1500°C, 2 hrs	-0.5 1600°C 2 hrs
Thermal Shock Resistance	Good	Excellent	Excellent	Excellent	Excellent	Excellent

TABLE—III

Properties of some Monolithic Refractories in use for Reheating Furnaces

Properties	Super Duty Plastic	Castables Mullite base	Castables Corundum base	Indigenous Plastic Super Duty	Indigenous Plastic High Alumina	Indigenous Castable Super Duty	Indigenous Castable Corundum base
PCE (Orton)	35-36	38	40	32-33	38	28-30	38
Al_2O_3, %	55-60	68-72	85-90	43-45	79-81	45-50	92-94
Fe_2O_3, %	1–2	0.5-1.0	0·2-0.5	0.7-1.5	1.5-2.0	1·5-2.5	0.5-0.8
BD, gm/cc after drying	2.2-2.3	2.3-2.4	2.7-2.8	2.3-2.4	2.8-2.9	2.0-2.2	2.7-2.8
MOR, kg/cm^2 after drying	4—6	30—40	40—50	20—30	4–6	50—100	40—50
Service Temperature	1650	1700	1800	1500	1700	1600	1800