Service performance of refractories in connection with pusher reheating furnaces in Bhilai Steel Plant

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Seven continuous pusher reheating furnaces are installed in 2.5 million tonne stage in the R & S. Mill, Merchant Mill and Wire & Rod Mill at Bhilai Steel Plant to cater the need of rolling of various finished products. In this paper, attempts have been made to brief out the service performance of refractories in various elements of the furnaces. The replacement of better refractory material and installation over original design in order to strengthen the weak link for continuous service ability of the furnace has also been discussed in brief.

Bhilai Steel Plant comprises of three finishing mills, which are equipped with continuous pusher reheating furnaces to heat blooms & billets from the blooming & billet mill at 2.5 M. T. stage. Reheating furnaces of rail & structural mill and merchant mill are of same design with three zones having 20 burners in each furnace (7 burners in top & bottom zone & 6 burners in soaking zone). The wire rod mill has got only one reheating furnace with 2 zones having 14 burners in each zone.

The merchant mill is equipped with 3 pusher type and charging, discharging reheating furnaces of overall length 26000 mm. & width 18000 mm. The length & breadth of active hearth of each furnace is 6500 mm and 20,000 mm respectively. The furnace is heated with a mixture of coke oven & blast furnace gas of the calorific value 1500 K Cal/M^3. The furnace pressure under soaking zone roof is upto 2.5 mm of water column. These furnaces are equipped with ceramic & metallic recuperators for pre-heating of air and gas upto 700 & 300°C respectively. The capacity of each furnace is 60 T/hr.

Three reheating furnaces are installed in rail & structural mill each of 72 T/hr. capacity to fulfill the demand of rolling and these are fired with a mixture of coke oven & blast furnace gas of calorific value 1500 K Cal/M^3 Air for combustion is preheated to 500°C in ceramic recuperators of 200M^3 usefull volume and the gas is preheated to 250°C in metallic recuperators of 620 M^2 surface area. The soaking temperature is between 1280 to 1300°C and the soaking time is normally 2 hours. The furnace is maintained at slightly positive pressure (2 mm water gauge). The active hearth is 6.7 M wide and 29 M long. There are 26 burners in each furnace, distributed in three zones. 7 in top zone, 7 in bottom zone and 6 in soaking zone. Automatic control devices have been provided in the furnace to ensure the effective burning of the gas and combustion products of all the three furnaces are discharged by a common chimney of 5 M dia & 90 M height.

There is only one continuous reheating furnace in wire rod mill with a sloping hearth, 18 M long & 12.6 M wide having side charging & discharging of the billets. The furnace capacity is 120 T/hr. The furnace is heated by means of a mixture of coke oven & blast furnace gas of calorific value 1500 K/M³.. The gas is preheated to 250°C in metallic recuperators & air is preheated in ceramic recuperators to a temperature approximately 500°C. The pressure of the gas in the furnace is about 1500 mm of water gauge. Combustion products of the furnace are disposed off through a chimney 3.5 M dia & 75 M height.

Wire rod mill reheating furnace

This furnace is of two zone continous side charging & discharging with curvilinear bottom having capacity 120 T/hr. The refractory failure in wire rod mill is mostly in burners, curved roof and hearth (mainly on ejector axis of soaking zone).

Standard chrome magnesite bricks of size 230 x 115 x 65 mm are laid on edge in the hearth. Erosion of these chrome magnesite bricks in the hearth, specially in the ejector axis of soaking zone, causes uneven surface and pits are formed in the hearth. Billets which are to be pushed out of the furnace when falls in these pits, they are at lower level than the water cooled ejector ram which is supposed to push these billets out of the furnace. This ejector ram some times misses these billets completely which are in these pits, and travels on top of the billets. Ultimately discharging of the billets out of the furnace becomes a problem. These pits are formed mainly because of continuous abrasion of ejector ram and hydration of chrome-magnesite bricks during discalling by spraying water on the ejector axis. To avoid this scale formation high alumina bricks (88% Al_2O_3) from indigenous suppliers with high alumina mortar, were used as these bricks had high abrasion resistance & other favourable properties. But use of these bricks were not at all satisfactory as the errosion & pit formation was much more higher than chrome magnesite bricks. Recently electrocast corundum blocks have been used in the ejector axis which is providing excellent performance. Abrasion of these blocks & pit formation are practically nil and descaling operation is much more easier. It has been reported that at the Cherepovets Works, U. S. S. R.

the mean life of the hearth, with corundum blocks has been extended upto average 2 years instead of 6 months in continuous furnace. There is a proposal of using corundum blocks in heating zone also, in wire rod mill of Bhilai Steel Plant. The chemical composition of corundum blocks used in wire rod mill at Bhilai Steel Plant is given in Table No. I.

TABLE—I Specification of electro-cast corundum blocks

Al_2O_3	90—95%
SiO_2	2—5%
TiO_2	0.5%
Fe_2O_3	0.7%
Other Oxides	3%
P. C. E.	1950°C
R. U. L. ta	1700°C
B. D.	3.0 gm/cc

The heating zone consists of partly uncooled solid skids and partly chrome magnesite brick work. Invariably, it has been observed that, the erosion of chrome magnesite bricks is maximum when the billets leave uncooled solid skids and ride on chrome magnesite bottom. It has been experienced in other plants that the use of corundum blocks in this load transformation region also can increase the life of the furnaces considerably by avoiding intermediate stoppage of the furnace for the repair of hearth at this region.

Failure of the water cooled burners (refractories) & burner heads (mechanical failure which ultimately causes refractory failure) is another bottle neck in reheating furnaces. In the begining burners were laid with shaped bricks of ten different shapes, which are leading to following inconveniences.

i) More inventory due to different shapes.

ii) Non-availability of one or more shapes resulting difficulty in laying of burners.

iii) Heavy in weights—which was causing inconveniency in transportation and laying of burners.

To avoid above problems, ramming masses of different types have been tried in casting of burners in reheating furnaces. The main types are air setting and hydraulic setting ramming masses of different composition. General compositions of air and hydraulic setting ramming masses are given in Table No. II. It has been observed

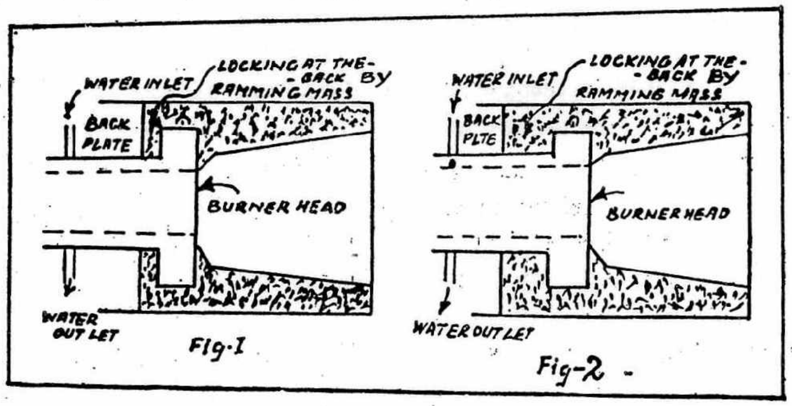
TABLE—II The properties of ramming masses used in burner of reheating furnaces.

Parameters	Hydraulic setting ramming masses	Air-setting ramming masses
1. Al_2O_3, %	36–40	60–65
2. Refractories	Over 1700°C	Over 1740°C
3. Grading 95% Min will be below the maximum grain size	(0–5) MM	(0–5)MM

that air setting ramming masses of higher alumina content (60% Al_2O_3) have taken up higher thermal load than hydraulic setting ramming masses whereas hydraulic setting ramming masses are easy to ram, have good green strength, provide a smooth profile of the burner. However, the shrinkage after firing of hydraulic setting masses is high. Some times this shrinkage causes such wide cleavages and burners ultimately collapse. The air setting masses have less shrinkage after firing but they have slightly less green strength and their surface profile is week if ramming is not done very carefully. The life of rammed burner is about 18—20 months. The main reason of burner failure is due to the failure of burner heads. Generally there are two types of failures in burners. First one is flame shoot out at the back of the burner head, & the other one is failure of water cooled burner heads & subsequent water leakage on the ramming mass. As shown in figures before ramming, steel plates are welded at the back of burner for the ramming mass. If this steel plate provides sufficient room for ramming at the back of the burner head, the ramming mass sort of locks the burner head from the back and this ultimately arrest any escape route of flame at the back of burner head (Fig. 2). When the steel plate is nearer to the burner head there is not much of space for the rammer to operate smoothly and ramming at the back is weak which is not strong enough to arrest shooting out of flames from the back side (Fig. 1).

Water leakages from water cooled burner heads on rammed burner and roof underneath to makes it wet which imparts severe thermal shock and ultimately burner of roof fails. In case of burner it may be due to pressure of steam which is developed by water leakage inside the ramming mass. Attempts were taken to cool the burne heads with chilled air, but it was also not very much successful as this process had its own limitation.

The curved roof or pre-regime roof of wire rod mill is of high alumina category refractory bricks (Al_2O_3 54%) and has an average life of 18 months, Mostly curved roof fails (beside the



Burner blocks Fig, 1. Before modification and Fig. 2. After modification.

refractory failure of unknown reason) because of leakage water from burner head dripping on it. During weekly repair day when the temperature of the furnace is brought down, these bricks which had cracked due to thermal shock caused by leakage water, are not able to take further thermal shock and fall down. The existing reheating furnace design of B. S. P. does not permit any replacement of curved roof bricks & from out side. The damaged portion is patched up by gunniting from inside but this also causes a operational problem as portion of gunniting mass which falls on the billets restricts proper heating of billets even though raking is done.

The side walls and roof of heating and soaking zone are of high grog fireclay bricks which imparts quite satisfactory performance.

Recuperator of wire rod mill has not given any problem so far. False checkers are there before the recuperators which restricts flue dust to go into the recuperator. These are cleaned during the capital repair of the furnace. The expected life of the recuperator is about 15 years.

Rail, structural and merchant mill reheating furnace

There are three zones and charging and sloping discharging continuous type furnaces. The average life of rail & structural mill reheating furnace is 6 to 8 months & that of merchant mill is 10—12 months. The refractory failure in rail & structural mill and merchant mill is mostly in burners, water cooled skids, side walls, roof, hearth & discharging end lintel.

Burners are rammed in the same way as described previously in wire rod mill section of the article. Reasons of failure are same as discussed above. However, some modifications were done to hold the ramming mass together with water cooled burner heads by welding anchor rods or wire nets arround the head as shown in the figures. But it was not very much successful as anchor rods (Fig. 3) were causing following inconveniences.

i) They were an obstacle for smooth operation of rammer.

ii) There ends were very near to the surface of ramming mass. Hence during operation they were highly heated up or were directly exposed to the flame & ultimately their purpose were not solved. Further, wire net welded to burner head (Fig. 4) is not much effective in holding ramming mass at burner mouth.

Skid insulation is a bottle neck in reheating furnaces of rail & stauctural mill and merchant mill. The life of skid insulation was found out to be 4—6 months in Rail & structural mill and 6—10 months in that of Merchant Mill. In reality life & capacity of skid insulation is the major factor in achieving low heat loss to the cooling members. This heat loss depends upon the quality

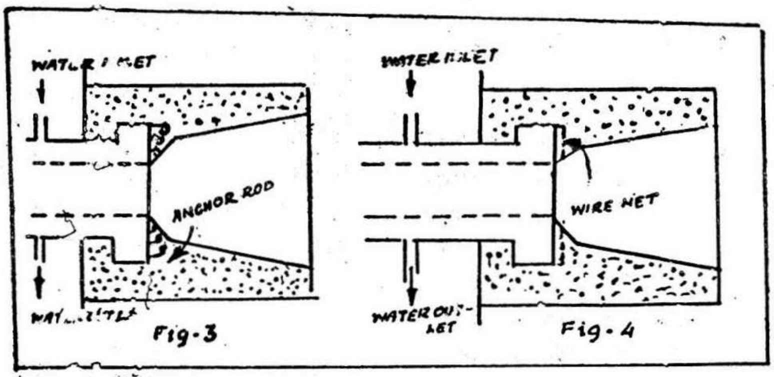


Fig. 3 Ramming mass of burner with anchor rod. Fig. 4. Ramming mass of burner with wire net.

of the insulating material, their installation technique and service condition of the furnace. The skids insulating material has to serve at a temperatures of 1250°C—1350°C with the reaction of mill scale at this elevated temperature. It also should have resistance to thermal shock and mechanical shock due to a number of operational problems. Following are the types of skid failure actually observed in rail & structural and merchant mill of Bhilai Steel Plant.

i) Skid insulation failure

ii) Puncture of skid

iii) Sagging of skid

Skids are generally insulated by hydraulic setting ramming masses of different varity from different manufacturers. Old insulation sticking to the skids is removed and then small pins or studs are welded on three sides of the skids for anchoring the ramming mass. Wooden scaffoldings are fixed around the skids, part by part, and then thick slurry of ramming mass is poured in these scaffoldings. Scaffoldings are removed when the material sets perfectly as shown in Fig. 5 to 9.

Problems occur when the pins welded to the skid are not perfect in size and protrude out of the ramming mass after the skid insulation come in direct contact of the flame and fail very shortly and the hold on ramming mass after the skid insulation or pins are not firmly welded to the skid. Pins protruding out of the insulation come in

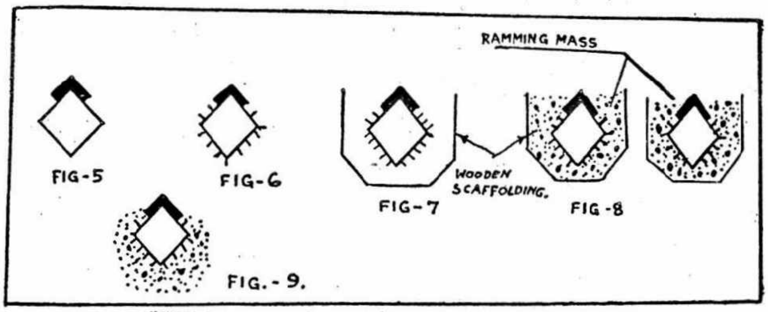


Fig. 5r—Fig. 9. Various modifications of insulating ramming mass for skid rails

direct contact of the flame and fail very shortly and the hold on ramming mass is very weak which slowly fails. Further, pin welding on old skids is not strong enough as the fused insulating material of last campaign adheres to the skid. This is not easy to remove completely and hence the welding is not proper. This ultimately causes failure of the insulation.

When insulation of the skid fails, skid is in direct exposer of flame and many a time it punctures. The cooling water through that puncture falls on chrome magnesite bottom of bottom zone hearth, which crumbles immediately. This further causes sinking of bottom and side walls which ultimately cause gap in side walls.

Water cooled skids rest on seperation walls. They are aligned and supported from bottom by tightening grooved castings below them (Fig. 10 & 11.) Due to the service condition these skids are not in perfect straight line. If the castings below the skids are not tightened perfectly or if the arches above the flue has sunk little bit, this causes tightened castings to become loose, then there is a gap between the skid and castings. The heavy stock which is travelling on these skids impart hammering effect on the loose castings or wall below it (Fig. 12) and wall collapses. This effect is more prominent if there is any variation in the distribution of load. This effect is less in the merchant mill reheating furnace, as stock travelling on the skids is lighter. As brick tightening below the castings was not giving good life, modification was done by using air setting ramming mass above the arches. This was favourable as ramming mass goes into every corner around & below the castings and provides better holding.

Service performance and bricks used in the curved roof, straight roof and side walls of reheating furnaces of rail & structural mill & merchant mill are same as discussed in case of wire rod

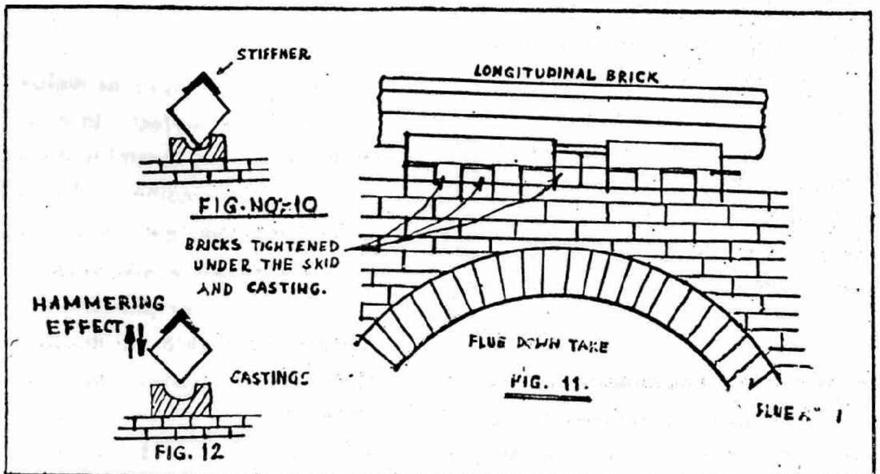


Fig. 10—12. Setting of skid and failure of the refractories.

mill. The life of curved roof is about 2 years. Soaking zone and bottom zone hearth does not give much problem. Soaking zone hearth also gives average life of 2 years.

Charging and lintel has a life of 3—4 months. The shaped brick used here are of fireclay (Fig. 13). These bricks are hanged to water cooled lintel by means of channels welded to the lintel. Due to improper distribution or pushing of the stock going inside the furnace, stock overlap and hit the lintel brick-work and the lintel is damaged. As the temperature of this zone is not very high no serious damage is done to the furnace structure even after the failure of the lintel brick work. However, there should be some modification in brick shape or design to achieve more life.

Conclusion

1. It is advisable to use electro-cast refractories in critical areas of the curvilinear bottom of wire rod mill reheating furnace, i.e., in ejector axis of soaking zone & at load transformation point of the heating zone.

2. Solid skids should be replaced by electro-cast refractories, and soaking hearth should be continued with the chrome magnesite or any other brick with expected life of 2 years.

3. Refractories used in curved roof and in soaking zone roof should be of high alumina type with 54% Al_2O_3 range and remaining portion of the roof may be continued with 38—42% Al_2O_3 brick.

4. Monolithic refractories must be upgraded to suit the demand of at least 2 years from 18 months which is the present life.

5. To achieve economy by reducing heat loss in the skids, it is urgent to develop refractories and its application technique to match with the service condition. Instead of ramming, shaped bricks and insulating rings may be used to achieve life of atleast 1 year.

6. Curved roof should be designed/modified so that any emergency repair may be taken up from outside the furnace.

7. The shape of the lintel brick should be changed so that it is more stronger as desired by the service conditions.

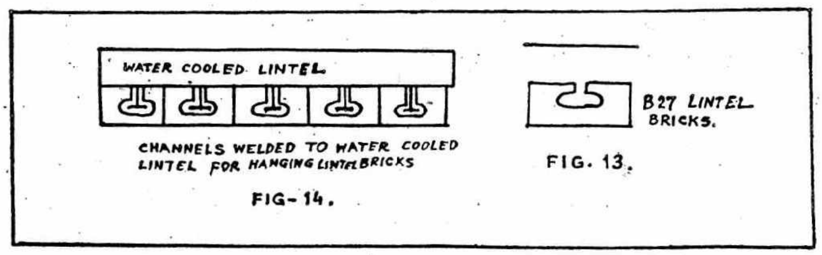


Fig. 13. Fireclay shapes used for lintel Fig. 14. Fireclay shapes with welded channels