

# USE OF SILICA RAMMING MASS IN INDUCTION FURNACES

## 1. INTRODUCTION:

Lining is the important part of induction furnace,  
Furnace performance is directly related to the  
Lining performance. Well – stabilized lining results  
In smooth working of furnace, optimum output and  
Better metallurgical control. The lining practice best  
Suited to particular foundry will depend upon the furnace  
Capacity and design, metal being melted and output etc.  
For successful and consistent lining practice monitoring  
The following parameters are essential.

- Use of proper grade of lining material
- Careful and systematic lining practice.
- Consistency in working conditions.

## 2. REQUIREMENTS OF A LINING:

**Important aspects** about refractory lining for  
Satisfactory lining life is listed as.

- thermal characteristics it should withstand the  
    Stresses developed by thermal cycles in operation
- Chemically inert to metal being melted.
- Structural strength under operating conditions.
- High erosion resistance.
- Ease of installation.
- Reparability.
- Ease of knocking.
- Economics.

As such it is very difficult to judge the suitability of particular lining under various conditions like operating temperature, metal being melted, & slag formed and furnace capacity. Chemical inertness to molten metal can be achieved by using acid lining for acidic slag while basic lining for basic slags.

## **TYPES OF RAMMING MASS**

The various types of ramming masses ranging from (A) acid (B) Basic (C) Neutral are available. The lining is termed as acid, basic and neutral depending upon its Chemical nature with the slag formed. Silica masses are acid ones; alumina is neutral mass while magnetite is basic mass. The typical

properties of 3 refractory materials, commonly used are listed in Table-1 and their expansion characteristics are given in Fig.1.

Out of three types of ramming mass discussed the most commonly used lining material for induction melting is high purity Silica ramming mix. Since it offers following advantages.

--On the face in contact with liquid metal there is a dense sintered layer where tightness of liquid metal is quite perfect.

--Thermal conductivity is lower than other refractoriness so the

Thermal loses are less than any other kind of refractory.

--Good resistance to temperature change.

--Low cost in furnace lining.

--Short heating and sintering time through dry preparation

Of masses.

--The price is very attractive compared to others.

Silica ramming mass can safely be used up to an operating temperature of 1600°C it expands very little so it is superior to both alumina and magnesia to resist thermal shocks. Secondly its cost is very low in comparison to alumina and magnesia.

Silica is normally used conventional grades of iron grey, ductile and malleable. It is also used for melting carbon steels with carbon content higher than 0.1% and iron alloys like Ni-

harden-resist and chrome iron. Temperature control is very essential for satisfactory lining life. Silica can be used for melting copper and copper alloys including cupronickels with change in amount of binding agent additions. For brasses melting silica lining is the "ideal" choice. The output of brasses is more than a Ton per kg of silica consumed. In Indian currency it works out to be less than 1/1000<sup>th</sup> of a Rupee for one kg of brass melting.

## **SILICA RAMMING MASS**

The silica (SiO<sub>2</sub>) used as lining is acidic in nature. It is used in powdered condition. The chemical analysis is given in table-2.

It is produced by crushing and grading of good quality quartzite having very purity. The impurities present will produce unpredictable and more amount of liquid phase at high temperature thereby lowering chemical and mechanical resistance of lining. High purity silica yields more lining life. It also results in considerable uniformity in physical properties.

The more compact lining results in greater strength and life. The compactness (packing density) depends upon granulometric composition of ramming mass. It should be such that it forms the least open space between particles. The

typical granulometric compositions of commercial silica ramming mass are shown in Table-3.

TABLE-3: Granulometric composition of commercial silica ramming mass.

SIZE	PERCENTAGE
--4mm to 1mm	33%
--1mm to 0.20mm	30%
--0.20mm to 0.06mm	17%
--0.06mm & below	20%

Particular attention should be paid towards the proportion of fines within a certain tolerance. It has adverse influence on the service behavior of lining if present in more amount than required. Since the finest particles mainly takes part in the sintering reaction.

### **BINDING/SINTERING AGENT:**

The binding agent is added so as refractory lining of crucible which is formed with silica mass, must sinter during heating up and develop strength before molten metal is charged. Boric acid is mixed as binder. The boric oxide reacts with silica particles to produce a low melting point glassy phase which fills the interstitial holes between the quartz grains. The

selection of correct amount of boric acid is very important for optimum life of lining. It depends upon: --

- Temperature of molten metal bath.
- Chemical composition of quartzite mass.
- Thickness of crucible wall.

Fig-2 shows typical amount of boric acid used for the different operating temperature.

## **RAMMING PROCESS:**

### **Mixing of the mass**

- Work out the quantity of ramming mass required, the exact Amount will depend upon the furnace design.
- Work out the quantity of boric acid required (fig-2)
- Preheat the mass in tray of sheet to 120°C in batch of 50 kgs. So as to remove the traces of moisture.
- Transfer it to cooling trays and cool down to 50°C.
- Add exactly weighed quantity of boric acid by sieving through 0.20mm screen.
- Mix it thoroughly by hand.
- Check the mixed batch for ensuring uniform mixing of boric

Acid.

## **TEST:**

By hand picking a small amount of mass make thick water slurry and dip ph paper in it. The presence of boric acid will report ph less than 7. Make such tests by picking 3 samples from each batch from different location in tray (Used distilled water)

## **COIL LINING**

--The water cooled copper coil is coated with refractory mortar

And dried well before start of lining.

--Thick asbestos sheets are layer in around, the coil lining.

## **RAMMING THE CRUCIBLE:**

### **RAMMING BY HAND**

--The furnace bottom is rammed by using flat head tools for

First 2 layers of 60-20mm while subsequent layers are

Alternately rammed with spiked and flat head tools. The

Ramming tools are shown in fig-3

--The bottom is built 10 mm above the required height and

Extra mass is scrapped uniformly. Check the level.

- The metallic former duly cleaned from outside is then placed perfectly concentric with the coils and held in Position by wooden spacers. Keep a heavy weight inside The former to resist its coming up during further Ramming.
- The angular space between the asbestos sheet and former is rammed in 50-60mm layers using spiked and flat head tools from the top.

**Hint:** DO NOT USE BLUNT & WORN TOOLS. It can result In poor compaction.

- Continue the ramming till 100mm gap from the top.
- Apply thin layer of sodium silicate solution over top of silica rammed crucible before topping mix ramming.
- For topping mix add dilute sodium silicate solution to The silica mass.
- Form the spout by the same topping mix.
- Pneumatic rammers/electric vibrators can be used in large furnaces for crucible formation.

## **SINTERING OF FURNACE CRUCIBLE**

### **INDUCTIVE SINTERING**

- The furnace is filled upto the coil upper edge with starting block care centred for mains frequency furnace while heavy



Scraps for medium frequency furnaces.

- The power supply must be regulated through switching on the lowest transformer tap, keep switching the power ON and OFF at few minutes intervals so that temp. Rise Of  $100^{\circ}\text{c}$  hour is achieved for furnaces up to 6 tones Capacity and  $50^{\circ}\text{c}/\text{hour}$  for big furnaces with thick lining.
- This rise in temperature is monitored up to about  $800^{\circ}\text{C}$ .
- After  $800^{\circ}\text{C}$  the power is raised and with about  $150^{\circ}\text{c}/\text{hour}$  The heating is continues up to the melting of sintering Charge.
- For measurement of temperature chromel/alumel thermo Couples are used.
- As the charge slowly melts the solid metal is charged to Produce a full furnace bath. The temperature is maintained low during entire melting through constant addition.
- As soon as the furnace is filled with liquid metal the power is Increased in order to reach the sinter temperature.
- The final metal temperature should be raised to app.  $30\text{-}50^{\circ}\text{C}$

above the normal operating temperature and held at this temperature for an hour to stabilize the temperature of the refractory lining and also sufficient thickness of refractory gets fritted to withstand the physical shock of crucible.

--The furnace shall not be put out of service or cooled under 1000°C during first 4 days of working as possible.

## **LINING REPAIR:**

During operation the furnace lining is subjected to various kinds of thermal stresses, mechanical loading and metal lining reactions. As a result lining wear takes place (fig.4). The following few methods of repair the lining depending upon the nature of wear are summarized.

## **CRACKING:**

Often small hair like cracks is seen on the lining surface after cooling. On cooling the lining contracts and when it cannot withstand contraction-stresses it develops small cracks and thereby release stresses. However cracks of this nature will close when the furnace is heated up. It is not advisable to change borings or fine metallic particles which can enter the crack and prevent from self closing.

## **LOCALIZED WEAR:**

Any small localized localized broken or worn out portion of the furnace lining can be easily patched by using air setting refractory should trowelled with pressure. The exposed surface of patch is left to allow moisture to escape.

### **EROSION OF BOTTOM:**

This can be repaired by pouring lining material on the eroded area and ramming with flat hammer for minor wear at the bottom.

### **EROSION OF SIDE WALLS:**

The worn section of the furnace can be repaired by using dry monolithic lining behind a part former. The former should be slightly less than original diameter of the lining.

### **SLAG-LINE EROSION:**

Grooves formed at slag level in the furnace can be repaired either in empty furnace by putting silica ramming mass similar as described in localized wear.

It can also be performed when furnace is working. Keep the metal level at the area to be repaired. Slag is removed and loose monolithic mass is added to the furnace through the movement of bath the mass is drawn to the side walls and adheres to the wall.

## **LINING FAILURES AND THEIR CAUSES:**

The life of furnace lined with silica, sintered and ready for use very much depend upon the lining practice and working conditions of furnace. While it is common to set inconsistent life of lining. Many occasions one has to face sudden failure of lining. The factors which cause problems with lining to be considered are listed below.

- Granulometric composition of mass.
- Non-uniform distribution of binding agent.
- superheating of molten bath.
- Metal penetration.
- Minimum slag free metal resulting in minimum erosion at slag line.
- Loss of refractory powder.
- Topping/lining interface cracking

## **RECORDS MAINTAINING:**

Foundries operating electric induction furnaces should maintain records about output, working temp. And performance of refractoriness etc. These recorded data can always be compared with running furnace performance and also can be good references when any problem arises. It also

provides information's on correct practice of furnace remaining and sintering which yielded optimum output also explains the reasons in case of particular poor lining life.

**TABLE - 1**

**TYPICAL PROPERTIES OF THREE REFRACTORY MATERIALS  
USED COMMONLY FOR MAKING INDUCTION FURNACE LININGS**

	<u>SILICA</u> ( $\text{SiO}_2$ )	<u>ALUMINA</u> ( $\text{Al}_2\text{O}_3$ )	<u>MAGNESIA</u> ( $\text{MgO}$ )
1) Nature	Acidic	Neutral	Basic
2) Melting Point, ( $^{\circ}\text{C}$ )	1723	2050	2800
3) Free Energy at 1450 $^{\circ}\text{C}$ , (kJ/mol)	-594	-758	-732
4) Average Thermal Conductivity between 0 $^{\circ}\text{C}$ and 1200 $^{\circ}\text{C}$ , (W/mk)	1.7	2.6	4.0
5) Expansion Coefficient between 0 $^{\circ}\text{C}$ and 1200 $^{\circ}\text{C}$ ( $\times 10^6$ )	12.2	8.2	13.8
6) Relative Cost (taking silica cost as unity)	1	5 to 10	5 to 10

**TABLE - 2**

**CHEMICAL ANALYSIS OF SILICA RAMMING MASS**

<u>CONTENTS</u>		<u>PERCENTAGE</u>	
$\text{SiO}_2$	—	98.9%	Minimum
$\text{Al}_2\text{O}_3$	—	0.6%	Maximum
$\text{Fe}_2\text{O}_3$	—	0.2%	Maximum
$\text{CaO}$	—	0.1%	Maximum

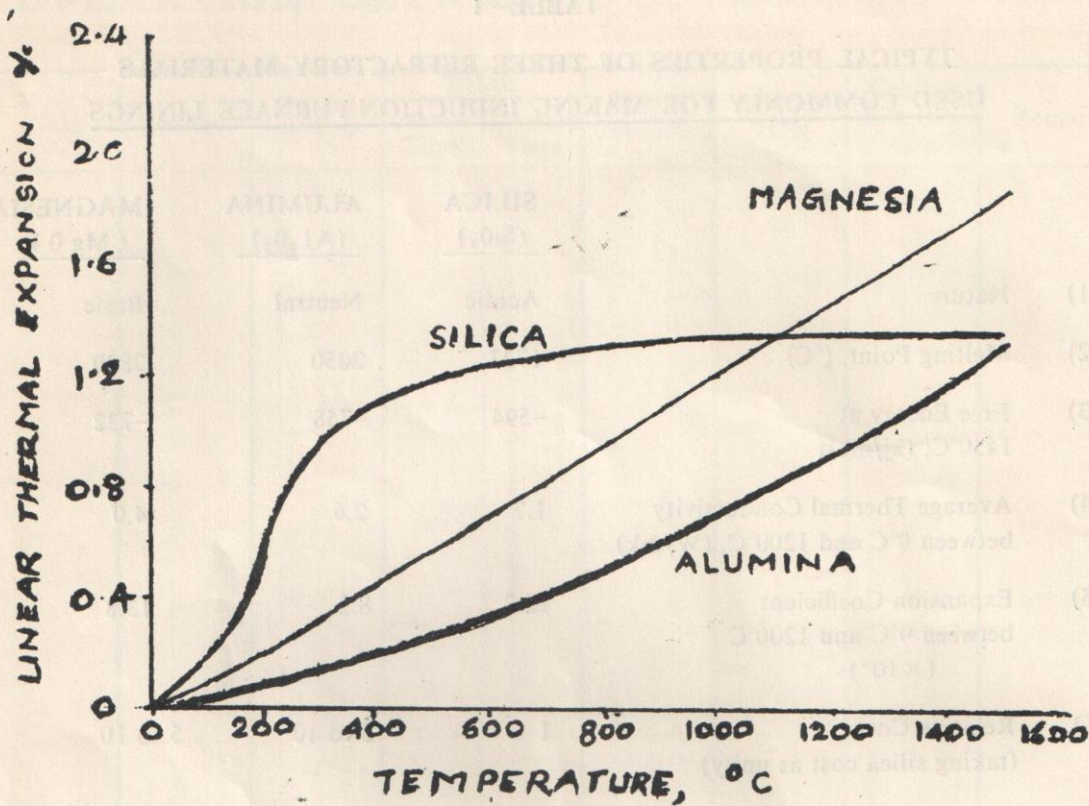


FIGURE-1  
THERMAL EXPANSION OF DIFFERENT REFRACTORIES

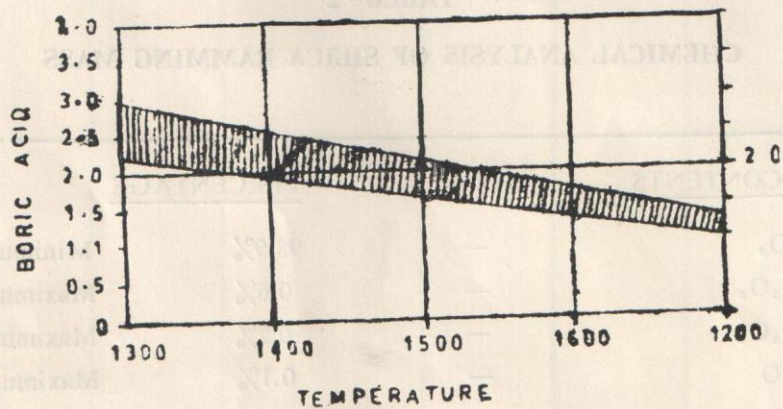


FIGURE-2  
RELATION BETWEEN PERCENTAGE OF BORIC ACID  
USED AND BATH TEMPERATURE

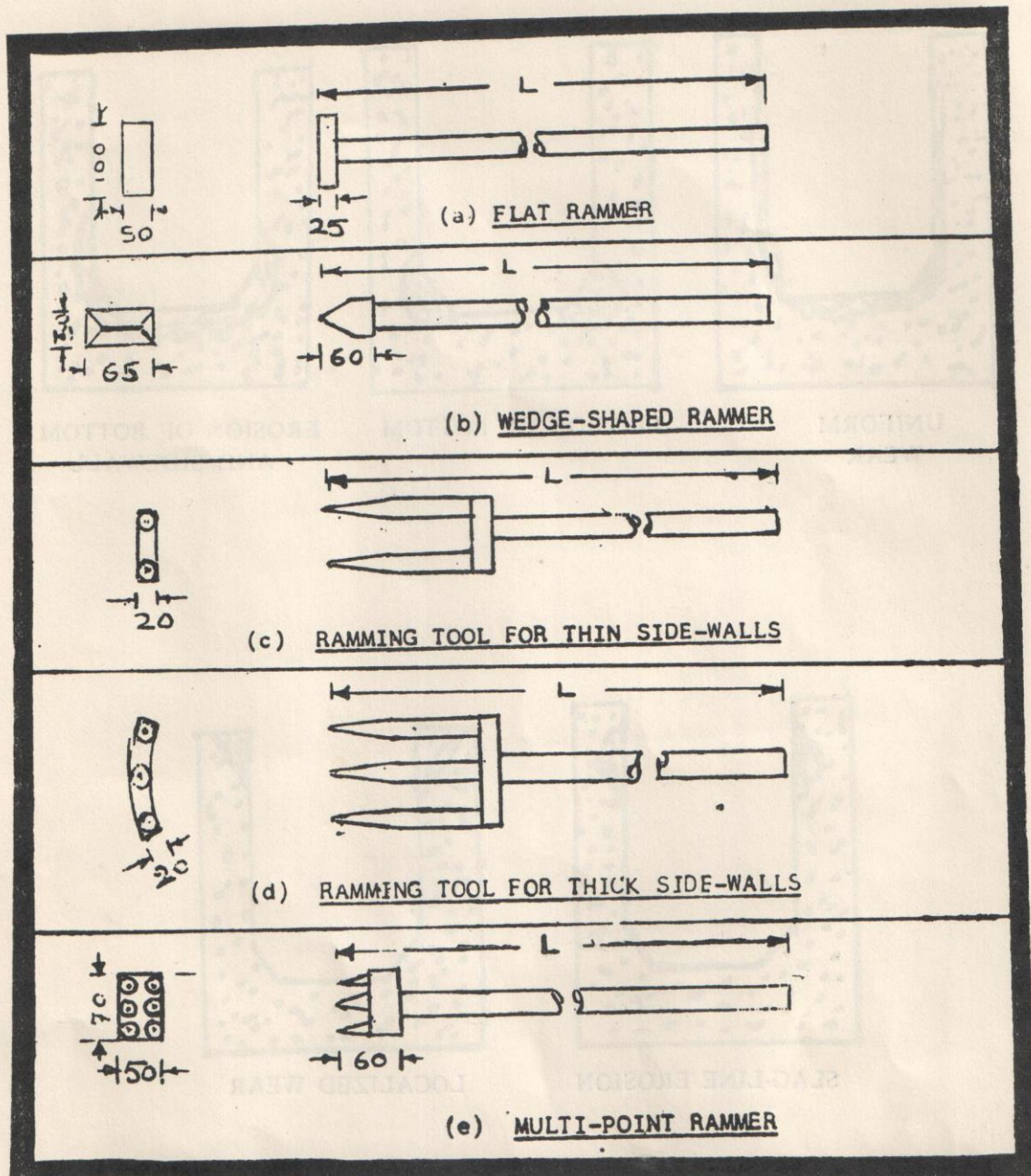
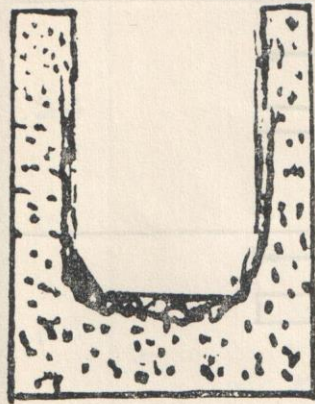


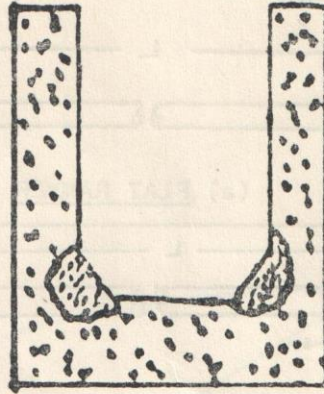
FIGURE - 3

RAMMING TOOLS FOR HAND RAMMING

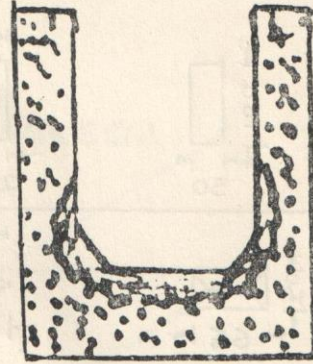




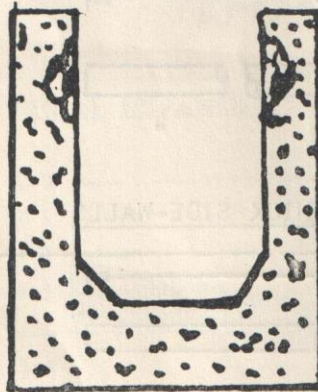
UNIFORM  
WEAR



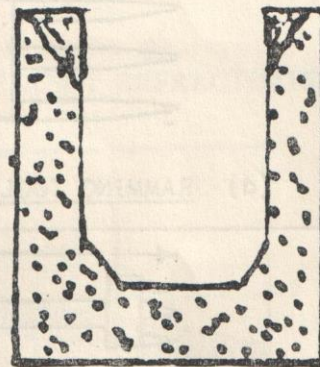
EROSION OF BOTTOM



EROSION OF BOTTOM  
AND SIDEWALL



SLAG-LINE EROSION



LOCALIZED WEAR

FIGURE - 4

DIFFERENT PATTERNS OF LINING WEAR