REFRACTORY BRICKS AND CASTABLES

No high temperature operation can go without heat management especially, in this ‘endless era’ of rising energy costs. The solution is of course, refractories and typically speaking, Insulating Refractories. The reason - it allows a furnace to reach temperature faster than without it, at the same time protects the unit’s surrounding environment from excessive heat and saves energy costs; add value to the customer’s product.

In one of our earlier articles **Insulating Refractories (Part–I)**, we reviewed the functions of insulating refractories, some of the fundamental technologies of high-temperature refractory insulation, mechanisms of heat transfer in industrial processes, rate of heat flow (heat loss), considerations of Thermal Conductivity in a refractory material, and how to calculate Heat Loss or Heat Transport and Thickness of Refractory Lining for a given furnace conditions etc. This article presents and discusses on the types or few qualities of insulating refractories, their manufacturing procedure including the various raw materials used, and also on the installation of insulating refractory bricks and castables.

There are several types of insulating refractories, including insulating fire brick (IFB), insulating castables, insulating pumpables, granular insulation, and ceramic fibre insulation [**How effective are Insulating Refractory (Ceramic) Fibers?**]. The insulating bricks may be classified mainly into two categories, one being used for the low temperatures, below 1000^{O}C (CFI) and the other (HFI) for any temperature above 1000^{O}C, depending on the raw material used in their manufacturing. Ceramic fibres of various compositions with corresponding application temperatures form another category of insulation.

<u>To be a good insulating refractory brick they must have the following properties</u>:

1. Low thermal conductivity.

2. Mechanically strong enough to bear the load of the structure.

4. High porosity.

5. Low permeability.

6. Withstand the heat of at which they are used.

7. Must not shrink or react chemically with the material with which they are in contact during use.

It is well known fact that vacuum is the best insulator. Next to this comes the motionless air. But can we create vacuum in a brick for having insulating properties? For obvious reasons, the answer is no. This property is introduced in a brick by including a large number of air spaces in its body. The air spaces inside the brick prevent the heat from being conducted but the solid particles of which the brick is made conduct the heat. So, in order to have required insulation property in a brick a balance has to be struck between the proportion of its solid particles and air spaces. The thermal conductivity is lower if the volume of air space is larger. Importantly, the thermal conductivity of a brick does not so much depend on the size of pores as on the uniformity of size and even distribution of these pores. Hence, uniformly small sized pores distributed evenly in the whole body of the insulating brick are preferred. The brick should have enough pore space at the same time cellular in texture. This cellularity for manufacturing insulating refractory bricks can be introduced by one of the following ways:

(a) By addition of a combustible substance in the composition (mixture) of brick e.g. saw dust, paper fiber, coal dust, rice husk ash, styrophore etc. During firing this burns out leaving behind a porous structure.

(b) By using minerals which expand and open up on heating e.g. raw kyanite, some china clays.

(c) By addition of a volatile compound in the composition (mixture) of brick e.g. naphthalene.

(d) By using substances which by themselves have open texture e.g. insulating brick grog, vermiculite, ex-foliated mica, raw diatomite etc.

(e) By chemical bloating. This is generally done by using aluminium (Al) powder in combination with NaOH solution.

(f) By aeration.

(g) By putting foaming agents in the mixture of the brick.

Amongst all these the first method is more common and easier for producing cellularity. The manufacturing of insulating refractory bricks and other insulating materials require a different approach. The low temperature insulating bricks are manufactured using granules of vermiculite, ex-foliated mica, and raw diatomite. While using any of the above raw materials, a good percentage of combustible or carbonaceous grains is used in the batch composition, which burns out during firing, leaving voids inside the texture of the brick. The high temperature insulating bricks are produced from mixtures of grains of calcined clay, raw kyanite with combustible material in the batch. Raw kyanite expands on heating by 15-18 per cent. This fact has made raw kyanite an excellent material for making insulating refractory bricks. When the bricks are fired, the kyanite expands and the bricks become porous. The addition of saw dust or any other combustible is helpful in the sense that on burning, the saw dust leaves open spaces and when kyanite expands, the expansion is borne well by these spaces and the structure is not disturbed [One complete 'Production Recipe' is given at the end of this article for manufacturing insulating refractory brick of two different compositions and properties].

Acid insulation bricks can be made similarly with crushed quartzite, fireclay and saw dust in batch. The use of combustible material may be eliminated by adopting the foaming technique during forming the shapes. In rice growing countries, the rice husk ash is a cheap and important insulating raw material suitable for use at a fairly high temperature 1500^{O}C. A small percentage of plastic clay as bond is used in both low temperature and high temperature insulating bricks. The firings of insulated bricks are carried out at a temperature depending on the raw materials used as well as on the temperature of their application. The firing temperature should be preferably higher than the temperature of their application. Naphthalene is also used produced cellularity. It is mixed with fireclay and insulating grog in powder form and pressed into bricks. On firing naphthalene volatilizes leaving a cellular mass. Sometimes aluminium powder is used with NaOH to produce chemical bloating or froth. Chemicals like ammonium sulphate, ammonium chloride, ammonium nitrate, calcium phosphate, phosphoric acid, and sulphuric acid are also used for manufacturing insulating refractories. But these are generally used in manufacturing basic insulating refractories like magnesite. Sulphuric acid acts in green state. CO_2 is expelled leaving the body of the brick porous. Other substances like ammonium chloride decompose on heating. The Cl_2 mixed with water vapour acts with magnesite and CO_2 is expelled.

Some Drawbacks of Insulating Fire Bricks (IFB)

Generally saw dust is used in the batch composition for manufacturing of insulating fire bricks which gives porous structure to the brick after firing. Although porosity decreases thermal conductivity and density of the brick, it also degrades the mechanical strength of the brick as compared to a dense refractory firebrick. The porosity also makes IFB more susceptible to chemical attack by gases, fumes, slags etc. The porosity in IFB or any other insulating refractories creates a large amount of free surface area. Since chemical attack starts at surfaces, porosity leads to poor chemical resistance as compared to dense refractories of similar compositions. Liquids such as slags, molten glass etc. at high temperatures can penetrate porous bricks easily, making insulating fire bricks unsuitable for direct contact with such liquids or gases.

The poor strength of IFB due to their high porosity can pose structural design problems. In addition, insulating fire bricks often suffer from thermal spalling problems, particularly in an environment of rapidly changing temperature. Since these bricks are good insulators, a substantial temperature gradient will occur between the hot and the cold face of each brick. The hot face will expand more than the cold face. The thermal gradient thus, gives rise to a mechanical stress in the body of the brick. Since, insulating fire bricks are not very strong, the surface can be spalled off by these stresses, especially if the temperature changes frequently.

Installation

The procedure of installation of insulating fire bricks is same as dense brick. **"Techniques of Installation of Fiber Refractory Linings"** and**"Techniques of Adding Insulation over the Existing Refractory Linings"** have been discussed in a separate post. Insulating fire bricks are used as the hot-face refractory materials in ceramic kilns and many heat-treating furnaces. They can not be used on the hot-face when severe temperature or operating conditions exist. But insulating fire bricks are often used backup insulation in such circumstances. When used as backup insulation, it is important that the interface temperature between the working face of the furnace and the backup insulating brick is known so that the proper grade of these insulating fire brick (IFB) can be selected. Similarly, insulating castable refractories are monolithic refractory mixes into which a large amount of porosity has been introduced. The method of manufacturing is much the same as described above for insulating bricks. One way is to put saw dust or any other combustible material in the aggregate to make this porous when it is fired. Then the aggregate is crushed and sized and mixed with more conventional bonding chemicals to prepare the castable. Another approach is to put foaming agents (as mentioned above) in the mix, which are activated when water is added for installation. By this porosity is introduced in the matrix instead of the aggregate. Installation of insulating castable refractories is almost the same as for a dense refractory castable but again with due attention to the mechanical weakness of these castables in design of the system. Insulating refractory castables may be poured into an intervening space deliberately left between the steel shell and a free-standing wall of working refractory bricks. This technique ensures an excellent fit between any irregularities in the brickwork and irregularities that are bound to occur in the surrounding shell. Some poured-in backup insulation is simply made of loose, porous, granular fired refractories. This, of course, has no mechanical strength at all. Its use tends to be limited small furnaces whose brickwork is entirely self-supporting and to a number of other similar situations in relatively small vessels. Typically mineral fiber or other low-duty refractory materials used as backup insulation generally degrade over time, allowing heat to channel through. *Insulating* *pumpables* are refractory materials which provide quick and easy refractory lining repair. Common insulating pumpable applications include – re-insulating hot-spot in utility boilers, industrial furnaces and kilns, sealing around burner blocks and flues, and placement between fiber modules that have shrunk excessively. And more recent addition to these is the *Insulating Foams* that are cast with different cellular configurations.

Manufacturing and Composition Recipe

Materials	Volume %	Firing Temp / ST (Shrinkage %)	Tentative Properties
China Clay (Ball Mill Fines) Saw Dust (Fines) Raw Kyanite (Fines)	45 32 23	1200^{O}C / 2hrs (1%)	Al_2O_3 = 40% Fe_2O_3 = 2% Service Temp = 1400^{O}C (max) BD = 1.1 gm / cc PCE = 32 ½ Apparent Porosity = 58% CCS = 40 kg/cm^2 Thermal Conductivity at 600OC H/F = 0.45 K.Cal/m/hr^{O}C
China Clay (Ball Mill Fines) Saw Dust (Fines) Insulating Grog (0 - 3mm)	55 35 10	1220^{O}C / 2hrs (1%)	Al_2O_3 = 30% Fe_2O_3 = 2% Service Temp = 1300^{O}C (max) BD = 0.8 gm / cc PCE = 30 Apparent Porosity = 70% CCS = 15 kg/cm^2 Thermal Conductivity at 600OC H/F = 0.35 K.Cal/m/hr^{O}C

PRODUCTION PROCESS

(a) Saw dust (containing 30% moisture max.) is screened through a Rotary screen (2mm). (b) Dry mixture is made. Materials are added by Volume per cent as per composition (e.g., here it is 8 boxes China Clay + 5 boxes Saw Dust + 1 box Insulating Grog = Total 14 boxes. If we calculate the same by weight then it comes about - China Clay 64%, Saw Dust 28% depending on its Moisture%, Insulating Grog 8%). (c) This dry mix is Pug Milled adding only water & kept in a Bunker under a plastic cover to avoid rapid drying. (d) Showering of water is done over this mix for 10-12 days. For accountability starting & last date of showering should be marked on the respective Bunker wall. (e) After 10-12 days of showering the same mixture is remixed in a Muller Mixer after adding some organic bond. After this final mixing, the Mixture is taken for moulding into clots as per the required size (provision in mould size should be kept for firing-shrinkage & final cutting). (f) After floor drying, clots are fired in a batch type kiln at about 1200-1220^{O}C / 2hrs or as mentioned above. (g) Fired clots after cutting & little bit finishing are ready for packing and despatch.

Source : http://viewforyou.blogspot.in/2010/09/types-of-insulating-refractory-bricks.html