Materials of Furnace Construction.

The materials for constructing the interior of electric and other furnaces, should be infusible at the temperature of the furnace; should resist the action of the metallic slags or other contents of the furnace; should retain the heat of the furnace as far as possible, and should be capable of being formed into bricks, or coherent linings which will resist the mechanical action of the charge in the furnace. The following are a number of the more important materials which can be employed.

Fireclay Bricks. The clay from which these are made consists of pure clay, or kaolin, Al_2O_3, $2SiO_2$, $2H_2O$, with a variable proportion of silica in addition to the amount present in the kaolin, and as little as possible of fluxing materials such as iron oxide, lime, magnesia, potash or soda. Even silica lowers the melting point, and should be present only in moderate amount. These bricks are largely used for lining ordinary metallurgical furnaces, but are not usually sufficiently refractory for electric furnaces; they can, however, be used as a backing for more refractory material. Being siliceous in composition, they are easily fluxed by slags containing metallic oxides. When not exposed to such slags they will stand temperatures up to about 1,400° C.—1,800° C., 2,500° F.—3,300° F. They should be laid in fireclay mud, instead of lime mortar, which would crumble away at a red heat.

Silica Bricks. These should contain about 95% to 97% of silica, SiO_2. The melting temperature of silica is a little above that of platinum, being about 1,830° C., or 3,330° F., and the silica brick should stand up to about 1,750° C., or 3,180° F. They are useful for the roof and other parts of open-hearth steel furnaces, that are exposed to a very high temperature, but not subjected to the action of metallic slags, which would soon flux them away. They have the property of expanding with the heat, instead of contracting like fire-clay bricks. Silica bricks should be laid in a siliceous mud for mortar, and in general, all refractory bricks should be laid in a mortar of the same composition as the brick, to avoid fluxing; thus it would not do to lay basic brick in siliceous mortar, as the mortar would combine with and flux part of the brick.

Lime, CaO. This is an extremely refractory material, and is useful for lining small electric furnaces. Its melting temperature is not exactly known, but may be about 2,040° C., or 3,700° F. Lime is obtained by burning limestone, (CaO, CO_2), thus driving off the carbon dioxide which it contains. Burnt lime absorbs moisture from the air and slakes, forming the hydroxide CaO, H_2O. Lime mortar contains slaked lime, and when it is heated in a furnace, the water that is combined with the lime is driven off, and the mortar crumbles away. Lime cannot be made into fire bricks by mixing it with water, as the bricks would crumble in the furnace, and it is difficult to render lime coherent by the use of any other material. This difficulty of binding and liability to slake has prevented the general use of lime for furnace linings. Small electric and oxy-hydrogen furnaces may be constructed of blocks of quick-lime or of the natural limestone which becomes converted internally into lime during the operation of the furnace. Being basic or non-siliceous in character, lime will resist the action of metallic slags, and it would form a valuable material for lining electric and other furnaces if it were not for the objections already mentioned. The use of lime in the electric furnace is also limited by its property of forming a fusible carbide when heated with carbon.

Magnesia. (Burnt Magnesite, Magnesite Bricks) MgO. Magnesia is even more refractory than lime, melting at perhaps 2,200° C., or 4,000° F. It is produced by burning magnesite (MgO, CO_2), thus driving off the carbon dioxide, in the same way that lime is produced from limestone. Although it resembles lime chemically, magnesia does not slake very easily, and when strongly burned it shrinks considerably, forming a heavy material very different from the light, chemically prepared magnesia which is used as a medicine. This shrunk magnesia can be cemented together to form a moderately strong fire-brick, which is extremely valuable for lining basic open-hearth furnaces and electric furnaces. It is not easily fluxed by metallic slags, since it is basic in composition. On account of their great compactness (a brick weighs about 8½ lbs.), they are very good conductors of heat, being about twice as good as fire-clay bricks, and in constructing electric furnaces of magnesite bricks an outer coating of some other material should be used to diminish the loss of heat, except when this cooling is desired to prevent the fluxing of the walls. Magnesite bricks are liable to crack under the influence of heat unless it is gradually applied. Their property of contracting when heated renders them unsuitable for building the arched roofs of furnaces, and silica bricks would be used for this purpose except in furnaces where the roof was exposed to a temperature at which they would melt. Furnace linings may also be constructed of burnt magnesite in the form of a powder; it is mixed with tar or pitch to make it bind, and rammed into place around a core by means of a hot iron rod. Magnesia does not combine with carbon to form a carbide, and on this account its use in the electric furnace is preferable to that of lime. Electrically fused magnesia has recently been obtained, and forms a very compact and refractory material for lining electric furnaces, or it may be applied as a paste mixed with silicate of soda to render ordinary fire-clay bricks more refractory.

Dolomite. This is a limestone containing a considerable proportion of magnesite, and when burnt it forms a valuable refractory material, which, like burnt magnesite, may be employed as a powder, or in the form of bricks. It resembles magnesite, but is not quite so good.

In furnaces constructed partly of silica bricks, and partly of dolomite, or magnesite bricks, it would be expected that they would flux one another at the line of contact. On this account, a course of chromite brick is sometimes introduced as a parting layer between the two, as this brick, itself very refractory, does not easily flux with either acid (siliceous) or basic materials. When magnesite bricks are used, however, it is found that this precaution is unnecessary.

Alumina, Al_2O_3. This is prepared from the mineral bauxite (Al_2O_3 $2H_2O$), which is also the source of the metal aluminium. Bauxite has long been used as a lining for furnaces, and recent attempts at purification with a view to improving it for use as a refractory material, have been successful; and the purified, calcined bauxite, bonded with a little fire-clay, sodium silicate, or lime, makes an excellent brick; which appears to be as good as magnesite brick for use in the basic open-hearth furnace. It is also said to be a good lining for rotary Portland cement kilns, and for lining lead refining furnaces, where they are exposed to the fluxing action of corrosive lead slags. Alumina is classed as a basic material, like magnesia or dolomite, and its melting temperature is stated to be about 2,200° C.

Carbon. (Coke, charcoal, Graphite). Carbon is the most refractory substance known; it has never been melted, but softens and volatilizes at the temperature of the electric arc, that is about 3,500° C., or 6,300° F. In its more compact forms it is a fair conductor of electricity and of heat, the former quality together with its infusibility enabling it to be used for electrodes to lead the current into electric furnaces. Being combustible it is liable to waste away when exposed to the air at a red heat, and for the same reason it is corroded when exposed to slags that contain easily reducible metallic oxides. Carbon exists in the three different forms of amorphous carbon, graphite and diamond; charcoal, coke and the other common forms of carbon being of the amorphous variety. When amorphous carbon, or the diamond are heated to the temperature of the electric arc, they are changed into graphite. Carbon blocks composed of coke or graphite can be used for lining furnaces, provided they are not exposed to air or to oxidising slags, but carbon has not been much used for metallurgical furnace linings. In the electric furnace it is often employed, forming a lining which also serves as an electrode, as in the Héroult iron smelting furnace, the aluminum furnace, (Fig. 5, p. 172), and the Wilson carbide furnace (Fig. 7, p. 172); but it cannot usually be employed for the entire lining, because it is so