MULLITE AND OTHER ALUMINO-SILICATE REFRACTORIES VIS-À-VIS ALUMINA - SILICA (AL2O3 - SIO2) BINARY PHASE DIAGRAM

Alumino-Silicate Refractories

Aluminosilicate or Alumino-Silicate minerals are the naturally occurring compounds mainly composed of aluminium, silicon and oxygen. These minerals are the major constituents of Kaolin and clay minerals. Besides Fireclay, Kyanite, Sillimanite, Andalusite and Mullite are some *alumino-silicate minerals* which constitute the main raw materials for *Alumino-Silicate refractories*.

By themselves, these minerals especially sillimanite and Andalusite have a high melting point, low coefficient of expansion after heating and excellent resistance to alkaline melts. Kyanite, Sillimanite, Andalusite and all other sillimanite group of minerals break down at or below 1545^{O}C and yield Mullite. Mullite is $3Al_2O_3.2SiO_2$(71.8% Alumina, 28.2% Silica by weight), and is found naturally or is formed by firing combinations of alumino-silicate raw materials or aluminous raw materials.

From the Alumina - Silica (Al_2O_3 - SiO_2) phase diagram below, it is clear that a mullite material with more than 73 wt% Alumina (Al_2O_3) will consist of mullite and alumina. Below 70 wt% Alumina (Al_2O_3), the material will contain mullite and silica. In these two cases, the temperatures at which the liquid will first appear are radically different.

By varying the alumina and silica ratio in alumino-silicate refractories, a wide range of properties can be realized. Low-alumina, high-silica refractories are used in areas where high strength at service temperature is required such as steel ingot soaking pits.

Alumino-Silicate refractories with 30 - 45% alumina (Fireclay refractories) have high-temperature volume stability and strength, excellent resistance to thermal spalling etc. because of which fireclay refractories are widely used in various metallurgical and non-metallurgical industries, furnace back-up lining and so on.

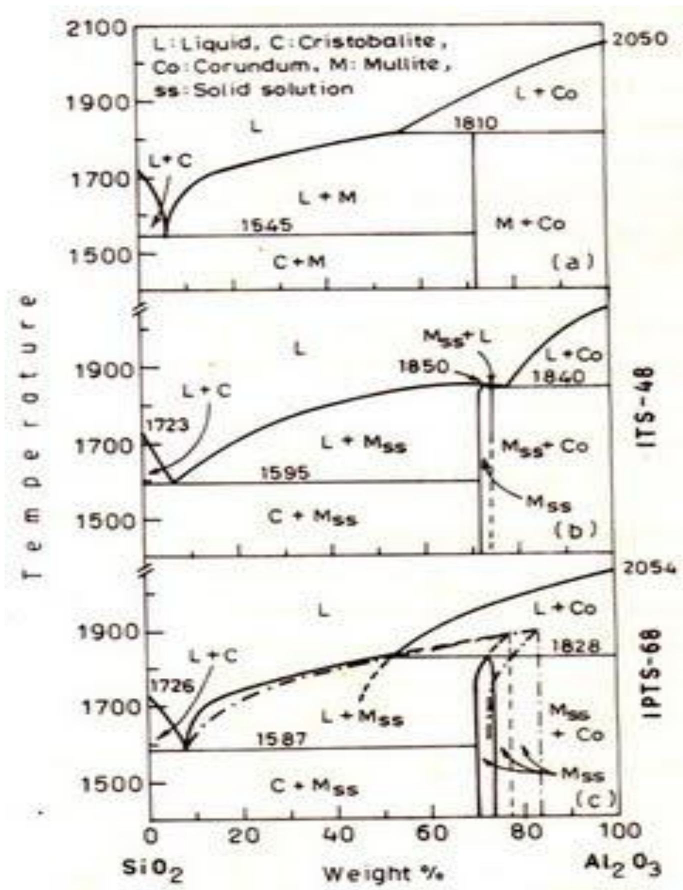

Fig: Versions of the binary phase diagram of the

Alumina - Silica (Al_2O_3 - SiO_2) system proposed from time to time

(a) Bowen and Grieg, Schairer

(b) Aramaki and Roy

(c) Aksay and Pask

A Review of Previous Work on Alumina - Silica (Al_2O_3 - SiO_2) Phase Diagram in relation to the Formation of Mullite

The Alumina - Silica (Al_2O_3 - SiO_2) refractory oxides system has been the subject of several investigations in the past. Though many papers were presented on the melting relations and range of composition of mullite, it remained a matter of controversy about the diagram in the region of the compound mullite ($3Al_2O_3$: $2SiO_2$) as has been discussed by Aramaki and Roy [Journal of American Ceramic Society, 45(5), 1962, p.229]. The first equilibrium diagram for the Alumina - Silica (Al_2O_3 - SiO_2) system presented by Bowen and Grieg [Journal of American Ceramic Society, 7(4), 1924, p.238] as shown in the adjacent phase diagram fig (a), shows incongruent melting of mullite. Other significant features which could not be explained on the basis of this phase diagram, e.g. deviation from stoichiometry of the composition of mullite found in refractory bricks, and the *crystallization of mullite* from a melt of its compositional range, could now be understood with the modifications introduced in the phase diagram by Aksay and Pask [Journal of American Ceramic Society, 58(11 - 12), 1975, p.507] as shown in fig (c). According to this phase diagram showing the stable phases (solid line) and two meta-stable versions (dashed and dot-dashed lines) in the Alumina - Silica (Al_2O_3 - SiO_2) system, mullite melts incongruently at the peritectic 1828^{O}C on the International Practical Temperature Scale of 1968 (IPTS-68) to a liquid containing about 53 wt% Alumina, which is far from the compositional range of stable mullite solid solution (70.5 - 74.0 wt% Alumina). In the phase diagram of Aramaki and Roy as shown in fig (b), mullite is shown to melt congruently at $1850^{O}C$ on the International Temperature Scale of 1948 (ITS-48), the second eutectic between mullite and corundum, $1840^{O}C$, is located at 77.5 wt% Alumina. The major changes introduced in the latest diagram (fig. c) are:

(i) The eutectic temperature was raised to $1595^{O}C$ by Schairer in 1942; the eutectic composition was also shifted.

(ii) Mullite was found to have a narrow but stable range of solid solution among other by Aramaki and Roy, around the stoichiometric composition of mullite, $3Al_2O_3.2SiO_2$, determined by Bowen and Grieg.

Because of the excellent load bearing capacity, volume stability, high resistance to glass, molten metal and slags, mullite refractories find wide spread applications in the glass and metallurgical industries. They are also used as kiln furniture.

Source: http://viewforyou.blogspot.in/2009/11/mullite-and-other-alumino-silicate.html