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REFRACTORY INDUSTRIES, ITS TYPES & FUNCTIONING WITH RESPECT TO SUPPLY & DEMAND

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Abstract

"Refractory" thing according to any Standard English dictionary is a material which is difficult to work with and is particularly impervious to warmth and weight. In useful terms, refractory's are items utilized for high temperature protection and disintegration or erosion and are made principally from non-metallic minerals. The study has been conducted to understand the present status of the refractory industry in India particularly regarding its competitiveness in domestic and global market. To counter the competitive challenges from the global players a new strategy is needed for the local players in the market.The objective of the current research is to design a comprehensive framework for the refractory industry in India so as to maintain its long term sustainability and global competitiveness.

1. INTRODUCTION

Refractories are inorganic, non-metallic, porous and heterogeneous materials composed of thermally stable mineral aggregates, a binder phase and additives. Refractories are heat-resistant materials manufactured in a wide variety of compositions and shapes according to their application. Refractories refer to inorganic nonmetallic materials that have refractoriness of no less than 1580℃and can bear corresponding physical and chemical changes and mechanical actions. With natural ores (including refractory clay, silica, magnesite and dolomite) as raw materials and produced according to some processes, they possess certain high-temperature mechanical properties and good volume stability and are integral materials for high-temperature equipment.

The principal raw materials used in the production of refractories are: the oxides of silicon, aluminum, magnesium, calcium and zirconium and some non-oxide refractories like carbides, nitrides, borides, silicates and graphite. The main types include fire-clay bricks, Castables, ceramic fiber and insulating bricks that are made in varying combinations and shapes for diverse applications.

2. CLASSIFICATION OF REFRACTORIES

Classification Based on Chemical Composition

Refractories are typically classified on the basis of their chemical behavior, i.e. their reaction to the type of Slags. Accordingly the refractory materials are of three classes - Acid, Basic & Neutral.

Classification Based on Physical Form

Refractories are classified according to their physical form. These are the *shaped* and *unshaped refractories*. The former is commonly known as refractory bricks and the latter as "monolithic refractories".

a) Shaped Refractory

Shaped refractory include bricks, shapes, crucibles, and monolithic. Shaped refractories are pre-fired to exhibit their ceramic characteristics. Table 1.1 below lists each type of shaped refractory and a brief description of its use.

b) Unshaped Refractory

The unshaped products include mortars, gunning blends, ca-stables (refractory cement), smashing, blends, and plastics. The production of unshaped refractory's contrasts somewhat from molded refractory. Unshaped refractory's regularly don't experience a terminating procedure until achieves the last buyer. These are introduced by showering, throwing, forming, or slamming. Table 1 underneath records each sort of refractory and a depiction of its utilization.

Table 1: Types and Descriptions of Refractory Produced

Kind	Definition
Shaped refractory	
Bricks	Refractories that have shapes and are used to line furnaces, kilns, glass tanks, incinerators, etc.
Insulating firebrick	Low thermal conductivity firebrick.
Unshaped refractory(Monolithic)	
Mortar	Materials for bonding bricks in a lining. The three types of mortar-heat-setting, air-setting, and hydraulic-setting-have different setting mechanisms.
Castables	Refractories for which raw materials and hydraulic-setting cement are mixed. They are formed by casting and used to line furnaces, kilns, etc.
Plastics	Refractories in which raw materials and plastic materials are mixed with water. Plastic refractories are roughly formed, sometimes with chemical additives.
Gunning mixes	Refractory that is sprayed on the surface by a gun.
Ramming mixes	Granular refractories that are strengthened by gunning formulation of a ceramic bond after heating. Ramming mixes have less plasticity and are installed by an air rammer.

c) Special Products:

In continuous casting, Gamex sheets of silica/magnesite for cold tundishes are utilized to encourage sequencing of warms. Different stream control gadgets, for example, confuses/dams/weirs made of magnesite are utilized in tundishes for improved nature of steel. Submerged passage spouts utilized between tundish outlet and form are made of alumina-carbon/magnesia-zirconia refractory. Covers and monobloclc plugs made of alumina-carbon/alumina-zirconia are utilized in tundishes of different sprout/section/billet

casting machines. 95 percent zirconia metering spouts are utilized for stream of steel into form of billet continuous casting machines for incredible disintegration opposition.

3. IMPORTANCE OF THE REFRACTORY INDUSTRIES

Boom in the client industries see a boom in the refractory part. Any client industry can't make completed products without utilization of refractory products. In this manner, the Indian refractory makers are bit by bit concentrating their endeavors on the operational requirement of the client industries to enhance the refractory covering life. Indian Refractory industries are experiencing an energizing and complex stage. As from one perspective, refractory producers have been including limits with the expectation that request from the client industries will ascend at a quicker pace and then again, none of the major declared new undertakings like Posco (the Pohang Iron and Steel Organization), Arcelor Mittal, Sterlite Iron and Steel Co Ltd, Aditya Aluminum Ltd, Welspun Power and Steel Ltd, Bhusan Steel and Strips Ltd, Uttam Galve Steels Ltd, Jindal India Thermal Power Ltd and so forth in Orissa have been set up , it's still on paper.

In 2011, according to metal-world diary the extent of the Indian refractory market has been pegged at Rs.2, 300 crore and it is expressed to develop at an 8-10 percent for every annum. Around 20 years prior, utilization of refractory per ton of steel was 30 kg and now the equivalent has come down to 12 kg on a normal for steel industry all in all and at a low of 7-8 percent in the more productive steel plants because of critical advancements in refractory material and innovation. The steel business is required to develop with the development of India's economy and with the proceeded with consideration of the administration to foundation improvement. The steel business, which is the single biggest client of refractory, is probably going to grow up, to 150 million tons by 2015. The bond and aluminum industries are additionally expected to develop exponentially.

The utilization of refractory in steel generation can achieve an immense decrease in the expense of creation through the improvement of refractory linings in impact heaters and steel converters, and through the advancement of new procedures to diminish the quantity of ventures for creation. Total creation limit of Indian refractory in December 2006 was 20lakh per annum, it has gone up by around 5-10% in 2007; though limit use was 11.5-12lakh tons for each annum which was around 60 percent16 . By 2010, with an expansion in the steel creation, the interest for Indian refractory has contacted 12lakh tons per annum. Steel still speaks to most of refractory utilization with 75 percent (World steel request is talked about and concrete industry is the second real utilization of refractory products with 12 percent. Increment in the worldwide interest for bond has made more open doors for refractory industries around the world to sustain the market

Table 2: World Cement Demand

WORLD (million metric tons)	CEMENT				DEMAND % Annual Growth
Item	2000	2005	2010	2005/00	2010/05
Cement Demand	1630.0	2250.0	2830.0	6.7	4.7
North America	149.6	170.0	196.0	2.6	2.9
Western Europe	197.7	208.0	236.0	1.1	2.2
Asia/Pacific	954.5	1500.0	1900.0	9.0	5.2
Other regions	328.2	405.0	500.0	4.1	4.7

Sources: free-press-release.eom, Mumbai, 2010

Table 2 depicts that the global demand for cement has increased to 2.8 billion metric tons in 2010 from 2.2 billion metric tons in 2005 with an annual growth of 4.7 percent. North America region including United States (US), third is the largest consumer for cement with 2.9 percent of growth annual demand. In Eastern Europe, even though there has been a degree o f recovery, the difficult economic environment persisted, following a substantial decline over the years. The strongest cement sales figures were achieved in Bulgaria, Romania and the Czech Republic. Market advances scenario is less robust in the developed areas of the US, Japan and Western Europe, as the growth for the demand of cement is mainly because of repair and maintenance.

4. REFRACTORIES AND THEIR RAW MATERIAL

Around 24 different industrial minerals are required to produce a wide range of refractory shapes and monolithics for primary heat process industries such as steel, non-ferrous metals, cement, glass, ceramics, petrochemicals, and municipal incinerators.

Alike all other sectors, refractory industries are also highly dependent on good quality raw material spread across the globe. Keeping in view the probable resource crisis which is quite imminent in future, this industry too needs exhaustive brainstorming to develop innovative ideas to fight the crisis.

Since the industrial revolution of late 18th century, study of refractories reaction mechanism while in use was taken up right earnestly. Main focus was on use of different types of materials. Today there are varieties of refractory raw materials in Oxide, Nitride and Metal Ceramic form are performing much better than their past performances. New developments having combination of Metals, Oxides, and Carbides have led to manufacture of many ‘Smart Refractories’.

The base raw material out of which these special materials have been derived, are spread in many countries across the globe. China today is the largest single source of these base raw materials.

It is established that the properties of these natural raw material vary considerably and in many cases where prime reserves have exhausted, there is depletion in quality. In order to bring back the desired properties to sustain the performance and to meet the prices efficiently in which these refractories are used, focus on following aspects of majority of natural raw material is essential:

- Development of Beneficiation Technology
- Blending and homogenization of feed material

- Development of Smart Refractories (combining Oxide, Nitrate, Carbides, etc)
- Generation of nano sizes and their use
- Development of new Synthetic products
- Phase encapsulation
- Use of Re-cycled Refractory Materials

Besides the above general parameters of raw material properties, the selection also depends on the properties of finally manufactured refractory products e.g. Thermal Expansion, Creep under Compression, Thermal Conductivity, Refractoriness, etc. The selection of raw material also depends, with respect to possibility of attaining permeability, modulus of rupture and elasticity, thermal shock resistance, besides properties like Density, Porosity & CCS.

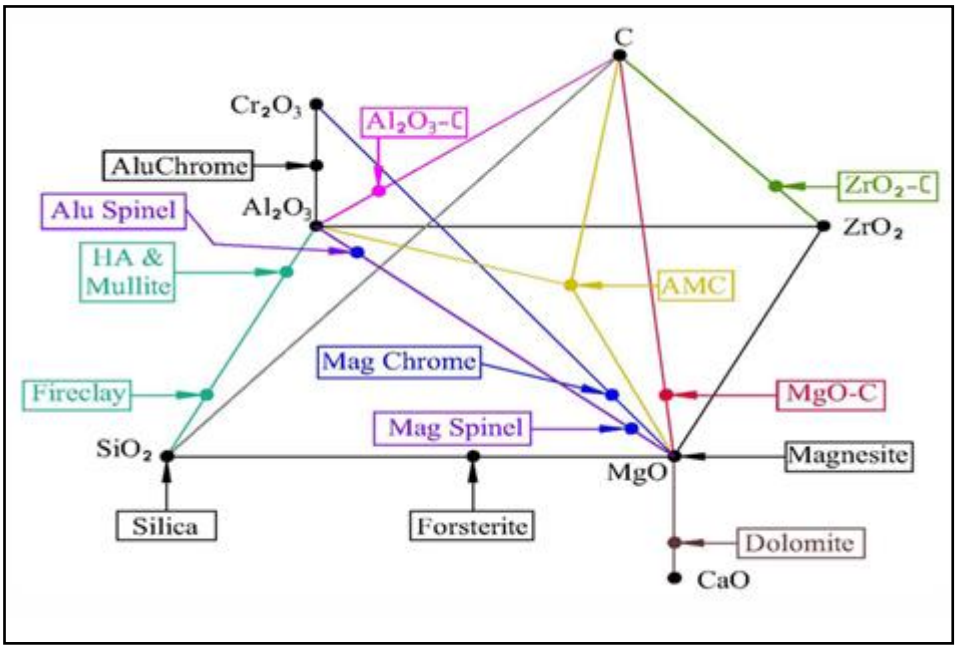

Figure 1: Various oxides and 'C' in graphical form

Figure-1 shows the various oxides and 'C' in graphical form. The combinations of the oxides among themselves and with carbon singly or jointly have led to creation of various types of refractories. The unique properties achieved after the combination determine their usage in manufacturing process of various materials. One such example is of use of Al_2O_3, Cr_2O_3 refractories which have found extensive use in Regenerator of Glass Tank Furnace.

4.1 Raw Materials for Refractories: The Global Situation for Supply and Demand

Global production of raw materials for refractories will likely face increased energy costs, changes in consumption levels and other market-specific factors in 2014 and beyond.

Refractory minerals are used to improve the performance of refractories products by imparting properties such as strength, protection from chemical and physical attack, and slag resistance. Refractories products can be broadly divided into basic, neutral and

acidic groups, which relate to the type of refractory environment the product has been designed for (e.g., basic oxygen steelmaking) and hence the minerals used in its manufacture.

Minerals commonly used for refractories include (but are not limited to) alumina, bauxite, graphite, kaolin, magnesia and zirconium. These minerals are produced globally but, in some cases, not always of grades suitable for refractory applications (e.g., alumina and bauxite). Owing to its favorable mineral resources, China is a leading producer of numerous refractory minerals, but is also a huge consumer of these raw materials for its own domestic refractories industry.

In 2012 and 2013, global production of refractory raw materials fell across most mineral groups. This was the result of lower demand from the refractories sector, which faced falling consumption from a range of end markets, including glass, cement, ceramics, and non-ferrous metals, but especially iron and crude steel output (the largest consuming sector).

1. **Alumina:** Alumina may be consumed in either metallurgical (e.g., Bayer alumina for aluminum production) or non-metallurgical (e.g. ceramics, refractories) applications. Alumina grades that are commonly used in refractories are those categorized as specialty calcined products, such as calcined, white fused and tabular alumina. Brown fused alumina (BFA) is also a type of specialty calcined alumina used in refractories. However, it is produced by fusing abrasive-grade calcined bauxite and is influenced more by demand for bauxite.
2. **Bauxite:** World production of bauxite is estimated to have totaled around 265 Mt in 2012. A large proportion of output is metallurgical grade and used for the production of alumina—itself consumed for aluminum production. There is also a significant market for non-metallurgical bauxite, used for applications such as Portland cement, slag conditioning, and calcined/fused grades for refractories. Non-metallurgical bauxite production is estimated to have been 10 Mt in 2012.
3. **Graphite:** Graphite is used in refractories as a source of carbon. The mineral can be produced from either natural or synthetic sources. Naturally occurring graphite is mined in the form of amorphous, flake or vein graphite, with the former two being the most common. Synthetic graphite is predominantly produced in the form of electrodes from calcined petroleum needle coke, which is crushed, shaped and carbonized over a six-month period into a high-purity, high-cost product. Only natural graphite is used in refractories production; it is lower cost than synthetic graphite and is able to meet the requirements of refractories producers.
4. **Magnesia:** Magnesia is produced in three forms: caustic calcined (CCM), dead burned (DBM) and fused (FM). The latter two are largely used in the production of refractories. DBM and FM grades are typically used in basic refractories in combination with graphite, dolomite, alumina, or chrome.
5. **Kaolin:** Kaolin is typically used in neutral or acid refractories as an aluminosilicate source, where alumina levels of 30-70% are required (low-high alumina). When an alumina

content of above 70% is desired, bauxite and specialty calcinedaluminas are more suitable.

6. **Zirconium:** Zirconium can be used in a variety of refractory products, mainly in the form of zircon, zirconia or alumina-zirconia-silica. Zircon is generally used in acidic refractory environments, while zirconia-based refractories are considered to be basic.

5. PRODUCTION PROCESS, INPUTS AND OUTPUTS OF REFRACTORY MATERIALS

Assembling of refractory relies upon specific mix of substance mixes and minerals used to deliver a predetermined dimension of thermal security, erosion obstruction, extension and different characteristics. It includes four procedures: crude material preparing, shaping, terminating, and at long last handled. Blended procedure managing crude materials is squashed into wanted shapes. This procedure commonly happens under sodden or wet conditions. After the refractory is shaped, the material is terminated. Terminating includes the warming of refractory material to high temperatures in an intermittent clump or consistent passage furnace to shape a fired bond. This procedure gives the crude materials their refractory properties. The last handled stage incorporates processing, granulating and sandblasting the completed item. At last completed products are impregnated with tar and pitch pursued result bundling.

5.1 Machines used in the Production Process

Several types of machines are used to produce refractory: - mixing/kneading machines, presses, and kilns.

- **Mixing/Kneading Machines:** There are two types of mixing and kneading machines: fixed vessel and driven vessel. Mixing homogenizes more than two types of bulk materials, and kneading machines make a uniform coating layer. Mixing and kneading machines are equipped with mixing blades or muller wheels. Heating, cooling, or de-airing equipment may also be applied to the vessel. Mixing and kneading machines are used for manufacturing shaped and unshaped refractory. Unshaped refractory, however, are not processed any further.
- **Presses:** Refractory pressing machines are comprehensively ordered into three gatherings: effect and static press, vibrating press, and cold press. Picking among the three gatherings of presses to a great extent relies upon the kind of crude materials utilized. Effect and Static Presses: Figure represents a vacuum press. Figure 3.2 is an outline of a water powered screw press, a sort of static press. Effect and static presses are regularly outfitted with a vacuum. Effect presses have a higher suitable most extreme compacting power than static presses. Be that as it may, static presses are utilized in the production of sophisticated refractory, for example, submerged spouts and covers. Bricks framed with static presses are level, uniform and conservative.
- **Kilns:** Refractories are terminated to build up the materials' refractory properties. The unfired ("green") refractory goes through a warmth treatment which results in a thermally steady refractory and/or

crystallization. The industries utilize three types of kilns:

- **Tunnel Kiln:** In a tunnel kiln, refractory products sequentially go through preheating, terminating, and cooling zones. The ignition gas from the terminating zone is regularly used to preheat the refractory. Warmth can be recouped from cooling terminated refractory and reused as burning air. Approximately 80 percent of molded refractories are terminated in passage kilns.
- **Round Periodic Kilns:** Round periodic kilns are typically used to fire silica bricks. Figure 5(Vide Page.41) is a diagram of a round periodic kiln. Kilns can be used to fire large refractory products that cannot be fired in a tunnel kiln and can easily accommodate changes in production.
- **Shuttle Kilns:** As illustrated in Figure 6, the design of a shuttle kiln resembles the firing zone of a tunnel kiln. Shuttle kilns effectively store heat and are used to fire fireclay and specialty bricks.

6. CONCLUSION

So it is concluded that The Indian Players in the Refractory Industries are facing a stiff challenge from the global major who have entered the Indian refractory market and finding it more & more difficult to compete with them because of their brand image, strong R & D, service orientation, changing domestic service dynamics, and challenges of environmental sustainability. Meanwhile, increasing level of industrialization is fuelling growth in the Indian Steel industry, providing ample growth opportunities for refractories. Iron and Steel industry continues to remain the major end use market for refractories.

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