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Review of Refractory Materials for Innovative Investigation and Testing

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Abstract –*This paper is a review of thermal analysis and testing of different refractory materials.Refractories are ceramic based materials that can withstand unusually high heat as well as abrasion and the corrosive effect of acid and alkalis. The Purpose of Refractories are in furnace, stills for the cracking of petroleum, electrolytic cells for aluminium production, ceramics kilns, boiler, as they minimize heat losses through structure also fill gap and lining in boiler and furnace.During the foundry furnace, kilns, steel reheating furnace operation the failures are fibre modules fallen from the roof, failing bricks walls, floor cracking, castable cracking and convection castable, heat losses are major problems. By some research papers, wefound manufacturing, properties, Composition of different refractory materials. Now a day's some testing properties and heat losses analysis of the refractory materials available. But about the life cycle of the different typerefractory materials are not available now days. We think solve this problem by finding the universal mathematical equation. We also work testing the thermal and physical properties of the different types of materials with the help of different machines are furnace, hot plate and other similar types of machines.*

Key words:*Refractory materials like Alumina, Silica, Fire Brickand Cold face insulation brick, Furnace, Hot Plate, Cold crushing machine*

I. INTRODUCTION:

The furnace is an equipment to use for melting the metals for casting or heating of material for changing shape and size like rolling, forging etc. It is also used for change of the properties of the metals like heat treatment processes. Generally, furnaces are classified into two types according to generating method of heat; it is combustion type and electric type. In combustion type furnace generally used as fuel is oil and coal. Then electric type furnace called as induction furnace. These are generally used in automobile and melting scrap industries. If we want to solve problem of simple heat transfer involving simple geometries with simple boundary condition then it is solved by analytical method but, when it will complex boundary condition than we cannot solve analytically. There are several ways of the numerical formulation and mathematical modeling of heat transfer problem such as finite difference method, finite element method, boundary element method. We have done an exhaustive literature study by considering this problem.

II. LITERATURE REVIEW:

The authorsSayel M. Fayyad, Ghazi S. Al-Marahleh, Suleiman Q. abu-Ein have work done in improvement of the refractoriness under load of fire-clay refractory bricks. In this research paper the raw material used is clay and produced the chamotte refractory bricks with initial temperature 1180℃. By adding varying percentages of Al_2o_3 in raw material as possibility of improved the Refractoriness under load. The clay used as research work. A fixed weight sample is packed into silica glass crucible and other compartment filled with inert material which has no thermal reaction. A chromate aludel junction is located in centre of both the test and the inert sample compartments. It indicated that the Dewechla clay is suitable for manufacturing refractory bricks after chemical analysis results indicates that the clay consists of 14% quarts and 86% kaolinite. The softening point of clay during heating is determined by the heating microscope. At the entrance of furnace light source is arranged which project enlarged contour of the specimen on projection screen through droplet formation during melting can be observed. It is not possible to manufacturing larger item from pure clays so that the chamotte are added in order to reduce the shrinkage. The ratio of 50/50, 70/30 and also aluminium oxide is added. After moulding and drying bricks were burned at different temperature and these bricks are investigated to refractoriness under load and the porosity. After calculation rise Al_2o_3% in material increases the physical and chemical properties. [1]Mr. Dharmendra k Dodiya, Mr. Vasim G. Machhar have done grate work in Optimization of wall thickness and thermal conductivity for minimum heat losses for induction furnace by FEA. The main objective of this research paper is to study the effect of thermal conductivity and wall thickness on wall heat losses and finding the optimum thermal conductivity and wall thickness of wall material of induction furnace. His paper deals with the optimization of wall thickness and material for minimum heat losses during melting iron. Silica mass used as refractory material to prevent losses. Analysis is done with material optimization of induction furnaces. The calculation has been done for theoretical heat loss by using existing furnace data which are later compared with FEA result for the validation of ANSYS software. Then He has done steady state thermal analysis of the induction furnace for different thermal conductivity and thickness of furnace wall on order to minimize heat losses and analysis of induction furnace with optimum thermal conductivity for different thickness of wall furnace. The analysis result shows that, heat flow in the process of melting decrease with decreasing thermal conductivity of wall material and heat flow in the process of melting decrease with increase thickness of furnace wall. Finally, optimum geometry and properties of ramming mass can reduce

total 38% losses with optimum thickness and properties of material of induction furnace. [2]S. j. Schneider and L. E. Mong have done work in Thermal Length Changes of Some Refractory Castables. In this research paper the amorphous alumina translates to "γ" alumina due to loss of water of hydration and the coil. The changes in length exhibited by a variety of refractory castables during complete heating and cooling cycles were determined. The thermal length-change properties of commercial brands of refractory Castables and laboratory prepared Castables were determined by using dilatometer assemblies that incorporated differential transformers as their sensing or indicating device. The effect of heat treatment was shown by length-change determinations on Castables initially heat treated at 110℃, 1050℃, or 1300℃. The data are presented graphically. For comparative purposes, the curve for neat high-alumina cement is included. Examination of the data indicates that the same general length-change characteristics were exhibited by Castables that had received the same curling and heat treatment. Below 1100℃, the thermal length-change properties of those castables heat treated at 110℃ were influenced by the original properties of their constituents, high-alumina cement and heat-resistant aggregate. Length-change curves of this castable group distinctly indicate length changes associated with reactions of the cement, especially the loss of water of hydration and the conversion of amorphous alumina to 'Y alumina, and silica inversions J of the aggregate. Typical curves of both the 1050℃ and 1300℃ groups indicated possible silica inversions. However, the length changes related to cement reactions were absent from these curves. As evidenced by curves of all three groups, sintering of the castable began only at temperatures above 1100℃. [3]Jagendran Ravindran, Soundarajan Krishnan have done work in Studies on Thermal Analysis of Cement Rotary Kiln Based on Clinker coating materials on Refractories, Energy and monetary Savings. This paper deals with the modelling of different coating thickness for a clinker-based ring with a thermal conductivity of 0.74W/m℃ with varying bed temperature for both burning and transition zones. The main concept is to study the thermal losses from kiln surface based on the assumption of no coating formation. In burning zone, the kiln shell temperature at no coating record and also fuel saving calculation is done using the heat loss and the piece of coal per kg as the basis. In translation zone also, same process is followed. The heat loss is decrease with increase coating thickness. [4]K.H.Jadeja, K.D.Saradava have done work in Properties analysis of alumina refractory bricks.This paper provides review of research concerning the property of refractory bricks which is manufactured by different materials compositions and adding some waste material and it investigates on the use of waste product of the industry to increase its property. it observed that technological advancement has greatly improved and eased human life at the expanse of several by product and wastes which are hazardous for not only human life as well as for flora and fauna.Here in this research paper wastes product in phosphoric acid plant and boron concentrators in producing structural bricks investigated. The sensitivity analysis indicated that bulk density and apparent porosity were the most significant input affecting compression strength within the limit of the modal whereas sintering temperature and brick volume were found to be relatively significant in the model. By reading this all paper it concludes that alumina has high refractory property, low cost, easily available so, it is suitable as refractory brick material. [5]Job AjalaAmkpa, Nur AzamBadarulzaman have done work in Thermal conductivity of Barkin-ladi fireclay bricks as refractory lining. The objective of this research paper was to investigate the Barkin-ladi fireclay and ascertain its suitability for production of fireclays refractory bricks as furnace linings. The barkin-ladi fireclay used for check its properties. The thermal conductivity of fire clays brick was determined using hot guided plate method as shown in fig. The refractoriness of the fireclay brick was investigated using the pyro metric cone equivalent to determine the temperature of softening in order to assist in the refractory material selection that will fit the temperature of working environment. The thermal shock resistance of fire clays was determined by recorded the number of cycle at which the clay sample cracks. The result show that the thermal conductivity value 0.03K, refractoriness was 1665℃ with correspond with Segar cone and thermal shock resistance was 24 cycles before it's fractured. [6]Wamei Lin, Jinliang Yuan, Bengt Sunden have done work in Review on graphite foam as thermal material for heat exchanger. This paper describes the structure of the graphite foam. Based on special structure, the thermal properties and the flowing characteristic of graphite foam outlined and discussed**.** There are some problems blocking the development of graphite foam heat exchanger is high pressure drop. The second problem is that the mechanical properties of graphite foam are not as good as those of the metal foam. The third foam is dust block. In order to mixing other materials with graphite foam might be helpful to reinforce the mechanical properties of graphite foam and also reduce the pressure drop. [7]Naveen Tiwari, Dr. Satyendra singh, Dr. D.N. Tripathi have grate done work in Measurements and analysis of thermal Conductivity of insulating materialThe main objective of this paper is to measure the thermal conductivity of alumina and ceramic based porous insulting materials has been carried out in the temperature range of 50℃ to 1100℃. The hot wire method is used for determining the thermal conductivity of not only heat insulating bricks, but also other types of refractory materials. The result shows that the material is heated continuous running apparatus for 96hrs duration. The analysis shows that the 50℃ the thermal conductivity 0.30w/m℃ and it will increase with increase temperatures and fusion of silica reduce the micro porosity of material. [8]ChaoukiSadik, AbderahamanAlbizane have done work in Composition and Refractory Properties of mixture of Moroccan Silica-Alumina Geometries and alumina**.** The main objective of this paper is to investigate the chemical and mechanical properties of material and correlated with their micro structure. The XRD analysis used to determine the nature of their clay material and semi quantitative composition. The length of mallite crystal was measured by the method of image analysis of saving electron microcopy. After result at optimum thermal conductivity has a grate in reduction in losses and temperature distribution. [9] Allen M Alper, Robert N Mcnally Ziroconia-alumina fused refractory material and structure. In this research the structure of ziroconia-alumina and related refractory materials are adding large size of ziroconia crystal and analytically structure adding weight at minimum level is 50% zro2, 1 to 29%al2o3, 0.1% to 2.5%sio2, 0.5 to 0.15 % earth oxide, 0 to 60 % p_2O_5 and add other

elements material composition applicable in glass tank express corrosion wear, high temperature, thermal shock resistance, low blistering and stoning. [10]George W Green, Donald G Sundberg have done work in Fire resistance wall board.Here I structure of board gypsum core of improved fire resistance property combined with low density property. Here generally some properties like comprising gypsum clay, colloidal silica mixtures. It must be applicable for improving fire resistance properties of core. In component focused important difference and improve in shrink resistance and strength properties of core composition of this study proved. [11]Stanley r pavlica, berhl e wishon have done work in Alumina silicate refractory brick. A fire clay brick is bonded ceramically and analysing less than 0.2% alkai oxide prepared to group with comprising alumino silicate grogs and bond clays for analysis 0.75% less alkali oxide. In this research alumino silicate includes some elements like clays, disappear, kyanites, bauxite and other etc. so all over in this research when alumina content with fireclay and high alumina brick so increased resistance to spalling on rapid temperature reduction in quantity of material here to get trying make more vulnerable to chemical attack of metallurgical,m slags. [12]Albert r lesar, glen w Charles have done work in Light weight insulating firebricks and method of manufacture. In this research found lightweight insulation of firebrick material which can increase superior strength, stability and other properties for stay at industrial application. here increase properties of firebricks can be produced by incorporating low melting glassy material in batch comprising calcined bauxite finally ground 70% Al_2O_3, fire brick grog and water-soluble alumina binder. [13]Chaoukisadik, AbderahmanAlbizane have work done in composition and refractory properties of mixtures of Moroccan silica-Alumina geometrical and alumina. In this research paper found chemical and mechanical properties of these materials were investigated and correlated with their microstructure. Refractoriness in this paper is defined as the temperature corresponding to the moment when a material begins to lose its shape. The samples tested here maintained their shape without undergoing any deformation up to $1600℃$. The length of mullite crystals was measured by a method of image analysis of scanning electron microscopy However, there are variations in the size of the mullite to the same sample, which is due to local fluctuations of composition. [14]J.B Agboola, O.K Abubakre have work done in Investigation of Appropriate Refractory Material for Laboratory Electric Resistance Furnace. This research work investigates the choice of appropriate local refractory material for the lining of laboratory electric resistance furnace. Refractory binders such as silicon carbide were experimented upon for strength and resistance to high temperature. The results obtained showed that Kankara fireclay containing 15% Sic (5.70 % linear shrinkage, 46.2% apparent porosity, 1.77gkm³ Bulk density, 18 cycles of spalling tests at 1300°C, 5.253KN/m² of cold strength) has appropriate properties for producing grooved bricks for lining of laboratory electric resistance Furnace. [15]Bhujbal Nitin B, S.B. Kumbhar have work done in optimization of wall thickness and material for minimum heat losses for induction furnace by FEA. The main objective of this paper is to identify the problem related with the induction furnace and calculate the heat losses through the side wall across the temperature distribution by using analytical method. Verification of analytical result is compared with actual measured valves on existing furnace and those are validated with APDL Ansys software. Here heat loss is determined that heat conduction through composite cylinder for calculations of heat losses and temperature distribution from furnace is proper method and it gives us accurate results. So, after analysis we can reduce 73% losses from properties optimization and 35% by geometrical optimization. [16]Muhammadu Masin Muhammadu have work done in An Investigation on Refractory Clays Properties for Application in Metallurgical Industries in Nigeria. In this research paper the Items produced from refractoriness include firebricks, crucibles, chimneys and electric insulators etc. Also, the different types of the testing are carried out on the materials like Apparent Porosity, Permeability, Cold crushing strength, Refractoriness. The result show that the alumina contents below 20%, the clay/glass frit mixtures were classified as refractory materials, at contents above 20%, as plastic clays. Samples with 50% frit had the highest cold crushing strength, with80% frit being the lowest strength. The sintering temperatures were 1025-1400°C. [17]David Onoja Patrick, Haruna MavakumbaKefas, Yakubu Mandafiya John and Victor IdankpoAmeh have work done in Investigation of the physical properties of tiles produced with Otukpo clay. In this research paperstudy focuses on the production of floor tiles using local clay from Otukpo, Nigeria by plastic forming and properties of the tiles such as absorption, acid resistance, bulk density, compressive strength, and colour change, modulus of rupture, plasticity, shrinkage and thermal shock resistance were investigated. The compressive strength and modulus of rupture were found to be highest, 482kg/cm^2 and 487.5kg/cm^2respectively for the clay tile sample. It bulk density was 2.31kg/cm^3 and water Absorption was 3%. The shrinkage of the clay sample was 16%, however with clay body of 40% clay, 20% feldspar and 40% quartz, it dropped to 6%. All the samples show good resistance to acid attack, thermal shock and have good plasticity. [18] R. A. Heindl and L. E. Mong have work done on Young's modules of elasticity, strength and extensibility of refractories in tension. In this research paper the tensile properties of 22 different brands of firebrick at room temperature were determined. The chemical composition, porosity, pyrometric-cone equivalent, and method of manufacture for most of the materials are included. A testing machine of the simple lever type, especially constructed for the study, is described. Deformation measurements were obtained with the Tuckerman optical strain gage, which permitted readings to be duplicated to within 0.000002 in. The range in extensibilities for all brands of bricks is from 0.0120 to 0.0465%, but the majority of firebricks are grouped within the comparatively narrow range from 0.0175 to 0.0235%. [19]EsoOluwasegunfalodun, Davies OladayoFolorunso, Samuel Rantioke,Joseph OlatundeBorode have work done on Investigating the Effects of High Alumina Cement and Silica Sandon the Suitability of Ikere Ekiti Clay for Refractory Applications. In this research improvement on the refractory properties of Ikere clay by the addition of high alumina cement and silica sand has been investigated. The result of the chemical analysis shows that the clay sample contained aluminium oxide and silica as major constituents making them suitable as alumino-silicate refractory materials. The refractoriness of 100% clay was $1450℃$. However, linear shrinkage

and apparent porosity of the samples were reduced by the addition of alumina. Compressive strength increased from 4856.50 N/mm^2 to 6522.49 N/mm^2 at 15 wt. % alumina cements before a downward trend was observed above 15 wt. % alumina cements. [20]

III. CONCLUSION

From these research papers, We conclude testing of the thermal and mechanical properties like cold compressive strength, Apparent porosity, Dry density, Specific heat and thermal conductivity etc.is very indispensable of the refractory material like Alumina, silica, fire Brick and Cold face insulation Brick with the assistance of the different machines like universal testing machine and other similar types of the machines and also we can find temperature distribution, stress distribution and life cycle for the all refractory materials with the help of universal mathematical equations by empirical method.

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