Practical Workbook

MY-206 Furnaces and Refractories

Name____________________________

Roll No__________________________

Batch___________________________

Year____________________________

Department______________________

Department of Metallurgical Engineering
NED University of Engineering and Technology
Karachi-75270, Pakistan

<u>Practical Workbook</u>

MY-206 Furnaces and Refractories

PREPARED BY

Dr. Laraib S. Khanzada

(Assistant Professor, MYD)

This is to certify that this practical book contains __________ pages.

APPROVED BY

Prof. Dr. Ali Dad Chandio
Chairman, MYD

Department of Metallurgical Engineering
NED University of Engineering and Technology
Karachi-75270, Pakistan

CERTIFICATE

It is certified that Mr. / Miss ____

Student of class **SE** Batch_______________Bearing Roll No. MY-________has completed his/her coursework in the subject of **MY-206 Furnaces and Refractories** as prescribed and approved by the Board of Review of the Metallurgical Engineering Department.

His/Her performance is reflected by the rubrics of his/her practical workbook. This overall performance of the student is going to address the assigned learning attribute.

____

Course Teacher

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MY-206 Furnaces and Refractories

<u>Safety Precautions</u>

1. Keep the work area clean. Wipe up oil and grease spills immediately to prevent injuries caused by slipping and falling. Keep paths to exits clear.
2. Wear lab coat at all times while in the sample preparation lab.
3. Use proper tools. Always use the proper-sized tools and equipment for the job.
4. Obtain the instructor's permission. Use equipment only with the instructor’s permission.
5. The instructor must be aware of all laboratory activities and will know if the equipment is in safe working order.
6. Wear proper clothing. Wear clothing that is not loose or bulky and wear hard-toed shoes with non-skid soles.
7. Restrain long hair. Restrain excessively long hair with a band or cap to keep hair from getting entangled in machines.
8. Know emergency procedures. In the event of an emergency, all students involved in or observing the emergency should call for help immediately as well as assist in correcting the situation. You should know the location of fire extinguishers and fire blankets and how to use them. You should also know the approved procedure for exiting the laboratory.
9. Report all injuries or accidents to the instructor immediately, no matter how slight. The instructor will secure medical help.
10. Avoid horseplay and loud talk. Loud talking as well as pushing, running, and scuffling that can cause serious accidents. Keep your mind on your work.
11. Turn off all equipment before leaving work area. Before leaving the laboratory or work station, make certain the equipment is properly shut off.

Experiment No. 1

Aim of the Experiment

To recognize different furnaces their uses and types.

Theory

A **furnace** is a device used for heating. The name derives from Latin fornax, oven. The earliest furnace was excavated at Balakot, a site of the Indus Valley Civilization, dating back to its mature phase (c. 2500-1900 BC). The furnace was most likely used for the manufacturing of ceramic objects. In American English and Canadian English, the term *furnace* on its own is generally used to describe household heating systems based on a central furnace (known either as a boiler or a heater in British English), and sometimes as a synonym for kiln, a device used in the production of ceramics. In British English the term *furnace* is used exclusively to mean industrial furnaces which are used for many things, such as the extraction of metal from ore (smelting) or in oil refineries and other chemical plants, for example as the heat source for fractional distillation columns. The term *furnace* can also refer to a direct fired heater, used in boiler applications in chemical industries or for providing heat to chemical reactions for processes like cracking, and are part of the Standard English names for many metallurgical furnaces worldwide. The heat energy to fuel a furnace may be supplied directly by fuel combustion, by electricity such as the electric arc furnace, or through Induction heating in induction furnaces.

In metallurgy, several specialized furnaces are used. These include:

Muffle furnace

A muffle furnace is a laboratory instrument used to heat materials to extremely high temperatures whilst isolating them from fuel and the byproducts of combustion from the heat source. Muffle furnaces allow for the isolation of a material to reduce the risks of cross-contamination and identify specific properties.

Fig 1: Muffle Furnace

Induction Furnace:

An **induction furnace** is an electrical furnace in which the heat is applied by induction heating of a conductive medium (usually a metal) in a crucible placed in a water-cooled alternating current solenoid coil. The advantage of the induction furnace is a clean, energy-efficient and well-controllable melting process compared to most other means of metal melting. Most modern foundries use this type of furnace and now also more iron foundries are replacing cupolas with induction furnaces to melt cast iron, as the former emit lots of dust and other pollutants. Induction furnace capacities range from less than one kilogram to one hundred tonnes capacity, and are used to melt iron and steel, copper, aluminium, and precious metals. The one major drawback to induction furnace usage in a foundry is the lack of refining capacity; charge materials must be clean of oxidation products and of a known composition, and some alloying elements may be lost due to oxidation (and must be re-added to the melt).

Fig 2: Induction Furnace

Box Furnaces:

Box Furnaces are suited to a wide variety of processes and temperatures, typically ranging from 1200°F to 1800°F and higher. Below those temperatures the term 'Oven' is often used.

Heating systems for Box Furnace thermal equipment can be gas or electric, and the atmosphere inside the furnace can be air, nitrogen, endothermic gas, or the products of combustion for direct gas-fired units, or others depending on the process.

Loading is by batch, with work pieces situated in baskets on various hearth systems, or on piers in the floor of the furnace. That floor can be hard refractory if wear resistance is needed; otherwise refractory fiber modules offer a floor that is more responsive to temperature changes.

Double-end furnaces have doors at both ends of the heating chamber, making them easy to integrate into manufacturing flow or specific material handling requirements.

Fig 3: Box Furnace

Questionnaire

Q1: Why not Electric Arc furnace is using everywhere in the world?
Ans:____
____
____
____

Q2. What is the major advantage of Muffle Furnace?
Ans:____
____
____

Q3: What is the purpose of using Induction Furnace? Why it is very common nowadays?
Ans:____
____
____

Investigation Corner

Name some furnaces & their locations which are using in Pakistan

1.______________________Location _________________________
2. ______________________Location__________________________
3. ______________________Location__________________________
4. ______________________Location__________________________

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Remarks	
Instructor's Signature with Date:	

Experiment No. 2

Aim of the Experiment

To perceive various constituents of Coal by Proximate Analysis.

To determine the percentage of moisture content

a. To determine the percentage of volatile matter
b. To determine the percentage of Ash content
c. To determine the percentage of fixed carbon

Material/Equipment

Muffle furnace, crucible, petri dish, oven, stop watch, balance, desiccator and given sample of coal.

MOISTURE CONTENT

Procedure

1. Take petri dish and tare it oven at about 105-110℃
2. Take 1gm of powdered air dried sample of coal (of 72 mesh British standard i.e. -72B.S) in petri dish and weigh it.
3. Place the sample in oven and heat it for about at 105-110 ℃ till a constant weight is obtained.
4. The difference in the weight is obtained by subtracting the weight after heating from the initial weight.
5. The weight of percentage (%) moisture is determined.

Observation and calculations

Weight of sample (air dried coal) Z_1= ___________________gm.

Weight of sample after heating Z_2= ____________________gm.

Loss in weight $Z_3 = Z_1 - Z_2$= ____________________gm.

Percentage (%) moisture $M_1 = (Z_3 / Z_1)*100$= ____________________%.

VOALTILE MATTER

Procedure

1. Take a translucent silica crucible and tare it, till constant weight is obtained.
2. Take 1gm of air dried coal (-72B.S) in crucible.
3. Heat the sample of exactly 7 minutes in the furnace at a steady temperature of 900~950 ℃ in the absence of air.
4. The loss in the weight is due to the volatile matter evolved as a result of decomposition of coal plus moisture that was already present in the coal as such and was measured in moisture test.

5. The measured moisture content is being subtracted from the total in weight as observed during volatile matter test and is reported as volatile matter less moisture.

Observation and calculations

Weight of sample (air dried coal) W_1= ___________________gm.

Weight of sample after heating W_2= ___________________gm.

Loss in weight $W_3 = W_1 - W_2$= ___________________gm.

Percentage (%) including moisture $M_2 = (W_3 / W_1)*100$= ___________________%.

Percentage (%) less moisture $M_2 = M_2 - M_1$= ___________________%.

ASH CONTENT

Procedure:

1. Take a crucible and tare it till a constant weight is obtained.
2. Take 1~2gm of air dried sample (-72B.S) in crucible.
3. Heat the sample in furnace at about 800 ℃ till all the organic matter has been burned away (ensuring complete combustion in gentle current of air) usually half to one hour.
4. The residue of inorganic matter is weight as ash. (OR)
5. First heat the sample at 400~450 ℃ for 30 minutes after which incineration is complete by heating the sample at 775 $\pm$ 25 ℃ for one hour. (initial rate of combustion is kept slow because some coal turned to spit or decrepitates).
6. The FBR (fuel research board) have found have that employing two stage heating, better results are obtained due to reduced decapitation of coal.

Observations and calculations:

Weight of sample (air dried coal) W_1= ___________________gm.

Weight of sample after heating W_2= ___________________gm.

Loss in weight $W_3 = W_1 - W_2$= ___________________gm.

Percentage (%) including moisture $M_4 = (W_3 / W_1)*100$= ___________________%.

Percentage (%) excluding moisture $M_3 = M_4 - M_1$= ___________________%.

FIXED CARBON

Procedure:

It is the solid carbonaceous residue (other than ash) resulting from volatile matter test. Its value is calculated by subtracting moisture, volatile matter and ash from 100%.

It brings the total of the proximate analysis automatically 100%.

Observation and calculations:

Percentage (%) fixed carbon $=100-(M_1+M_3+M_4)=$ ____________________%

$M_5=100-(M_1+M_3+M_4)=$ _____________________%

Results:

The complete analysis is:

1. Percentage (%) moisture content = __________________
2. Percentage (%) volatile matter = ___________________
3. Percentage (%) ash content = ____________________
4. Percentage (%) fixed carbon = ____________________

Discussion:

____
____
____
____
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____

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Experiment No. 3

Aim of the Experiment

To perceive Induction Furnace & its operations.

The Induction Furnace

An **induction furnace** is an electrical furnace in which the heat is applied by induction heating of a conductive medium (usually a metal) in a crucible placed in a water-cooled alternating current solenoid coil. The advantage of the induction furnace is a clean, energy-efficient and well- controllable melting process compared to most other means of metal melting. Most modern foundries use this type of furnace and now also more iron foundries are replacing cupolas with induction furnaces to melt cast iron, as the former emit lots of dust and other pollutants. Induction furnace capacities range from less than one kilogram to one hundred tonnes capacity, and are used to melt iron and steel, copper, aluminium, and precious metals. The one major drawback to induction furnace usage in a foundry is the lack of refining capacity; charge materials must be clean of oxidation products and of a known composition, and some alloying elements may be lost due to oxidation (and must be re-added to the melt).

Fig 4: An induction furnace.

Operating frequencies range from utility frequency (50 or 60 Hz) to 400 kHz or higher, usually depending on the material being melted, the capacity (volume) of the furnace and the melting speed required. Generally the smaller the volume of the melts the higher the frequency of the furnace used; this is due to the skin depth which is a measure of the distance an alternating current can penetrate beneath the surface of a conductor. For the same conductivity the higher frequencies have a shallow skin depth - that is less penetration into the melt. Lower frequencies can generate stirring or turbulence in the metal.

A preheated 1-tonne furnace melting iron can melt cold charge to tapping readiness within an hour. An operating induction furnace usually emits a hum or whine (due to magnetostriction), the pitch of which can be used by operators to identify whether the furnace is operating correctly, or at what power level.

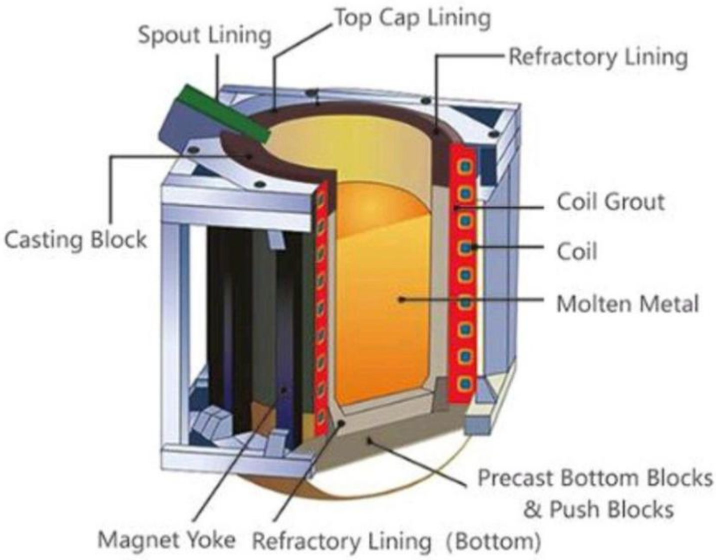

Fig 5: Induction Furnace Schematic**.**

Questionnaire

Q.1: Define Induction Furnace in your own words?
A:____

Q.2: What is the main purpose of using Induction furnace?
A:____

Q.3: How you will distinguish an induction furnace with reduction furnace?
A:____

Q.4: What is the similarity b/w induction furnace and electric arc furnace?
A:____

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Experiment No. 4

Aim of the Experiment

To observe the particle size distribution of refractory.

Materials/Apparatus

Set of sieves, sieve shaker, electronic balance.

Theory

Screening is a method of separating particles according to the required size particles and one screen are passed by the screen immediately ahead of it two numbers are needed to specify the size range of an increment, one for the screen through which the fraction passes and the other an which it is retained.

Procedure

- Take sample of 500 gm and weight it on the electronic balance.
- Now put the weighed sample of 500 gm in the upper most sieves.
- Close the top of set of sieves and put the whole stock on the sieve shaker.
- Fix the time 10 to 12 minutes on the rotor.
- After shaking it will stop take out the sieve and weigh the sample on each sieve.

Observations

Questionnaire

Q.1: Why we are doing sieve analysis?
A:____

Q.2: What are Limitations of sieve analysis?
A:____

Q.3: What are modern alternate methods of sieve analysis?
A:____

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Experiment No. 5

Aim of the Experiment

To observe how Plaster is made for slip casting.

Material/Apparatus

Gypsum (Plaster of Paris, CaSO4) & water.

Theory

The most commonly used porous mold material for slip casting is gypsum (plaster of Paris CaSO4) with water. The mold for slip casting must have controlled porosity so that it can remove the fluid from the slip by capillary action.

Chemical Reaction

The mold is prepared by following chemical reaction.

$$CaSO_4 + 0.5H_2O + 1.5\ H_2O \xrightarrow{180°C} CaSO_4 + 2H_2O$$

Procedure

Plastic molds are prepared by mixing water with a plaster of Paris powder pouring the mix into a pattern to set. Thus produces a smooth surface mold deprecating the counter of the pattern for a shape. Above reaction is satisfied by chemically addition of 18% water but considerably more water is necessary to provide a mixture with adequate faulted for mold making.

Observations

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Experiment No. 6

Aim of the Experiment

To observe how slip casting is made by mold of plaster of Paris.

Material

Mold (commonly made plaster of Paris).

Theory

Ceramic shapes can be cast by using a unique process is called slip casting. This method consist of suspending powdered raw material in liquid to slurry of slip casually clays water. That is powder into porous mold which is usually made of gypsum.

Procedure

1. Preparation of powdered ceramic material and a liquid usually clays & water, into a stable suspension called slop.
2. Pouring the slop into a porous mold (commonly made of plaster of pairs allowing the liquid portion (water) of the slop to be absorbed by the mold, as the liquid is removed from the slop a layer of semi hard material is formed against the mold surface.
3. This process may be continued initial the entire mold cavity become solid and it may be turbinate when the solid shell wall reaches the desire surface by inverting the mold & pouring out the excess.
4. The material in the mold allow to dry (as cast piece dried) to provide adductors strength for hard longs the subsequent parts may relies from the mold wall at this time.
5. Finally, the cast part is fired to attention the required microstructure & properties.

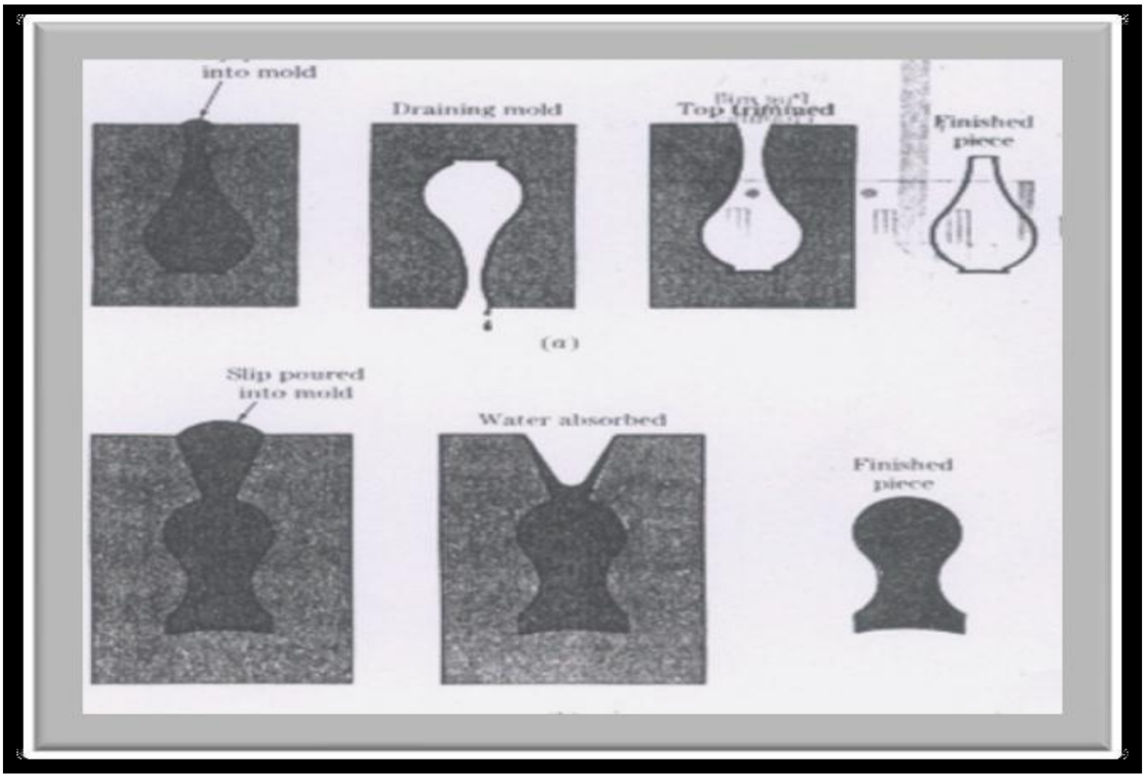

Fig 6: Slip Casting

Observations:

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Weighted CLO (Psychomotor Score)	
Remarks	
Instructor's Signature with Date:	

Experiment No. 7

Aim of the Experiment

To observe the Manufacturing of Refractories.

Procedure

The following physical operation and chemical conversion are used in the manufacturing of refractories, Grinding, Screening, Mixing, Pressing or Molding and repressing-drying and burning.

Grinding

Obviously one of the most important factors in the size of the particles in batch is known as that a mixture in which the proportion of coarse and fine particles is about 55:45 with only few intermediate particles, gives the densest mixture.

Mixture

This stage the process of manufacturing or processing is very important and a through an intimate mixture of sand, lime and water must be form to facilitate thus. The real function of the mixing is the distribution of the plastic material.

Molding

The great demand for refractory bricks of greater strength, volume and uniformly has a re-malted in the dry-press method of molding with a mechanically operated pressure (In this pressure the machine is used where the pressure of about 100kh/square cm is applied.

Hardening

After pressing back slash molding the bricks are sent directly to hardening cylinder. In this process the long steel cylinder of about 15 meter length and 2 m in diameter carrying the press bricks are directly pugged in these cylinder and doors are directly close.

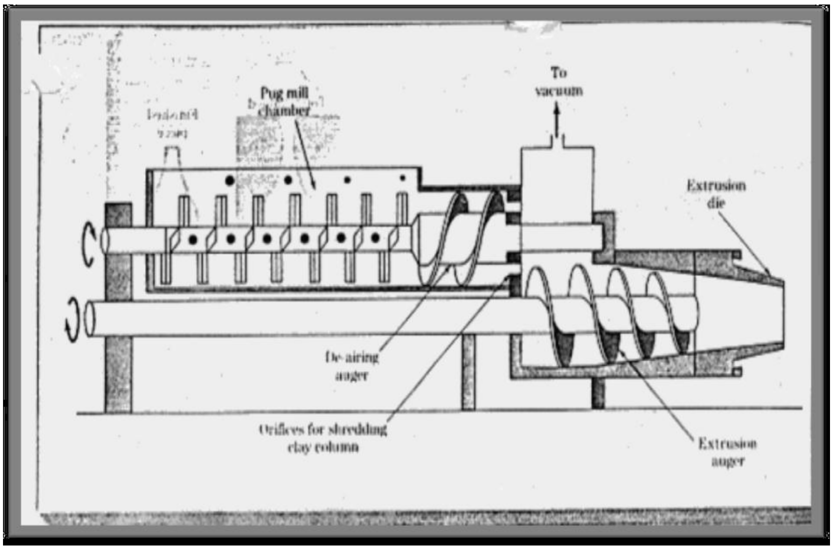

Fig 7: Mixing Mill (Pug Mill)

Manufacturing of fire clay Refractories

Furnaces use in the manufacturing are:
(i) Down draught kilns:
This is the most important type firing refractories. It is either round or rectangular in shape. Refractories are stacked over the floor of the kiln and heating is commenced. The temperature is raised at a fixed rate. Flue gases and other combustion products go down downward, pass over the reformatories and ultimately go to chimney.

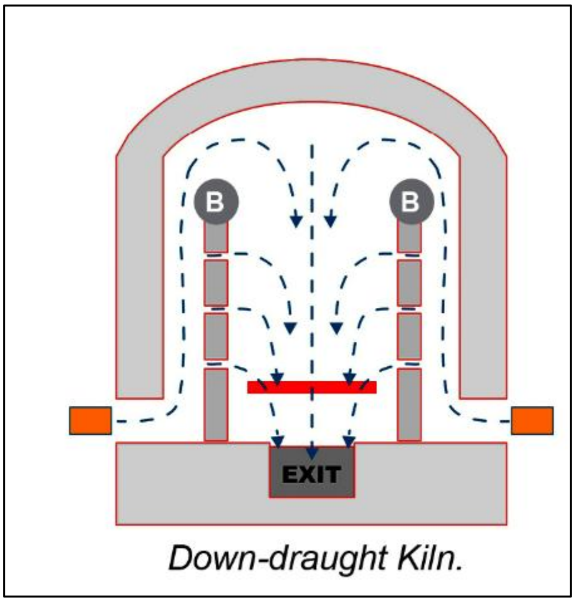

Fig 8: The Down draught kilns

Tunnel kiln:

As the name represent it is a continuous kiln and consist of a long tunnel through which trolleys fitted with stacked for refractories are continuously passed. The trolleys are moved in the kiln very slowly (3-5foot per hour) and generally a trolley remains in the tunnel for 50 – 100 hours depending upon the nature of the refractories. The condition remains constant in all parts of the tunnel and at all the time.

Fig 9: The tunnel kilns.

Manufacture of fireclay refractories:

Raw fireclay is dried, crushed by gyratory crusher, ground finely in an edge runner and mixed with ground grog. The mixture is so in water for about 34 hours or more so that water is properly distributed throughout the whole mass. After soaking, the mixture is transferred to a pug mill where the whole mass is thoroughly mixed. The whole mass is now transferred to a coal cellar where it is allowed to mature fir a number of days. The completely matured mixture is molded (by hand or by machines) into bricks and blocks etc. them molded refractories are dried event y and properly at room temperature.

Dried refractories are arranged in a kiln which may be down draught, up draught or horizontal draught type, single kiln or continuous kiln. Temperature is raised slowly up to 1300 C and then cooled slowly.

Observations:

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Psychomotor Domain Assessment Rubric-Level P3					
Skill Sets	Extent of Achievement				
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Remarks	
Instructor's Signature with Date:	

Experiment No. 8

Aim of the Experiment

To detect resistance to Thermal Shock (SPALLING).

Theory

The resistance to thermal shock is an important attribute for a refractory in many applications to avoid cracking, spalling and premature failure. Over the years a number of tests have been used to measure thermal shock resistance. These tests include ASTM's C-1171-91 and C-1100-88, and the prism spalling test. Thermal shock resistance parameters have also been estimated, which can be correlated to some of these test results.

Thermal cycling testing

ASTM C-1171-91 uses 6 x 1 x 1 in. (15.2 x 2.5 x 2.5 cm) bars to measure the loss of strength when cycled from 1200 ℃ to room temperature. A total of five cycles from 1200 ℃ to ambient temperature are required. After cycling, the bars are tested for modulus of elasticity (MOE) and modulus of rupture (MOR).

Apparatus

A furnace of the muffle or semi-muffle type is required, of such a size that when the cooled test pieces are inserted the fall in temperature does not exceed 20 ℃ and the test temperature is regained within 5 minutes. A thermocouple and temperature indicator, tongs and protective gloves are also needed.

Test material

Three test pieces shall be cut or ground to the shape of prisms 3 in high and with a square base of 2 in side. The test pieces shall be thoroughly, dried before being tested.

Procedure

Period of heating and cooling. Towards the end of each cooling period, the test pieces shall be examined for cracks or loss of corners and a pull shall be exerted on the test piece either by hand or a stress by means of a rig*. The test shall be concluded when the specimens can be pulled apart in this way.

Reporting of results. The report shall include a note of the temperature used, the number of complete cycles of heating and cooling required to promote fracture and a note of the cycle during which cracks first appeared, together with a description of the nature of the failure. The three individual results shall be reported.

Observations

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Course Code & Title ____________________

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