BEHAVIOUR ANALYSIS OF METALLIC ANCHORING IN REFRACTORY WITH EXPERMENTAL SET-UP

1.Sneha S. jaunjal 2. Sulas G. Borkar 3. Amol S. Kinkar 4. Sarang Deshmukh 5. R. Chokkar

Guru Nanak Institute of technology

ABSTRACT

Refractories are heat reissuance materials that provide the lining for high temperature furnaces and reactors and other processing units. In addition to being resistant to thermal stress and other physical phenomena induced by heat, refractories are usually required to withstand physical wear and corrosion by chemical agents refractories are often exposed to environments above 538ºC.

Depending upon the application, refractories must resist chemical attack, withstand molten metal and slag erosion, thermal shock, physical impact, catalytic heat and similar ad adverse conditions, generally while at high temperature. Refractory materials have a crucial impact on the cost and quality of steel product. The diversification on steel products and their cleanliness requirement in recent year increased the demand for high quality refractory.

This paper is intended to comprehensively give and account of knowledge related to refractory and its failure due to metallic anchoring by the experimental set up. In that we have provided the strain gauge over the metallic anchor which is embedded in refractory material as well as one strain gauge in castable to check the elongation of metallic anchor and castable at certain temperature. The result obtained from this experiment are helpful to understand the actual elongation of refractory material and metallic anchor at certain temperatures and this will help to calculate the life of refractory product for certain industries and to increase the economy of the industries.

KEYWORDS: *Refractory material, metallic anchor, strain gauge, stress and strain, heat transfer calculation.*

INTRODUCTION:

Industrialisation through innovation in manufacturing processes first stared with the industrial revolution in the north-west and midlands of England in 18th century. It spread to Europe and North America in 19th century. Process industries deal with temperature for the manufacturing process like cement industries, steel industries, and power plant and so on. For the protection of shell from temperature required refractory material. Refractory materials must be chemically and physically stable at high temperature depending upon operating environment, they must resistant to thermal shock. Refractory must be chosen according to the conditions they face. Some application required special refractory material. Refractory has to be design as per different parameters. For holding of refractory required some metallic support. When this composite structure come in contact with temperature, there is chances of failure of refractory as well as metallic item. To overcome such problem we have do experiment to check the linear expansion of refractory material as well as metallic anchor.

LITERATURE SURVEY:

Number of incident happen in processing industries like cement, steel making, petrochemicals any many others where shutdown are taken due to failure of refractory material. There are various cause of refractory failures.one of them could be due to metallic anchor failure. Lot of research had been done in failure of refractory because of metallic anchor embedded in it with different reason like improper welding of metallic anchor, improper installation of refractory, material quality of metallic anchor, improper selection of steel grade of metallic anchor and refractory materials etc.

N. Patel [1] focused on survey on the Factor affecting the lifespan of cast refractory linings. In this survey he has been very much concentrated on installation of refractory as per installation procedure and operating condition etc. for the installation of refractory need a skill labour and proper installation technique as per material. [1].

Dr Greg Palmer [2] focused on Design and failure of monolithic refractories structure. The failure of refractory is a reason of improper selection of refractory to the oxidization environments. Material has to decide by the 'heat transfer calculation'. By designing of refractory lining engineering should be done in proper manner like section of refractory material, selection of metallic or ceramic anchor as per temperature and spacing for anchor etc. If metallic anchor in in application then it should be considered a proper grade of steel because it affected the refractory life [2].

Michael C Walton and Paul A Plater [3] focused on When refractory failure isn't!-Some anchor issues. In this paper they have find out the different various reason for the failure of refractory like refractory may be failure because of mechanical cause like weld defects, sigma phase embrittlement and creep strength of various stainless steel and alloys sued in their manufacture [3].

C. Andrieux , P. Boisse ,Y. Dutheillet, V. Gabis , A. Gasser , J. Rousseau,[4] focused on two layer composite shell for anchored refractory lining computing. Refractory may be failure due to temperature gradient and thermal expansion. During heating and cooling high level of stress occur within refractory. In this paper they have studied different behaviour of refractory material, shell and metallic anchor [4].

REQUIREMENT OF REFRACTORY?

Refractories are used by the metallurgy industry in the internal linings of furnaces, kilns, reactors and other vessels for holding and transporting metal and slag. In non-metallurgical industries, the refractories are mostly installed on fired heaters, hydrogen reformers, ammonia primary and secondary reformers, cracking furnaces, incinerators, utility boilers, catalytic cracking units, coke calciner, sulfur furnaces, air heaters, ducting, stacks, etc. Majority of these listed equipment operate under high pressure, and operating temperature can vary from very low to very high (approximately 900°F to 2900°F). The refractory materials are therefore needed to withstand temperatures over and above these temperatures. Listed below is the sample melting temperatures of key metallurgical elements where refractory application is critical.
The general requirements of a refractory material can be summed up as:

- Its ability to withstand high temperatures and trap heat within a limited area like a furnace;
- Its ability to withstand action of molten metal, hot gasses and slag erosion etc;
- Its ability to withstand load at service conditions;
- Its ability to resist contamination of the material with which it comes into contact;
- Its ability to maintain sufficient dimensional stability at high temperatures and after/during repeated thermal cycling;
- Its ability to conserve heat.
- To minimize heat loss from the chamber.
- Increases the efficiency of process.

ANCHORS:

Anchor is use in refractory to hold refractory on position, which is embedded in refractory. Metallic anchor having a different grade, used as per requirements and according to temperature. The Stainless Steel Refractory Anchors offered by us are available in assortment of shapes and sizes but usually they are in the shape of Y, U and V.

Figure 1: Type of Anchor

PROBLEM IDENTIFICATION:

Refractory may be failure by any of reason, because in operating condition refractory material come in contact with different parameter like thermal stress, operating parameter such as alkali, sulphur and other chemical reaction may be happened inside the furnace, temperature variation etc. And other reason for failure of refractory because of metallic anchor embedded in it. Sometime anchor may have different reason like improper welding of metallic anchor, improper installation of refractory, material quality of metallic anchor, improper selection of steel grade and refractory materials etc. Many problem faced by industries because of failure of refractory such as sudden shut down, incomplete production, impact on economy and so on.

Some fluidized bed combustion boilers failure occur mainly in Cyclone target wall, Cyclone inlet Duct & Loop Seal etc. Failure of a critical component results in shutdown of the entire power plant and requires immediate attention, making material issues the most immediate concern for the plant operators. Thus, a good selection of materials and the understanding of their behaviour in a fluidized bed environment are critical to the operators.

The combustor roof and cyclone inlet are subjected to impact by high-velocity flue gases containing large particle clusters at high temperatures (800 to 900°C). Both gas and bed materials change direction here, and thereby cause greater impact on the wall.

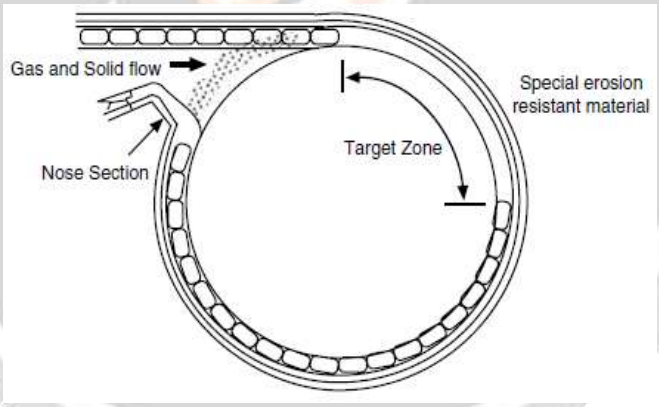


Figure 2: Cyclone Target Area

AIM AND OBJECTIVES:

Refractory materials are such materials which are use where metal component have to withstand very high temperature. The selection of refractory is essential part as failure in refractory cause down time in production process & this down time leads to extra cost on production. To avoid this downtime the refractory should perform well during the process.

Most uncertain & unplanned activity due to failure of refractory is the shutdown of furnace operation. To bring back furnace into operation is cumbersome activity. So it is always advisable to avoid the unplanned shutdowns. Aim & objective is to understand the cause of failure & serve the solution with technical aspects. For this we need to check the life of refractory material by small furnace where we test the material at certain temperature.

1. The aim of this project is to view and analyse the failure of anchor and refractory.
2. Purpose of this project to analyse the thermo mechanical effect on metallic anchor during testing at temperature.
3. By this project we can calculate the linear expansion of material and metallic anchor.

4. To check the thermal variation on metallic item at different temperature.
5. To measure the thermal stress in refractory & anchor "σ"
6. Linear thermal expansion coefficient for steel embedded in refractory "α" & Thermal Strain "ε"

To achieved above aim need to prepared one furnace with the arrangement of metallic anchor into it and tested at some temperature. For this to follow below

- Requirements of expariments
- Information collection
- Experimental setup preparation
- Pros and cons
- Results interpretation
- Installation
- Future prospects

1. REQUIREMENT OF EXPERIMENT:

List/ specification of requirements to be given below

- Steel drum as a furnace
- Metallic anchor ("V" type of metallic anchor with 35mm height)
- Refractory material (ACCGUN INS 11)
- Strain gauge
- Strain gauge recorder
- Heating coil
- Thermocouple
- Control panel

2. PROCEDURE FOR THE EXPERIMENTS:

- Select steel drum as furnace. Then do welding of metallic anchor into it.

Figure 3: Steel Drum with welded anchor

- Then keep strain gauge on metallic anchor with proper fixing arrangements of proper adhesive. And provide foil before casting.

Figure 4: Anchor with strain gauge wrap with foil paper

- Select refractory castable (ACCGUN INS 11). And then doing casting as per application procedure. Frist do floor and then do cylinder circumference.

Figure 5: Casting process

- Keep this set-up, up to setting castable then remove shuttering and will get casted furnace.

Figure 6: After dry out

- Doing all connection in proper manner like strain gauge connection to the data logger from which to take all fluctuated values on different temperature, give power supply etc.
- Cover the furnace by Ceramic fibre blanket having capacity of 1260°C.

Figure 7: Furnace cover by Ceramic Fiber Blanket

- Switch on power supply to the heating coil, and set the temperature in control panel.
- Take different values of strain which is putting on metallic anchor and back surface of refractory at different temperature.

Figure 8: Furnace is in working condition

3. EXPERIMENTAL SETUP:

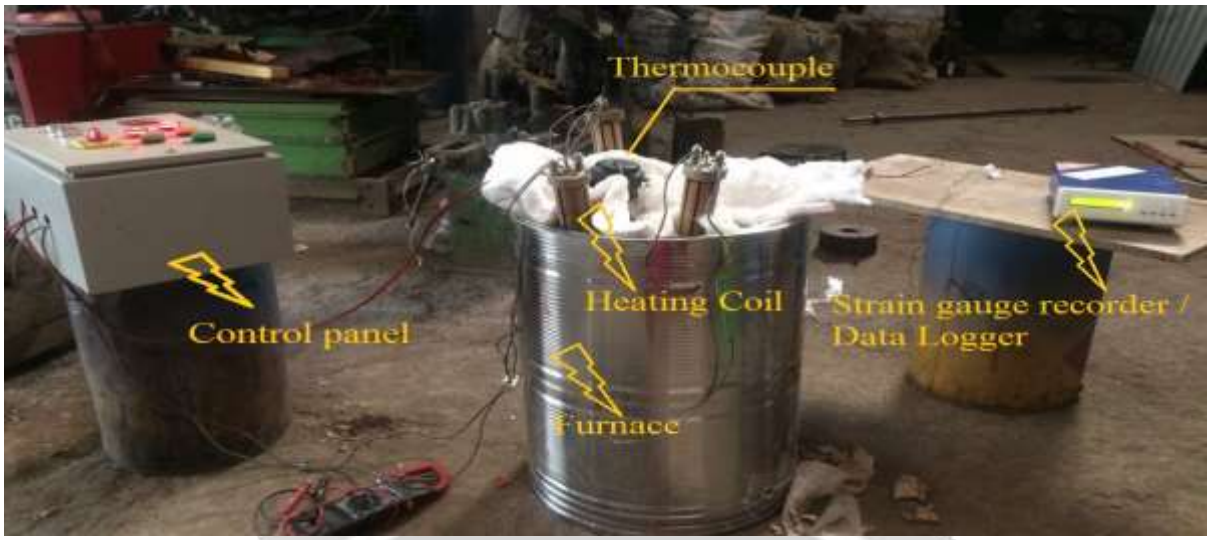


Figure 8: Project Set Up

4. OUTPUT OF EXPERIMRNTS:

Graph for Strain vs Temperature
Reading 1- Date 07.04.2017

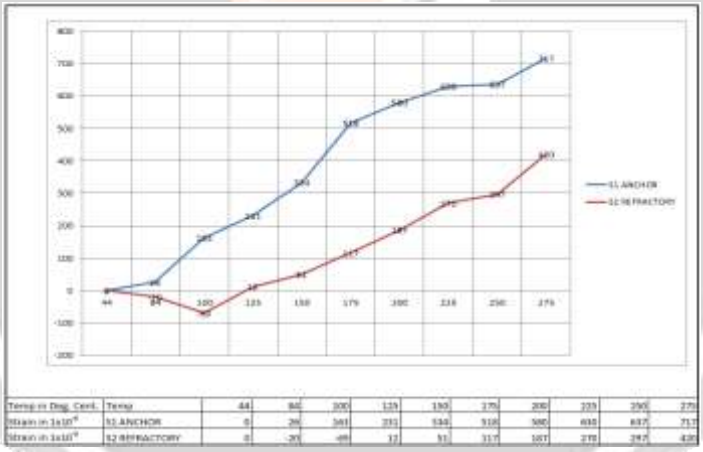


Figure 8: Graph of 1st experiment reading

Graph for Strain vs Temperature
Reading 2- Date 17.04.2017

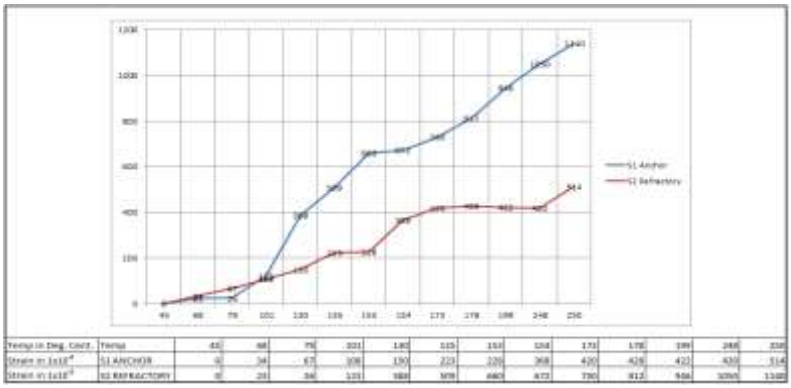


Figure 9: Graph of 1st experiment reading

5. RESULT AND DISCUSSION

Cross validation of output of result with analysis.

Analysis is performed on small area of 300x300 instead of full equipment to compare the experiment result with software result.

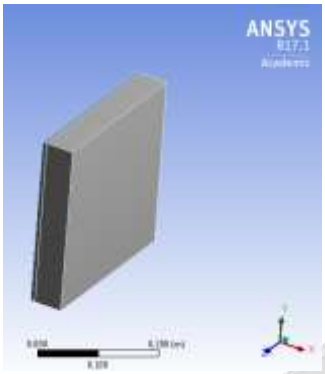
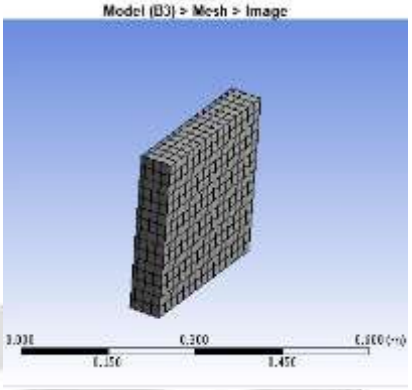
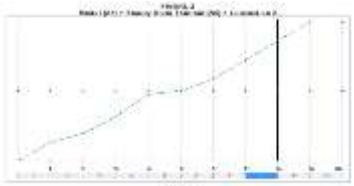


FIGURE 1
Model (B3) > Mesh > Image





Bounding Box	
Length X	5.8e-002 m
Length Y	0.3 m
Length Z	0.3 m
Properties	
Volume	5.22e-003 m³
Mass	16.002 kg
Scale Factor Value	1.

Model (A4) > Steady-State Thermal (A5) > Convection 2 > Image

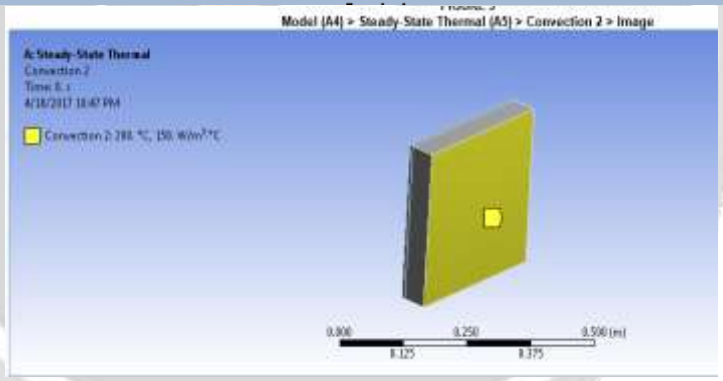


FIGURE 7
Model (A4) > Steady-State Thermal (A5) > Solution (A6) > Temperature

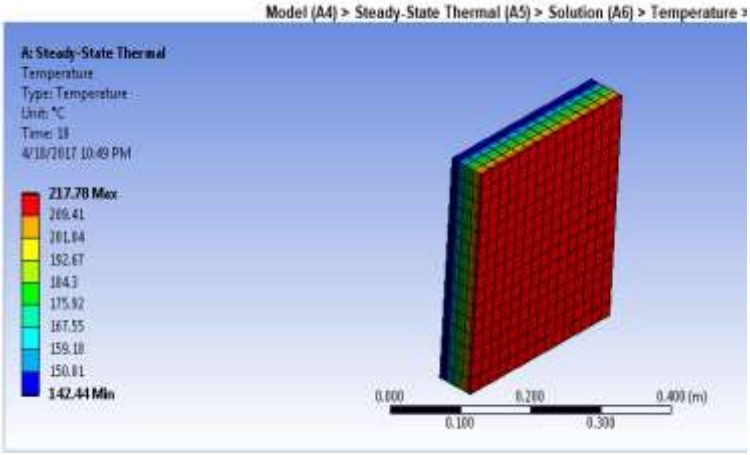


FIGURE 8
Model (A4) > Chart

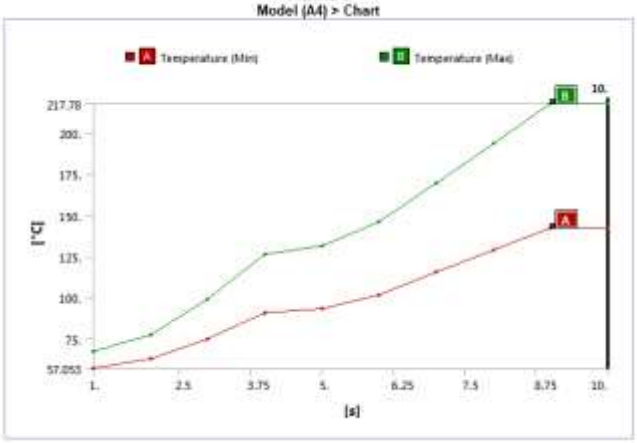


TABLE 20
Model (A4) > Chart

Steps	Time [s]	[A] Temperature (Min) [°C]	[B] Temperature (Max) [°C]
1	1.	57.053	67.043
2	2.	63.035	77.604
3	3.	75.	98.727
4	4.	90.773	126.57
5	5.	93.492	131.37
6	6.	101.65	145.77
7	7.	115.25	169.78
8	8.	128.84	193.78
9	9.	142.44	217.78
10	10.		

FIGURE 3
Model (B3) > Static Structural (B4) > Imported Load (A6) > Imported Body Temperature >

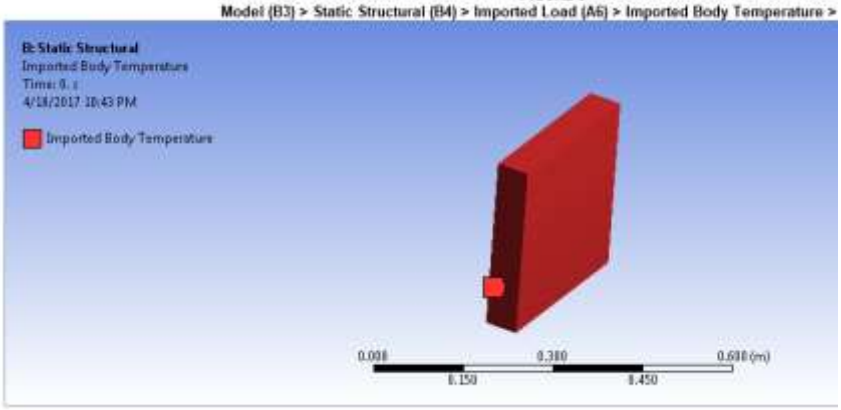


FIGURE 11
Model (B3) > Static Structural (B4) > Solution (B5) > Thermal Strain yDirection > Image

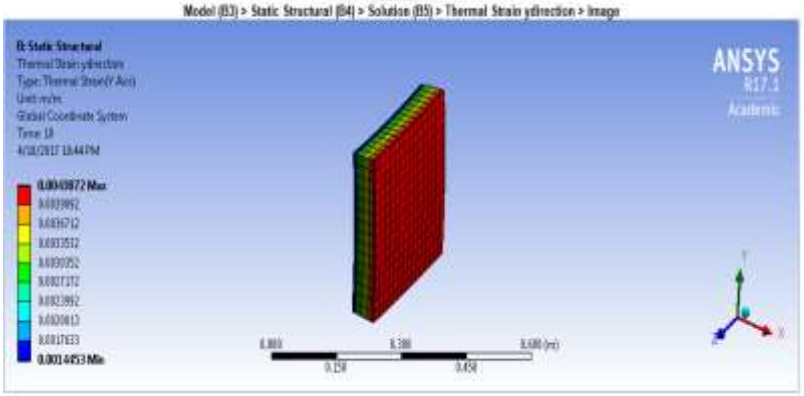


FIGURE 12
Model (B3) > Chart

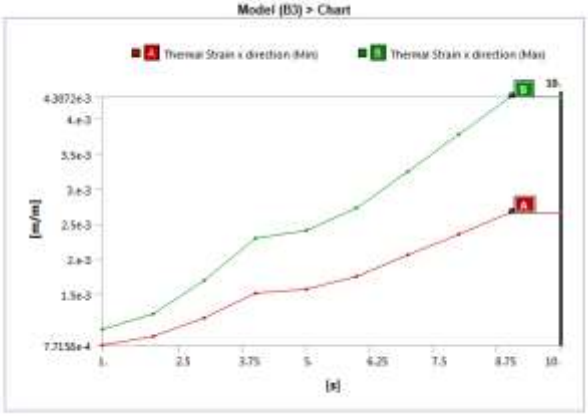


TABLE 22
Model (B3) > Chart

Steps	Time [s]	[A] Thermal Strain x direction (Min) [m/m]	[B] Thermal Strain x direction (Max) [m/m]
1	1	7.7158e-004	9.9094e-004
2	2	9.0339e-004	1.2233e-003
3	3	1.167e-003	1.688e-003
4	4	1.5145e-003	2.3005e-003
5	5	1.5744e-003	2.4062e-003
6	6	1.7542e-003	2.723e-003
7	7	2.0537e-003	3.2511e-003
8	8	2.3533e-003	3.7791e-003
9	9	2.6528e-003	4.3072e-003
10	10		

Finally we reached the below conclusion.

Strain Measurement with Experiment @225°C = ~ 4.21e-3
Strain Measurement with Ansys @225°C = 4.31 e-3

6. PROS & CONS:

- ✓ The experiment will help us to generate data & analysis can be carried out for different monolithic for number of cycle of heating & cooling
- ✓ The experiments will give the Liner thermal expansion coefficient /°C "α" for any type of refractory as well as for the Metallic anchors embedded in refractory.
- ✓ Experiment will help to measure the actual thermal stress in refractory at elevated temperatures along with strain.
- ✓ Experiment will also help to measure the thermal stress on anchor embedded in refractory & actual expansion requirement.

- ✓ Strain gauge availability for high temperature.
- ✓ Limited suppliers have this type of working experience.
- ✓ Strain gauges can short at elevated temperature & give faulty readings.
- ✓ Cost of strain gauge is higher for higher temperature.
- ✓ Strain gauges are consumables cannot be used multiple time.

7. FUTURE PROSPECTS:

- ✓ Installation of new furnace to conduct the thermal strain measurement study for various monolithic.
- ✓ Formulating the values captured from experiment to get the linear thermal expansion/°C "α".
- ✓ Pilot project was installed only to measure the axial strain but new furnace can be design for axial as well bending strain measurement.

- ✓ The furnace can be used for Stress analysis on various refractory materials & effect of Thermal Cycling on different Refractory materials.

8. REFERANCE:

[1.] Dr Greg Palmer "Design and failure of monolithic refractories structure":
[2.] N. Patel "factors affecting on the lifespan of cast refractory linings".
[3.] Michael C Walton and Paul A Plater: "When refractory failure isn't!-Some anchor issues": RefMet
[4.] C. Andrieux , P. Boisse ,Y. Dutheillet, V. Gabis , A. Gasser , J. Rousseau: "Two layer composite shell for anchored refractory lining computing": ECF 12 fracture from defects.
[5.] C Andrieux, P Boisse, Y Dutheillet, V Gabis and A Gasser "Damage modelling of refractory concrete under thermal solicitations".
[6.] ASM metals handbook "volume 1, properties and selection :steels and High performance alloy".pp708-711.ASM,1990
[7.] Sanvik technical datasheet s-1743-ENG "sandvik 2563MA ", March 1999.
[8.] TILLACKS,dj & Guthric,J.E. Wrought and" cast heat resistance stainless steel and nickel alloy for the refining and petrochemical industries", Nickel development institute technical series publication #10071.
[9.] Andrieux, C , Thesis of university of Orleans , France, 1998
[10.] Schnur, D.S., Zabaras, N., "An inverse method for determining elastic material properties and a material interface", International Journal for Numerical Methods in Engineering, Vol. 33, 1992, pp. 2039-2057

[11.] Andrieux-Mamdy, C., Gabis, V., Gasser, A., Boisse, P., Rezakhanlou, R., "Castable anchoring optimization to improve service life of refractory linings", Proceedings UNITECR'97, New Orleans (USA), 1997, pp. 317-326.