Journal of Advanced Zoology
ISSN: 0253-7214
Volume 45 Issue 2 Year 2024 Page 451:462

Study of Lead Recycling by the Cupola Furnace and Rotary Furnace Using Different Refractory Materials.

Kunal Chouhan[1*], Mohammed Ali[2], SatyanarayanDubey[3], PalashSoni[4]

[1]M.Tech Scholar (TE), Oriental University, Indore, Madhya Pradesh, India.*
Email: kunal0251chouhan@gmail.com
[2]Associate Dean Research and Head Department of Mechanical Engineering, Oriental University, Indore, M. P., India. Email: mohammedali@orientaluniversity.in
[3]Assistant professor, Oriental University, Indore, Madhya Pradesh, India,
Email: satyanarayandubey@orientaluniversity.in
[4]Assistant Professor, Oriental University, Indore, Madhya Pradesh, India,
Email: palashsoni@orientaluniversity.in

***Correspondence Author:** Kunal Chouhan*
Email: kunal0251chouhan@gmail.com

Abstract

In this thesis we are discussing lead recycling by the cupola furnace and the rotary furnace. And the changes are replacing the raw materials with the refractory materials. First, useless batteries have been collected after they broke it and the lead containing materials has been separated. After separating material has been put in the cupola furnace mixing with the coal and then starts firing it and apply pressure by the blower. Which makes it start melting and lead has been exerted out and using moldings and casting making bars by which it can be transferred from one place to another place easily. And after that ace has been collect from bags in chimneys are known as fly ace and the scrape which are left in cupola furnace are containing lead are not separate by primary smelting process in cupola furnace that's why rotary furnace has been used for secondary smelting process that fly ace and scrape (kita) are used for separating lead. And parts of cupola furnaces and the rotary furnaces parts are described and refractory materials which are used to construct and making some changes for increasing the production rate.

1. INTRODUCTION: -

Lead is a harmful metal. The use of the lead increases day by day in India as well in other countries. And because of the lead containing toxic substances which are harmful for global atmosphere which makes lead non-disposable substance, if lead were thrown in environment, it will harm full for ground (soil) as well as for the underground water it affects the fundamentals assets of it. According to the scientific survey, the lead in the batteries is lead-oxide. And this lead is purified by the recycling smelting process. Batteries are rechargeable but having a point when they reached on that point it is not rechargeable after that it is only recycle by the various kind of process.

A. PRIMARY SMELTING PROCESS: -

In primary smelting process the lead has been recycled by the cupola furnace at the first but this lead are not purified 100% it having some impurities in it. The impurities were purified by the other method with the rotary furnace and after this process, there is lead also remained in the ace of the cupola furnace had been used in the first smelting process.

I. CUPOLA FURNACE: -

The primary smelting process in this process is first unusable batteries are cut and broken plastic scraped, remove its plastic after lead-containing substances or materials. That material was put in a cupola furnace with the coal after some time lead started melting and that had been melted down in the bottom side of the furnace in the form of slag, there is a storage tank where the melted lead has been stored from there they are having a big size ladle, they poured these ladle in these tank and then take out lead from tank to module. After all these processes the waste out from the furnace is not said to be waste because lead is exerted 100 % from it and these wastages contain lead so it is sent for a secondary process.

Fig.1.1 CUPOLA FURNACE

B. SECONDARY SMELTING PROCESS: -

Secondary smelting process is started by the ending of primary smelting process aces or kita and fly ace have been like the slag. So, we must wait until the kita has been cooled and there is no need for coal because the rotary furnace is used in this process. Rotary furnaces are run by diesel and oil burning inside it. The blower and motor are used to increase the fire pressure and the required melting temperature.

II.DIESEL BASED ROTARY FURNACE: -

In the rotary furnace, the scrape or the fly ace and kita of the primary smelting process, or the Hindi word used for this material is KITA has been used for smelting lead, and rotary furnaces are also used for providing less impurities in melted lead produce by the Rotary furnace. A rotating furnace or rotary furnace is perhaps the most utilized modern heater, which is a sort of Process involving a pyrolysis gadget that comes in barrel-formed and is utilized in a constant cycle to raise materials to a high temperature. These comprise a few parts, for example, the heater body, the heater lining, the inside heat source, and the drive gear, and every one of them has its capabilities and qualities.

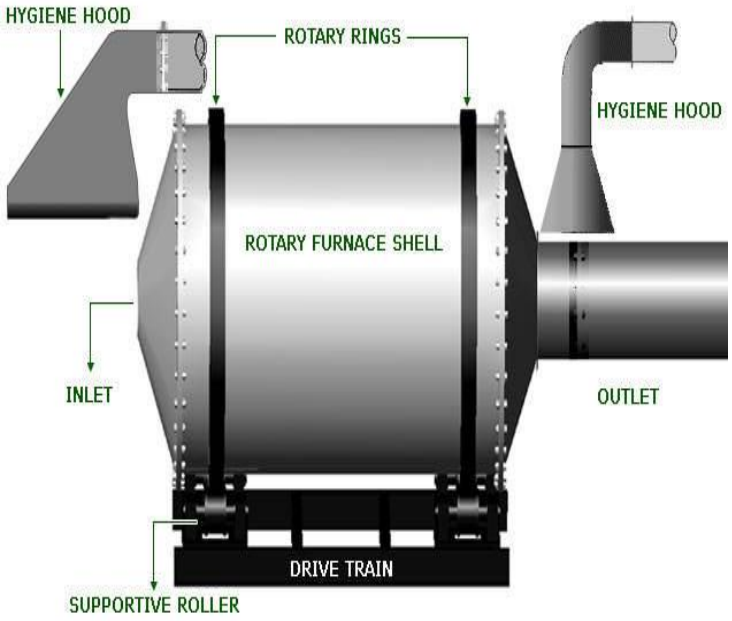

Fig.2.1 DIESEL BASED ROTARY FURNACE.

2. LITERATUREREVIEW: -

K. Ramus & P. Hawkins (In 1990),
The significant parts of charging, execution to date and future exercises of the Isasmelt cycle have been examined. As is common where new innovation is being progressed, changes would have been made given the advantage of knowing the past. Luckily, the basics of this new innovation for auxiliary lead activity are sound in both cycle and designing. By mid-1993, it is unhesitatingly expected that both lead.

R. Jolly and C. Rhin (In 1994),
The lead corrosive battery is a perplexing purchaser great, made of a few unique materials (metal, plastics, and fluids). The reusing of such items requires a division cycle for creation of important concentrates of lead and polypropylene. Further handling of these concentrates has been created to deliver attractive items. Reused polypropylene chip quality has been concurred by the vitally European vehicle producers, for instance for inward wheel curve moldings. The lead composites created in the purifying system can be utilized straight by battery makers.

Chulsung Kim and Say-Kee Ong (In 1999),
A strategy to reuse Pb-EDTA (Ethylene diaminetetraacetic corrosive) waste water has been introduced. In view of the trial results, the Pb-EDTA waste water can be reused a few times without losing a lot of its extractive capacities. The reusing strategy includes subbing the Pb complexed with EDTA with Fe-III particles at low pH values, trailed by precipitation of lead particles with one or the other phosphate or sulfate particles. Fe-III in the Fe-EDTA arrangement is then encouraged at high pH. The Fe-encouraged EDTA arrangement was viewed as similarly as compelling as new EDTA and might be reused a few times without losing itsextractivepower.OntheoffchancethattheFe-IIIisn'thastened,theFe-EDTAarrangement might be utilized as an extraction arrangement however isn't generally so powerful as the Fe-accelerated arrangement and should be applied at pH more note worthy than 7. Precipitation of lead utilizing phosphate particles was found to give a somewhat preferable reused EDTA arrangement over precipitation with sulfate particles. The reusetechniqueproposedwillgivesignificantdecreaseinthewastewatercreatedthedirtwashinginnovation and will likewise diminish how much EDTA utilized.

Hai-Yong Kang and Julie M. Schoenung (In 2004),
For redirection of EOL hardware, the reusing choice is thought of. To explain the reusing choice, the creator has explored the electronic reusing innovations. A significant test for e-squander reusing is the absence of innovations for reusing. Until now, numerous parts of reusing rely upon manual activities. Likewise there is a requirement for leap forwards in reusing, particularly CRT and plastic reusing advances, despite the fact that a few advances have been created. At long last, to additional adult the reusing business, having markets

for their used materials is vital.

M.A. Kreusch, M.J.J.S. Ponte, H.A. Ponte, N.M.S. Kaminari, C.E.B. Marino, V. Mymrin (In 2007),
This work empowered us to reach a few determinations about the creation, utilization and reusing interaction of battery plates to remove optional lead. The slag delivered ahead of the pack reusing process and the outflows of particulates are answerable for the majority of the world's lead-related ecological corruption. Creation yields of optional lead change significantly on the grounds that the cycle is in effectively worked, ailing in such fundamental necessities as a satisfactory technique and normalization, innovation and specialized skill.

T. Oishi, M. Yaguchi, K. Koyama, M. Tanaka, J.C. Lee (In 2007),
The Pb(II)dissolvability in the ammoniacal chloride arrangement expanded with the smelling saltsfixation,presumablyinviewofthedevelopmentofaleadamminecomplex.Theexpansion of 0.01 M phosphate diminished the Pb (II) focus in the draining arrangement by two significant degrees. Potentiostatic electrolysis uncovered that lead was co-stored during copper electrode position even at a potential territory more positive than the harmony redox potential for the Pb/Pb (II) couple on the lead plate. This could be made sense of by compound development, and demonstrated the trouble of electro winning an unadulterated copper cathode from a Pb (II) - containing arrangement. Galvanostatic electrolysis, in any case, showed that the decreased Pb (II) fixation, due to the expansion of phosphate, was okay forgetting a copper cathode having adequately low lead content.

M. Cecchi, C. Dumat, A. Alric, B. Felix-Faure, P. Pradere, M. Guiresse (In 2008),
Concerning relationship with significant components, the minor components didn't have a similar example along the profile. Ni and Cr showed a steady direct connection versus Fe along the profile demonstrating that their normal beginning is made sense of by geochemistry. In actuality, Pb, Sb, Sn, As, Cu, and Zn didn't comply with a similar model from the dirt to the marl. At long last, the worldwide pedological approach utilized in this study demonstrates that this modern region has been seriously impacted by the movement of the lead-reusing plant, prompting gatherings of multi-metallic tainting. For sure, high Pb, Sb and Sn focuses and, less significantly, As, Cu, and Zn have been noted in the surface soil contrasted and foundation levels. Specifically, lead is for the most part gathered in the surface soil skyline because of its generally low versatility and solid relationship to soil constituents.

Dr. Sander Arnout, Dr. Els Nagels, Prof. Bart Blanpain (In 2011),
The thermodynamics of lead recycling has been studied in this work. A key issue understands the chemistry and mutual solubility of the different solution phases. A model system hasbeenusedtodrawpO2-pS2diagramsfortypicalPbrecyclingprocesses.Finally, thermodynamic calculations on a simplified process was performed. The effect of the carbon addition, a main parameter that can be changed industrially to reach more oxidizing or reducing parameters, was studied. The evolution of metal yield, and the slag and matte chemistry could be modelled using this approach.

G. Uzu, S. Sobanska, G. Sarret, J.J. Sauvain, P. Pradere and C. Dumat (In 2011),
The present study has highlighted that particles collected at various workplaces of a lead recycling plant were heterogeneous in terms of chemical compositions and Pb speciation. Though containing the same major phases (Pb, PbS, PbO, PbSO4 andPbO·PbSO4), the nature and amount of minor phases differed. Particles also differed by their morphology and size distribution. No simple relationship between metal content or speciation and origin or particle size was observed in our study, probably due to high complexity and heterogeneity of process PM. Moreover, particle composition evolved with time, likely through an atmospheric oxidation.

Takashi Okada and Susumu Yonezawa (In 2014),
Reduction–melting is a promising method for the effective recovery of lead from CRT funnel glass. In this study, the phase separation of sodium and the crystallization of sodium silicates were combined with the reduction–melting method to enhance the leach ability of sodium in the oxide phase and to extract the sodium for recovery of the sodium added to the glass as flux (i.e., Na2CO3). The reductive atmosphere promotes phase separation and crystallization, thereby enhancing the leach ability of sodium in the oxide phase. Furthermore, in the water leaching process, sodium is effectively extracted from the oxide phase in to

water.

3. MATERIALSANDMETHODS:-

The Materials Used for Construction are:-

I. Materials Used For Cupola Furnace;-

1. Bricks Used in Cupola furnace;

a. Half-Round arch Bricks / Cupola Bricks:-

Round arch bricks are generally used to make cupola furnace and sometimes it used to make the chimneys as well because of the semi-circular shape. These lining of insulation bricks is between the metallic body of the cupola furnace and the standard bricks lining.

Description of the half-round arch bricks/cupola bricks:-

These bricks are semi-circular in shape.
Round arch bricks can taking too much heat without melting or reacting, it resists up to 1600 degree Celsius.
And its weight is 3.350 kg.
It is brownish red in color.

b. Insulation Bricks:-

This bricks are used for neglect the heat transfer from the furnace to the metallic body of the furnace or from the system to surrounding in technical term. These bricks are known as insulation bricks.
These lining of insulation bricks is between the metallic body of the cupola furnace and the standard bricks lining.

Description of the insulation bricks:-

These bricks are rectangular in shape.
The size is 9 In. x 3 In. x 4 In.
And it's capacity to resisting fire to 6– 8 hours easily.
And its dry density is 550-650kg/m3.
The features of this bricks are accurate in dimension, durable, light weight and reliable.
It is white in color.

c. Standard Bricks:-

The bricks used build cupola furnace at placed of mud bricks for maintaining the required temperature of the cupola furnace for melting the lead. These bricks layer lining after the insulation brick layer lining, it makes more efficient.
A fire brick is a block of refractory earthenware material utilized in covering heaters, ovens, fireboxes, and chimneys. A refractory brick is planned mostly to endure high intensity, however ought to likewise ordinarily have a low thermal conductivity to save energy.

Description of the standard bricks:-

These bricks are rectangular in shape.
The size is 9 In. x 3 In. x 4.5 In.
Fire bricks can maintain taking too much heat without melting or reacting, it resists up to 1600 degree Celsius.
And its weight is 3.850kg.
It is brownish red in color.

2. Refractory Alumina Half-Round Block:-

Refractory alumina half round blocks are used to cover the roofs of the cupola furnace, in the rolling mills, in the boilers, glass melter's regenerative glass melter's. A flexible space frame framework utilizing machined strong hubs and exact welded radiates from empty segments. Profile are regularly rectangular yet can likewise be round. High strength consumption safe latches are covered up. Usually that blocks are used in walls support, the both sides of the block are placed at the supported wall or the rigid supports.
This half round block are used where the rounded surface needed in centre for example this blocks are used for covering roofs and the door side view of the cupola furnace.

Description of the Refractory Alumina Half-Round Block:-
These bricks are rectangular in shape.
Thesizeis6 In.x12 In. x26/28/30In.(according to the requirement).
Fire blocks can maintain taking too much heat without melting or reacting, it resists up to 1800-2100 degree Celsius.
And its weight is 26/28/30kg.
It is brownish red in color.

3. Fire Cement and Fire Crete:-
Fire cement and Custable are used to brick layer lining work at the placed of normal cement (concrete). The reason behind using these refractory material at the placed of raw material is because concrete need watering process to make it more solidify and this refractory material are need slow firing process to make it solidify and make it more efficient because of containing some kind of chemicals. And it is easily set doesn't required much like concrete needs.
Fire cement is used to sealing the layers of the bricks and blocks by using the paste of the water and fire cement or acoset 50.
Custable or fire crete is to fixing the gaps between the bricks or the space where the brick are not puts then custable for filled. And these materials has started becomes solid, when this materials becomes in moisture or when these materials are mixed with water.

Description of the Fire Cement (Accoset 50):-
It is in powdered in form.
Its gain size is 0-1.5.
It generally packing in two kinds in plastic bag 25kg. And 50kg.
These materials need to pour in water for sometime before the use.

Description of the Fire Crete (Custable):-
It is in powdered in form and having some amount of calcites and bauxite.
Its gain size is 1.5-2.
It generally packing in two kinds in plastic bag 25kg. And50kg.
And these materials are fixed within minutes.

II. Materials Used For Rotary Furnace;
1. Bricks Used in Rotary Furnace;-

a. Side Arch Bricks in Different size (size are e.g. 1.15 inches, 2 inches, 2.50 inches and 2.75 inches) are Used in Double layer of refractory bricks lining work:-
Double layers of refractory bricks lining work in rotary furnace are firstly developed method for maintaining the temperature for lead recycling by replacing the raw materials to the refractory materials. Which helps to minimize the loss of heat and that's increases the production rate and makes the recycling of the lead easier. And that the reason behind demand of the rotary furnace were increases day by day and replacing the cupola furnace but cupola are needed for the primary smelting process by which fly ace and kita are produced for running the rotary furnace.
And side arch bricks are used for the circular formation mainly used for the rotary furnace. These are different in shape bricks are used to construct the rotary furnace as e.g. 1.15 inches, 2 inches, 2.50 inches and 2.75 inches.

b. End Arch Bricks in Different size (size are e.g. 1.15 inches, 2 inches, 2.50 inches and 2.75 inches) are Used in Single layer of refractory bricks lining work:-
Single layer of refractory bricks lining work in rotary furnace are secondly developed method for minimize the loss of the heat and the molten lead because of the more gaps in the bricks that's makes the rotary shell damage by the heat and becomes red hot by the absorbing heat. And therefore single bricks are replacing the first developed method of double layer of bricks lining.
End arch bricks are used in the rotary furnace for the circular formation of the rotary in the form of single layer brick lining method as shown in Fig.3.33 and Fig.3.34 shown the brick end arch used in rotary furnace.

c. Insulation Bricks:-
Same used in rotary furnace as like cupola furnace.

2. Ceramic Block:-
Ceramic block layer lining works in rotary furnace are third developed method for approximately neglected the loss of the heat and the recycling process are becomes easier than primary developed method. Ceramic blocks are also used in the rotary furnace for the circular formation of the rotary in the form of single layer brick lining method.

3. Insulation Sheet:-
Insulation sheet are used to neglected the heat loss in rotary furnace, this sheet are used at rotary shell before the bricks layer lining and makes that shell protective and makes it longer period service means its increases the time period of the rotary furnace.

4. Fire Cement:-
Same used in rotary furnace as like cupola furnace but some high tendency example thermotech.

5. Fire Crete Super:-
Same used in rotary furnace as like cupola furnace but some high tendency example Fire crete super.

III. RESULTSANDCONCLUSSION:-

CONCLUSIONINTERMOFTHERMODYNAMICS:-
The thermodynamics of lead recycling have been studied in this work. A key issue understands the chemistry and mutual solubility of the different solution phases. A model system has been used to draw pO2-pS2 diagrams for typical Pb recycling processes. Finally, thermodynamic calculations on a simplified process were performed. The effect of the carbon addition, a main parameter that can be changed industrially to reach more oxidizing or reducing parameters, was studied. The evolution of metal yield, and the slag and matte chemistry could be modelled using this approach.

- **Advantages and Disadvantage of Rotary Furnace / Burners:-**

We realize that the rotary furnace is a huge scope refining gear, so the burner of the rotary furnace assumes a key part. To make the hardware work better, clients ought to dive more deeply into the design of the gear Composition, this article imparts to us the benefits and burdens of its burner:
The burner of the rotary furnace is a general line that radiates fine fuel petroleum gas without extra combustion air. The burner goes through the circulation of the essential air between the external hub essential air channel and the spiral essential air direct in the fuel channel, so the flame can be better controlled. This accomplishes a decent combination of combustion air and fuel, and oxygen enters at the centre of the flame.
However, because of the rapid ignition of the fuel and the high flame temperature, a lot of nitrogen oxides are emitted, which is the disadvantage of this burner. The development of burner technology started with a very simple eruption system using a general tube, and continued to modern multi-fuel, multi-channel, low-NOx burners.
In the course of this skill development, the mission of the burner manufacturer has changed a lot. In particular, the use of alternative fuels has a lasting impact on the planning of rotary furnace burners.
The introduction of the burner of the rotary furnace is the above. In order to make the equipment operate better, the reasonable use of the burner occupies an important point. Therefore, we must regularly maintain and protect it to make it more efficient and long-term operation.

RESULTS:-

Rotary furnace already replaced the small scale cupola furnaces used for recycling of metals. And because of its huge production & low duration time for melting metals its demands' increases. But because of the primary smelting process cupola are also needed for it. And might be in future it will take place in market because of the changes in its running demand, now a day's its runs by electric power as well as unless it's basically run by oil and diesel by firing on it.
The cupola furnace which is constructed by the using of raw materials are not fulfilled the required because

of the loss in temperature and not recycled properly and that is there as on behind the replacing the raw materials by the refractory materials. If we comparing the production between the two kinds of cupola furnace by in one day, the raw materials cupola furnace are produced 30-35 lead bars(sillies) and the refractory materials cupola furnace are produced 75-80 lead bars(sillies).

IV.FUTURESCOPE:-

ELECTRICBASEDROTARYFURNACE:-

In Electric furnace, the heating chamber are heated by the supplying the electricity and the heating chamber accomplished at the high temperature to melt the alloys or metals and refectories. The electricity has no Chemical electrolysis effect on the metals but simply heats it and makes it started melting.

Fig.5.1ELECTRICBASEDROTARYFURNACE

Might be in future it is possible that electric based rotary furnace will definitely replacing the rotary furnace. But electric based rotary furnace is very costly as comparing the normal rotary furnace and this furnace having high efficient in output product and providing less impurities over others plant.

TEMPERATURES-POWER SUPPLY METER OF THE CUPOLA FURNACE AND ROTARY FURNACE:-

In industries sector there is no temperature thermometer or temperature meter are used for a single measured and power supplied are also remains equally to the cupola and the rotary furnace as well because of the large production or a big amount of recycled lead have to be produced.

And in the small industries there is separate thermometer are used to maintain the temperature but according to the requirement of the industries various of the thermometer are used and because of the requirement or demand rate which are high they need to maintain the temperature as required for the lead melting.

And they run the industries 24*7 that are the reason behind they never change temperature by without asking to operators. Operators need to stop the rotary only when the rotary need to fill with fly ace or kita and the cupola are filled while the cupola has been running.

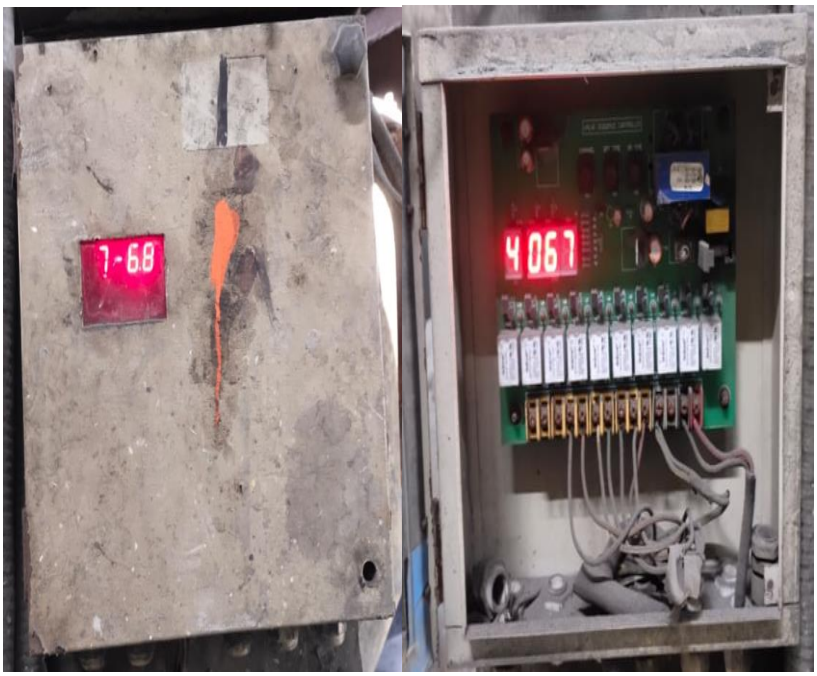

Fig.3.1 and Fig.3.2 TEMPERATURES / POWER SUPPLY METER OF THE CUPOLA FURNACE AND ROTARY FURNACE

- **THERMAL IMAGES OF THE CUPOLA FURNACE AND ROTARY FURNACE:-**

1. ROTARY FURNACE'S THERMAL IMAGES:-

Fig.4.1 is the normal image of the rotary furnace and the other side Fig.4.2 are shows the thermal image of the rotary furnace. In which reddish color shows the high temperature which are heat and sunlight, lightest orange color shows the some of the heat absorbed by the metallic surface, the greenish color shows the low temperature but the few of amount of heat were presents in it and the blackish blue color are lowest temperature absorbent.

Fig.4.1 and Fig.4.2 ROTARY FURNACE'S THERMAL IMAGES.

2. CUPOLA FURNACE'S THERMAL IMAGES:-

Fig.5.1 is the normal image of the cupola furnace and the other side Fig.5.2 are shows the thermal image of the cupola furnace. In which reddish color shows the high temperature which are heat and sunlight, lightest orange color shows the some of the heat absorbed by the metallic surface, the greenish color shows the low temperature but the few amount of heat were presents in it and the blackish blue color are lowest temperature absorbent.

Fig.5.1 and Fig.5.2 CUPOLA FURNACE'S THERMAL IMAGES.

3. THERMAL IMAGES OF POT FURNACE :-

Pot furnace are used to purifying the melted lead by the heating it and by applying a rotating force by the mixing type shaft were attached at the top of the pot furnace. And melted lead heated by firing the wood and coal below the pot and that is the furnace of the pot.

Fig.6.1 is the normal image of the pot furnace and the other side Fig.6.2 are shows the thermal image of the pot furnace. In which reddish color shows the high temperature which are heat and sunlight, lightest orange color shows the some of the heat absorbed by the metallic surface, the greenish color shows the low temperature but the few amount of heat were presents in it and the blackish blue color are lowest temperature absorbent.

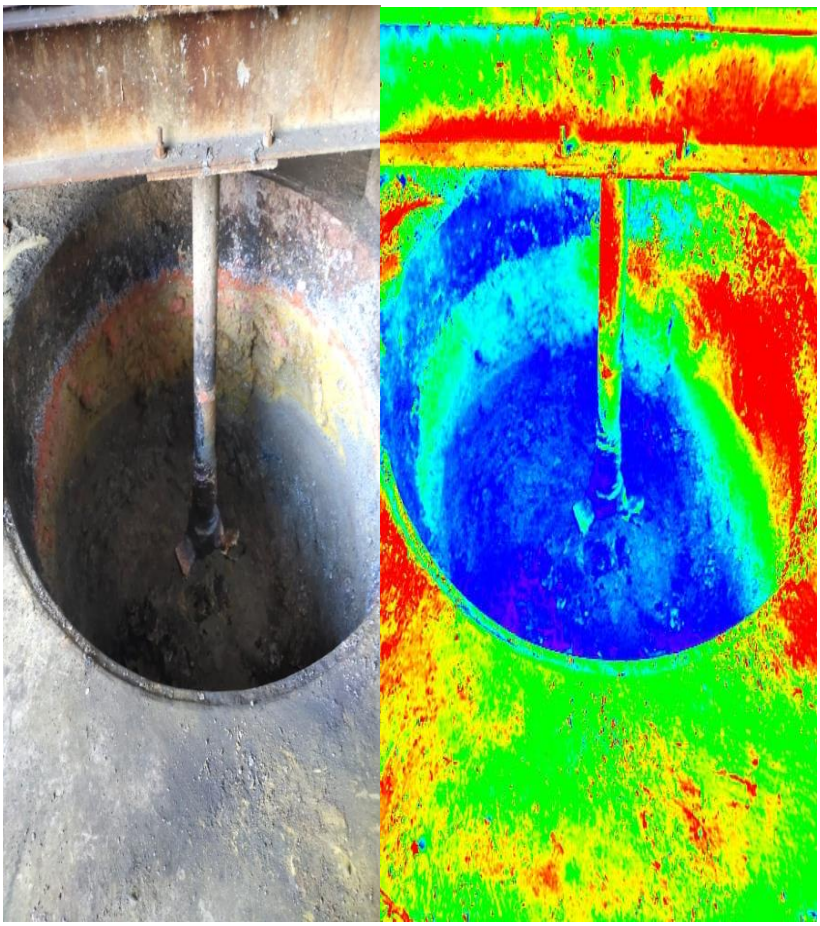

Fig.6.1 and Fig.6.2 THERMAL IMAGES OF POT FURNACE.

IV. *BIBLOGRAPHY&WEBRESOURCES*

BIBLOGRAPHY:-

This thesis is based on **"Study of lead recycling by the cupola furnace and rotary furnace using different refractory materials"**. I completed this thesis with help of my father's experience of this field he has more than 25 years of experience because he is contractor in refractory lining construction field. Also thankful for our faculties who supported me and guidance I whenever we need their help and by them me were completed my thesis. This thesis is submitted at department of mechanical engineering, **"Oriental University of Indore"**.

Guided &helped to completing my thesis:-

Dr. Palash Soni, Assistant professor, Mechanical department, Oriental University Indore. Thanking you.

I visited some industries for completing my thesis, those industries are;

1. Shree Sharda Industries.
2. Gurukripa Industries.
3. Agrawal's Metals.
4. Vijay's Metals.

CONTRIBUTIONS:-

My father was Suggests for conception of the research area, design and supervision of work and preparation of final versions of the paper. He collected the data, design and i did the internship under him for experiencing how difficult to build it but realizing this work having different technique which makes me to do this work. He was responsible for contributing to conception of the research area, guidance on analysis and interpretation of data and final drafting of the paper.

COMPETATINGINTERESTS:-

I have no competing interests.

FUNDING:-

This work was funded by the Shree Sharda Refectories.

- **REFERENCE:-**

1. Olalere, A. A. Dahunsi O. A. Akintunde, M. A., and Tanimola, M. O. (2015):- Development of crucile furnace fired with spent engine oil using locally sourced materials, international journal of innovation and applied studies.
2. Jena, S. and Ravastngadi, S.T. (1992):- Commissioning and Operating an Induction Furnace at Zimasco (KweKwe Division) to Melt High carbon Ferrochromium, IFACON 6; Proceedings of the 6th International Ferroalloys Congress, Cape Town.
3. Karl-Heinz Funken, Martin Roeb, Peter Schwarzboezl, and HeikoWarnecke, et al (2001):- Aluminium remelts using directly solar- Heated rotary kilns, Journal of solar energy engineering.
4. Hago, A.W. and A. A., Rawas (2008):- Design of a Rotary Kiln for Production of Sarooj, the Journal of Engineering Research.
5. Sweleng, D.T (2013):- Low-cement chrome-oxide-free castable for use in iron is making rotary kilns, the journal of the Southern African Institute of mining and metallurgy.
6. Nikolas Kantiranis (2004):- Re-Cycling of sugar-ash: a raw feed material for rotary kilns", Waste Management.
7. UweKussel, Dirk Abel, Matthias Schumacher, and Martin Weng, (2009):- Modelling of rotary kilns and application to limestone Calcinations, Proceedings 7th Modelica Conference, and Como, Italy.
8. Ortiz, O. A. Martínez, N. D. Mengual, C. A. And Aballaym, P. M. (2007):- Optimal operation profit of a pilot rotary kiln for charcoal activation, Latin American Applied Research.
9. Nihar P. Bara (2013):- Finite Element Analysis of Induction Furnace for Optimum Heat Transfer, International Journal of Innovative Research in Science, Engineering and Technology.
10. Titiladunayo I. F. and Fapetu O. P. (2011):- Selection of appropriate clay for furnace lining in a pyrolysis process, journal of emerging trends in engineering and applied sciences