PROJECT REPORT
BHILAI STEEL PLANT

SUBMITTED BY-

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ELECTRICAL ENGINEERING.

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DESIGN

OF

ELECTROMAGNETS

BHILAI STEEL PLANT

ACKNOWLEDGEMENT

I would like to thank Mr. Remy Thomas (SR. Manager, ERS) because of his supervision this project was successful and special thanks to Mr. R.K Nayyar (SR. Manager, MTRS) & all the staff of ERS & MTRS who provided me all the basic knowledge and related support material required for the project report.

CERTIFICATE

This is to certify that Pragati Agrawal, student of 7th Semester, Electrical Engineering, **National Institute of Technology, Raipur** has successfully completed his Industrial Training Project on **Design of Electromagnets (Magnet and Transformer Repairing Shop)** at **SAIL-Bhilai Steel Plant**. During the project he was highly responsive, dedicated and hard working. On the basis of his interest and devotion towards the assigned tasks and keenness to complete within stipulated period, I certify him to have completed the project successfully under my guidance. It was a great pleasure for me to guide him and share the knowledge.

I wish him great success in life.===-

DATE: 23-06-2023

MR. REMY THOMAS

SR. MANAGER (ERS)

INTRODUCTION

The **Bhilai Steel Plant**, located in Bhilai, in the Indian state of Chhattisgarh, is India's first and main producer of steel rails, as well as a major producer of wide steel plates and other steel products. The plant also produces and markets various chemical by-products from its coke ovens and coal chemical plant. It was set up with the help the USSR in 1955.

The eleven-time winner of the Prime Minister's Trophy for best integrated steel plant in the country, Bhilai Steel Plant (BSP), has been India's sole producer of rails and heavy steel plates and major producer of structural steel. The plant is the sole supplier of the country's longest rail tracks, which measure 260 metres (850 ft). The plant also produces products such as wire rods and merchant products. Bhilai Steel Plant has been the flagship integrated steel plant unit of the Public Sector steel company, The **Steel Authority of India Limited** and is its largest and most profitable production facility. It is the flagship plant of SAIL, contributing the largest percentage of profit.

Bhilai Steel Plant functions as a unit of SAIL, with corporate offices in New Delhi. Over the years, Bhilai Steel Plant developed an organizational culture that forces its commitment to values and stimulates continuous improvements and higher levels of performance. The Chief Executive Officer controls operations of the plant, township and iron mines. The CEO is assisted by his DRO, i.e. the functional heads, executive directors, Chief general Manager concept of zonal heads, and HODs who integrate functions with clear accountability for achieving corporate vision, company goals and objectives.

ELECTRIC REPAIR SHOP (ERS)

Electric repair shop is also known as ERS. It is the shop which repairs all the AC as well as DC electrical machines of the plant. Steel plant uses several motors in different operation, therefore variety of motors are utilized and brought here for repair. ERS has different sections for motor repairing. It has HT section for high voltage AC stator windings, big winding section for armature and rotor winding, medium and big assembly section etc. Heavy motors are dismantled and brought here for repairing. Electric cranes are used for lifting motor parts. Generally 3 phase 440 V AC supply is present in most of the shops however 11Kv supply is also there for high voltage motors. All the connections are underground

ERS has its branch MTRS (Magnet & Transformer repair shop) which deals with static/non movable electric machine like magnet & transformers. All the magnets of different size & shape are here for repair .Circular magnets & rectangular magnets are highly used in the plant for lifting iron particles. Magnetic copper coils are imported from Russia & America.

ELECTROMAGNETS

An electromagnet is a natural or artificial magnet which can hold tons of iron. It is powered by current which flows through the coils once a dc supply of 220V is applied.

All electromagnets use a coil of wire and a core of iron to produce their magnetism. The coil furnishes the magnetic flux and the iron concentrates it. All conductors carrying current are surrounded by a field of flux.

An energized Electromagnet acts like a normal Magnet. By placing a magnetic material, e.g. an iron next to it, a Magnetic Force is exerted on the Iron and they attract each other unlike permanent magnets. The magnetic field is characterized by Magnetic Flux Density (B) which is related to the permeability of the Medium (u), the Number of Turns of the Coil (n) and the current flowing through the coil (I). For a given Electromagnet, u and n are constant, we can change I to control its strength of magnetic Field.

As a daily-life example, a circuit Breaker contains an Electromagnet. When the current flowing through the Electromagnet exceeds the allowed limits, its Magnetic Force becomes large enough to open the switch.

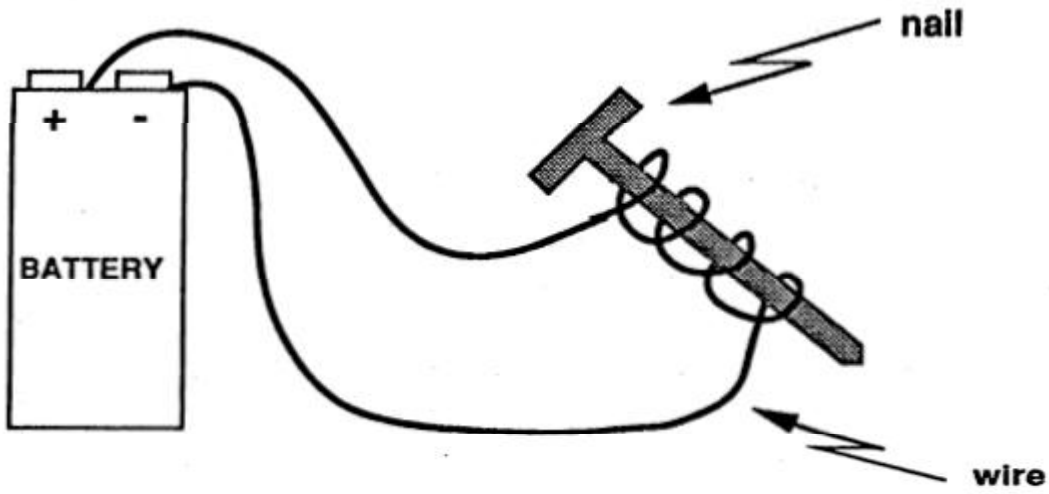
There are 3 types of electromagnets under work in the plant:

1. Rectangular Magnet
2. Round Magnet
3. In-house Magnet

PRINCIPLE BEHIND ELECTROMAGNET:

An electromagnet is a magnet that can be turned on and off. In this experiment, the battery is a source of electrons. When you connect the wire to the battery, the electrons flow through the wire. If there is not a complete circuit, the electrons will not flow. Electrons behave like little magnets and when they flow through a wire, they

create a magnetic field, which turns the nail into a magnet that can pick up paper clips and staples!



COMPLETE REPAIRING PROCESS FOR LOAD LIFTING ELECTROMAGNET

The complete procedure basically contains of the main parts i.e. External supervision, dismantling assembly. Procedures are same for most of the lifting magnets the only difference is terminal box which is waterproof in case of underwater magnets.

SUPERVISION:

- Identifying the job number of the magnet which is to be repair
- Using cranes putting magnet is repair section carefully & opening it using proper tools
- External inspection by looking at outer terminal, magnetic& nonmagnetic body of magnet.
- Recording the fault present in the magnet & highlighting it by using painting mark.
- Testing the insulation resistance using merger .If resistance is zero then magnet will be opened for further repairing process.

DISMANTLE:

- First the outer terminal box is removed using gas cutter. In case of underwater magnet the M seal coating is chiselled out & then gas cutters are used.
- Silicon compound is taken out keeping the metrosil (surge arrestor) safe.

- Check the metrosil, terminals & studs. Replace it if required.
- Put the Silicon compound after replacement and cover the terminal using MM plate and seal it using MS rod wielding .For Underwater magnet M-seal coating over terminal is necessary
- To open the magnet from centre pole shoe gas cutting is required. Depending on the magnet nonmagnetic plate & sims plate is cut out
- Winding insulation is checked & reassembled if failure occurs in the magnet.
- If fault is in the winding coil , using tools silicon compound is removed & separated from centre pole. Winding resistance is measured and recorded.
- Insulation layer is removed and cleaned.

ASSEMBLE:

- After cleaning the inner part of cell is provided with texo lite bush for the leads.
- Internal cell is given by thermosetting varnish
- Bottom of the cell is insulated by double layers of mica sheet & double layers of 1.6mm permanite sheet or 3.2 mm single Permanente sheet
- One more layer of mica sheet is provided & thermosetting varnish is done over the layer.
- Centre pole is insulated & rolled with mica up to appropriate height & then it is varnished.
- After the insulation, varnishing is done to remove the moisture & allowed to settle by putting weight on it.
- Heating is done in heating furnace for 12 hours up to120^{o}C.
- Once it is done then it is allowed to cool & weights are removed.
- Good quality coils are used. It is cleaned & insulation is removed for brazing.
- Coils are in series, number of coils represents the ampere turn & magnetic field capability of magnet.

- Bechtel red varnish is used in both sides of coil winding.
- Brazing is done to take out lead from copper coil. T.C.I cleaning agent is used & then rolled with glass tape
- To tight the coil, mica sheet & permanent sheets are put into the gaps between the coil & centre pole as well as between the cell & winding .
- Jumper is taken out from the coil for series coil connection.
- For putting another coil in series same layers of insulation are provided with same procedure.

LOAD LIFTING MAGNETS

As per the shape & the size of Magnets are basically classified into two types

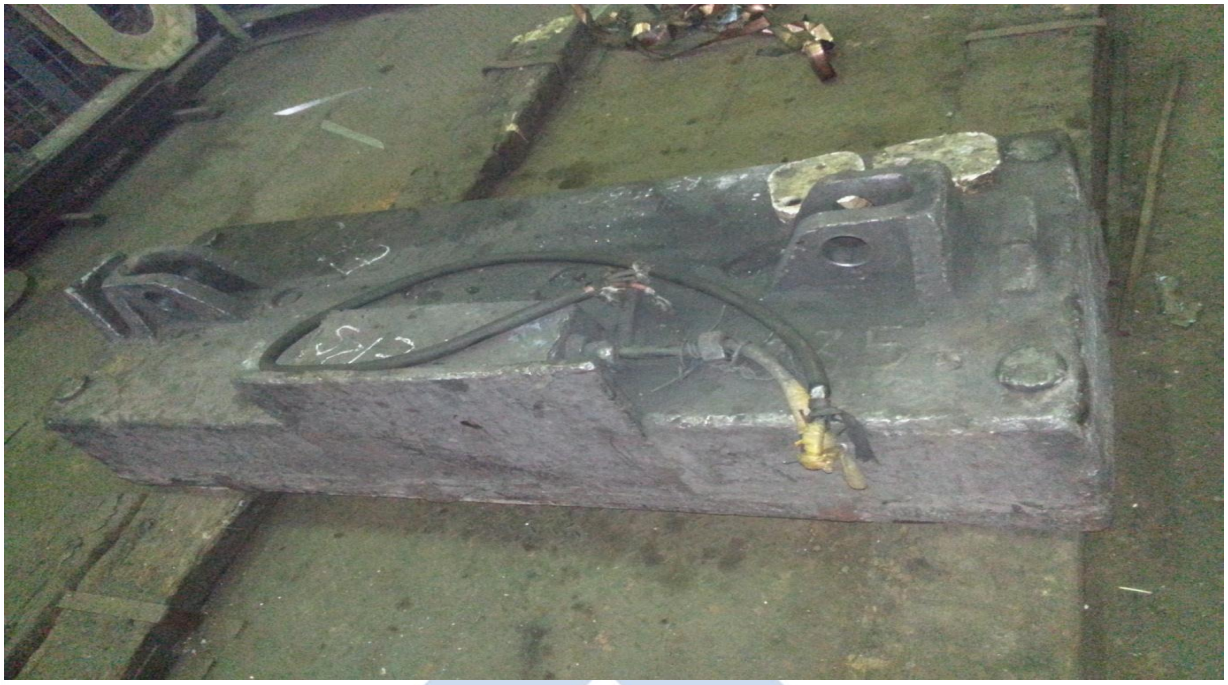
1) Circular magnets
2) Rectangular magnets

CIRCULAR MAGNETS :

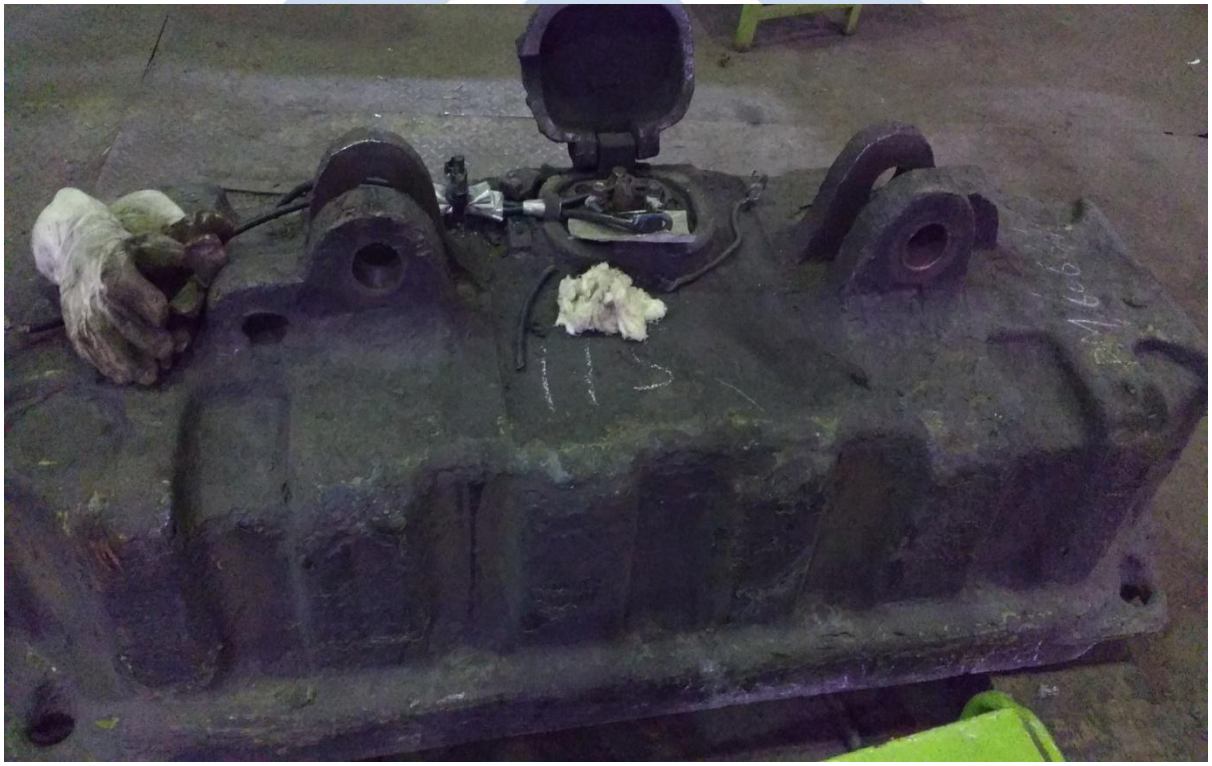
Circular type lifting magnets have been designed for the high-demanding lifting application of scrap handling. It is being used in scrap yards, for drop ball application, in steel mills for charging of scrap buckets, in foundries but as well for loading of trucks, railcars or vessels. You will find those lifting magnets under operation onto excavators, mobile cranes, overhead travel cranes, gantry or harbor cranes. In accordance to customer requirements and specification, alternatively, version with ribbed type steel casted housing and version with smooth type steel welded housing is available.

RECTANGULAR MAGNETS :

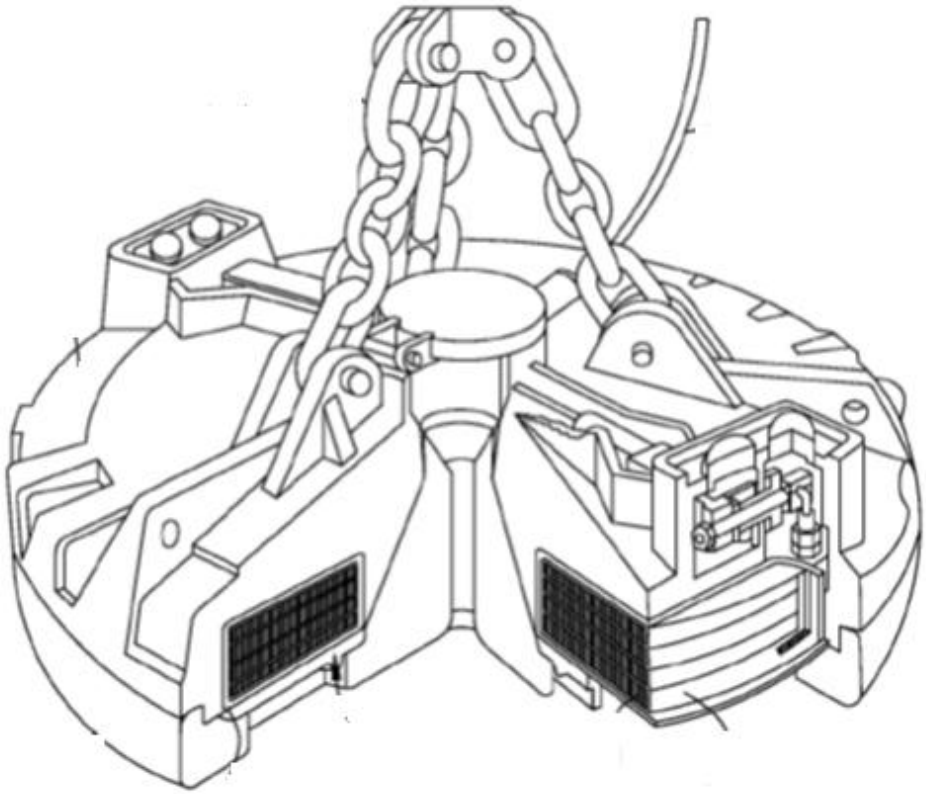
Rectangular magnets has applications in the handling of Sheets and plates, Billets, bundles, bars ,Structural products, Slab turning and Hot slab handling, Hot billet and boom handling, Hot structural material handling heavy Duty fabricated case design, available in aluminum or copper coil designs 220 VDC standard, special voltages are also available.



DIFFERENT SHAPES OF MAGNETS



DESIGN AND CONSTRUCTION



COILS :

- The conductor material shall be of copper strips, conforming to IS 1897:1983 `Copper strip for electrical purposes (second revision) (superseding IS 3285)' and shall be free from burrs and will not have more than two joints in any single coil/cake. The joints shall be lap jointed and brazed all round. There shall be no joint in the portion of the coil immediately connecting to the leads for at least five turns. The last lap of the coil shall be reinforced with a phosphor-bronze strip. The coils shall be in the form of cakes. The insulation provided between the coil cakes shall be of class H. Provision of RTDs may be considered
- Rectangular copper conductor shall be covered with double layer varnish bonded glass-fiber, lapped firmly, evenly, closely and continuously around the conductor. These should conform to IS 13730 (Part 0/sec 5): 2003 The construction and other test parameters shall generally be in line with IS 4685:1968(Part-1) `Varnish bonded glass-fire covered copper conductors Round wires'.
- The coils shall be suitably insulated with ceramic tape as turn to turn. For layer insulation between the cakes, mica insulation shall be used. Flexible mica shall be used for body insulation.
- All magnets shall have minimum class H insulation. The manufacturer shall use class C insulation for handling materials at temperatures higher than 300^{o}C.
- The annular space between the coil and the magnet body shall be filled with silicon based compound. The filling compound shall be non-hygroscopic and shall have low co-efficient of thermal expansion and high thermal conductivity. It shall be able to withstand the rise in temperature corresponding to the class of insulation and shall be easily removable during the repair of the magnets.

- The leads shall be firmly secured on to terminals inside the coil assembly and shall be protected from moisture and dust. The leads shall be brought out on the outer part of the coil so that it is safe from fracture caused by expansion/contraction of coil. Leads should be distinctly marked indicating the starting and ending winding.
- Ceramic sheets of adequate thickness to be provided in between the coil and bumping plate for hot application magnets (for above 300 degree C).

MAGNET BODY :

Magnet body shall be cast from high permeability steel conforming to Grade 2 of IS 4491:1994 `Steel casting for high magnetic permeability. The suspension lugs which are attached shall be cast integral with the magnet body. Or any equivalent material mutually agreed between the purchaser and the supplier. In case of rectangular magnets, fabricated design may be adopted, using steel of grade Fe 410WC according to IS 2062:2006 `Steel for general structural purposes – Specification (fifth revision) (superseding IS 226)'.

- The periphery of the shell shall be heavily ribbed to give added mechanical strength and increased radiation surface.
- The lifting magnet shall be supplied along with suitable chain sling conforming to IPSS:1-07-038-96 `Specification for alloy steel chain sling(first revision)'.

MAGNET POLES :

Outer poles must be integral part of the magnet. Inner poles shall preferably be integral part for circular magnet. However in case of bolted design, inner pole shall be fixed on to the magnet body with adequate number of bolts of minimum

19 mm dia. The heads of the bolts should be countersunk into the bodies of the poles and suitably locked.

BUMPING PLATE :

For hot magnets double bumping plate of high manganese nonmagnetic alloy conforming to Grade ¼ of IS 276:2000 `Austenitic – Manganese steel castings – specification (fifth revision)' shall be provided at the bottom for circular magnets to protect the coil from shock. For rectangular magnets, non-magnetic stainless steel or nonmagnetic manganese steel bumping plate of adequate strength shall be provided at the bottom to protect the coil from shock.

BOLTS :

High tensile steel bolts shall be used wherever necessary in the magnet construction.

TERMINALS AND TERMINAL BOX :

Each magnet shall have two terminals securely placed in the terminal box, which shall be capable of accommodating continuous duty copper cables. The terminal box shall be so located to prevent damages while loading hitting and shall be of three compartment types. The coil leads shall terminate in first compartment through insulated bushings. The terminal studs in the second

Compartment shall be connected permanently to the termination points of the first compartment. The third compartment shall house the non-linear discharge resistor. The external feeding cables shall be connected to the terminal studs of the second compartment by the user. The terminal box

shall be suitably enclosed to make it either water, steam, fume and oil proof or water tight or water resistant. Suitable provision for earthing shall be made. An additional identical terminal box with separate set of leads from the winding shall be provided as per mutual agreement between the purchaser and the supplier. One terminal box may

be allowed in case of smaller and rectangular magnets. The enclosure protection class of the Terminal Box should be defined like IP-55

EXTERNAL LEADS :

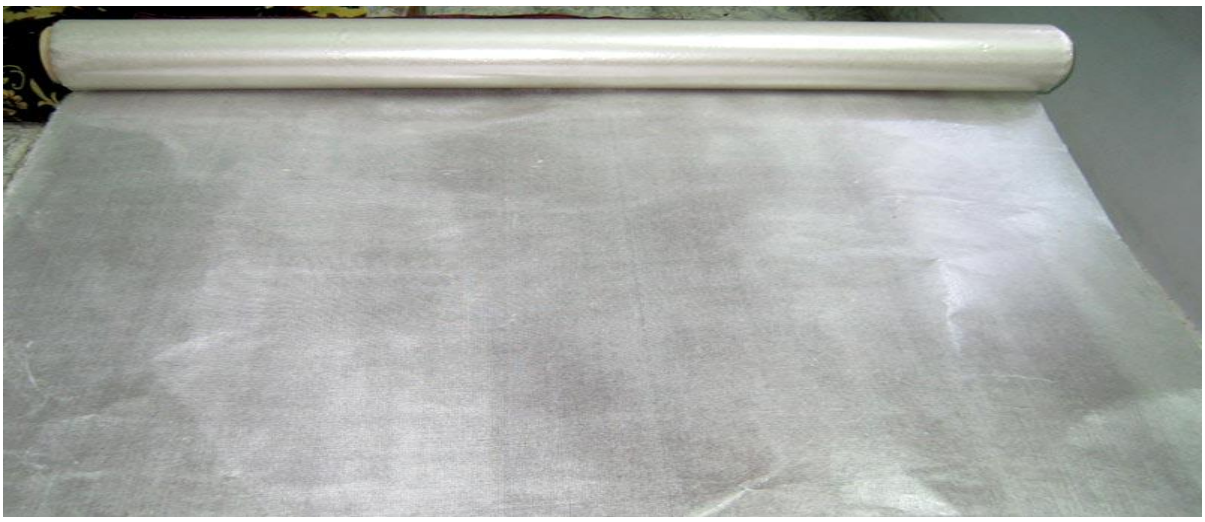
A one meter long 3 core flexible EPR/CSP copper cable of suitable cross-section shall be connected through a water tight gland. A suitable plug-socket shall be provided.

CLAMPING :

Suitable clamping arrangement shall be made near the terminal box of the magnet to hold the feeding cable firmly against jerks or vibration and also to prevent any pull of the leads.

MATERIALS USED FOR INSULATION

INSULATION SHEET-



CONDUCTOR

COPPER COIL-

TECHNICAL PARAMETERS FOR LIFTING MAGNETS

(A) Circular Magnet				
Size (dia) of Magnet in mm (± 25 mm)	900	1150	1350	1600
Cold current at 220 V dc and 40°C, Max, A	32.0	45.0	64.6	87.5
Duty cycle, %	50	50	50	50
Rated Lifting capacities in hot condition of magnet in (kg)				
Solid slabs	8000	16000	21500	31000
Skull cracker balls (with normal pole shoes)	4500	7000	8000	10000
Sheet pressed and packed	-	-	-	3000
Heavy steel scraps	300	700	1000	1800
Pig iron castings	300	700	1200	1800
Light steel scraps	250	400	550	800
(B) Rectangular Magnets				
Size of Magnet in mm (± 25 mm)	900 mm x 600 mm	1400 mm x 600 mm	1700 mm x 700 mm	
Cold current at 220 V dc and 40°C, Max, A	14.5	22.0	27.4	
Duty cycle, %	50	50	50	
Rated Lifting capacities in hot condition of magnet in (kg)				
Solid slabs	8000	11000	14000	
Sheet pressed and packed	2000	3200	5650	
Blooms	-	7200	12800	

CONCLUSION

The training at SAIL-Bhilai Steel Plant has provided me valuable knowledge about the whole process in electromagnets repair as well as the different methods employed for testing and detecting fault. After completion of the project I am aware of various electrical machines and uses of electromagnets within the plant.

The guide provided to me played a very important role in the completion of the project and helping me clear my doubts and exposing to the real industrial scenario faced day to day.

I thank all the people involved in guiding me through out the process.