National Program

on

Promoting Energy Efficiency and Renewable Energy in MSME Clusters in India

Indore Foundry Cluster

Detailed Energy Audit Report
Mangla Enterprise Pvt. Ltd.

Submitted to

Submitted by

InsPIRE Network for Environment

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Abbreviations

APFC	Automatic Power Factor Controller
BEE	Bureau of Energy Efficiency
CO_2	Carbon Di-oxide
CT	Cooling Tower
CI	Caste Iron
FRPB	Fiber Reinforced Plastic Blades
GEF	Global Environment Facility
IGBT	Insulated Gate Bipolar Transistor
HP	Horse Power
kcal	Kilo Calories
kg	Kilogram
kVA	Kilo Volt Ampere
kW	Kilo Watts
kWH	Kilo Watt Hour
MDC	Maximum Demand Controller
MSME	Ministry of Micro Small and Medium Enterprises
PF	Power Factor
PG	Pig Iron
ppm	Parts per Million
SEB	State Electricity Board
SEC	Specific Energy Consumption
SME	Small and Medium Enterprise
TDS	Total Dissolved Solids
UNIDO	United Nation's Industrial Development Organization
VFD	Variable Frequency Drive

About the Project

The project promoting "Energy Efficiency and Renewable Energy in Selected MSME clusters in India" supported by Global Environment Facility (GEF), United Nations Industrial Development Organization (UNIDO), and Bureau of Energy Efficiency (BEE) aims to bring down the energy consumption in Indore Foundry cluster located in Indore (Madhya Pradesh) by supporting them to adopt Energy Efficient and Renewable Energy practices. There are more than 70 Small and Medium Enterprise (SME) foundry units operating in the various industrial pockets of the district. InsPIRE Network for Environment, New Delhi has been appointed as the executing agency to carry out the activities in the cluster.

The activities to be conducted under the proposed energy efficiency study in Indore Foundry Cluster include following:

- Conducting Pre-activity Workshop
- Comprehensive energy audit in 6 Foundry units
- Discussion with 3 cluster experts and 2 equipment suppliers to develop best operation practice document
- Development of Best Operating Practices Manual for top 5 technologies
- Identification of monitoring parameters and measuring instruments
- Conducting 3 post energy audit technical workshops for knowledge dissemination

As part of the activities conducted under the energy efficiency study in Indore Foundry cluster, detailed energy audits in 6 Foundry units in Indore was conducted in the month of June'2015.

Executive Summary

Name of SME unit : M/s Mangla Enterprise Pvt. Ltd.

Location of the SME unit : Plot No. 129/2, Palnagar, Industrial Area No. 3, AB Road, Dewas, Madhya Pradesh

Based on the measurements carried out and data collected during field visit in the month of June'2015 and analysis of the data, process wise scope for energy efficiency improvement are identified and relevant recommendations are made. The proposed energy saving measures along with the annual savings, investment required and the simple payback period is given the Table 1 below:

Table 1: *Cost Economic Analysis*

SN	Energy Efficient Measures	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Year)
1	Switching off the main grid power supply to transformer during non-operation of Induction furnace	31,447	Nil	NA
2	Avoiding overfilling of metals in the Induction Furnace	193,843	Nil	NA
3	Avoiding super heating of metals in the Induction Furnace	102,024	Nil	NA
4	Laddle Preheating	102,024	Nil	NA
5	Installation of timers in Cooling Tower (CT) fan system	8,905	17,000	1.91
6	Replacing conventional blades of cooling tower fans with energy efficient Fiber Reinforced Plastic Blades (FRPB)	7,417	20,000	2.70
7	Installation of Variable Frequency Drive (VFD) across selected motors	636,773	300,000	0.47
8	Installation of capacitor banks across motors	441,701	30,000	0.07
9	Installation of VFD in Compressor	132,698	300,000	2.26

- **Electrical Panels:**

The unit has got connected load of 650 kVA. The unit has installed two separate transformers of 550 and 500 kVA. One transformer (550 kVA) is used to directly supply electricity to the induction furnace, whereas, other transformer (500 kVA) is used to cater electricity requirements of other loads. The Unit has installed Automatic Power Factor Controller (APFC). Unit has installed a separate energy meter to record power consumption for induction furnace. During field visit to the unit, it was found that the induction is not disconnected from the grid main supply when the induction furnace is not in operation, this results in energy loss as fixed (or no load) loss to the extent of 402 electrical units per month in the distribution transformer. It is therefore suggested to switch off the main grid power supply to the transformer when induction furnace is not in operation. This would result in energy saving of around 402 units per month without any investment.

Induction Furnace:

Induction furnace is the most energy intensive equipment being used in the unit. There were many deficiencies observed in the current operation practices including scrap loading above coil level etc. Based on the observations and measurements detailed recommendations and best practices measures were suggested. On the cooling circuit for induction furnace, it is suggested to use a fan to cool the hot crucible for few hours and reduce the running of motor / pump to save energy.

Electric Motors:

The unit has several motors of different size and capacity installed in different areas of the foundry. The rated HP of the motors varies from 7.5 to 25 HP and operated depending on the requirements. Like the motors in the cooling circuit of the induction furnace, sand mixing area, shot blasting area etc. It was observed that most of the motors are under loaded with low power factor. It is therefore recommended to replace these oversized motors with motors according to load requirement. A properly balanced voltage supply is suggested which would help in assuring a voltage balance while minimizing voltage losses. Even Variable Frequency Drive (VFD) with the motors wherever required may be installed and also installation of capacitors across motors with a high rating to reduce the distribution losses is recommended.

Compressor:

The unit has installed two air compressors of capacity 3.34 (m^3/min) and 30 HP each, one is operated continuously and the other acts as a backup. The capacity of the air receiver is 1,000 liters. Air compressor is used to compress air for sand coating, fettling, induction furnace and sand blasting section. Based on the information collected, it is strongly recommended to carry out leakage trail fortnightly to assess the leakage level and necessary actions to be taken if any. Further, suggestion regarding relocation of one reservoir nearer to sand blasting section is made to avoid sudden jerks and to operate smoothly. It is also suggested to install VFD across compressor motors.

Introduction

1.1 ABOUT THE UNIT

M/s Mangla Enterprise Pvt. Ltd. is engaged in manufacturing of different types of Caste Iron (CI) casting. The unit has recently started production in their plant after going through a major technological upgradation and relocation to a new place. The unit came in operation on July 19th 2015 and therefore production and electricity consumption data was received for a single month. Since, recently the unit started its commercial operations so the filled up standard questionnaire was not made available by the unit. Most of the castings produced in the unit are used for captive consumption only.

The monthly production of the Unit was found to be around 100 tons. The Unit uses electricity supply from State Electricity Boards (SEBs) for various process and utility applications in premises. The Unit has got contract demand of 650 kVA and incoming supply voltage is 33 kV. Major electricity consumption is required by electrical induction furnace for scrap melting operation. Based on the energy consumption data collected for one month, the Specific Electrical Energy (SEC) consumption of the unit is 1.52 kWh per kg of product. The total specific energy consumption (in kCal) is 1,307 kCal per kg of product. Specific energy consumption details of the unit are provided in Table below:

Table 1.1: ***Details of Mangla Enterprise Pvt. Ltd.***

SN	Parameter	Value	Unit
1	Name and address of unit	Plot No. 129/2, Palnagar, Industrial Area No. 3, AB Road, Dewas, Madhya Pradesh	
2	Contact person	Mr. Mitesh Raghuvanshi (Plant Head) 08818889304	
3	Manufacturing product	C.I. Casting	
4	Monthly Production	100 Tons	
	Energy utilization		
5	Average monthly electrical energy consumption	152,423	kWh/ month
6	Specific electrical energy consumption	1.52	kWh/kg of product
7	Specific energy consumption	1307.2	kCal/kg of product
8	Electrical energy cost	9.98	Rs/kg of product
9	Total energy cost	9.98	Rs/kg of product

Note:

Thermal equivalent for one unit of electricity is 860 kCal/kWh.

Cost of Electricity = Rs. 6.5 per unit (average cost calculated from electricity bill)

1.2 ENERGY AUDIT METHODOLOGY

The primary objective of the energy audit was to study prevailing energy consumption pattern and to identify scope for energy efficiency improvement through technical intervention as well as inclusion of best operation practices. Figure 1.1 depicts the flow chart of activities being adopted for detailed energy audit study.

The activities for the current project started with organization of a pre-activity workshop attended by local unit owners, representatives from UNIDO. During the workshop, project objectives along with support required from the units were also discussed. After this workshop, six units for further consideration of energy audit studies were selected by the local association.

After selection of units, preliminary information relating to the energy consumption by the units was collected in a structured questionnaire. The intent of this preliminary data collection was mainly to get preliminary details about the units to make the energy audit process more effective. Thereafter, field visit to selected industries was carried on a mutually decided dates. During energy audits, detailed data related to specific fuel consumption, various losses, operation practices being followed at the units were measured and collected. Further the gathered data is analyzed to assess prevailing energy consumption of each unit. Further, based on the observation as well as data analysis recommendations related to energy conservation opportunities are also made. List of measuring instruments used during detailed energy audit are summarized in Table 1.2.

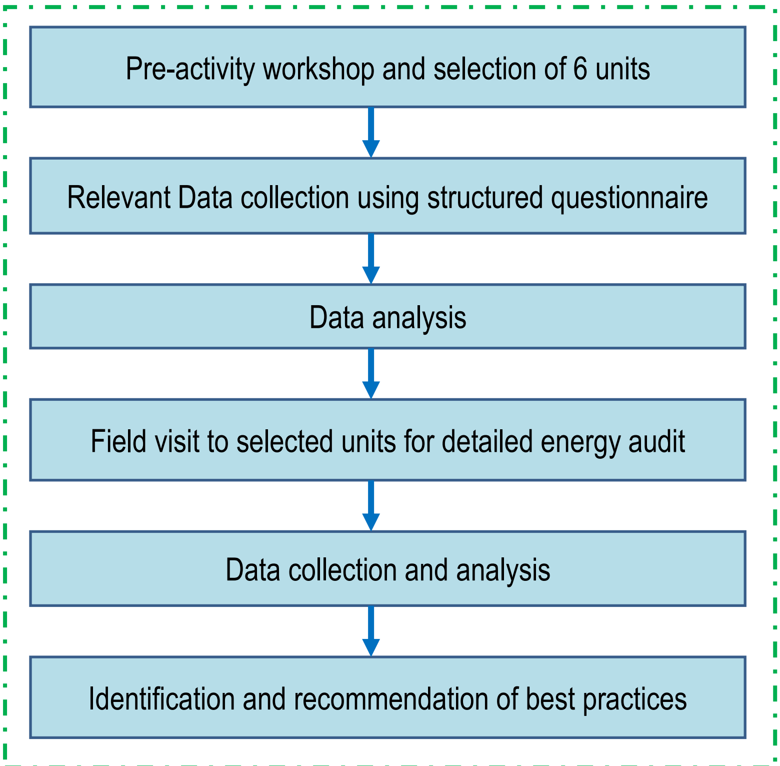

Figure 1.1: *Flowchart depicting sequence of activities followed for carrying out detailed energy audit*

Table 1.2: ***List of instruments used during energy audit***

SN	Name of Instrument	Make / Model
1	Three Phase Power Quality Analyzer	Fluke/434/UNI
2	Single Phase Power Quality Analyzer	Fluke/43B
3	Ultra Sonic Water Flow Meter	GE Panametrics/PT878
4	Rotating Vane Anemometer	Prova Ltd., Taiwan/AVM-05
5	Lux Meter	Metravi/1332
6	Portable Non-contact Infrared Thermometer	Raytek, USA/ST 80
7	Flue Gas Analyzer	Kan May, KM 900

Present Process, Observations and Proposed Technology

2.1 PRODUCTION PROCESS OF PLANT

The complete process of C.I. casting production being manufactured in the Unit can mainly be categorized into Core shop department, Moulding department, Melting department, Fettling department and Inspection department. Overall process flow chart of the process being followed in the Unit is shown in Figure 2.1. The detailed description of each step along with the type of energy input and details related to critical parameters are provided in subsequent paragraphs.

▶ Core Preparation:

The main purpose of using core in casting and molding processes is to produce internal cavities and re-entrant angles. These cores are made of disposable material and are finally destroyed to get it out of the piece. Cores are placed into a mould cavity to form the interior surfaces of castings. The void space is filled with molten metal and eventually becomes the casting. The key steps followed in the core preparation process include core preparation, core dressing and core inspection. The Unit uses dry silica sand for preparation of core which is received after checking its silica content, size and moisture content. Sand cores are prepared using core box filling process. These cores are thoroughly inspected for surface finish to avoid any as irregularity in the surface which may cause problem during metal pouring.

▶ Moulding:

Moulding is nothing but the mould preparation activities for receiving molten metal. This process usually involves: (i) preparing the consolidated sand mould around a pattern held within a supporting metal frame, (ii) removing the pattern to leave the mould cavity with cores. The mould cavity contains the liquid metal and it acts as a negative of the desired product.

Moulding sand being used in the process is received from knock out section after going through cooling and mixing operation. The sand received from knock out section is supplied to sand cooler through belt conveyors where it is cooled in a rotating drum and sent to hopper. From hopper, sand is sent to mixer where it is mixed with bentonite, coal dust, water and fresh silica to attain the desired properties of mould. This sand from mixer is sent for moulding operation using belt conveyers. This sand is periodically checked for its required properties using the instruments available within the unit and the same is recycled back without using if not found suitable. Further details related to electrical energy consumption are summarized in Table 2.1.

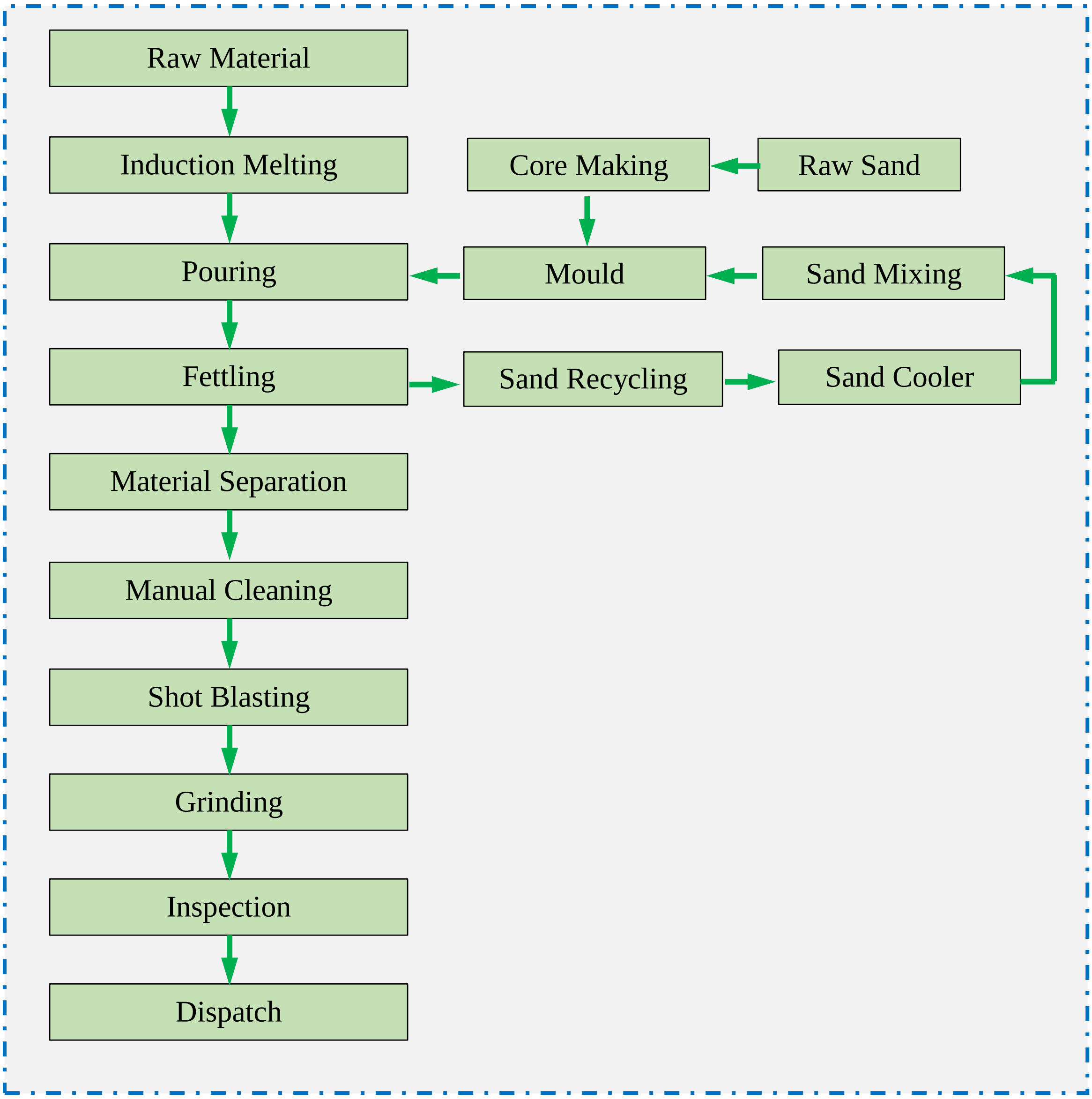

Figure 2.1: ***Process flow chart***

▶ Melting:

In this process, scrap material is melted using an electrical induction furnace. The raw material to be melted in the induction furnace includes mixture of C.I. scrap, Pig Iron (PG) and foundry return material. The unit has installed induction furnace based on IGBT (Insulated Gate Bipolar Transistor) technology incorporating digital control system and much higher efficient in comparison with analog control system. The energy consumption details of the induction furnace along with observations are present in the later section. The furnace temperature is increased to around 1550^{0}C to melt the material. The material is slightly overheated to take care of temperature drop expected during the pouring. Once the material is melted and desired temperature is achieved in the furnace, composition of molten metal is analyzed and accordingly if required, correction is made to make the required composition of molten metal. This process requires electrical energy input for induction furnace as well as for pumps and motors used in the cooling circuit of induction furnace. The critical parameters to be observed in this process are composition of the molten metal as well as temperature of the molten material.

- **Metal Pouring:**

In this step, molten metal from induction furnace is poured into the moulds using laddle. To ensure the required quality of casting, temperature is measured before pouring. There is drop of around 100~150^{0}C in the temperature of molten metal from furnace to pouring. After pouring, mould is left for natural cooling for around 1.5 hours.

- **Knockout:**

In this step, the mould containing solid metal is broken and sand is separated from the casting. This process is achieved using vibrator being operated using an electrical motor. The sand removed in this process is recycled back to hopper after passing it through sand coolers. The castings are further subjected to decoring operation where cores from inside of the castings are removed manually.

- **Fettling:**

This process includes shot blasting and grinding operations. Unit has installed two shot blasting machines in which surface finish of the casting products is improved. In the shot blast process, small sorts of 0.8 mm are thrown over the metal at high velocity. This process results into good surface finish of the metal. Castings received after shot blast operation are subjected to manual grinding to remove residues from the surface of the products.

- **Painting and Dispatch:**

Casting products received from grinding process are inspected for their accuracy and send for final painting and dispatch if found suitable. After painting casting products are subjected to 4 to 6 hours of drying. Finally, the products are sent for dispatch.

Pictorial Representation of Production Process

Figure 2.2: ***Scrap material to be used for melting in Induction furnace***

Figure 2.3: ***Silica sand being used for moulding and core making process***

Figure 2.4: ***Sand cores of different shapes being manufactured***

Figure 2.5: ***Induction furnace control panel***

Figure 2.6: ***Separate transformer and energy meter for induction furnace***

Figure 2.7: ***Pouring of molten metal from Induction furnace to the Laddle***

Figure 2.8: ***Sand mixture***

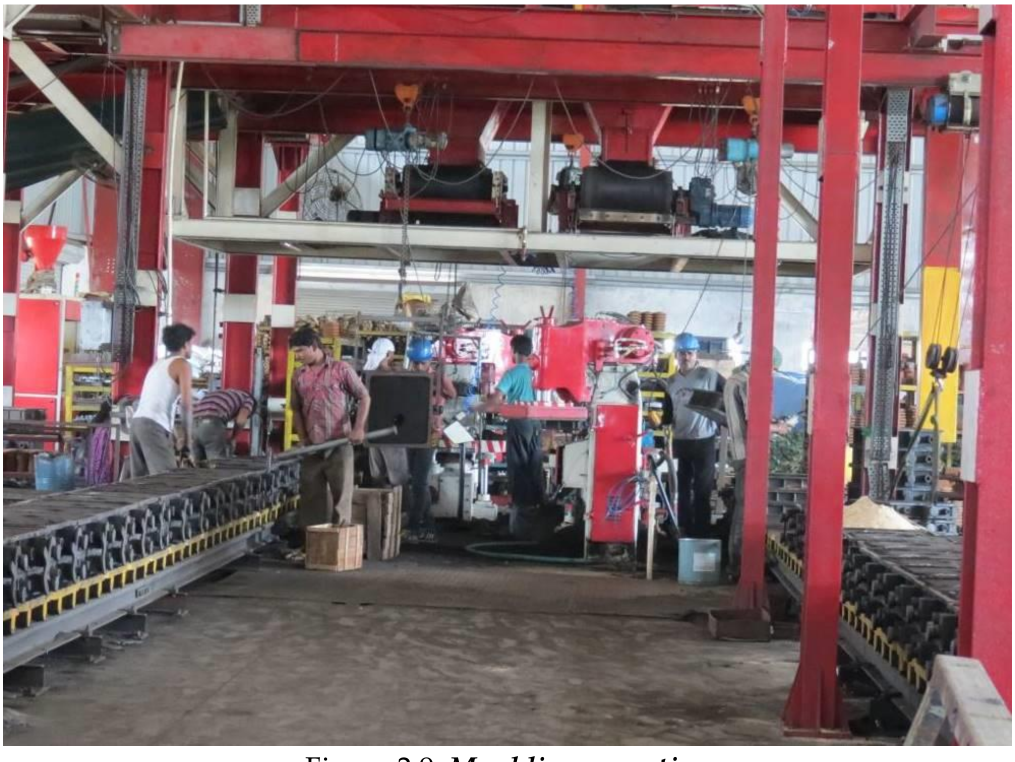
Figure 2.9: ***Moulding operation***

Figure 2.10: ***Sand cores being placed in moulds***

Figure 2.11: ***Pouring of molten metal from laddle to mould***

Figure 2.12: ***Manual de-coring of castings***

Figure 2.13: ***Sand mixture and dust separator***


Figure 2.14: ***Shot blast machine***

Figure 2.15: ***Products after shot blast operation***

Figure 2.16: ***Grinding of the products***

Figure 2.17: ***Painting of castings***

Figure 2.18: ***Castings ready for dispatch***

2.2 PRESENT TECHNOLOGIES ADOPTED

The list of equipment and appliances installed in the Unit for various foundry processes are mentioned in the table 2.1.

Table 2.1: ***Process wise energy consumption information***

SN	Process	Number	Energy Source	Rated consumption	Hrs of operation per day	Days per month	Capacity	Critical Parameter
1	Melting Induction Furnace	1	Electricity	550 kW	8:30 to 12:00 Average 15 hrs	26	500 kgs	Temperature and composition of molten metal is important
2	Knock out	1	Electrical motor for vibration	5 HP, 0.75 HP (Vibrator Feeding)	8 hrs	26	Around 6 to 7 tons moulds are knocked out	Not so critical as remaining sand is removed in subsequent sections
3	Shot Blast	2	Electricity	7.5 HP (Shot blast 1) 7.5 HP (Shot blast 2)	8 -12 hrs	26	50 kgs per batch in both machines	Surface finishing
4	Grinding	3	Electricity	5 HP (each)	8 hrs (2 are mostly operated)	26	4-5 tons per day	Surface finishing
5	Sand Core making	2 (Cold Box and Oil Core)	Electricity	2 kW motor in cold box	8 hrs	26	60 cores /hr (Per core average weight ranges from 300 to 500 gms)	Hardness of core is measured
6	Sand Cooler	1	Electricity	5 HP for drum rotation, 7.5 HP blower to remove dust and other impurities	8 – 10 hrs	26	8-10 tons/ hrs	Knock out sand has temperature of 75 ^{0}C. By the time it reaches cooler the temperature is 69 ^{0}C. Normally the temperature of sand after cooler is in the range of 35 to 40 ^{0}C.
7	Sand Mixer (Moulding section)	1	Electrical	12.5 HP (2 nos.) 25 HP	8-10 hrs	26	450 kgs per batch	Permeability, GCS, moisture (3-5 %), and compatibility are some of the important parameters.
8	Compressor	2	Electrical	30 HP (each)	8 hrs. (one is operated continuously and other is kept as stand by)	26	3.34 (m^3/min)	Regular simple maintenance measures
9	Cooling water motor	2	Electricity	7.5 and 5 HP	5-6 hours	26	As per requirement of water flow	Temperature of the water is critical

^A shift is equal to 8 effective hours of working/ operation.

2.3 DETAILED ENERGY AUDIT

During the field visit to the unit detailed measurement of the following equipment were carried out. Following sections provides present observations and recommendations for each equipment to improve energy efficiency.

2.3.1 Electrical Panels

- **Present System:**

The unit has got connected load of 650 kVA. The unit has installed two separate transformers of 550 kVA and 500 kVA. One transformer (550 kVA) is used to directly supply electricity to the induction furnace, whereas, other transformer (500 kVA) is used to cater electricity requirements of other loads. The Unit has installed Automatic Power Factor Controller (APFC). Unit has installed separate energy meter to record power consumption for induction furnace.

Figure 2.19: ***Pictorial depiction of transformers and electrical panel installed***

Given below in the table is the technical specification of the Oil filled distribution transformer.

Table 2.2: ***Transformer specifications***

Make	Mehi Power Transformer, Indore
Specification Reference	IS 2026/IEC60076
KVA	550
Volts at No Load (Primary)	33000
Volts at No Load (Secondary)	415
Ampere (Primary)	8.74
Ampere (Secondary)	695.6
Phases (Primary)	3
Phases (Secondary)	3
Frequency (Hz)	50
Winding	Copper
Vector Group	Dy11
Year of Manufacture	2015
Type of Cooling	ONAN
Maximum Temperature Rise Top Oil/Winding (0C)	45 / 55

▶ **Observations:**

As the production in the Unit has started since in July 2015, the historical electricity consumption data is not available. The contract demand of the unit is 650 kVA, because of which induction furnace is operated at part load 400 kW (rated capacity 550 kW) to avoid penalty related to crossing the maximum demand. It was found that the induction furnace is operated daily for around 8 ~ 10 hours per day. It was observed that even by having separate distribution transformer (550 kVA) supplying the induction furnace, the transformer is not disconnected from the grid main supply when the induction furnace is not in operation for a longer time or holidays. This results in energy loss as fixed (or no load) loss incurred in the distribution transformer. For the transformer, 550 kVA oil filled transformer, no loss or fixed load losses is around 900 watts. In the unit, transformer is ideal for around 112 hours per week (67% ideal time) resulting into loss of around 402 electrical units per month.

▶ **Recommendations:**

It is suggested to switch off main grid power supply to the transformer when induction furnace is not in operation. This would result in energy saving of around 402 units per month (refer Table 2.3). Considering per unit cost of Rs. 6.5, this measures would provide annual benefit of around Rs. 31,447. The contract demand of the unit needs to be increased to facilitate induction furnace operation at full load.

Table 2.3: *Cost Economic Analysis – Induction Furnace*

SN	Energy Efficient Measure	Estimated Energy savings (kWh/Year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Year)
1	Switching off the main grid power supply to transformer during non-operation of Induction furnace	4838	31,447	No investment	NA

2.3.2 Induction Furnace

▶ **Present System:**

The Unit has installed induction furnace based on IGBT (Insulated Gate Bipolar Transistor) technology incorporating digital control system and much higher efficient in comparison with analog control system. Unit has installed electrical furnace supplied by Oritech Solutions. The induction furnace is 550 kW with crucible capacity of 500 kgs. Using this, scrap is melted at a temperature of around 1550^{0}C. Unit has also installed one standby crucible of the same capacity. During energy audit, detailed study pertaining to performance assessment of induction furnace was carried out. In the operation, crucible is filled with the scrap material and heating is done. The material is slightly overheated to take care of temperature drop expected during the pouring. Once the material is melted and desired temperature is achieved in the furnace, composition of molten metal is analyzed and accordingly if required, correction is made to make the required composition of molten metal. The melting temperature is typically attained in 1.3 to 1.45 hours except for the cold start, for which 2 hours more time is required.

Table 2.4: ***Furnace specifications***

Model/Make	Oritech Solutions
Energy Input	Electricity, 550 kW
Capacity	500 kg

Figure 2.20: ***Induction furnace along with crucibles installed***

Figure 2.21: ***Separate panel for electricity supply to induction furnace, Electrical panel of induction furnace***

▶ Observations:

During field visit to the unit, detailed performance study of induction furnace was carried out for single charges. The observations made are summarized in Table 2.5. The specific energy consumption for one charge is shown in Figure 2.22.

Table 2.5: ***Summary of performance study***

EE Trial No.	Total Metal (Kg)	Furnace Start Time (hh:mm)	Furnace End Time (hh:mm)	Total Melt Time (hh:mm)	Tapping temp (^{0}C)	Total kWh consumed	Average SEC (kWh/ ton)	Remarks
1	550	12:08	13:22	01:14	1510	359	653	Pouring completed in around 17 minutes.

From the performance study table the following points were observed;

- Melting time taken per charge (550 Kg) is around 74 minutes of which 57 minutes was for melting operation and rest 17 minutes is for pouring operation
- Specific Energy Consumption (SEC) was found to be 653 kWh/ton, which is very close to the average SEC 654 kWh/ton as shown in figure 2.22 below
- The induction furnace is operated at part load condition below 400 kW (where the rated capacity of the furnace is 550 kW). The part load operation is practiced to avoid cross contract maximum demand, as currently the contract demand is less
- The scrap material was properly weighed before each charge – an accurate calculation of necessary charge was made for minimizing melting times and power needs
- Proper documentaiton of energy consumed, measuring of each charge material and alloying additives
- The power supply to the induction furnace is reduced during furnace holding period thus thereby reduction of energy consumption in holding the molten metal
- Pouring temperature achieved as 1500~1550 ^{0}C.
- The meterial was loaded above the induction furance coil level this causes overheating of furnace components in the top part of the furnace leading to energy loss. In addition, with the furnace overfilled, the lid cannot be closed. Ideally, the furnace lid should be left closed as much as possible, to retain heat in the furnace.

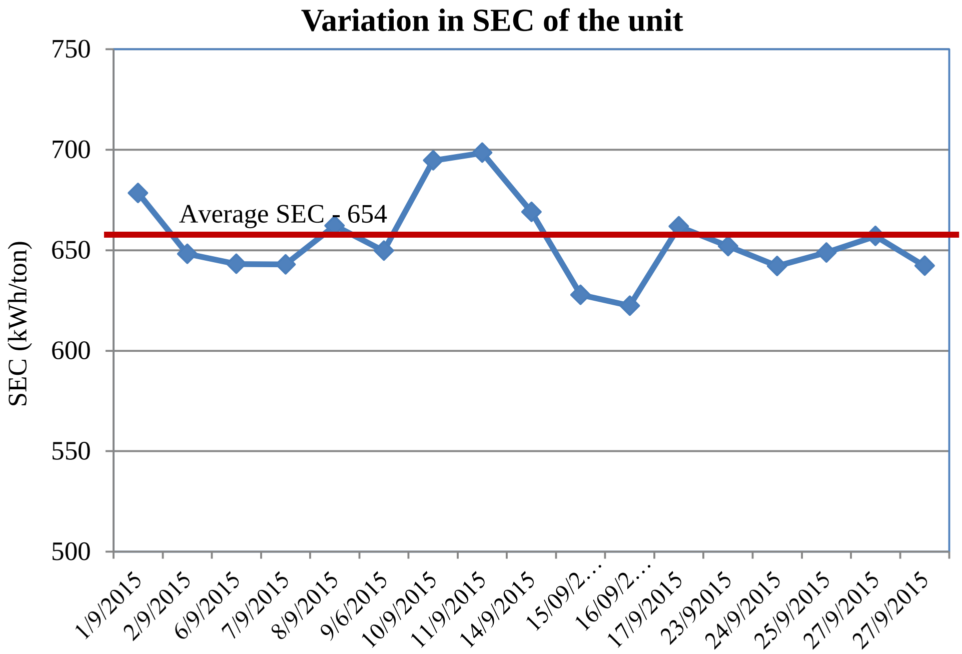

Figure 2.22: ***Variation in SEC for the month of september***

Recommendations:

- Best Practice #2 (Furnace Loading & Operation): Level of molten metal should not exceed the level of induction furnace coil (See ***Annexure 1***).
- As far as possible, no overheating of material beyond the required temperature should be carried out as it directly consumes energy.
- It is suggested to increase the contract demand of the unit so as to operate the Induction furnace at its rated capacity and thereby increase its efficiency
- Holding of furnace should be avoided by proper planning of moulds in advance
- During pouring and scrap composition measurement, power supply to the induction furnace should be reduced to around 25% of the full capacity
- Use clean scrap as dirty scrap and charge materials waste tremendous amount of energy and increase electrical consumption
- The cost economic analysis of the above suggested measures are compiled in Table 2.6. It can be observed that all the measures suggested towards energy efficiency improvements of furnaces have good payback period of less than 6 months.

Table 2.6: ***Cost Economic Analysis – Induction Furnace***

SN	Energy Efficient Measure	Estimated Fuel savings (kWh/year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Year)
1	Avoiding overfilling of metals in the Induction Furnace	29,822	193,843	Nil	No Applicable
2	Avoiding over heating of metals in the Induction Furnace	15,696	102,024	Nil	No Applicable
3	Laddle preheating	15,696	102,024	Nil	No Applicable

2.3.3 Cooling Circuit for Induction Furnace

- **Present Arrangement:**

To avoid heating of the coils being used in induction furnace, cooled water is continuously circulated through coils. The schematic of the water circuit for the same is shown in Figure 2.23. Water in the cooling circuit operates even after closing of furnace operation to remove the residual heat from the crucible. In the present arrangement, heated water coming from coil is directly put back in water sump. The heat from the furnace panel is removed by the DM water which in turn exchanges the heat with normal water using a plate type heat exchanger. The heated normal water is circulated through cooling tower remove heat. In addition, unit has also installed an overhead tank from which water is circulated through coils for cooling when the induction furnace is shut down. This also serves cooling in case of power outage during operation.

- **Observations:**

In the present system there are two motors installed in the cooling water circuit of the induction furnace. The rated HP the motors are 5 HP and 7 HP and operated for 5 to 6 hours. It is observed that heated water after receiving heat from coil is put back directly to the common tank without passing it through cooling tower. Measurement of motor loading for different motors being used in the cooling circuit was carried out. The results are summarized in Table 2.7. Both the pump was found to have loading in the range of 57 to 58%. Overall PF for both the pumps was around 0.62. In addition, the value of water quality parameter observed in the raw water being circulated through coil was found to be higher than the limit prescribed by the induction supplier (ref Table 2.8 & 2.9).

Table 2.7: *Measurements of Loading of Cooling Water Motors / Pumps*

Pump Details	Current (Amps)				Voltage (Volts)	Actual Power (kW)	Rated Motor HP	Loading (%)	PF
	R	Y	B	Average					
Raw Water Cooling Pump	5.0	5.0	5.0	5.00	415	2.13	5.0	57	0.60
Furnace Coil water cooling pump	7.1	6.8	7.1	7.00	414	3.25	7.5	58	0.65

As observed in the table the total hardness of the raw water through the coil is around 700 Parts Per Million (ppm) whereas the prescribed hardness should be less than 100 ppm. Total Dissolved Solids (TDS) in this case are 924 mg/L whereas the prescribed limit is less than 250 mg/L. Calcium hardness is 420 mg/L and the prescribed limit says less than 100 mg/L.

Table 2.8: *Water Quality Parameters in Raw water for Cooling Tower*

Parameters in PPM	Make up	CT
Total Hardness	300 ppm	700 ppm
Calcium Hardness	180 ppm	420 ppm
P Alkalinity	-	20 ppm
M Alkalinity	110 ppm	160 ppm
Total Alkalinity	110 ppm	180 ppm
P.H.	7.0	8.5
TDS	427 ppm	924 ppm
Temperature (^{0}C)	-	-

Table 2.9: ***Prescribed Water Quality Parameters in Raw water***

Contents	Soft water for furnace cooling
Total suspended solids	<10 mg/L
Max. particle size	<0.2 mm
Total dissolved solids (TDS)	<250 mg/L
Chlorides	<75 mg/L
Total hardness as CaCO3	<100 mg/L
PH value	7.0 – 8.5
Total oil content	Nil
Conductivity	NA
BOD	<30 mg/L
COD	<80 mg/L
Silica	<2 ppm

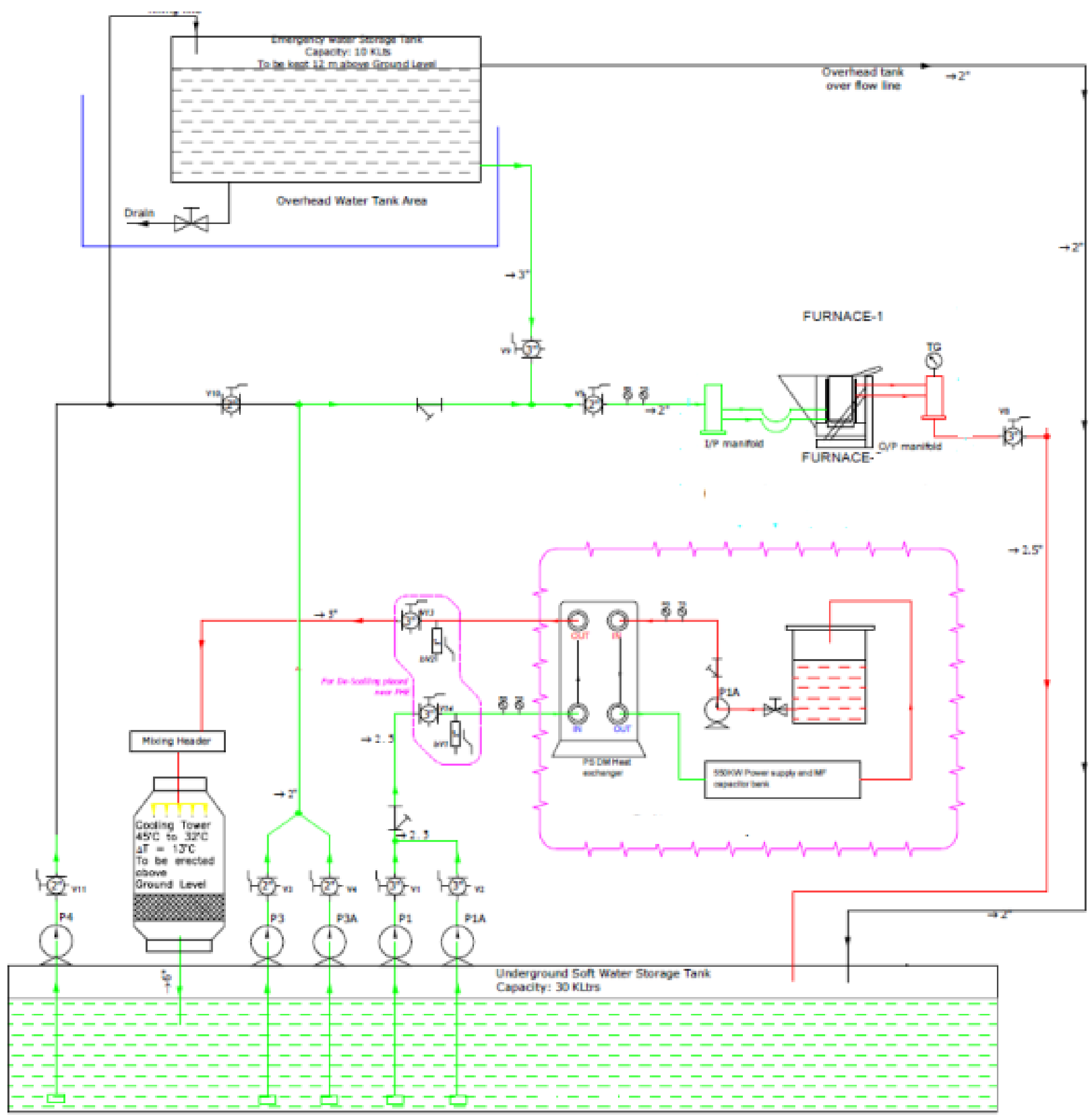

Figure 2.23: ***Flow diagram of cooling water circuit***

Figure 2.24: C*ooling Tower*

▶ Recommendations:

Presently, after the furnace operation is stopped the cooling water motor / pump is kept operating for around 5~6 hours to cool the coil and panel and the water is put back in the sump directly, after circulating in the cooling tower for water coming from the panels. In order to reduce the operation of motors / pump, it was suggested to use a fan to cool the hot crucible for few hours and reduce the running of motor / pump. This initiate would save electrical energy used in motor / coil.

It is suggested to install timers in cooling tower fan system and replace the conventional cooling tower fan blades with fiber reinforced plastic blades. This will lead to sufficient energy saving achievement owing to the better aerodynamic shape of its blades. The cost benefit analysis for the above recommendations is given below. It can be seen from the table that by Installation of timers in cooling tower fan system energy saving of 1,370 kWh/annum can be achieved and by replacing cooling tower fans with energy efficient fiber reinforced plastic blades energy saving of 1,141 kWh/annum can be achieved.

Table 2.10: *Cost Economic Analysis – Cooling Tower*

SN	Energy Efficient Measure	Estimated Energy savings (kWh/Year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback period (Years)
1	Installation of timers in Cooling Tower (CT) fan system	1,370	8,905	17,000	1.91
2	Replacing conventional blades of cooling tower fans with energy efficient Fiber Reinforced Plastic Blades (FRPB)	1,141	7,417	20,000	2.70

It has also been observed that the loading of the raw water cooling pump and the furnace coil water cooling pump are in the range of 57-58% and power factor is 0.60 & 0.65. It is suggested to install capacitor banks across the motors to improve power factor of the pumps.

Based on the water analysis report, it is suggested to install water softening plant to have parameters within limits as prescribed by the induction furnace supplier.

2.3.4 Electrical Motors

Present Arrangement:

In the present system there are number of motors of different size and capacity installed in different areas of the foundry Unit. The rated capacity of these motors varies from 7.5 HP to 25 HP. During visit, sample of motors for measurements were selected based on their capacity and usage hours.

Observations:

Measurement of motor loading for different motors being used in the foundry was carried out. The results are summarized in Table 2.11. The loading of the motors varies from 29% to 88 %. The sand mixer motors are of higher capacity (25 HP and 12.5 HP), they operate for more hours but the loading of the 25 HP motor is only 63.3%, whereas, for the other two motors it is below 50% loading. The percentage loading of the conveyor and blower motor is also relatively less.

Table 2.11: ***Measurements of Loading of different Motors / Pumps***

Section	Equipment Name	Current			Average Current (Amps)	Voltage (V)	Actual Power (kW)	Rated Motor kW (HP)	% Loading
		R	Y	B					
Sand Mixing Area	Sand Mixer	21	22	21	21.3	410	11.82	18.65 (25)	63.36
	Sand Mixer (13)	7.8	7.3	8.0	7.70	412	3.57	9.33 (12.5)	38.30
	Sand Mixer (12)	7.9	8.7	8.9	8.50	412	4.25	9.33 (12.5)	45.53
	Blower	3.5	3.2	3.4	3.37	411	1.63	5.60 (7.5)	29.13
	Conveyer (BC-2)	4.5	4.7	5.1	4.77	410	2.67	5.60 (7.5)	47.79
	Conveyer (BC-3)	5.5	5.3	5.6	5.47	411	3.07	5.60 (7.5)	54.95
Shot Blasting	Shot Blast-1	7.0	8.0	7.0	7.33	410	3.12	5.60 (7.5)	55.85
	Shot Blast-2	11.0	11.0	10.0	10.67	411	4.94	5.60 (7.5)	88.21

Recommendations:

- Most of the motors are under loaded and therefore not efficiently operating, it is therefore suggested to replace the oversized motors with appropriately sized energy efficient motors
- It is suggested to ensure equal loads on all three phases of the electric motors which would assure a voltage balance while minimizing voltage losses and increase life of the motor
- It is also suggested to install Variable Frequency Drive (VFD) with the motor which results into huge energy saving and small payback period
- It is suggested to install capacitors across motors with a high rating to reduce the distribution losses and efficient utilization of electric power
- Given below is the cost benefit analysis of the above suggestions. It can be seen from the table that by improving power factor in selected motor energy saving upto 0.67 Lakhs kWh/Year can be achieved, which amounts to an energy saving of Rs 4.4 Lakhs /year

Table 2.12: ***Cost Economic Analysis - Motors***

SN	Energy Efficient Measure	Estimated Energy savings (kWh/Year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Year)
1	Installation of capacitors across motors having low power factor	67,954	441,701	30,000	0.07
2.	Installation of VFD across motors having higher capacity and high operating hours	97,965	636,773	300,000	0.47

2.3.5 Compressor

▶ Present System:

The unit has installed air compressor to meet compressed air demand in the Unit. The specifications of the compressor are provided in Table 2.13. The compressed air is mainly used for sand coating, fettling, moulding, sand blower, induction furnace and sand blasting section. The Unit has installed two compressors of capacity 3.34 m^3/min each from which compressed air is supplied using overhead and underground air pipes. The capacity of the Air Receiver is 1.0 m^3. The schematic of compressor network observed in the unit is shown in Figure 2.24 and Figure 2.25.

Table 2.13: ***Specifications of compressor and receiver***

Ingorsoll Rand Air Receiver Details	Values
Capacity (m^3)	1.0
Shell Thickness (mm)	5
Dish Thickness (mm)	6
Maximum Working Pressure (kg/cm^2) G	7.5
Hydraulic Test Pressure (kg/cm^2) G	12.5
Temperature Range (^{0}C)	0-150
Ingorsoll Rand Compreessor-1 Details	
Maximum Working Pressure (Bar)	8.5
Motor Power (kW)	22.0
Capacity (m^3/min)	3.34
Total Package Current (Amps)	43.0
Voltage (Volts)	400
Phase/Hertz	3 / 50
Gross Mass (kg)	540.0
Ingorsoll Rand Compreessor-2 Details	
Maximum Working Pressure (Bar)	8.5
Motor Power (kW)	22.0
Capacity (m^3/min)	3.34
Total Package Current (Amps)	43.0
Voltage (Volts)	400
Phase/Hertz	3 / 50
Gross Mass (kg)	540.0

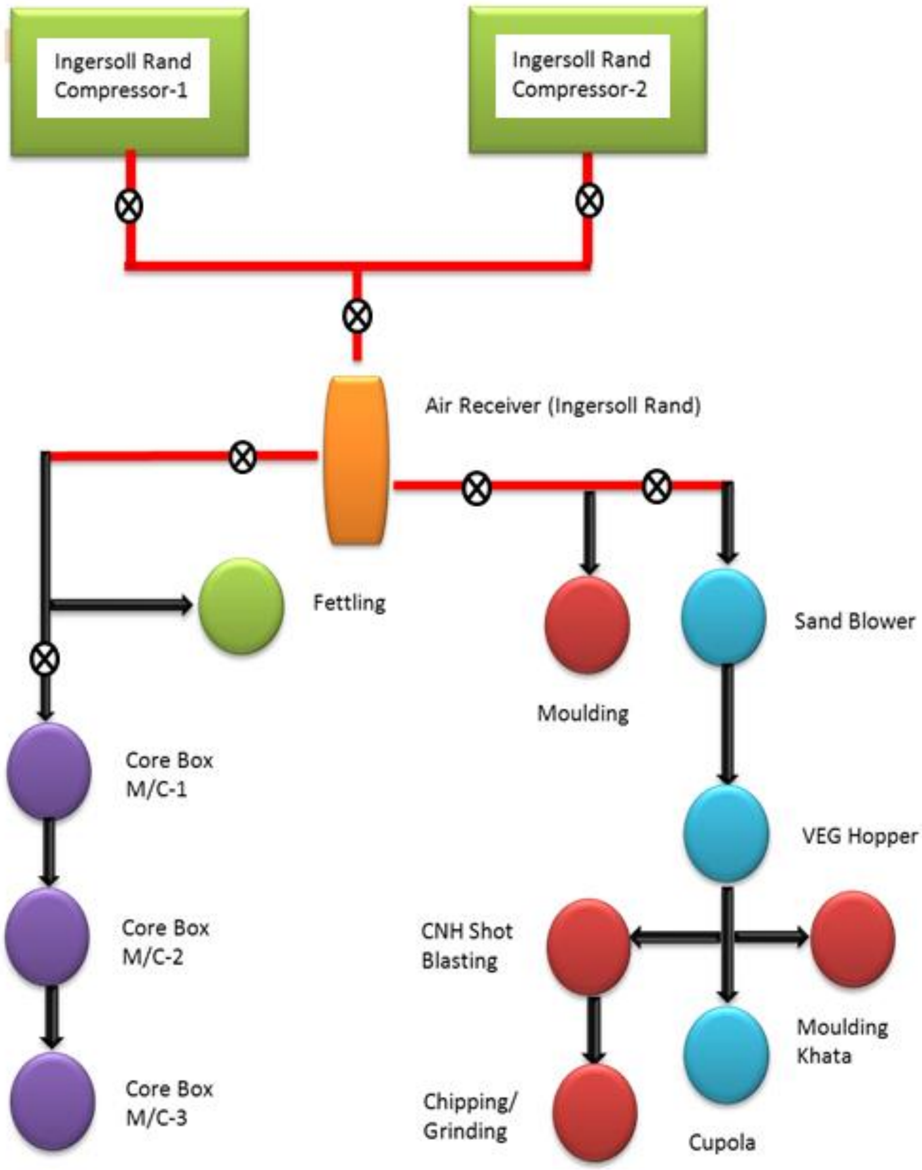

Figure 2.25: ***Single line diagram of compressor system***

Figure 2.26: C*ompressor system*

▶ Observations:

Measurement of electrical parameters was carried out to estimate percentage loading of compressor. These observations are summarized in Table 2.14. Compressor leakage test could not be performed as the unit was in operation. Further, Unit has planned to change the piping material of compressed air supply line. Based on the measured data, it is observed that compressor motor is overloaded during loading i.e. when compressor motor is ON. During unloading when compressor motor is OFF, the loading is found to be 44%.

Table 2.14: ***Measurements performed on the compres***sor

Loading Condition	Current (Amps)				Voltage (Volts)	PF	Actual Power (kW)	Rated Motor (HP)	Loading (%)
	R	Y	B	Average					
Unload	18	19	22	19.67	421	0.74	10.61	30	44.4
Load	35	34	38	35.67	420	0.91	23.61	30	105

▶ Recommendations

- Best Practice #3 (Compressor Leakage Test): It is strongly recommended to carry out leakage trail fortnightly to assess the leakage level and necessary actions to be taken if any (See ***Annexure 2***).
- Use of compressed air is higher at sand blasting section, but the reservoir is located far from this section. It is recommended to relocate the reservoir at a nearer place from sand blasting section to avoid sudden jerks and to operate smoothly.
- Locating the compressor away from heat source such as kilns and dryers would result I lower inlet temperature and reduced energy consumption
- Inlet Air filters to be cleaned regularly

- It is further suggested to install VFD in Compressor. Given below is the cost benefit for installation of VFD in Compressor. It can be seen from the table that by using VFD in Compressor energy saving upto 20,415 kWh / year can be achieved, which amounts to an energy saving of Rs 3.0 Lakhs / year.

Table 2.15: ***Cost Economic Analysis - Compressor***

SN	Energy Efficient Measure	Estimated Energy savings (kWh/Year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback period (Years)
1	Installation of VFD in Compressor	20,415	132,698	300,000	2.26

2.3.6 Exploring Opportunity for Renewable Energy Usage

During field visit, opportunities of using renewable energy applications were explored. Based on the process requirement observed in the unit, possibility of using solar thermal technology was explored. However, due to non-availability of area, this option was ruled out. Further, unit owner also rejected the idea of using renewable energy due to lesser anticipated savings against the cost and operational complexity associated with renewable energy interventions.

Annexure 1:

Best Operating Practice – Induction Furnace

Following are the best practices to be followed for efficient operation of induction furnaces

- Maintain log records of type and quantity of scrap material being used and electricity consumed for every charge
- Loading of scrap material should always be done till the induction furnace coil height.
- As far as possible, no overheating of material beyond the required temperature should be carried out as it directly consumes energy.
- Holding of furnace should be avoided by proper planning of moulds / shells in advance.
- Heel metal in the induction furnace should be avoided.
- During pouring and scrap composition measurement, power supply to the induction furnace should be reduced to around 25% of the full capacity.

Annexure 2:

Best Operating Practice

COMPRESSOR LEAKAGE TRIAL FORMAT

	(DATE) / (DAY) : (dd/mm/yyyy) / (day) …………………	
	START TIME (hh:mm): …………	END TIME (hh:mm): …………
	COMPRESSOR ID: ………………	CAPACITY: ……… CFM
	PRESSURE SETING : Max - ………. bar; Min - ………. bar	MOTOR: ……….. kW

	S. NO.	ON TIME				OFF TIME			
		START TIME	END TIME	AMPERE	ON TIME (MINS)	START TIME	END TIME	AMPERE	OFF TIME (MINS)
	(A)	(B)	(C)	(D)	(E) = (C) - (B)	(F)	(G)	(H)	(I) = (G) - (F)
	1								
	2								
	3								
	4								
	5								
	6								
	7								
	8								
	9								
	10								
			Average				**Average**		

Percentage Leakage Calculation:

Total Cycle Time = (E) + (I)

Percentage Leakage = { (E) X 100 }/ { (E) + (I) }

Interpretation:

If percentage leakage is below 10% "Well Maintained System"

If percentage leakage is between 10 ~ 20% "Average Maintained System" - Requires leakage plugging

If percentage leakage is above 30% "Poorly Maintained System" - Requires immediate leakage plugging

NOTE :

1 : READING SHOULDBE TAKEN WITH BALL VALVES AT OPEN POSITION

2 : READING SHOULD BE CONSISTENT