National Program

on

Promoting Energy Efficiency and Renewable Energy in MSME Clusters in India

Indore Foundry Cluster

Detailed Energy Audit Report
Porwal Auto Components Ltd.

Submitted to

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Contents

List of Tables

List of Figures

Abbreviations

APFC	Automatic Power Factor Controller
BEE	Bureau of Energy Efficiency
CT	Cooling Tower
CI	Caste Iron
CRC	Cold Rolled Coil
CO_2	Carbon Di-oxide
FRPB	Fiber Reinforced Plastic Blades
GEF	Global Environment Facility
GI	Grey Iron
HP	Horse Power
kcal	Kilo Calories
kg	Kilogram
kVA	Kilo Volt Ampere
kW	Kilo Watts
kWH	Kilo Watts Hour
kVAR	Kilo Volt Ampere Rating
MDC	Maximum Demand Controller
MSME	Ministry of Micro Small and Medium Enterprises
PF	Power Factor
PLC	Programmable Logic Controller
PG	Pig Iron
RR	Runner Riser
SEB	State Electricity Board
SEC	Specific Energy Consumption
SME	Small and Medium Enterprise
SS	Stainless Steel
SG	Spheroidal Graphite
TOD	Time of Day
THD	Total Harmonics Distortion
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 : Porwal Auto Components Ltd.

Location of the SME unit : 209 & 215, Sector -1, Industrial Area, Pithampur, 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 best practices measures in different sections are discussed below:

Table 1: *Cost Economic Analysis*

SN	Energy Efficient Measures	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Year)
1	Installation of capacitors across motors having low power factor	3,160,000	150,000	0.05
2	Avoiding super heating of metals in the Induction Furnace	830,293	Nil	NA
3	Installation of timers in Cooling Towers	51,408	20,000	0.39
4	Replacement of cooling tower fan blades with fiber reinforced plastic blades	51,408	50,000	1.0
5	Reducing Energy Loss due to Leakage in Compressor	2,504,000	Nil	NA
6	Installation of Variable Frequency Drive (VFD) in Compressor	1,687,562	300,000	0.18

▸ Electrical Panels:

The unit has installed three separate transformers of 780, 1725 and 900 kVA rating. 780 kVA & 1725 kVA transformer is used to directly supply electricity to the induction furnace, whereas, 900 kVA transformer is used to cater electricity requirements of other loads. It was observed that there is provision of switching off the power supply from the mains to the transformer when the furnace is not in operation. The Contract Demand of the unit is 2,800 KVA and it is observed that the demand exceeds the contracted value over a period of time. It is therefore suggested to install Maximum Demand Controller (MDC) so as not to exceed the contracted Maximum Demand Limit by shedding off non critical loads.

▸ Induction Furnace:

Induction furnace is the most energy intensive equipment being used in the unit. There were many deficiencies observed in the current operation practice including scrap loading above coil level, reduction in melting capacity by replacing a smaller size crucible, whereas, the power supply and the axillary equipment was not replaced, it was also found that the furnace had many a times higher holding time due to non-availability of moulds, laddle waiting for metal and super heating of metals, practice of keeping heel metal, etc. Based on the observations and measurements detailed recommendations are made.

- It is suggested that the overfilling above the furnace coil height should be avoided to save energy and time to melt.

- The furnace operator had the practice of keeping heel metal of 10~15% of the capacity of the furnace and carried forward with every heat. This does not lead to easy melting but rather wastage of energy. It is therefore suggested to avoid this practice.
- It is recommended to install timers in cooling towers to automatically switch off the cooling tower at pre-set time.
- The use of FRP blades instead of metallic/aluminium blades will save energy and improve the performance of the cooling towers owing to the better aerodynamic shape of its blades.
- The harmonics generated by the furnace have been measured by Power Quality Analyzer and the Total Harmonic Distortion (THD) in the unit was found to be around 10 to 11 %. Harmonics can lead to power system inefficiencies like conductor heating, capacitor rapture, excessive overheating in the transformer windings, meters may record measurements incorrectly. It is suggested to install Harmonic filters to reduce Harmonics within the limits. The unit should include a system evaluation, including a harmonic distortion analysis, while planning facility construction or expansion

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 100 HP and operated depending on requirements. There are motors in the cooling circuit of the induction furnace, sand mixing area, shot blasting area. It was observed that most of the motors are under loaded with low power factor. It is also suggested to install capacitor banks in selected motors to improve the power factor. By installing capacitor banks across motors having low power factor energy saving of the order of 4.21 lakh kWh can be achieved accounting to annual monitory saving of Rs. 31.6 lakhs with investment of around Rs.1.5 Lakhs and payback period of only 1 month. It is also recommended to replace the oversized 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.

Compressors:

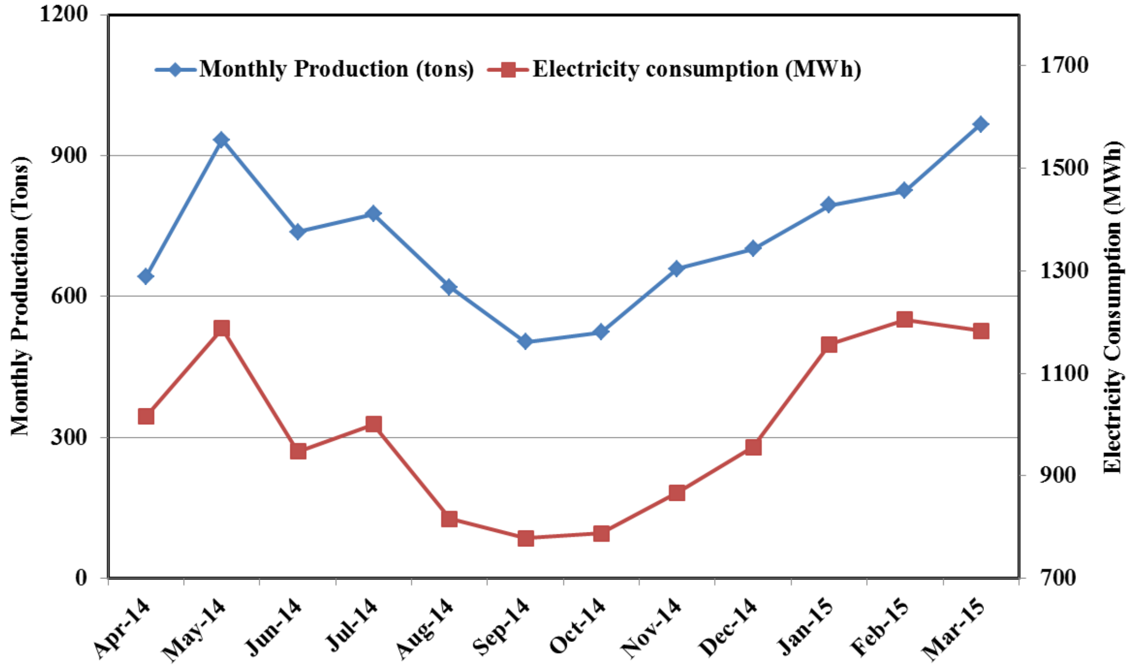
The unit has installed air compressor to use compressed air for sand coating, fettling, induction furnace and sand blasting section. During field visit leakage test of the compressor was carried out and it was observed that the percentage leakage was around 36.3% which contributes to significant energy loss; it is therefore strongly recommended to carry out leakage trail fortnightly to assess the leakage level and necessary actions to be taken if any. It has been observed that by reducing leakage energy saving of the order of 3.34 lakh kWh can be achieved accounting to annual monitory saving of Rs. 25 lakhs with no investment. Further, suggestion regarding relocation of one reservoir nearer to sand blasting section is made to avoid sudden jerks and to operate smoothly.

Introduction

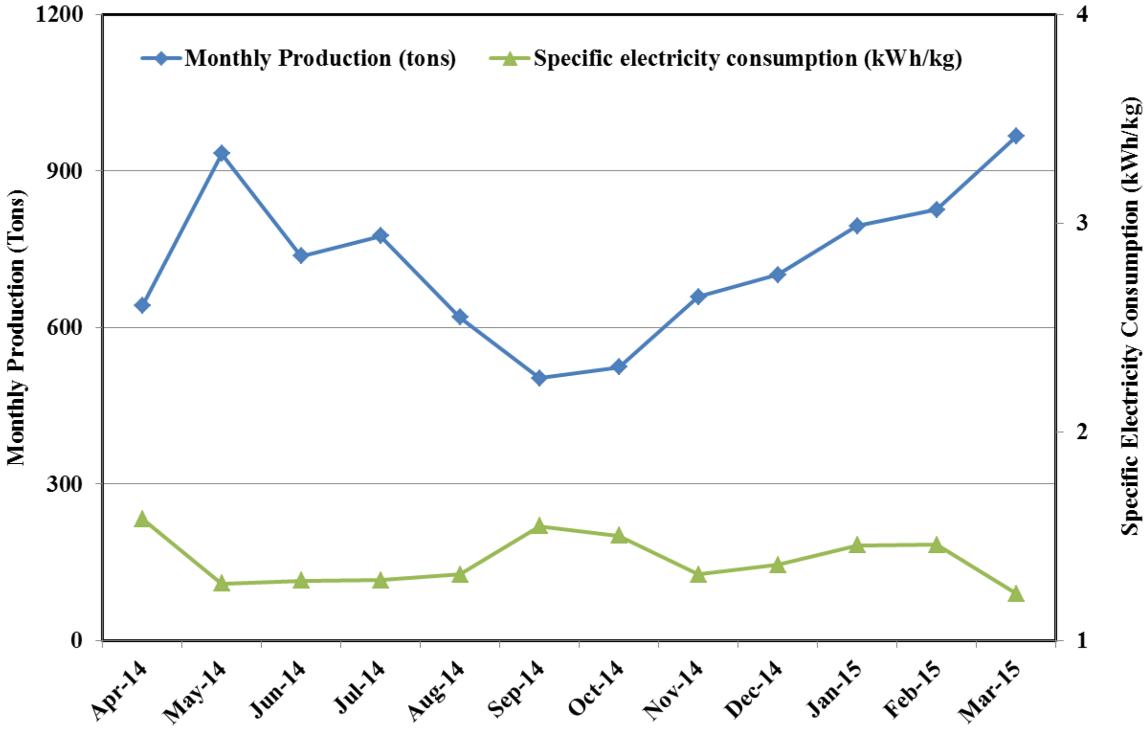
1.1 ABOUT THE UNIT

Porwal Auto Components Ltd. (PACL) is involved in the manufacturing of a variety of Ductile Iron, Grey Cast Iron Steel and Steel Alloy, Casting Components and Sub-assemblies. The unit was incorporated in the year 1995 and caters to the various sectors including Automobile, Engineering, Pumps and Valves, Agriculture and Tractor equipment, Construction Equipment, Machine Tools, Railways etc. Further details of the unit are provided in Table 1.1.

The monthly production of the Unit is around 723 tons. The Unit uses electricity supply from SEBs for various process and utility applications in premises and diesel for sand drying application. Figure 1.1 depicts monthly electricity consumption vis-à-vis total monthly production of the unit for last one year. The Unit has installed VFD, and power factor controller to reduce energy bill.



(a) – Monthly variation of production and electricity consumption



(b) – Monthly variation of production and specific electricity consumption

Figure 1.1: ***Electricity consumption and production details***

Inference: It can be observed from the above figures that the monthly energy consumption is directly proportional to the production for a month. However, specific energy consumption is inversely proportional to the production. Lower the productivity of the plant, higher is the specific electricity consumption. This implies that lower productivity means lower utilization of the equipment thus leading to higher downtime and high specific energy consumption.

However, as observed in Fig a and b above, anomalies in direct relationship between production and electricity consumption can be observed in certain months like March 2015 and February 2014. For the month of March 2014, the unit has a low production and a high energy consumption and reverse in the month of February 2014, wherein the unit has a high production with low energy consumption. These anomalies can be related to reasons such as lower productivity due to low demand, idle running of machines, higher rate of rejections, lower utilization and high peak hour operations.

Major electricity consumption is required by electrical induction furnace for scrap melting operation. Unit has installed two induction furnace of 1500 kW (dual track, 2 ton capacity) and 650 kW (1 ton capacity) respectively. Unit uses diesel for sand drying application. The monthly consumption of diesel is observed to be around 3,000 liters. According to the assessment of the energy consumption data collected, the specific thermal energy consumption and specific electrical energy consumption is 0.004 Liters per kg and 1.37 kWh per kg of product respectively. The total specific energy consumption (in kCal) is 1216.7 kCal per kg of product. Details of annual electrical and thermal energy consumption and specific energy consumption in M/s Porwal Auto Components Ltd. are presented in table1.1 below:

Table 1.1: ***Details of Porwal Auto Components Ltd.***

SN	Parameter	Value	Unit
1	Name and address of unit	Porwal Auto Components Ltd., 209 & 215, Sector -1, Industrial Area Pithampur, Madhya Pradesh	
2	Contact person	Mr. Guduru Murali, 07292-421300	
3	Manufacturing product	Casting Components for Automobile and Engg. Industries in S.G. Iron, Gray Iron & Plain carbon steels	
4	Production	723 tons per month	
	Energy utilization		
5	Average monthly electrical energy consumption	991,722	kWh per month
6	Average monthly thermal (Diesel energy consumption)	2,991	Liters per month
7	Average thermal specific energy consumption	0.004	Liter /kg of product
		38.5	kCal/kg of product
8	Electrical specific energy consumption	1.37	kWh/kg of product
		1178.22	kCal/kg of product
9	Specific energy consumption	1216.7	kCal/kg of product
10	Electrical energy cost	12.6	Rs/kg of product
11	Thermal energy cost	0.2	Rs/kg of product
12	Total energy cost	12.8	Rs/kg of product

Note:

Specific gross calorific value of Diesel is considered as 9300 kCal / liters

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

Cost of Diesel = Rs. 58 per liters (the purchase price provided by the unit)

Cost of Electricity = Rs. 9.2 per unit (average cost calculated from electricity bills of last three months)

Figure 1.2 and Figure 1.3 provides annual energy mix for both electrical and thermal energy on cost as well as kCal basis. It can be observed that the share of thermal energy is very low (3%) as compared to electrical energy (97%) as thermal energy (diesel) is used only in the diesel furnace for sand drying purpose.

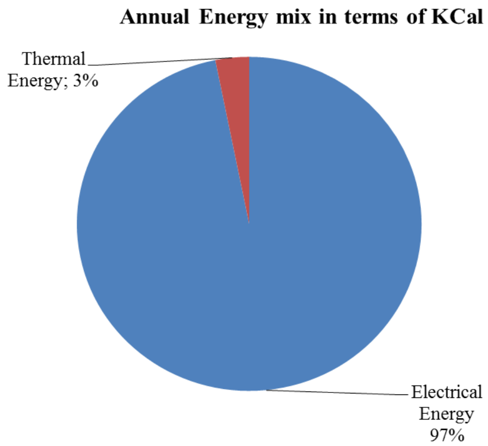


Figure 1.2: ***Annual energy mix (%) in terms of kCal***

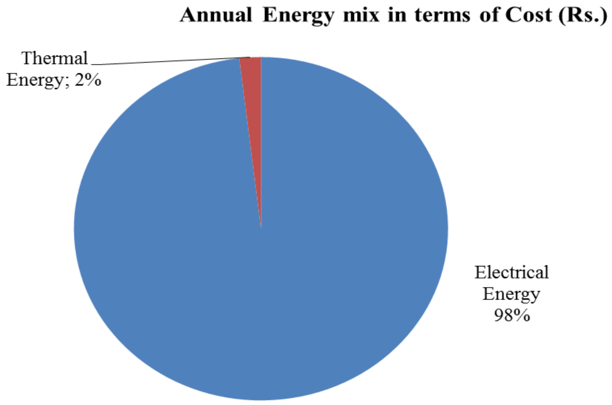


Figure 1.3: ***Annual energy mix (%) in terms of Rupees***

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 1.4 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. A copy of the same questionnaire is attached as ***Annexure 1***. 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.

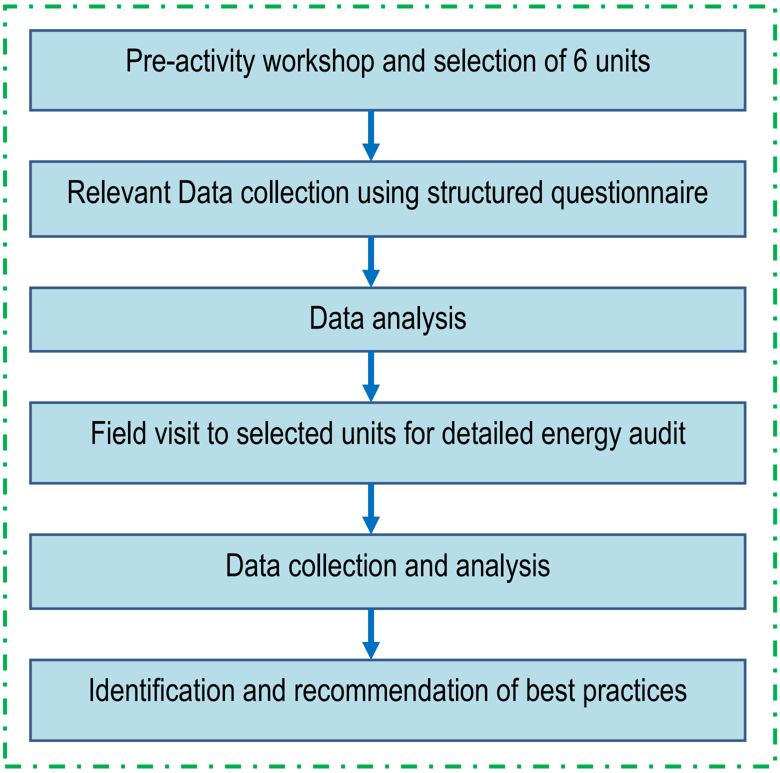


Figure 1.4: ***Flowchart depicting sequence of activities followed for carrying out detailed energy audit***

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 operation in the Unit can be majorly classified 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:**

Cores are placed into a mould cavity to form the interior surfaces of castings. Thus the void space is filled with molten metal and eventually becomes the casting. The key steps to be followed in the core preparation process include sand preparation, core preparation, core dressing and core inspection. The process of core preparation starts with sand preparation. Unit uses silica sand which can withstand temperature of around 1700^0C. The sand is initially checked for its silica content, size and moisture content. This sand is used both for core making as well as moulding section. The sand which is being used in core section is subjected to drying if required.

For sand drying, either it is dried naturally and/or diesel fired furnace is used. This drying process reduces the moisture content from 4% to 0.3%. Further details of the system are compiled in Table 2.1. After sand drying, sand is pumped to core shop where it is mixed in Programmable Logic Controller (PLC) controlled hopper with sodium silicate to improve strength and adhesiveness. Using this sand core of required shapes are prepared after passing CO_2 from it to acquire required hardness. Further core painting, dressing and inspection of the sand core are carried out. Inspection of surface finish is important as even small irregularity in the surface may cause problem during metal pouring. Sometimes these sand cores are subjected to heating to remove moisture content from it.

The unit has facilities for core box filling, cold box and no-bake process for sand core making and uses these process based on product requirement.

- **Moulding:**

Moulding is 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.

In this process, sand mixing consumes significant amount of electrical energy for mixing. The sand from knock out is recycled back to the hoppers using conveyors after passing it through sand coolers. 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 and composition of this sand is continuously monitored from control room and the sand is recycled without using if not found suitable. Further details related to electrical energy consumption are summarized in Table 2.1.

- **Melting:**

In this process, scrap material is melted using an electrical induction furnace. There are two induction furnaces with dual track mode installed in the unit to carry out melting operation. The energy consumption details of the induction furnace along with observations are present in the later section. The furnace temperature is increased to around 1500^{0}C during heating to melt the scrap. 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 using spectrometer and accordingly if required, correction is made to bring required composition of molten metal.

The melting 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 molten metal temperature.

- **Metal Pouring:**

In this step, molten metal from induction furnace is poured in the moulds from the furnace. Before pouring, laddle is pre-heated to ensure quality; normally temperature is measured before pouring. The temperature drop in the molten material from furnace to mould is observed in the range of 100^{0}C for Spheroidal Graphite (S.G) material and 50 to 60^{0}C for Caste Iron (C.I) material. After pouring, mould is left for natural cooling for around 1.5 hours.

- **Knockout:**

In this step, the mould containing solid metal is broken to remove sand and get the foundry casting product. This process is achieved using a vibrator operated by an electrical motor. The sand removed in this process is recycled back to moulding and the casting is 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 blast 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 grinding to remove residues from the surface of the products. Depending upon the size and design of the casting both pneumatic and electrical grinding machines are used. Further based on the requirement of surface finish, some products may again be subjected to shot blasting operation.

- **Painting and Dispatch:**

Casting products received after fettling and grinding process are inspected for their accuracy and defects, send for final painting and dispatch if found suitable. Most of the casting products are sent outside for painting operation due to space constrained. However, around 20% of the castings are painted in house. These castings are first cleaned using compressed air and then painting is carried out. After painting casting products are subjected to 4 to 6 hours of drying. Finally, the casting products are sent for dispatch.

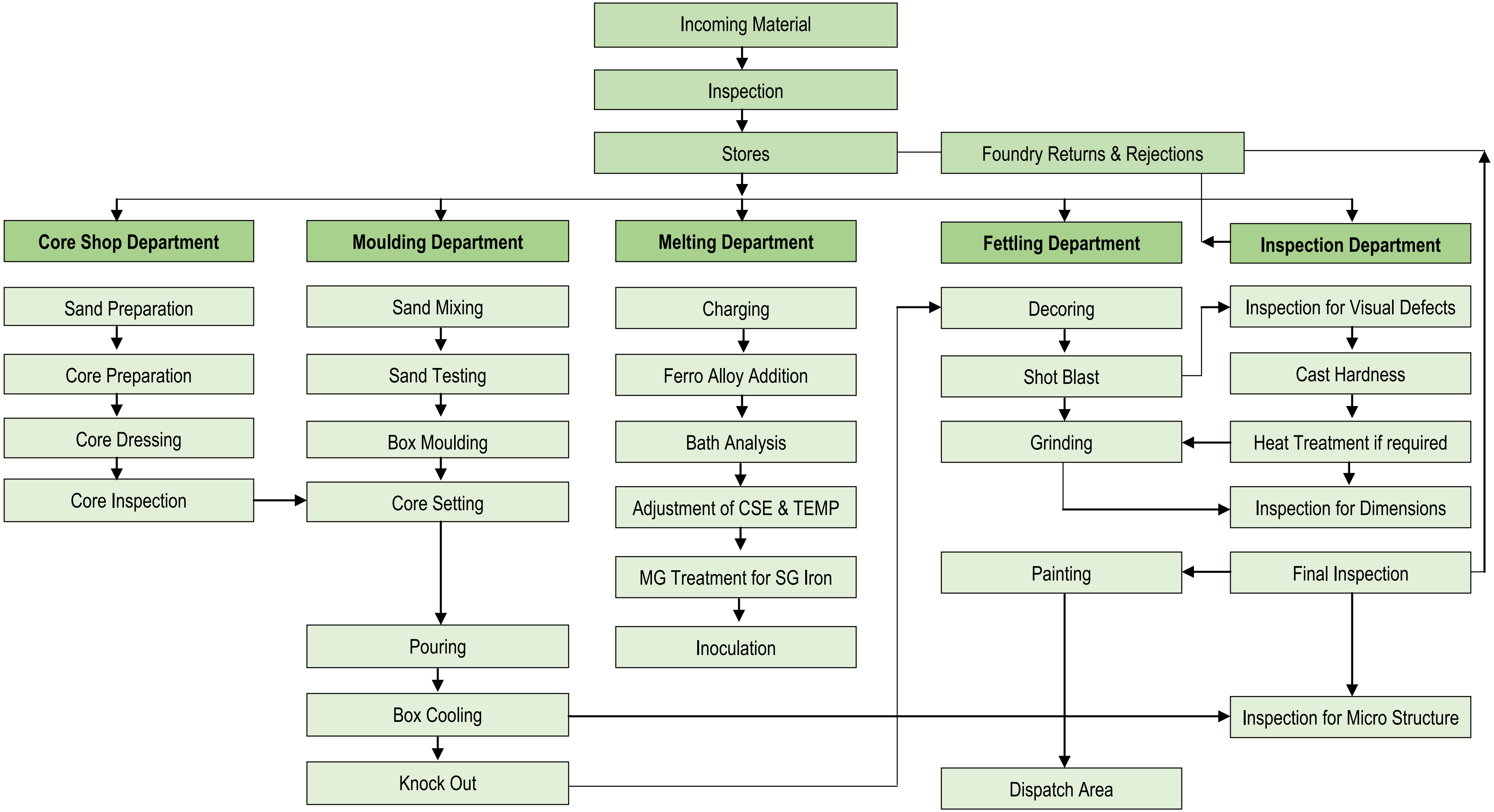


Figure 2.1: *Process flow diagram*

Pictorial Representation of Production Process

Figure 2.2: ***Silica sand being used for moulding and core making process***

Figure 2.3: ***Sand dryer for reducing moisture content of the sand***

Figure 2.4: ***Sand mixer and pumping machine***

Figure 2.5: ***Core making in progress***

Figure 2.6: ***Sand cores of different shapes being manufactured***

Figure 2.7: ***Final sand cores after performing finishing and painting operations***

Figure 2.8: ***Melting of scrap material in the furnace***

Figure 2.9: ***Transfer of molten metal from furnace to laddle***

Figure 2.10: ***Laddle containing molten metal***

Figure 2.11: ***Sand moulding in progress***

Figure 2.12: ***Half Sand mould containing required cavity***

Figure 2.13: ***Pouring of molten metal***

Figure 2.14: ***Sand moulds after metal pouring***

Figure 2.15: ***Manual de-coring of castings***

Figure 2.16: ***Casting before sand blasting operation***

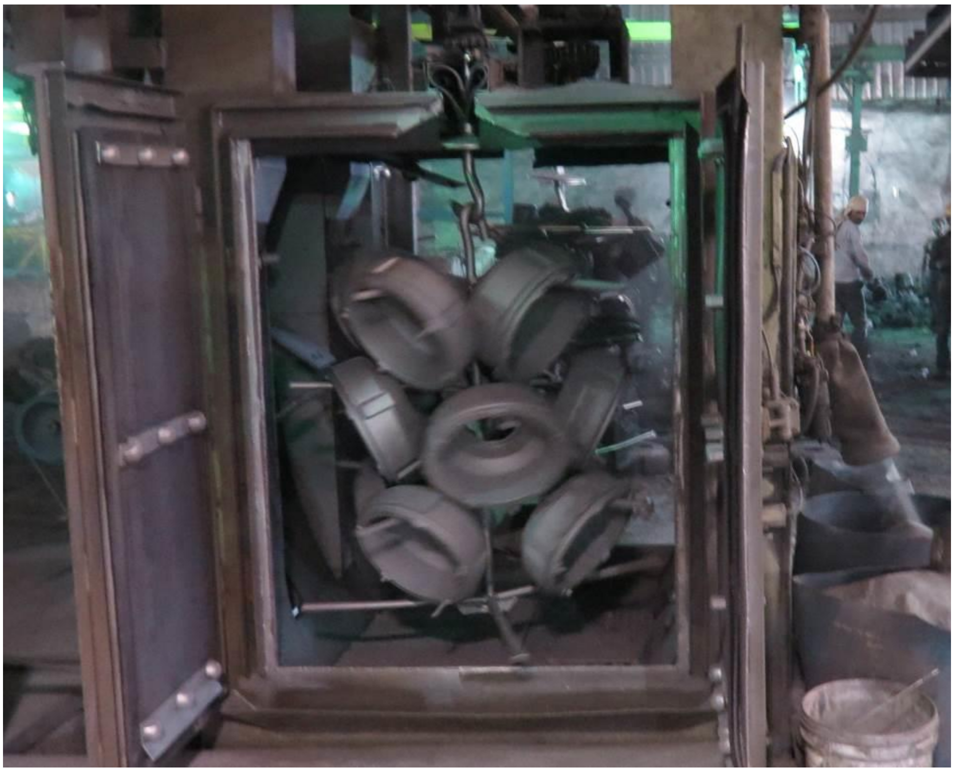


Figure 2.17: ***Casting after sand blasting operation***

Figure 2.18: ***Grinding of the casting***

Figure 2.19: ***Grinding of casting using pneumatic tool***

Figure 2.20: ***Final casting after painting***

2.2 PRESENT TECHNOLOGIES ADOPTED

Details related to type of energy being used, electrical ratings, hours of operation, capacity of key electrical equipment is provided in the Table 2.1 below.

Table 2.1: ***Process wise installed capacity of equipment***

SN	Process	Number	Energy Source	Rated Consumption	Hrs of operation per day	Days per month	Capacity	Remarks
1	Sand Drying	1	Thermal – Diesel	6 - 7 ltrs/hr	10-15 hrs (Rainy season)	20	1500 – 1800 kg/hr	Moisture content to be reduced from 4% to 0.3%.
2	Sand Mixer (Moulding section)	2	Electrical - Motor	75 HP; 25 HP	24 hrs	20	80 Tons	Composition of moulding sand is important
3	Induction Furnace	02	Electricity	1500 kW; 650 kW	24 hrs	20	2 tones for 1500 kW; 1 ton for 650 kW	Temperature and composition of molten metal is important
4	Knock out	03	Electrical – Motor for vibration	7.5 HP each	24 hrs (2 lines); 12 hrs (1 line)	20	Mould used for daily production are knocked out	Not so critical as remaining sand is removed in subsequent sections
5	Shot Blast	02	Electricity	50 HP (Shot blast 1); 35 HP (Shot blast 2)	12 hrs	20	500 kgs of casting per charge	Per charge takes around 5 mins.
6	Compressor	03	Electrical	200 HP; 150 HP; 100 HP	24 hrs (200 HP); during maintenance (100 HP)	20		One compressor of 200 HP is operated to meet compressed air demand.

2.3 DETAILED ENERGY AUDIT

During the field visit 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 contract demand of unit is 2,800 kVA. The unit has got connected load of 4,109 kVA. The unit has installed three separate transformers of 780, 1,725 and 900 kVA. The transformers (780 kVA & 1725 kVA) is used to directly supply electricity to the induction furnace, whereas, other one (900kVA) is used to cater electricity requirements of other loads in the unit. The unit has installed Automatic Power Factor Controller (APFC). The unit has installed separate energy meter to record power consumption for induction furnace.

Figure 2.21: ***Pictorial depiction of transformers and power capacitor installed***

▶ Observation

The unit has 24 hours operation working in two shifts. Apart from regular consumption tariff, the State Electricity Board (SEB) has time of day (TOD) tariff – a rebate of 7.5% is provided for operations between 10 pm to 6 am and a penalty of 15% is levied for electricity usage between 6 pm to 10 pm. It is observed from the Electricity bills that the total monthly maximum demand of the unit is often exceeds the contract demand value of 2,800 kVA. Further, Unit has installed automatic power factor controller because of which the PF of the unit is observed to be higher (close to unity).

It was found that unit has made provision for disconnecting main supply to the transformer when the furnaces are not in operation. This arrangement avoids dead energy loss in transformer even when the system is not operational.

The harmonics generated by the furnace have been investigated, measurements were carried out by Power Analyzer and the Total Harmonic Distortion (THD) in the unit was found to be around 10 to 11 %. This high value of THD may be due to the presence of two induction furnaces requiring electricity at high voltage and frequency.

Harmonics cause damage of the electric components in the unit and leads to the higher maintenance costs. In order to reduce the harmonic impacts, there is a need to eliminate or reduce the harmonics under the standard limitations by means of passive filters. Based on the observation made regarding THD values in the unit, it is suggested to install harmonic filters to reduce THD within the limits.

2.3.2 Induction Furnace

The unit has installed 2 tons dual track induction furnace (1500 kW) and another 1 ton induction furnace (650 kW). Both the furnaces are Inductotherm make. The advantage of the induction furnace is a clean, energy-efficient and well-controllable melting process compared to most other means of metal melting. The dual track induction furnace, which has one power supply supporting two furnaces simultaneously. And one of these furnaces is used for melting and the other controls the temperature for pouring and heat preservation purposes. The 2 ton dual track furnace earlier was of 3 ton capacity, the melting capacity was reduced to 2 tons to manage the capacity of pouring and moulding lines. The melting capacity was reduced by replacing a smaller size crucible, whereas the power supply and the axillary equipment were not replaced.

The furnace is operated in two extended shift, namely, "A" and "B", covering 24 hour operations. Weekly off is observed on Saturday. On a sample basis during the study four days melting log book details has been taken out and analysis was carried out. It is observed that during a normal day operation the unit is able to take around 13 to 14 melt per shift and the liquid metal produced is in the range of 28 to 30 tons per shift.

The average furnace loading is 2.11 tons, which is above the capacity of the furnace crucible (2 tons). It was also observed during the study visit; the furnace operators have the habit of over filling above the induction coil level to about 6 to 8 inches. On discussion with the furnace operators it was revealed that the overfilling is practiced to enhance the production. In induction melting technology, the heat transfer mechanism takes place from coil to change / melt via induction till the coil height and above the induction coil height, heat transfer takes place from melt to melt (or metal to metal) via conduction instead of coil to metal. The overfilling has couple of disadvantages; firstly it takes more time to heat (or melt) the metal / charge above induction coil height and secondly, it takes more energy (or SEC) to melt the metal due to conduction heat transfer. The coil height filling would take less time to melt thus allowing more number of heats for day resulting in more production. A specific case of overfilling above the induction coil was recorded on 13th June 2015, the overfilling was of 6 inches above the coil height and the total charge was 2,350 kgs, around 350 kgs more than the furnace capacity (see table 2.2).

It was suggested that the overfilling above the furnace coil height should be avoided to save energy and time to melt. This suggestion was well accepted by the management and was immediately implemented.

Table 2.2: ***Analysis of Melting Log Book***

Date	Shift - wise Production and SEC					Day - wise Production and SEC			Remarks
	Shift	Nos. of Heat taken	Shift Production (Tons)	SEC (kWh/ Tons)	Furnace Loading (Tons / heat)	Nos. of Heat taken	Shift Production (Tons)	SEC (kWh/ Tons)	
09/6/2015	A	14	28.33	641	2.02	28	55.83	644	
	B	14	27.5	647	1.96				
10/6/2015	A	11	21.3	644	1.94	23	46.6	634	Grid power cut for 200 min
	B	12	25.3	626	2.11				Grid power cut for 55 min
11/6/2015	A	14	30	641	2.14	27	58.5	627	
	B	13	28.5	612	2.19				
12/6/2015	A	13	30	611	2.31	27	60.5	614	
	B	14	30.5	618	2.18				
Average		**13.13**	**27.68**	**630**	**2.11**	**26.25**	**55.36**	**630**	

The SEC is 630 kWH per ton of liquid metal. The lowest and highest SEC recorded was 611 and 647 respectively. This SEC is better off than various other melting units in Indore. The study team carried out performance assessment of the induction furnace on 12th June 2015 shifts "B" and found that the SEC was 615 kWh per ton.

It was found that the furnace had many a times higher holding time due to non-availability of moulds, laddle waiting for metal and super heating of metals. Non-availability of moulds was recorded on 12th June 2015 at heat no 199; the liquid metal was ready 7:35 am and was waiting for moulds to come till 9:05 am, around 90 minutes. During this time the furnace was put on holding (with 25% of power) wasting 562 kWh, which is nearer to SEC required for a heat. In another incident it was observed that the metal was overheated (or superheated) by almost 100OC and then cooled off to the required pouring temperature. The metal overheating resulted in use of more energy which was cooled by pouring the liquid metal from one laddle to another one. It took 20 minutes to bring down the required temperature; as a result, the production was lowered. Given below is the cost benefit for avoiding overheating of metals in the induction furnace. It can be seen from the table 2.3 that by avoiding superheating of metal in the furnace energy saving upto 1.1 Lakhs kWh per year can be achieved, which amounts to an energy saving of Rs 8.3 Lakhs per annum.

Table 2.3: ***Cost Economic Analysis – Avoid Super Heating***

SN	Energy Efficient Measure	Estimated Energy savings (kWh/Year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Year)
1	Avoiding super heating of metals in the Induction Furnace	110,706	830,293	Nil	Immediate

The unit has standardized the percentage (or quantity) of charged metal as well as the sequence in which the charge would be put in furnace to melt. This is one of the good practices found adopted by the unit. The quantity / percentage of charge and sequence of charge for Grey Iron (GI) and SG 400 are provided in Table 2.4 and Table 2.5.

Table 2.4: ***Percentage and Quantity of Various Charges – Grey Iron***

SN	Type of Charge	%age	Quantity (in Kg)
1	Pig Iron (PI)	5	100
2	Spillage	25	500
3	Runner Riser (RR) Rejection	25	500
4	Boring	20	400
5	CRC Scrap	25	500
	Total	**100**	**2,000**

The sequence of charge to produce Grey Iron (GI) of 2 tons is Pig Iron (100 kgs), both spillages (500 kgs) and RR rejection (500 kgs) simultaneously, followed by boring (400 kgs) and finally Cold Rolled Coil (CRC) scrap (500 kgs).

Table 2.5: ***Percentage and Quantity of Various Charges – SG 400***

SN	Type of Charge	%age	Quantity (in Kg)
1	CRC Scrap	55	1100
2	Pipe Scrap	15	300
3	RR Rejection	30	600
	Total	**100**	**2,000**

The sequence of charge to produce SG 400 of 2 tons is CRC scrap around 100 kgs, pipe scrap (300 kgs), RR rejection (600 kgs) and finally the CRC (1000 kgs) remains.

The unit has installed 3 bundling hydraulic machines of capacity 8 ~ 9 tons per hour to condense the metal sheet scrap. This helps to reduce the scrap volume and enhance the density, also helps in putting the scrap at one time. It reduces the SEC and saves time to melt.

The furnace operator had the practice of keeping heel metal of 10~15% of the furnace capacity. It is kept and carried forward with every heat. While discussion with the furnace operator, suggested that it helps in melting the charge when actually, the heel metal does not help in accelerating the melt. On discussion with the management, the prevailing practice of keep heel metal was discussed and management decided to avoid keeping forced heel metal.

The use of furnace lid was not noticed. On inquiring, it was found that the supplier had provided furnace lid cover along with the furnace but due to poor workmanship the lids are not being used. It is proposed to use the lid cover atleast when the furnace is on hold for either sample checks, or any other unavoidable reasons. This will reduce the heat transfer from the furnace mouth requiring less holding power.

2.3.3 Cooling Circuit for Induction Furnace

Present Arrangement

Induction furnaces of all types and sizes normally are cooled by water flowing through the furnaces' coils, which are made of heavy copper tubing. These coils generate high levels of heat, principally from the enormous electrical currents flowing through them even Induction power supplies require water cooling of their electrical components. Without an effective cooling system, induction furnaces will trip. In the present arrangement, heat of the water coming from coil is exchanged with cold water coming from heat exchanger using a plate heat exchanger. There are two separate circuits for cooling of hot water coming from furnace power supply panel and coils using two plate type heat exchangers. The cooling circuit is shown in Figure 2.22. Each pump in the cooling circuit has got one stand-by to restore operation in case of any break-down. The cooling water circuit in the unit is slightly different from the one provided by Inductotherm. In order to avoid any damage, maximum temperature limits for the water flowing in the coil has been set beyond which system automatically shuts off.

Observation

Measurement related to motor loading for different motors being used in the cooling circuit was carried out. Further, temperature of different streams across heat exchanger was also monitored. The results are summarized in Table 2.6 and Figure 2.22. Based on the temperature values, it is observed that heat exchangers are working fine. All the pumps were found to have loading in the range of 70 to 85%. However, PF across all the motor pumps was in the range of 0.61 to 0.65.

Table 2.6: ***Measurements of Loading of Cooling Water Motors / Pumps***

Pump Details	Current (Amps)				Voltage (Volts)	PF	Actual Power (kW)	Rated Motor HP	Loading (%)
	R	Y	B	Average					
Pump for circulating water through Furnace supply panel	12.41	12.23	12.54	12.39	410	0.62	5.46	10	73.14
Pump for circulating water through Furnace coil	18.03	18.08	17.59	17.90	410	0.64	8.14	15	72.70
Cooling tower pump for Coil Cooling	11.26	11.63	11.24	11.38	411	0.62	5.02	10	67.31
Cooling tower pump for Panel Cooling	10.44	11.67	10.59	10.90	409	0.63	4.86	7.5	86.94
Cooling tower fan motor	9.74	10.01	10.72	10.16	415	0.65	4.75	7.5	84.81

Note: ^ the pf recorded in 3 phases were, 0.83, 0.92 and 0.09. In one phase the pf was observed very low (0.09)

the pf recorded in 3 phases were, 0.78, 0.95 and 0.14. In one phase the pf was observed very low (0.14)

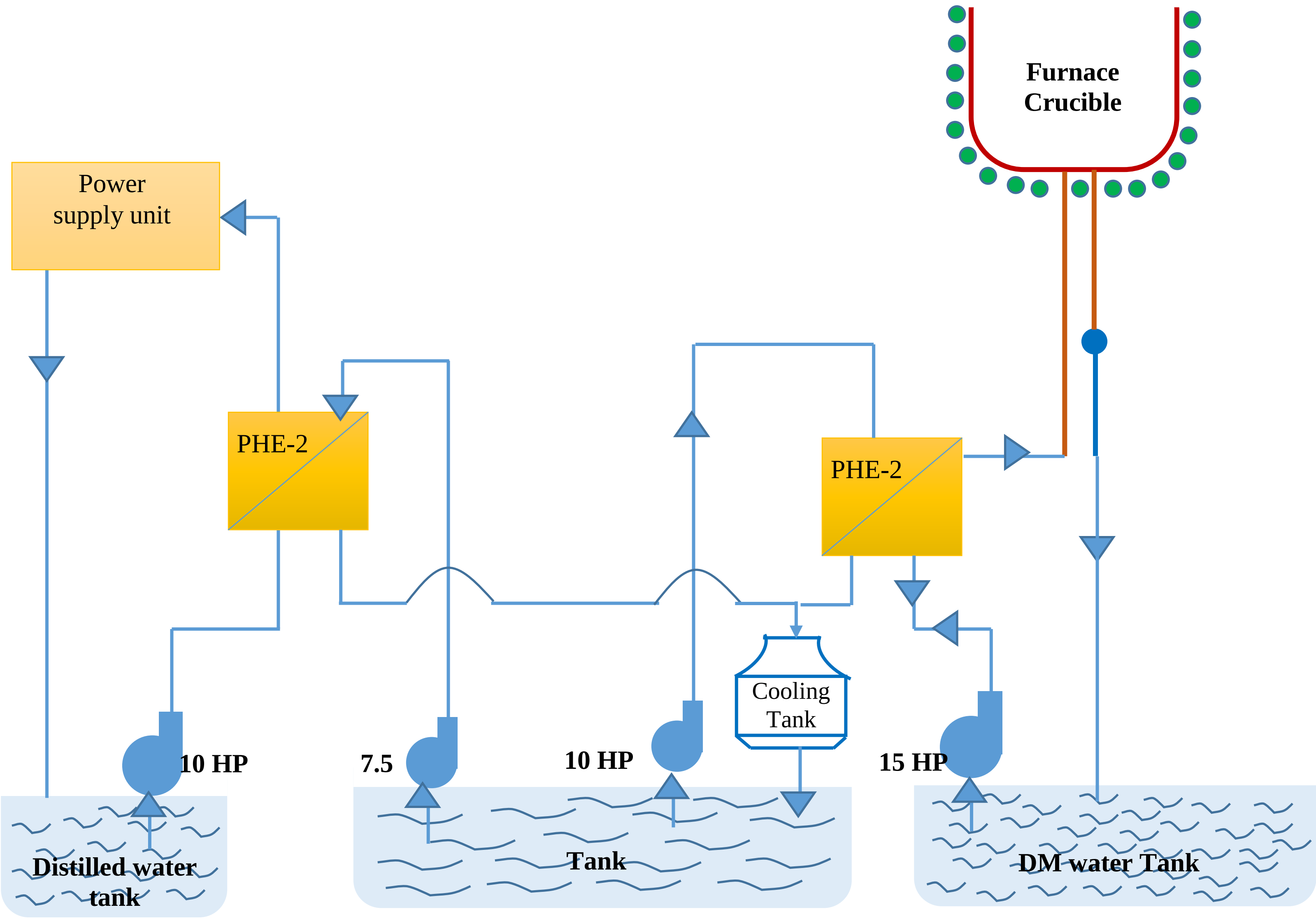


Figure 2.22: *Flow diagram of cooling circuit*

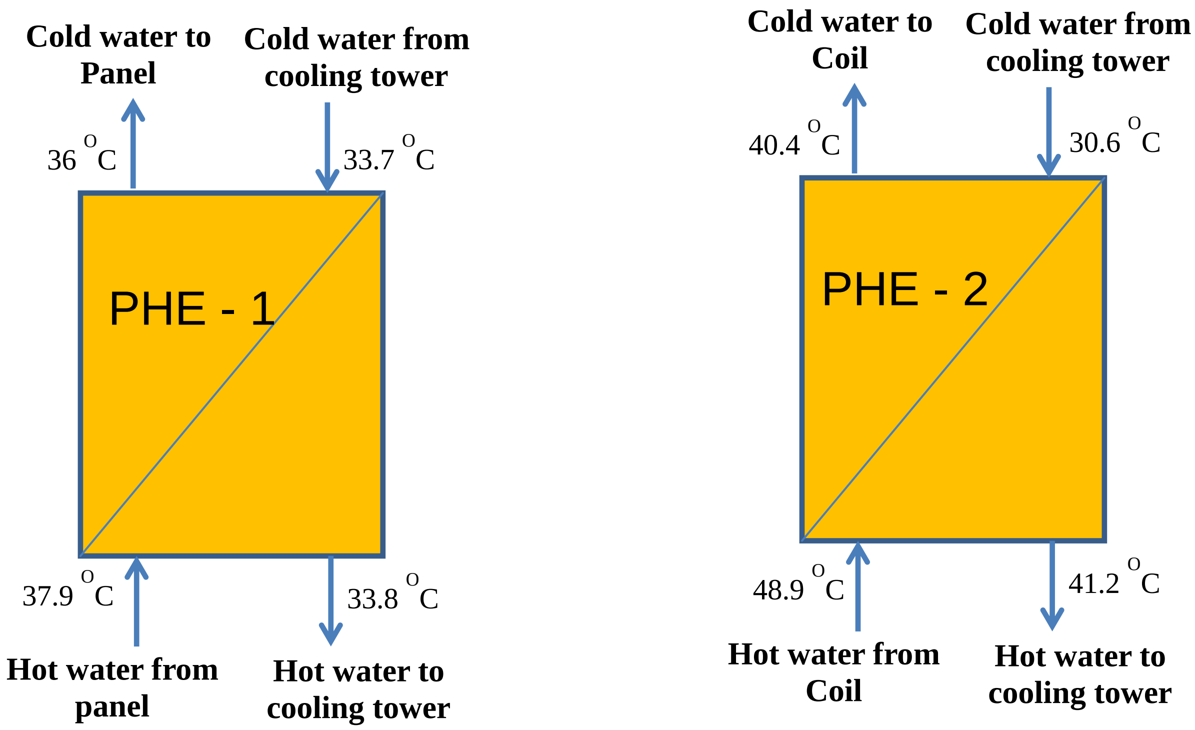


Figure 2.23: *Temperature measurement across heat exchangers*

Figure 2.24: *Pumps and plate type heat exchanger being used in cooling circuit*

- **Recommendation**
  - It is suggested to install capacitors with individual motors to improve power factor of the pumps.
  - It is also recommended to install timers in cooling towers. The cost benefit analysis is given below : It can be seen from the table 2.7 that by installation of timers in cooling tower energy saving upto 6,854 kWh / year can be achieved, which amounts to an energy saving of Rs 0.514 Lakhs / year

Table 2.7: *Cost Economic Analysis – Timer for Cooling Tower*

SN	Energy Efficient Measure	Estimated Energy savings (kWh/Year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Year)
1	Installation of timers in Cooling Towers	6,854	51,408	20,000	0.39

The use of FRP blades instead of metallic/aluminium blades will save energy and improve the performance of the cooling towers owing to the better aerodynamic shape of its blades. The power measurements show that the fan with FRP blades consumes less power compared to the metallic blade fan. The difference in power consumption is around 25 to 30%. It is recommended to replace existing metallic/aluminium fan blades in the cooling tower with Fiber Reinforced Plastic Blades (FRPB).

Given below is the cost benefit for use fiber reinforced plastic blades in cooling tower fans. It can be seen from the table 2.8 that by using fiber reinforced plastic blades in cooling tower fans energy saving up to 6,854 kWh / year can be achieved, which amounts to an energy saving of Rs 0.51 Lakhs / year.

Table 2.8: *Cost Economic Analysis – FRP Blades for Cooling Tower*

SN	Energy Efficient Measure	Estimated Energy savings (kWh/Year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Year)
1	Replacement of cooling tower fan blades with fiber reinforced plastic blades	6,854	51,408	50,000	1.0

2.3.4 Electrical Motors

▶ Present System

Electrical motors of different sizes are employed in the unit to carry out different operations. A higher rating of electrical motors was observed in the moulding section, sand mixer, shot blast etc. In addition there are several electrical motors installed having capacity in the range of 7.5 to 100 HP.

▶ Observation

Motor loading analysis of the selected motors was carried out. The results are summarized in Table 2.10. From table it can be observed that most of the motors are under loaded. Electrical motors being used in knock out sections are highly under loaded. This under loading of motors significantly affects the efficiency of the motors. LPP motor being used in moulding section is slightly overloaded. During measurements, low PF was also observed for some of the motors. This low power factor may result into energy loss and increase maintenance costs with excessive heating of the motor.

▶ Recommendations

- It is suggested to replace the electrical motors having very low loading factor with appropriate size motors.

- For overloaded motors, it is suggested to provide overload protection. For electrical motors observed with low PF factor and of higher capacity, it is suggested to install capacitor bank to improve the PF. A detailed sheet including section wise Capacitor (kVAR) capacity for greater than 10 HP motors is attached as ***Annexure 4***. Given below is the cost benefit. It can be seen from the table 2.9 that by improving power factor in selected motor energy saving up to 4.2 Lakhs kWh / year can be achieved, which amounts to an energy saving of Rs. 31.6 Lakhs / year.

Table 2.9: ***Cost Economic Analysis – Installation of Capacitor***

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	421,635	3,160,000	150,000	0.05

Table 2.10: ***Summary of measurements performed on electrical motors***

SN	Section	Equipment Name	Current			Average Current	Voltage	Actual Power (kW)	Rated Motor HP	Rated Motor kW	% Loading	THD (%)	PF	Remarks
			R	Y	B									
1	Moulding	LPP Motor-1	136	137	128	133.67	410	85.43	100	74.6	114.51	10.34	0.90	Overloaded
2	Sand Plant	Knock Out-1 Motor-1	7	7	7	7.00	410	0.89	7.5	5.595	15.99	10.4	0.18	Highly under loaded
3	Sand Plant	Knock Out-1 Motor-2	7	8	7	7.33	412	0.89	7.5	5.595	15.90	9.93	0.17	Highly under loaded
4	Sand Plant	Sand Cooler HPML (Main Drive)	24	24	23	23.67	414	15.10	20	14.92	101.23	7.9	0.89	Overloaded
5	Sand Plant	Mixer (ARPA) Carousel	30	30	29	29.67	412	17.57	25	18.65	94.21	10.7	0.83	Overloaded
6	Sand Plant	Mixer (HPML) Carousel	27	27	26	26.67	410	15.53	25	18.65	83.26	10.7	0.82	Fine
7	Sand Plant	Belt Conveyor 7-1	5	5	5	5.00	410	1.49	7.5	5.595	26.65	-	0.42	Highly under loaded
8	Fettling	Short Blast-1 (Impeller Motor-1)	21	20	20	20.33	415	8.04	20	14.92	53.88	10.33	0.55	Slightly under loaded
9	Fettling	Short Blast-1 (Impeller Motor-2)	21	20	19	20.00	410	11.93	20	14.92	79.96	9.46	0.84	Fine
10	Line 1 (HPML)	Knock Out Motor-1	7	7	7	7.00	412	0.90	7.5	5.595	16.07	9.93	0.18	Highly under loaded
11	Line 1 (HPML)	Knock Out Motor-2	7	8	7	7.33	413	0.89	7.5	5.595	15.94	9.89	0.17	Highly under loaded
12	Scrap Yard	Bundling M/C 1 (Hydraulic Pump)	20	20	19	19.67	414	11.00	20	14.92	73.72	10.22	0.17	Fine
13	Dust Extraction System	DC 1 (Blower)	30	29	27	28.67	415	15.04	30	22.38	67.21	11.53	0.73	Fine

2.3.5 Compressor

Present System

The unit has installed three air compressors of 100 HP (Reciprocating type), 150 HP and 200 HP (both screw type) to meet compressed air demand. Out of these three compressors, 100 HP compressors is used only for maintenance activity. The 150 HP compressor is mostly being used as standby while 200 HP compressor is mostly used to fulfil compressed air demand of the unit. The compressed air is used in core shop, moulding section, induction furnace, fettling section and painting section.

Observation

Measurement of electrical parameters was carried out to estimate the percentage loading of 200 HP compressors, the detailed specifications of which are provided in Table 2.11. Measurement/observations are summarized in Table 2.12. Compressor leakage test could not be performed as the unit was in operation. However, a leakage test pro-forma was shared and training provided to the maintenance team to take readings when the compressor is not operating. Based on the information provided by the maintenance team regarding compressor leakage trail, the leakage percentage of the 200 HP compressor was found to be around 36%. This value of leakage is very high as for a well maintained system the leakage should be less than 10%. The best practices for compressor leakage trial format are attached as ***Annexure 2***. The detailed calculation of the leakage trail is attached as ***Annexure 3***.

Table 2.11: *Specifications of compressor*

Make	Godrej
Model	LS20S – 200 HAC
Serial number	38112020200
Capacity (ltrs/s)	96
Power requirement (HP)	200
Capacity (CFM)	950

Table 2.12: *Measurements performed on the compressor*

Loading Condition	Average Current (Amps)	Voltage (Volts)	Actual Power (kW)	Rated Motor kW (HP)	Loading (%)
Unload	118.39	416	82.74	149.2 (200)	55
Load	274.56	416	191.89	149.2 (200)	128

Based on the measured data, it is observed that compressor motor is overloaded (128%) during loading i.e. when compressor motor is ON. During unloading when compressor motor is OFF, the loading is found to be 55%.

Recommendations

- Based on the compressor leakage trial, it is suggested to plug-in leakage in the compressed air line to bring it below acceptable limits.
- It is strongly recommended to carry out leakage trail every week or fortnightly to assess the leakage level and necessary actions to be taken if any.

- This leakage reduction would also bring down the power consumption and thereby overloading of the system.

Given below in the table 2.13 is the cost benefit analysis for reducing leakage in the Compressor System. It can be seen from the table that the reduction in compressor leakage results in energy saving up to 3.34 Lakhs kWh / year which amounts to an energy saving of Rs 25 Lakhs / year.

Table 2.13: ***Cost Economic Analysis – Leakage Plug-in***

SN	Energy Efficient Measure	Estimated Energy savings (kWh/Year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Year)
1	Reducing Energy Loss due to Leakage in Compressor	333,913	2,504,000	No investment	NA

- 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 2.14 that by using VFD in Compressor energy saving upto 183,431 kWh / year can be achieved, which amounts to an energy saving of Rs 16.8 Lakhs / year.

Table 2.14: ***Cost Economic Analysis – Installing VFD***

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	183,431	1,687,562	300,000	0.18

2.3.6 Exploring Opportunity for Renewable Energy Usage

During field visit, opportunities of using renewable energy applications were explored. The unit is already generating solar power at a separate place and availing rebate on electricity bill. Hence, no additional recommendation on use of renewable energy is being given to the unit.

Annexure 1:

Questionnaire*

Energy Audit – Questionnaire Form

Promoting Energy Efficiency and Renewable Energy in MSME Clusters in India – Indore Foundry Cluster"

Name of the MSME unit:	Porwal Auto Components Ltd.
Address:	209 & 215 Sector -1 Industrial area Pithampur.
Ph. No:	07292-421300
Name of the respondent	Guduru Murali
Designation:	V.P. Operation

1. Year of Establishment: __1995________________
2. Type of Products: a) Casting Components for Automobile and Engg. Industries in
   b) S.G.Iron , Gray Iron &
   c) Plain carbon steels
3. Installed Capacity: 21,600 Tons Per Annum
4. Operating hrs per day: 24hrs.
5. Connected Load: Contracted Demand 2800KVA, Connected Load 4109KVA
6. Supply Voltage: 33000 Volts
7. Annual Energy Consumption/ Production:

Financial Year (April to March)	2012	2013	2014
Coke consumed (tons)	Nil	Nil	Nil
Cost of coke (in Rs. Lakhs)	Nil	Nil	
Electrical units consumed (In kWh)	13,264,600	13,522,003	8,747,197
Electricity charges (In Rs. Lakhs)	65,772,853	71,579,265	52,766,752
LDO/HSD/ FO consumption (kL)	72.6	34.15	24.8
Fuel Cost (In Rs. Lakhs)	32,29,452	16,84,884	14,44,792
Production (Tones)	12,701.784	9,774.103	6,517.266

*Unit specific questionnaire were sent to units prior to the conduction of energy audits. Some portion of the questionnaire was not filled or left blank by the units, due to lack of understanding. However, data used for the energy audit calculations and reporting were subsequently collected during the physical visit of the energy audit team to the site.

8. Source and Calorific Value of Fuels:

Fuel	Source	Calorific Value (kCal)
Coke (Kg)	-	-
HSD (kL)	General Marked	9,300
LDO (kL)		
FO (kL)		

Fuel	Source
Electricity (kWh)	MPPKVVCL

9. Monthly Energy Consumption and Production Data:

Month	Production (Tons)	Coke consumption (Tons)	Electricity consumption (kWH)	HSD/LDO /FO (kL)	Any other fuel (specify units)
April, 14	641.236		1,015,412	1.025	
May, 14	933.591		1,187,697	1.125	
June, 14	736.958		947,821	1.051	
July, 14	775.404		1,000,013	2.990	
August, 14	619.476		816,318	3.721	
September, 14	502.724		778,447	4.305	
October, 14	524.130		787,918	2.798	
November, 14	658.492		866,916	3.412	
December, 14	701.204		955,671	3.607	
January, 15	794.371		1,156,349	5.321	
February, 15	825.432		1,204,886	3.533	
March, 15	966.190		1,183,211	3.000	
Total	**8,679.208**		**11,900,659**	**35.888**	

10. Duration of electricity supply: __24______Hours/ day

11. Cost variables per Ton of Production:

Cost Variable	Cost/ ton of production(14-15)
Electricity Cost	7,229.42
Coke Cost	-
Fuel Cost (LDO/HSD/FO) etc.	258.10
Labour Cost	6,832.536
Material Cost	41,231.855
Other Cost	21,517.246
Total Production Cost	77,069.157

12. Major Energy Consuming Equipment:

SN	Equipment	Energy source	Make/ Supplier	Year of Installation	Technical Specification	Use	Comments
1	Induction Furnace	MPPKVVCL	Inductotherm India ltd.	2005	2T, 1500 KW Dual Trak	Melting Furnace	
2	Induction Furnace	MPPKVVCL	Inductotherm India ltd.	1995	1T,650 KW Dual Trak	Melting Furnace	
3	AIR Compressor	MPPKVVCL	Godrej	2012	200 HP, 1480 RPM,982 CFM at 7 kg/cm2	To Produce Compressed air	
4	Sand Plant	MPPKVVCL	Fondarc	2005	80 T/hr., 453hp	To Prepare green sand	
5	Moulding	MPPKVVCL	Fondarc/ARPA	2005	HPML ARPA 450 ARPA 900	To Prepare Moulds	
6	Core Shop	MPPKVVCL	Galaxy Machine	2013	3 L-2 Nos. 7.5-1 Nos. 30/60 -1 No.	To Prepare core	
7	Fettling (Short Blast)	MPPKVVCL	Meera Indust. Patel			Grinding & Finishing of castings.	
8	Lighting	MPPKVVCL			50kw	Lighting purpose	

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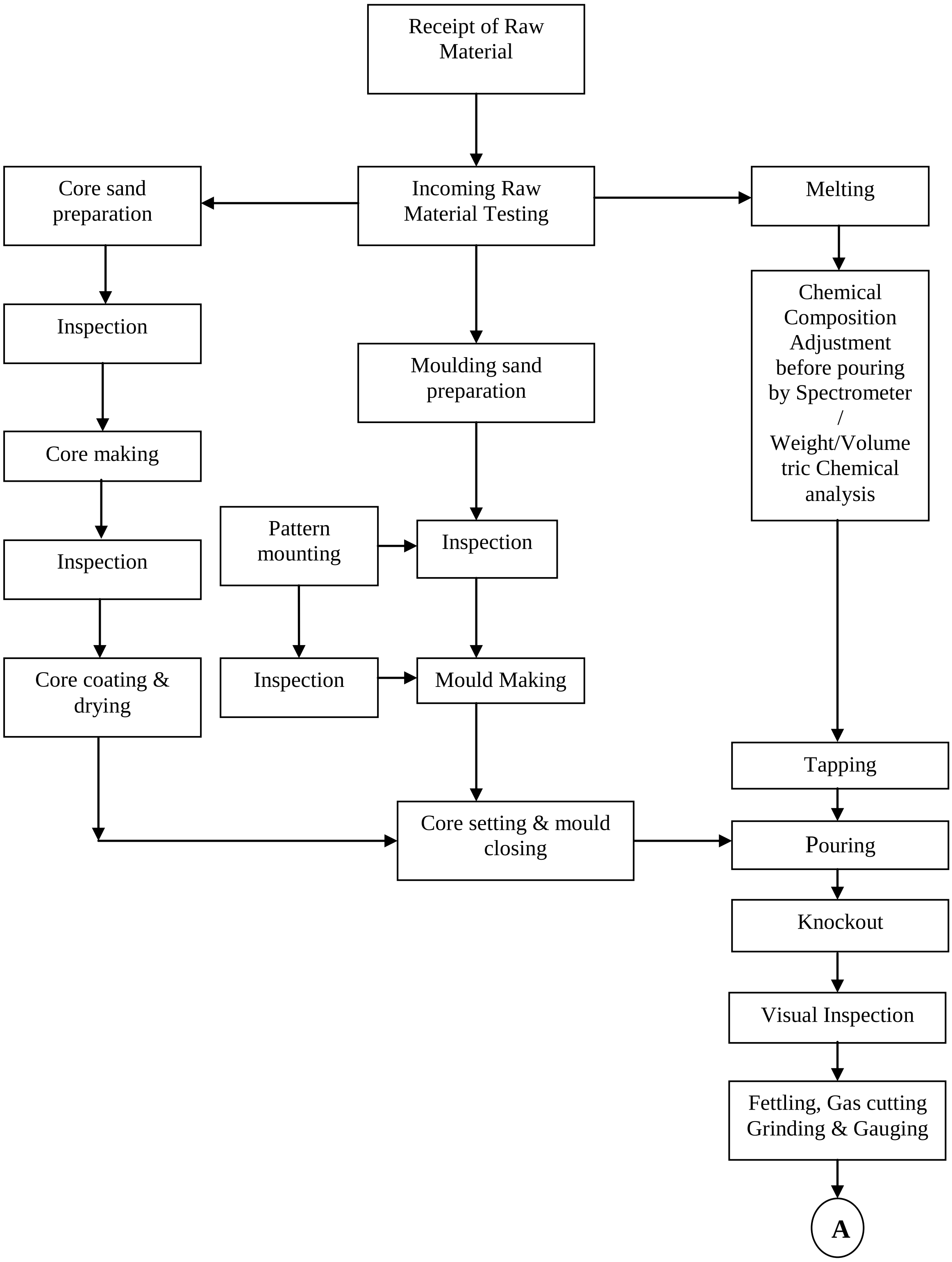
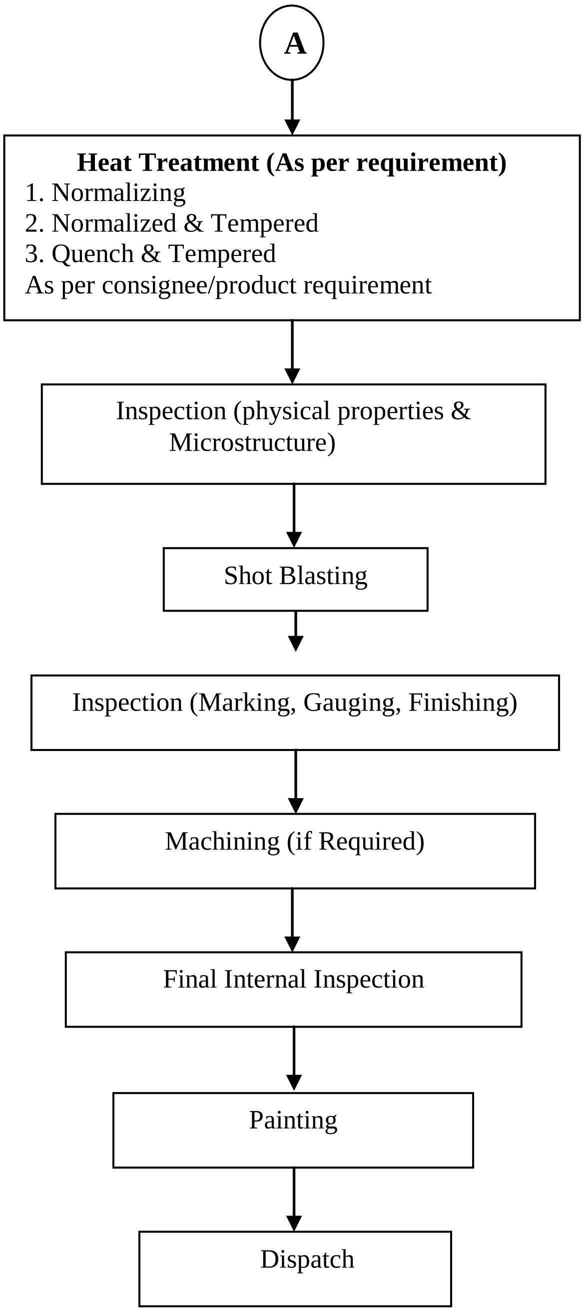
13. Factory Layout (Please provide sketch of factory layout):

Layout attached.

14. Please provide detailed manufacturing process for each major products manufactured:

Process Flow chart indicating process of manufacture for an individual Product, with quality control points:




A
Heat Treatment (As per requirement)
1. Normalizing
2. Normalized & Tempered
3. Quench & Tempered
As per consignee/product requirement
Inspection (physical properties & Microstructure)
Shot Blasting
Inspection (Marking, Gauging, Finishing)
Machining (if Required)
Final Internal Inspection
Painting
Dispatch

15. Any Energy Efficient Technology installed in the unit:

Technology	Specification	Cost	Year of Installation
Induction furnaces are of latest technology			
Energy efficient water pump.	KBL Make 7.5 hp, 10.0 hp		
Screw compressor-	Make Sullar model LS205-200H The devices name is Spiral value.	In built in the machine	2012
Automation of moulding line no.3 (ARPA-900)			

16. Any Energy Efficient Technology the management wants to implement in the unit:

Technology	Cost	Use
Solar lighting system		
Solar water pumps		
LED Lighting		
Replacement of 1 T furnace		

17. Any factory expansion plan:

1. New online fettling shop and new machine shop with VMC & HMC.
2. Automation of moulding line -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

Annexure 3:

Compressor Leakage Trial

Date : 14/06/2015 Sunday										
Start Time : 17: 00							End Time : 17:34			
Compressor ID : CMP 2							Capacity : 950 CFM			
SN	**On Time**				**Off Time**				**On**	**Off**
	Start time	**End time**	**Ampere**	**Pressure**	**Start time**	**End time**	**Ampere**	**Pressure**	**Time (mins)**	**Time (mins)**
1	17:04:05	17:04:50	273.6	7.7	17:04:50	17:06:07	119.2	7	0:00:45	0:01:17
2	17:06:07	17:06:51	274.8	7.7	17:06:51	17:08:10	118.5	7	0:00:44	0:01:19
3	17:08:10	17:08:54	276.1	7.7	17:08:54	17:10:14	118.3	7	0:00:44	0:01:20
4	17:10:14	17:10:59	273.4	7.7	17:10:59	17:12:16	117.2	7	0:00:45	0:01:17
5	17:12:16	17:13:00	274.5	7.7	17:13:00	17:14:18	119.1	7	0:00:44	0:01:18
6	17:14:18	17:15:01	275.8	7.7	17:15:01	17:16:21	118.3	7	0:00:43	0:01:20
7	17:16:21	17:17:05	276.3	7.7	17:17:05	17:18:25	117.3	7	0:00:44	0:01:20
8	17:18:25	17:19:09	274.8	7.7	17:19:09	17:20:29	118.7	7	0:00:44	0:01:20
9	17:20:29	17:21:24	273.6	7.7	17:21:24	17:22:44	117.2	7	0:00:55	0:01:20
10	17:22:44	17:23:29	273.5	7.7	17:23:29	17:24:49	118.3	7	0:00:45	0:01:20
11	17:24:49	17:25:34	274.5	7.7	17:25:34	17:26:52	118.8	7	0:00:45	0:01:18
12	17:26:52	17:27:37	275.2	7.7	17:27:37	17:28:57	117.9	7	0:00:45	0:01:20
13	17:28:57	17:29:41	275.4	7.7	17:29:41	17:31:01	119.8	7	0:00:44	0:01:20
14	17:31:01	17:31:45	273.8	7.7	17:31:45	17:33:06	118.4	7	0:00:44	0:01:21
15	17:33:06	17:33:51	273.1	7.7	17:33:51	17:35:11	118.8	7	0:00:45	0:01:20
			274.56				**118.39**		**0:00:45**	**0:01:19**

ON time (in Min) =	0.75
OFF time (in Min) =	1.32
Total Cycle time(in min)=	2.07
%age leakage =	36.3%

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Suggested Capacitor Bank Size for Motors

Section wise Capacitor (kVAR) required for greater than 10 HP motors

SN	Equipment name		HP	Suggested Capacitor (in kVAR)
A	**Melting**			
1	Power Pack 3 ton		10	3
2	Power Pack 1 ton		10	3
3	Crane 5 ton	Hoist	15	4
4	Crane 3 ton	Hoist	12.5	4
5	Fume Extraction System	Blower	30	9
6	Crane 3 ton Hand Moulding	Hoist	12.5	4
		Sub-total	**90**	**27**
B	**Moulding**			
	HPML			
1	LPP Motor-1		100	32
2	HPP Motor-2		15	4
3	Hydraulic pump 1		20	6
4	Hydraulic pump 2		20	6
		Sub-total	**155**	**48**
C	**Sand Plant**			
1	Sand Cooler Darpa	Main Drive	30	9
		Fan	12.5	4
2	Sand Cooler HPML	Main Drive	20	6
		Fan	12.5	4
3	Bucket Elevator		15	4
4	Mixer (ARPA)	Rotor	75	22
		Carousel	25	8
5	Mixer(HPML)	Rotor	75	22
		Carousel	25	8
6	Power Pack Motor-1		15	4
		Sub-total	**305**	**91**
D	**Core Shop**			
1	Scrubber	Blower	12.5	4
2	Sad Mixer	Mixer Motor	10	3
		Sub-total	**22.50**	**7**
E	**Decoring**			
1	Tumbling Barrel -1		10	3
		Sub-total	**10**	**3**

SN	Equipment name		HP	Suggested Capacitor (in kVAR)
F	**Fettling**			
1	Shotblast 1	Impeller motor 1	20	6
		Impeller motor 2	20	6
		Exhaust fan	10	3
2	Shotblast 2	Impeller motor 1	15	4
		Impeller motor 2	15	4
3	Pedestal Grinder		10	3
4	Pedestal Grinder		10	3
5	Swing Frame Grinder		10	3
6	Swing Frame Grinder		10	3
7	Swing Frame Grinder		10	3
8	Swing Frame Grinder		10	3
9	Swing Frame Grinder		10	3
10	Swing Frame Grinder		10	3
11	Swing Frame Grinder		10	3
12	Swing Frame Grinder		10	3
	Sub-total		**180**	**53**
G	**Furnace Pump room**			
1	Pump 1(DM) 1ton F/C		10	3
2	Pump 2(DM) 1ton F/C		10	3
3	Pump 5(PHE-2) 1ton F/C		10	3
4	Pump 6(PHE-2) 1ton F/C		10	3
5	Pump Distill Water for F/C 1ton		10	3
6	Pump 1(DM) 2ton F/C		10	3
7	Pump 2(DM) 2ton F/C		10	3
8	Pump 5(PHE-2) 2ton F/C		10	3
9	Pump 6(PHE-2) 2ton F/C		10	3
10	Pump Distill Water for F/C 2ton		10	3
	Sub-total		**100**	**30**
H	**Dust Extraction System**			
1	DC 1		30	9
2	DC 2		30	9
3	DC 3		30	9
	Sub-total		**90**	**27**