National Program

on

Promoting Energy Efficiency and Renewable Energy in MSME Clusters in India

Indore Foundry Cluster

Detailed Energy Audit Report
Pioneer Engineering Industries Ltd.

Submitted to

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InsPIRE Network for Environment

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Abbreviations

APFC	Automatic Power Factor Controller
BEE	Bureau of Energy Efficiency
CI	Caste Iron
CT	Cooling Tower
FRPB	Fiber Reinforced Plastic Blades
GEF	Global Environment Facility
GI	Grey Iron
HP	Horse Power
kcal	Kilo Calories
kg	Kilogram
kVA	Kilo Volt Ampere
kVAR	Kilo Volt Ampere Rating
kW	Kilo Watt
kWh	Kilo Watt Hour
MDC	Maximum Demand Controller
MSME	Ministry of Micro Small and Medium Enterprises
MPEB	Madhya Pradesh Electricity Board
PF	Power Factor
SEC	Specific Energy Consumption
SME	Small and Medium Enterprise
SG	Spheroidal Graphite
TOD	Time of Day
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 Pioneer Engineering Industries Ltd.

Location of the SME unit : 75/8 & 9, Industrial Area, Maxi Road, Ujjain, M.P-456010

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	Avoiding overfilling of metals in the Induction Furnace	661,052	No investment	NA
2	Avoiding super heating of metals in the Induction Furnace	347,922	No investment	NA
3	Installation of timers in Cooling Tower (CT) fan system	7,990	17,004	2.13
4	Installation of energy efficient Fiber Reinforced Plastic Blades (FRPB)	13,697	20,000	1.5
5	Installation of Variable Frequency Drive (VFD) across selected motors	859613	300,000	0.35
6	Installation of capacitor banks across motors having low power factor	1,746,510	74,958	0.04
7	Installation of VFD in Compressor 1 (Kaesser BSD-81)	309,156	300,000	0.97
8	Installation of VFD in Compressor 2 (Kaesser BSD-65)	189,436	300,000	1.58

▶ Electrical Panels:

The unit has installed three separate transformers of 420 kVA, 600 kVA and 500 kVA rating. Two transformer (420 kVA and 600 kVA) are used directly to supply electricity to all three induction furnace (1, 2 & 3), whereas, 500 kVA transformer is used to cater electricity requirements of other loads of the unit. It was observed that there is provision to switch off the power supply from the mains to the transformer when the furnace is not in operation.

▶ 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 like furnace was kept on hold for no availability of mould, scrap loading above coil level etc. It is suggested to avoid overfilling of metals in the furnace and overheating. On the cooling circuit for induction furnace, it is suggested to use energy efficient fan blades and timers.

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 15 to 60 HP and operated depending on requirements, like the 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 recommended to replace these oversized motors with appropriate sized motors according to load requirement. A properly balanced voltage supply is suggested which would help in assuring a voltage balance while minimizing voltage losses. It is further suggested to install Variable Frequency Drive (VFD) with the motors wherever required and installation of capacitors across motors with a high rating to reduce the distribution losses.

Compressors:

The unit has installed air compressor to use compressed 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 further suggested to install Variable Frequency Drive (VFD) in the compressor motors.

Introduction

1.1 ABOUT THE UNIT

M/s Pioneer Engineering Industries Ltd is engaged in manufacturing of different types of Grey Iron (GI) casting and Spheroidal Graphite (SG). Iron castings. The unit was established in 2004. Some of the key customers of the unit include VE Commercial Vehicles Limited Pithampur, Cummins Dewas, Eicher Tractors Limited etc. Further details of the unit are provided in Table 1.1.

The monthly production lies in the range of 250 to 340 tons, and yearly production touching around 5,000 tons. Electricity is supplied by Madhya Pradesh Electricity Board (MPEB) is the major source of energy being used by Unit for carrying out its operations. Electricity consumption varies from 380 MWh to 500 MWh per month. The specific energy consumption range from 1.3 ~ 1.7 kWh per kg of the product produced. Major portion of electricity is consumed in melting, sand mixing, compressor and shot blast sections. Figure 1.1 depicts monthly electricity consumption vis-à-vis total monthly production of the unit for last one year. The unit has also installed VFD, and power factor controller to reduce energy expenditure.

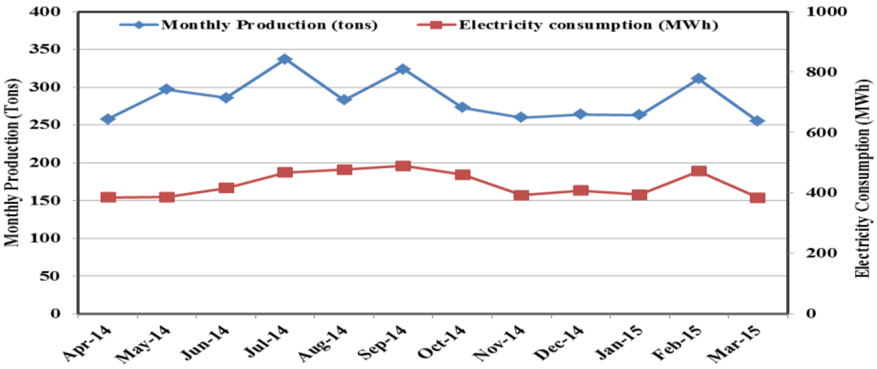


Figure 1.1(a): ***Monthly variation of production and electricity consumption***

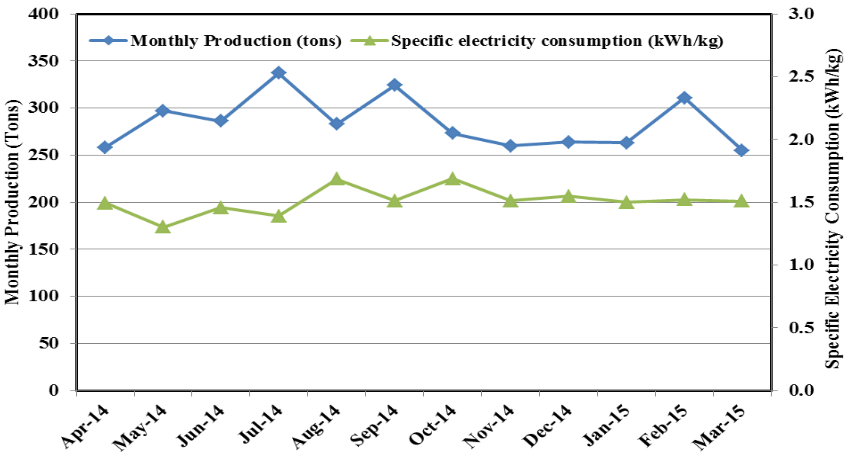


Figure 1.1(b): ***Monthly variation of production and specific electricity consumption***

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 July 2014 and August 2014. For the month of July 2014, the unit has a low production and a high energy consumption and reverse in the month of August 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.

Table 1.1: ***Details of M/s Pioneer Engineering Industries***

SN	Parameter	Value	Unit
1	Name and address of unit	Pioneer Engineering Industries, (Auto casting division), 75/8 & 9, Industrial area, Maxi road, Ujjain, M.P-456010	
2	Contact person	Mr. C. Harinarayan, Contact Number: 0734-2517762	
3	Manufacturing product	Grey Iron Castings & S.G Iron Castings	
4	Production	5,000 tons per annum	
	Energy utilization		
5	Average monthly electrical energy consumption	428,123	kWh per month
6	Electrical specific energy consumption	1.51	kWh/kg of product
		1298.6	kCal/kg of product
7	Specific energy consumption	1298.6	kCal/kg of product
8	Electrical energy cost	8.0	Rs/kg of product
9	Total energy cost	8.0	Rs/kg of product

Note:

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

Cost of Electricity = Rs. 5.3 per unit (average cost calculated from electricity bills)

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 1.2 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. The flow chart depicting the sequence of activities is given in Figure 1.2. The List of measuring instruments used during detailed energy audit are summarized in Table 1.2.

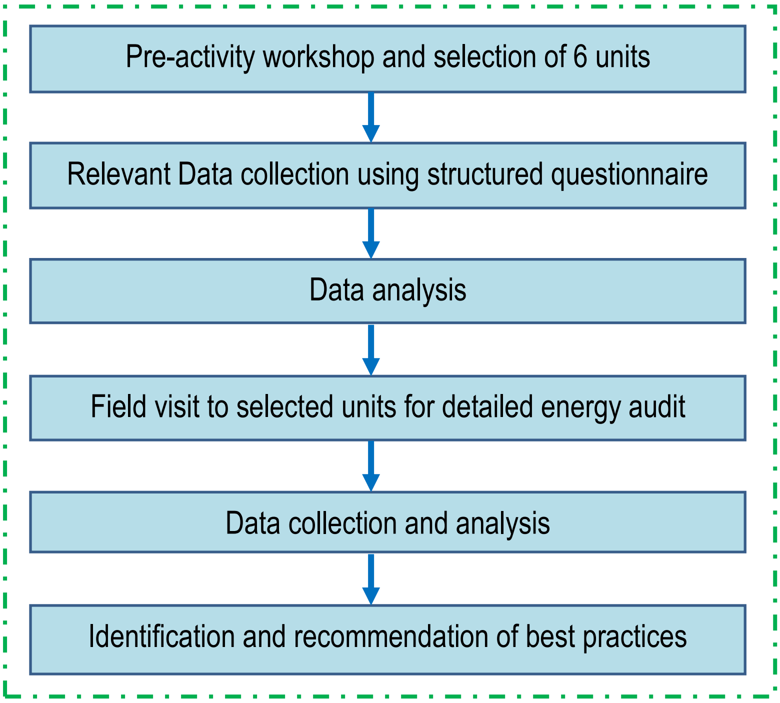


Figure 1.2: ***Flowchart depicting sequence of activities followed for carrying out detailed energy audit***

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 foundry produces castings that are close to the final product shape. The simple process of casting involves pouring molten metal into moulds, with cores used to create hollow internal sections. After the metal has cooled sufficiently, the casting is separated from the mould and undergoes cleaning and finishing techniques as appropriate. The complete process of Grey Iron (GI) and Spheroidal Graphite (SG) Iron Casting as followed in the unit is discussed in with the help of Flow Chart in Figure 2.1 followed by pictorial representations.

Casting production being followed in the unit can mainly be categorized into Core shop department, Moulding department, Melting department, Fettling department and Inspection department. 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 moulding 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 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 online monitoring 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.

▶ 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 Grey Iron, SG Iron scrap, pig iron and foundry return material. The Unit has installed two induction furnace; one induction furnace is monotrack of capacity 500 Kgs per charge and the other one is of dual track capacity 500 Kgs pre charge. The energy consumption details of the induction furnace along with observations are present in the later section. The furnace temperature is increased to around 1560°C for SG Iron and 1480°C for Caste Iron (CI) material to melt. The material is slightly overheated to take care of temperature drop expected during the pouring operation. 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 process requires electrical energy input for induction furnace as well as for pumps and motors being 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 metal.

▶ 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°C in molten metal temperature to bring it 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 castings. This process is achieved using vibrator 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.

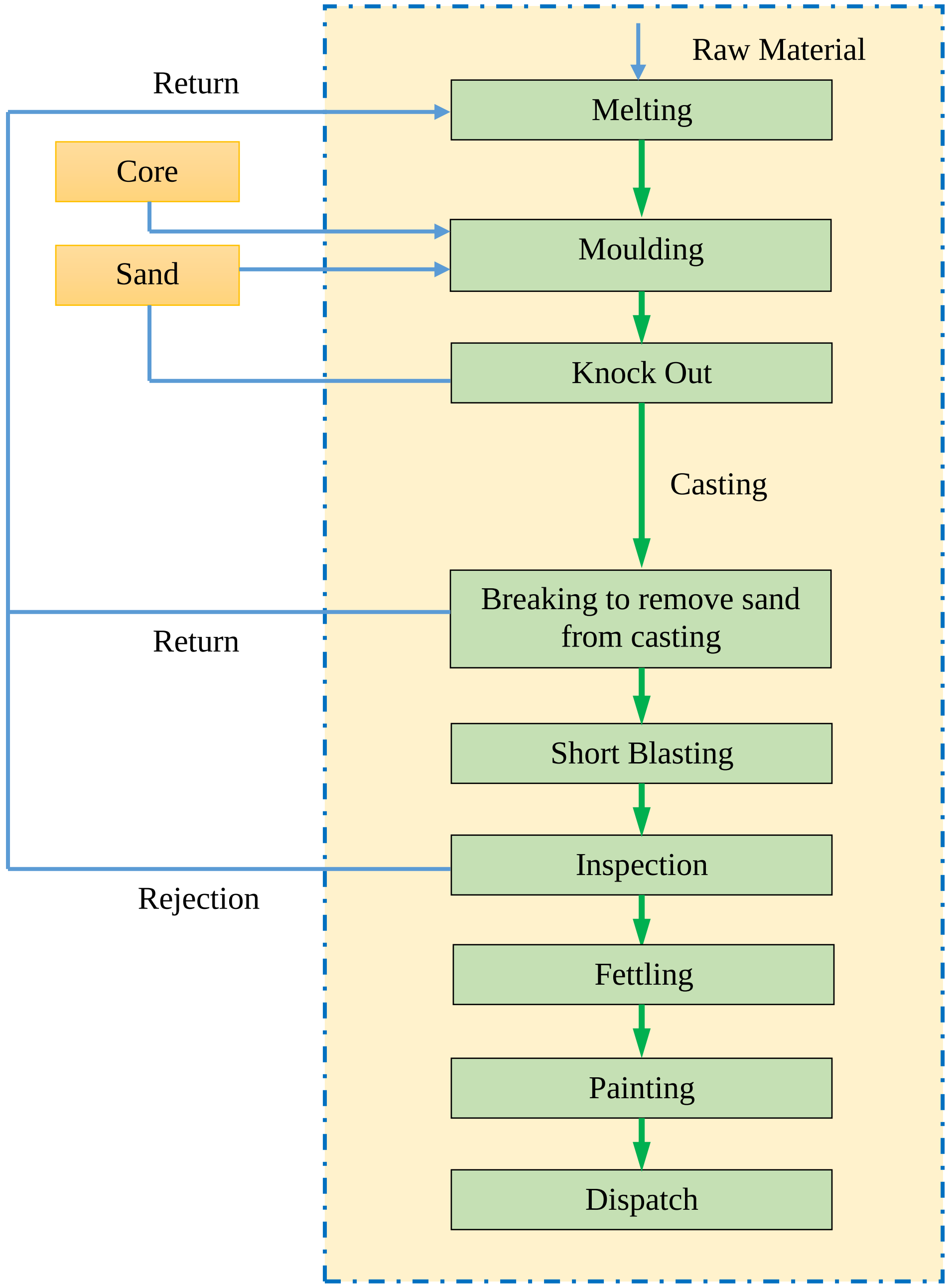


Figure 2.1: ***Process flow diagram***

Pictorial Representation of Production Process

Figure 2.2: ***Sand being used for core making***

Figure 2.3: ***Drying of sand using wood based burning***

Figure 2.4: ***Cold box machine and cores prepared***


Figure 2.5: ***Moulding sand mixer***

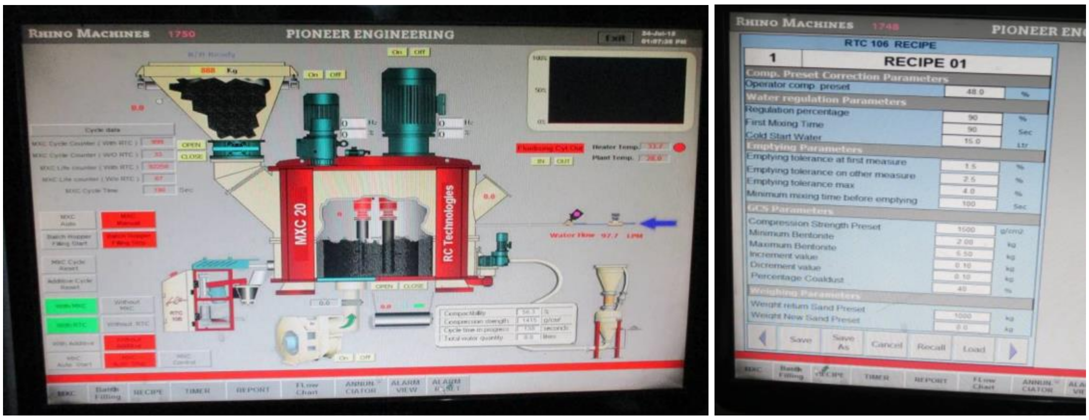


Figure 2.6: ***Online monitoring arrangement for moulding sand composition***

Figure 2.7: ***Hardness testing of moulds***

Figure 2.8: ***Raw material to be used in Induction furnace***

Figure 2.9: ***Melting of scrap material in Induction furnace***

Figure 2.10: ***Measurement of temperature of molten material***

Figure 2.11: ***Heat exchanger for removal of furnace heat***

Figure 2.12: ***Preheating of laddle and pouring of molten material into laddle***

Figure 2.13: ***Moulds after pouring***

Figure 2.14: ***Removal of residual sand from castings***

Figure 2.15: ***Shot blast machine***

Figure 2.16: ***Castings before shot blast operation***

Figure 2.17: ***Grinding of castings to improve surface finish***

Figure 2.18: ***Final castings after painting***

2.2 PRESENT TECHNOLOGIES ADOPTED

The list of energy consuming equipments and appliances installed in the unit and used for foundry process are as follows:

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

SN	Process	Number	Energy Source	Rated consumption	Daily operation in hours	Days per month	Capacity	Remarks
1	Sand Mixer	2	Electricity	2 HP (each)	8 hrs (CO_2 based) 18 hrs (Cold box)	25	100 tons per month of cores (40 tons from CO_2 based and 60 tons from cold box)	Core hardness, quality and surface finish is important
2	Sand Mixers (Moulding Section)	1	Electricity	75 HP & 30 HP	24 hrs	25	18~20 tons/hr.	Sand composition is important which is monitored online
3	Induction furnace – Mono track	1	Electricity	350 kW	24 hrs	25	600 kgs per charge	Melting temperature of the metal is important
4	Induction furnace – Dual track	1	Electricity	550 kW	24 hrs	25	600 kgs per crucible per charge	Melting temperature of the metal is important
5	Tumbling barrel	1	Electricity	7.5 HP	12 hrs	25	Depends on per day production	This is essentially a pre-treatment step to shot blast in which sand from casting is removed
10	Shot Blasting	2	Electricity	15 HP & 25 HP	12 hrs	25	15 tons per day	Average slot blast time required is 2.3 min and 5 min
11	Grinding	4	Electricity	3 HP (each)	12 hrs	25	10-12 tons per day	Final finish is important

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 unit has got connected load of 1,475 kW and has installed three separate transformers of 420 kVA, 600 kVA and 500 kVA. One transformer 420 kVA is used to directly supply electricity to the induction furnace 1, and 600 kVA transformer is used to supply electricity to Furnace 2 & 3, whereas, the 500 kVA transformer is used to cater electricity requirements of other loads in the Unit. Unit has installed separate energy meter to record power consumption for each induction furnace. The Unit has installed automatic power factor controller to maintain the pf.

Apart from regular consumption tariff, the 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, the total monthly maximum demand of the unit is close to its contract demand value of 1,200 kVA. Further, Unit has installed automatic power factor controller because of which the PF of the unit is observed to be higher (0.97).

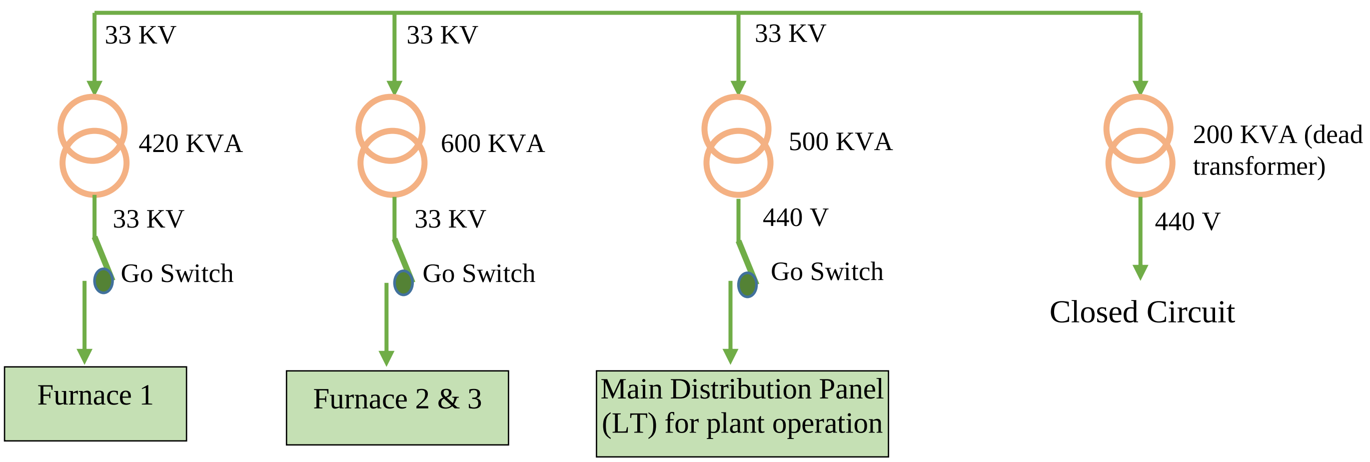


Figure 2.19: ***Single Line Diagram of Electricity Distribution System***

Figure 2.20 (a): ***Pictorial depiction of transformers installed***

Figure 2.20 (b): ***Pictorial depiction of electrical panels installed***

▶ Observation:

During field visit to the unit, it was found that the induction furnace is operated 24 hours a day in two shifts. There is provision to switch off power supply from the mains of the transformer when the furnace is not in operation.

2.3.2 Induction Furnace:

- **Present System:**

The Unit has installed two electrical furnace one 350 kW Mono- track and another 550 kW Dual Track supplied by Inductotherm (India) Pvt. Ltd. The pictures of the Induction furnace are given in Figure 2.21 to Figure 2.22. The capacities of the induction furnace are 500 kgs each. Using this, scrap is melted at a temperature of 1510°C to 1560°C for SG Iron and 1450 °C to 1480°C for CI material. During energy audit, the performance assessment of induction furnace was carried out. In the operation, crucible is filled with the scrap material and heating is done by switching on the power supply. The required temperature is typically attained in 1.34 hours for 350 kW furnace and 50 minutes for 550 kW furnace. However, this melting time may be more in case of cold start. Once the metal is melted, its composition is checked using spectrometer and based on the results, if required necessary correction is made. Temperature of the molten metal is measured using a pyrometer. Once melting of the scrap in the furnace crucible is achieved, small amount of silica is added to the molten metal which absorbs the slags present in scrap material and brings it on the top. This slag is removed from the top of the molten metal after that the molten metal is ready for pouring. The complete specification of the furnace is given in the Table 2.2 below.

Table 2.2: *Furnace specifications*

Model/Make	Inductotherm India Pvt. Ltd
Energy Input	Electricity, 1. 350 kW Mono- track 2. 550 kW Dual Track
Capacity	500 kgs each crucible

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

Figure 2.22: ***Filling of scrap material in the induction furnace***

To avoid the heating of the coils used in induction furnace, cooled water is continuously circulated through the coils. Water in this cooling circuit operates even after closing of furnace operation to remove the residual heat from the crucible.

▶ Observations:

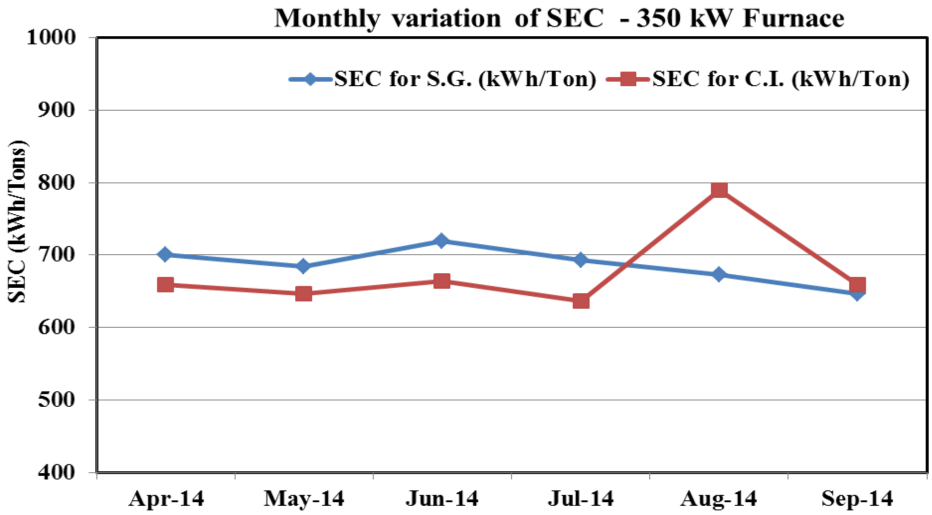
During field visit to the unit, detailed performance study of induction furnace was carried out for two charges. Although crucible capacity is 500kg but normally 610 to 625 kg material is loaded. Total number of charges taken per day is around 40. The observations made are summarized in Table 2.3. It is observed that first charge being a cold start, took more time for melting operation. The specific energy consumption for the two charges is shown in Figure 2.23.

Table 2.3: ***Summary of performance study***

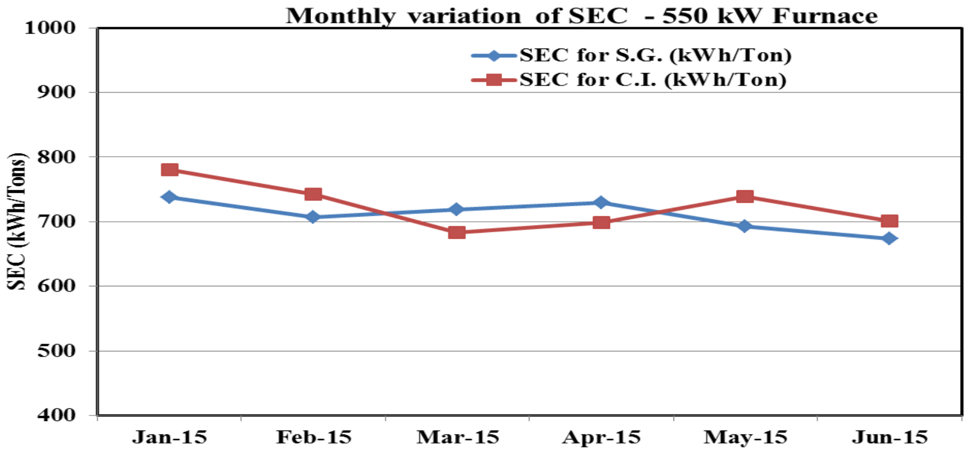
EE Trial No.	Total Metal (Kg)	Furnace Start Time (hh:mm)	Furnace End Time (hh:mm)	Total Melt Time (hh:mm)	Tapping temp (⁰C)	Initial kWh reading	Final kWh reading	Total kWh consumed	SEC (kWh/ ton)	Remarks
1	606	11:16	13:23	02:07	1462	8681751	8681339	412	679.8	350 kW Furnace was on hold due to non-availability of moulds
2	502	14:53	15:56	01:03	1495	9053358	9052968	390	776.8	550 kW Induction furnace was not operational for three hours before this trial.

SEC details has been obtained and graphs were prepared. From the graphs below it has bn observed that the SEC for the 350 kW furnace varies in the range of 690 kWh/ton to 730 kWh/ton for SG Iron and in the range of 680 kWh/ton to 800 kWh/ton for CI material.

For the 550 kW furnace, it has been observed that the SEC varies in the range of 690 kWh/ton to 730 kWh/ton for SG Iron and in the range of 690 kWh/ton to 790kWh/ton for CI material. It was observed that the furnace was over loaded.



(a) *Monthly variation of SEC for 350 kW furnace*



(b) *Monthly variation of SEC for 550 kW furnace*

Figure 2.23: *Specific energy consumption of Induction furnace*

Other Observations include;

- There was proper documentation of energy consumed and metering of each charge materials and alloying additives
- Operation of both the induction furnaces, mono-track and dual track, simultaneously produces more molten metal then the capacity of moulding lines. The mismatch between furnace over capacity and moulding line under capacity results in putting furnace in hold position.
- is results in due to which the holding of the furnaces
- The practice of reducing power supply during furnace holding results in reducing energy consumption due to holding the molten metal until it is poured

- The scrap was loaded above the furnace induction coil level this causes overheating of furnace components in the top part of the furnace leading to energy loss (refer figure 2.22). 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.
- The furnace was kept on hold due to unavailibility of moulds and this leads to huge energy wastage (There was drop in pouring temperature to 1495^{0}C).
- The pouring time was more due to use of smaller laddle size
- The laddles are preheated which helped to minimize thermal shock and damage to the refractory lining and to reduce the molten metal temperature drop

Recommendations:

- Induction furnace has to be kept on hold due to unavailability of moulds, as the furnace capacity is higher than the moulding line. Therefore, it is suggested to operate only the dual track induction furnace, which is sufficient to balance the moulding line production and keep the smaller size induction furnace (350 kW) as stand by furnace.
- Proper planning between both sections, melting and moulding section, is required to minimize the furnace holding time. It is strongly suggested to coordinate timings with other foundry activities so that furnace containing liquid metals are not kept waiting for laddles or moulds are prepared for pouring. In addition to high energy wastage, holding liquid metal can adversely affect nucleation if the carbon level drops.
- Best Practice #1 (Material Log Book): Maintain log records of type and quantity of scrap material being used and electricity consumed for every charge (See ***Annexure2***).
- Best Practice #2 (Furnace Loading & Operation): Level of molten metal should not exceed the level of induction furnace coil (See ***Annexure 3***).
- As far as possible, no overheating of material beyond the required temperature should be carried out as it directly consumes energy.
- Heel metal 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.

Cooling tower is used for cooling of the Induction furnace cooling circuit. It is suggested to install timers in the cooling tower fan system and to replace the conventional cooling tower fan blades with fiber reinforced plastic blades which leads to sufficient energy saving owing to the better aerodynamic shape of its blades

The cost economic analysis of the above suggested measures are compiled in Table 2.4. It can be observed that all the measures suggested towards energy efficiency improvements of furnaces have good energy saving with less payback period.

Table 2.4: *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	88,140	661,052	Nil	Not Applicable
2	Avoiding super heating of metals in the Induction Furnace	46,390	347,922	Nil	Not Applicable
3	Installation of timers in cooling tower fan system	1,065	7,990	17,004	2.13
4	Installation of energy efficient fiber reinforced plastic blades	1,826	13,697	20,000	1.5

2.3.3 Motor Loading:

- **Present System:**

In the present system there are different motors of different size and capacity installed in different areas of the foundry. The rated HP of the motors varies from 15 to 60 HP and operated depending on requirements.

To assess the performance of the motor loading, sampling was carried out based on the size and operating hours of the motor. Motors above 15 HP capacities, like the motors used in shot blasting, sand mixing areas and in dust collection section were chosen for which measurements like current, voltage, pf and actual power consumption was carried out to determine the percentage loading of the motors.

- **Observation:**

The measurement related to motor loading for different motors (generally motors of high capacity and longer operating hours are chosen like sand mixing motors) being used in the foundry was carried out.

The results are summarized in Table 2.5. It has been observed that the loading of the motors varies from 24.6% to 89.87%. The motors installed in both the dust collectors are highly under loaded i.e. below 30% and the power factor is also low below 0.4.

Table 2.5: *Measurements of Loading of higher capacity Motors*

Equipment Section	Current (Amps)				Voltage (Volts)	PF	Actual Power (kW)	Rated Motor (HP)	Loading (%)
	R	Y	B	Average					
Shot Blast – 1	15	14	15	14.7	415	0.68	7.17	20	48.05
Shot Blast - 2	29	27	30	28.67	422	0.69	14.46	30	64.60
Dust collector-1	11	10	12	11.00	425	0.34	2.75	15	24.60
Dust collector-2	11	10	11	10.67	424	0.4	3.13	15	28.00
Sand Mixing - RMC20 Mixer Rotor	63	60	64	62.33	414	0.9	40.23	60	89.87
Sand Mixing - RMC20 Mixer Corousel	16	12	16	14.67	416	0.82	8.67	30	38.72

- **Recommendations:**

- It is observed from the measurements and analysis that most of the motors are under loaded and therefore they are operated in inefficient manner. It is therefore suggested to replace the oversized motors with appropriately sized energy efficient motors. Both the motors installed in dust collectors are only 30% loading; these motors may be replaced with appropriate size motors. The sand mixing - RMC20 Mixer Corousel is also under loaded (40% only), this motor requires appropriate motor size.
- It is also 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

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.

Table 2.6: *Cost Economic Analysis - Motors*

SN	Energy Efficient Measure	Estimated Energy savings (kWh/Year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Years)
1	Installation of capacitors across motors having low power factor	229,997	1,746,510	74,958	0.04
2	Installation of VFD across selected motors	114,615	859,613	300,000	0.35

2.3.4 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 2.7. The compressed air is mainly used for sand coating, fettling, induction furnace and sand blasting section. The unit has installed three receiver capacities of 3,000 liters each totaling to 9,000 liters from which compressed air is supplied using overhead and underground air pipes. The schematic of compressor network observed in the unit is shown in Figure 2.24.

Table 2.7: *Specifications of compressors*

Compressor Reference	Compressor-1	Compressor-2
Rated kW	45	30
Model/Make	Kaesser BSD-81	Kaesser BSD-65
Year of manufacture	2011	2014
Tank storage capacity (ltrs)	3 storage tanks each 3,000 liters in Compressor section, Fettling Section and Moulding Section are installed. (total 3 receivers capacity is 9,000 liters)	
Upper pressure settings (bar)	8.0	8.0
Lower pressure settings (bar)	7.5	7.5

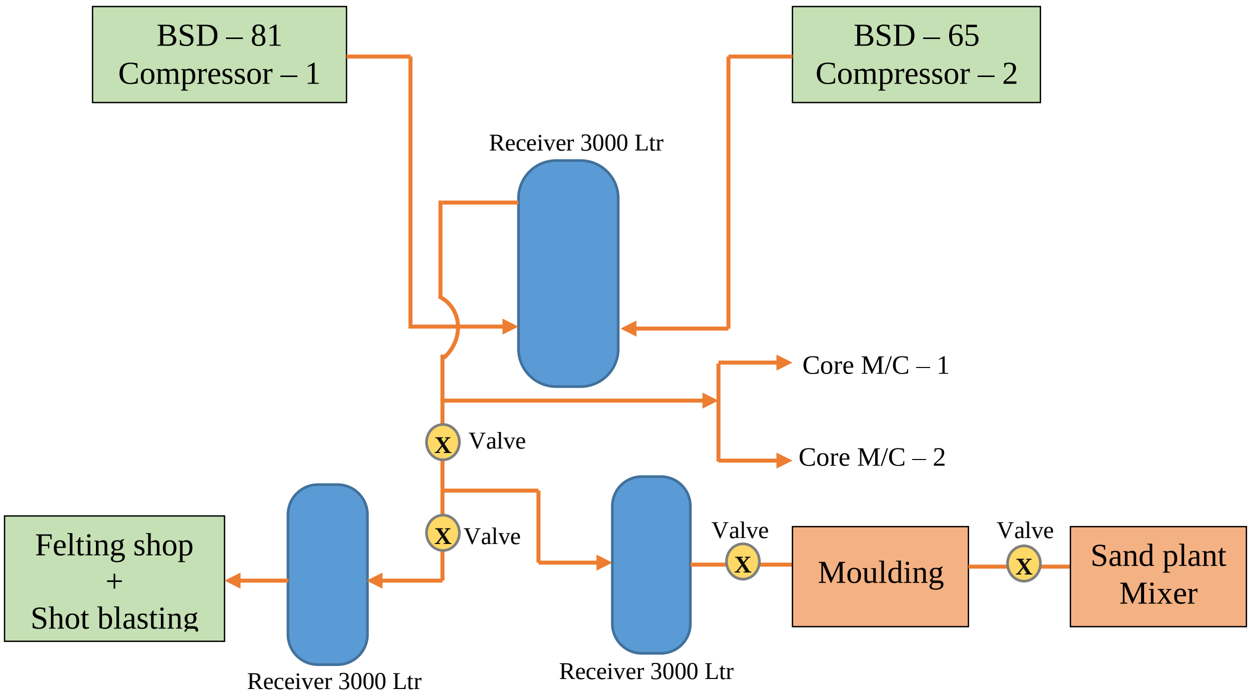


Figure 2.24: ***Single line diagram of compressor system***

▶ Observations:

The measurement of electrical parameters was carried out to estimate percentage loading of compressor. These observations are summarized in Table 2.8 & 2.9. Compressor leakage test could not be performed as the unit was in operation. Leakage is the major source of energy loss in compressed air systems. A typical plant may lose up compressed air through poorly maintained pipe joints, fittings, couplings and equipment.

- Based on the measured data, it is observed that both the compressor motors are overloaded during loading i.e. when compressor motor is ON. The motor loading was found to be 119.11% and 115.33% for compressor 1 and compressor 2 respectively. During unloading, the loading is found to be 41.33% and 33% for compressor 1 and compressor 2 respectively.
- It was observed that hoses, joints and fittings are not tight enough and there was heavy air leakage in grinders in Fettling section, this can be improved by better control and maintenance.
- It was observed that the most of the air guns were having leakages. The compressed air was leaking from the joints between air guns nozzle and compressed air pipe. It was observed that the air leakage was deliberately done by the machine operators to use air for cooling themselves.

Figure 2.25: T*emporary arrangement made to prevent air leakages*

Table 2.8: ***Measurements performed on the compressor – 1 (Kaesser BSD-81)***

Loading Condition	Current (Amps)				Voltage (Volts)	PF	Actual Power (kW)	Rated Motor (kW)	Loading (%)
	R	Y	B	Average					
Unload	32	32	34	32.67	417	0.89	18.6	45	41.33
Load	80	79	68	75.67	417	0.96	53.6	45	119.11

Table 2.9: ***Measurements performed on the compressor – 2 (Kaesser BSD-65)***

Loading Condition	Current (Amps)				Voltage (Volts)	PF	Actual Power (kW)	Rated Motor (kW)	Loading (%)
	R	Y	B	Average					
Unload	26	14	17	19.00	417	0.79	10.8	30	36.00
Load	59	45	50	51.33	417	0.94	34.6	30	115.33

- **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 4***).
- It is suggested to change worn out or leaked guns to improve compressor efficiency.
- It is suggested to check and clean the inlet air filters regularly to remove dust, dirt and moisture which may lead to clogging a pressure drop in the system
- It is further suggested to reduce compressor delivery pressure, wherever possible, to save energy
- The cost economic analysis of the above suggested measures are compiled in Table 2.10. It can be observed that all the measures suggested towards energy efficiency improvements of furnaces have good payback period.

Table 2.10: ***Cost Economic Analysis – Air 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 1 (Kaesser BSD-81)	41,220	309,156	300,000	0.97
2	Installation of VFD in Compressor 2 (Kaesser BSD-65)	25,258	189,436	300,000	1.58

2.3.5 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 for de-waxing operation 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.

Questionnaire*

Energy Audit – Questionnaire Form

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

Name of the MSME unit:	Pioneer Engineering Industries (Auto casting division)
Address:	75/8 & 9, Industrial area, Maxi road, Ujjain, MP-456010
Ph. No:	0734-2517762
Name of the respondent	Mr. C. Harinarayan
Designation:	GM

1. **Year of Establishment: 2004**
2. **Type of Products: a) Grey Iron Castings**

   b) S.G .Iron Castings

3. **Installed Capacity: _ 5000 tons / annum**
4. **Operating hrs per day: 24 Hrs.**
5. **Connected Load: 1475 kW _ (kVA or kW please specify)**
6. **Supply Voltage: 33 kVolts**
7. **Annual Energy Consumption/ Production:**

Financial Year (April to March)	2012-13	2013-14	2014-15
Coke consumed (tons)	Nil	Nil	Nil
Cost of coke (in Rs. Lakhs)	Nil	Nil	Nil
Electrical units consumed (In kWh)	4,293,840	3,974,440	5,137,480
Electricity charges (In Rs. Lakhs)	244.58	416.23	278.0
LDO/HSD/ FO consumption (kL)	Nil	Nil	Nil
Fuel Cost (In Rs. Lakhs)	Nil	Nil	Nil
Production (Tones)	3,131	2,952	3,411

*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)	Nil	Nil
HSD (kL)	Nil	Nil
LDO (kL)	Nil	Nil
FO (kL)	Nil	Nil

Fuel	Source
Electricity (kWh)	**MPEB**

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	258	Nil	385,360	Nil	Nil
May, 14	297	Nil	386,280	Nil	Nil
June, 14	286	Nil	416,800	Nil	Nil
July, 14	337	Nil	468,360	Nil	Nil
August, 14	283	Nil	476,880	Nil	Nil
September, 14	324	Nil	490,040	Nil	Nil
October, 14	273	Nil	460,920	Nil	Nil
November, 14	260	Nil	393,000	Nil	Nil
December, 14	264	Nil	408,440	Nil	Nil
January, 15	263	Nil	394,360	Nil	Nil
February, 15	311	Nil	472,560	Nil	Nil
March, 15	255	Nil	384,480	Nil	Nil

10. Duration of electricity supply: 24 Hours/ day

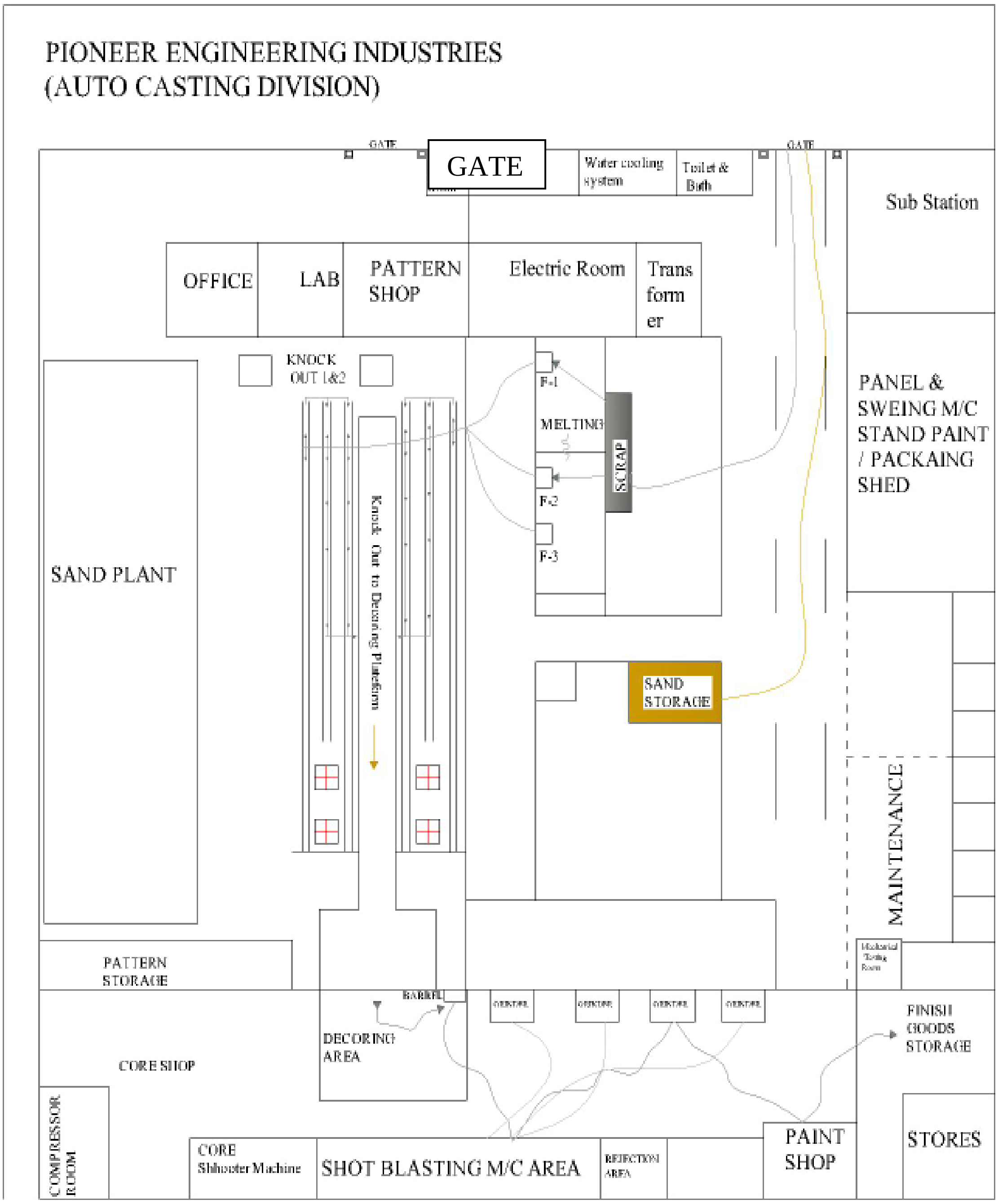
11. Cost variables per Ton of Production:

Cost Variable	Cost/ ton of production
Electricity Cost	Rs. 8150 per Ton
Coke Cost	Nil
Fuel Cost (LDO/HSD/FO) etc.	Nil
Labour Cost	-----
Material Cost	-----
Other Cost	-----
Total Production Cost	-----

12. Major Energy Consuming Equipment:

SN	*Equipment*	*Energy source*	*Make/ Supplier*	*Year of Installation*	*Technical Specification*	*Use*	*Comments*
1	Induction Furnace	Electricity	INDOCTOTHERM		550 kW / 500 Kg	Melting	Duel Track
2	Induction Furnace	Electricity	INDOCTOTHERM		550 kW / 500 Kg	Melting	
3	Induction Furnace	Electricity	INDOCTOTHERM		350 kW / 500 Kg	Melting	
4	Compressor	Electricity	KEASAR		280 CFM	Moulding and Fettling	
5	Compressor	Electricity	KEASAR		200 CFM	Moulding and Fettling	
6	Shot blasting Machine	Electricity	PATEL		500 Kg	Shot blasting (Hanger Type)	
7	Shot blasting Machine	Electricity	PATEL		300 Kg	Shot blasting (Belt Type)	
8	Sand Mixer	Electricity	RIHNO		20 Tons/hr	Sand Making	
9	Motors	Electricity			FHP to 60 HP	At various locations	

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



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

Process Flow Description (SG Iron)	Process Flow Description (Cast Iron)
Raw Material Incoming Inspection	Raw Material Incoming Inspection
New Pattern Inspection	New Pattern Inspection
Core Making	Core Making
Moulding Sand Preparation	Moulding Sand Preparation
Moulding	Moulding
Mould Closing	Core setting & Mould Closing
Melting	Melting
Magnesium Treatment	Innoculantion
Innoculation	Pouring
Pouring	Knockout / Decoring
Knockout / Decoring	Microstructure Inspection
Microstructure Inspection	Barrelling & Shot Blasting
Barrelling & Shot Blasting	Primary / Visual Inspection
Primary / Visual Inspection	Mechanical Testing
Mechanical Testing	Fettling
Fettling	Final Inspection
Final Inspection	Primer
Primer	Finish Material Storage
Finish Material Storage	Dispatch
Dispatch	Transportation
Transportation	

15. Any Energy Efficient Technology installed in the unit:

Technology	Specification	Cost	Year of Installation
Cold box core making	7 kg & 3 kg capacity each	10 lakhs	2014

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

Technology	Cost	Use

17. Any factory expansion plan:

NIL

Material Log Book – Induction Furnace

Furnace ID:	…………………………	Date	………………	Charge Number	………..	Material Type	………………

Time Details

Melting		Holding		Pouring	
Start Time (A)	………..	Start Time (D)	………	Start Time (G)	………
End Time (B)	………..	End Time (E)	………	End Time (H)	………
Total time (C) = (B) – (A)	………..	Total time (F) = (D) – (C)	………	Total time (I) = (F) – (E)	………

Temperature Details

Melting Temperature (^{0}C)	………………….
Tapping Temperature (^{0}C)	………………….
Pouring Temperature (^{0}C) at start of pouring	………………….
Pouring Temperature (^{0}C) at end of pouring	………………….

Electricity Consumption (kWh)

Initial Reading (J)	……………………
Final Reading (K)	……………………
Total Electricity consumption (L) = (K)-(J)	……………………

Material Input

SN	Material Type	Quantity (kg)
1	………………………………….	…………….
2	………………………………….	…………….
3	………………………………….	…………….
4	………………………………….	…………….
5	………………………………….	…………….
6	………………………………….	…………….
7	………………………………….	…………….
Total Input Material (M)		…………….
Total Material Output (N)		…………….
Material Lost (O) = (M) – (N)		…………….
Specific Electricity consumption (kWh/tons) (P) = (L) * 1000/ (M)		…………….

Remarks: Please capture any other information related to operation like reason for furnace holding, higher time taken for furnace holding etc…

Annexure 3:

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 4:

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