National Program

on

Promoting Energy Efficiency and Renewable Energy in MSME Clusters in India

Indore Foundry Cluster

Detailed Energy Audit Report

Jash Engineering Limited

Submitted to

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nsPIRE

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Abbreviations

ACB	Air Circuit Breaker
APFC	Automatic Power Factor Controller
BEE	Bureau of Energy Efficiency
CO	Carbon Mono-oxide
CFR	Coke to Fed Ratio
DBC	Divided Blast Cupola
DG	Diesel Generator
GEF	Global Environment Facility
HP	Horse Power
kcal	Kilo Calories
kg	Kilogram
kVA	Kilo Volt Ampere
kW	Kilo Watts
kWh	Kilo Watt Hour
LPG	Liquefied Petroleum Gas
MDI	Maximum Demand Indicator
MDC	Maximum Demand Controller
MCCB	Molded Case Circuit Breaker
MS	Mild Steel
MSME	Ministry of Micro Small and Medium Enterprises
PF	Power Factor
PG	Pig Iron
SEB	State Electricity Board
SEC	Specific Energy Consumption
SME	Small and Medium Enterprise
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 : M/s Jash Engineering Limited

Location of the SME unit : 31, Sector -C, Industrial Area, Sanwer Road, Indore, MP

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	Installation of Variable Frequency Drive (VFD) in air blower to supply air to cupola furnace	97,720	300,000	3.07
2	Replacing conventional v belts with synchronous belts	5,649	20,000	3.5
3	Installation of capacitors across motors having low power factor	420,000	20,000	0.04
4	Reducing Energy Loss due to Leakage in Compressor 1 (GA 22)	344,000	Nil	NA
5	Reducing Energy Loss due to Leakage in Compressor 2 (GA 11)	98,000	Nil	NA
6	Installation of VFD in Compressor 1 (GA 22)	141471	300,000	2.12
7	Installation of VFD in Compressor 2 (GA 11)	68,146	300,000	4.4

▸ Electrical Panels:

The unit has connected load of 449.32 kW. One transformers of 500 kVA capacity is installed to cater to the electrical load requirements. The unit has installed Automatic Power Factor Controller (APFC) and Maximum Demand Controller (MDC).

▸ Divided Blast Cupola

Divided Blast Cupola (DBC) is the melting furnace employed by the foundry unit for melting of the typical raw material mix consisting of Mild Steel (MS), Pig Iron (PG) and foundry returns. The unit has three DBCs of 30, 42 and 48 inch diameter. The coke used has calorific value is 7,200 kCal/kg. Coke bulk density was measured and found to be 575 kg/m^3. Coke to fed ratio (CFR) is in the range of 4.7~6.7 (considering bed coke) and 7.5~9.9 (excluding bed coke). It is proposed to install VFD in air blower to supply air to cupola furnace as the loading of the blower motor was found to be less. The replacement of conventional V-belts with synchronous belt (or flat belt) will lead to better transmission efficiency; hence it is proposed to replace V-belts with synchronous belt used in air blower in cupola.

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 10 to 25 HP and operated depending on the requirements. A performance assessment of motor loading was conducted through selecting sample of motors, it was found that the motor loading varies from 55~91% and none of the motors were over loaded. In knockout section, the electrical motor used in dust collector is under loaded (55%). This under loading of motors significantly affects the efficiency of the motors. Total Harmonic Distortion (THD) in percentage was measured across motors and was found in the range of 2.1~3.1%. The power factor was found low (0.7~0.9) resulting into energy loss and increase maintenance costs with excessive heating of the motor. It is suggested to install capacitor banks in selected motors to improve the power factor. By installing capacitor banks across motors having low power factor annual energy saving of the order of 0.6 lakh kWh can be achieved. It is recommended to replace the oversized motors (or under loading motors) with appropriate size motors according to the load requirement (e.g. the dust collector motors – 55% loading). A properly balanced voltage supply is suggested which would help in assuring a voltage balance while minimizing voltage losses.

Compressor

The unit has installed two air compressors with motor rating of 32 HP and 17 HP to use compressed air for moulding section, fettling section and sand blasting section. The specific electricity consumption of the compressed air is in the range of 76 to 191 kWh per MT and the average comes to 122 kWh per MT. Based on the compressor leakage trial test, it was found that the percentage leakage was 33% for compressor 1 (32 HP) and around 21% for compressor 2 (17 HP), which contributes to significant energy loss. Arresting the compressed air leakage the annual monetary saving would be Rs. 4.42 lakhs. It is thus, strongly recommended to carry out leakage trail fortnightly to assess the leakage level and necessary actions to be taken if any. It is proposed to install VFD in both the compressors, to save energy upto 29,654 kWh per year, which amounts to annual saving of Rs 2.08 lakhs. It is suggested to ensure that the air intake to compressors is not warm and humid by locating compressors in well ventilated area.

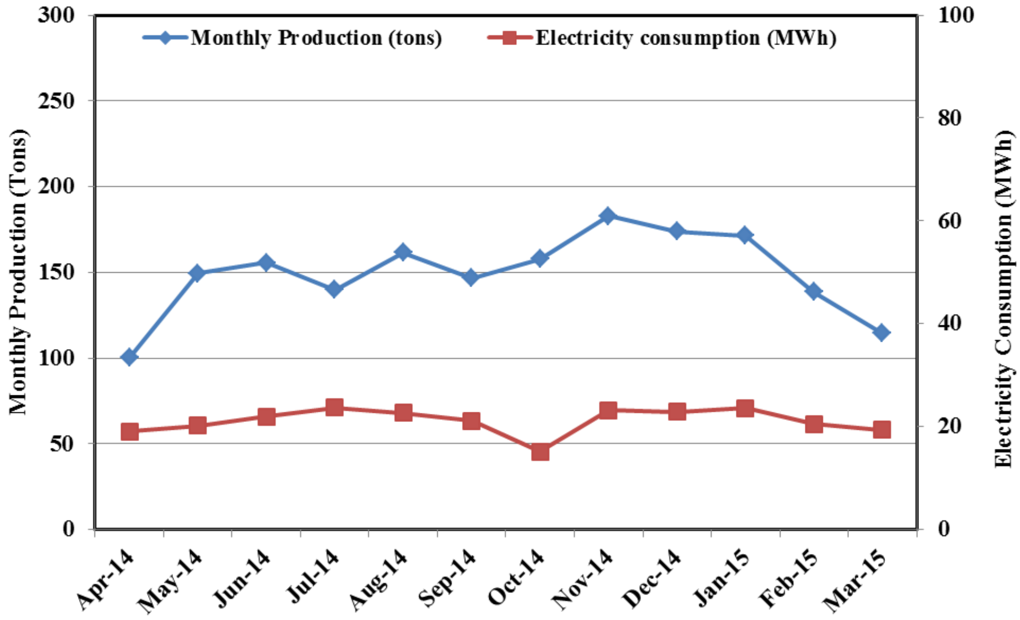
Introduction

1.1 ABOUT THE UNIT

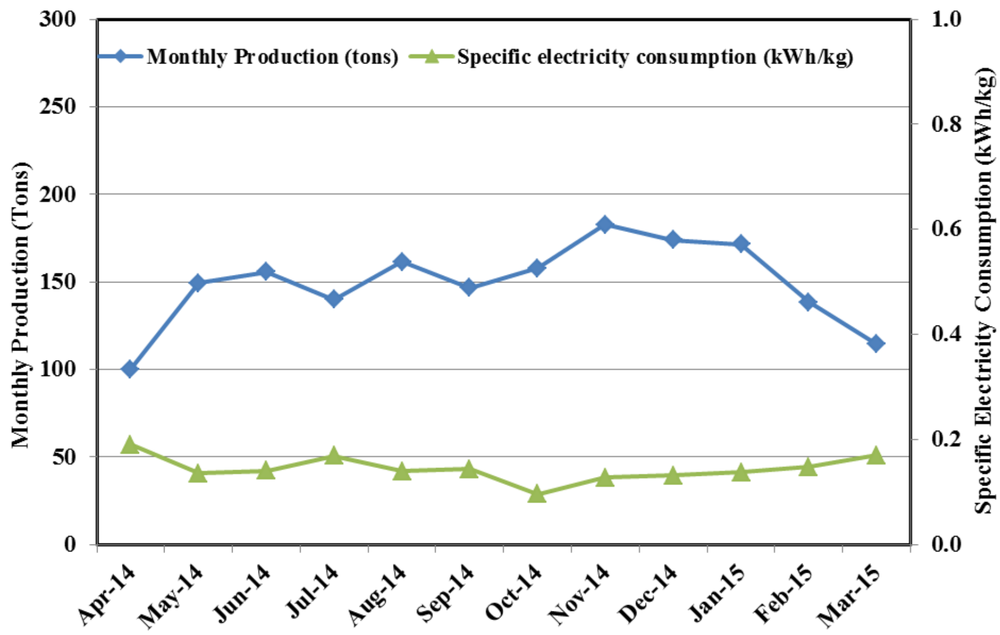
Jash Engineering Ltd. is engaged in manufacturing of Sluice Gate, Valve, Bed Plate and Surface Plates and was established in the year 1977. Jash Engineering Ltd. has all the necessary facilities like pattern making, foundry machining, fabrication, inspection and testing in-house. In-house availability of all manufacturing facility ensures reliable quality, timely delivery and ability to meet individualized customer needs.

The installed capacity of the unit is 300 tons per month. The Unit uses electricity, coke, diesel and Liquefied petroleum gas (LPG) to meet various process and utility applications in the premises. The unit has installed Divided Blast Cupola (DBC) furnace for melting, where coke is used as main fuel and thus the coke consumption is higher compared to electricity usage. Diesel is used for laddle preheating and heating liquid metal holding tank. The contract demand of the unit is 375 kVA with a supply voltage of 400 volts.

Figure 1.1 depicts monthly electricity consumption vis-à-vis total monthly production of the unit for last one year. The Unit has installed Maximum Demand Controller (MDC) and Automatic Power Factor Controller (APFC) to reduce energy expenditure.



(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 October 2014 and March 2015. For the month of October 2014, the unit has a low production and a high energy consumption and reverse in the month of March 2015, 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.

The monthly production of the unit is 150 ton. According to the assessment of the energy consumption data collected, the average specific thermal energy consumption and specific electrical energy consumption is 1774.1 kCal/kg and 0.14 kWh/kg of product respectively. The total specific energy consumption (in kCal) is 1895.6 kCal per kg of product. Details of annual electrical and thermal energy consumption and specific energy consumption in Jash Engineering Ltd. are presented in Table 1.1 below:

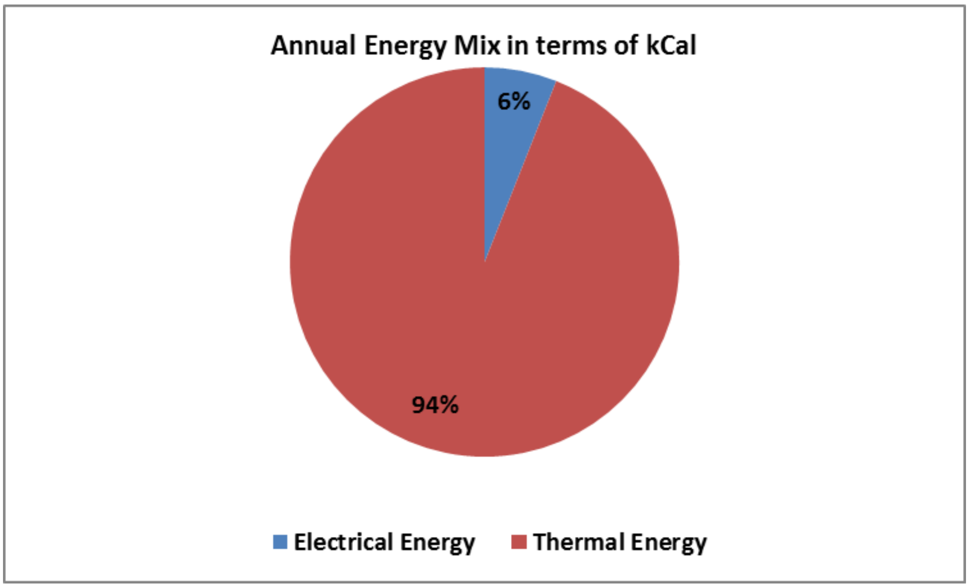
Table 1.1: ***Details of M/s Jash Engineering Limited***

SN	Parameter	Value	Unit
1	Name and address of unit	Jash Engineering Limited., 31, Sector -C, Industrial Area, Sanwer Road, Indore-MP	
2	Contact person	Shri L.D. Amain, Contact Number: 0731-6732701, M: 09755416000	
3	Manufacturing product	Sluice Gate, Valve, Bed Plate, Surface Plates	
4	Monthly Production	150 tons	
	Energy utilization		
5	Average monthly electrical energy consumption	21,096	kWh per month
6	Average monthly thermal (Diesel) energy consumption	2,050	Liters per month
	Average monthly thermal (coke) energy consumption	33,984	kgs per month
7	Average thermal specific energy consumption	1774.1	kCal/kg of product
8	Electrical specific energy consumption	0.14	kWh/kg of product
		120.4	kCal/kg of product
9	Specific energy consumption	1894.5	kCal/kg of product
10	Electrical energy cost	0.98	Rs/kg of product
11	Thermal energy cost	6.0	Rs/kg of product
12	Total energy cost	6.98	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. 7.0 per unit (average cost calculated from electricity bills)

Figure 1.2 provides annual energy mix for both electrical and thermal energy on cost as well as kCal basis. It is observed that on kCal basis share of thermal energy (94%) is very high as compared to electrical energy (6%), this is mainly due to operation of cupola furnace using thermal energy.



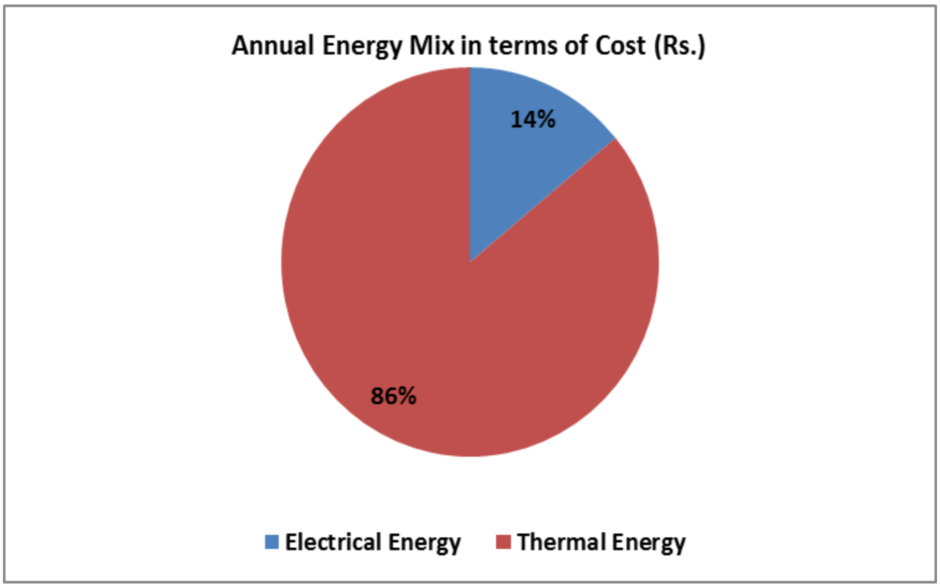


Figure 1.2: ***Annual energy mix in terms of kCal and Rupees***

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 1.3 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.

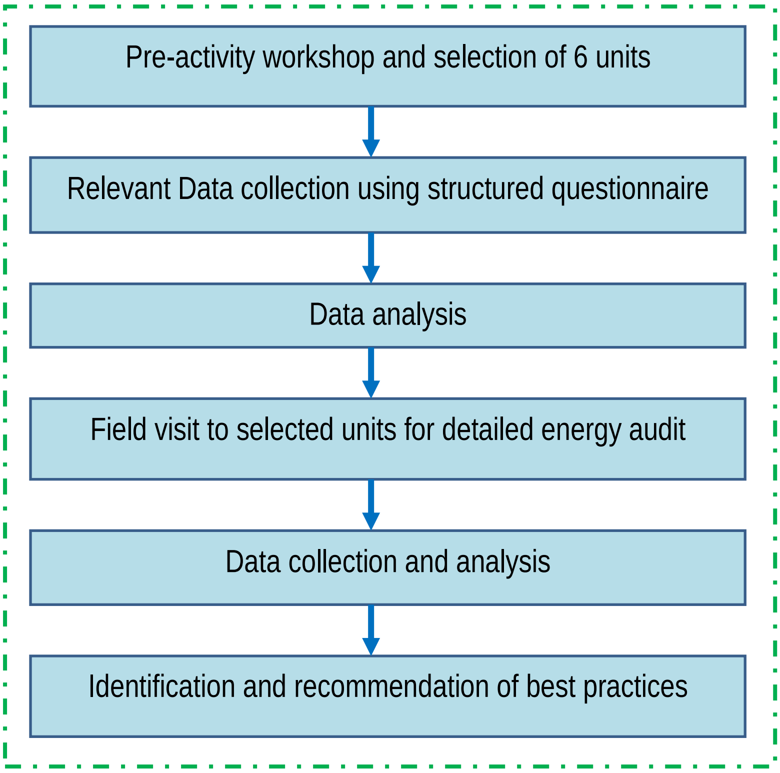


Figure 1.3: ***Flowchart depicting sequence of activities followed for carrying out detailed energy audit***

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 production process being followed in the unit can mainly be categorized into Core shop department, Moulding department, Melting department, Fettling department and Inspection department. Overall process flow diagram 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 Making:

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 to be 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 irregularity on the surface which may cause problem during metal pouring.

▸ Moulding:

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

Moulding sand being used in the process is received from knock out section after going through cooling and mixing operation. The sand received from knock out section is supplied to sand cooler 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. This sand is periodically checked for its properties, if the properties are found as per standard then it is used else it is sent back to make as per standards. Further details related to electrical energy consumption are summarized in table 2.1.

Melting:

In this process, scrap material is melted using Divided Blast Cupola (DBC) furnace. A typical operation cycle for a Cupola Furnace consist of preparing the hearth bottom filled with layers of coke and ignited with wood to start the coke burning then air is introduced through ports from the sides called tuyeres. Once the coke bed is ignited and the required bed height is attended, alternate layers of metal, flux and coke are added until the level reaches the charging door. The metal charge would typically consist of pig iron, scrap steel and domestic returns. The air reacts chemically with the carbonaceous fuel thus producing heat of combustion. Soon after the blast is turned on, molten metal collects on the hearth bottom where it is eventually tapped out into laddle. As the metal is melted and fuel consumed, additional charges are added to maintain the level at the charging door and provide a continuous supply of molten iron. After the charging is stopped, air blast is maintained until all of the metal is melted and tapped off. The air is then turned off and the bottom doors are opened allowing the residual charge material to be dumped out.

Poorly designed cupolas lead to high consumption of coke resulting in increased input costs of melting. A DBC reduces Carbon Mono-oxide (CO) formation by introducing a secondary air blast at the level of reduction zone. Thus the DBC has two rows of tuyeres with the upper row located at around 1 meter above lower row. Dividing the blast air has benefits in terms of energy savings. However, to realize the full benefits of energy efficiency, optimal design of the divided blast system is crucial. The coke consumption in the DBC is reduced by almost 35%. It increases tapping temperature by about 50°C and the melting rate is also increased.

Metal Pouring:

In this step, molten metal from DBC furnace is poured into the moulds using preheated laddle. To ensure the required quality of casting, temperature is measured before pouring. There is temperature drop of 100~150°C in the molten metal from furnace to pouring. After pouring, mould is left for natural cooling for around 1.5-48 hours depending on the size and weight of casting.

Knockout:

In this step, the mould containing solid metal is broken and sand is separated from the casting. 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 de-coring 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 fettling and grinding process are inspected for their accuracy and send for final painting and dispatch if found suitable. After painting casting products are placed for 4 to 6 hours to dry naturally. Finally, the products are sent for dispatch.

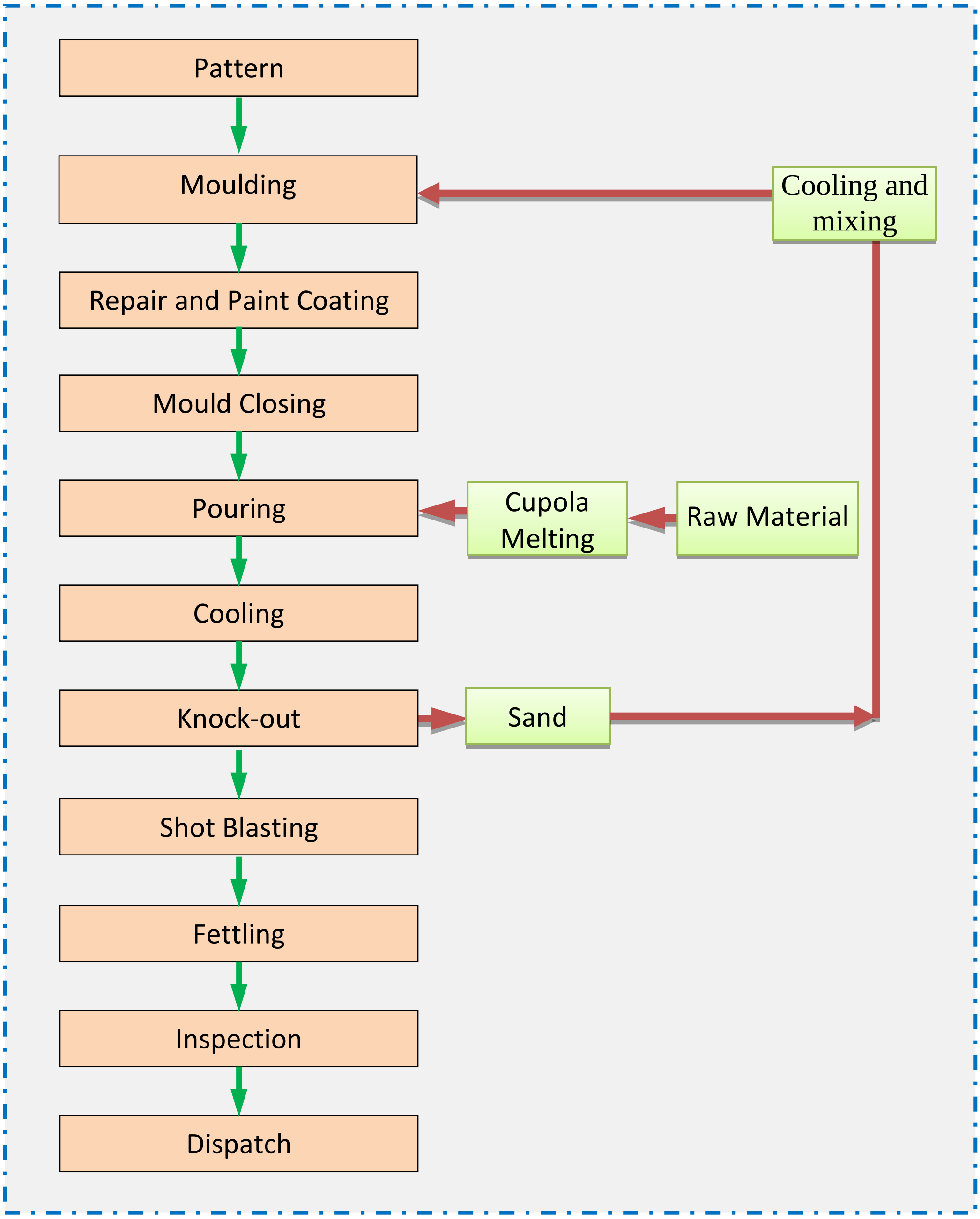


Figure 2.1: ***Process flow diagram***

Pictorial Representation of Production Process

Figure 2.2: ***Different shaped patterns prepared***

Figure 2.3: ***Moulding of sands in the pattern***

Figure 2.4: ***Moulding of sands in the pattern***

Figure 2.5: ***Moulds ready for pouring***

Figure 2.6: C***oke, lime and raw material to be used in cupola***

Figure 2.7: ***Preheating of laddle using firewood***

Figure 2.8: ***Preheating of laddle using diesel fired burner***

Figure 2.9: ***Upper portion of the cupola***

Figure 2.10: ***Flow of molten metal from cupola***

Figure 2.11: ***Preheating of laddle to avoid any cooling of molten metal***

Figure 2.12: ***Pouring of molten metal to moulds***

Figure 2.13: ***Scrap material flowing out of cupola***

Figure 2.14: ***Charge loaded from the top during cupola operation***

Figure 2.15: ***Two separate air flow arrangements in cupola operation***

Figure 2.16: ***Compressor installed***

Figure 2.17: ***Pressure measurement point on the air supply line***

Figure 2.18: ***Blower to supply air for cupola operation***

Figure 2.19: ***Manometer to measure air flow rate***

Figure 2.20: ***Cupola power supply panel***

Figure 2.21: ***V-belt drive being used***

2.2 PRESENT TECHNOLOGIES ADOPTED

The list of equipment's and appliances installed in the unit and used for foundry process are mentioned in table 2.1:

Table 2.1: *Process wise energy consumption information*

SN	Process	Number	Energy Source	Rated consumption	Daily operation (hours)	Days per month	Capacity	Remarks/ Critical Parameter
1	Cupola (30")	1	Thermal (coke) & Electricity (blower motors)	22 kW motor & 7.5 kW charging motor	6 hrs	3	3 tons per hour	Molten metal temperature should be more than 1270^{o}C
2	Cupola (42")	1	Thermal (coke) & Electricity (blower motors)	30 kW motor, 7.5 kW for charging motor and 2.2 kW for hot metal receiver	6 hrs	3	6 tons per hour	Molten metal temperature should be more than 1270^{o}C
3	Cupola (48")	1	Thermal (coke) & Electricity (blower motors)	45 kW motor and 7.5 kW for charging and 2.2 kW for hot metal receiver	6 hrs	3	8 tons per hour	Molten metal temperature should be more than 1270^{o}C
4	Knock Out	1	Electrical – Motor for vibration	5 HP	8~12 hrs	26	6~7 tons per day	-
5	Shot Blast	2	Electricity	7.5 HP (2)	8 hrs	26	6~7 tons per day	To bring finish in the castings
6	Grinding	9	Electricity	3 HP (8) & 2 HP (1)	8~12 hrs	26	6~7 tons per day	Finishing of casting
7	Moulding Sand Mixture	1	Electricity	20 HP	16 hrs	25	20 tons per hour	Mixing of sand, hardener, catalyst/binder (automatic mixture to make the required composition of moulding sand)
8	Attrition Machine	1	Electricity	7.5 HP	8~12 hrs	26	Depends on feed	Crushing sand
9	Compressor	2	Electrical	22 kW & 11 kW	8 hrs	26	62.8 lps & 32.1 lps	
10	Scrubber	1	Electricity	7.5 kW	6 hrs	9		To clean the exhaust gas
11	Cranes	NA	Electricity	NA				Material movement

2.3 DETAILED ENERGY AUDIT

During the field visit to the unit detailed measurement of various equipment's 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 connected load of 449.32 kW. One transformers of 500 kVA capacity is installed to cater to the electrical load requirements. The unit has installed Automatic Power Factor Controller (APFC) and Maximum Demand Controller (MDC). The single line diagram for the electrical system is given below in Figure 2.22. The details of the connected load are attached as ***Annexure 2*** of this report.

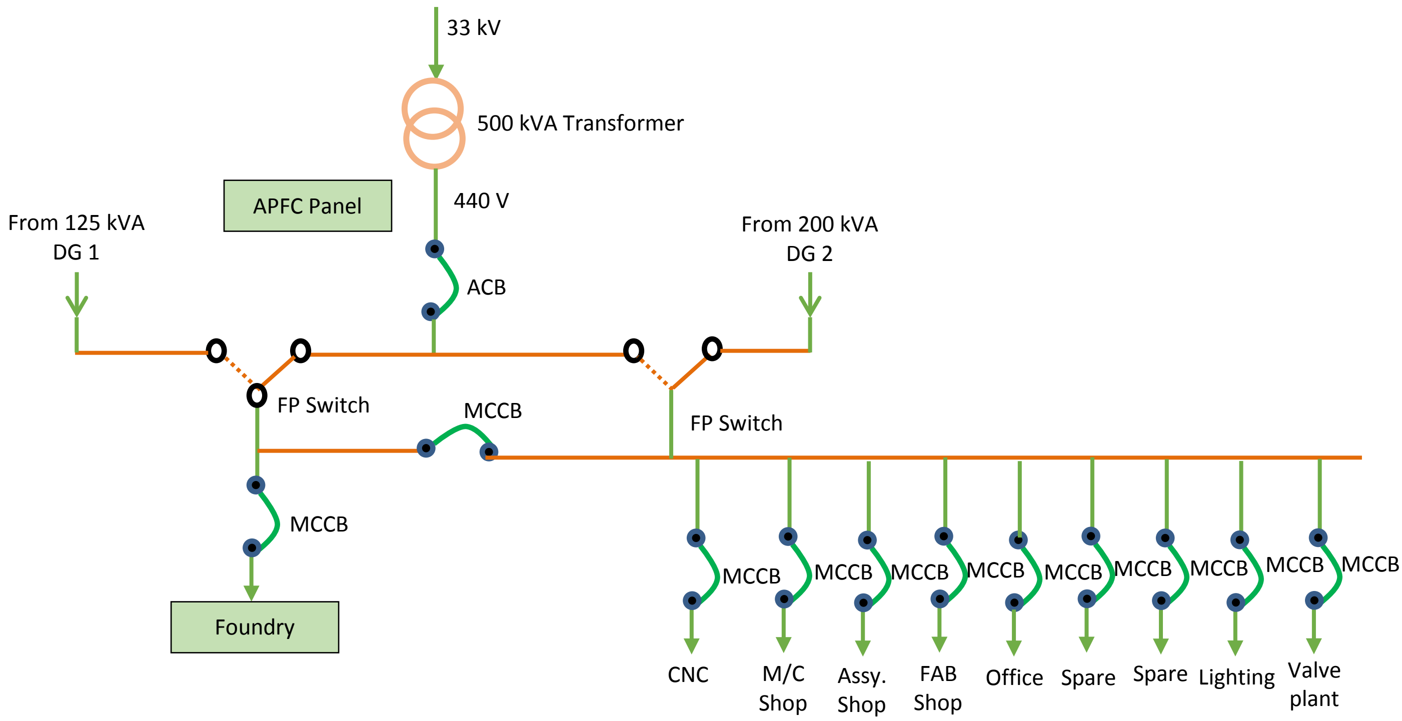


Figure 2.22: *Electrical system*

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. Figure 2.23 provides the monthly variation of electricity consumption, Maximum Demand Indicator (MDI) and Power Factor (PF) for the unit. It is observed, the total monthly maximum demand of the unit is close to its contract demand value of 375 kVA. Further, Unit has installed APFC because of which the PF of the unit is observed to be higher.

▶ Observations:

Most of the electrical distribution panel including main Air Circuit Breaker (ACB) in foundry shop is unsafe to operate and it's highly unsafe to operate in rainy seasons. Haphazard cabling and connections in the panel was observed as there is no cable trench. No insulating / rubber mats were found on front of main ACB. Neutral points/links are not well connected in some cases.

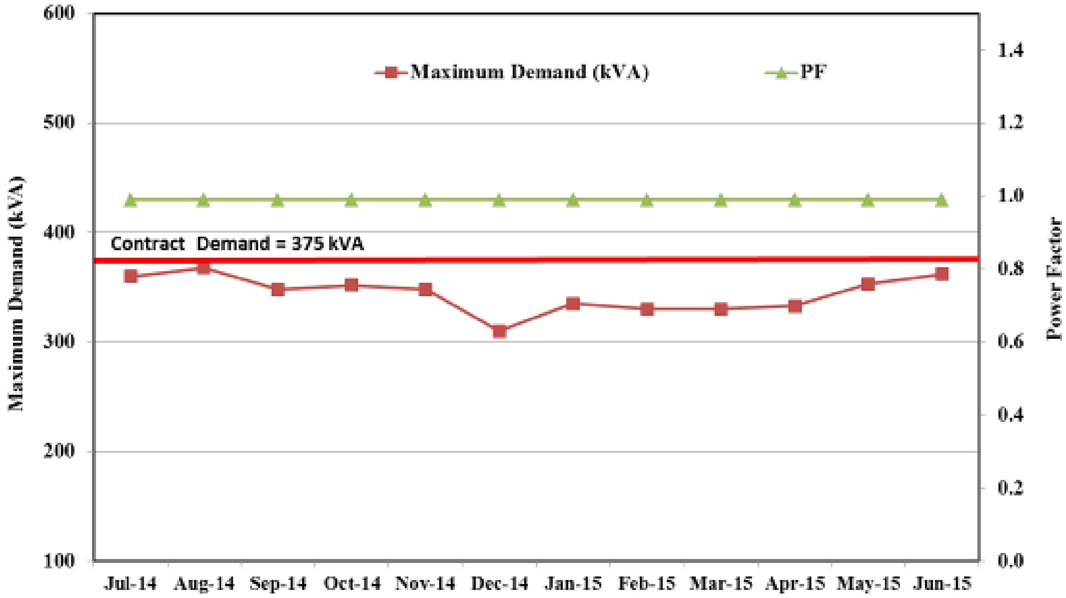


Figure 2.23: ***Monthly variation of maximum demand and PF***

Energy consumption in different sections of the foundry unit is given in Figure 2.24. It can be seen from the figure that maximum energy is consumed by the compressor (45%) followed by the cupola furnace (33%) and in sand moulding operations (20%).

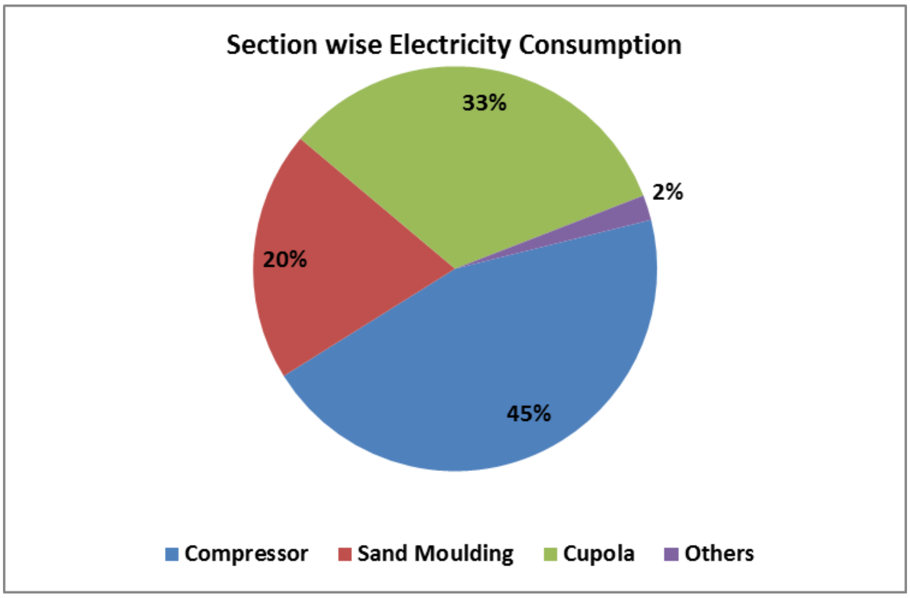


Figure: 2.24: ***Section wise energy consumption in foundry unit***

- **Recommendations:**

It is suggested to implement electrical preventive maintenance and housekeeping steps to cover all open junction boxes, cover loose and unsupported wirings and prevent dust build up in electrical switching equipment. Place insulated / rubber mats on front of all the electrical distribution panels to minimize the risk of electrical shocks when working with electrical systems and equipment.

2.3.2 Divided Blast Cupola:

- **Present System:**

The unit has three DBC of 30, 42 and 48 inches diameter which are operated based on the molten metal requirement. During field visit, DBC of 30 inch diameter was operational for which measurements were undertaken. The hearth bottom is filled with layers of coke and wood is initially burnt to create initial ignition, within 5 minutes first charge of coke (100 kg) is fed inside the cupola. Then the coke is fed in the cupola at a regular interval (10~15 mins) till the bed height is attended. For the 30 inch diameter cupola, 665 kgs of coke was charged. Then the air blower is operated for 2 to 5 mins to remove the ash accumulated, which comes out of the spout. Then the air blower is switched off and 180 kg of lime stone is added to remove the bed coke impurities. After that the charging in cupola starts, every charge contains a mixture of scrap material / pig iron (300 kgs), lime stone (25 kgs) and coke (30 kgs). The charging is done at an interval of 2 to 3 mins. During the cupola operation, total metal of 8,100 kgs was charged and the total molten metal of 7,745 kgs, leading to metal yield of 95.62%.

- **Observations:**

Based on the data measurements during trial run of the cupola the following observations are made;

- The cupola operations had to be abruptly stopped due to leakage of molten metal from the opening of mouth. Prior to this incident, the same 30 inch diameter cupola leakage happened twice within a year. This mishap hampered to glean compete cupola melting measurements cycle.
- The preheating time of 91 minutes was higher than normal course of only 30 minutes. The preheating time (furnace holding time) was deliberately made 3 times higher due to the delay from moulding section, as the moulds were not ready for pouring.
- Air leakage was observed in the upper pipe supplying air to the cupola as well as in the lower main tuyer.
- The differential pressure gauge to measure the amount of air flow ratio in both upper and lower pipe was not functional. Therefore, it was not feasible to assess whether the cupola was operating at design values or not? The cupola was operating under the judgement of operator (refer Figure 2.25).

Figure 2.25: ***Pressure gauge to measure air flow rate***

- There were leakages observed at two places on the wall of the cupola leading to heat loss (refer Figure 2.26).

Figure 2.26: ***Leakage on cupola wall***

- The chemical properties of coke used now and one year before was studied and it was found that now the coke calorific value is 7,200 kCal/kg, whereas, this value was earlier 6,800 kCal/kg. Recently, there is an increase in calorific value of nearly 6% which should be appropriately adjusted by reducing the coke input to the cupola.
- Coke bulk density was measured and found to be 575 kg/m^3 (See Figure 2.27) Considering a bed height of 1.2 meter, 690 kgs of coke would be required to achieve the bed height, instead 665 kgs of coke was actually used. The discussion with the foundry manager and cupola operator revealed that the use of less amount of coke (4% less) was not to compensate towards increase in coke calorific value but it was from cupola furnace operator experience. The increase in coke calorific value was pointed out to foundry manager during the study and was asked to reduce the coke input by nearly 5~6% both during bed preparation and charging (i.e for bed preparation 650 kgs and during charging 28 kgs).

Figure 2.27: ***Coke bulk density measurement***

- The temperature profiling at various operations was carried out; the temperature of 1500°C was at spout, 1300°C at laddle before pouring, and immediately after pouring was 1000°C. The temperature profiling of liquid metal is depicted in Figure 2.28.

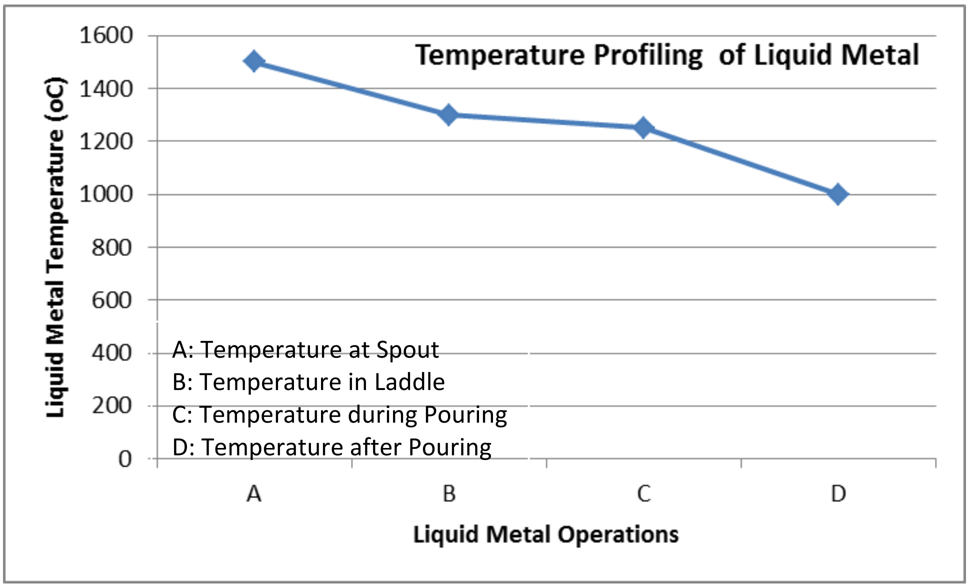


Figure 2.28: ***Liquid metal temperature profiling***

- The month wise kg of metal produced from per kg of coke (metal to coke ratio) consumed comes to 4.7~6.7 (considering bed coke) and 7.5~9.9 (excluding bed coke). The month wise data is plotted in Figure 2.29.

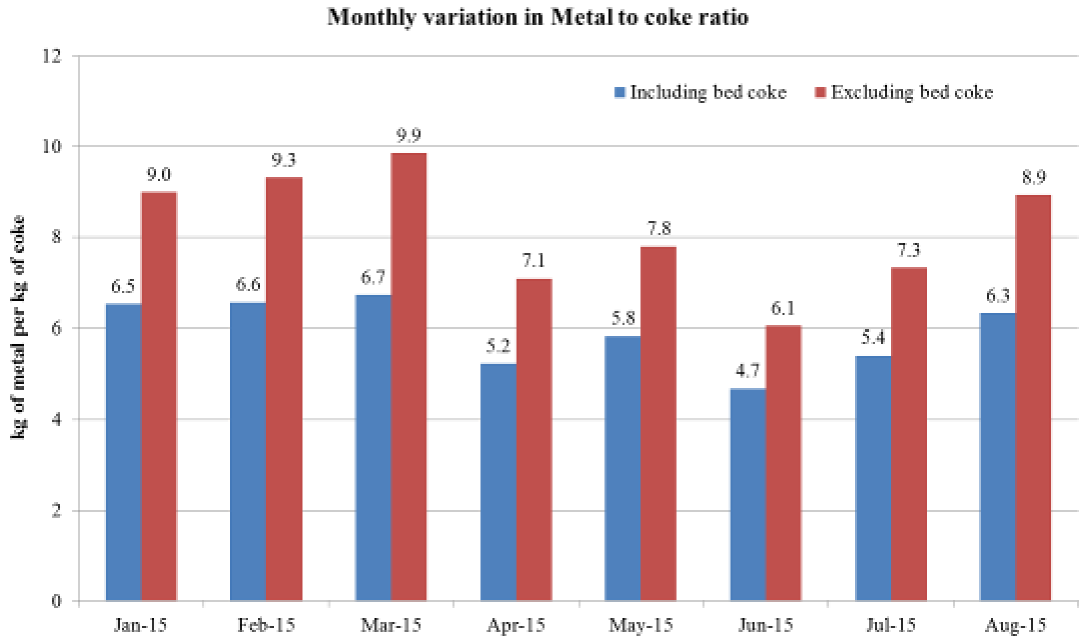


Figure 2.29: ***Variation in metal to coke ratio***

➥ The monthly percentage casting output varies from 88.77 to 96.67 and the average casting output is 93.32%. (See Figure 2.30).

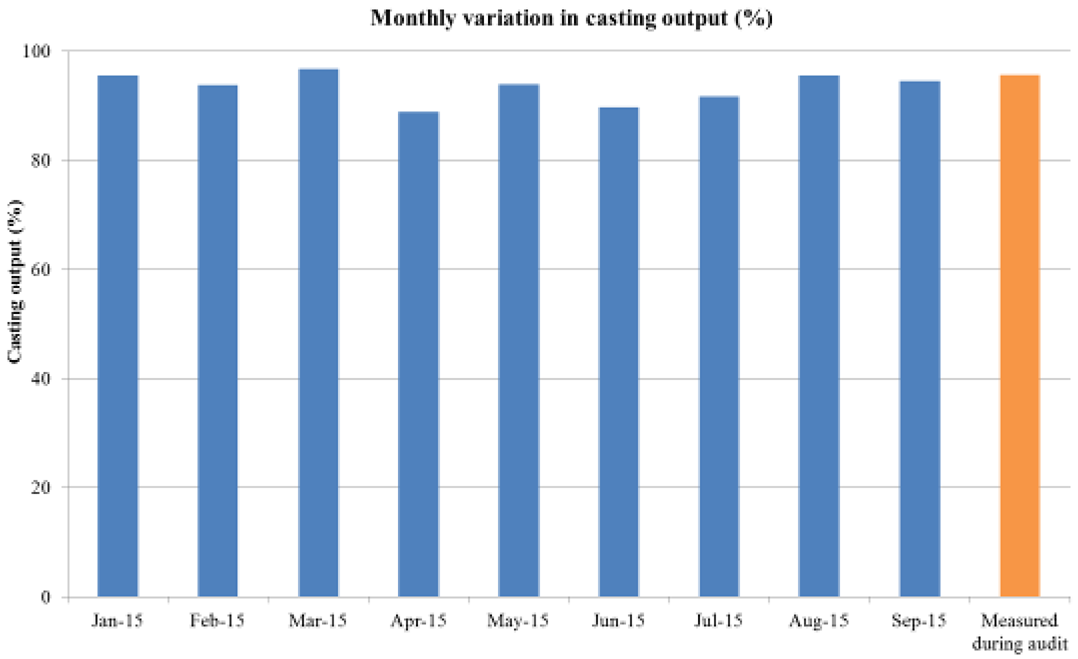


Figure 2.30: ***Monthly variation in casting output***

▶ Recommendations:

Based on the energy audit studies carried out at the unit, following recommendations are made to improve cupola operation efficiency.

➥ The cupola is set up and fired earlier in the morning when moulding section personnel are not available. The information of moulds not ready for pouring is not available and hence the preheating time gets extended unnecessary burning coke in cupola. It is suggested to establish close coordination between melting and moulding section to reduce the preheating time and help to decide when to fire the cupola saving coke consumption.

- It is suggested to install proper measurement devices to accurately measure the air flow being supplied to cupola as primary (60%) and secondary (40%) air.
- V-belts have power transmission efficiency of only 93% resulting in a loss of 7% energy input due to inherent design problems of V-belts. It is recommended to replace V-belts of the Cupola air blower motor with energy efficient synchronous transmission belt, which have higher transmission efficiency of 98% compared to V-belts. The increase in efficiency of flat belts is due to superior material properties and operational characteristics.
- The option of retrofitting Variable Frequency Drive (VFD) in the air blower motor of cupola may be further explored. This will reduce energy consumption substantially as the air blower motor is running on part loading.
- It is suggested to carry out preventive maintenance of the air blower supplying air to cupola. During the cupola shutdown, gases and water vapour from cupola pass through blower blade causing deposits / corrosion over them which gets accumulated over time affecting the blower performance. This can be avoided by regular cleaning of the air blower through preventive maintenance exercise.
- It is suggested to use waste heat of exhaust gases coming out of cupola at a temperature of 250^{o}C to preheat the combustion air. This will result in increase of melting temperature, cupola output and reduce coke consumption.
- It is suggested to carry out periodic coke bulk density and its chemical and physical properties especially when the source of coal supply is changed. Based on the results, necessary corrections in coke consumption should be made.
- It is suggested to plug all the air leakages in the air supply pipes and wall of cupola.

Table 2.2 below provides the cost benefit analysis of the suggested energy efficient measures in the unit.

Table 2.2: ***Cost benefit analysis of suggested energy efficient measures***

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 air blower to supply air to cupola furnace	13,960	97,720	300,000	3.07
2	Replacing conventional V-belts with synchronous belts	807	5,649	20,000	3.5

2.3.3 Electrical Motors:

Present System:

Electrical motors of different sizes are employed in the Unit to carry out different operations. Most of the electrical motors installed are in the range of 10 to 25 HP. A slightly higher rating of electrical motors was observed in knockout section, and sand mixing section.

▶ Observations:

The motor loading measurement and analysis of the few selected motors based on size and usage hours was carried out. The motor loading varies from 55~91%. None of the motors were over loaded. In knockout section the electrical motors used in dust collector is slightly under loaded (55%). This under loading of motors significantly affects the efficiency of the motors. Total Harmonic Distortion (THD) in percentage was measured across these motors and was found in the range of 2.1~3.1%. The power factor was low (0.7~0.9) resulting into energy loss and increase maintenance costs with excessive heating of the motor. The results are summarized in table 2.4.

▶ Recommendations:

- It is suggested to replace the under loaded electrical motors with appropriate size motors.
- For higher sized electrical motors with low PF, it is proposed to install capacitor bank at the motor terminal end to improve upon the PF.
- Given below in table 2.3 is the cost benefit analysis for PF improvement, by installing capacitor banks across motors having low power factor. This intervention would save annually energy of the order of 0.6 lakh kWh with annual monitory benefit of Rs. 4.2 lakhs with just an investment of around Rs. 0.2 Lakhs and payback period of only a month.

Table 2.3: *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	60,000	420,000	20,000	0.04

Table 2.4: ***Summary of measurements performed on electrical motors***

SN	Section	Equipment Name	Current (Amps)			Average Current (Amps)	Voltage (V)	Actual Power (kW)	PF	Rated Motor kW (HP)	% Loading	THD (%)
			R	Y	B							
1	Sand Mixing Area	Sand Mixer (20T)	18.2	17.9	18	18.0	401	11.15	0.89	14.92 (20)	74.71	2.40
2	Knockout	Dust Collector	17	17	16	16.67	403	8.14	0.7	14.92 (20)	54.58	2.50
3	Sand Mixing Area	Dust Collector	17.7	17	17.3	17.33	389	8.17	0.7	11.19 (15)	73.05	1.70
4	Sand Mixing Area	Blower	17	16.8	17	16.90	390	10.27	0.9	11.19 (15)	91.81	2.10
5	Fettling	Shot Blast	17.2	16.7	16.6	16.83	389	8.96	0.79	11.19 (15)	80.07	2.30
6	Cupola Operation	Chimney Motor	18.1	17.8	17.6	17.83	391	10.87	0.9	14.92 (20)	72.85	3.10

2.3.4 Compressor:

Present System:

The unit has installed two air compressors having free air delivery of 62.8 and 32.1 litres per second respectively to meet compressed air demand in the unit. The compressor motor rating is 32 HP and 17 HP respectively. The compressed air is used in core shop, moulding section, fettling section and painting section. The detailed specifications of both the compressors are given below in the tables 2.5.

Table 2.5: *Specifications of compressor*

Parameters	Atlas Copco GA-22	Atlas Copco GA-11
Free Air Delivery (L/S)	62.8	32.1
Maximum Final Pressure (Bar)	7.5	7.5
Motor kW/HP	22/32	11 / 17
Compressor Load (Bar)	5.7	5.7
Compressor unload (Bar)	6.8	7

Figure 2.31: C*ompressors installed*

Observations:

Measurement of electrical parameters was carried out to estimate percentage loading of 32 and 17 HP compressors. The percentage loading of compressors motor during load (or ON) condition is cent percentage, whereas, it's just below 40% during unload (or OFF) condition. The percentage loading of both the compressor during load and unload condition is found to be satisfactory. The PF across compressor (Atlas Copco GA-11) during unload and load condition is less, 0.58 and 0.87 respectively, which requires correction. The measurements are summarized in table 2.6.

Table 2.6: *Measurements performed on the compres*sor

Compressor Name	Loading Condition	Current (Amps)				Voltage (Volts)	PF	Actual Power kW (HP)	Loading (%)
		R	Y	B	Average				
Atlas Copco GA-22	Unload	13	13	14	13.33	402	0.9	8.36 (32)	35.00
	Load	32	36	36	34.67	405	0.98	23.83 (32)	99.83
Atlas Copco GA-11	Unload	13	12	11	12.00	398	0.58	4.80 (17)	37.83
	Load	23	22	20	21.67	388	0.87	12.67 (17)	99.89

InsPIRE

Compressor leakage test could not be performed as the unit was in operation. However, a compressor leakage test format (See ***Annexure 3***) was shared with maintenance team and demonstration on how to conduct compressor leakage test was impacted. This has helped the maintenance team to perform the compressor leakage test when the compressed air was not in use by any equipment and shared the measurement readings. Based on the information provided by the maintenance team regarding compressor leakage trail, the compressed air leakage percentage of 32 HP compressors was found to be around 33% and for the 17 HP compressor it was 21%. The compressed air leakage values for both the compressors is found to be on very high side as for a well maintained system the leakage should be less than 10%. The detailed calculation of the compressor air leakage trail is attached as ***Annexure 4***.

The ventilation in the compressor room (See Figure 2.32) was found to be very poor as facilities for venting in fresh air is not made. The compressor room was found to contain high moisture in the air.

Figure 2.32: C*ompressor house*

For the compressor, the specific electricity consumption (SEC) in terms of kWh per MT was calculated. The specific electricity consumption varies from 76 to 191 kWh/MT and the average comes to 122 kWh/MT (See Figure 2.33). The highest SEC recorded was 191 kWh/MT in April 2014 which was 69 units higher than the average value and the lowest SEC was in October 2014, only 76 kWh/MT, around 46 units less than the average SEC. The higher SEC recorded may be attributed by the high compressed air leakage.

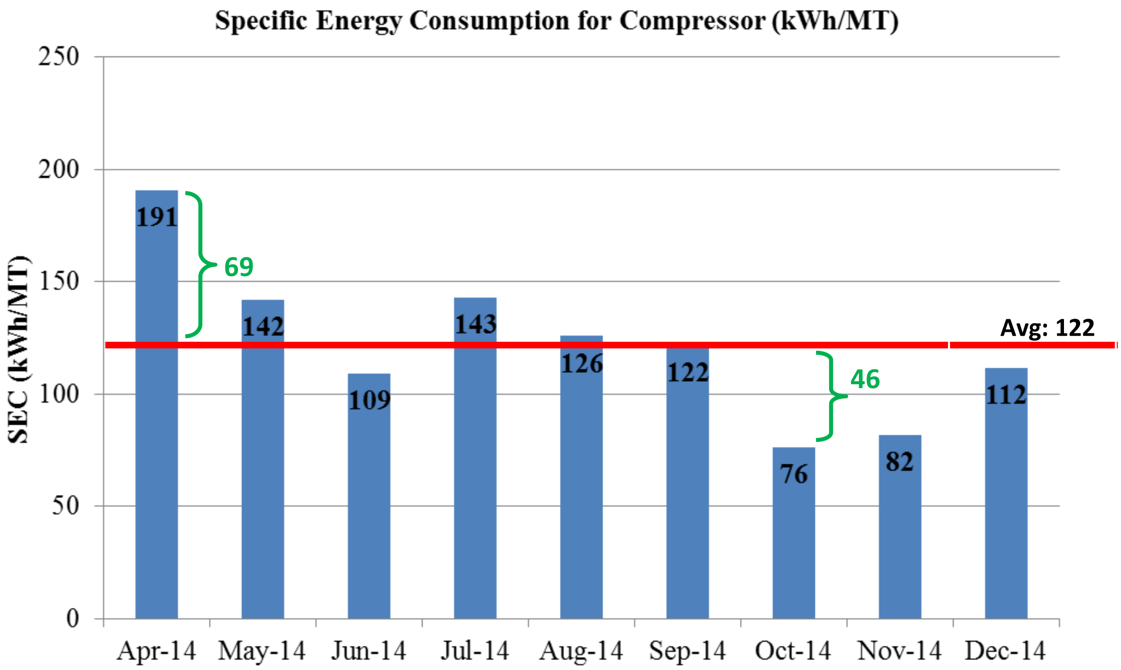


Figure 2.33: *Compressor Specific Energy Consumption (in kWh/MT)*

Recommendations

- Based on the compressor leakage trial, it is suggested to plug-in leakage in both the compressed air line to bring it below acceptable limits (i.e 10%). The cost benefit analysis for reducing leakage in the compressor system is given in table 2.7. It has been observed that by reducing leakage energy saving of the order of 0.59 lakh energy units can be achieved accounting to an annual monitory saving of Rs. 4.42 lakhs with no investment.

Table 2.7: *Cost Economic Analysis for Compressor*

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 1 (GA 22)	45,917	344,000	Nil	NA
2	Reducing Energy Loss due to Leakage in Compressor 2 (GA 11)	13,065	98,000	Nil	NA
	Total	**58,982**	**442,000**	**Nil**	**NA**

- 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. The leakage reduction would bring down the power consumption and thereby overloading of the system.
- It is proposed to install VFD in both the compressors. Given below is the cost benefit for installation of VFD in both the compressors. It can be seen from the table 2.8 that by using VFD in compressor energy saving upto 29,945 kWh / year can be achieved, which amounts to an energy saving of Rs 2.09 Lakhs / year.

Table 2.8: *Cost Economic Analysis – Installing VFD in 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 (GA 22)	20,210	141,471	300,000	2.12
2	Installation of VFD in Compressor 2 (GA 11)	9,735	68,146	300,000	4.4
	Total	**29,945**	**209,617**		

- Ensure air intake to compressor is not warm and humid by locating compressors in well ventilated area.
- Clean air inlet filters regularly
- It is suggested to keep the valves in good conditions
- Reduce compressor delivery pressure wherever possible to save energy
- Log books should be checked regularly for abnormal readings

2.3.5 Exploring Opportunity for Renewable Energy Usage

Discussions were held for the possibility of using renewable energy applications with the officials during field visit. But there were certain barriers evolved like non-availability of area and local resources, inadequate information, lack of access to capital, proper trained personal etc. there is also this less anticipated savings against the cost and operational complexity associated with renewable energy interventions. Thus the idea was wholly rejected.

Questionnaire*

Energy Audit – Questionnaire Form

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

Name of the MSME unit:	Jash Engineering Limited
Address:	31, Sector -C, Industrial Area, Sanwer Road, Indore-MP
Ph. No:	0731-6732701, M: 09755416000.
Name of the respondent	Sri L.D. Amin
Designation:	Managing Director

1. **Year of Establishment: 1977**
2. **Type of Products: a) Sluice Gate**

   b) Valve

   c) Bed Plate, Surface Plates
3. **Installed Capacity: 300 Ton/Month**
4. **Operating hrs per day :16 Hrs**
5. **Connected Load: 375 KVA (kVA or kW please specify)**
6. **Supply Voltage: 400 Volt**
7. **Annual Energy Consumption/ Production:**

Financial Year (April to March)	2012	2013	2014
Coke consumed (tons)	377051	383636	407800
Cost of coke (in Rs. Lakhs)	10086114	9506500	9645010
Electrical units consumed (In kWh)	236052	222242	253151
Electricity charges (In Rs. Lakhs)	1416312	1555694	1772057
LDO/HSD/ FO consumption (kL)	29935	26240	24600
Fuel Cost (In Rs. Lakhs)	11532361	11088434	11441667
Production (Tones)	1930.54	1723.2	1791.5

*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)	Imported Coke	
HSD (kL)	Indore Local	
LDO (kL)	Indore Local	
FO (kL)		

Fuel	Source
Electricity (kWh)	MADHYA PRADESH ELECTRIC BOARD (MPEB)

9. Monthly Energy Consumption and Production Data:

Month	Production (Kg)	Coke consumption (Kg)	Electricity consumption (kWH)	HSD/LDO /FO (kL)	Any other fuel (specify units) (LPG Cylinder)
April, 14	100196	20690	19007	1600	8
May, 14	149425	21890	20216	1800	4
June, 14	155695	42300	21940	1400	15
July, 14	139945	43480	23652	3000	19
August, 14	161543	34500	22619	3400	23
September, 14	146676	33330	21073	2800	30
October, 14	157744	41220	15099	2000	18
November, 14	182772	44650	23215	2800	18
December, 14	173826	38090	22832	1400	6
January, 15	171409	35650	23635	2400	17
February, 15	138527	28620	20472	1200	9
March, 15	114350	23390	19391	800	5

10. Duration of electricity supply: 24 Hours/ day

11. Cost variables per Ton of Production:

Cost Variable	Cost/ ton of production
Electricity Cost	Approx. Rs1000/ton
Coke Cost	Approx. Rs 5400/ton
Fuel Cost (LDO/HSD/FO) etc.	Approx. Rs 15/ton
Labour Cost	Approx. Rs 6500/ton
Material Cost	Approx. Rs 50000/ton
Other Cost	Approx. Rs 8000/ton
Total Production Cost	**Approx. Rs 70000/ton**

12. Major Energy Consuming Equipment:

SN	Equipment	Energy source	Make/ Supplier	Year of Installation	Technical Specification	Use	Comments
1	Sand Mixer	Electric	IMF, Italy	2010	20 Ton Continuous Mixer 20 HP	Sand Mixing with binder and catalyst for moulding	
2	Compaction Table	Electric	J.K. Foundry Ahmadabad	2007	10 HP	Moulding	
3	Compaction Table	Electric	J.K. Foundry Ahmadabad	2007	02 HP	Core Making	
4	Crane	Electric	Sky Line		15 Ton	Material Handling	
5	Crane	Electric	'---		15 Ton	Material Handling	
6	Crane	Electric	Hitech		7. 5 Ton 13.6 HO	Material Handling	
7	Knockout Grid	Electric			05 HP	Knockout	
8	Attrition M/C	Electric	J.K. Foundry Ahmadabad	2007	7.5 HP	Crushing Lump	
9	Bucket Elevator	Electric	Rihno M/C Baroda	2007		Transporting sand to storage hopper	2 No.
10	Cooler Classifier	Electric	IMF, Italy	2010		Colling Sand	
11	Culler Grinder 7"	Electric			3 HP	Cutting runner, gates etc	06 No.
12	Bur Grinder	Electric	Kaustibo Engg	2014	3 HP	Finishing casting	02 No.
13	Vibrator/Chipper	Electric	Hitachi		1 HP	Removing sand from casting	2 No.
14	Angle Grinder 5"	Electric	Rauli wolf	2014	2 HP	Finishing casting	1 No.

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

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

PROCESS FLOW CHART `(PATTERN) FULLY PATTERN CHECKED MOVE FOR FURTHER PROCESS MOULDING REPAIR & PAINT COATING MOULD CLOSING CUPOLA MELTING POURING COOLING KNOCK-OUT SHOT-BLASTING FETTLING INSPECTION DISPATCH

15. Any Energy Efficient Technology installed in the unit: NA

Technology	Specification	Cost	Year of Installation

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

Technology	Cost	Use

17. Any factory expansion plan: YES

Annexure 2:

Connected Load Details – Foundry Shop

S.No.	Equipment Name	Equipment Code	Connected load	
			(in kW)	(in HP)
1	Dust Collector		15	20.1
2	Mixer 20T		15	20.1
3	Mixer 3T		2.2	2.9
4	New Dust Collector		11.37	15.2
5	Cupola Furnace 1 (48")		55	73.7
6	Cupola Furnace 2 (42")		25	33.5
7	Cupola Furnace 3 (30")		10.7	14.3
8	Bucket Elevator 1		14	18.8
9	Bucket Elevator 2		14	18.8
10	Vibrator 1		5.7	7.6
11	Vibrator 2		5.7	7.6
12	Muller		5.5	7.4
13	Compressor -1	CP-2	11	14.7
14	Compressor -2	CP-3	22	29.5
15	Crane 7.5 T	EOT-11	10.7	14.3
16	Crane 15 T	EOT-9	21	28.2
17	New Crane 15 T		20	26.8
18	Crane 10 T	EOT-10	13.4	18.0
19	Crane 3 T		4.8	6.4
20	Crane 3 T		4.8	6.4
21	Crane 3 T		4.8	6.4
22	Crane 3 T		4.8	6.4
23	Crane 300 kg		3.7	5.0
24	Crane 300 kg		3.7	5.0
25	Crane 300 kg		3.7	5.0
26	Shot Blasting		11	14.7
27	Welding M/c		38	50.9
28	Oil Welding M/c		9	12.1
29	Lab		5	6.7
30	Cutter Grinder		15	20.1
31	Cooling Tower		5	6.7
32	Chimney		18.7	25.1
33	Compressor (ELGI)		5.5	7.4
34	Muller 300 Kg		1.5	2.0
35	Water Pump		2.2	2.9
36	Water Pump		2.2	2.9
37	Diesel Pump		0.5	0.7
38	Diesel Pump		0.5	0.7
39	Compaction Table		5.5	7.4
	Total Load		**427.17**	**572.4**

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 4:

Compressor Leakage Trail

Compressor - Atlas Copco GA-22

SN	Load Time (Sec)	Unload Time (Sec)	Total Cycle Time (Sec)	% Leakage
1	53	122	175	30.29
2	63	131	194	32.47
3	66	130	196	33.67
4	68	128	196	34.69
5	65	127	192	33.85
Average	**63**	**127.6**	**190.6**	**33.05**

Compressor - Atlas Copco GA-11

SN	Load Time (Sec)	Unload Time (Sec)	Total Cycle Time (Sec)	% Leakage
1	119	430	549	21.68
2	118	426	544	21.69
3	124	424	548	22.63
4	108	450	558	19.35
5	122	431	553	22.06
Average	**118.2**	**432.2**	**550.4**	**21.48**