National Program

on

Promoting Energy Efficiency and Renewable Energy in MSME Clusters in India

Jamnagar Brass Cluster

Detailed Energy Audit Report
Gold Metal Extrusion

Submitted to

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Contents

List of Tables

List of Figures

Abbreviations

APFC	Automatic Power Factor Controller
BEE	Bureau of Energy Efficiency
FO	Furnace Oil
GEF	Global Environment Facility
HP	Horse Power
Kcal	Kilo Calories
Kg	Kilogram
kVA	Kilo Volt Ampere
kW	Kilo Watts
kWh	Kilo Watt Hour
MDI	Maximum Demand Indicator
MDC	Maximum Demand Controller
MSME	Ministry of Micro Small and Medium Enterprises
PF	Power Factor
SEB	State Electricity Board
SEC	Specific Energy Consumption
SME	Small and Medium Enterprise
UNIDO	United Nations Industrial Development Organization
VFD	Variable Frequency Drive

About the Project

The project titled "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 Jamnagar Brass cluster located in Jamnagar (Gujarat) by supporting them to adopt Energy Efficient and Renewable Energy practices. There are more than 4,000 Small and Medium Enterprise (SME) Brass 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 Jamnagar Brass Cluster include following:

- Conducting Pre-activity Workshop
- Comprehensive energy audit in 6 Brass units
- Discussion with 3 cluster experts and 2 equipment suppliers to develop best operation practice document for 5 key technologies
- Enumeration of common regularly monitor able parameter at the process level which have impact on energy performance, and listing of appropriate instrumentation for the same
- Identification of set of energy auditing instruments that should be used for carrying out periodic energy audits in the units
- Conducting 3 post energy audit technical workshops for knowledge dissemination

As part of the activities conducted under the energy efficiency study in Jamnagar Brass cluster, detailed energy audits in 6 Brass units in Jamnagar was conducted in the month of July'2015.

Executive Summary

Name of SME unit : M/s Gold Metal Extrusion

Location of the SME unit : Shade No. 770/C, G.I.D.C, Phase-II, Dared, Jamnagar, Gujarat

Based on the measurements carried out and data collected during field visit in the month of July'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 in the Table 1 below:

Table 1: *Cost Economic Analysis*

SN	Energy Efficient Measure	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Year / months)
1	Installation of Air Fuel ratio controller	142,933	125,000	11 months
2	Installation of waste heat recovery system (recueperator)	206,079	100,000	6 months
3	Installation of Variable Frequency Drive (VFD) in extrusion press (3 VFDs for 3 motors)	227,460	900,000	4 years
4	Avoiding over loading of metals in the Induction Furnace	57,551	Nil	Immediate
5	Avoiding over super heating of metals in the Induction Furnace	30,290	Nil	Immediate
6	Replace old pump 7.5 HP mold cooling pump with 5 HP energy efficient pump	48,723	57315	1 Year 2 months
7	Replacement of old 7.5 HP pump with 3.3 HP energy efficient pump	172544	79980	6 Months
8	Replace conventional ceiling fan with Energy Efficient (BLDC) Ceiling fan	20296	66,000	3.1 years
9	Replace 55W florescent tube light with T-8 (20W) LED light	27,776	26,000	10 Months
10	Replace 85W CFL with 45 W rocket LED lamp	17,856	25,275	1 Year 5 months
11	Replace 250W halogen light with 120W LED street light	169,616	30,950	5 Year 6 Months
	Total	**11,21,124**	**14,10,520**	

- **Electrical Panels:**

The unit has contract demand of 350 kVA. The unit has installed one transformer of Kirloskar make with capacity of 500 kVA. This reduces the supply voltage from 11 kV to 440 V. The unit has also installed Automatic Power Factor Controller (APFC) to maintain power factor close to unity. The voltage Total Harmonic Distortion (THD) was measured to be in the range of 1.2 to 2.8%. However, there were safety concerns identified during the audit. The construction of the electricity supply house was unplanned construction on front of the entry gate. The floor level of the electricity supply house is at lower level as compared to the unit floor which encounters water logging problems especially in the rainy seasons, making it difficult to operate the electrical panels as well as faces safety issues. It is suggested to properly place rubber (or insulating) mats on front for each of the electrical panels for safety reasons as well as replace the damaged once. It is suggested to reconstruct the electricity supply house as per the guidelines of State Electricity Boards (SEBs) in order to avoid water logging and any accident during rainy seasons.

- **Oil Fired Billet Reheating Furnace:**

The furnace oil based billet reheating furnace being used in the unit. The reheating furnace efficiency was assessed through direct method and found to be on lower side, nearly 15%. Based on the information collected, it is suggested to use air preheater and air fuel ratio controller to improve the efficiency. The thermocouples being used for temperature measurement were not operational and decision regarding completeness of heating was being made based on the operator's judgement. It is suggested to replace proper temperature measurement device at proper locations to measure furnace temperature.

- **Induction Furnace:**

Induction furnace is the most energy intensive equipment being used in the unit. The unit has installed induction furnace of 250 kW. Based on the detailed measurement carried out at the unit, it was found that cold start of the furnace consumes 18% more electrical power. It was observed that, 33% (3 of 9) melts were on "furnace holding" mode consuming nearly 8.3% more power. The energy consumption, in terms of kWh per tons of molten metal (as defined as SEC), comes to 340 (excluding the SEC for furnace cold start). Further, there were many deficiencies observed in the current operation practice including no data logging, scrap loading above coil level etc. To improve the energy performance, it is suggested to maintain log records of type and quantity of scrap material being used and electricity consumed for every charge. Further specific format for following the best practices are also developed to be utilized as the guiding document.

- **Extrusion Press:**

The unit has installed extrusion machines employing three motors of 60 HP. Based on the detailed field measurement, the average load and unload time of extrusion press motor was found to be 0.16 seconds and 1.18 minutes respectively. Similarly percentage loading for three motors during loading was around 46, 51 and 77%. During loading power factor was found to vary from 0.72 to 0.83. During non-loading conditions these values are lower with average loading of around 10% and PF of around 0.18. It is suggested to measure the temperature of the billet being pressed in the extrusion press as lesser temperature of the billet would consume higher electrical power during the pressing operation. Installation of VFDs in all the three 60 HP motors of extrusion press would lead to good amount of energy savings as they are under loaded during no load conditions (only 10% loading measured).

- **Installation of energy efficient pumps, lightings and ceiling fans:**

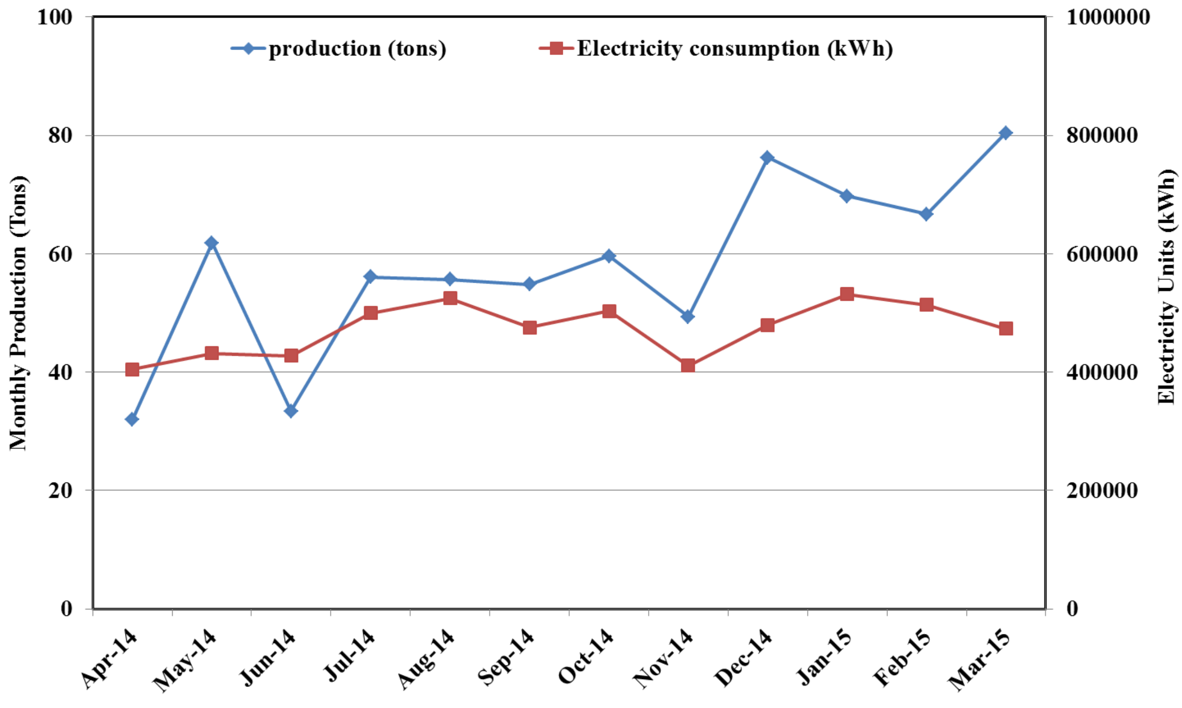
The unit has installed conventional lightings, ceiling fans and pumps in their factory premises which are presently consuming a significant amount of energy. Replacement of these equipment and fixtures with energy efficient equivalent will lead to significant savings in terms of energy consumption of the unit.

Introduction

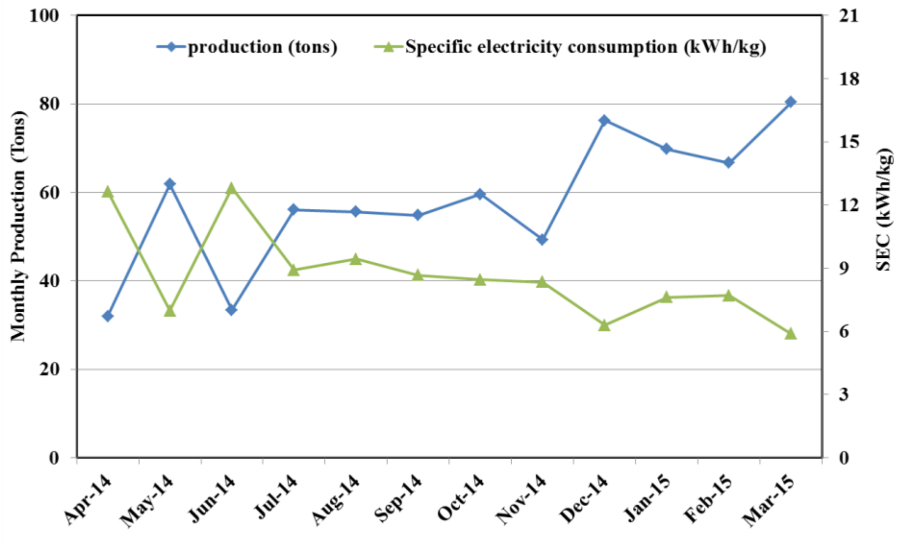
1.1 ABOUT THE UNIT

Gold Metal Extrusion is an ISO 9001:2008 certified company and is engaged in manufacturing of different types of brass extrusion including extruded brass rod, brass ingot, brass billet, extruded brass profile, extruded brass section in conformation to different standards like IS, BS, DIN, ASTM etc. These Brass Extrusions find application in the manufacture of Brass Components etc.

The monthly production of the unit is around 58 tons. The unit uses electricity supply from SEBs for various process and utility applications in premises and FO for reheating furnace. Figure 1.1 depicts monthly electricity consumption vis-à-vis total monthly production of the unit for last one year.



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

Major electricity consumption is required by electrical induction furnace for scrap melting operation. Unit has installed one furnace oil based reheating furnace for carrying out heating of billets.

The monthly Furnace Oil (FO) consumption in the unit is around 324,325 liters. According to the assessment of the energy consumption data collected, the specific thermal energy consumption and specific electrical energy consumption is 7.0 Liters per kg and 9.0 kWh per kg of product respectively. The total specific energy consumption (in kCal) is 49,355 kCal per kg of product. Details of annual electrical and thermal energy consumption and specific energy consumption details in Gold Metal Extrusion are presented in Table 1.1 below:

Table 1.1: ***Details of M/s Gold Metal Extrusion***

SN	Parameter	Value	Unit
1	Name and address of unit	Gold Metal Extrusion, Shade No. 770/C, G.I.D.C, Phase-II, Dared, Jamnagar, Gujarat	
2	Contact person	Mr. Rameshbhai A Viramgama, 0288-2730733	
3	Manufacturing product	Extrusion Brass Rod	
4	Monthly Production	58 tons per month	
	Energy utilization		
5	Average monthly electrical energy consumption	473,018	kWh/ month
6	Average monthly thermal (FO) energy consumption	324,345	Liters/ month
		3,249,043	MCal/month
7	Average specific thermal energy consumption	7.0	Liter /kg of product
8	Specific electrical energy consumption	9.0	kWh/kg of product
9	Specific energy consumption	49,355	kCal/kg of product
10	Electrical energy cost	55	Rs/kg of product
11	Thermal energy cost	215	Rs/kg of product
12	Total energy cost	270	Rs/kg of product

Note:

Specific gross calorific value of FO is considered as 10017 kCal / liters
Thermal equivalent for one unit of electricity is 860 kCal / kWh
The unit operates for 25 days a month (1 shift of 8 effective hours per day).
Cost of FO = Rs. 30 per liters (the purchase price provided by the unit)
Cost of Electricity = Rs. 6.4 per unit (average cost calculated from electricity bills)

Figure 1.2 provides annual energy mix for both electrical and thermal energy on cost (in Rs.) as well as kCal basis. It can be observed share of thermal energy is high as compared to electrical energy mainly due to presence of reheating furnace.

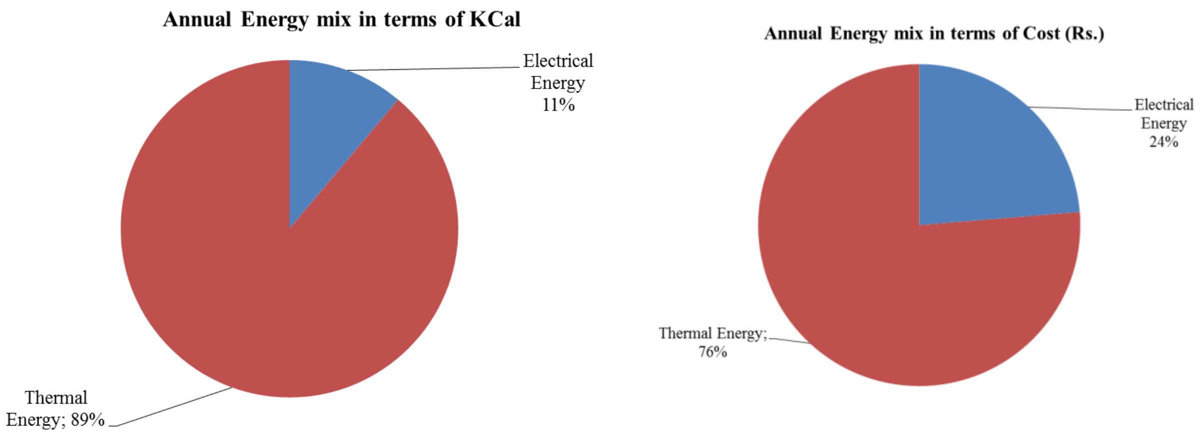


Figure 1.2: ***Annual energy mix of the unit in terms of kCal and Rupees***

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.

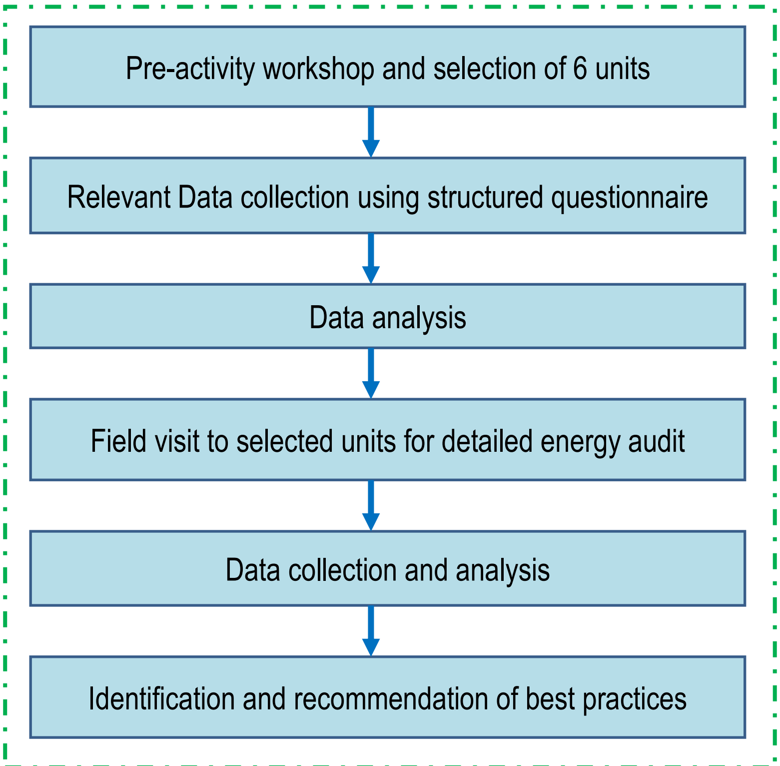


Figure 1.3: *Flowchart depicting sequence of activities followed for carrying out detailed energy audit*

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

Gold Metal Extrusion is involved in the production of finished brass products including different size rods and sections. The process flow chart 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.

- **Raw Material Sorting and Scrap Pressing:**

The raw material received in the unit is first subjected to manual sorting based on their composition. After sorting, low density raw material are compressed in a hydraulic press having motor of 10 HP. This scrap pressing is carried out only for selected raw materials and therefore machine is not operated regularly.

- **Metal Melting:**

The sorted as well as compressed material is subjected to melting in the electrical induction furnace. Based on the final product requirement, raw material composition in the induction furnace is decided. Scrap material is heated to around 1050^{0}C. The 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 molten metal temperature.

- **Metal Pouring:**

The molten metal in the induction furnace is poured directly in the dies after checking its temperature and material composition. The unit has installed 6 dies connected in series having the required cavity of the billet to be produced. Water is circulated in the outer shell of the dies to facilitate cooling of the poured material. Molten metal is poured from the top and after some time bottom lid is opened to remove the hot billet from the dies. This hot billet is then left for natural cooling and then used for subsequent phase of operations.

- **Billet Cutting and Reheating in Oil Fired Furnace:**

The billets are cut into smaller pieces based on the final product requirement using a bend saw machine having a motor of 3 HP. This motor is operated for 8 to 10 hours per day. These cut pieces are then subjected to heating in oil fired furnace before extrusion process. The material is heated up to a temperature of 750^{0}C. This heating process requires electrical energy in the form of blower and thermal energy being supplied through FO. The detailed description of this is further provided in the subsequent section of the report.

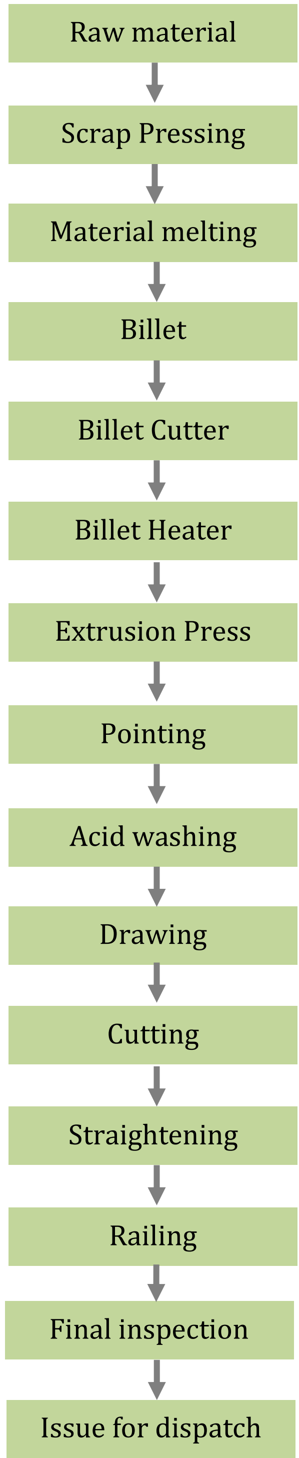


Figure 2.1: ***Process flow diagram***

- **Extrusion Press:**

In this process hot billet from reheating furnace is squeezed in the extrusion press to produce long rods of required dimensions. The required shape and size is achieved by forcing the hot material to pass through dies. These dies are also heated before passing material from these. So this essentially a size reduction step in which hot billet of larger diameter is converted into long rods of small diameter. The extrusion press 60 HP motor along with one 2 HP motor for cooling and 5 HP motor to operate hydraulic valve. The temperature of the hot billet is very critical to this extrusion process. If the material being put in extrusion press has lower temperature, then the electrical energy required by the press will be more. This process also results in material loss due to the removal of upper surface of the hot billet pieces.

- **Cutting of Brass Rods as per Final Product Requirement:**

After hot drawing in the extrusion press, material is left in open for 3 to 4 hours to facilitate natural cooling. The brass rod then goes through series of machining operations including Pointing, Acid washing, drawing, cutting, straightening and railing. The machining process is job specific and varies from one product to another. Major energy used in all these processes is electrical energy. Pointing process is carried out to make end of the brass rod suitable for subsequent operation. Acid wash of the brass rods is carried out mainly to remove surface impurities. Thereafter, material is subjected to cold drawing. This process would bring uniformity in the rod size throughout its length. After drawing, material is subjected to cutting to size the rods in required sizes. Finally rods are subjected to straightening operation to make the rods straights. In railing operation, brass rods are passed through rollers to make these straight as well as improve the surface finish. Finally the material is dispatched after proper inspection. The details of the electrical motors being used in these operations are summarized in the Table 2.1. Further Figure 2.2 to 2.19 provides pictorial depiction of the production process being followed in the unit.

<u>Pictorial Representation of Production Process</u>

Figure 2.2: ***Raw material being used***


Figure 2.3: ***Sorting of raw material***


Figure 2.4: ***Bailing machine being used for compaction of selected raw material***

Figure 2.5: ***Raw material after compaction in the bailing machine***

Figure 2.6: ***Melting of raw material in the induction furnace***

Figure 2.7: ***Pouring of raw material in cylinders to make billets***

Figure 2.8: ***Billet prepared from the molten material***

Figure 2.9: ***Shearing machine for cutting of the billets***

Figure 2.10: ***Pieces of billets after cutting***

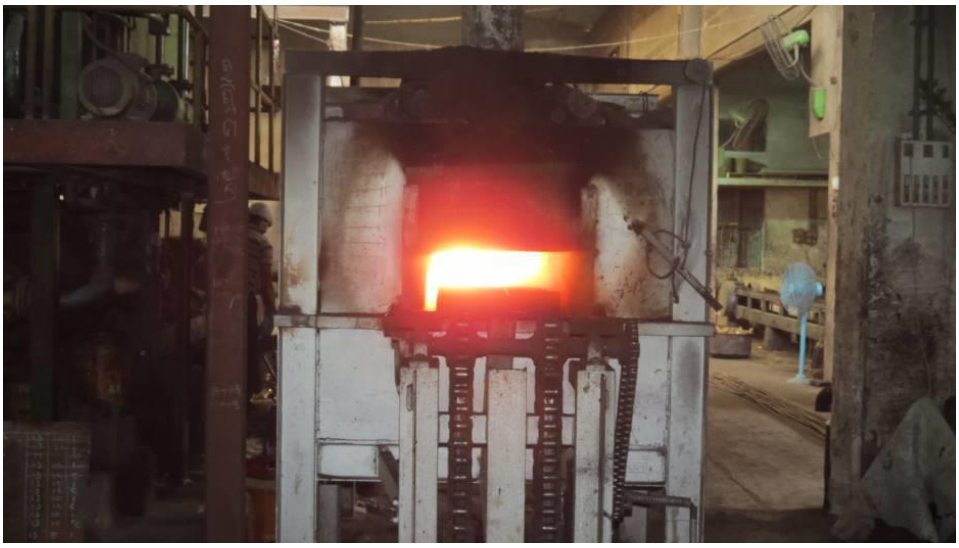


Figure 2.11: ***Heating of material in reheating furnace***

Figure 2.12: ***Heated material coming out from reheating furnace***

Figure 2.13: ***Drawing of the heated material in the required shape & size in the extrusion press***

Figure 2.14: ***Front end of the rod material before pointing and pointing operation in progress***

Figure 2.15: ***Drawing of rods***

Figure 2.16: ***Cutting of rods***

Figure 2.17: ***Straightening of rods***

Figure 2.18: ***Packaging of rods***

Figure 2.19: ***Material ready for dispatch***

2.2 PRESENT TECHNOLOGIES ADOPTED

Although unit has employed electrical motors of various sizes to carry out different operations, material melting and billet reheating are the two major energy consuming operations. Figure 2.20 provides the operation wise distribution of electrical energy consumption for a typical month. It can be observed that furnace consumes almost 61 % of the electrical energy followed by extrusion process (20%). Further process wise details pertaining to energy consumption in the unit are summarized in Table 2.1.

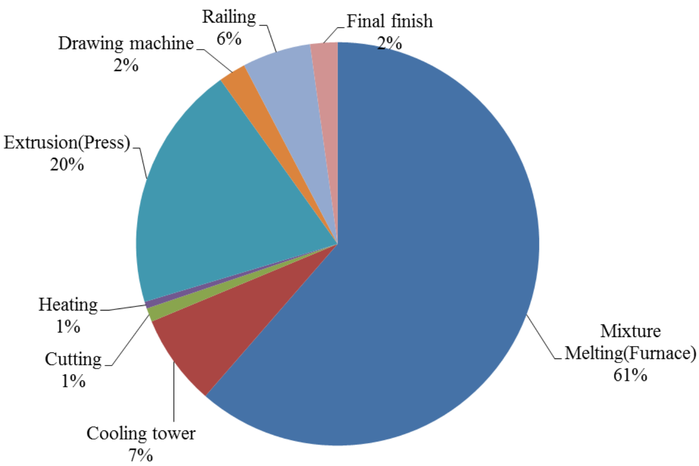


Figure 2.20: ***Operation wise distribution of electrical energy consumption***

Table 2.1: *Process wise energy consumption information*

SN	Process	Number	Energy Source	Rated consumption	Daily operation in hours	Days per month
1	Scrap Pressing	1	Electricity	10 HP	1 hour	6
2	Induction Furnace	1	Electricity	Induction Furnace (250 kW), Cooling motor/ pumps (10 HP)	12 hours (furnace), 17 hours (cooling motor/pumps)	25
3	Billet Cutting	1	Electricity	3 HP	8-10 hours	25
4	Billet Reheating Furnace	1	Electricity (Blower), Thermal (FO)	Blower (5 HP)	8 hours	25
5	Extrusion Press	1	Electricity	60 HP x 3 motor (450 Ton press)	8 hours	25
6	Pointing	2	Electricity	3HP & 2 HP	3-4 hours	25
7	Drawing	2	Electricity	15 HP & 7 HP	8 hours	25
8	Cutting	2	Electricity	1 HP (each)	4 hours (both)	25
9	Straightening	2	Electricity	1 HP (each)	3-4 hours (both)	25
10	Railing	3	Electricity	5 HP (2 Nos) & 7 HP (1)	3-4 hours	25

2.3 DETAILED ENERGY AUDIT

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

2.3.1 Electrical Panels

- **Present System:**

The unit has contract demand of 350 kVA. The unit has installed one transformer of Kirloskar make with capacity of 500 kVA. This reduces the supply voltage from 11 kV to 440 V. The unit has installed automatic power factor controller to maintain power factor close to unity. It has installed a separate energy meter to record power consumption for induction furnace.

The unit has been operating close to the contract demand (350 kVA), as evident from couple of electricity monthly bills, the maximum demand recorded is 347 and 352 kVA. Furthermore, due to automatic power factor controller installation the power factor of the unit was observed to be on the higher side (close to unity). The voltage total harmonic distortion was measured to be in the range of 1.2 to 2.8%.

- **Observations:**

It was observed that the rubber (or insulating) floor mats on front of the electrical control panels are not placed for all the electrical panels. This may raise safety concerns while operating the electrical panels where rubber mats are not available.

The construction of the electricity supply house was unplanned construction on front of the entry gate. The floor level of the electricity supply house is at lower level as compared to the unit floor. Due to which the unit encounters water logging problems especially in the rainy seasons, making it difficult to operate the electrical panels as well as faces safety issues.

▶ Recommendations:

It is suggested to properly place rubber (or insulating) mats on front for each of the electrical panels for safety reasons as well as replace the damaged once. It is suggested to reconstruct the electricity supply house as per the guidelines of State Electricity Boards in order to avoid water logging and any mishap during rainy seasons.

2.3.2 Oil Fired Reheating Furnace

▶ Present System:

The unit has installed oil fired reheating furnace to bake the billets at temperature of around 750^{0}C. The furnace has got one burner located on the front side (discharging side) of the furnace. Fuel is supplied through nozzles from an overhead tank and air for combustion is supplied using motor driven blower of capacity 5 HP. Cut billets are placed from the back side (charging side) of the furnace, whereas, they are taken out from the discharging side. The details of the furnace specifications and the schematic drawing are given in Table 2.2 and Figure 2.21 & 2.22.

Table 2.2: *Furnace specifications*

Shell Heating Furnace Dimensions	1.2 m x 1.2 m x 1 .2 m
Fuel type input	Furnace Oil
Fuel tank dimension	45"x 48" x 36" (L x W X H)
Fuel flow	Gravity
Blower motor rating	5 HP
Fuel consumption	22 liters per hour
Hours of operation per day	7-8 hours

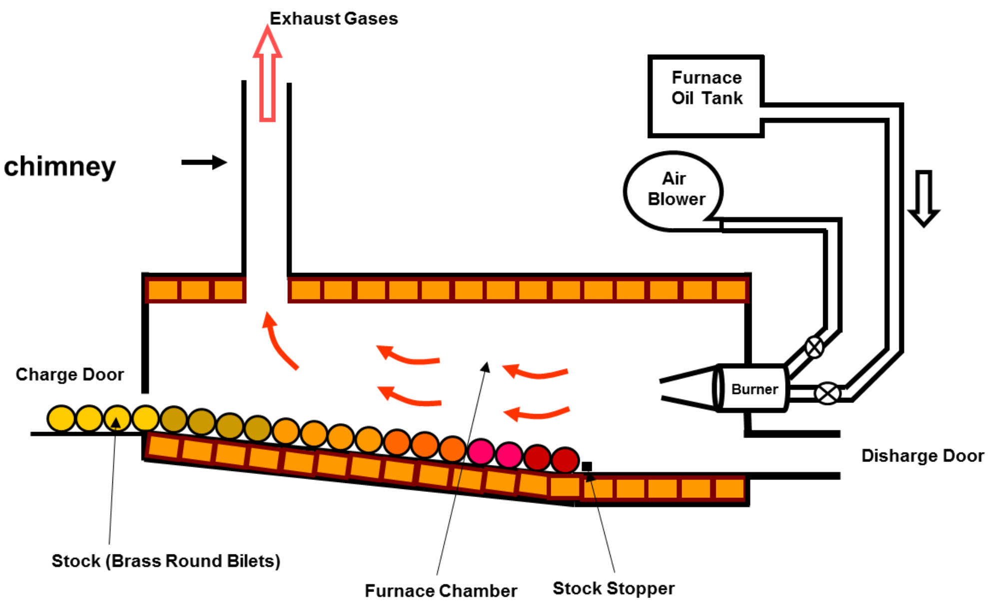


Figure 2.21: *Schematic diagram of the reheating furnace*

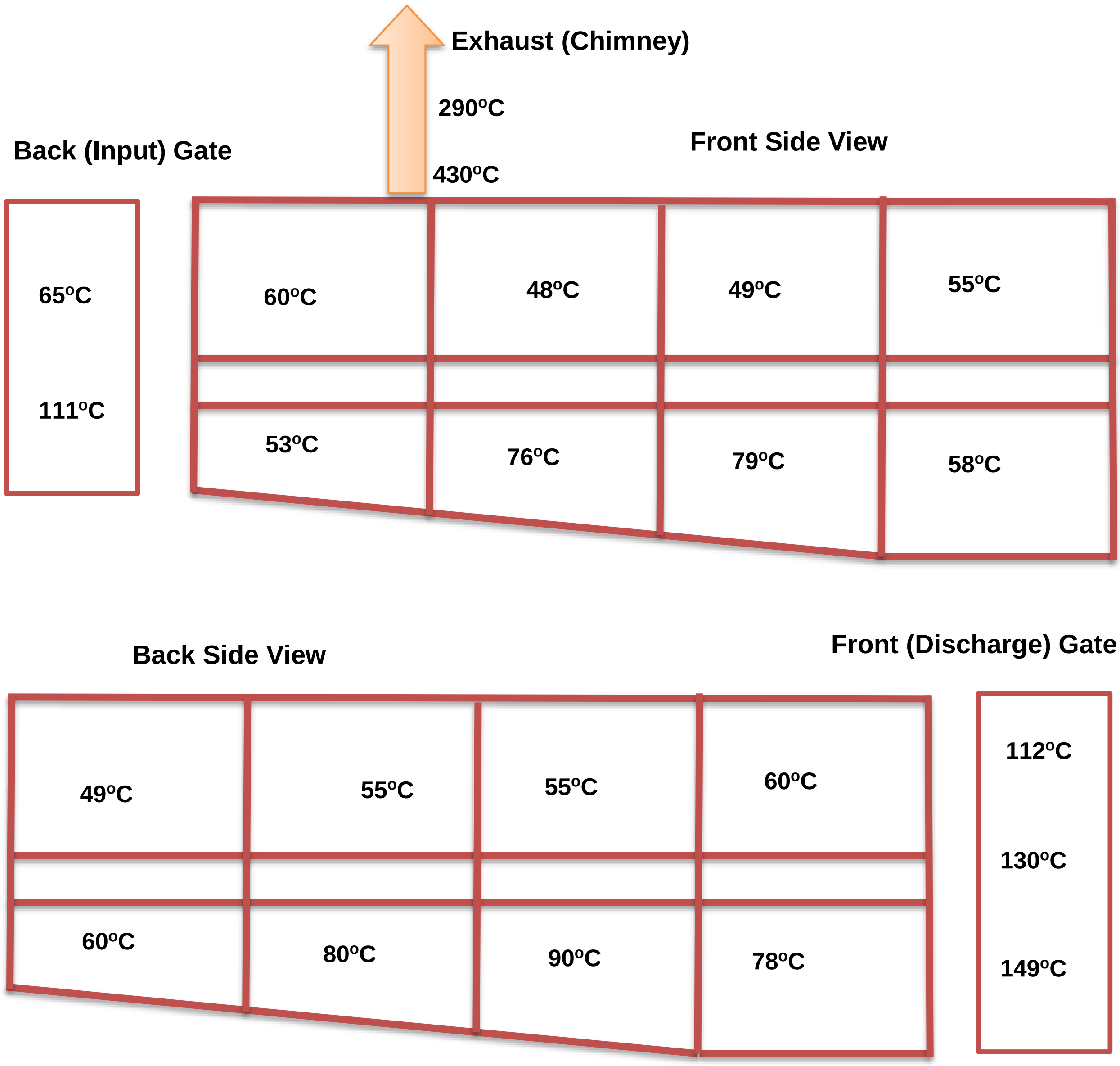


Figure 2.22: *Temperature Profiling of Existing re-heating furnace*

Observations:

During field visit to the unit, detailed measurement of billet reheating furnace performance assessment was carried out. Data related to fuel consumption, time of operation, furnace temperature, exhaust measurement (flue gas composition & temperature) was measured. All these data related to one charge was measured and collected. Based on the measurement and field visit, following observations are made.

- It was found that the furnace temperature was controlled by increase or decrease (open or close of fuel valve) of fuel supply. The open/close of fuel valve was governed by the judgement of the operator by length and color of the flame.
- It was found that thermocouple installed for temperature measurement inside the furnace was not functioning. Moreover, the thermocouple was placed close to flame and near to the burner. Thermocouple should be placed under suitable insulating

material, avoiding direct penetration with the flame. The most preferable position of placing a thermocouple is the furnace roof.

- Location of blower is very close to the furnace wall thereby hindering suction of fresh air.
- Furnace oil was observed to leak near the valve point.
- Roof Surface of billet reheating furnace was observed to be broken.
- Overall skin temperature of the billet reheating furnace was found to be in the range of 50 to 65^{0}C except in the lower portion of the back side where it is in the range of 80 to 90^{0}C.
- Furnace exhaust flue gas temperature was found to be around 538^{0}C which was discharged in atmosphere through a chimney.
- The composition of exhaust flue gas was found to have 10 % of CO_2 and around 6% of O_2 indicating significant amount of excess air. This high excess air supply lowers the furnace efficiency as useful fuel energy is wasted to heat the extra amount of air (See Table 2.3).
- Specific FO fuel consumption was found to be around 22 liters per hour. The operational efficiency of the reheating furnace was calculated to be around 15.12 %. The detailed efficiency calculation is attached as ***Annexure 2.***

Table 2.3: ***Flue Gas Analyzer Measurement Reading***

Exhaust Temp (^{0}C)	CO_2 (%)	O_2 (%)	CO (ppm)
538	10	6	186

Figure 2.23: ***Pictorial depiction of billet reheating furnace***

▶ **Recommendations:**

1. **Maintain Air-fuel ratio**: It becomes difficult to maintain air fuel ratio manually, it is suggested to install automatic air-fuel ratio to have complete combustion and enhance the furnace efficiency.

2. **Installation of waste heat recovery system (recuperator):** The temperature of flue gas was measured to be around 538^{0}C which is being discharged to the atmosphere. It is suggested to use a suitable design waste heat recovery system (recuperator) in the exit flue duct to pre-heat the air being used for combustion using the waste exhaust heat to improve overall efficiency of the furnace.

3. **Online temperature measurement**: It is suggested to monitor the temperature of the combustion chamber using thermocouples installed at appropriate locations. This would help in heating the material to the required temperature without causing any judgmental error.

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 payback period of less than 1 year. Further contact details of suppliers of each energy efficient measures suggested are provided in A*nnexure 3.*

Table 2.4: *Cost Economic Analysis – Reheating Furnace*

SN	Energy Efficient Measure	Estimated Fuel savings (Liters/year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Year / months)
1	Installation of Air Fuel ratio controller	4,764	142,933	125,000	11 months
2	Installation of waste heat recovery system (recuperator_)	6,000	240,000	150,000	7 months
	Total	**10,764**	**382,933**	**275,000**	

2.3.3 Induction Furnace

▶ **Present System and Observations:**

The present operational practice of the induction furnace (250 kW) was studied in details (See Table 2.5 for furnace specifications) and an analysis of the same is carried out. It was observed that daily around 9 to 10 melts are produced. The furnace operation starts early in the morning 7 am and till 8 pm (daily operation of around 12 to 13 hours). In the morning, cold start of the furnace is carried out, which consumes 18% more electrical power. It was observed that, 33% (3 of 9) melts were on "furnace holding" mode consuming nearly 8.3% more power. The molten metal was placed on hold in the induction furnace for more than 40 minutes thrice, while the furnace was consuming power to keep the molten metal at the required temperature (1040^{0}C). The furnace holding is considered as bad practice, it enhances energy consumption pattern and in this case, it consumed 27 units per tons (8%) more electrical power than usual normal operation. A good planning in subsequent processes, like, timely completion of sample testing should be lined up, make moulds ready for pouring, etc may be meticulously followed. Figure 2.23 provides pictorial representation of installed furnace.

Table 2.5: ***Furnace specifications***

Model/Make	Electrotherm
Energy Input	Electricity, 250 kW
Capacity	750 kg

The energy consumption, in terms of kWh per tons of molten metal (as defined as SEC), comes to 340 (excluding the SEC for furnace cold start). A segregated analysis of SEC on the basis of furnace holding and normal operation records 357 and 330 respectively.

The average time logged for sample testing was 12 minutes, with minimum and maximum values as 8 and 15 minutes respectively, which is on a higher side, it should be completed within 4~5 min Sample time is considered as crucial time from energy consumption view points as the furnace has to put on hold (drain 25% of furnace full power, 63 kWh) until the sample is tested and molten metal is corrected. The present sample timing is taking 3 times more. The induction furnace data was collected for a typical day and analyzed, given in Table 2.6.

It was observed that the furnace operator overloads the furnace or loads the metal above the induction coil. Furnace overloading consumes more power as well as takes more time to melt. Furnace overloading is common practice adopted, assuming that more metal is melted. It was observed that the heel metal is kept in the furnace which again is also a bad practice adopted and consumes more energy.

Table 2.6: ***Induction Furnace Data - 250 kW (on 6/7/2015)***

No. of Charge	Power Consumption (kWh)	Sample Time Unit (min)	Tame taken (hh.mm)	Total Billet Weight (kg.)	SEC (kWh per ton)	Remarks
1	311	9	1.30	752	413.56	Furnace cold start up
2	260	10	2.25	752	**345.74**	SEC increased due to Furnace holding
3	252	8	1.35	752	335.11	
4	246	10	1.20	752	327.13	
5	275	14	2.10	752	**365.69**	SEC increased due to Furnace holding
6	239	12	1.20	752	317.82	
7	249	13	1.20	752	331.12	
8	270	13	2.05	752	**359.04**	SEC increased due to Furnace holding
9	285	15	1.30	846	336.88	

The present operation of induction furnace was studied and recorded capturing the power consumption, time taken to carry out each sub-activities, input material, furnace rheostat setting (kW consumption), etc. The present operational practice was discussed with the management and the furnace operator. It was pointed out, what are the best practices not being followed effectively consuming more energy. Both the management and the furnace operator(s) were taken under confidence and a trial of the induction furnace was undertaken. The demonstration of the energy saving using the best practices resulted immediate benefit to the unit by saving 9% of energy used as shown in Table 2.7.

Table 2.7: ***Induction Furnace Trial Data***

No. of Trial Charge	Power Consumption (kWh)	Total time to melt (HH:mm)^	Total pouring time (hh:mm)	Total Billet Weight (Kg.)	SEC (kWh per ton)	SEC savings (kWh per ton)#	Percentage saving
1	298	1.06	0.13	752	261	31	9%

^ includes time taken for single sample analysis
# Actual SEC is taken as 329 kWh per tons (discarding the cold start up and higher holding time)

Figure 2.24: ***Heating of material in reheating furnace***

- **Recommendations:**

- 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 ***Annexure 4***).
- Best Practice #2 (Furnace Loading & Operation): Level of molten metal should not exceed the level of induction furnace coil (See ***Annexure 5***). Given below (Table 2.8) is the cost benefit for avoiding over loading of metals in the induction furnace.

Table 2.8: ***Cost Economic Analysis – Avoid Over Loading***

SN	Energy Efficient Measure	Estimated Energy savings (kWh/Year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Year)
1	Avoiding over loading of metals in the Induction Furnace	8,992	57,551	Nil	Immediate

- As far as possible, no overheating of material beyond the required temperature should be carried out as it directly consumes energy. Given below (Table 2.9) is the cost benefit for avoiding super heating of metals in the induction furnace.

Table 2.9: *Cost Economic Analysis – Avoid Super Heating*

SN	Energy Efficient Measure	Estimated Energy savings (kWh/Year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Year)
1	Avoiding over super heating of metals in the Induction Furnace	4,733	30,290	Nil	Immediate

- Holding of furnace should be avoided by proper planning in advance for sample analysis / testing and make available moulds.
- Heel metal should be avoided.
- During checking of metal composition (or sample testing) and pouring of molten metal in moulds, power supply to the induction furnace should be reduced to around 25% of the full capacity.

2.3.4 Extrusion Press:

▶ Present System:

The unit has installed extrusion press machines employing three motors of 60 HP motor each. This extrusion press normally operates for 8 hours per day. As per the prevailing practices, hot billet from reheating furnace is placed in the extrusion press which is further converted into the brass rod of desired dimension through use of metal die (Figure 2.25). This metal die is also heated before being placed in the extrusion process.

Figure 2.25: ***Hot drawing in extrusion press***

▶ Observations:

During field visit, measurements were performed on the extrusion motors. During observation, hot billet of 13 inch length was processed. During operation, total on and off time, cycle time, and percentage loading of motor during loading and unloading period was measured. These observations are summarized in Table 2.10 and 2.11. Based on the measured data, the average load, unload and cycle time of extrusion press motor was found to be 0.16 seconds, 1.18 minutes and 1.36 minutes respectively.

Similarly percentage loading for three motors during loading was around 46, 51 and 77 %. During loading power factor was found to vary from 0.72 to 0.83. During non-loading conditions these values are lower with average loading of around 10% and PF of around 0.18.

Table 2.10: *Extrusion press on and off cycle data*

SN	Load Time (mm:ss)	Unload Time (mm:ss)	Total Cycle Time (mm:ss)
1	0.19	1.14	1.33
2	0.20	1.19	1.39
3	0.15	1.23	1.38
4	0.15	1.17	1.32
5	0.13	1.15	1.30
Average	**0.16**	**1.18**	**1.36**

Table 2.11: *Electrical Measurements performed on the extrusion press motor*

	Loading Condition	Current (Amps)				Voltage (Volts)	PF	Actual Power (kW)	Rated Motor HP	Loading (%)
		R	Y	B	Average					
Motor No. 1	Load	45	47	41	44.33	410	0.73	22.98	60	51.34
	No Load	30	34	29	31.00	412	0.17	3.76	60	8.40
Motor No. 2	Load	40	43	39	40.67	410	0.72	20.79	60	46.45
	No Load	31	34	29	31.33	414	0.19	4.27	60	9.54
Motor No. 3	Load	60	60	56	58.67	410	0.83	34.58	60	77.25
	No Load	30	32	27	29.67	412	0.21	4.45	60	9.93

Recommendations:

It is suggested to measure the temperature of the billets being pressed in the extrusion press as lesser temperature of the billet would consume higher electrical power during the pressing operation. The lower temperature of the billets may also enhance the rejection rate and may compromise on the quality of final product.

Installation of VFDs in all the three 60 HP motors of extrusion press would lead to good amount of energy savings as they are under loaded during no load conditions (only 10% loading measured). Given below is the cost benefit for installation of VFD in extrusion press. It can be seen from the Table 2.12 that by using VFD in extrusion energy saving upto 35,541 kWh / year can be achieved, which amounts to an energy saving of Rs 2.27 lakhs / year.

Table 2.12: *Cost Economic Analysis – Installing VFD*

SN	Energy Efficient Measure	Estimated Energy savings (kWh/Year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Years)
1	Installation of VFD in extrusion press (3 VFDs for 3 motors)	35,541	227,460	900,000	3.96

2.3.5 Installation of Energy Efficient Pumps, Lighting and Fans

- **Present System:**

The unit has installed conventional traditional lighting systems in the factory premises, comprising of florescent tube lights, compact florescent lamps and halogen lights. The ceiling fans used in the factory premises are of traditional design, consuming significant amount of energy. In addition to this, 2 nos. of pumps installed in the unit at mold cooling station and coil cooling station respectively, are of conventional and obsolete design, The unit has 22 nos. of conventional design ceiling fans of 60 W each, 40 nos. of florescent tube lights of 55 W each, 15 nos. of compact florescent lamps of 85 W each, 15 nos. of halogen lights of 250 W each, 2 nos. of conventional design pumps of 7.5. HP each.

- **Observations:**

During the plant visit, a study was carried out to find out the energy saving potential from replacement of existing pumps, lightings and fans with energy efficient equipment and fixtures. A detailed compilation of energy consumed by the lighting, pumps and ceiling fan was carried out and compared vis-à-vis to the use of energy efficient pumps, lightings and fans. In order to find out the capacity required for the new equipment, a detailed load analysis study was carried out in the existing units. For lightings, existing lux level was checked and desired capacity of replaced energy efficient lighting based on the existing lux level was determined. Similarly for ceiling fan, capacity determination on the basis of application was carried out.

- **Recommendations:**

Based on the observation made at site and detailed analysis of the existing system, it is suggested to replace the existing pumps, lighting and ceiling fan with energy efficient pumps, lightings and ceiling fans. The table below summarizes the list of equipment and fixtures to be replaced with energy efficient equipment and fixtures:

Table 2.13: ***Replacement of conventional pumps, lightings and ceiling fans with energy efficient equivalents.***

Existing system	Equivalent Propose system
7.5 HP mold cooling pump – 1 Nos.	4 HP energy efficient pump -1 No
7.5 HP coil cooling pump – 1 Nos.	3.3 HP energy efficient pump – 1 No.
60W Conventional ceiling fan - 22 Nos.	28W Energy Efficient (BLDC) Ceiling fan – 22 Nos.
55W florescent tube light – 40 Nos.	T-8 (20W) LED light – 40 Nos.
85W compact florescent lamp – 15 Nos	45 W rocket LED lamp – 15 Nos.
250W halogen light – 15 Nos.	120 W LED street light – 15 Nos.

The estimated annual savings, estimated investment and simple pay-back for replacement of existing pumps, lightings and ceiling fans with energy efficient equivalent is summarized below:

Table: 2.14: ***Cost-benefit analysis – installation of energy efficient ceiling fans, lightings and pumps***

SN	Energy Efficient Measure	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Year / months)
1	Replace old pump 7.5 HP mold cooling pump with 5 HP energy efficient pump	48,723	57315	1 Year 2 months
2	Replacement of old 7.5 HP pumps with 3.3 HP energy efficient pump.	172544	79980	6 Months
3	Replace conventional ceiling fan with Energy Efficient (BLDC) Ceiling fan	20296	66,000	3.1 years
4	Replace 55W florescent tube light with T-8 (20W) LED light	27,776	26,000	10 Months
5	Replace 85W CFL with 45 W rocket LED lamp	17,856	25,275	1 Year 5 months
6	Replace 250W halogen light with 120W LED street light	169,616	30,950	5 Year 6 Months

2.3.6 Exploring Opportunity for Renewable Energy Usage

During field visit, opportunities of using renewable energy applications were explored. However, based on the higher temperature requirement in the operation process possibility of using solar thermal technology for thermal applications may not be applicable. Further, there were also constraints related to the area. Finally, during discussion with unit owner, possibility of using renewable energy was ruled out due to lesser anticipated savings against the cost and operational complexity associated with renewable energy interventions.

Annexure 1:

Questionnaire*

Name of the MSME unit:	Gold Metal Extrusion
Address:	Shade No. 770/C, G.I.D.C, Phase-II, Dared, Jamnagar, Gujarat
Ph. No:	0288-2730733
Name of the respondent	Rameshbhai A Viramgama
Designation:	Partner

1. Year of Establishment: 2005
2. Type of Products: a) Extrusion Brass Rod
   b) Section
3. Installed Capacity:
4. Operating hrs per day : 12
5. Connected Load: 350 KVA
6. Supply Voltage: 440 Volt
7. Annual Energy Consumption/ Production:

Financial Year (April to March)	2012	2013	2014
Coke consumed (kg)	-	-	-
Cost of coke (in Rs.)	-	-	-
Electrical units consumed (In kWh)			8,24,188
Electricity charges (in Rs.)			56,76,221
LDO/HSD/ FO consumption (L)	40,000 Kgs. Average.	45,000 Kgs. Average.	50,000 Kgs. Average.
Fuel Cost (in Rs.)	14,43,587	18,12,144	22,70,413
Production (kg)	4,11,603	4,87,124	6,95,738

8. Source and Calorific Value of Fuels:

Fuel	Source	Calorific Value (kCal)
Coke (kg)	-	-
HSD (L)		
LDO (L)		
FO (L)		

*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.

Fuel	Source
Electricity (kWh)	

9. **Monthly Energy Consumption and Production Data:**

Month	Production (kg)	Coke consumption (kg)	Electricity consumption (kWH)	HSD/LDO /FO (L)	Any other fuel (specify units)
April, 14	32,005.80	-	4,04,850	3,83,149	-
May, 14	61,852.90	-	4,31,430	-	-
June, 14	33,404.35	-	4,27,799	4,82,267	-
July, 14	56,081.25	-	4,99,693	-	-
August, 14	55,616.80	-	5,24,617	-	-
September, 14	54,838.90	-	4,75,464	3,64,958	-
October, 14	59,573.50	-	5,03,349	2,30,430	-
November, 14	49,326.50	-	4,11,277	2,39,337	-
December, 14	76,222.67	-	4,79,537	-	-
January, 15	69,753.70	-	5,31,242	1,80,926	-
February, 15	66,656.10	-	5,13,548	3,89,346	-
March, 15	80,405.95	-	4,73,415	-	-

10. **Duration of electricity supply: 24 Hours/ day**

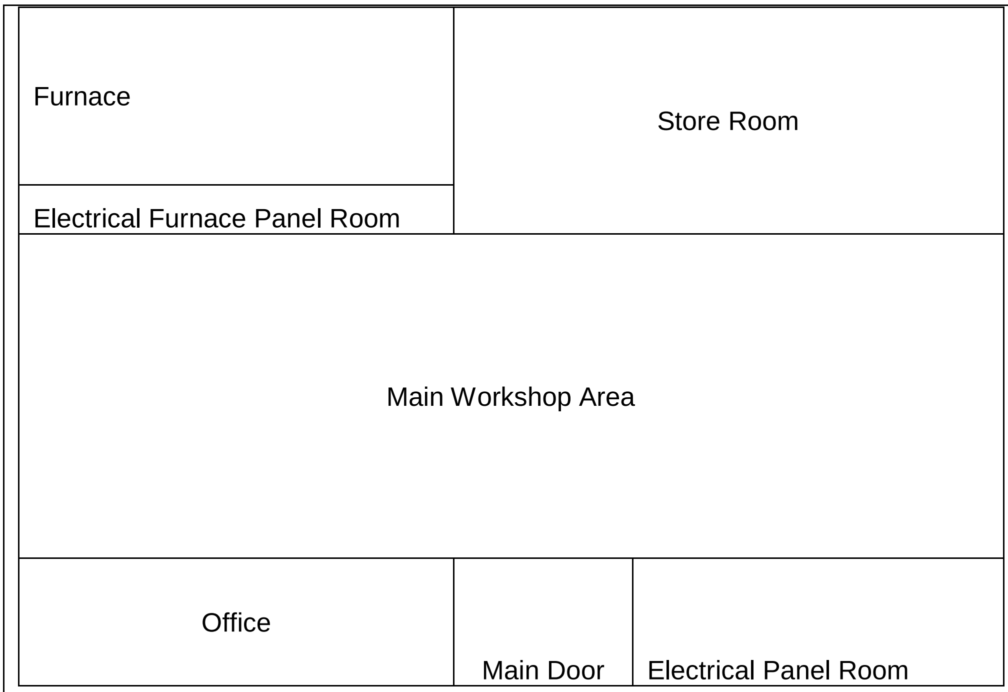
11. **Cost variables per Kg of Production:**

Cost Variable	Cost/ kg of production
Electricity Cost	
Coke Cost	
Fuel Cost (LDO/HSD/FO) etc.	
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/ capacity	Use	Comments
1	Induction – 250 kW	Electricity	Electrotherm	2008	750 kg.	Brass melting	-
2	Extrusion Press	Electricity	SPM	2005	450 MT, 60 HP motor – 3 Nos	Hydraulic Extrusion Press	-

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



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

15. Any Energy Efficient Technology installed in the unit:

Technology	Specification	Cost	Year of Installation
-	-	-	-

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

Technology	Cost	Use
-	-	-

17. Any factory expansion plan: No

Annexure 2:

Reheating Furnace Efficiency Calculations

Parameter	Unit	Value
Total weight of cut billets heated	kg	525.6
Specific heat of Brass[1]	kCal/kg ^{0}C	0.09
FO fuel consumption	kg	22
Calorific value of FO	kCal/kg	10,100
Initial temperature of cut billets	^{0}C	40
Final temperature of cut billets	^{0}C	750
Total input energy	kCal	222,200
Total output heat	kCal	33,586
Furnace efficiency by direct method	%	15.12

[1] Specific heat value of Brass is taken from www.engineeringtoolbox.com/specific-heat-solids-d_154.html

Annexure 3:

Contact Details of the suppliers

SN	Equipment	Supplier contact details
1	Air Fuel controller	**WESMAN Group** 8 Mayfair RoadKolkata 700 019, India Tel: +91 (33) 40020300 Web: http://www.wesman.com/index.php/controls-and-accesories
2	Air preheater	**MICO HYDRAULICS** Plot No. 3653 / 3654, 'N' Road, Phase - III, G.I.D.C., Dared, Jamnagar - 361 004. Gujarat. INDIA. Phone: +91 288 2730439 **Mr. Prakash R. Parati (Proprietor)** Mobile : +91 98242 83806 E-mail : prakash@micohydraulics.com **Aerotherm Products** No. 2406, Phase - 4, G. I. D. C. Estate, G. I. D. C., Vatva Ahmedabad - 382445, Gujarat, India Mobile: +(91)-9879104473
3	Insulation	Local Suppliers

Annexure 4:

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 5:

Best Operating Practice

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.