National Program

on

Promoting Energy Efficiency and Renewable Energy in MSME Clusters in India

Jamnagar Brass Cluster

Detailed Energy Audit Report
Turn & Forge Metal Tech.

Submitted to

Submitted by

InsPIRE Network for Environment

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Abbreviations

BEE	Bureau of Energy Efficiency
CO	Carbon Mono-oxide
CO_2	Carbon Di-oxide
FO	Furnace Oil
GEF	Global Environment Facility
HP	Horse Power
Kcal	Kilo Calories
Kg	Kilogram
kVA	Kilo Volt Ampere
kW	Kilo Watts
kWe	Kilo Watts Electrical
MDI	Maximum Demand Indicator
MSME	Ministry of Micro Small and Medium Enterprises
PF	Power Factor
Ppm	Parts per Million
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 monitorable 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 Turn & Forge Metal Tech.

Location of the SME unit : Plot No. 37 to 40, Patel Estate, Near Octroi Post, 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.

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 Temperature Gauge in Coke Fired Pit Furnace	69,054	20,000	3 months
2	Improvement of Insulation in Coke Pit Furnace	54,000	30,000	7 months
3	Replacement of Conventional Coke Fired Furnace with Gas Fired Furnace	150,131	350,000	2 years 4 months
4	Replacement of conventional Coke Fired Furnace with Induction Furnace	202,293	1,000,000	4 years 11 months
5	Installation of Air Pre-heater in Reheating Furnace	206,079	20,000	7 months
6	Installation of Air Fuel Ratio Controller	52,164	30,000	7 months
7	Installation of Thermocouple to Measure Temperature in the Reheating Furnace	17,100	20,000	1 year 2 months
8	Installation of Variable Frequency Drive (VFD) in Extrusion Press	325,335	300,000	11 months
9	Replace conventional ceiling fan with Energy Efficient (BLDC) Ceiling fan	9,225	30,000	3 year 1 months
10	Replace 55W florescent tube light with T-8 (20W) LED light	6,944	6,500	10 months
12	Replace 300W halogen light with 120W LED street light	14,284	84,808	5 Months 10 Months
	Total	**11,06,609**	**18,91,308**	

▸ Oil Fired Reheating Furnace:

The furnace oil based reheating furnace being used in the unit was measured to have lower efficiency around 15%. From energy use and technology audit study, it was observed that high level of excess air was present in flue gas. Though a representative amount of excess air is required for proper combustion, but larger quantities of excess air result in excessive heat loss through flue gases, as well as cooling of the combustion chamber due to excess air. It is recommended to install proper air-fuel control system in conventional reheating furnace system. The cut billet temperature is being assessed by furnace operator's experience. It was observed that cut billet temperature is more than required temperature for pressing operation; this increases fuel consumption in reheating furnaces. Apart from that, this reduces the quality of material. It is recommended to install temperature gauges in reheating furnaces for proper temperature control.

Coke Fired Pit Furnace:

The unit has installed a coke fired pit furnace of crucible capacity 300 kgs for scrap melting. Presently, brass melting Units are using high grade hard coke as fuel for melting purpose. From energy use and technology audit studies it was observed that conventional coke furnaces have low operational efficiencies as well as causes environmental issues leading to difficult working atmosphere. Therefore, it is recommended to replace conventional coke fired pit furnace with either gas fired furnace or Induction melting furnace.

Extrusion Press:

The Unit has installed extrusion press machines employing motor of 50 HP. The press motor loading during pressing operation was around 86.87% with PF 0.84 and during idle condition the motor loading was around 14.39% and PF of 0.27. It is suggested to measure the cut billet temperature just before pressing operation by using non-contact type optical pyrometer on a sample basis to confirm the required temperature has been attended. If the cut billet temperature is of lower temperature then the extraction press will consume higher electrical power. Also Variable Frequency Drive (VFD) is suggested to be installed in the Extrusion Press Motors to reduce energy consumption.

Installation of energy efficient lightings and ceiling fans:

The unit has installed conventional lightings and ceiling fans 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.

CHAPTER 1:

Introduction

1.1 ABOUT THE UNIT

Turn & Forge Metal Tech. started its production in 2014 and is engaged in manufacturing of different types of brass products like, Nut Bolts, Fasteners, and Forging parts.

The daily production of the unit is 500 kgs of finished products. The unit operates daily from 8:30 AM to 6:00 PM with one hour lunch break. The Unit uses three forms of energy usage, namely, hard coke for melting metal in coke fired pit furnace (or "*Bhatti*" called in local language), electricity supplied from State Electricity Board (SEBs) for various processes like extrusion press motors, machining operations and other utility applications and Furnace Oil (FO) for reheating furnace. The discussion with the unit owner revealed, the daily coke consumption is around 130 to 150 kgs. There is no record maintained to share the monthly production figures or energy consumption.

1.2 ENERGY AUDIT METHODOLOGY

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

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

After selection of units, preliminary information relating to the energy consumption by the units was collected in a structured questionnaire. The intent of this preliminary data collection was mainly to get preliminary details about the units to make the energy audit process more effective. 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 1.1.

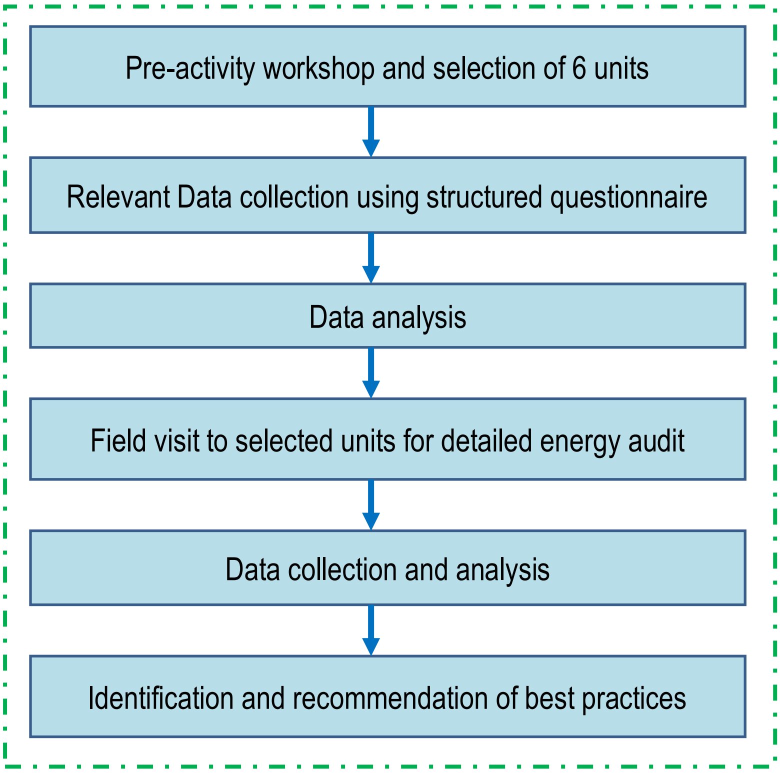


Figure 1.1: ***Flowchart depicting sequence of activities followed for carrying out detailed energy audit***

Table 1.1: ***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

Turn & Forge Metal Tech. is involved in the manufacturing of finished brass products of different types of brass products like, Nut Bolts, Fasteners, and Forging parts. 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 material composition. After sorting, low density raw material are compressed by hydraulic press having motor of 10 HP. The scrap pressing operation is carried out only for selected raw materials with low density and therefore the press machine is not operated regularly.

▶ Metal Melting:

The sorted as well as compressed material is subjected to melting in the coke fired 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 molten material composition as well as its temperature or tapping and pouring temperature.

▶ Metal Pouring:

The molten metal in the induction furnace is poured directly in the billet dies after checking its temperature and material composition. The unit has installed 4 billet 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 solidification the billet die bottom lid is opened to discharge the hot billet from the dies. The hot billets are then left for natural cooling and used for subsequent phase of operations.

▶ Billet Cutting and Heating in Oil Fired Furnace:

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

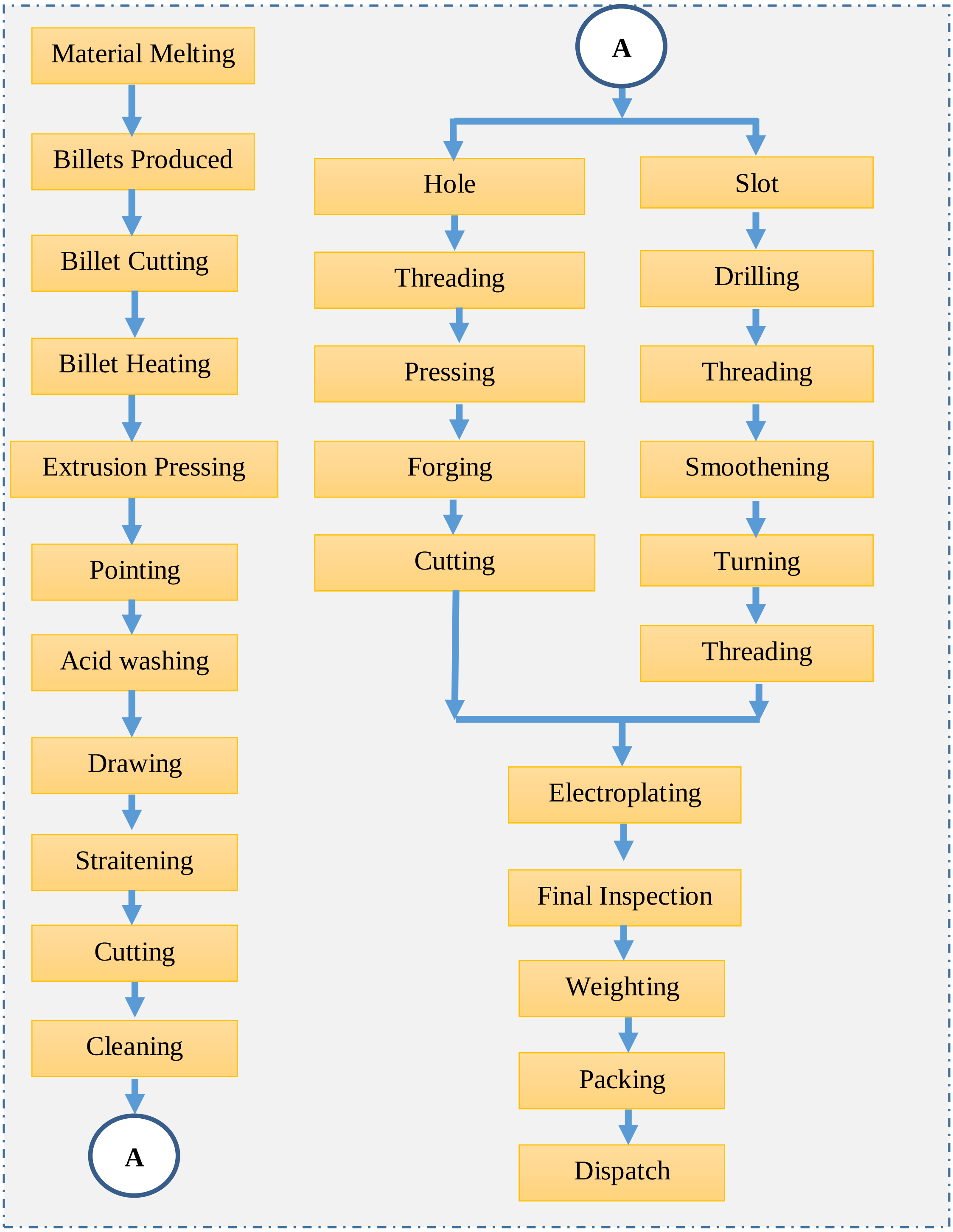


Figure 2.1: ***Process flow diagram***

- **Extrusion Press:**

In this process hot cut billets 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 cut billets to pass through dies. These dies are also heated before passing material from these. So this process is essentially a size reduction step in which hot cut billet of larger diameter is converted into long rods of small diameter. The main motor of extrusion press is 50 HP along with one 2 HP motor for cooling and 5 HP motor to operate hydraulic circuit. The cut billet temperature is critical to the extrusion process. If the cut billet temperature is lower, the electrical energy required by extrusion press will go up. This process results in material loss due to the removal of tail of the hot cut billets.

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

After hot drawing in the extrusion press, the hot rods / sections are left in open for 3 to 4 hours to facilitate natural cooling. The brass rods / sections are then passed through series of machining operations including Pointing, Drawing, Cutting, Straightening, Railing and Acid washing. The machining process is job specific and varies from one product to another. Major energy used in all these processes is electrical energy. Some processes like electroplating is outsourced. The details of the electrical motors being used in these operations are summarized in the Table 2.1. Further Figure 2.2 to 2.14 provides pictorial depiction of the production process being followed in the unit.

Pictorial Representation of Production Process

Figure 2.2 ***Scrap materials being used***

Figure 2.3: ***Inner view of coke Bhatti***

Figure 2.4: ***Melting of scrap in coke pit furnace***

Figure 2.5: ***Dies ready for pouring of molten metal***

Figure 2.6: ***Removal of crucible from Bhatti at the end of operation***

Figure 2.7: ***Circular saw machine for cutting of billets***

Figure 2.8: ***Oil fired Reheating furnace***

Figure 2.9: ***Hot billet coming out of furnace***

Figure 2.10: ***Extrusion press machine***


Figure 2.11: ***Heating of pieces using LPG before forging***

Figure 2.12: ***Forging press for production of bolts***

Figure 2.13: ***Machining operation for the production of nut bolt***

Figure 2.14: ***Final production of nuts***

2.2 PRESENT TECHNOLOGIES ADOPTED

Although unit has employed electrical motors of various sizes to carry out different operations, melting and billet reheating are the two major energy consuming operations. Figure 2.15 provides the operation wise distribution of electrical energy consumption for a typical month. It can be observed that motors greater than 5 HP consumes almost 54% of the electrical energy followed by motors less than 5 HP (40%). Further process wise details pertaining to energy consumption in the unit are summarized in Table 2.1 (Details in ***Annexure 2***).

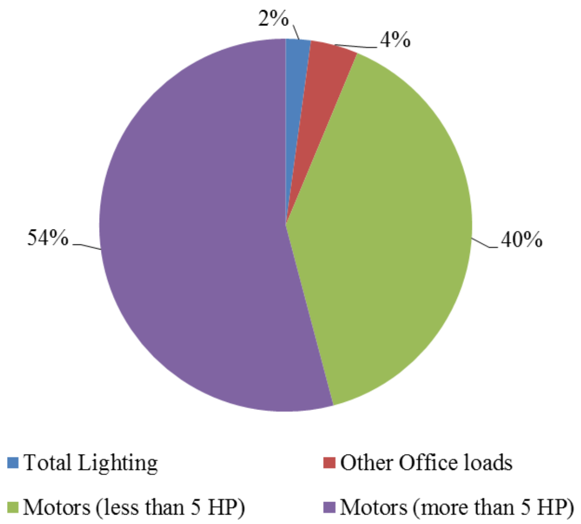


Figure 2.15: D*istribution of connected load*

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

SN	Equipment	Number	Energy Source	Rated Capacity	Daily Operation in hours	Days per month
1	Coke Bhatti	1	Hard Coke & Electricity	300 kgs crucible capacity, Blower (1 HP)	8 hours (coke *Bhatti*)	15
2	Billet Cutting	1	Electricity	10 HP & 2 HP	8 hours	15
3	Reheating furnace	1	Thermal (FO), Electricity (Blower)	Blower (1 HP)	8 hours	15
4	Extrusion press	1	Electricity	50 HP & 22 HP	8 hours	15
5	Drawing machine	1	Electricity	3 HP	16 hours	25
6	Cutting machine	2	Electricity	1 HP & 0.5 HP (each)	8 hours	25
7	Forging machine	2	Electricity	7 HP & 5 HP	8 hours	25
8	Turning machine	7	Electricity	2 HP (4 Nos) & 1 HP (3)	8 hours	25
9	Threading machine	7	Electricity	2 HP (4 Nos) & 1 HP (3)	8 hours	25
10	Grinding machine	4	Electricity	0.5 HP (3 Nos) & 1 HP (1)	8 hours	25

2.3 DETAILED ENERGY AUDIT

The unit has contract demand of 100 kVA. There is no step down transformer installed in the premises of the unit. The unit had installed 6 capacitors bank to maintain power factor close to unity. The main capacitor is of 10 kVAR and the rest are of 3 kVAR each. 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 Oil Fired Reheating Furnace:

▶ Present System:

The unit had installed furnace oil (FO) fired reheating furnace to heat the cut billets at temperature of around 750⁰C. The furnace has one burner located on the hot billet discharge side of the furnace. FO fuel is supplied, by gravity from an overhead fuel tank, to the burner and air for combustion is supplied using motor driven blower of capacity 5 HP. The combustion air is preheated using recuperator by using the hot flue gas. Smaller size cut billets are placed from the changing door of the furnace whereas it is taken out from the other side (discharge door). The details of the furnace specifications and the schematic drawing are given in Table 2.2 and Figure 2.16.

Table 2.2: *Furnace specifications*

Reheating furnace dimensions	5 m x 1.4 m x 1 m
Fuel type input	Furnace Oil
Fuel tank dimension	35"x 35.1" x 27" (L x W X H)
Fuel flow	Gravity
Blower motor rating	5 HP

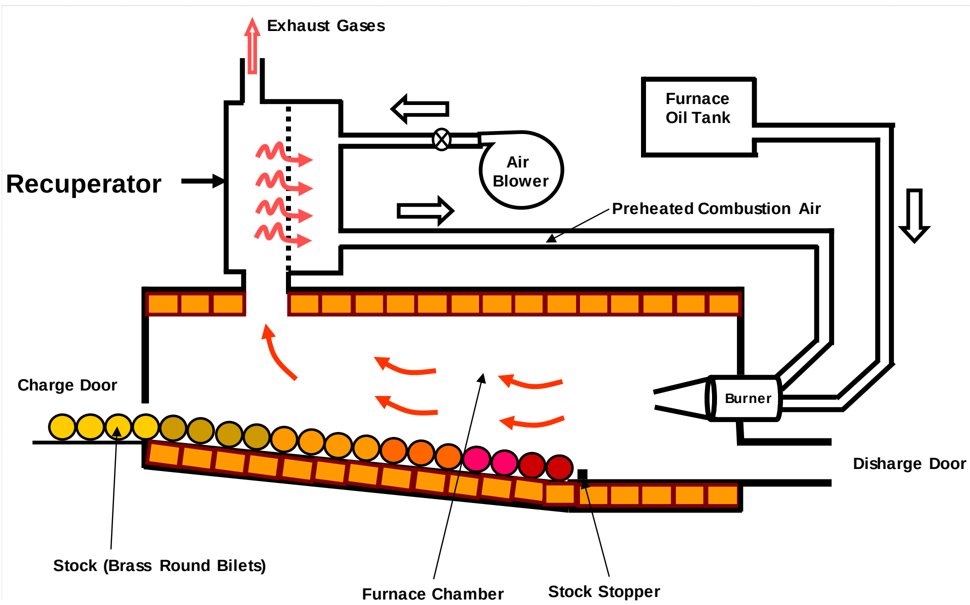


Figure 2.16: *Schematic diagram of the reheating furnace*

▶ Observations:

During field visit performance assessment of reheating furnace was conducted for furnace at steady state condition. Data related to fuel consumption, time of operation, furnace temperature, nos. & weight of cut billets heated, flue gas temperature and flue gas composition was recorded. The key observations made during the performance assessment are following;

- The furnace temperature was controlled by increase or decrease of fuel supply by regulating fuel valve manually by the furnace operator. Regulating of fuel valve was governed by the judgement of the operator by seeing the flame length and its color.
- There was no provision to measure temperature inside the furnace. The temperature inside the furnace is judged by the furnace operator's experience.
- The combustion air blower is located closer to the furnace wall thereby blocking suction intake air. The intake air blockage develops higher blower suction pressure and more energy is required.
- Furnace exhaust flue gas temperature was found to be around 470^{0}C which was discharged in atmosphere through chimney.
- The composition of exhaust flue gas was found to have 11% of CO_2 and around 5.6% of O_2 indicating significant amount of excess air is supplied (See table 2.3). The higher excess air supply lowers the furnace efficiency as useful fuel energy is wasted to heat the extra amount of air.

Table 2.3: *Flue Gas Analyzer Measurement Reading*

Exhaust Temp (^{0}C)	CO_2 (%)	O_2 (%)	CO (ppm)
470	11	5.6	160

- The furnace skin temperature was found to be in the range of 46 to 57^{0}C except at the discharge gate where it was in the range of 68 to 74^{0}C (see Figure 2.17). The lower skin furnace temperature indicates that the construction and insulation of the furnace is in good conditions.

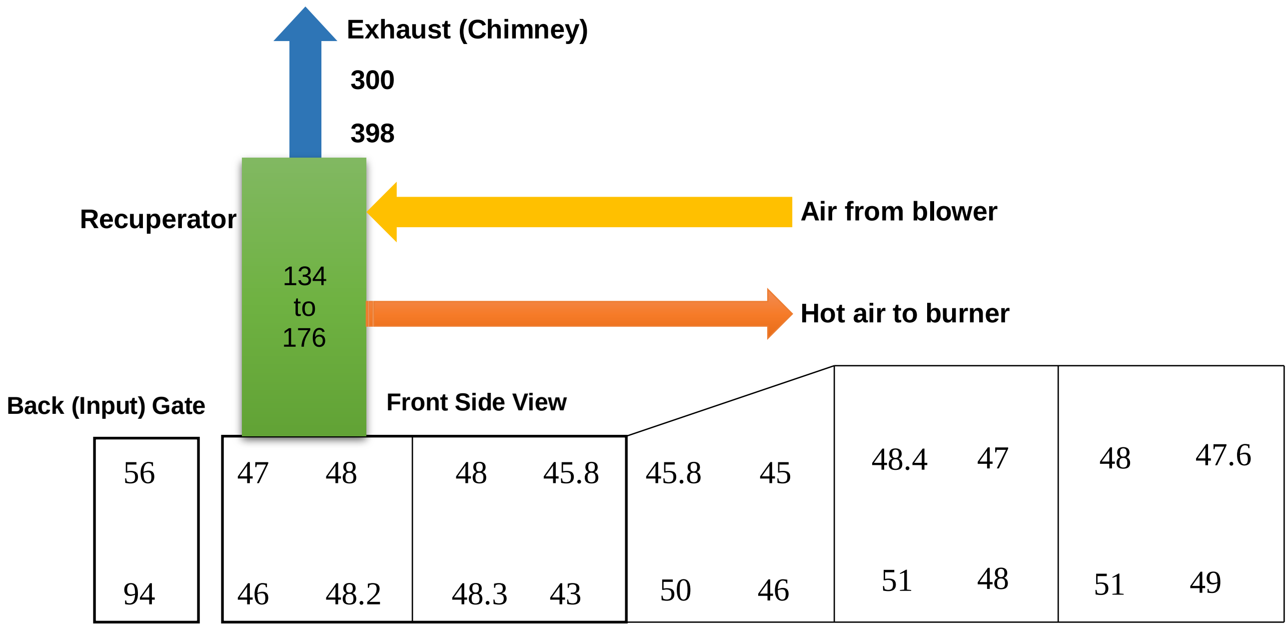


Figure 2.17: *Skin temperature profiling of reheating furnace*

- The reheating furnace efficiency was assessed by direct method. Total cut billet of 542.5 kgs was heated using 23.39 kgs of FO. The operational efficiency of the reheating furnace was calculated to be around 14.67%. The detailed efficiency calculation is attached as ***Annexure 3.***
- Although the Unit has installed recuperator to preheat the combustion air, however, it was found that recuperator was not working satisfactorily as the preheated air temperature was received at only 70^{0}C. This may be attributed due to the non-insulated long pipe length from recuperator exit to burner inlet. As the pipe is non-insulated the preheated air temperature drop exits. The non-function of recuperator may be due to dust accumulation on the heat transfer surface, it also may be due to lower preheat air temperature.

Figure 2.18: ***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. **Replacement of air recuperator:** The temperature of flue gas was measured to be around 540^{0}C which is being discharged to the atmosphere at a temperature of 470^{0}C after passing it through the recuperator. It is suggested to replace the existing recuperator with another modified recuperator to use waste exhaust heat more efficiently to improve overall efficiency of the furnace.
3. **Online temperature measurement**: It is suggested to continuously monitor the temperature of the furnace combustion chamber using thermocouples installed at appropriate locations. This would help in heating the cut piece billets to the required temperature without causing any judgmental error.
4. **Billet Reheating arrangement:** As per the prevailing practice, cut billet at atmospheric temperature are fed into the furnace to heat them to around 750^{0}C. It is suggested to preheat these cut billets to temperature of around 250~300^{0}C to increase the overall furnace efficiency.

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 attractive payback period. Further contact details of suppliers of each energy efficient measures suggested are provided in ***Annexure 4.***

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 (Years / months)
1	Installation of Air Fuel ratio controller	1,863	52,164	30,000	7 months
2	Installation of Temperature Gauges in reheating furnace	450	17,100	20,000	1 year 2 months
3	Installation of Air preheater (recuperator) in Reheating furnace	6,869	206,079	20,000	7 months

2.3.2 Coke Fired Pit Furnace:

► Present System and Observations:

The unit uses coke fired pit furnace of crucible capacity 300 kgs for scrap melting. Figure 2.19 provides schematic and actual pictorial representation of coke pit furnace. The furnace is initially ignited using firewood. After 20~25 minutes of firewood firing, crucible is put inside the furnace. Hard coke is then filled from the sides of the crucible from time to time. Thereafter, scrap material is placed inside the crucible. It is also mixed with in-house cutting and turning including runner and risers and return material. The scrap is fed manually into the melting crucible while the furnace is kept in firing mode. It generally takes 1.2 to 1.5 hours for the material to melt completely. Completeness of melting is checked by testing the flow ability of the molten material and based on the requirement further hard coke is added to get the required temperature. Molten metal is drawn from the crucible and the same is poured in the moulds.

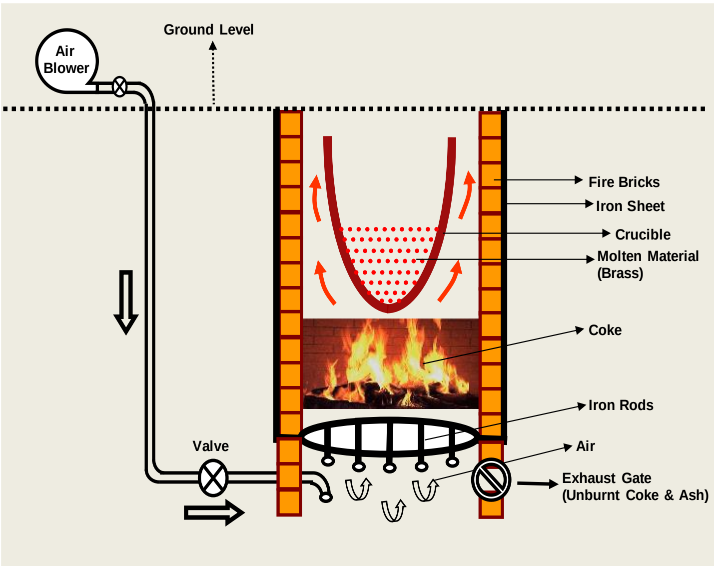


Figure 2.19: ***Schematic of coke fired pit furnace***

Figure 2.19 a: ***Actual coke fired pit furnace***

The present operational practice of the coke fired pit furnace (300 kgs crucible capacity) was studied in details and an analysis of the same is carried out (refer: Table 2.5). It was observed that daily four melts are taken. Each charge after pouring provides 16 numbers of billets with each billet weighing around 28.4 kgs. The furnace operation starts early in the morning 6:30 AM and till 2:00 PM (daily operation of around 8 hours).

▶ Observations:

The melting furnace at Turn & Forge Metal Tech. was audited to find out the specific fuel consumption for melting, melting cycle time etc. All the data pertaining to the material inflow and outflow from the furnace was noted. The key observations made during operation of coke fired pit furnace are presented below.

Table 2.5: ***Observations on Coke Fired Pit Furnace***

No. of Charge	Material Input (Kgs)	Material Output (Kgs)	Coke Consumed (kgs)	Melting Time (hh:min)	Pouring Time (mm)	Burning Loss (%)	SEC (kg of Coke/ton)
1	499.0	478.75	51.8	1:15	24	4.00	104
2	488.6	466.24	46.0	1:20	27	4.57	94
Average	**493.8**	**472.5**	**48.9**	**1:18**	**25.5**	**4.3**	**108**

- The specific energy consumption, in terms of kgs of coke per ton of molten metal (as defined as SEC), comes to around 108 kgs of coke per ton of molten metal.
- There is no data logbook maintained by the Unit to record the billets produced, material input & output and coke consumption. A material logbook for coke pit furnace is developed and placed in ***Annexure 5***. Furthermore, there is no temperature measurement taken for the molten metal.
- During pouring of molten metal, air supply is reduced to nearly 25% using damper control.
- Substantial quantity of fumes and dust are observed when brass scrap is melted in crucible furnaces. The fumes and smoke are occurring due to burning of hard coke, combustible matter, oil & grease that are stuck to the scrap and volatilization and oxidation of alloying metals having low melting / burning point (like zinc).

- The presence of black smoke indicates incomplete combustion of the hard coke fuel in the furnace resulting into lower operational efficiency.
- It was observed that average surface temperature of furnace is high indicating poor quality as insulation.
- There is no preheating of charge being carried out currently.
- Flames are seen to come out of the crucible mouth opening, as the operators try to melt more number of batches per shift by quickly firing hard coke which results in more heat loss from furnace.

Hence, there are possibilities of complete redesigning of the combustion furnace system so that quantity of air and fuel can be regulated. Besides this, the whole system needs to be properly insulated because the heat losses from the furnace structure are huge.

- **Recommendations:**

The combustion system employed by the unit for brass melting operation is a conventional one with no control over the quantity of fuel (coke) or air supplied. Further, quantity of fuel fed is also random. Based on the observations made during the visit, following recommendations are made to improve energy performance in the unit.

- Replacement of conventional coke fired furnace with gas fired furnace
- Replacement of conventional coke fired furnace with induction furnace
- Improving the melting furnace lining and insulation
- Use of thermocouples to measure the temperature of molten metal
- Preheating of charge material

- **Replace Coke Fired Pit Furnace with Gas Fired Furnace:**

Presently, Brass melting furnace at Turn & Forge Metal Tech is using high grade hard coke. From energy use and technology audit study the efficiency of the coke fired pit furnace was found to be lower. In addition, there are other environment related issues like fume / dust generated, and higher temperature at working area due to heat loss makes it extremely difficult to work. It is recommended to replace conventional coke fired pit furnace with more efficient gas fired furnace. Major advantages of replacing the conventional coke fired brass melting pit furnace with gas fired melting furnace are presented below;

- Specific fuel cost in gas fired melting furnace will be lower compared to coke fired melting furnace
- Can attain higher furnace efficiency
- Environment friendly
- Productivity improvements
- Improved working environment

The cost economic analysis of the above suggested measures are compiled in Table 2.6. It can be observed that the energy efficiency improvements of furnaces have payback period of 2.3 years.

Table 2.6: ***Cost Economic Analysis – Gas Fired Melting Furnace***

SN	Energy Efficient Measure	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Years / months)
1	Replacement of conventional coke fired pit furnace with gas fired furnace	150,131	350,000	2 years 4 months

- **Replace Coke Fired Pit Furnace with Induction Melting Furnace:**

The conventional coke fired pit furnace has low efficiency. Apart from poor furnace efficiency, coke fired pit type of furnace has melting loss of around 4~5% and operational & maintenance cost is more. It is recommended to replace conventional coke fired pit furnace with induction melting furnace. Major advantages of replacing the conventional coke fired brass melting pit furnace with electric induction melting furnace are presented below:

- Can regulate and control more precisely energy inflow leading to higher furnace efficiency
- Specific fuel cost in induction furnace is low
- Reduction of burning loss (saving in material)
- Environment friendly
- Productivity improvements
- Improved working environment

The cost economic analysis of the above suggested measures are compiled in Table 2.7. It can be observed that the energy efficiency improvements of furnaces have payback period of 4.9 years.

Table 2.7: ***Cost Economic Analysis – Induction Melting Furnace***

SN	Energy Efficient Measure	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Years / months)
1	Replacement of conventional coke fired pit furnace with Induction melting furnace	202,293	1,000,000	4 years 11 months

- **Improving Insulation of Pit Furnace:**

It is suggested to improve furnace insulation to reduce heat loss as the current insulation uses low material quality. In existing furnace, it was observed that average surface temperatures are around 98^{0}C, which leads to high radiation losses through the furnace, which sometimes accounted as high as 3-5% of the overall losses.

To overcome this shortcoming, the insulation thickness, it is recommended that furnace should be redesigned by constructing minimum 3 layers of firebricks, then refractory lining and finally 2 layers of red brick. This would minimise the heat losses from the furnace and enhances the efficiency of the coke fired pit furnace as shown in Figure 2.20.

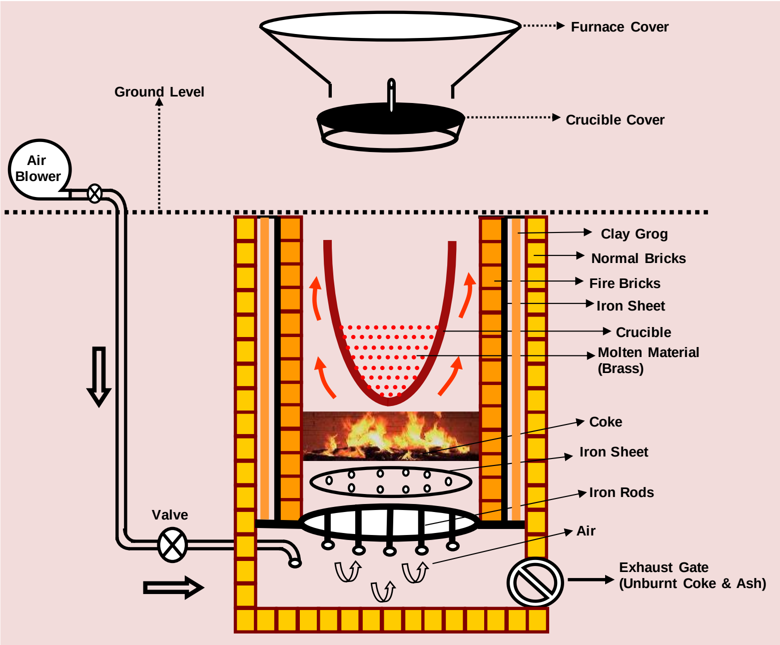


Figure 2.20: ***Conceptual design improved coke pit furnace***

Major advantages of improving the insulation of coke fired brass melting pit furnace are presented below:

- Reduction of melting time which automatically leads to energy savings
- Reduction of heat loss
- Productivity improvement
- Improved working environment

The cost benefit analysis of the above suggested measure is given in Table 2.8. It is clear that by improving insulation on the coke fired pit furnace substantial energy saving can be achieved.

Table 2.8: ***Cost Economic Analysis – Insulation Replacement***

SN	Energy Efficient Measure	Estimated Energy savings (kgs/Year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Years / months)
1	Improvement of Insulation In Coke Fired Pit Furnace	3,000	54,000	30,000	7 months

- **Use of Thermocouples / Dipstick to Measure Molten Metal Temperature:**

It was observed that the molten metal temperature is assessed by its colour and fluidity by the furnace operator. The assessment of temperature of molten metal is dependent on the experience and judgement of the furnace operator. The operator often tends to overheat the metal, just to make sure the required pouring temperature has attended. This increases the energy consumption many folds, which can be easily addressed by using temperature measuring instruments - thermocouples or dipstick. Major advantages of use of temperature controllers are presented below:

- Reduction of reheating time, it automatically leads to energy savings
- Quality improvements

- Reduction in burning loss
- Productivity improvements

The cost benefit analysis of the above suggested measure is given in Table 2.9. It is clear that installation of thermocouple gauge in coke fired pit furnace is attractive in energy and economic point of view

Table 2.9: ***Cost Economic Analysis – Temperature Controller***

SN	Energy Efficient Measure	Estimated Energy savings (kWh/Year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Years / months)
1	Use of Temperature Controller in Coke Fired Pit Furnace	2,877	69,054	20,000	3 months

2.3.3 Extrusion Press:

- **Present System:**

The unit has installed extrusion press machine employing three motors of 50 HP. The extrusion press normally operates for 8 hours per day. As per prevailing practices, hot cut billet from reheating furnace is processed through the extrusion press, converted into the brass rod of desired dimension through use of metal die (Figure 2.21). This metal die is also heated before being placed in the extrusion process.

Figure 2.21: ***Hot drawing in extrusion press***

- **Observations:**

Measurements were performed on the extrusion press motors when hot cut billet of 13 inch length was processed. During press operation, motor loading for pressing operation period and idle period was measured (See Table 2.10). It is found that press motor loading during pressing operation period load touches 86.87% and during idle period it was around 14.39%. Power factor was found to vary from 0.84 (loading condition) to very low 0.27 (unloading condition).

Table 2.10: ***Motor loading on the extrusion press motor***

Loading Condition	Current (Amps)				Voltage (Volts)	PF	Actual Power (kW)	Rated Motor (HP)	Loading (%)
	R	Y	B	Average					
Load	54	54	53	53.67	415	0.84	32.40	50	86.87
Unload	28	28	27	27.67	415	0.27	5.37	50	14.39

- **Recommendations:**

- It is suggested to measure the temperature of the cut hot billets being pressed in the extrusion press as lesser temperature of the hot billets consumes 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.
- It is further suggested to install VFD to reduce energy consumption of the extrusion press. The cost benefit analysis for the same is given below in the Table 2.11. It can be observed that the measure suggested towards energy efficiency improvements of the extrusion press have use energy saving payback period is less than a year.

Table 2.11: ***Cost Economic Analysis – VFD Installation***

SN	Energy Efficient Measure	Estimated Energy savings (kWh/Year)	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Years / months)
1	Installation of VFD across the Extrusion Press motor	43,378	325,335	300,000	11 months

2.3.4 Installation of Energy Efficient Lighting and Ceiling Fans

- **Present System:**

The unit has installed conventional lighting fixtures 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. The unit has 10 nos. of conventional design ceiling fans of 60 W each, 10 nos. of florescent tube lights of 55 W each and 4 nos. of metal halide lamp of 300 W each

- **Observations:**

During the plant visit, a study was carried out to find out the energy saving potential from replacement of existing lightings and ceiling fans with energy efficient equipment and fixtures. A detailed compilation of energy consumed by the lighting and ceiling fan was carried out and compared vis-à-vis to the use of energy efficient lightings and ceiling fans. In order to find out the capacity required for the lighting fixtures, 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 lighting and ceiling fan with energy efficient lightings and ceiling fans. The table below summarizes the list of equipment and fixtures to be replaced with energy efficient equipment and fixtures:

Table 2.12: ***Replacement of conventional lightings and ceiling fans with energy efficient equivalents***

Existing system	Propose system
55W florescent tube light – 10 Nos.	T-8 (20W) LED light – 10 Nos.
300W metal halide lamp – 4 Nos.	120W LED street light – 4 Nos.
Conventional ceiling fan (60W) – 10 Nos.	Energy Efficient (BLDC) Ceiling fan (28W) – 10 Nos.

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

Table 2.13: ***Cost-benefit analysis – installation of energy efficient ceiling fans and lightings***

SN	Energy Efficient Measure	Annual Savings (In Rs)	Estimated Investment (In Rs)	Simple Payback Period (Year /months)
1	Replace conventional ceiling fan with Energy Efficient (BLDC) Ceiling fan	9,225	30,000	3 year 1 months
2	Replace 55W florescent tube light with T-8 (20W) LED light	6,944	6,500	10 months
3	Replace 300W halogen light with 120W LED street light	14,284	84,808	5 Months 10 Months

2.3.5 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 was also constrained 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.

Questionnaire*

Energy Audit – Questionnaire Form

"Promoting Energy Efficiency and Renewable Energy in MSME Clusters in India – Jamnagar Brass Unit"

Name of the MSME unit:	Turn and Forge Metal Tech.
Address:	Plot no. 4727, Phase-3, Dared, Jamnagar
Ph. No:	7600000609, 9016080007
Name of the respondent	Mr. Nitin Rathod
Designation:	Partner

1. **Year of Establishment: 1985**
2. **Type of Products: a) Brass turned and forged items as per drawing**

   b) ________________

   c) ________________
3. **Installed Capacity: 100 kW**
4. **Operating hrs per day : 12 hours**
5. **Connected Load: (kVA or kW please specify)**
6. **Supply Voltage: 415 Volt**
7. **Annual Energy Consumption/ Production:**

Financial Year (April to March)	2012	2013	2014
Coke consumed (kg)			27000
Cost of coke (in Rs.)			59400
Electrical units consumed (In kWh)			
Electricity charges (in Rs.)			
LDO/HSD/ FO consumption (L)			13500
Fuel Cost (in Rs.)			472500
Production (Kg)			189000

*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)	Gujarat NRE	6500
HSD (L)		
LDO (L)		
FO (L)		

Fuel	Source
Electricity (kWh)	PGVCL

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	15750	2250		1125	
May, 14	15750	2250	1418	1125	
June, 14	15750	2250	2736	1125	
July, 14	15750	2250	2577	1125	
August, 14	15750	2250	1853	1125	
September, 14	15750	2250	2262	1125	
October, 14	15750	2250	2550	1125	
November, 14	15750	2250	3119	1125	
December, 14	15750	2250	2427	1125	
January, 15	15750	2250	4100	1125	
February, 15	15750	2250	3394	1125	
March, 15	15750	2250	2500	1125	

10. Duration of electricity supply: 24 Hours/ day

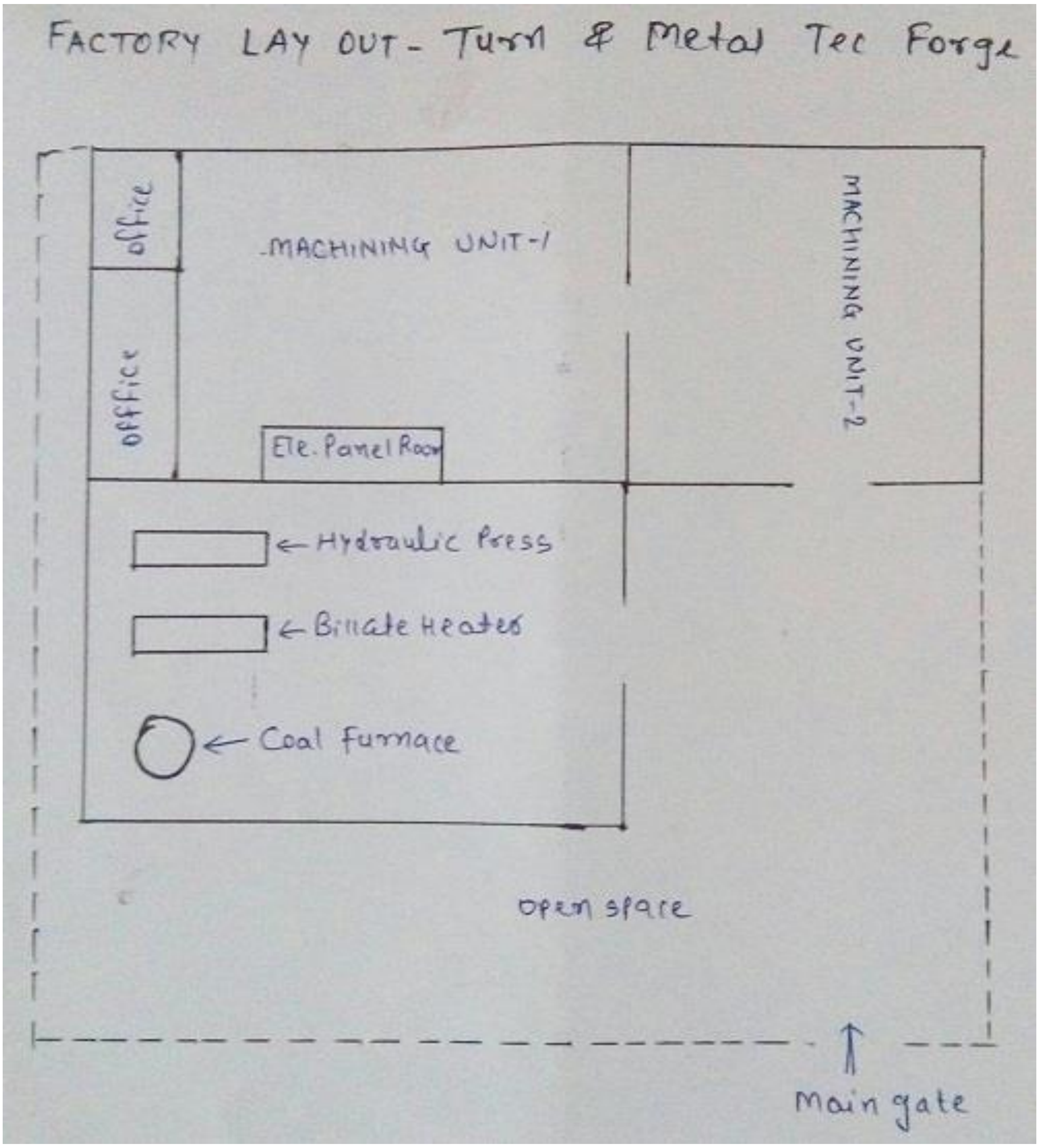
11. Cost variables per Kg of Production:

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	

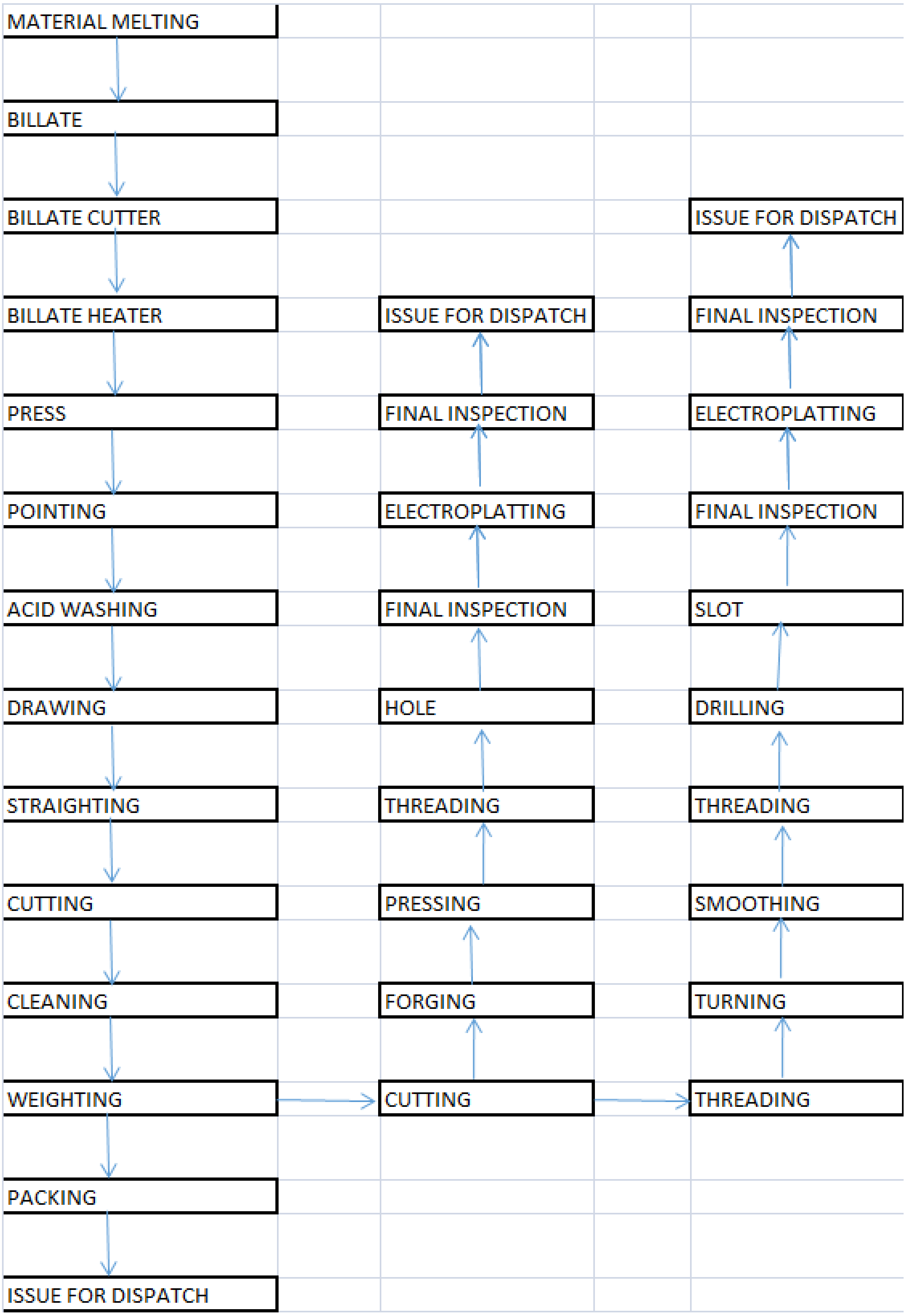
12. Major Energy Consuming Equipment:

SN	Equipment	Energy source	Make/ Supplier	Year of Installation	Technical Specification/ capacity	Use	Comments
1	Blower	Electricity			1 HP	In coal furnace	
2	Chimney fan	Electricity			1 HP	In coal furnace	
3	Heater	Electricity			1 HP	Use in billet heater	
4	Wire Pointing	Electricity			0.5 HP	Manufacturing Unit	
5	Drawing machine	Electricity			3 HP	Manufacturing Unit	
6	Straightening machine	Electricity			1 HP	Manufacturing Unit	
7	Wire cutting	Electricity			0.5 HP	Manufacturing Unit	
8	Wire cutting	Electricity			1 HP	Manufacturing Unit	
9	Pressing	Electricity			0.5 HP	Manufacturing Unit	
10	Threading	Electricity			0.5 HP	Manufacturing Unit	
11	Threading	Electricity			0.5 HP	Manufacturing Unit	
12	Threading	Electricity			0.5 HP	Manufacturing Unit	
13	Threading	Electricity			0.5 HP	Manufacturing Unit	
14	Threading	Electricity			1 HP	Manufacturing Unit	
15	Rounding machine	Electricity			1 HP	Manufacturing Unit	
16	Grinding	Electricity			0.5 HP	Manufacturing Unit	
17	Grinding	Electricity			0.5 HP	Manufacturing Unit	
18	Grinding	Electricity			1 HP	Manufacturing Unit	
19	Turning	Electricity			2 HP	Manufacturing Unit	
20	Turning	Electricity			1 HP	Manufacturing Unit	
21	Drilling machine	Electricity			1 HP	Manufacturing Unit	
22	Slotting machine	Electricity			1 HP	Manufacturing Unit	
23	Surface Smoothing	Electricity			0.5 HP	Manufacturing Unit	
24	Forging machine	Electricity			5 HP	Manufacturing Unit	
25	Forging machine	Electricity			7 HP	Manufacturing Unit	
26	Billet cutter	Electricity	Kirloskar		10 HP	Manufacturing Unit	
27	Extrusion Press	Electricity	Kirloskar		50 HP	Manufacturing Unit	

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
Electrical furnace	Rs. 10 Lakh	Material melting

17. Any factory expansion plan:

Yes,

They replace coal furnace and purchase 300 kG electrical induction furnace (make indo power)

Annexure 2:

Major Energy Consuming Equipment

SN	Equipment	Energy Source	Technical Specification/Capacity
1	Coke Pit Furnace	Thermal (Hard Coke)	300 kgs
2	Blowers motors for furnace	Electric	1 HP, 2 x 0.5 HP
3	Extrusion Press (Kirloskar)	Electric	50 HP
4	Pointing Machine	Electric	0.5 HP
5	Drawing Machine	Electric	3 HP
6	Straighting Machine	Electric	1 HP
7	Cutting Machine	Electric	2 x 0.5 HP, 9 x 1 HP, 1 x 10 HP (Kirloskar make)
8	Pressing Machine	Electric	2 x 0.5 HP
9	Forging Machine	Electric	7 HP, 5 HP
10	Threading Machine	Electric	4 x 2 HP, 3 x 1 HP
11	Drilling	Electric	2 x 1 HP
12	Grinding	Electric	3 x 0.5 HP, 1 x 1 HP
13	Turning	Electric	4 x 2 HP, 3 x 1 HP
14	Surface Smoothing	Electric	2 x 0.5 HP
15	Sloting	Electric	1 HP
16	DG Sets (Kirloskar make)	Thermal (Diesel)	7.5 kVA
17	Capacitors for Power Factor Correction	Electric	1 x 10 kVAR, 5 x 3 kVAR

Annexure 3:

Reheating Furnace Efficiency Calculations

Parameter	Unit	Value
Total weight of cut billets heated	kg	542.5
Specific heat of Brass[1]	kCal/kg ^{0}C	0.09
FO fuel consumption	kg	23.39
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	236,240
Total output heat	kCal	34,666
Furnace efficiency by direct method	%	14.67

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

Annexure 4:

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
4	Gas fired Pit Furnace	**EM EM Engineers** A-4/235, Paschim Vihar, Paschim Vihar, New Delhi, Delhi 110063 Mr. Manish Kumar Soota Mobile: 098104 30765

Material Log Book – Coke Fired Pit Furnace

<table>
<tr><td>Furnace ID:</td><td colspan="2">…………………………..</td><td>Date</td><td colspan="2">………………..</td><td>Charge Number</td><td>………..</td><td>Material Type</td><td>………………..</td></tr>
<tr><td colspan="6"><u>Time Details</u></td><td colspan="4"><u>Material Input</u></td></tr>
<tr><td colspan="2">Melting</td><td colspan="2">Holding</td><td colspan="2">Pouring</td><td rowspan="2">SN</td><td colspan="2" rowspan="2">Material Type</td><td rowspan="2">Quantity (kg)</td></tr>
<tr><td>Start Time (A)</td><td>………..</td><td>Start Time (D)</td><td>……….</td><td>Start Time (G)</td><td>………</td></tr>
<tr><td>End Time (B)</td><td>………..</td><td>End Time (E)</td><td>……….</td><td>End Time (H)</td><td>………</td><td>1</td><td colspan="2">…………………………………….</td><td>……………...</td></tr>
<tr><td>Total time (C) = (B) – (A)</td><td>………..</td><td>Total time (F) = (D) – (C)</td><td>……….</td><td>Total time (I) = (F) – (E)</td><td>………</td><td>2</td><td colspan="2">…………………………………….</td><td>……………...</td></tr>
<tr><td colspan="6"><u>Temperature Details</u></td><td>3</td><td colspan="2">…………………………………….</td><td>……………...</td></tr>
<tr><td colspan="3">Melting Temperature (^{0}C)</td><td colspan="3">……………………</td><td>4</td><td colspan="2">…………………………………….</td><td>……………...</td></tr>
<tr><td colspan="3">Tapping Temperature (^{0}C)</td><td colspan="3">……………………</td><td>5</td><td colspan="2">…………………………………….</td><td>……………...</td></tr>
<tr><td colspan="3">Pouring Temperature (^{0}C) at start of pouring</td><td colspan="3">…………………...</td><td>6</td><td colspan="2">…………………………………….</td><td>……………...</td></tr>
<tr><td colspan="3">Pouring Temperature (^{0}C) at end of pouring</td><td colspan="3">…………………...</td><td>7</td><td colspan="2">…………………………………….</td><td>……………...</td></tr>
<tr><td colspan="6"><u>Hard Coke Consumption (kgs)</u></td><td colspan="3">Total Input Material (M)</td><td>……………...</td></tr>
<tr><td colspan="3">Total hard coke consumption (L)</td><td colspan="3">……………………...</td><td colspan="3">Total Material Output (N)</td><td>……………...</td></tr>
<tr><td colspan="3"></td><td colspan="3"></td><td colspan="3">Material Lost (O) = (M) – (N)</td><td>……………...</td></tr>
<tr><td colspan="3"></td><td colspan="3"></td><td colspan="3">Specific Coke consumption (kgs/ton) (P) = (L) * 1000/ (M)</td><td>……………...</td></tr>
<tr><td colspan="10">Remarks: Please capture any other information related to operation like reason for furnace holding, higher time taken for furnace holding etc…</td></tr>
</table>