COMPREHENSIVE ENERGY AUDIT REPORT

"PROMOTING ENERGY EFFICIENCY AND RENEWABLE ENERGY IN SELECTED MSME CLUSTERS IN INDIA"

Juneja Forgings

5th-Milestone, Kapurthala Road, Jalandhar, Punjab – 144013

16-05-2015

Submitted to

ENERGY IS LIFE

BEE

CONSERVE IT

BUREAU OF ENERGY EFFICIENCY

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Submitted by

DESL

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DISCLAIMER

ACKNOWLEDGEMENT

DESL places on record its sincere thanks to Global Environment Facility (GEF), United Nations Industrial Development Organization (UNIDO) and Bureau of Energy Efficiency (BEE) for vesting confidence in DESL to carry out the assignment "Conducting energy audit and dissemination programs in MSME clusters" under their national project *"promoting energy efficiency and renewable energy in selected MSME clusters in India"*.

As a part of this assignment, work in Jalandhar Hand-tools cluster was awarded to DESL and DESL is grateful to GEF-UNIDO-BEE PMU for their full-fledged coordination and support throughout the study

The study team is indebted to Mr. Sarabjit Singh, Director for showing keen interest in the energy audit and also thankful to the management of M/s Juneja Forgings for their wholehearted support and cooperation for the preparation of this comprehensive energy audit report, without which the study would not have steered to its successful completion. Special thanks to other members of the unit for their diligent involvement and cooperation.

It is well worthy to mention that the efforts being taken and the enthusiasm shown by all the plant personnel towards energy conservation and sustainable growth are really admirable.

Last but not the least, the interaction and deliberation with Mr. Sukh Dev Raj, President, Hand tool manufacturers association, Jalandhar, technology providers and all those who were directly or indirectly involved throughout the study were exemplary. The entire exercise was thoroughly a rewarding experience for DESL.

DESL Team

DESL Team

Project Head	**Mr. R. Rajmohan** Chief Executive Officer
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ABBREVIATIONS

Abbreviations	Expansions
APFC	Automatic Power Factor Correction
BEE	Bureau of Energy Efficiency
CEA	Comprehensive Energy Audit
CFL	Compact Fluorescent Lamp
CRV	Chromium Vanadium
DESL	Development Environergy Services Limited
DG	Diesel Generator
EE	Energy Efficiency
EPIA	Energy Performance Improvement Action
FO	Furnace Oil
GEF	Global Environment Facility
HSD	High Speed Diesel
HVAC	Heating Ventilation and Air Conditioning
LED	Light Emitting Diode
LT	Low Tension
MD	Maximum Demand
MS	Mild Steel
MSME	Micro, Small and Medium Enterprises
MT	Metric Tons
MTOE	Million Tons of Oil Equivalent
MV	Mercury Vapour
No.	Number
PF	Power Factor
PID	Proportional-Integral-Derivative
PNG	Piped Natural Gas
PSPCL	Punjab State Power Corporation Limited
R & C	Radiation & Convection
RE	Renewable Energy
SEC	Specific Energy Consumption
SEGR	Specific Energy Generation Ratio
SLD	Single Line Diagram
SME	Small and Medium Enterprises
UNIDO	United Nations Industrial Development Organization
VFD	Variable Frequency Drives

EXECUTIVE SUMMARY

Bureau of Energy Efficiency (BEE) in association with the United Nations Industrial Development Organization (UNIDO) and Global Environment Facility (GEF) is implementing a project titled "Promoting energy efficiency and renewable energy technology in selected MSME clusters in India". The objective of the project is to provide impetus to energy efficiency initiatives in the micro, small and medium enterprises (MSMEs) sector in India.

As part of this project, DESL has been engaged to implement the project in the MSME hand tool cluster in Jalandhar, Punjab. There are about 400 units scattered over three industrial areas in Jalandhar, viz. focal point, old industrial area and basti area. The major products manufactured include spanners and wrenches, pliers, screw drivers, etc with an average annual production of 50,000 metric tons in the cluster.

The project awarded to DESL consists of six major tasks:

- Conducting pre – activity cluster workshop defining the agenda of this engagement.
- Comprehensive energy audit in 6 selected units.
- Development of cluster specific best operating practices document for the top 5 energy using equipments / processes in the industry.
- Identification of set of energy auditing instruments that should be used for carrying out periodic energy audits in the units.
- Enumeration of common regularly monitorable parameters at the process level, which have impact on energy performance and listing of appropriate instrumentation for the same.
- Conducting 3 post energy audit training workshops based on preceding outputs of this activity.

Brief Introduction of the Unit

Table 1 Details of Unit

Name of the Unit	M/s Juneja Forgings
Constitution	Private Limited
MSME Classification	Small
No. of years in operation	NA
Address: Registered Office	5th-Milestone, Kapurthala Rd, Jalandhar, Punjab-144013
Administrative Office	5th-Milestone, Kapurthala Rd, Jalandhar, Punjab-144013
Factory	5th-Milestone, Kapurthala Rd, Jalandhar, Punjab-144013
Industry-sector	Hand Tool
Products Manufactured	Combination Spanners, Double Open Ended Spanners, Ring Spanners etc
Name(s) of the Promoters / Directors	Mr. Sarabjit Singh

Comprehensive Energy Audit

The study was conducted in 3 stages:

- **Stage 1:** Walk through energy audit of the plant to understand the process, energy drivers, assessment of the measurement system, assessment of scope, measurability, formulation of audit plan and obtaining required information
- **Stage 2:** Detailed energy audit data collection and field measurements for performance evaluation of equipments/ systems, estimation of savings potential, technology assessment and understanding of project constraints
- **Stage 3**: Data analysis, initial configuration of projects, savings quantification, vendor consultation, interaction with the unit and freezing of projects for implementation and preparation of energy audit report

The production process of the unit

The main process equipments in the unit include the following:

The production process includes blanking, heating, forging, trimming, broaching, grinding, barreling, heat treatment, shot blasting, calibration, polishing, electroplating and packing.

The raw materials used are mainly MS and CRV steel. The raw material is blanked and then sent to a forging furnace for heating. The heated material (work piece) is removed from the forging furnace and forged using hammers. The forged work piece is then cut and trimmed into desired shapes and the unnecessary burrs along the edges are removed in the trimming operation.

The trimmed work piece is then treated in the heat treatment furnace for hardening, quenching and tempering to attain desired metallurgical properties like strength, stability and durability.

Post heat treatment, in order to get the necessary surface finish and polish, the work pieces are shot blasted after which they are placed in vibrating glazing machines along with a measured quantity of ceramic material (in form of ceramic stones). Due to the vibration action of this machine, the work pieces and the ceramic materials rub against each other. In this process, the work piece gets further polished.

The polished work piece is then sent for electroplating, where it is dipped for a certain period of time inside hot nickel and chromium baths to attain the desired final glaze and finishing. From the electroplating section the finished products are packed and dispatched.

The main process equipments are furnace, hammer, broaching machines, blanking machines, heat treatment furnace, vibrators, shot blasting machine.

Identified Energy Performance Improvement Actions

The comprehensive energy audit covered all of the equipments which were operational during the field study. Thermal energy constitutes 68% (FO, HSD, Wood) and grid electricity constitutes 32% of total plant energy. The identified energy performance improvement actions are given in Table – 2.

Table 2: Summary of EPIA

Sl. No.		Estimated energy savings						
		FO	Electricity	HSD	Material Savings	Monetary savings	Estimated investment	Simple payback period
		Litre/y	kWh/y	Litre/y	Rs./y	Rs. lakh/y	Rs. lakh	y
1	Installation of PID controller for excess air control on forging-8	11169.6	1969.4		3.7	8.3	7.00	0.8
2	Installation of PID controller for excess air control on forging-4	10586	1969.4		3.9	9.1	7.00	0.8
3	Installation of PID controller for excess air control on forging-5	4591	1969.4		2.3	4.3	7.00	1.6
4	Skin loss reduction from furnace surface of forging 4 and 5	744.4				0.3	0.10	0.32
5	VFD on broaching machine 11		5251.7			0.4	0.79	2.3
6	Installation of energy efficient fan instead of conventional fan		36085.5			2.4	4.05	1.7
7	Retrofit of CFL 40 watt to led tube light of 16 watt		10692.0			0.7	0.84	1.2
8	Replacement of CFL 65W ,50W halogen watt,250W MV with LED light		39982.1			2.69	5.06	1.9
9	Leakage Arrest on Compressor 1		13806			0.9	0.10	0.1
10	Replacement of reciprocating compressor with screw compressor		15303			1.02	3.00	2.9
11	DG Replacement - 125 kVA			3232		1.62	7.61	4.7
12	Replacement of present burner with energy efficient burner	17820.0				7.13	1.21	0.2
	Total	**44910.5**	**127028.2**	**3232.4**	**9.9**	**38.8**	**43.8**	**1.1**

The projects proposed will bring the energy savings of up to 6.62 % and upto 38.8 lakh of cost saving in the plant on implementation.

1 INTRODUCTION

1.1 Background and Project objective

Bureau of Energy Efficiency (BEE) in association with the United Nations Industrial Development Organization (UNIDO) and Global Environment Facility (GEF) is implementing a project titled "Promoting energy efficiency and renewable energy technology in selected MSME clusters in India". The objective of the project is to provide impetus to energy efficiency initiatives in the micro, small and medium enterprises (MSMEs) sector in India.

The targeted 12 MSME clusters under the project and the indicative information are given below:

Table 3: List of 12 targeted MSME clusters covered under the project

Sl. No.	Sub – sector	Cluster
1	Brass	Jagadhri, Jamnagar
2	Ceramic	Khurja, Morbi, Thangarh
3	Dairy	Gujarat, Madhya Pradesh
4	Foundry	Belgaum, Coimbatore, Indore
5	Hand tools	Jalandhar, Nagaur

The objectives of this project are as under:

- Increasing capacity of suppliers of energy efficiency (EE) and renewable energy (RE) based products, service providers and financing institutions;
- Increasing the levels of end-use demand and implementation of EE and RE technologies and practices by MSMEs;
- Scaling up of the project to the national level;
- Strengthening policy, institutional and decision making frameworks.

1.2 Scope of work for Comprehensive Energy Audit

The general scope of work for comprehensive energy audits is as follows:

- Data Collection
    - Current energy usage (month wise) for all forms of energy for the period April-2014 to March-2015 (quantity and cost)
    - Data on production for the corresponding period (quantity and cost)
    - Data on production cost and sales for the corresponding period (cost)
    - Mapping of process
    - Company profile including name of the company, constitution, promoters, years in operation and products manufactured
    - Existing manpower and levels of expertise
    - List of major equipments and specifications

- Analysis:
  - Energy cost and trend analysis
  - Energy quantities and trend analysis
  - Specific consumption and trend analysis
  - Performance evaluation of major energy consuming equipments / systems
  - Scope and potential for improvement in energy efficiency
- Correlate monthly production data with electricity and fuel consumption for a period of 12 months of normal operation for individual sections of the overall plant.
- Detailed process mapping to identify major areas of energy use.
- To identify all opportunities for energy savings in the following areas:
  - Electrical: Power Factor, transformer loading, power quality, motor load, compressed air systems, conditioned air systems, cooling water systems, lighting load, electrical metering, monitoring and control system.
  - Thermal: Furnaces, steam and hot water systems (including hot water lines tracing, pipe sizes, insulation), heat recovery systems, etc.
- Evaluate the energy consumption vis-à-vis the production levels and to identify the potential for energy savings / energy optimization (both short term requiring minor investments with attractive payback, and mid to long terms system improvement needing moderate investments and with payback period of 4.7 years).
- Classify parameters related to EE enhancements such as estimated quantum of energy savings, investment required, time-frame for implementation, payback period, re-skilling of existing manpower, etc. and to classify the same in order of priority.
- Design an "energy monitoring system" for effective monitoring and analysis of energy consumption, energy efficiency.

1.3 Methodology

1.3.1 Boundary parameters

Following boundary parameters were set for coverage of the audit.

- Audit covered all possible energy intensive areas & equipment which were operational during the field study
- All appropriate measuring systems including portable instruments were used
- The identified measures normally fall under short, medium and long-term measures

1.3.2 General methodology

Following flow chart illustrates the methodology followed for carrying out different tasks:

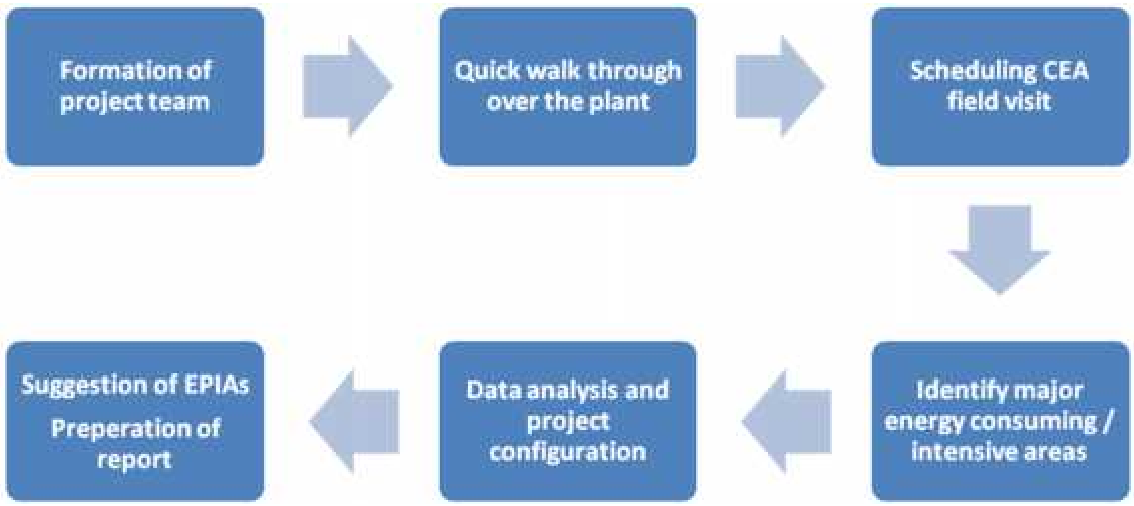

Figure 1: General methodology

The study was conducted in 3 stages:

- **Stage 1:** Walk through energy audit of the plant to understand the process, energy drivers, assessment of the measurement system, assessment of scope, measurability, formulation of audit plan and obtaining required information
- **Stage 2:** Detailed energy audit-testing and measurement for identification of savings potential, technology assessment and understanding of project constraints
- **Stage 3**: Desk work for data analysis, initial configuration of projects, savings quantification, vendor consultation, interaction with unit and freezing of projects for implementation and preparation of energy audit report

1.3.3 Comprehensive energy audit – field assessment

A walk through was carried out on the before the audit with a view to:

- Understand the manufacturing process and collect historical energy consumption data
- Obtain cost and other operational data for understanding the impact of energy cost on the units financial performance
- Assess the energy conservation potential at macro level
- Finalize the schedule of equipments and systems for testing and measurement

The audit identified the following potential areas of study:

- Heating and Forging
- Electrical motors used in process
- Fans and lighting loads

The further activities carried out by the team after walk through study included:

- Preparation of the process and energy flow diagrams
- Study of the system and associated equipments

- Conducting field testing and measurement
- Data analysis for preliminary estimation of savings potential at site
- Discussion with the unit on the summary of findings and energy efficiency measures identified

Audit methodology involved system study to identify the energy losses (thermal / electrical) and then finding solutions to minimize the same. This entailed data collection, measurements / testing of the system using calibrated, portable instruments, analyzing the data / test results and identifying the approach to improve the efficiency. The various instruments used for the energy audit are:

Table 4 Energy audit instruments

Sl. No.	Instruments	Make	Model	Parameters Measured
01	Power Analyzer – 3 Phase (for un balanced Load) with 3 CT and 3 PT	Enercon and Circutor	AR-5	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 1 sec interval
02	Power Analyzer – 3 Phase (for balance load) with 1 CT and 2 PT	Elcontrol Energy	Nanovip plus mem	AC Current, Voltage, Power Factor, Power, Energy, Frequency, Harmonics and data recording for minimum 2 sec interval
03	Digital Multi meter	Motwane	DM 352	AC Amp, AC-DC Voltage, Resistance, Capacitance
04	Digital Clamp on Power Meter – 3 Phase and 1 Phase	Kusam - Meco	2745 and 2709	AC Amp, AC-DC Volt, Hz, Power Factor, Power
05	Flue Gas Analyzer	Kane-May	KM-900	O2%, CO2%, CO in ppm and Flue gas temperature, Ambient temperature
06	Digital Temperature and Humidity Logger	Dickson		Temperature and Humidity data logging
07	Digital Temp. & Humidity meter	Testo	610	Temp. & Humidity
08	Digital Anemometer	Lutron and Prova	AM 4201 And AVM-03	Air velocity

Sl. No.	Instruments	Make	Model	Parameters Measured
09	Vane Type Anemometer	Testo	410	Air velocity
10	Digital Infrared Temperature Gun	Raytek	Minitemp	Distant Surface Temperature
11	Contact Type Temperature Meter	Testo	925	Liquid and Surface temperature
12	High touch probe Temperature Meter	CIG		Temperature upto 1300 deg C
13	Lux Meter	Kusum Meco (KM-LUX-99) and Mastech		Lumens
14	Manometer	Comark	C 9553	Differential air pressure in duct
15	Pressure Gauge	Wika		Water pressure 0 to 40 kg

1.3.4 Comprehensive energy audit – desk work

Post audit off-site work carried out included:

- Re-validation of all the calculations for arriving at the savings potential
- Quick costing based on DESL's database or through vendor interactions as required
- Configuration of individual energy performance improvement actions
- Preparation of audit report

2 ABOUT THE MSME UNIT

2.1 Particulars of the unit

Table 5: General particulars of the unit

Sl. No.	Particulars	Details
1	Name of the unit	M/s Juneja Forgings
2	Constitution	Private Limited
3	Date of incorporation / commencement of business	NA
4	Name of the contact person Mobile/Phone No. E-mail ID	Mr. Sarabjit Singh +91-181 – 2651200,300,400 sarabjit@junejaforgings.com
5	Address of the unit	5th-Milestone, Kapurthala Rd, Jalandhar, Punjab-144013
6	Industry / sector	Hand Tools
7	Products manufactured	Combination Spanners, Double Open Ended Spanners, Ring Spanners, etc
8	No. of operational hours/day	12
9	No. of shifts / day	1
10	No. of days of operation / year	330
11	Whether the unit is exporting its products (yes / no)	Yes
12	No. of employees	200-300

3 DETAILED TECHNICAL FEASIBILITY ASSESSMENT OF THE UNIT

3.1 Description of manufacturing process

3.1.1 Process & Energy flow diagram

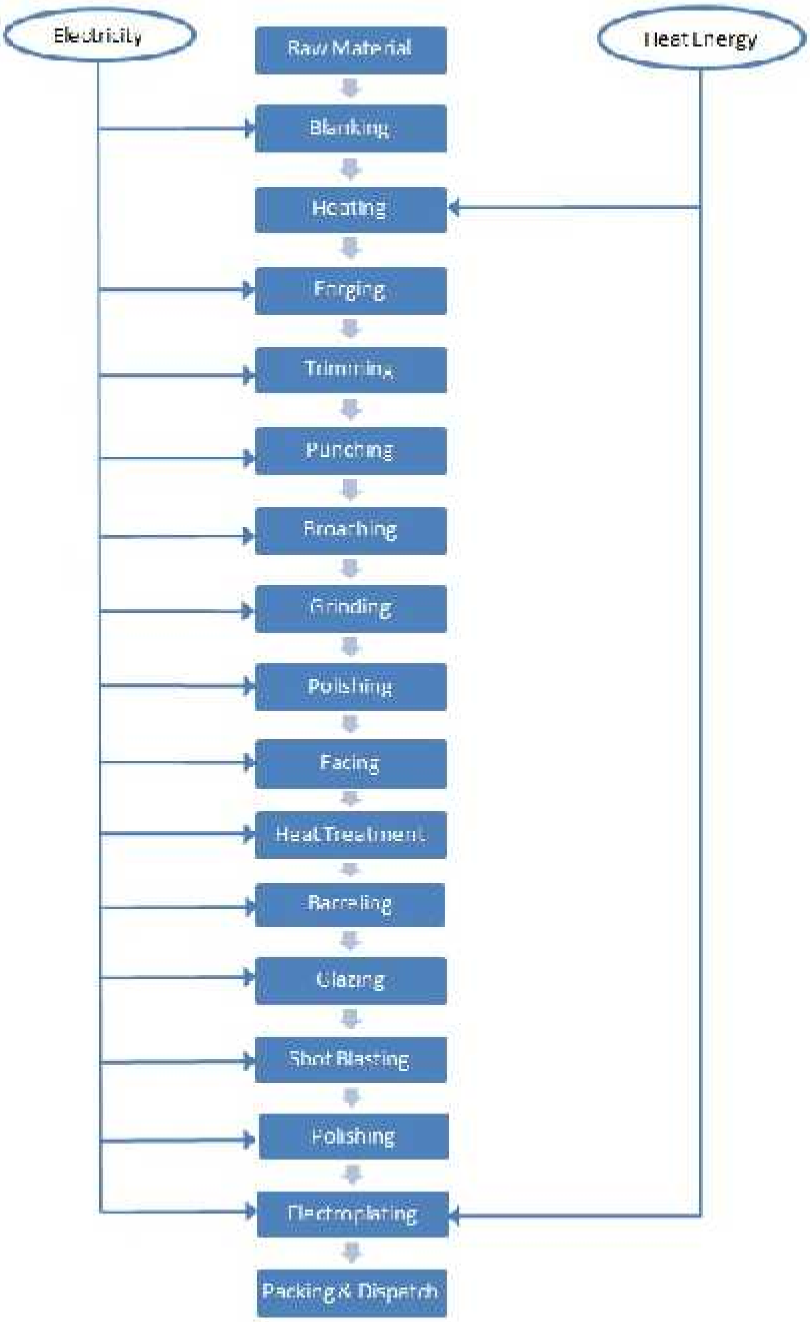

Figure 2: Process flow diagram

3.1.2 Process description

M/s Juneja Forgings manufacture Combination Spanners, Double Open Ended Spanners, Ring Spanners, etc.

The process description is as follows:

Raw Material

The main raw materials used are round and flat Mild Steel and Chromium Vanadium Steel.

Blanking

It is a process in which the work piece is removed from the primary metal strip and the piece removed is called blank metal scrap.

Heating

The unit has 5 oil fired forging furnaces for heating the work pieces. The temperature maintained is around 1000^0C.

Forging

The red hot work pieces taken out from the forging furnace are placed on the lower fixed die above the anvil. A ram moves downwards with gravity action. Below the ram is placed the upper die which is fixed to it. After several strokes of the upper die on the work piece, the work piece takes the desired shape.

Trimming

In this machine, the forged material is pressed to give it a uniform shape by removing the unnecessary burrs along the edges. The speed of the press is controlled and it travels at a low speed when it comes down and exerts maximum pressure just before pressing.

Grinding

This is a process where-by a sand paper is used for side grinding of the “trimmed work-piece”.

Broaching

It is similar to trimming operation, whereby a toothed tool called broach is used to remove materials from the ground work piece. Two types of broaches are used, i.e. linear for open sections and rotary for circular sections.

Barreling

In this operation, ceramic stones are used to remove the scales from the work piece using a rubbing action.

Heat Treatment

Heat treatment is done to impart the required metallurgical properties to the work piece that will improve the working life of manufactured equipment (hand-tool). The main processes involved are hardening, quenching and tempering. Electrical heat treatment furnaces are used for this purpose.

Shot Blasting

This is done to clean and polish the work piece.

Calibration and inspection

The finished product is calibrated to check the dimensions, size, shape, etc before the final finishing process.

Glazing

In this machine, the ceramic material and the work pieces are placed together on the vibrating glazing machine. Due to the vibrating action of this machine, the work piece and the ceramic materials (in the form of solid stones) rubs against each other and in this process the work piece gets polished.

Electro plating

The final shining and glazing of the product is done using electroplating, where-by, air is circulated using a blower inside a nickel tank. The final product is dipped inside this tank and kept in that condition for a certain period of time and then taken out and cleaned in a hot water tank.

3.2 Inventory of process machines / equipments and utilities

Major energy consuming equipments in the plant are:

- **Blanking Machine:** Here, the raw material is cut into required shape before it is heated in a furnace.
- **Forging furnace:** FO fired forging furnaces are used for heating the material for forging. The operating temperature of FO fired furnace is around 1000-1100^{0}C oil fired furnaces are used in the plant.
- **Hammer:** Hammers are used in forging process, in which material is pressed against a die using a drop hammer. There are 5 hammers which are used in the plant, each adjacent to a forging furnace.
- **Broaching machine:** This machine is used to remove materials from edges of the work piece to give it a better edge finish. Large motors are employed in this machine for this purpose.
- **Heat treatment furnace:** The heat treatment furnace consists of electrical heaters for hardening and tempering. Hardening is done around a temperature of 750 – 800^{0}C and tempering is done at around 300 -350^{0}C.
- **Electroplating:** Electroplating is the process of plating one metal onto another by hydrolysis, most commonly for decorative purposes or to prevent corrosion of a metal. There are specific types of electroplating such as copper plating, silver plating, and chromium plating.

3.2.1 Types of energy used and description of usage pattern

Both electricity and thermal energy are used in different manufacturing processes. The overall energy use pattern in the unit is as follows:

- Electricity is sourced from two different sources:
    - From the Utility, Punjab State Power Corporation Limited (PSPCL)

- Captive backup Diesel Generator sets for the whole plant

- Thermal energy is used for following applications :
    - Fuel Oil for forging furnace
    - Wood for boiler to generate steam for heating electroplating baths

Total energy consumption pattern for the period April-14 to March-15, from different sources are as follows:

Table 6: Energy cost distribution

Particulars	Rs.(Lakhs)	% of Total	Consumption (MTOE)	Energy sharing (%)
Grid –Electricity	268.95	52%	361.9	32%
Diesel –DG	23.40	5%	44.1	4%
FO	192.78	37%	472.5	41%
Wood	30.00	6%	262.5	23%
Total	**515.13**	**100%**	**1141.05**	**100%**

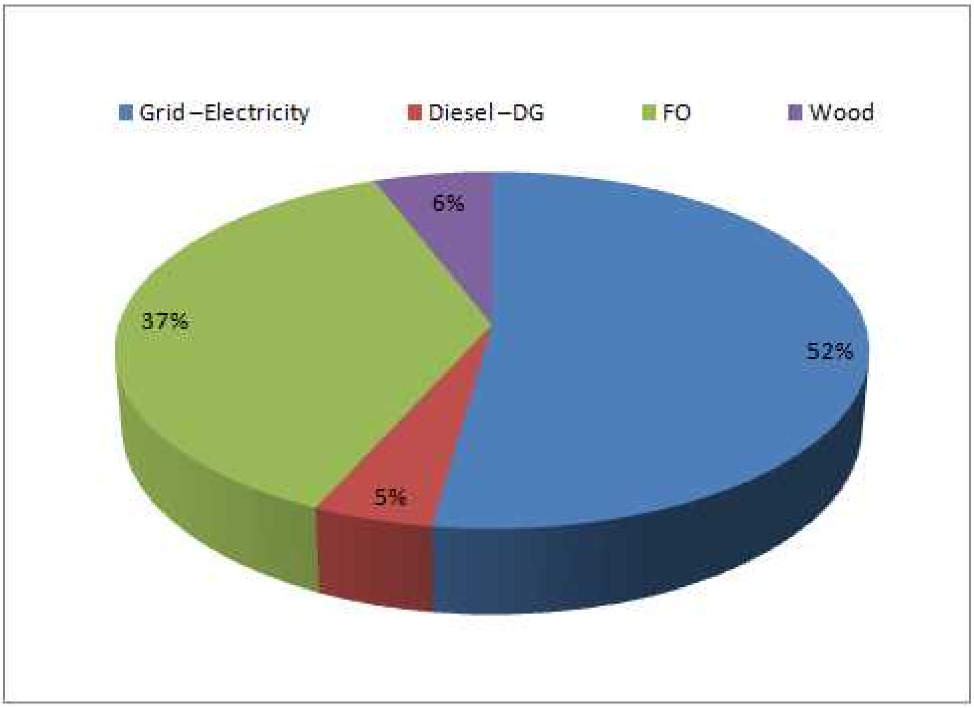

Figure 3: Energy cost share

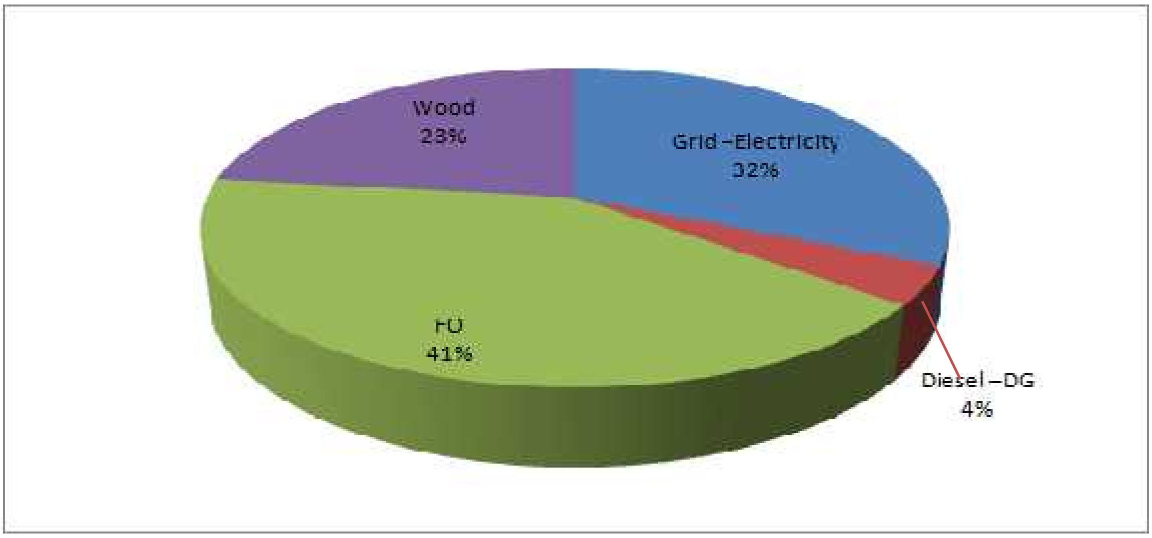

Figure 4: Energy use share

Major observations are as under:

- The unit uses both thermal and electrical energy for manufacturing operations. Electricity is sourced from the grid as well as self generated through DG sets when the grid power is not available. Thermal energy consumption is in the form of FO which is used in forging furnace and wood which is used in boiler
- FO used in furnace account for 37% of the total energy cost and 41% of overall energy consumption.
- Electricity used in the process accounts for 52% of the energy cost and diesel used for captive electricity generation is 5% of the overall cost.

3.3 Analysis of electricity consumption by the unit

3.3.1 Baseline parameters

Following are the general base line parameters, which have been considered for the techno-economic evaluation of various identified energy cost reduction projects. The costs shown are the landed costs.

Table 7: Baseline parameters

Electricity Rate (Excluding Rs./kVA)	6.14	Rs. / KVAh inclusive of taxes
Weighted Average Electricity Cost	6.54	Rs. / kWh
Percentage of total DG based Generation	2%	
Average Cost of HSD	50.00	Rs./Litre for April 2015
Average Cost of FO	40.00	Rs./Litre for April 2015
Annual Operating Days per year	330	Day/yr
Annual Operating Hours per day	24	Hr/day
Production	5433	MT

Electricity load profile

Following observation has been made from the utility inventory:

- The plant total connected load is 1,577.7 kW

3.3.2 Sourcing of electricity

The unit is drawing electricity from two different sources:

- Utility (PSPCL) through regulated tariff
- Captive DG set which is used as a backup source and supplies electrical power in case of grid power failure

The share of utility power and DG power is shown in the table and figure below:

Table 8: Electricity share from grid and DG

	Consumption (kWh)	%	Cost (Rs. lakh)	%
Grid Electricity	4208490	98%	269.0	92%
Self Generation	85950	2%	23.4	8%
Total	**4294440**	**100%**	**292.4**	**100%**

This is graphically depicted as follows:

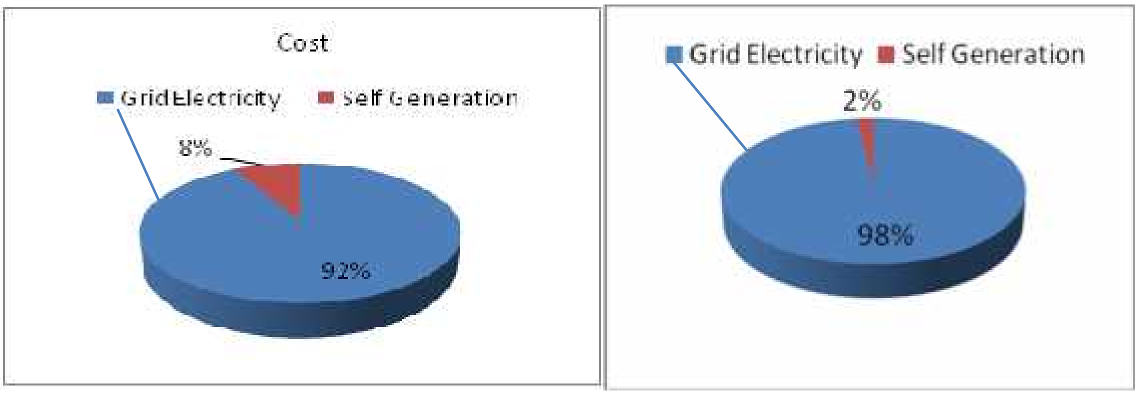

Figure 5: Share of electricity by source and cost

The share of electrical power as shown in the above chart indicates the condition of power supply from utility. The requirement of power from backup source, i.e. DG sets is about 3% of the total power which is not very high. Although the share of DG power in terms of kWh is just 3% of the total electrical power, however, it accounts for about 8% in terms of total cost of electrical power. For economical operation of the plant, the utilization of DG sets needs be minimized, but it will depend upon the supply condition of the grid as well as the power requirement of the plant.

3.3.3 Supply from utility

Electricity is supplied by PSPCL. The unit has one HT energy meter provided by the distribution company in the premise. Details of grid supply are as follows:

a) Power Supply : 11 kV line
b) Contract Demand : 1225 kVA
c) Sanctioned Load : 1577.27 kW
d) Nature of Industry : HT – G

The grid electricity tariff structure is as follows:

Table 9: Tariff structure

Particulars	Tariff Structure	
Present energy charge	6.14	Rs./kVAh
Fuel Surcharge	0.05	Rs./kVA
Octroi Charge	0.10	Rs./kVAh
Municipality tax	0.00	Rs./kVAh
Electricity duty	0.00	Rs./kVah

(As per bill of Feb 2015)

Note: Since only monthly consumption was given by operating person verbally and no records were maintained for EB, hence the average value is taken for the evaluation which is correspondingly computed annually too.

Power factor

The utility bills of the unit reflect the average monthly power factor of the plant. A study was conducted by logging the main incomer and recording all the electrical parameters. The average power factor recorded was found to be 0.99.

Maximum demand

The average maximum demand recorded from electricity bill analysis was 885 kVA.

3.3.4 Self – generation

The unit has 2 DG sets for captive electricity generation as a back-up for grid electricity. The unit does not have a system for monitoring energy consumption and fuel usage in the DG. The DG performance test was conducted on two 125 kVA DG sets during the audit and specific fuel consumption (SFC) was calculated as 1.60 kWh / litre and 2.06 kWh / litre respectively. Diesel consumption by DG sets is 45000 liters annually costing Rs. 23.4 lakh with a power generation of 85,950 kWh.

Note: Since only monthly consumption was given by operating person verbally, hence the average value is taken for the evaluation which is correspondingly computed annually too.

3.3.5 Month wise electricity consumption

Month wise total electrical energy consumption from different source is shown as under:

Table 10: Electricity consumption & cost

	Electricity Used (kWh)			Electricity Cost, Rs.		
	Grid	DG	Total	Grid	DG	Total
Months	kWh	kWh	kWh	Rs.	Rs.	Rs.
Apr-14	350,708	7,163	357,870	2,241,272	195,000	2,436,272
May-14	350,708	7,163	357,870	2,241,272	195,000	2,436,272
Jun-14	350,708	7,163	357,870	2,241,272	195,000	2,436,272
Jul-14	350,708	7,163	357,870	2,241,272	195,000	2,436,272
Aug-14	350,708	7,163	357,870	2,241,272	195,000	2,436,272
Sep-14	350,708	7,163	357,870	2,241,272	195,000	2,436,272
Oct-14	350,708	7,163	357,870	2,241,272	195,000	2,436,272
Nov-14	350,708	7,163	357,870	2,241,272	195,000	2,436,272
Dec-14	350,708	7,163	357,870	2,241,272	195,000	2,436,272
Jan-15	350,708	7,163	357,870	2,241,272	195,000	2,436,272
Feb-15	363,135	7,163	370,298	2,241,272	195,000	2,436,272
Mar-15	338,280	7,163	345,443	2,241,272	195,000	2,436,272
Total	**4,208,490**	**85,950**	**4,294,440**	**26,895,264**	**2,340,000**	**29,235,264**

The month wise variation which is taken as an average for all the months as the bills were not provided by the unit is shown graphically in the figure below:

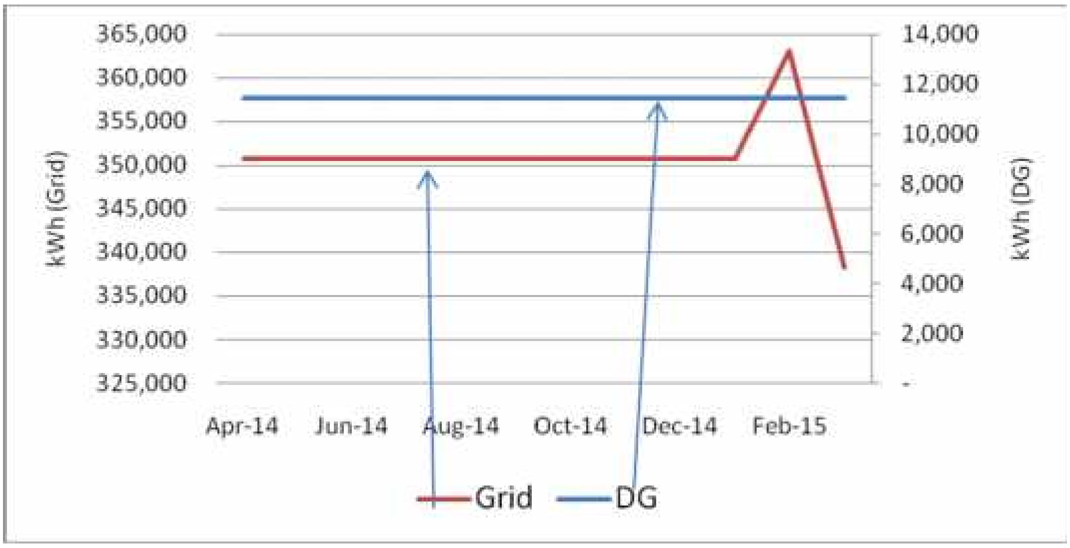

Figure 6: Month wise variation in electricity consumption from different sources

As shown in the figure above, the consumption of electrical energy was on the higher side during the month of Feb 2015. However, it was noticed that electricity consumption during the month of Mar 2015 was less, which indicates that production during that month might have been low. The corresponding month wise variation in electricity cost is shown graphically in the figure below:

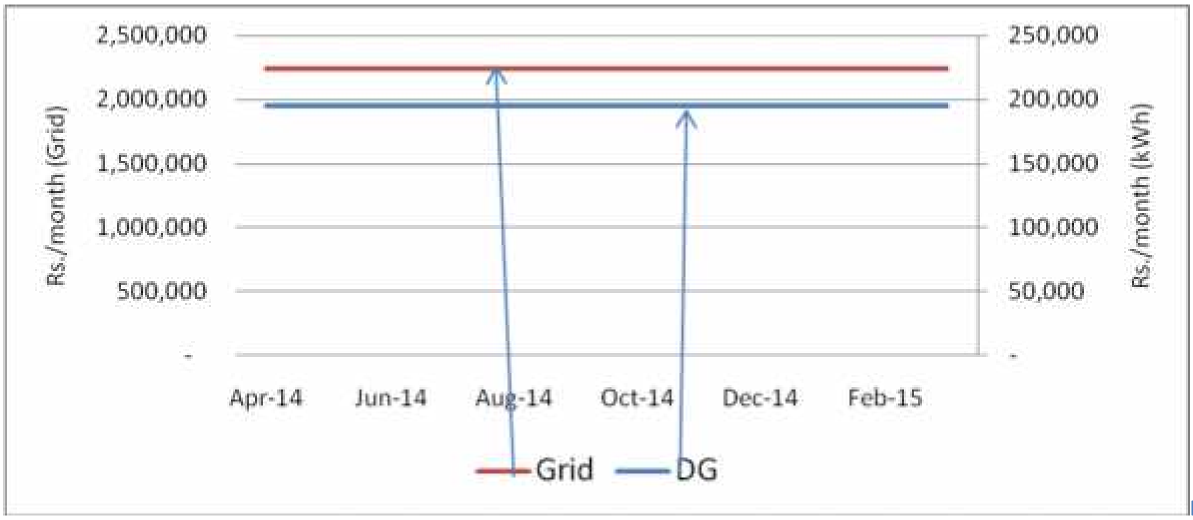

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Figure 7: Month wise variation in electricity cost from different sources

The annual variation of cost of energy from utility as well as DG sets is shown in the figure below:

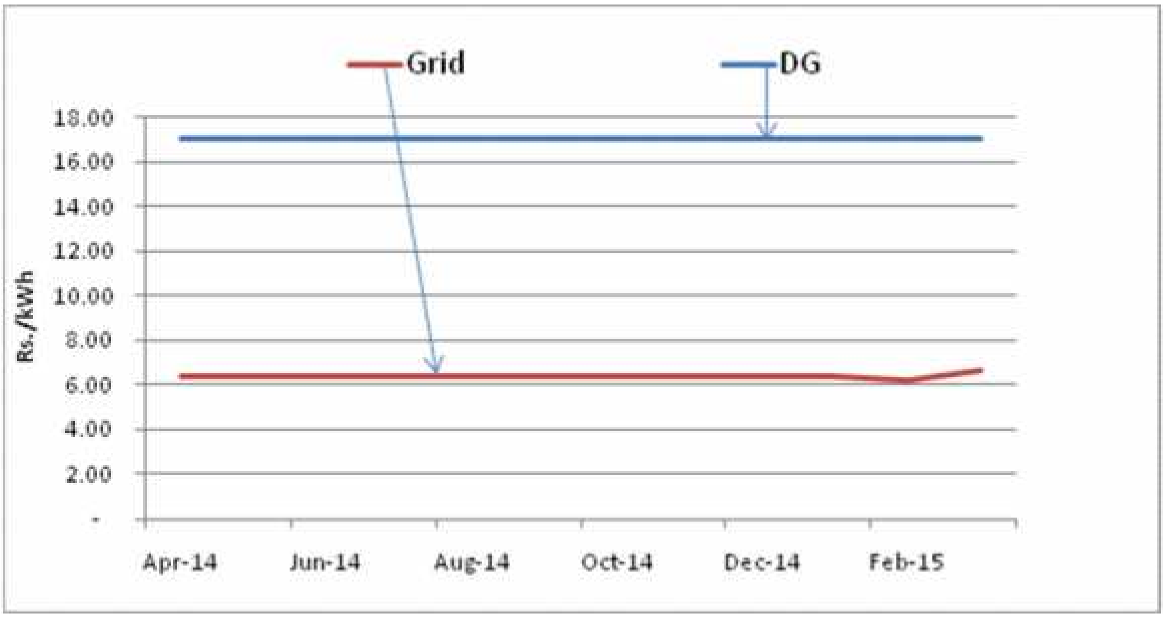

Figure 8: Average cost of power (Rs./kWh) from different sources

From the above graph, it can be seen that the cost of electrical energy from DG sets is very high, nearly 3 times the cost of utility power.

3.4 Analysis of thermal consumption by the unit

The fuel used in forging furnace is FO whose cost is Rs 40 per liter. There was no meter installed for the measurement of fuel consumption in forging furnace. In the electroplating section, wood is used as fuel in boiler for generation of hot water. Load cell for measurement of wood consumption in boiler was not present. The data of fuel consumption and cost is given below:

Table 11: FO and wood used as fuel

Month	FO (litre/month)	Cost Rs.	Wood (kg/month)	Cost Rs.
Apr-14	40,163	1606512	62,500	250,000
May-14	40,163	1606512	62,500	250,000
Jun-14	40,163	1606512	62,500	250,000
Jul-14	40,163	1606512	62,500	250,000
Aug-14	40,163	1606512	62,500	250,000
Sep-14	40,163	1606512	62,500	250,000
Oct-14	40,163	1606512	62,500	250,000
Nov-14	40,163	1606512	62,500	250,000
Dec-14	40,163	1606512	62,500	250,000
Jan-15	40,163	1606512	62,500	250,000
Feb-15	40,163	1606512	62,500	250,000
Mar-15	40,163	1606512	62,500	250,000
Total	**481,954**	**19,278,141**	**750,000**	**3,000,000**

The fuel consumption in furnace and boiler is considered constant, as no data was recorded and it is based on average value given by the unit personnel.

3.5 Specific energy consumption

Production data was available from the unit in metric tons (MT). Based on the available information, various specific energy consumption parameters have been estimated as shown in the following table. ***It is to be noted here that though annual production value was provided, the monthly data for the same was not provided by the unit.***

Table 12: Overall specific energy consumption

Parameters	Value	UoM
Annual Grid Electricity Consumption	4,208,490	kWh
Annual DG Generation Unit	85,950	kWh
Annual Total Electricity Consumption	4,294,440	kWh
Diesel Consumption for Electricity Generation	45000	Litres
Annual Thermal Energy Consumption (FO)	481,954	Litre
Annual Thermal Energy Consumption (Wood)	750,000	kg
Annual Energy Consumption; MTOE	1141.05	MTOE
Annual Energy Cost	515.13	Rs. lakh
Annual Production	5433	MT
SEC; Electricity from Grid	790	kWh/MT
SEC; Thermal	89	Litre/MT
SEC; Overall	0.210	MTOE/MT
SEC; Cost Based	9481	Rs./MT

Basis for estimation of energy consumption in terms of tons of oil equivalent are as follows:

- Conversion Factors
  - Electricity from the Grid : 860 kCal/KWh
  - 1koe : 10,000 kCal
- GCV of Diesel : 11840 kCal/ kg
- Density of HSD : 0.8263 kg/litre
- GCV of FO : 10,500 kCal/kg
- Density of FO : 0.9337 kg/litre
- GCV OF wood : 3,500 kCal/kg
- CO_2 Conversion factor
  - Grid : 0.89 kg/kWh
  - Diesel : 3.07 tons/ton
  - FO : 3.1 tons/litre

3.6 Identified energy conservation measures in the plant

Diagnostic Study

A detailed study was conducted during the CEA in the unit. Observations regarding energy performance of various processes / equipments were recorded and a few ideas of EPIAs were developed. Summary of key observations is as follows:

3.6.1 Electricity Supply from Grid

The electrical parameters at the main incomer from PSPCL of the unit were recorded for 5 hours using a portable power analyzer. Following observation has been made:

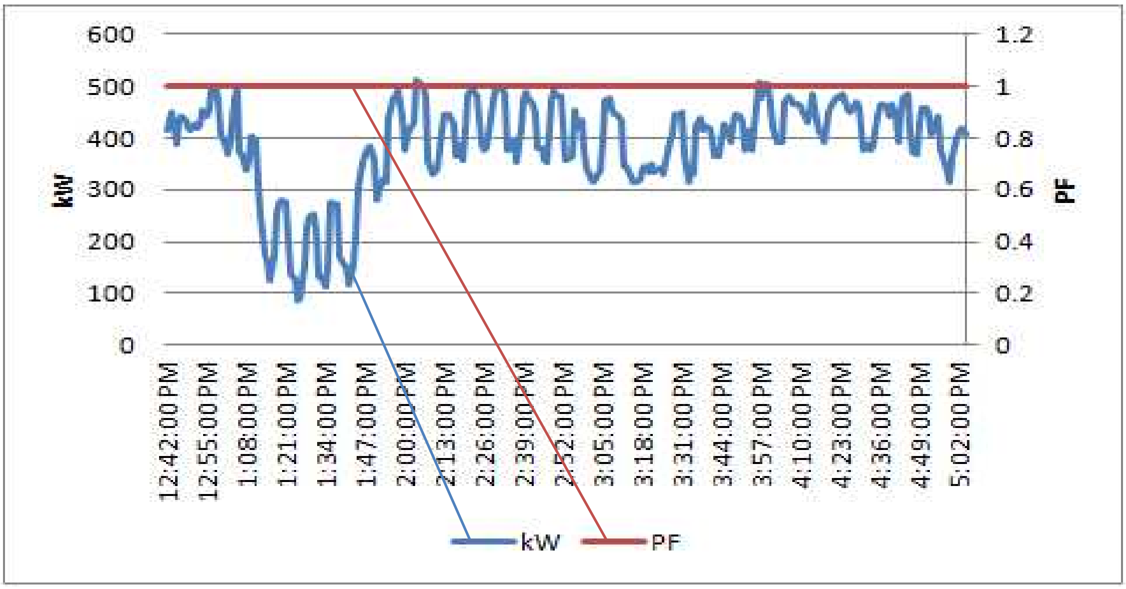

Figure 9: Power factor and load profile

Figure 10: Current and Voltage Profile

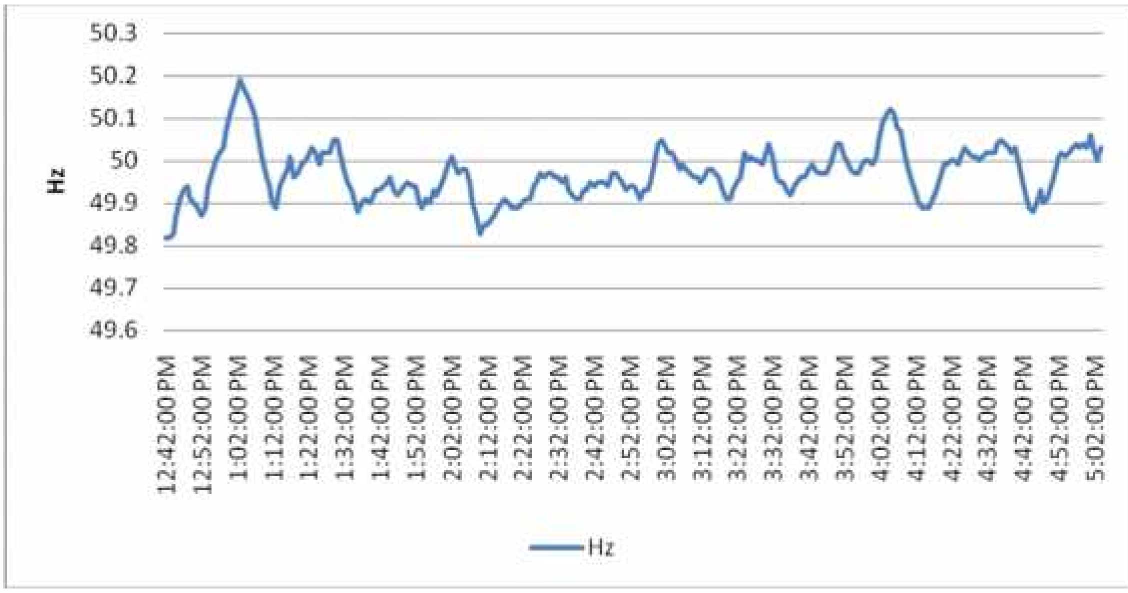

Figure 11: Harmonics profile

Table 13: Diagnosis of electric supply

Name of Area	Present Set-up	Observations during field Study & measurements	Ideas for energy performance improvement actions
Electricity Demand	Power is supplied to this unit from PSPCL through a transformer. The unit has a HT connection. The contract	The maximum kVA identified from the electricity bill was 885.3 kVA which is less than the contract demand.	No EPIAs were suggested.

	demand of the unit is 1,225 kVA and sanctioned load is 1,577.27 kW.		
Power Factor	The unit has a HT connection and billing is in kVAh. The utility bills reflect the PF of the unit. The unit has an APFC panel installed to control the power factor.	The average PF found during the measurement was 0.99.	No EPIA's were suggested.
Voltage variation	The supply to the plant is taken from two transformers.	The voltage profile of the unit was satisfactory.	No EPIA's suggested.

In order to monitor the overall energy performance, the installation of a basic energy monitoring system has been proposed for the unit.

3.6.2 DG Performance

The unit has 2 DG sets for captive generation. The unit does not have a system for monitoring the energy generation and fuel usage in DG. The DG performance was done on two 125 kVA DG sets during the audit and specific fuel consumption (SFC) was calculated as 1.60 kWh / litre and 2.06 kWh / litre for DG-1 and DG-2 respectively. Diesel purchase records are maintained by the unit. As part of the performance testing, measurements were conducted on the DG sets by keeping track of the diesel consumed (by measuring the top up to the diesel tank) and recording of kWh generated during the same period. The key performance indicators of the DG sets were evaluated and Specific Fuel Consumption of the DG are as follows:

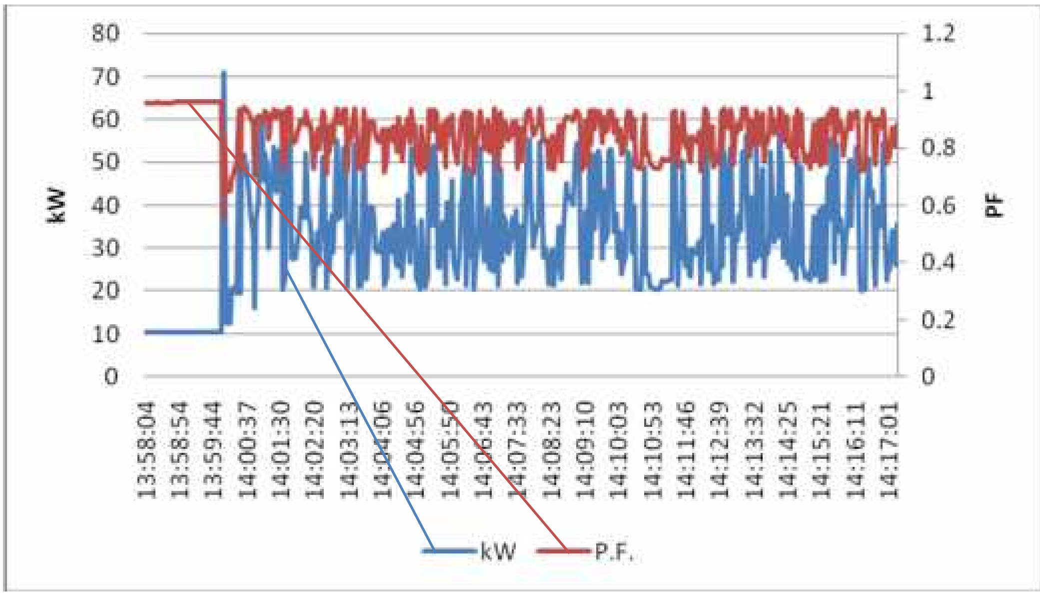

Figure 12: Power factor and load profile of DG set 1-125 kVA

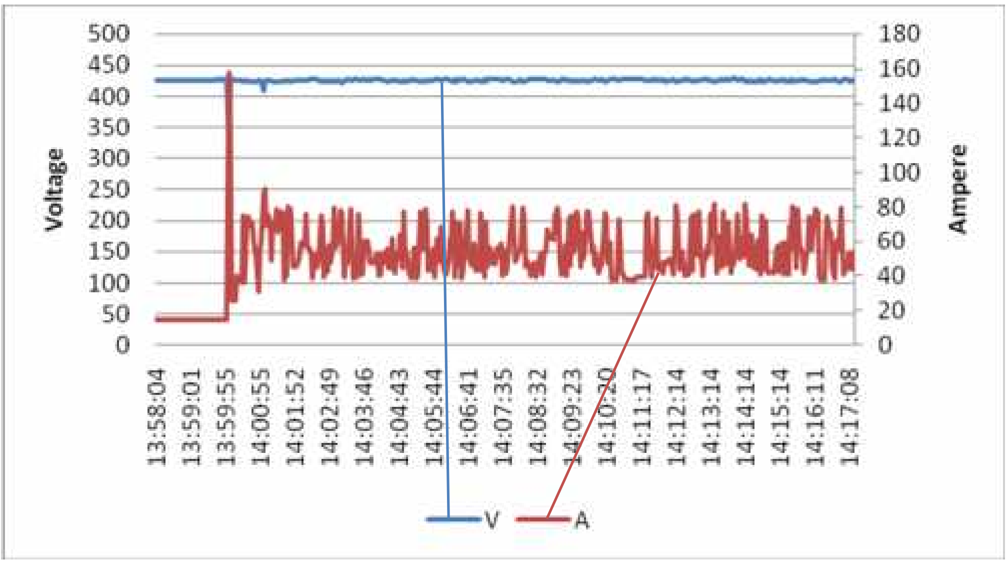

Figure 13: Voltage and current profile of DG Set 1-125 kVA

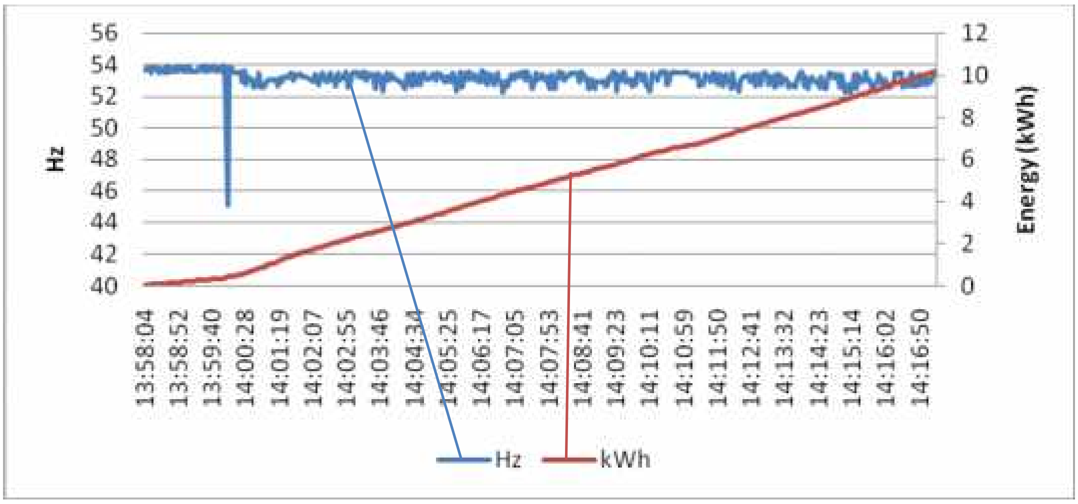

Figure 14: Energy and Harmonics profile of DG set 1- 125 KVA

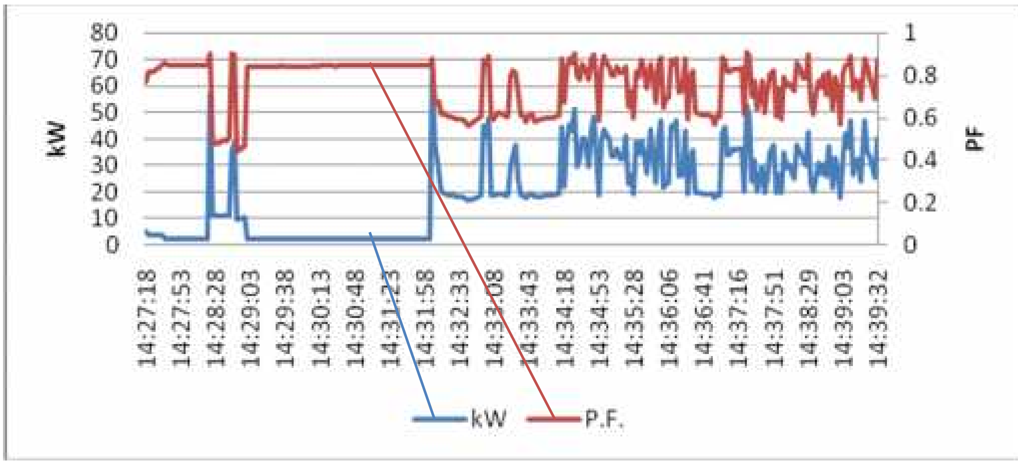

Figure 15: Power factor and load profile of DG Set 2-125 KVA

Figure 16: Voltage and current profile of DG set 2- 125 kVA

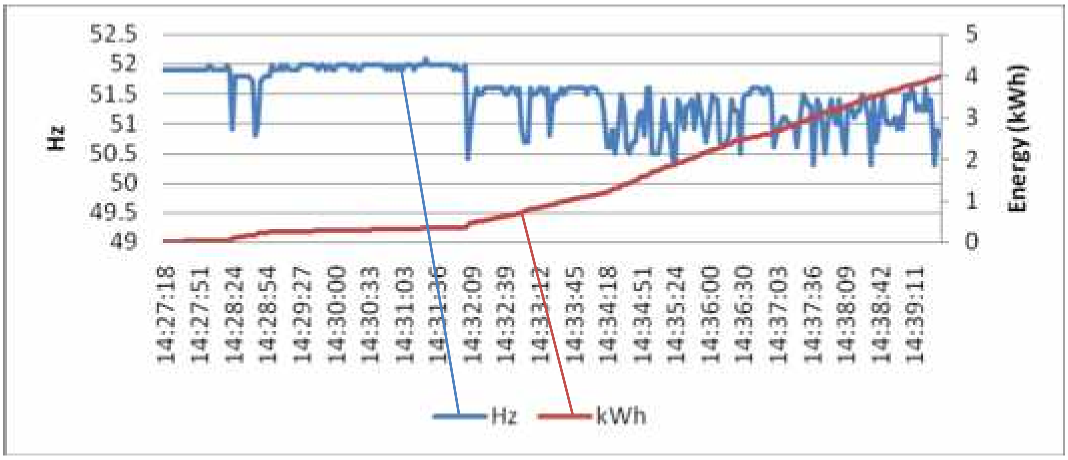

Figure 17: Harmonics and Energy profile of DG set 2-125 KVA

Table 14: Analysis of DG set

Particulars	DG -1	DG-2
Rated KVA	125	125
Specific Energy Generation Ratio (kWh/Litre)	1.60	2.06

The observations made are as under:

Parameters	Unit	DG#1	DG#2
Capacity	kVA	125	125
Average Load	kW	32	19
Average Demand	kVA	37	26
Operating average PF	PF	0.86	0.76
Diesel Consumption	Litres/Hr	4	4
Loading Percentage	%	30	21
SEG	kWh/L	2	2
Specific unit cost	Rs./kWh	31.3	24.3

3.6.3 Electrical consumption areas

The details of the observations, measurements conducted and ideas generated for energy conservation measures are as follows:

<table>
<tr><th>Name of Area</th><th>Present Set-up</th><th>Observations during field Study & measurements</th><th>Proposed Energy performance improvement actions</th></tr>
<tr><td>Forging hammers</td><td>There are 5 hammer motors for forging with rating of 60 HP each.</td><td>Study was conducted on a hammer motor 4

The results of the study are as below:<table><tr><th>Machine</th><th>Avg. Current (A)</th><th>Avg. Power (kW)</th></tr><tr><td>Hammer #4</td><td>41.54</td><td>7.591</td></tr></table></td><td>No EPIAs were suggested for forging hammers.</td></tr>
<tr><td>Broaching</td><td>Rated power of broaching machines used in the plant varies from 20 HP to 30 HP and study was conducted on machine # 11.</td><td>It was found that during the unloading time power is consumed by motor which contributes to the total energy consumed.

The results of the study are as below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Broaching #11</td><td>3.21</td><td>0.51</td></tr></table></td><td>VFD is suggested in broaching machine to reduce the power during unloading.</td></tr>
<tr><td>Compressor</td><td>3 air compressors were installed in the plant, which were the major source of energy consumption.</td><td>FAD test was conducted on all the 3 compressors. 2 compressors were of reciprocating type and one compressor was of screw type.

The results of the study are as below:<table><tr><th>Machine</th><th>Avg. kW</th><th>SPC (kW/CFM)</th></tr><tr><td>Compressor 1 ELGI 22 kW</td><td>17.02</td><td>0.08</td></tr><tr><td>Compressor 2 Ingersoll 11.19 kW</td><td>10.16</td><td>0.21</td></tr></table></td><td>Leakage arresting on compressor number 1.

Replacing compressor number 2 with screw compressor.</td></tr>
</table>

<table>
<tr><th>Name of Area</th><th>Present Set-up</th><th>Observations during field Study & measurements</th><th>Proposed Energy performance improvement actions</th></tr>
<tr><td></td><td></td><td><table><tr><td>Compressor 3 Ingersoll 7.5 kW</td><td>6.87</td><td>0.16</td></tr></table></td><td></td></tr>
<tr><td>Heat treatment section</td><td>In heat treatment section, the study was conducted on both hardening and tempering sections which consist of hardening heaters, tempering heaters, conveyor and blower motors.</td><td>All heaters, blowers and conveyors were studied.

The results of the study are as below:<table><tr><th>Machine</th><th>Avg. kW</th><th>Avg. PF</th></tr><tr><td>Hardening heater</td><td>8.77</td><td>0.99</td></tr><tr><td>Tempering heater 1</td><td>29.11</td><td>0.99</td></tr><tr><td>Tempering heater 2</td><td>24.58</td><td>1.00</td></tr><tr><td>Tempering heater 3</td><td>20.57</td><td>0.99</td></tr></table></td><td>No EPIAs were suggested.</td></tr>
</table>

3.6.4 Thermal consumption areas

As discussed in the earlier section, about 18 % of energy cost and 30% of the energy was being used in the forging furnace. The details of present set-up, key observations made and potential areas for energy cost reduction have been mentioned in the table below:

Name of Area	Present Set-up	Observations during field Study & measurements	Proposed Energy performance improvement actions
Furnace	The fuel used for heating in furnace is FO.	There was no metering system available for measuring fuel consumption.	Installation of flow meters are recommended.
	The required air for burning of fuel is supplied by electrical driven blower fan.	The O_2 level in flue gas at the outlet of furnace 2, 4 and 5 was above 10 %.	Installation of PID for excess air control.
	The insulation provided in furnace was poor.	The temperature of furnace surface walls was high which clearly indicates that insulation is poor.	Reduction of skin losses by using high refractory materials.

4 EE TECHNOLOGY OPTIONS AND TECHNO – ECONOMIC FEASIBILTY

During CEA of the plant, all energy consuming equipments and processes were studied. The analysis of all major energy consuming equipment and appliances were carried out which haves already been discussed in earlier section of this report.

Based on the analysis, Energy Performance Improvement Actions (EPIA) has been identified as below:

4.1 EPIA 1, 2 & 3: Excess air control using PID

Technology description

It is necessary to maintain optimum excess air levels in combustion air supplied for proper combustion of the fuel. The excess air levels are calculated based on oxygen content in the flue gases. The theoretical air required for combustion of any fuel can be known from the ultimate analysis of the fuel. All combustion processes require a certain amount of excess air in addition to the theoretical air supplied. Excess air supplied needs to be maintained at optimum levels, as too much of excess air results in excessive heat loss through the flue gases. On the other hand, too little excess air results in incomplete combustion of fuel and formation of black coloured smoke in flue gases.

Generally, in most of the furnaces, fuel is fired with too much of excess air. This results in formation of excess flue gases, taking away the heat produced from the combustion and increasing the fuel consumption. This also results in formation of excess GHG emissions. The excess air effects on the formation of ferrous oxide resulting in increase in the burning losses.

A PID controller, if installed, will measure the oxygen levels in the flue gases at the exit of the furnace, and based on that the combustion air flow from FD fan (blower) can be regulated.Subsequently, proper temperature and optimum excess air can be attained in the furnace.

Study and investigation

At the time of CEA, it was found that there was no proper automation and control system installed to maintain the optimum excess air levels. Fuel was fired from the existing burner and no air flow control mechanism was in place for maintaining proper combustion of the fuel. It was found that the oxygen level in furnace 1, furnace 2 and furnace 3 were 12.48 %, 11.60 % and 10.00 % respectively, which indicate very high excess air levels. This results in high heat loss due to dry flue gas from the furnace.

Recommended action

It is recommended to install PID control system to regulate the supply of excess air for maintaining optimum excess air levels and ensuring complete combustion. As a thumb rule, reduction in every

10% of excess air will save 1% in specific fuel consumption. The cost benefit analysis of the energy conservation measure is given below:

Table 15: Cost benefit analysis (EPIA 1) – Forging furnace 8

Parameters	UOM	Present	Proposed
Production of material	Tph	0.22	0.22
Oxygen level in flue gas	%	12.48	4.00
Excess air control	%	146.48	23.53
Dry flue gas loss	%	53.58	
Specific fuel consumption	kg/t	57.89	50.77
Savings in specific fuel consumption	kg/h		1.58
Operating hours of forging furnace	hr/y	6,600	6,600
Saving in fuel consumption per year	kg/y		10429.04
Savings in fuel cost	Rs. lakh/y		4.47
Installed capacity of blower	kW	3.73	3.73
Running load of blower	kW	2.98	2.69
Operating hours	hr/y	6,600	6,600
Electrical energy consumed	kWh/y	19,694	17,725
Savings in terms of power consumption	kWh/y		1,969
Savings in terms of cost of electrical energy	Rs. lakh / y		0.13
Reduction in the burning loss inside the furnace	%		0.50
Total material savings	tpy		7.33
Cost of saved material	Rs. lakh / y		3.66
Monetary savings	Rs. lakh/y		8.26
Estimated investment	Rs. lakh		7.00
Simple payback	Years		0.85

Table 16: Cost benefit analysis (EPIA 2) - Forging furnace-4

Parameters	UOM	Present	Proposed
Production of material	Tph	0.15	0.15
Oxygen level in flue gas	%	11.60	4.00
Excess air control	%	123.40	23.53
Dry flue gas loss	%	45.71	
Specific fuel consumption	kg/t	101.13	91.91
Saving in specific fuel consumption	kg/h		1.50
Operating hrs of forging furnace	hr/y	6,600	6,600
Saving in fuel consumption per year	kg/y		9883.73
Savings in fuel cost	Rs. lakh/y		4.23
Installed capacity of blower	kW	3.73	3.73
Running load of blower	kW	2.98	2.69
Operating hours	hr/y	6,600	6,600
Electrical energy consumed	kWh/y	19694	17724.96

Savings in terms of power consumption	kWh/y	1969.44
Savings in terms of cost of electrical energy	Rs. lakh/y	0.99
Reduction in the burning loss inside the furnace	%	0.80
Total material saving	TPY	7.81
Cost of saved material	Rs. lakh / y	3.91
Monetary savings	Rs. lakh / y	9.13
Estimated investment	Rs. lakh	7.00
Simple payback	Years	0.77

Table 17: Cost benefit analysis (EPIA 3) – Forging furnace 5

Parameters	UOM	Present	Proposed
Production of material	tph	0.09	0.09
Oxygen level in flue gas	%	10.00	4.00
Excess air control	%	90.91	23.53
Dry flue gas loss	%	53.60	
Specific fuel consumption	kg/t	109.53	102.15
Saving in specific fuel consumption	kg/h		0.65
Operating hrs of forging furnace	hr/y	6,600	6,600
Saving in fuel consumption per year	kg/y		4286.55
Savings in fuel cost	Rs. lakh/y		1.84
Installed capacity of blower	kW	3.73	3.73
Running load of blower	kW	2.98	2.69
Operating hours	hrs/y	6,600	6,600
Electrical energy consumed	kWh/y	19,694.40	17,724.96
Savings in terms of power consumption	kWh/y		1,969.44
Savings in terms of cost of electrical energy	Rs. lakh/y		0.13
Reduction in the burning loss inside the furnace	%		0.80
Total material savings	tpy		4.65
Cost of saved material	Rs. lakh/y		2.32
Monetary savings	Rs. lakh/y		4.29
Estimated investment	Rs. lakh		7.00
Simple payback	Years		1.63

4.2 EPIA 4: Reduction in radiation and convection losses from surfaces of forging furnace 4 and 5

Technology description

A significant portion of the losses in a furnace occurs as radiation loss from the furnace walls and the roof. These losses are substantially higher in areas of openings or in case of infiltration of cold air in some of the furnaces. Ideally, optimum amount of refractory and insulation should be provided in the furnace walls and the roof to maintain the surface temperature of the furnace at around 50-60 °C to avoid heat loss due to radiation and convection. Refractories are heat-resistant materials that constitute the linings for high-temperature furnaces and other processing units. In addition to being resistant to thermal stress and other physical phenomena induced by heat, refractories must also withstand physical wear and corrosion by chemical agents.

Thermal insulations are used to get reduction of heat transfer between objects in thermal contact or in range of radiative influence.

The furnace walls are designed in combination of refractories and insulation layers, with the objective of retaining maximum heat inside the furnace and avoiding losses from the furnace walls.

Study and investigation

The average temperature of furnace surface has to be about 10°C above ambient temperature, I.e. about 45-50°C. During audit, the furnace surface temperature was 70.48°C in furnace 4 & 76.04°C in furnace 5, which implicates that both the furnaces need to be properly insulated to keep the surface temperature within the specified range.

Recommended action

Recommended furnace surface temperature has to be brought to within 45-50°C to reduce the heat loss through radiation and convection and utilize the useful heat.

In the below table, the amount of heat lost through radiation and convection in firing zone of furnace 4 and furnace 5 is given.

Table 18: R & C losses

Parameters	UOM	Forging-4	Forging-5
Natural convection heat transfer rate from sidewall surfaces	kCal/m^2 deg C	1.5	1.5
External temp. of hearth	deg C	70	76
Hearth surface area	m2	3.85	2.50
Room temperature	deg C	33	33
Recommended temperature	deg C	50	50
Loss at current situation	kCal/hr	1,018	783
Loss after insulation	kCal/hr	396	257
Temperature at current condition	deg C	70	76
Operating hours	hr/y	6,600	6,600

Table 19: Cost benefit analysis (EPIA 4)

Parameters	UOM	Forging-4		Forging-5	
		Present	Proposed	Present	Proposed
Temperature of hearth	deg C	70.48	50.00	76.04	50.00

Total hearth area	m^2	3.86	3.86	2.50	2.50
Heat loss from surface	kCal/hr	1,018.44	396.38	783.04	257.22
Reduction in heat loss	kCal/hr		622.06		525.82
Savings in fuel	kg/hr		0.06		0.05
Operating hours of furnace	hr/y	6,600	6,600	6,600	6,600
Savings in fuel per year	kg/y		376.66		318.39
Monetary savings	Rs. lakh		0.16		0.14
Estimated investment	Rs. lakh		0.06		0.04
Simple payback period	Years		0.36		0.28

4.3 EPIA 5: Installation of VFD on broaching machine

Technology description

For fluctuating loads it is always recommended to install a variable frequency drive (VFD) to control the speed of the motor. A VFD will reduce the power consumption accordingly to the load variation in the broaching machine. During loading periods, the current drawn by the broaching machine will be very high, as an external force is also applied for the process to take place. During no load / unloading periods, the motor of broaching machine will draw some current which is 1/3 or 1/4th of the total current. Hence, this drawn current can be reduced by installing VFD. The installation of a VFD will help in regulating the speed of the broaching machine's motor, thereby resulting in lower current drawn and reduction in power consumption.

Study and investigation

During measurements, it was found that the existing broaching machine No – 11 draws high current even during unloading periods.

Recommended action

It is recommended to install VFD with the broaching machine No. 11. This will ensure that the machine draws minimal current during unloading. The cost benefit analysis of the energy conservation measure is given below:

Table 20: Cost benefit analysis (EPIA 5)

Sl. No.	VFD on broaching machine		Broaching M/c-11	
	Parameters	**Unit**	**As Is**	**To Be**
1	Installed capacity of motor	kW	14.92	14.92
2	Estimated energy saving by installing VFD on compressor	%		20.0
3	Average power consumption	kW	3.3	3
4	Percentage load	%	22.2	17.8
4	No of operating hours per day	hr	24.00	24

5	Operating days per Year	days	300.00	300
6	Average electricity consumption per year	kWh	26259	21007
7	Savings in terms of power consumption	kWh/y		5252
8	Average weighted cost	Rs./kWh	6.67	6.67
9	Monetary savings	Rs. lakh		0.35
10	Estimated investment	Rs. lakh		0.8
11	Simple Payback	Years		2.3

4.4 EPIA 6: Replacing old conventional ceiling fans with EE fans

Technology description

Replacing old fans of conventional types installed in various sections of the plant with energy efficient fans will reduce power consumption by half. The energy efficient fans have a noiseless operation and are controlled by electronic drives which on speed reduction automatically sense the rpm and reduce power consumption.

Study and investigation

The unit is having about 135 fans which are very old and are recommended to be replaced with energy efficient fans.

Recommended action

It is recommended to replace the existing fans with energy efficient fans. The cost benefit analysis of the same is given in the table below:

Table 21: Cost benefit analysis (EPIA 6)

Data & Assumptions	UOM	Ordinary fan	Super fan
Number of fans in the facility	Nos.	135	135
Run hours per day	hr / day	18	18
Power consumption at maximum speed	Watts	75	35
Number of working days/year	Days	330	330
Average Weighted cost	Rs. / kWh	6.67	6.67
Fan unit price	Rs. / pc	1,500	3,000
Electricity consumption:			
Electricity demand	kW	10.80	4.73
Power consumption by fans in a year	kWh/y	64,152	28,067
Savings in terms of power consumption	kWh/y		36,086
Monetary savings	Rs. Lakh/y		2.41
Estimated investment	Rs. Lakh/y		4.05
Payback period	Years		1.68

4.5 EPIA 7 & 8: Replacing present conventional lights with Energy Efficient light fixtures

Technology description

Replacing conventional lights like T-12s, CFLs etc with LED lights helps reduce power consumption and also results in higher illumination (lux) levels for the same power consumption.

Study and investigation

The unit is having about 50 nos. T12 tube lights, 87 nos. 45W CFL, 20 nos. 23W CFL and 9 nos. 250W halogens lamp.

Recommended action

All light fixtures have to be replaced with energy saving LED lamps which can reduce energy consumption immensely, and for T12 tube lights, retrofit LED lights can be obtained.

The savings assessment has been given in the table below:

Table 22: Cost benefit analysis (EPIA 7)

Particulars	Unit	Existing	Proposed
Fixture	**UOM**	**T-12**	**16 Watt LED tube light**
Power consumed of T-12	W	40	16
Power consumed	W	12	0
Total power consumption	W	52	16
Operating hours/day	Hr	18	18
Annual days of operation	day	330	330
Energy Used per year/fixture	kWh	309	95
Average weighted cost	Rs./kWh	6.67	6.67
No. of Fixtures	Nos.	50	50
Power consumption per year	kWh/y	15,444	4,752
Operating cost per year	Rs. lakh / y	1.03	0.32
Saving in terms of power consumption	kWh/y		10,692
Monetary savings	Rs. lakh/y		0.71
Investment per fixture of LED	Rs.		1,675
Investment of project	Rs. lakh		0.83
Payback period	Years		1.17

Table 23: Cost benefit analysis (EPIA 8)

Particulars	Unit	Existing	Proposed	Existing	Proposed	Existing	Proposed
		45 W CFL	**18 Watt LED Square Round Panel**	**23 W CFL**	**10 Watt LED Star Bulb**	**250 W MV lamp**	**80 Watt LED Bay light**
Power consumed	W	65	25	50	18	250	80
Operating hours/day	hr	18	18	18	18	18	18
Annual days of operation	day	330	330	330	330	330	330
Energy Used per year/fixture	kWh	463	149	362	107	1,148	317
Average weighted cost	Rs/kWh	6.67	6.67	6.67	6.67	6.94	6.94
No. of Fixtures	Nos.	87	87	20	20	9	9
Power consumption per year	kWh/y	40309	12920	7247	2138	10336	2851
Operating cost per year	Rs. lakh/y	2.69	0.86	0.48	0.14	0.72	0.20
Saving in terms of power consumption	kWh/y	27389		5108		7484	
Monetary savings	Rs. lakh/y	1.83		0.34		0.52	
Investment per fixture of LED	Rs.	0.04		0.0235		0.123	
Investment of project	Rs. lakh	3.48		0.47		1.107	
Payback period	Years	1.90		1.38		2.13	

4.6 EPIA 9: Leakage arrest in compressor 1

Technology description

Leakage test was conducted on compressor by filling the receiver tank and closing all the valves at user end so that air from tank will reach the point of usage but will not be utilized. During this time, the loading and unloading time of compressor is noted. The entire amount of air that is used during this period will be due to leakage.

Study and investigation

Leakage test was conducted on the air compressor and total leakage was established at about 24%.

Recommended action

It is recommended to check all the pipes and valves and arresting all leakages, if any. This activity needs to be conducted periodically as a planned maintenance schedule. The cost benefit analysis for installation of energy monitoring system in the unit is given below in the table:

Table 24: Cost benefit analysis (EPIA 9)

Parameters	Unit	AS IS	TO BE
Cut in Pressure	kg/cm2	6.5	6.5
Cut out Pressure	kg/cm2	6.9	6.9
Free Air Discharge	Nm^3/Min	5.70	5.70
Average Load time (T)	Min	2.32	-
Average Unload time (t)	Min	7.016	-
Leakage Quantity	Nm^3/min	1.41	0.57
Average Operating Power	kW	16	16
Specific Energy Consumption	kW/Nm^3	0.05	0.05
Operating Requirements	hr/day	20	20
Operating Requirements	day/y	300	300
Annual Energy Consumption	kWh/y	23,121	9,315
Savings in terms of power consumption	kWh/y	-	13,806
Weighted Average Cost	Rs./kWh		7
Monetary Savings	Rs. lakh/ y		0.92
Estimated Investment	Rs. lakh		0.10
Payback Period	Years		0.11

4.7 EPIA 10: Replacement of reciprocating compressor No. 2 with screw compressor

Technology description

Free air delivery test was conducted on compressor No. 2 by emptying the compressor receiver (of a known volume) and closing its outlet valve. The compressor was started and the receiver tank was filled from its initial pressure to final pressure and time taken to fill the tank was recorded. Power consumed by the compressor during this time was also recorded. Based on this test, the specific power consumption of compressor was estimated. For an efficient compressor, the SPC should be in the range of 0.17 – 0.18 kW/CFM.

Study and investigation

The FAD test established that the SPC of this compressor was 0.21 kW / CFM and it was on the higher side.

Recommended action

It is recommended to replace the old reciprocating compressor with a new energy efficient screw compressor in order to reduce the SPC.

The cost benefit analysis of the energy conservation measure is given below:

Table 25: Cost benefit analysis (EPIA 10)

Parameters	Unit	AS IS	TO BE
Design Pressure	kg/cm2	12.3	12.30
Average Receiver Pressure	kg/cm2	12.3	12.3
Operating Pressure (Compressor Panel Reading)	kg/cm2	12.3	12.3
Specific Power Consumption	kW/CFM	0.21	0.17
Average Air Required	CFM	47.3	47.3
Average Power Consumption	kW	10	8.04
Size of Compressor	CFM	50	50
Loading on Compressor	%	95	95
Running hours per day	hr/day	24	24
Annual operating days	days/y	300	300
Annual Energy Consumption	kWh/y	73,174	57,871
Savings in terms of power consumption	kWh/y	-	15302.6
Average weighted Cost	Rs./kWh		6.67
Monetary Savings	Rs. lakh/y		1.0
Investment	Rs. lakh		3
Years	Years		2.9

4.8 EPIA 11: Replacement of present inefficient DG set with new EE DG set

Technology description

The replacement of DG with new DG helps in increasing the specific energy generation ratio, i.e. units of electricity generated from 1 litre of diesel. Normally, the standard specific fuel consumption (SFC) given for new DG is 3.5 kWh/litre.

Study and investigation

The SFC of 125 kVA DG was established to be 1.60 kWh / litre which is very low as per standards.

Recommended action

It is recommended to replace the 125 kVA DG with new DG having SEGR of 3.5 kWh / litre. The cost benefit analysis of the DG replacement is given in the table below:

Table 26: Cost benefit analysis (EPIA 11)

Parameters	UOM	AS IS	TO BE
Rated kVA	kVA	125	125
Operating Hours	hr	1500	1500
No of Units generated	kWh/y	9498.01	9498.01
Annual Diesel Consumption	Litres	5946.09	2713.72
Specific Energy Consumption	kWh/litre	1.60	3.5
Annual Diesel saving	Liters/y		3232
Diesel Cost	Rs./litre		50
Investment	Rs. lakh		7.61
Monetary Savings	Rs. lakh		1.62
Simple Payback	Years		4.71

4.9 EPIA 12: Replacement of present inefficient burners with new EE burners

Technology description

The EE burners are decided on the basis of furnace temperature, dimensions and the production. They have a film technology, where each droplet of oil is surrounded by the air increasing the surface area exposed to air resulting in efficient burning. Hence, the fuel consumption is reduced.

Study and investigation

The present fuel firing for the given production was high. It was monitored during the CEA that production of most of the furnaces was much lower than their standard capacity.

Table 27: Furnace specifications for the EE burners

Parameters	UoM	Forging furnace-2	Forging furnace-3	Forging furnace-4	Forging furnace-5	Forging furnace-8
Fuel Firing rate	Liters/hr	69.116	77.522	100.872	52.304	207.348
Production	kg/hr	106.00	122.00	148.00	88.00	222.00
Area of the furnace	m2	2.3484	2.2134	3.857	2.5029	3.6309

Recommended action

It is recommended to replace inefficient burners with new EE burners. The cost benefit analysis of burner replacement is given in the table below:

Table 28: Cost benefit analysis (EPIA 12)

Replacing present burners with energy efficient burners		Forging furnace-2		Forging furnace-3		Forging furnace-4		Forging furnace-5		Forging furnace-8	
Parameters	Unit	As Is	To Be	As Is	To Be	As Is	To Be	As Is	To Be	As Is	To Be
Production rate of the forging furnace	kg/hr	106	106	122	122	148	148	88	88	222	222
Total numbers of burners	Nos.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total numbers of energy efficient burner required	Nos.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Estimated saving by energy efficient burner	%		5.0		5.0		5.0		5.0		5.0
Current fuel firing in forging furnace	kg/hr	8	8	9	9	13	12	8	8	11	11
Savings in fuel per hours	kg/hr		0.42		0.47		0.65		0.42		0.56
Number of operating days	days	330	330	330	330	330	330	330	330	330	330
Number of operating hours per day	hrs	20	20	20	20	20	20	20	20	20	20
Total savings per year into fuel firing	kg/yr		2773		3081		4314		2773		3697
Unit cost of fuel	Rs./kg		42.84		42.84		42.84		42.84		42.84
Monetary savings	Lakh Rs./yr		1.19		1.32		1.85		1.19		1.58
Estimated investment for all burners	Lakh Rs.		0.2		0.2		0.2		0.2		0.2
Payback period	Yr		0.2		0.2		0.1		0.2		0.2

5 ANNEXURE

Furnace 2 efficiency calculations

Input parameters

Input Data Sheet		
Type of Fuel		**Furnace Oil**
Source of fuel	**Local vendor**	
	Value	**Units**
Furnace Operating temperature (Heating Zone)	1100	*Deg C*
Final temperature of material (at outlet of Heating zone)	1048	*Deg C*
Initial temperature of material	35	*Deg C*
Average fuel Consumption	9.6	*kg/hr*
Flue Gas Details		
Flue gas temperature	562	*deg C*
Preheated air temperature	110	*deg C*
O_2 in flue gas	6.2	*%*
CO_2 in flue gas	12.36	*%*
CO in flue gas	19.4	*Ppm*
Atmospheric Air		
Ambient Temperature	35	*Deg C*
Relative Humidity	45.6	*%*
Humidity in ambient air	0.03	*kg/kg dry air*
Fuel Analysis		
C	*84.00*	**%**
H	*12.00*	**%**
N	*0.00*	**%**
O	*1.00*	**%**
S	*3.00*	**%**
Moisture	*0.00*	**%**
Ash	*0.00*	**%**
Weighted Average GCV of Fuel	*10,500*	kcal/kg
Ash Analysis		
Unburnt in bottom ash	*0.00*	%
Unburnt in fly ash	*0.00*	%
GCV of bottom ash	*0*	kCal/kg
GCV of fly ash	*0*	kCal/kg
Material and flue gas data		
Weight of material (Raw material) being heated in furnace	106	*Kg/Hr*
Weight of Stock	106	*kg/hr*
Specific heat of material	0.12	*Kcal/kgdegC*

Avg. specific heat of fuel	0.417	*Kcal/kgdegC*
fuel temperature	70	*deg C*
Specific heat of flue gas	0.26	*Kcal/kgdegC*
Specific heat of superheated vapour	0.45	*Kcal/kgdegC*
Heat loss from surfaces of various zone		
For Ceiling		
Natural convection heat transfer rate from ceiling	2.8	*Kcal/m2degC*
External temp. of ceiling	346	*deg K*
Room Temperature	308	*deg K*
Ceiling surface area	3.55	*m2*
Emissivity of furnace body surface	0.75	
For side walls		
Natural convection heat transfer rate from sidewall surfaces	2.2	*Kcal/m2degC*
External temp erature of side walls	318	*deg K*
Sidewall surface area	7.8828	*m2*
For Hearth		
Natural convection heat transfer rate from flue gas duct surfaces	1.5	*Kcal/m2degC*
External temperature. of side walls	315.81	*deg K*
External surface area	2.3484	*m2*
Outside dia of flue gas duct	*0.15*	*M*
For radiation loss in furnace(through charging and discharging door)		
Time duration for which the material enters through preheating zone and exits through Furnace	1	*Hr*
Area of opening in m2	0.3111	*m2*
Coefficient based on profile of furnace opening	0.7	
Maximum temperature of air at furnace door	428	*deg K*

Efficiency calculations

Calculations	Values	Unit
Theoretical Air Required	14.01	kg/kg of fuel
Excess Air supplied	41.89	%
Actual Mass of Supplied Air	19.87	kg/kg of fuel
Mass of dry flue gas	19.79	kg/kg of fuel
Amount of Wet flue gas	20.87	Kg of flue gas/kg of fuel
Amount of water vapour in flue gas	1.08	Kg of H2O/kg of fuel
Amount of dry flue gas	19.79	kg/kg of fuel
Specific Fuel consumption	90.93	kg of fuel/ton of material
Heat Input Calculations		
Combustion heat of fuel	954,814	Kcal/ton of material
Sensible heat of fuel	1,321	Kcal/ton of material
Total heat input	956,134	Kcal/ton of material

Heat Output Calculation		
Heat carried away by 1 ton of material (useful heat)	127,780	Kcal/ton of material
Heat loss in dry flue gas per ton of material	246,609	Kcal/ton of material
Loss due to H2 in fuel	80,642	Kcal/ton of material
Loss due to moisture in combustion air	141	Kcal/ton of material
Loss due to partial conversion of C to CO	68	Kcal/ton of material
Loss due to convection and radiation (openings in furnace - inlet & outlet door of furnace)	1,977	Kcal/ton of material
Loss Due to Evaporation of Moisture Present in Fuel	-	Kcal/ton of material
Total heat loss from furnace body	21,102	Kcal/ton of material
Heat loss due to unburnts in Fly ash	-	Kcal/ton of material
Heat loss due to unburnts in bottom ash	-	Kcal/ton of material
Unaccounted heat lossess	477,816	Kcal/ton of material
Heat loss from furnace body and ceilings		
Heat loss from furnace body ceiling surface	1615	Kcal/hr
Heat loss from furnace body side walls surfaces	522	Kcal/hr
Heat loss from hearth	100	Kcal/hr
Total heat loss from furnace body	21102	Kcal/tons
Furnace Efficiency	**13.38**	%

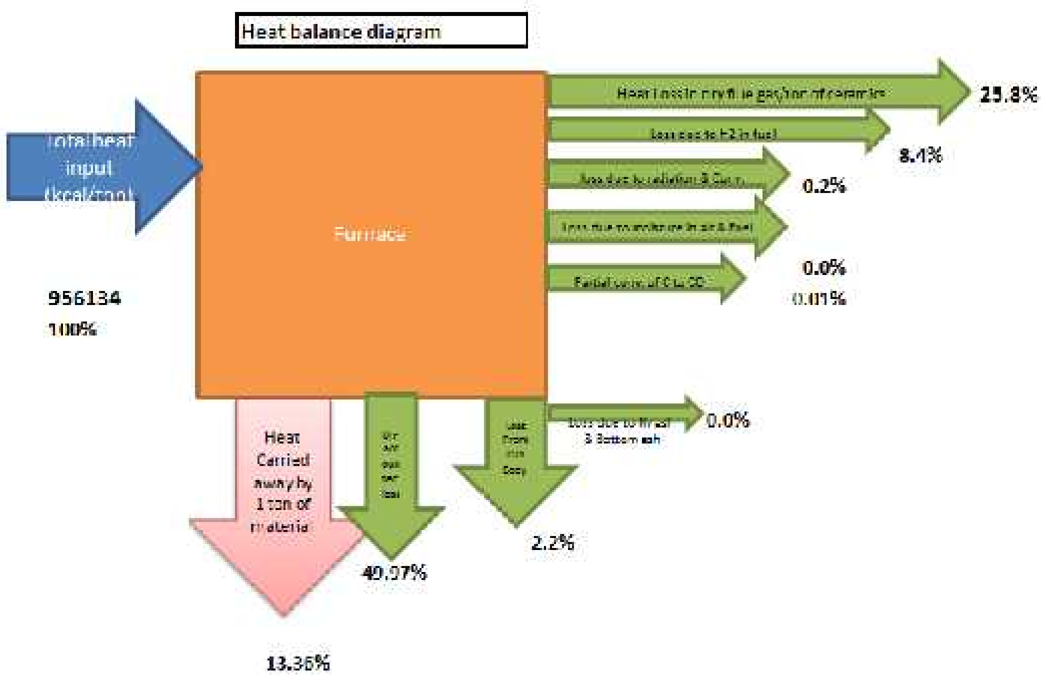

Figure 18: Sankey diagram furnace 2

Furnace 3 efficiency calculations

Input Data Sheet		
Type of Fuel		Furnace Oil
Source of fuel	Local vendor	
	Value	Units
Furnace Operating temperature (Heating Zone)	1150	*Deg C*
Final temperature of material (at outlet of Heating zone)	1150	*Deg C*
Initial temperature of material	37	*Deg C*
Average fuel Consumption	10.7	*Kg/hr*
Flue Gas Details		
Flue gas temp erature	672	*deg C*
Preheated air temp erature	110	*deg C*
O2 in flue gas	8	*%*
CO2 in flue gas	10.3	*%*
CO in flue gas	12.4	*ppm*
Atmospheric Air		
Ambient Temperature	37	*Deg C*
Relative Humidity	45.6	*%*
Humidity in ambient air	0.03	*kg/kgdry air*
Fuel Analysis		
C	*84.00*	**%**
H	*12.00*	**%**
N	*0.00*	**%**
O	*1.00*	**%**
S	*3.00*	**%**
Moisture	*0.00*	**%**
Ash	*0.00*	**%**
Weighted Average GCV of Fuel-mix	*10500*	kcal/kg
Ash Analysis		
Unburnt in bottom ash	*0.00*	%
Unburnt in fly ash	*0.00*	%
GCV of bottom ash	*0*	kCal/kg
GCV of fly ash	*0*	kCal/kg
Material and flue gas data		
Weight of material (Raw material) being heated in furnace	122	*Kg/Hr*
Weight of Stock	122	*kg/hr*
Specific heat of material	0.12	*Kcal/kgdegC*
Average specific heat of fuel	0.417	*Kcal/kgdegC*
fuel temp	70	*deg C*
Specific heat of flue gas	0.26	*Kcal/kgdegC*
Specific heat of superheated vapour	0.45	*Kcal/kgdegC*
Heat loss from surfaces of various zone		
For Ceiling		
Natural convection heat transfer rate from ceiling	2.8	*Kcal/m2degC*

External temp. of ceiling	365	*deg K*
Room Temperature	310	*deg K*
Ceiling surface area	3.43	*m2*
Emissivity of furnace body surface	0.75	
For side walls		
Natural convection heat transfer rate from sidewall surfaces	2.2	*Kcal/m2degC*
External temperature of side walls	329	*deg K*
Sidewall surface area	8.4419	*m2*
For Hearth		
Natural convection heat transfer rate from flue gas duct surfaces	1.5	*Kcal/m2degC*
External temperature of side walls	335	*deg K*
External surface area	2.2134	*m2*
Outside dia of flue gas duct	*0.15*	*m*
For radiation loss in furnace(through charging and discharging door)		
Time duration for which the material enters through preheating zone and exits through Furnace	1	*Hr*
Area of opening in m2	0.4392	*m2*
Coefficient based on profile of furnace opening	0.7	
Maximum temperature of air at furnace door	464	*deg K*

Efficiency calculations

Calculations	Values	Unit
Theoretical Air Required	14.01	kg/kg of fuel
Excess Air supplied	56.02	%
Actual Mass of Supplied Air	21.85	kg/kg of fuel
Mass of dry flue gas	21.77	kg/kg of fuel
Amount of Wet flue gas	22.85	Kg of flue gas/kg of fuel
Amount of water vapour in flue gas	1.08	Kg of H2O/kg of fuel
Amount of dry flue gas	21.77	kg/kg of fuel
Specific Fuel consumption	87.79	kg of fuel/ton of material
Heat Input Calculations		
Combustion heat of fuel	921,769	Kcal/ton of material
Sensible heat of fuel	1,225	Kcal/ton of material
Total heat input	922,994	Kcal/ton of material
Heat Output Calculation		
Heat carried away by 1 ton of material (useful heat)	133,614	Kcal/ton of material
Heat loss in dry flue gas per ton of material	315,843	Kcal/ton of material
Loss due to H2 in fuel	82,484	Kcal/ton of material
Loss due to moisture in combustion air	187	Kcal/ton of material
Loss due to partial conversion of C to CO	50	Kcal/ton of material

Loss due to convection and radiation (openings in furnace - inlet & outlet door of furnace)	3,998	Kcal/ton of material
Loss Due to Evaporation of Moisture Present in Fuel	-	Kcal/ton of material
Total heat loss from furnace body	34,045	Kcal/ton of material
Heat loss due to unburnts in Fly ash	-	Kcal/ton of material
Heat loss due to unburnts in bottom ash	-	Kcal/ton of material
Unaccounted heat lossess	352,772	Kcal/ton of material
Heat loss from furnace body and ceilings		
Heat loss from furnace body ceiling surface	2550	Kcal/hr
Heat loss from furnace body side walls surfaces	1268	Kcal/hr
Heat loss from hearth	336	Kcal/hr
Total heat loss from furnace body	34045	Kcal/tons
Furnace Efficiency	**14.50**	%

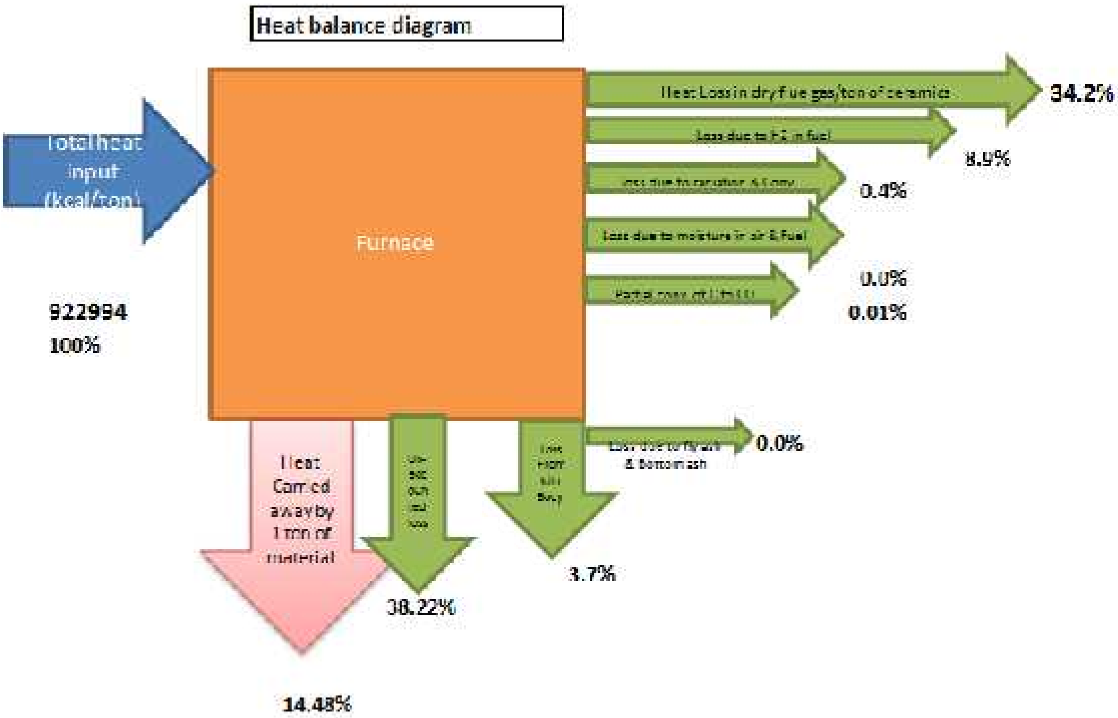

Figure 19: Sankey diagram furnace 3

Furnace 4 efficiency calculations

Input Data Sheet	
Type of Fuel	Furnace Oil
Source of fuel	Local vendor

	Value	Units
Furnace Operating temperature (Heating Zone)	1100	*Deg C*
Final temperature of material (at outlet of Heating zone)	1100	*Deg C*
Initial temperature of material	33	*Deg C*
Average fuel Consumption	15	*Kg/hr*
Flue Gas Details		
Flue gas temperature	625	*deg C*
Preheated air temperature	110	*deg C*
O2 in flue gas	12	*%*
CO2 in flue gas	6.8	*%*
CO in flue gas	34.6	*ppm*
Atmospheric Air		
Ambient Temperature	33	*Deg C*
Relative Humidity	45.6	*%*
Humidity in ambient air	0.03	*kg/kgdry air*
Fuel Analysis		
C	*84.00*	%
H	*12.00*	%
N	*0.00*	%
O	*1.00*	%
S	*3.00*	%
Moisture	*0.00*	%
Ash	*0.00*	%
Weighted Average GCV of Fuel-mix	*10500*	kcal/kg
Ash Analysis		
Unburnt in bottom ash	*0.00*	%
Unburnt in fly ash	*0.00*	%
GCV of bottom ash	*0*	kCal/kg
GCV of fly ash	*0*	kCal/kg
Material and flue gas data		
Weight of material (Raw material) being heated in furnace	148	*Kg/Hr*
Weight of Stock	148	*kg/hr*
Specific heat of material	0.12	*Kcal/kgdegC*
Average specific heat of fuel	0.417	*Kcal/kgdegC*
fuel temp	70	*deg C*
Specific heat of flue gas	0.26	*Kcal/kgdegC*
Specific heat of superheated vapour	0.45	*Kcal/kgdegC*
Heat loss from surfaces of various zone		
For Ceiling		
Natural convection heat transfer rate from ceiling	2.8	*Kcal/m2degC*
External temp. of ceiling	375	*deg K*
Room Temperature	306	*deg K*
Ceiling surface area	5.29	*m2*

Emissivity of furnace body surface	0.75	
For side walls		
Natural convection heat transfer rate from sidewall surfaces	2.2	*Kcal/m2degC*
External temperature of side walls	345	*deg K*
Sidewall surface area	12.3728	*m2*
For Hearth		
Natural convection heat transfer rate from flue gas duct surfaces	1.5	*Kcal/m2degC*
External temp. of side walls	343	*deg K*
External surface area	3.857	*m2*
Outside dia of flue gas duct	*0.15*	*m*
For radiation loss in furnace(through charging and discharging door)		
Time duration for which the material enters through preheating zone and exits through Furnace	1	*Hr*
Area of opening in m2	1.17	*m2*
Coefficient based on profile of furnace opening	0.7	
Maximum temperature of air at furnace door	474	*deg K*

Efficiency calculations

Calculations	Values	Unit
Theoretical Air Required	14.01	kg/kg of fuel
Excess Air supplied	123.40	%
Actual Mass of Supplied Air	31.29	kg/kg of fuel
Mass of dry flue gas	31.21	kg/kg of fuel
Amount of Wet flue gas	32.29	Kg of flue gas/kg of fuel
Amount of water vapour in flue gas	1.08	Kg of H2O/kg of fuel
Amount of dry flue gas	31.21	kg/kg of fuel
Specific Fuel consumption	101.31	kg of fuel/ton of material
Heat Input Calculations		
Combustion heat of fuel	1,063,771	Kcal/ton of material
Sensible heat of fuel	1,559	Kcal/ton of material
Total heat input	1,065,330	Kcal/ton of material
Heat Output Calculation		
Heat carried away by 1 ton of material (useful heat)	128,028	Kcal/ton of material
Heat loss in dry flue gas per ton of material	486,994	Kcal/ton of material
Loss due to H2 in fuel	93,064	Kcal/ton of material
Loss due to moisture in combustion air	250	Kcal/ton of material
Loss due to partial conversion of C to CO	243	Kcal/ton of material
Loss due to convection and radiation (openings in furnace - inlet & outlet door of furnace)	9,894	Kcal/ton of material
Loss Due to Evaporation of Moisture Present in Fuel	-	Kcal/ton of material
Total heat loss from furnace body	68,857	Kcal/ton of material

Heat loss due to unburnts in Fly ash	-	Kcal/ton of material
Heat loss due to unburnts in bottom ash	-	Kcal/ton of material
Unaccounted heat lossess	278,000	Kcal/ton of material
Heat loss from furnace body and ceilings		
Heat loss from furnace body ceiling surface	5026	Kcal/hr
Heat loss from furnace body side walls surfaces	4280	Kcal/hr
Heat loss from hearth	884	Kcal/hr
Total heat loss from furnace body	68857	Kcal/tons
Furnace Efficiency	**12.04**	%

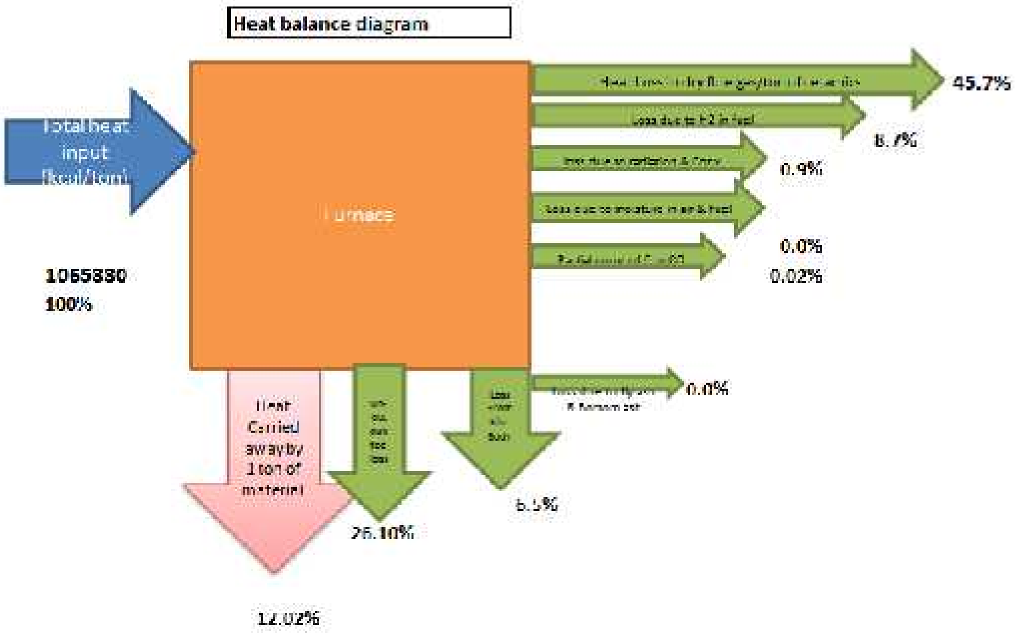

Figure 20: Sankey diagram furnace 4

Furnace 5 efficiency calculations

Input Data Sheet		
Type of Fuel	Furnace Oil	
Source of fuel	Local vendor	
	Value	**Units**
Furnace Operating temperature (Heating Zone)	1210	*Deg C*

Final temperature of material (at outlet of Heating zone)	1210	*Deg C*
Initial temperature of material	38	*Deg C*
Average fuel Consumption	9.6	*Kg/hr*
Flue Gas Details		
Flue gas temperature	851	*Deg C*
Preheated air temperature	110	*Deg C*
O2 in flue gas	10	*%*
CO2 in flue gas	8.3	*%*
CO in flue gas	88.7	*ppm*
Atmospheric Air		
Ambient Temperature	38	*Deg C*
Relative Humidity	45.6	*%*
Humidity in ambient air	0.03	*kg/kg dry air*
Fuel Analysis		
C	*84.00*	%
H	*12.00*	%
N	*0.00*	%
O	*1.00*	%
S	*3.00*	%
Moisture	*0.00*	%
Ash	*0.00*	%
Weighted Average GCV of Fuel-mix	*10500*	kcal/kg
Ash Analysis		
Unburnt in bottom ash	*0.00*	%
Unburnt in fly ash	*0.00*	%
GCV of bottom ash	*0*	kCal/kg
GCV of fly ash	*0*	kCal/kg
Material and flue gas data		
Weight of material (Raw material) being heated in furnace	88	*Kg/Hr*
Weight of Stock	88	*kg/hr*
Specific heat of material	0.12	*Kcal/kgdegC*
Average specific heat of fuel	0.417	*Kcal/kgdegC*
fuel temp	70	*deg C*
Specific heat of flue gas	0.26	*Kcal/kgdegC*
Specific heat of superheated vapour	0.45	*Kcal/kgdegC*
Heat loss from surfaces of various zone		
For Ceiling		
Natural convection heat transfer rate from ceiling	2.8	*Kcal/m2degC*
External temperature of ceiling	379	*deg K*
Room Temperature	311	*deg K*
Ceiling surface area	3.81	*m2*
Emissivity of furnace body surface	0.75	
For side walls		

Natural convection heat transfer rate from sidewall surfaces	2.2	*Kcal/m2degC*
External temp. of side walls	338	*deg K*
Sidewall surface area	8.6008	*m2*
For Hearth		
Natural convection heat transfer rate from flue gas duct surfaces	1.5	*Kcal/m2degC*
External temp. of side walls	349	*deg K*
External surface area	2.5029	*m2*
Outside dia of flue gas duct	*0.15*	*m*
For radiation loss in furnace(through charging and discharing door)		
Time duration for which the material enters through preheating zone and exits through Furnace	1	*Hr*
Area of opening in m2	0.5084	*m2*
Coefficient based on profile of furnace opening	0.7	
Maximum temperature of air at furnace door	474	*deg K*

Efficiency calculations

Calculations	Values	Unit
Theoretical Air Required	14.01	kg/kg of fuel
Excess Air supplied	90.91	%
Actual Mass of Supplied Air	26.74	kg/kg of fuel
Mass of dry flue gas	26.66	kg/kg of fuel
Amount of Wet flue gas	27.74	Kg of flue gas/kg of fuel
Amount of water vapour in flue gas	1.08	Kg of H2O/kg of fuel
Amount of dry flue gas	26.66	kg/kg of fuel
Specific Fuel consumption	109.53	kg of fuel/ton of material
Heat Input Calculations		
Combustion heat of fuel	1,150,116	Kcal/ton of material
Sensible heat of fuel	1,460	Kcal/ton of material
Total heat input	1,151,577	Kcal/ton of material
Heat Output Calculation		
Heat carried away by 1 ton of material (useful heat)	140,637	Kcal/ton of material
Heat loss in dry flue gas per ton of material	617,192	Kcal/ton of material
Loss due to H2 in fuel	112,358	Kcal/ton of material
Loss due to moisture in combustion air	293	Kcal/ton of material
Loss due to partial conversion of C to CO	558	Kcal/ton of material
Loss due to convection and radiation (openings in furnace - inlet & outlet door of furnace)	7,231	Kcal/ton of material
Loss Due to Evaporation of Moisture Present in Fuel	-	Kcal/ton of material
Total heat loss from furnace body	70,469	Kcal/ton of material
Heat loss due to unburnts in Fly ash	-	Kcal/ton of material
Heat loss due to unburnts in bottom ash	-	Kcal/ton of material

Unaccounted heat losses	202,839	Kcal/ton of material
Heat loss from furnace body and ceilings		
Heat loss from furnace body ceiling surface	3675	Kcal/hr
Heat loss from furnace body side walls surfaces	1919	Kcal/hr
Heat loss from hearth	607	Kcal/hr
Total heat loss from furnace body	70469	Kcal/tons
Furnace Efficiency	**12.23**	%

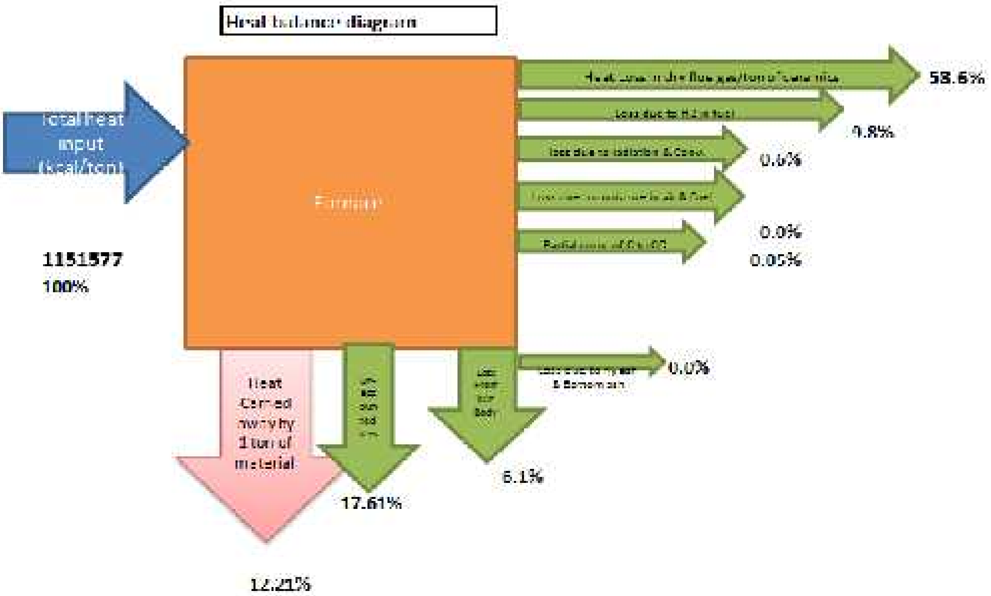

Figure 21: Sankey diagram furnace 5

Furnace 8 efficiency calculations

Input Data Sheet		
Type of Fuel		**Furnace Oil**
Source of fuel	**Local vendor**	
	Value	**Units**
Furnace Operating temperature (Heating Zone)	1170	*Deg C*
Final temperature of material (at outlet of Heating zone)	1170	*Deg C*
Initial temperature of material	33	*Deg C*

Average fuel Consumption	12.9	*Kg/hr*
Flue Gas Details		
Flue gas temperature	662	*Deg C*
Preheated air temperature	110	*Deg C*
O2 in flue gas	12	*%*
CO2 in flue gas	7.3	*%*
CO in flue gas	43.5	*ppm*
Atmospheric Air		
Ambient Temperature	33	*Deg C*
Relative Humidity	45.6	*%*
Humidity in ambient air	0.03	*kg/kg dry air*
Fuel Analysis		
C	*84.00*	%
H	*12.00*	%
N	*0.00*	%
O	*1.00*	%
S	*3.00*	%
Moisture	*0.00*	%
Ash	*0.00*	%
Weighted Average GCV of Fuel-mix	*10500*	kcal/kg
Ash Analysis		
Unburnt in bottom ash	*0.00*	%
Unburnt in fly ash	*0.00*	%
GCV of bottom ash	*0*	kCal/kg
GCV of fly ash	*0*	kCal/kg
Material and flue gas data		
Weight of material (Raw material) being heated in furnace	222	*Kg/Hr*
Weight of Stock	222	*kg/hr*
Specific heat of material	0.12	*Kcal/kg degC*
Average specific heat of fuel	0.417	*Kcal/kg degC*
fuel temp	70	*deg C*
Specific heat of flue gas	0.26	*Kcal/kg degC*
Specific heat of superheated vapor	0.45	*Kcal/kg degC*
Heat loss from surfaces of various zone		
For Ceiling		
Natural convection heat transfer rate from ceiling	2.8	*Kcal/m2 degC*
External temp. of ceiling	361	*deg K*
Room Temperature	306	*deg K*
Ceiling surface area	5.07	*m2*
Emissivity of furnace body surface	0.75	
For side walls		
Natural convection heat transfer rate from sidewall surfaces	2.2	*Kcal/m2degC*
External temp. of side walls	325	*deg K*

Sidewall surface area	9.7224	*m2*
For Hearth		
Natural convection heat transfer rate from flue gas duct surfaces	1.5	*Kcal/m2degC*
External temperature of side walls	333	*deg K*
External surface area	3.6309	*m2*
Outside dia of flue gas duct	*0.15*	*m*
For radiation loss in furnace(through charging and discharging door)		
Time duration for which the material enters through preheating zone and exits through Furnace	1	*Hr*
Area of opening in m2	0.88	*m2*
Coefficient based on profile of furnace opening	0.7	
Maximum temperature of air at furnace door	463	*deg K*

Efficiency calculations

Calculations	Values	Unit
Theoretical Air Required	14.01	*kg/kg of fuel*
Excess Air supplied	146.48	*%*
Actual Mass of Supplied Air	34.52	*kg/kg of fuel*
Mass of dry flue gas	34.44	*kg/kg of fuel*
Amount of Wet flue gas	35.52	*Kg of flue gas/kg of fuel*
Amount of water vapour in flue gas	1.08	*Kg of H2O/kg of fuel*
Amount of dry flue gas	34.44	*kg/kg of fuel*
Specific Fuel consumption	57.89	*kg of fuel/ton of material*
Heat Input Calculations		
Combustion heat of fuel	607,869	*Kcal/ton of material*
Sensible heat of fuel	892	*Kcal/ton of material*
Total heat input	608,761	*Kcal/ton of material*
Heat Output Calculation		
Heat carried away by 1 ton of material (useful heat)	136,434	*Kcal/ton of material*
Heat loss in dry flue gas per ton of material	326,186	*Kcal/ton of material*
Loss due to H2 in fuel	54,215	*Kcal/ton of material*
Loss due to moisture in combustion air	293	*Kcal/ton of material*
Loss due to partial conversion of C to CO	164	*Kcal/ton of material*
Loss due to convection and radiation (openings in furnace - inlet & outlet door of furnace)	4,348	*Kcal/ton of material*
Loss Due to Evaporation of Moisture Present in Fuel	-	*Kcal/ton of material*
Total heat loss from furnace body	25,423	*Kcal/ton of material*
Heat loss due to unburnts in Fly ash	-	*Kcal/ton of material*
Heat loss due to unburnts in bottom ash	-	*Kcal/ton of material*

Unaccounted heat losses	61,696	*Kcal/ton of material*
Heat loss from furnace body and ceilings		
Heat loss from furnace body ceiling surface	3,674	*Kcal/hr*
Heat loss from furnace body side walls surfaces	1,397	*Kcal/hr*
Heat loss from hearth	573	*Kcal/hr*
Total heat loss from furnace body	25,423	*Kcal/tons*
Furnace Efficiency	**22.44**	*%*

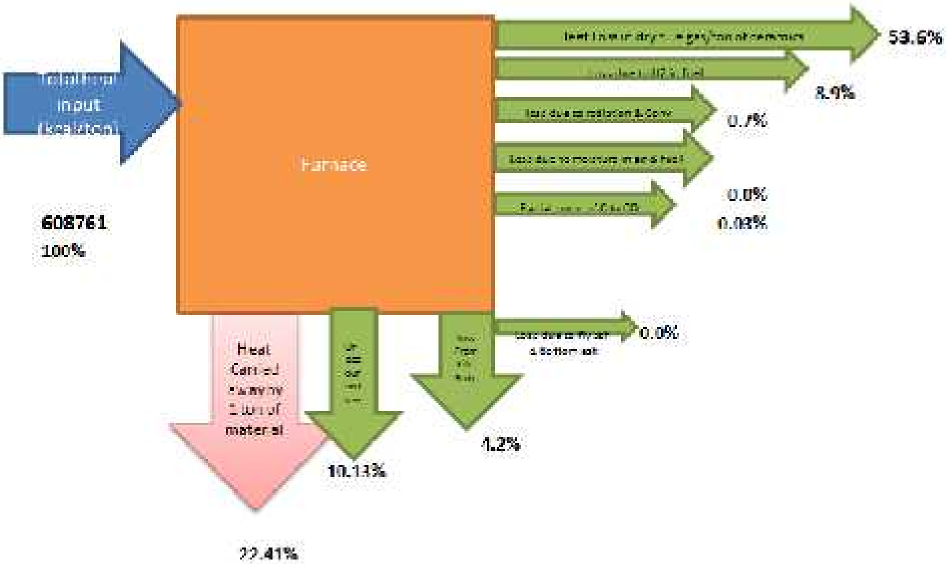

Figure 22 Sankey: diagram of forging furnace 8

6 LIST OF VENDORS

The details of some of suppliers for energy equipments are given in the table below:

EPIA 1, 2 & 3: Excess Air Control

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
Automation				
1	Delta Energy Nature Contact Person Gurinder Jeet Singh, Director	F-187, Indl. Area, Phase-VIII-Bm Mohali-160059	Tel.: 0172-4004213/ 3097657/ 2268197 Mobile: 9316523651 9814014144 9316523651	dengjss@yahoo.com den8353@yahoo.com
2	International Automation Inc Contact Person Sanjeev Sharma)	# 1698, First Floor, Canara Bank Building, Near Cheema Chowk, Link Road, Ludhiana	Office: +91-161-4624392, Mobile: +91-9815600392	Email: interautoinc@yahoo.com
3	Happy Instrument	Yogesh 20, Proffulit Society, Nr Navo Vas, Rakhial, Ahmedabad-380021	079-22771702 9879950702	yogesh@happyinstrument.com
4	Wonder Automation	Kulwinder Singh E-192, Sector 74, Phase 8-B, Industrial Area, SAS nagar Mohali	0172-4657597 98140 12597	info@wonderplctrg.com admn.watc@gmail.com hs@wonderplctrg.com

EPIA 4: Skin loss reduction

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Morgan Advanced Materials - Thermal Ceramics	P.O. Box 1570, Dare House Complex, Old No. 234, New No. 2, NSC Bose Rd, Chennai - 600001,	T 91 44 2530 6888 F 91 44 2534 5985 M 919840334836	munuswamy.kadhirvelu@morganplc.com mmtcl.india@morganplc.c

Sl. No.	Name of Company	Address	Phone No.	E-mail
		INDIA		om ramaswamy.pondian@morganplc.com
2	M/s LLOYD Insulations (India) Limited,	2,Kalka ji Industrial Area, New Delhi-110019	Phone: +91-11-30882874 / 75 Fax: +91-11-44-30882894 /95 Mr. Rajneesh Phone : 0161-2819388 Mobile : 9417004025	Email: kk.mitra@lloydinsulation.com

EPIA 5: VFD on broaching machines

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Schneider Electric Contact Person: Mr. Amritanshu	A-29, Mohan Cooperative Industrial Estate, Mathura Road, New Delhi-110044, India.	9871555277 (Rinki), Mr.Amritanshu (9582941330), 0124-3940400	amit.chadha@schneider-electric.com
2	Larson & Toubro Contact Person: Mr. Rajesh Bhalla	Electrical business group,32,Shivaji Marg,Near Moti nagar,Delhi-15	011(41419500),9582252422(Mr.Rajesh),7838299559(Mr.Vikram-sales),(PrIthvi power-technical)-9818899637,9810028865(Mr.Ajit),8510999637(Mr.Avinash Vigh)	Email: bhallar@lntebg.com, vikram.garg@lntebg.com, prithvipowers@yahoo.com, rajesh.bhalla@lntebg.com ,ajeet.singh@lntebg.com

EPIA 6: Installation of EE fans instead of conventional fans

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Super fans	351B/2A, Uzhaipalar street, GN Mills PO, Coimbatore. INDIA 641029.	Mob: 9489078737	Email: superfan@versadrives.com
2	Usha pumps Contact Person: Mr. KB Singh	J-1/162, Rajouri Garden, Rajouri Garden New Delhi, DL 110005	011(23318114),011 2510 4999,01123235861(Mr.Manish)	Email: kb_singh@ushainternational.com

EPIA 7 & 8: Energy Efficient Lights

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Osram Electricals Contact Person: Mr. Vinay Bharti	OSRAM India Private Limited,Signature Towers, 11th Floor,Tower B, South City - 1,122001 Gurgaon, Haryana	Phone: 011-30416390 Mob: 9560215888	vinay.bharti@osram.com
2	Philips Electronics Contact Person: Mr. R. Nandakishore	1st Floor Watika Atrium, DLF Golf Course Road, Sector 53, Sector 53 Gurgaon, Haryana 122002	9810997486, 9818712322(Yogesh-Area Manager), 9810495473(Sandeep-Faridabad)	r.nandakishore@phillips.com, sandeep.raina@phillips.com
3	Bajaj Electricals Contact Person: Mr. Kushgra Kishore	Bajaj Electricals Ltd,1/10, Asaf Ali Road, New Delhi 110 002	9717100273, 011-25804644 Fax : 011-23230214 ,011-23503700, 9811801341(Mr.Rahul Khare), (9899660832)Mr.Atul Baluja,	kushagra.kishore@bajajelectricals.com, kushagrakishore@gmail.com; sanjay.adlakha@bajajelectricals.com

Sl. No.	Name of Company	Address	Phone No.	E-mail
			Garving Gaur(9717100273), 9810461907(Kapil)	

EPIA 9 & 10: Replacement of reciprocating compressor with screw compressor

Sl. No.	Name of Company	Address	Phone No.	E-mail
1	Elgi Equipments-Supplier Contact Person: Mr. Ankur Saxena	23, Near Karampura, Opposite to DCM, Shivaji Marg, Delhi, - 110015	9717294729(Gaurav Luthra) Mr.Anshul Malhotra-9811025837,011-49491900(Dealer-Elgi equipment)	gauravl@elgi.com,sales@serviceequipmentcompany.com
2	Kaeser compressors India Pvt. Ltd. Contact Person: Amit Rajpal	811 A, D Mall,A-01, Netaji Subhash Place, Pitam Pura, Delhi - 110034	011-27353552,9818380792,Fax-27353552	Email: amit.rajpal@kaeser.com

EPIA 11: DG Replacement

Sl. No.	Name of Company	Address	Phone No.	E-mail / Website
1	Mahindra Powerol Engines & DG set Contact Person: Mr.Pankaj Katiyar Marketing	Jeevan Tara Building,5,Parliament street,delhi-1	Mobile: +91-9818494230	katiyar.pankaj@mahindra.com

Sl. No.	Name of Company	Address	Phone No.	E-mail / Website
2	Cummins Power Generation Contact Person: Rishi Gulati Senior Manager-Power Electronics	Cummins India Limited Power Generation Business Unit 35/A/1/2, Erandawana, Pune 411 038, India	Phone: (91) 020-3024 8600 , +91 124 3910908 Mobile: +91 9350191881	cpgindia@cummins.com rishi.s.gulati@cummins.com
3	BNE Company Contact Person: Mr Bhavneet Singh, Marketing	7B, Kiran Shankar Roy Road, 3rd Floor, Kolkata 700 001	Mobile : +91- 9831048994	bnecompany@gmail.com, bne_company@yahoo.com

EPIA 12: Installation of EE Burners

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
Automation				
1	ENCON Thermal Engineers (P) Ltd Contact Person: Mr V B Mahendra, Managing Director Mr. Puneet Mahendra, Director	297, Sector-21 B Faridabad – 121001 Haryana	Tel.: +91 129 4041185 Fax: +91 129 4044355 Mobile: +919810063702 +919971499079	sales@encon.co.in kk@encon.co.in www.encon.co.in
2	TECHNOTHERMA FURNACES INDIA PVT. LTD.	206, Hallmark Commercial Complex, Near Nirmal Lifestyles, L.B.S. Marg, Mulund West, Mumbai - 400 080. India.	T: 022-25695555	Furnace@technotherma.net

Sl. No.	Name of Company	Address	Phone No	E-mail /Website
3	Therm process	Mr. Sanjay Parab B/1203-O2 Commercial Complex, Minerva Estate, Opp Asha Nagar, P.K.Cross Road, Mulund (W) Mumbai-400080	T: 022-25917880/82/83 M: 9967515330	thermprocess@yahoo.com sanjay@thermprocess.com