BEE's National Program
on
Energy Efficiency and Technology Up-gradation in SMEs

Ludhiana Forging Cluster

Baseline Energy Audit Report
Rajendra Forge Pvt. Ltd.

Submitted to

Submitted by

InsPIRE Network for Environment

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About The Project

The project BEE's National Program on "Energy Efficiency and Technology Up gradation in SMEs - Ludhiana Forging Cluster" supported by Bureau of Energy Efficiency (BEE), Ministry of MSME and Ludhiana Auto Parts Manufacturers Association aims to bring down the energy demand of forging industries located at Ludhiana by supporting them to implement Energy Efficient Technologies in the SME units.

Executive Summary

1. Unit Details

Unit Name	:	**Rajendra Forge (P) Ltd.**
Address	:	B-34, Phase-V, Focal Point, Ludhiana-10
Contact Person	:	Mr. Suresh Kumar Sood & Mr. Kapish Sood (Cell No. 9815077866)
Products	:	Railway, Auto and other forging parts
Production	:	3.5 TPD
DIC Number	:	030091204746 (Part – II)
Bank Details	:	HDFC Bank, Mall Road, Ludhiana Account Number – 00342320000556
TAN / PAN No.	:	TAN: 03641079117; PAN: AACCR3233M
Contract demand	:	521.762 kVA

2. Existing Major Energy Consuming Technology

FO –Based re-heating technology

- Conventional Technology with higher losses
- Prevailing energy consumption 0.11 liters of FO per kg of the production

3. Proposed Energy Saving Technologies with Cost Economics

Proposed Energy Saving Measures

- Replacement of FO fired re-heating furnace with 250 kW induction re-heating furnace

Table 1: *Cost Economic Analysis*

Technology	Estimated Energy Savings (%)	Savings	Investment	Simple Payback period (Years)
Induction re-heating furnace (250 kW)	69	2,076,203	2,229,025	1.1
Total		**2,076,203**	**2,229,025**	

Introduction

1.1 ABOUT THE UNIT

M/s Rajendra forge pvt. Ltd. is engaged in manufacturing of different types of rough steel forging of auto parts including full yoke, half yoke, cross, cross holder etc. The manufacturing unit is located at B-34, Phase-V, Focal Point, Ludhiana -141010, Punjab.

The raw material procured by the unit for making products includes, EN19, EN9, EN8D, M.S. etc. The daily production of the unit is around 3.5 tons per day. The unit utilizes primary energy, namely, Furnace Oil (FO) and Electricity supply from SEBs for various process and utility applications in premises. The monthly FO consumption of the unit is around 15000 liters and cost comes to around Rs. 6.75 Lakhs monthly (@ Rs. 45/ Liter). The monthly average electricity consumption of the unit is 29000 units resulting into total electricity bill of Rs. 2.17 lacs per month. The FO is purchased from local fuel suppliers and electricity is purchased from Punjab State Power Corporation Limited. Detailed data related to both thermal as well as electrical energy consumption for the past one year is presented in Figure 1.1. To manufacture the products, the unit has installed four FO based re-heating furnace, forging presses, and shot blast machine etc.

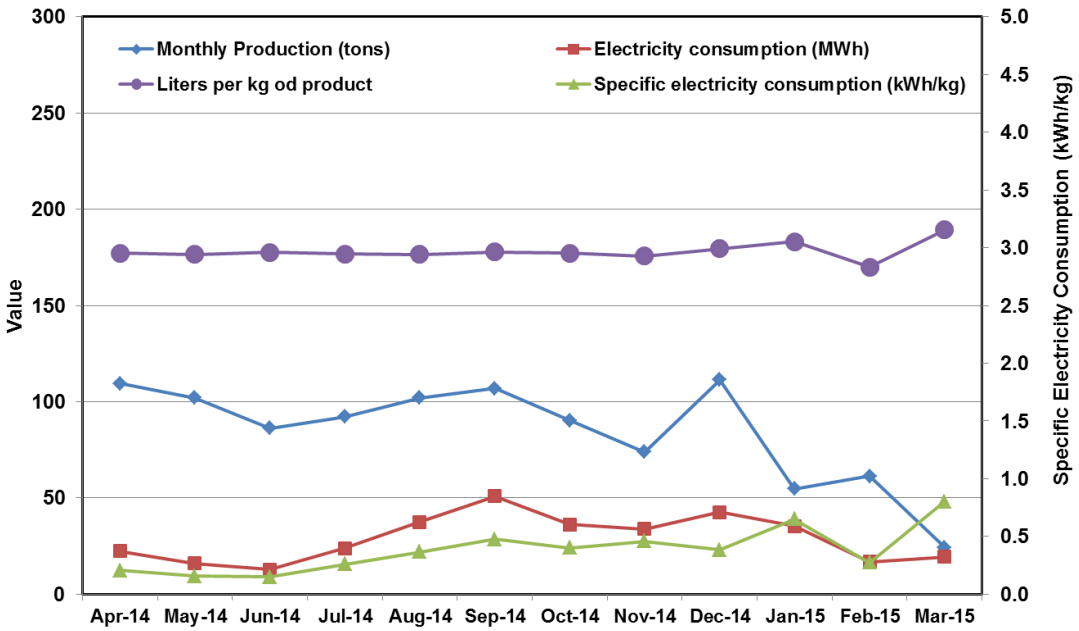

Figure 1.1: ***Production and energy consumption data of the unit***

According to the assessment of the energy consumption data collected, the specific thermal energy consumption and specific electrical energy consumption is 0.18 L/kg (1810 kcal/kg) of product and 0.34 kWh/kg (295 kcal/kg) of product respectively. The total specific energy consumption (in kCal) is 2105.8 kCal/ kg of product. Details of annual electrical and thermal energy consumption and specific energy consumption details in M/s Rajendra forge Pvt. Ltd. is presented in Table below:

Table 1.1: ***Details of M/s Rajendra Forge Pvt. Ltd.***

SN	Parameter	Value	Unit
1	Name and address of unit	M/s Rajendra Forge Pvt. Ltd., B-34, Phase-V, Focal Point, Ludhiana-141010	
2	Contact person	Mr. Suresh K Sood	
3	Manufacturing product	Railway, Auto and other forging parts	
4	Daily Production	3.5 TPD	
	Energy utilization		
5	Average monthly electrical energy consumption	29000	kWh per month
6	Average monthly thermal (FO) energy consumption	15000	Liters per month
7	Average thermal specific energy consumption	0.177514793	Liter /kg of product
		1810.650888	kCal/kg of product
8	Electrical specific energy consumption	0.34	kWh/Kg of product
		295.15	kCal/kg of product
9	Specific energy consumption	2105.80	kCal/kg of product
10	Electrical energy cost	2.57	Rs/Kg of product
11	Thermal energy cost	8.875739645	Rs/kg of product
12	Total energy cost	11.45	Rs/kg of product

Note:

^1: Specific gross calorific value of FO is considered as 10,200 kcal / liters

^2: Thermal equivalent for one unit of electricity is 860 kCal/kWh.

^3: The unit operates for 25 days a month (1 shift of 8 effective hours per day).

1.2 PRODUCTION PROCESS OF PLANT

The following figure shows the typical process employed at manufacturing of forged products at M/s Rajendra forge pvt. Ltd. (refer Figure 1.2). The raw material in round or square shape is first cut into pieces of required sizes using shearing machines. After cutting, these pieces are heated in an oil fired furnace to a temperature of around 1150 ^{0}C. These heated pieces are subjected to forging into the required shape using required shape dies. After forging, these pieces are naturally cooled for around 4 hrs. Thereafter trimming of the forged material is carried out to remove some material from the sides. This trimmed material is thereafter sent to power press. In order to bring the required surface finish, the product piece is subjected to shot blast. Finally material is dispatched after proper inspection.

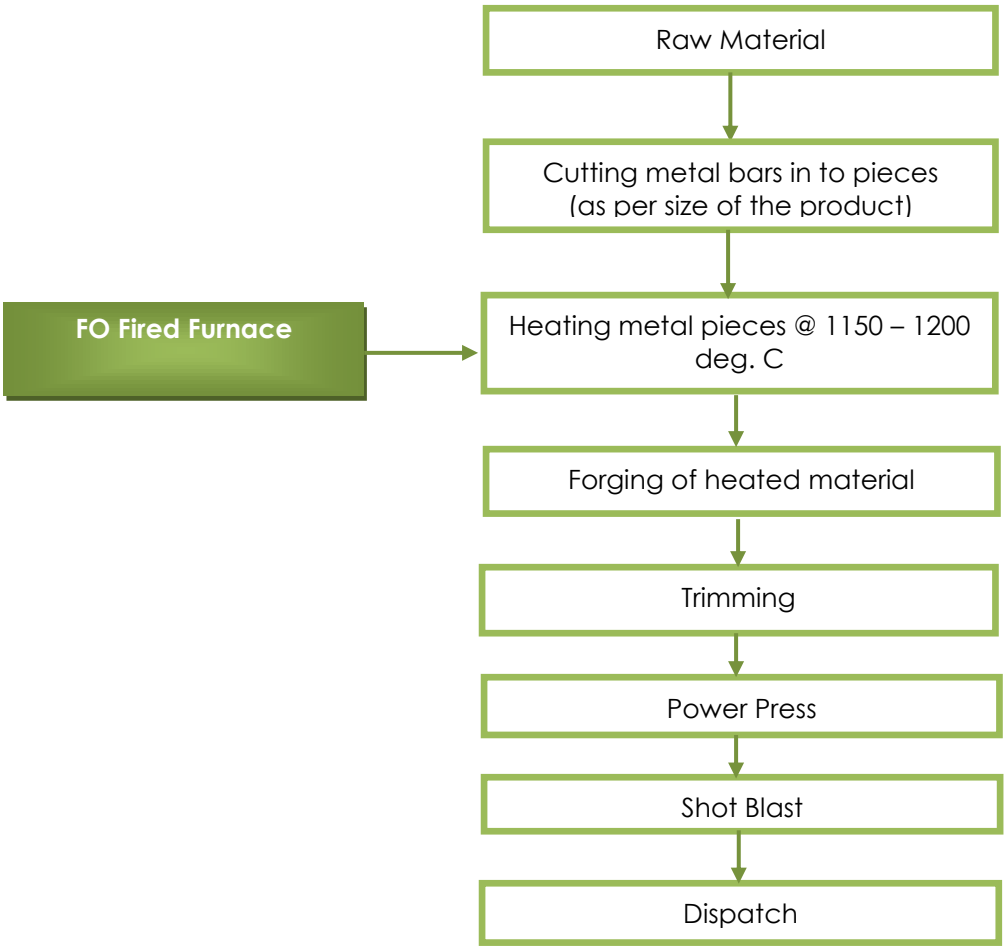

Figure 1.2: ***Production process of the unit***

Pictorial Description of the process being followed in the unit

Figure 1.3: ***Raw material being used in the unit***

Figure 1.4: ***Raw material after being cut into the pieces***

Figure 1.5: ***Cut pieces being put into the furnace***

Figure 1.6: ***Heated material taken out of the furnace***

Figure 1.7: ***Heated material being forged in the forging press***

Figure 1.8: ***Forging press installed in the unit***

Figure 1.9: ***Material being processed in the forging press***

Figure 1.10: ***Heated material after operation in forging press lying for natural cooling***

Figure 1.11: ***Material piece before shot blast operation***

Figure 1.12: ***Material piece after shot blast operation***

1.3 ENERGY AUDIT METHODOLOGY

The primary objective of the energy audit was to quantify the existing fuel consumption pattern and to determine the operating efficiencies of existing systems. The key points targeted through energy audits were determination of specific fuel consumption, various losses, operation practices like hot metal temperature, production, fuel consumption, scale formation etc. Pre – planned methodology was followed to conduct the energy audits. Data collected at all above steps was used to calculate various other operating parameters like material feeding rate (Kg/hr), fuel firing rate, specific fuel consumption (kg/tonne), etc.

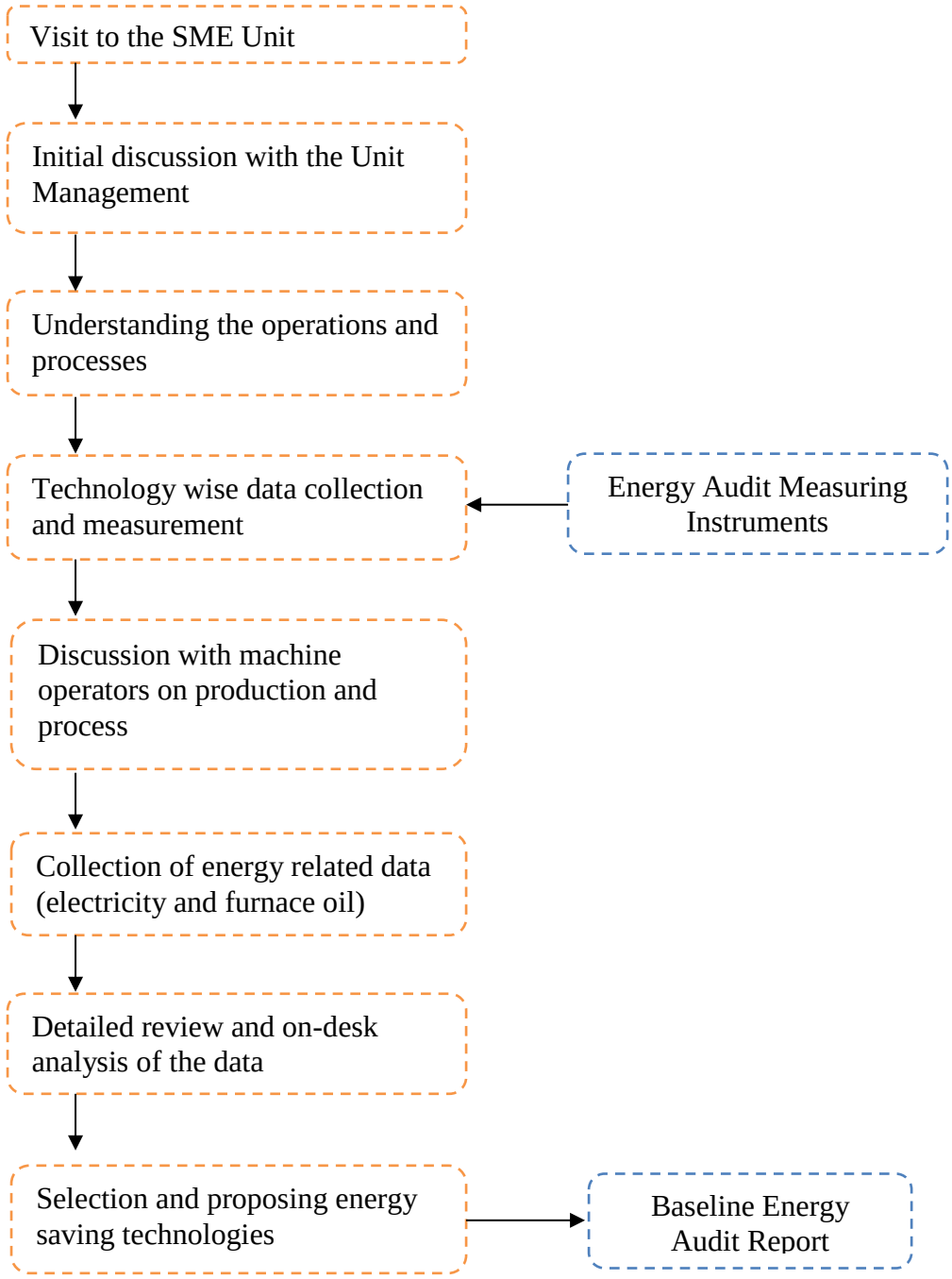

Figure 1.13: ***Energy audit process of the unit***

1.4 PRESENT TECHNOLOGIES ADOPTED

The list of energy consuming equipment's installed in M/s Rajendra forge pvt. Ltd. and used for forging process are as follows. The unit has installed four oil fired heating furnaces of different capacity for carrying out heating operation. Unit has also installed one induction furnace of smaller capacity. With each re-heating furnace, forging press is attached. For carrying out the finish operation, unit has also installed shot ballast machine. Based on the observation made during audit, it was found that most of the energy consumption is in the heating furnaces.

Table 1.2: List of energy consuming equipment's installed ***of the unit***

SN	Equipment	Number	Energy Source	Rated capacity
1	Cutting machine (03 Bend saw machine, 0_2 Shearing machine	05	Electricity	30 hp
2	Oil Fired Heating Furnace	05	Electricity & Furnace Oil	Details of each are provided in table 2.1
3	Forging Press	05	Electricity	-------
4	Trimming machines	03	Electricity	30 hp
5	Power Press	07	Electricity	---------
6	Induction Furnace		Electricity	150 kW + 22 kW
7	Shot Blast	02	Electricity	14 hp each, production of 300 kg/hr

^A shift is equal to 8 effective hours of working/ operation.

Present Process, Observations and Proposed Technology

2.1 ELECTRICITY CONSUMPTION PATTEN

The unit has got connected load of 521 kW and electricity supply is received at a voltage of 11 KV. The contract demand of the unit is 400 kW. Based on the electricity data for the last one year, the average MDI is observed to be 258 kW. The power factor in the unti is found to be in the range of 0.95 to 0.99. Figure 2.1 provides the monthly variation of electricity consumption, MDI and power factor for the unit.

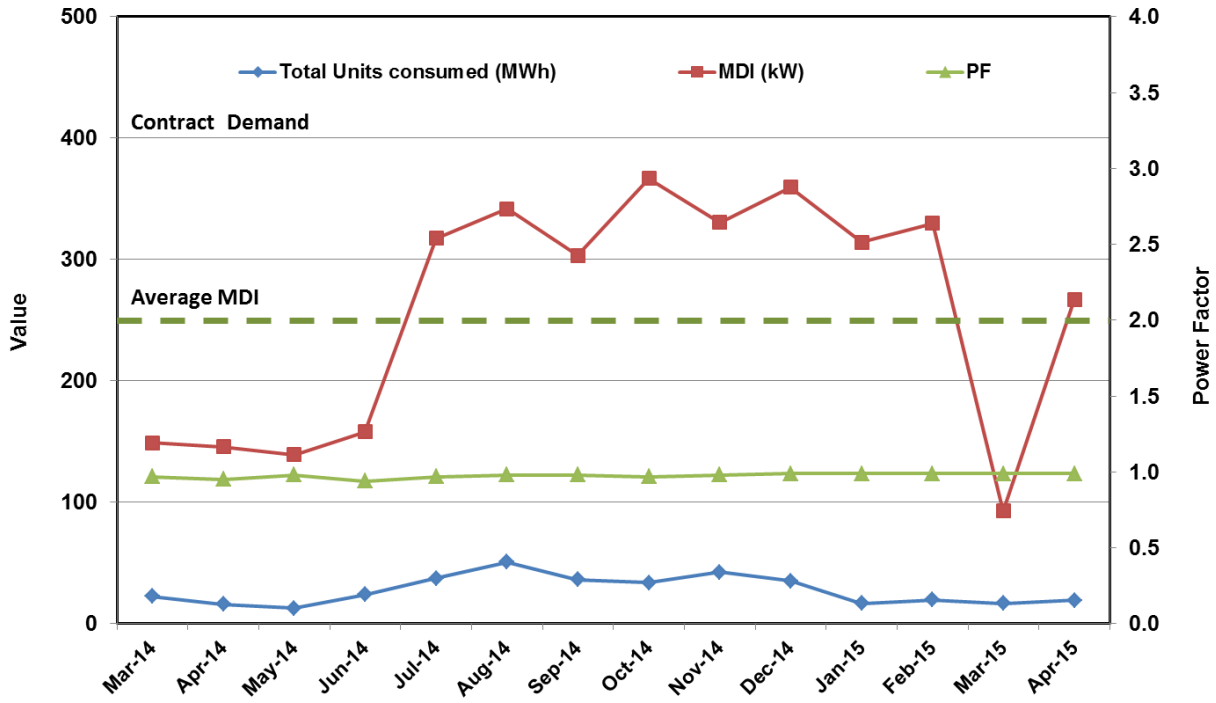

Figure 2.1: ***Monthly variation of electricity consumption, PF and MDI in the unit***

2.2 HEATING FURNACE (FURNACE OIL FIRED)

2.2.1 Present Process:

M/s Rajendra forge pvt. Ltd. has installed four furnace Oil (FO) fired heating furnace to heat the metal pieces for forging process. The metal pieces to be forged are heated to a temperature of 1150 - 1200 ◦ C. After that, the heated metal piece is then kept on the forging die having the cavity of the product to be formed. The hot metal piece then forged on the forging press into the product. Details of these furnaces are summarized in table 2.1.

Table 2.1: ***Fuel consumption and Production data of Furnace Oil based re-heating furnace***

SN	Furnace Type	Energy Source	Blower capacity	Size of the pieces (Kg)	Fuel Consumption	Op. Hours	Days per month	Hammer Specification
1.	Oil Fired Heating Furnace -01	Electricity & Furnace Oil	7.5 hp	(2 kg – 5 kg)	175 – 200 L	8 hr.	5-7 days	1.5 ton & 75 hp
2.	Oil Fired Heating Furnace -02	Electricity & Furnace Oil	7.5 hp	(5 kg – 15 kg)	350 – 400 L	8 hr.	15 days	2 ton & 100 hp
3.	Oil Fired Heating Furnace -03	Electricity & Furnace Oil	7.5 hp	(15 kg - 37 kg)	350 – 400 L	8 hr	7-10 days	3 ton & 125 hp
4.	Oil Fired Heating Furnace -04	Electricity & Furnace Oil	7.5 hp	0.9-2.25 kg	150 – 175 L	8 hr	15-20 days	0.75 ton & 50 hp

2.2.2 Observations

During visit to the units, Oil Fired Heating Furnace number 03 as mentioned in the table was operational. It was being used to heat metal pieces of 27 kg. Based on the study and analysis of the FO technology and other auxiliary equipment installed, following observations and drawbacks of the present re-heating FO technology are discussed. Overall, material loss in the complete operation was found to be around 15%.

The exiting furnace is old having conventional design burner with manual control option for fuel firing. Since, the efficiency of such furnace is lower, new technology induction furnaces maybe installed for re-heating process. Further, since the flame of the furnace directly hits the surface of the metal during the heating period varying from 20 – 30 minutes deteriorates the atomic/ grain structure of the piece and also leads to the higher scale formation due the oxidation of the metal at high temperature ultimately leading to material/ production loss. In order to attain the exact temperature profile of the material in less time, 3Ts has to be followed, Time, Turbulence and Temperature, if these three parameters can be followed in a right manner proper temperature can be archive in a minimum time, which would help in reducing the excessive heating of the material and reduction in scale loss.

Figure 2.2: ***Cut pieces being put into the furnace***

Figure 2.3: ***Heated material piece being taken out from furnace for forging***

Figure 2.4: ***Manual control of fuel in the furnace***

The specific energy consumption of furnace oil was observed to be around 0.15 to 0.17 liters of FO per kg of the production which is higher in comparison to the latest technologies available for carrying out the same purpose. During operation, fuel supply was controlled manually without controlling the air flow rate. Further, there was no provision for measuring the temperature inside the furnace and to what time the material should be heated. The judgment regarding completeness of heating was taken by the operator based on the color of the heated material. The surface temperature of the furnace observed near the combustion side was found to be 85 to 90 ^{o}C.

In addition, the existing reheating furnace usage furnace oil as a source of energy to heat the metal pieces. The burning of FO releases harmful gases like CO, CO_2, SO_X, NO_X, smoke etc. During the visit, it was observed that furnace has no exhaust mechanism, ID fan and flue gas pipe, to pass the flue gases out of the factory. All these factors affect the

environment and also the health of the worker handling the furnace and other machineries installed in the factory.

Conclusion:

As per the past studies conducted in forging industries, the replacement of the FO fired re-heating furnace with an induction re-heating furnace saves up to 60% of the energy cost. The production rate of the furnace observed during study is observed to be low (20 to 25 Pieces per hour) and varies with the product size.

Based on the data shared by the unit and information collected during field visit, it is found that furnace number 02 and 03 are mostly operated in the unit (Ref Table 2.1). Therefore, it is proposed to replace both these existing re-heating technology (FO Based) with Energy Efficient Induction Reheating furnaces.

This replacement would provide following benefits:

- Environmental cleaner technology
- Reduces Specific Energy Consumption
- Faster operation and reduced scale formation
- User friendly technology
- Improved quality of the product output
- Higher output with fewer crop cuts or short bars

2.2.3 Cost Economics Analysis

The comparison of FO based re-heating technology and induction technology, specific energy consumption, cost savings, investment required and simple payback period of the investment on induction technology is given in Table 2.2. The detailed calculation to finalize the size of induction furnace is provided as ***Annexure 3***.

Table 2.2: ***Cost Economics analysis for Induction Furnace***

Parameter	Unit	Value
Furnace oil consumption on existing re-heating furnace	Liters/hr	45.00
Production in terms of Kg	Kg/hour	400.00
Specific energy consumption on FO based re-heating furnace	Liters/Kg	0.11
Cost of energy consumption	Rs./Kg	5.06
Power consumed by proposed induction furnace (rated capacity 250 kW operating at 185 kW)	kW	185.00
Production in terms of Kg	Kg/hr	450.00
Specific energy consumption on induction reheating furnace	kWh/Kg	0.41
Cost of energy consumption	Rs./Kg	3.14
Reduction in cost of energy required	Rs./Kg	1.92
Operating hours	Hrs	8.00
Annual operating days	Days	300.00
Annual cost savings	Rs	2,076,203
Investment required for Induction furnace (250 kW)	Rs	2,229,025
Simple payback period	Years	1.07

As per the detailed calculations done, it is proposed to install an induction re-heating furnace of capacity 250 kW for carrying out heating of heavier metal pieces. Based on the discussion with concerned person in the unit, it came out that maximum weight of the individual piece is around 37 kgs. The cycle time required to re-heat the metal piece of 37 kgs would be around 5 mins.

The cost of energy saved per Kg of material forged is calculated as Rs. 3.14. The investment required for implementing the induction technology estimated as Rs 22.29 Lakhs with annual saving of Rs 20.76 Lakhs. The simple payback period of the technology is 1.07 years.

Annexure 1

Basic details and energy utilization pattern of M/s Rajendra Forge Pvt. Ltd.

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Note:
^1: Specific gross calorific value of FO is considered as 10,200 kcal / liters
^2: Thermal equivalent for one unit of electricity is 860 kCal/kWh.
^3: The unit operates for 25 days a month.

Annexure 2

Induction furnace capacity and heating cycle time calculation

Induction furnace capacity calculations:

Induction furnace design standard: 2.7 – 3 kg/ kW/hr

Hourly material to be heated = 450 Kg

Induction furnace capacity requirement (theoretical) = 60/2.7 kW/hr
= 166.66 kW/hr

As discussed with technology manufacturer, we have taken the lower value 2.7 kg/kW/hr for calculations.

Induction furnace capacity requirement (actual) (efficiency = 90%) = 166.66kW/hr /.90
= 185.18 kw/hr
= 185 kW approximately

Heating cycle time calculation:

Hourly material to be heated = 450 kg
Weight of the metal pieces = 37 gram
No. of pieces to be heated in an hour = 12 pieces
Heating time required per piece = 5 Min. approximately

Keeping in mind the variety of products manufactured by M/s Rajendra forge pvt. Ltd having variable weight, size, geometry, composition etc. induction furnace of 250 kW is proposed.

Note:

*** For more accurate capacity options, induction furnace manufacturer should be consulted prior to the implementation*

Annexure 3

Energy saving calculation for Induction furnace

Parameter	Unit	Value
Furnace oil consumption on existing re-heating furnace	Liters/hr	45.00
Production in terms of Kg	Kg/hour	400.00
Specific energy consumption on FO based re-heating furnace	Liters/Kg	0.11
Cost of energy consumption	Rs./Kg	5.06
Power consumed by proposed induction furnace (rated capacity 250 kW operating at 185 kW)	kW	185.00
Production in terms of Kg	Kg/hr	450.00
Specific energy consumption on induction reheating furnace	kWh/Kg	0.41
Cost of energy consumption	Rs./Kg	3.14
Reduction in cost of energy required	Rs./Kg	1.92
Operating hours	Hrs	8.00
Annual operating days	Days	300.00
Annual cost savings	Rs	2,076,203
Investment required for Induction furnace (50 kW)	Rs	2,229,025
Simple payback period	Years	1.07