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

Ludhiana Forging Cluster

Baseline Energy Audit Report
NN Products (India)

Submitted to

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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	:	**NN Products (India)**
Address	:	3741, St No.14, Daba Road, Shimlapuri, Ludhiana, Punjab - 141003
Contact Person	:	Mr. Jagdish Mitter Sharma & Mr. Nitin Sharma (Cell No: 9417029692)
Products	:	Bolts, Auto and Tractor Components
Production	:	500 – 600 kg/ day
DIC Number	:	030091103210 Part – II
Bank Details	:	State Bank of India; Branch: Miller Ganj, Ludhiana; Account Number, 10330880574
TAN / PAN No.	:	TAN: 03481134107; PAN: ADNPS0202N
Contract demand	:	48.98 kVA

2. Existing Major Energy Consuming Technology

FO Based re-heating technology

- Conventional Technology with higher losses
- Prevailing energy consumption 0.18 liters of FO per kg of the production

Lathes Machine

- Manually operated lathe machines for machining job work including facing, turning, grinding, drilling etc as well as long reduction process
- Electrical motor rating of 3 HP with production of around 25 pieces per hour per lathe machine.

3. Proposed Energy Saving Technologies with Cost Economics

Proposed Energy Measures

- Replacement of FO fired re-heating furnace with 30 kW induction re-heating furnace
- Replacement of manual lathe machines by one CNC based Special Purpose Machine (SPM) for turning operation and one CNC based Special Purpose Machine (SPM) hydraulic long reduction machine.

Table 1: *Cost Economic Analysis*

Proposed Technology	Estimated Energy Savings (%)	Savings (in Rs.)	Investment (in Rs.)	Simple Payback period (Years)
Induction re-heating furnace (30 kW)	80.3	1039040	727388	0.70
SPM machine – Turning	77.9	189360	550000	2.90
SPM machine- Hydraulic long reduction	80.6	234900	650000	2.77
Total		**1,463,300**	**1,927,388**	

Introduction

1.1 ABOUT THE UNIT

M/s NN Products (India) is engaged in manufacturing of different types of bolts, auto and tractor parts in various sizes as per the customer requirement. The manufacturing unit is located at 3741, St No.14, Daba Road, Shimlapuri, Ludhiana – 141003, Punjab.

The raw material procured by the unit for making bolts and other auto & tractor components include Mild Steel, EN8, EN15 etc.

The daily production lies in the range of 500 – 600 kgs per day (or 15 MT per month with 25 working days). M/s NN Products is using primary energy, namely, Furnace Oil (FO) and Electricity supply from SEBs for various process and utility applications in premises. The monthly FO consumption falls in the range of 900 – 1000 liters and cost comes to around Rs. 45,000 – 50,000 monthly (@ Rs. 50/ Liter). It was observed that the monthly electricity consumption comes in the range of 1200 – 1600 kWh. The average electricity consumption around 1482 kWh/month and electricity bill of Rs. 11,611/- per month. The FO is purchased from local fuel supplier and electricity is purchased from Punjab State Power Corporation Limited. Diesel is also used as fuel to run the Diesel Generator set installed in the unit for generation of electricity when electricity cut is there. Presently electricity cuts are very less therefor DG set is rarely used.

To manufacture the products, the unit has installed a FO based re-heating furnace, a forging press, pressing machine, grinding/ facing/ trimming lathes, threading machine etc.

According to the assessment of the energy consumption data collected, the specific thermal energy consumption and specific electrical energy consumption is 0.066 L/kg (6.268 kcal/kg) of product and 0.13 kWh/kg (115.43) of product respectively. The total specific energy consumption (in kCal) is 783.6 kCal/ kg of product. Details of annual electrical and thermal energy consumption and specific energy consumption details in M/s NN Products is presented in table below:

Table 1.1: ***Details of M/s NN Products***

SN	Parameter	Value	Unit
1	Name and address of unit	M/s. NN Products, 3741, St No.14, Daba Road, Shimlapuri, Ludhiana – 141003, Punjab	
2	Contact person	Mr. Nitin Sharma	
3	Manufacturing product	Bolts, auto and tractor components	
4	Daily Production	500 – 600 kg/ day	
	Energy utilization		
6	Average monthly electrical energy	1482	kWh per month

SN	Parameter	Value	Unit
	consumption		
7	Average monthly thermal (FO) energy consumption	723	Liters per month
8	Average specific thermal energy consumption^1	0.066	Liter /kg of product
		668.2	kCal/kg of product
9	Specific electrical energy consumption^2	0.13	kWh/Kg of product
		115.43	kCal/kg of product
10	Specific energy consumption	783.6	kCal/kg of product
11	Electrical energy cost	6.15	Rs/Kg of product
12	Thermal energy cost	2.6	Rs/kg of product
13	Total energy cost	8.77	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 NN Products are presented below:

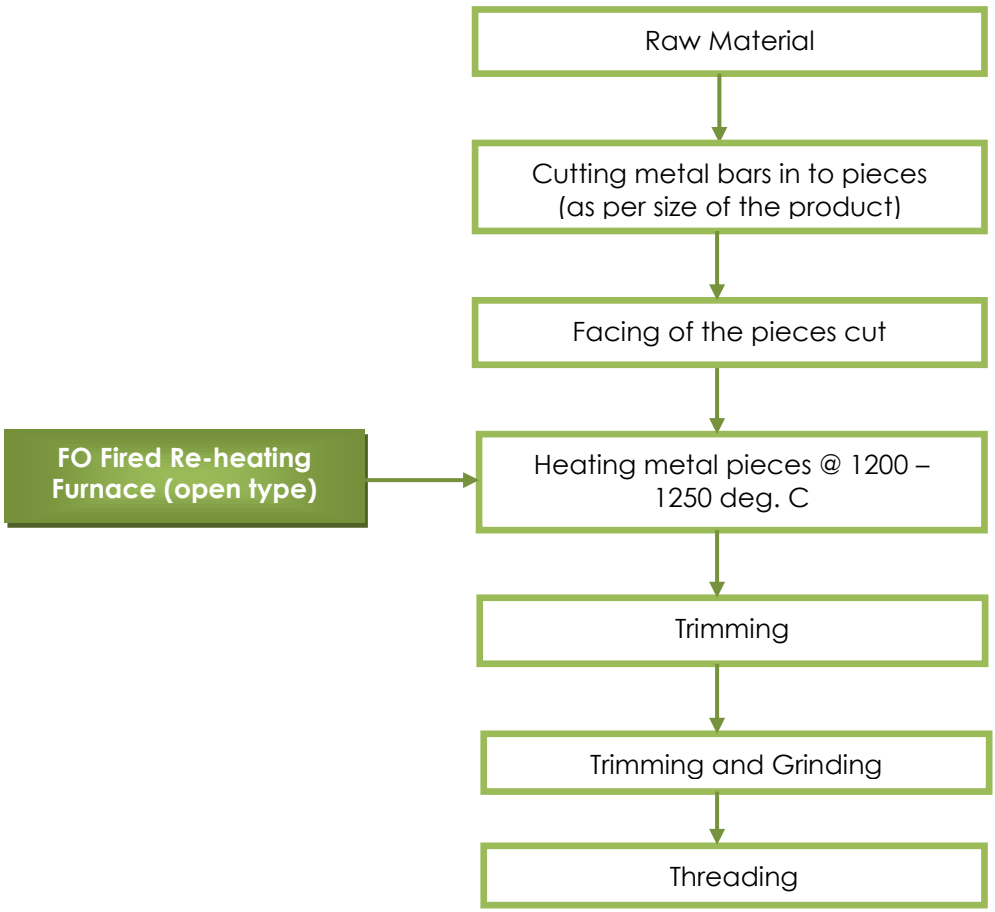

Figure 1.1: ***Production process of the unit***

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.

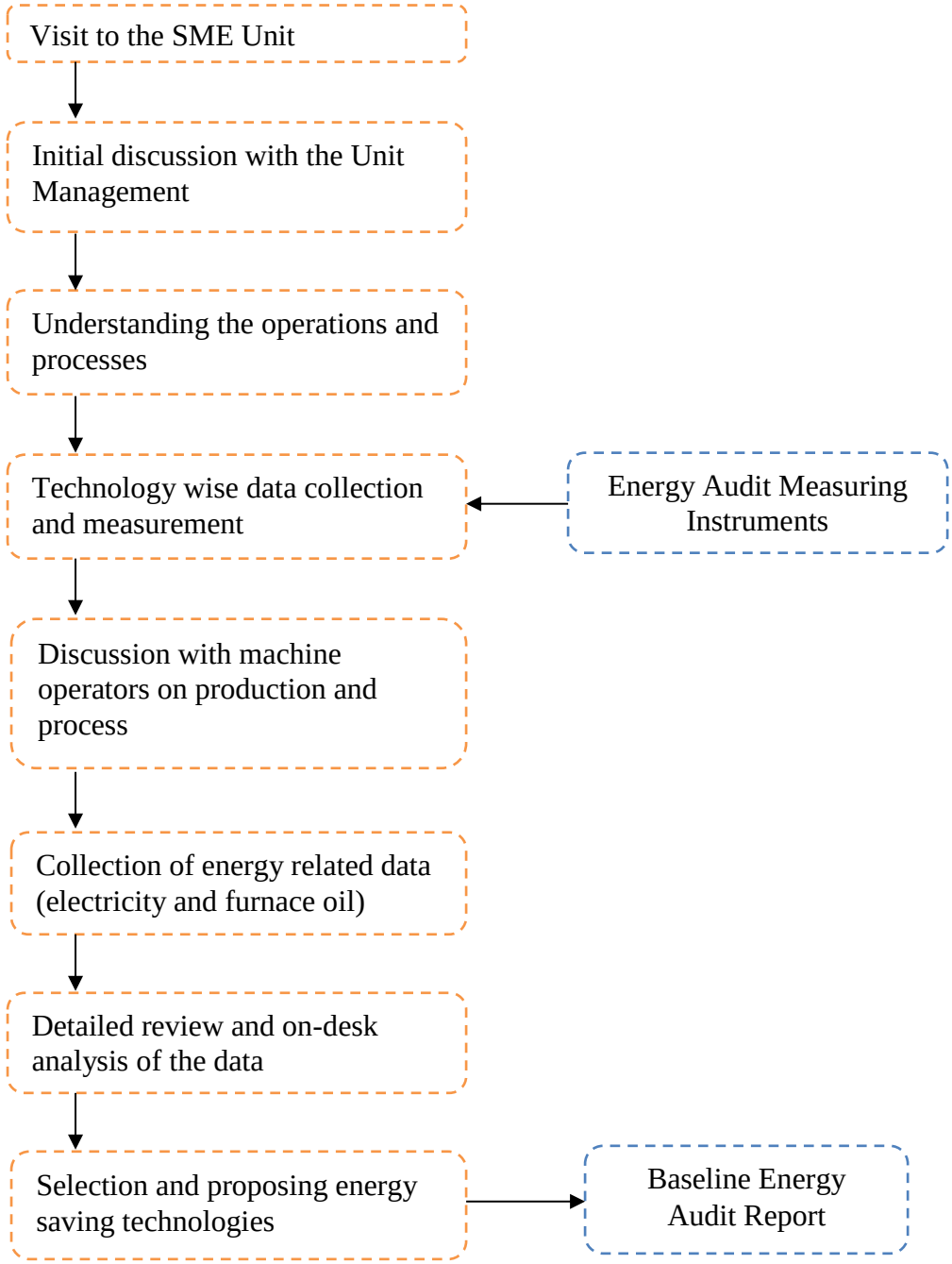

Figure 1.2: ***Energy audit process of the unit***

1.4 PRESENT TECHNOLOGIES ADOPTED

The list energy consuming installed in NN Products and used for forging process are as follows:

SN	Equipment	Energy Source	Rated capacity	Year of Installation
1	Reheating Furnace	Furnace Oil	35-40 L/ shift^	2006
2	Blower of the furnace	Electricity	1.5 hp/hr	2006
3	Forging Press	Electricity	10 hp/hr	2006
4	Power Press	Electricity	5 hp/hr	2006
5	Turning Centre	Electricity	2 hp/hr	1994
6	Grinding Machine	Electricity	8 hp/hr	1994
7	Lathe Machine	Electricity	2 hp/hr	1991
8	Threading Machine	Electricity	8 hp/hr	1992
9	DG Set	Diesel	25 kVA	NA

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

Present Process, Observations and Proposed Technology

2.1 RE HEATING FURNACE (FURNACE OIL FIRED)

2.1.1 Present Process:

M/s NN Enterprises has installed a Furnace Oil (FO) fired reheating furnace to heating the head of the metal piece for forging process. The metal piece to be forged is heated to a temperature of 1200 deg. C for 15-20 minutes. 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.

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

Time	Input (No. of Pcs.)	Output (No. of Pcs.)	FO Tank Level (L)	Remarks
9:25 - 10:00	62	0	52.43	Pre-heating of the furnace
10:00 - 10:15	56	61	49.16	Forging Started with Tank level measurement
10:15 - 10:30	45	46		
10:30 - 10:45	45	41		
10:45 - 11:00	45	41		
11:00 - 11:15	30	37	42.6	Forging Stopped with Tank level measurement
Total	**283**	**226**	**9.83**	**FO consumption is 9.83 liters for 226 nos. of pieces forged**

The energy consumption and production data related to detailed study conducted for the furnace oil based re-heating furnace installed at NN Products is shown in table XX. Initially, before start of the forging of the metal pieces, the re-heating furnace was pre-heated for about 35 minutes from 9:25 AM to 10:00 AM along with the material to be heated/ forged. The oil level in the fuel tank was measured with "Dip-Measurement" technique and it was noted that 3.27 liters of FO was consumed for pre-heating of re-heating furnace. The forging of the metal pieces was started at around 10:00 AM and the fuel level in the tank was measured. The study of the re-heating furnace was conducted for 1 hour and 15 minutes (5 cycles of 15 minutes). The metal pieces to be forged were heated to a temperature of around 1200 deg. C. The number of pieces feed to the furnace during the study was 283 and the number of pieces forged during this time was 226 with fuel consumption of 9.83 liters. The cost of furnace oil noted as Rs. 50 per liter.

Apart from the re-heating furnace, a blower was also installed to supply the combustion air to the re-heating furnace. The blower motor was single phase induction motor with capacity of 1 HP which runs around 10 hours a day.

2.1.2 Observations:

Based on the study and analysis of the FO technology and other auxiliary equipment installed, the observations and drawbacks of the present re-heating FO technology are as given below:

- **Conventional Technology:**

  The exiting furnace is very old, purchased as 2nd party and fabricated by the local manufacturer without following any design standards. The burner used in the furnace is also based on the conventional design having manual control option for fuel firing rate. Since, the efficiency of such furnace is lower, new technology induction furnaces must be installed for re-heating process.

- **Material deterioration and oxidation loss:**

  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.

- **High energy consumption:**

  As per the data collected during the walk through energy audit activity, the reheating furnace consumes around 0.25 liters of FO per kg of the production which higher if we compare the same with the latest technologies available in the market like induction heating furnace.

- **Low production rate:**

  Since the existing furnace is open type and most of the heat of the flame goes out of the furnace leading to higher heating time and more fuel consumption. Because of this the material under heating takes time to attain the desired temperature profile and thus leads to the lower production rate. Apart from the open heating, labor handling the furnace also responsible for slower production rate due to their own unorganized pattern of working.

- **Environmental and Health Issues:**

  The existing reheating furnace requires furnace oil as a source of energy which is burnt to heat the metal pieces. The burning of FO releases harmful gases like CO, CO_2, SO_X, NO_X, smoke etc. During the preliminary visit, it was also noted black soot is coming out of the furnace and getting deposited in the factory itself. The black soot

is basically due to the incomplete combustion of the FO, which ageing reduces the efficiency of the furnace and increases the fuel loss. The 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.

- **Lack of skilled labour:**
  Another factor which is creating the problem in Ludhiana is shortage of skilled workforce. Present re-heating technology requires 2-3 workers to control the furnace operations and feed in / discharge of material from the furnace.

- **Ideal running of forging press:**
  It was noted that there is miss match between the operating capacity of the furnace and forging press. As studied, in a cycle of 5 minutes, the re-heating furnace produces only 10-13 pieces which were being forged in 2 minutes only the remaining 3 minutes the forging press runs ideal. During this ideal running time, the forging press only consumes energy instead of producing any output.

- **Choking at blower suction end:**
  While studying the re-heating furnace, it was seen that the suction inlet of the blower is not working properly and there was no suction of the air.

- **Space constrained for storing fuel:**
  It was observed during baseline audit, another big issue is fuel storage problem. NN Products has space limitations and there for finding problems with maintaining the inventory of the furnace oil in the unit.

2.1.3 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 the walk through study is approximately 180 Pieces per hour, which is again, quit low.

Based on the above observations done during the baseline data collection and discussions with the unit management it is proposed to replace the existing re-heating technology (FO Based) with Energy Efficient Induction Reheating furnace.

Benefits of the EE re-heating technology:

- 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

2.1.4 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.

Table 2.2: ***Cost economic analysis***

Parameter	Unit	Value
Furnace oil consumption on existing re-heating furnace	Liters/ hr	13.50
Production in terms of Kg	Kg/hr	75.00
Specific energy consumption on FO based re-heating furnace	Liters/Kg	0.18
Cost of energy consumption	Rs./Kg	8.10
Power consumed by proposed induction furnace (rated capacity 30 kW)	kW	30
Production in terms of Kg	Kg/hr	81.23
Specific energy consumption on induction reheating furnace	kWh/Kg	0.37
Cost of energy consumption	Rs./Kg	2.8
Reduction in cost of energy required	Rs./Kg	5.33
Operating hours	Hrs	8
Annual operating days	Days	300
Annual cost savings	Rs	1,039,041
Investment required for Induction furnace (30 kW)	Rs	727,388
Simple payback period	Years	0.70

As per the detailed calculations done, it is proposed to install an induction re-heating furnace of capacity 30 kW (proposed for larger products also). On the day of study, the hub-bolt was under process and the data was collected for the same. To reheat the metal pieces, the proposed furnace must be run at 30 kW with production of 60 kg/ hour. The cycle time required to re-heat the metal piece of 175 gram was calculated as 10-12 seconds.

The cost of energy saved per Kg of material forged is calculated as Rs. 5.33. The investment required for implementing the induction technology estimated as Rs 7.27 Lakhs with annual saving of Rs 10.39 Lakhs. The simple payback period of the technology is 0.7 years.

2.2 SPECIAL PURPOSE MACHINES (SPM)

2.2.1 Present Process:

M/s NN Products has installed manually operated 5 lathe machines for various components machining job work like facing, turning, grinding, drilling etc. These machine runs on electrical motors having the capacity varying from 3 HP to 10 HP with production/ machining of 1000- 1200 pcs/day.

Machine	Numbers	Motor rating
Grinding Lathe	1	10 HP
Turning	1	2 HP
Facing	2	2 HP
Drilling	1	2 HP

2.2.2 Observations

Since these machines are manually operated, the process through which components are manufactured is very slow and time consuming. Apart from the slow process, the components manufactured are not very precise, identical and of high quality. Some times what happens that the machine keeps on running even there is no component on the machine or the operator is busy in some other work. All these factors lead to the loss of energy and production of low quality components.

2.2.3 Conclusion

In order to promote the energy efficiency and reduction in the overall energy cost in the factory, it is recommended to covert the existing manual machines into automatic special purpose machine (SPMs) by implementing PLC control mechanism. Since the modified machines will run on the pre-installed programming technique, the consumption of electricity will only happen when there is a function or operation required on the component. In the ideal condition the machine will remain in dead mode/ no operation mode.

Apart from the operation, the machine automatically loads the component for machining. The cycle time of the each component will be fixed in the business logic of the PLC / SPM machine therefore each component will take specific time for processing or machining. The SPM machines results in 30-50% percent of the energy savings depending upon the type of component, operation, material, cycle time etc.

Benefits of the Automatic SPM/ CNC machines:

- Reduced energy consumption
- Faster operation and reduced down time
- Improved product quality and symmetrical product dimensions
- Higher productivity
- Environment friendly technology

2.2.4 Cost Economics Analysis

The comparison of production on old manual/ conventional lathe machine and modified SPM machine, specific energy consumption, cost savings, investment required and simple payback period of the investment on SPM machines is given in Table 2.3.

For facing, turning and drilling operation:

Parameter	Unit	Value
Power consumed by old manual lathe machine	kW	6.71
Production on manual lathe machine	Pcs/hr	25
Specific power consumption on manual machine	kWh/Pcs	0.27
Power consumed by SPM Machine (motor capacity 2HP) @ 60% Loading	kW	4.48
Production on SPM machine (Projected)	Pcs/hr	55
Specific power consumption on SPM machine	kWh/Pcs	0.08
Reduction in specific power consumption	kWh/Pcs	0.188
Percentage savings	%	77.9
Operating hours	Hrs	8
Annual operating days	Days	300
Annual electricity savings	kWh	25,248
Annual cost savings	Rs.	189,360
Investment required	Rs.	550,000
Simple payback period	Years	2.9

As per the detailed calculations done, it is proposed to convert existing manual lathes into automatic Special Purpose Machines (SPMs). The specific power consumption on a manual machine is 0.08 kWh/ pcs whereas the specific power consumption in modified SPM machine would be around 0.188 kWh/pcs resulting in 82% savings in electrical energy. The investment required for making an SPM machine would be around Rs 5.5 Lakhs with annual saving of Rs 1.89 Lakhs. The simple payback period of the technology is 2.90 years.

For grinding operation:

Parameter	Unit	Value
Power consumed by old manual grinding machine	kW	5.968
Production on manual grinding machine	Pcs/hr	80
Specific power consumption on manual machine	kWh/Pcs	0.0746
Power consumed by SPM Machine (motor capacity 5HP) @ 70% Loading	kW	2.2007
Production on SPM machine (Projected)	Pcs/hr	150
Specific power consumption on SPM machine	kWh/Pcs	0.015
Reduction in specific power consumption	kWh/Pcs	0.060
Percentage savings	%	80.3
Operating hours	Hrs	8
Annual operating days	Days	300
Annual electricity savings	kWh	21,574
Annual cost savings	Rs.	234,900
Investment required	Rs.	650,000
Simple payback period	Years	2.77

As per the detailed calculations done, it is proposed to convert existing conventional grinding machine into automatic Special Purpose Machines (SPMs). The specific power consumption on a conventional grinding machine is 0.015 kWh/ pcs whereas the specific power consumption in modified SPM machine would be around 0.060 kWh/pcs resulting in 80.3% savings in electrical energy. The investment required for making an SPM machine would be around Rs 6.5 Lakhs with annual saving of Rs 2.34 Lakhs. The simple payback period of the technology is 2.77 years.

Annexure 1

Basic details and energy utilization pattern of NN Products (India)

SN	Parameter	Value	Unit
1	Name and address of unit	M/s. NN Products, 3741, St No.14, Daba Road, Shimlapuri, Ludhiana – 141003, Punjab	
2	Contact person	Mr. Nitin Sharma	
3	Manufacturing product	Bolts, auto and tractor components	
4	Daily Production	500 – 600 kg/ day	
	Energy utilization		
6	Average monthly electrical energy consumption	1482	kWh per month
7	Average monthly thermal (FO) energy consumption	723	Liters per month
8	Average specific thermal energy consumption^1	0.066	Liter /kg of product
		668.2	kCal/kg of product
9	Specific electrical energy consumption^2	0.13	kWh/Kg of product
		115.43	kCal/kg of product
10	Specific energy consumption	783.6	kCal/kg of product
11	Electrical energy cost	6.15	Rs/Kg of product
12	Thermal energy cost	2.6	Rs/kg of product
13	Total energy cost	8.77	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.

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 = 75Kg

Induction furnace capacity requirement (theoretical) = 75/2.7 kW/hr
= 27.77 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%) = 27.77 kW/hr /.90
= 30.86 kw/hr
= 30kW approximately

Heating cycle time calculation:

Hourly material to be heated = 75 kg
Weight of the metal pieces = 1325 gram
No. of pieces to be heated in an hour = 343 pieces
Heating time required per piece = 11 seconds approximately

Keeping in mind the variety of products manufactured by NN Products (India) having variable weight, size, geometry, composition etc. induction furnace of 30 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	13.50
Production in terms of Kg	Kg/hr	75.00
Specific energy consumption on FO based re-heating furnace	Liters/Kg	0.18
Cost of energy consumption	Rs./Kg	8.10
Power consumed by proposed induction furnace (rated capacity 40 kW operating at 25 kW)	kW	30
Production in terms of Kg	Kg/hr	81.23
Specific energy consumption on induction reheating furnace	kWh/Kg	0.37
Cost of energy consumption	Rs./Kg	2.8
Reduction in cost of energy required	Rs./Kg	5.33
Operating hours	Hrs	8
Annual operating days	Days	300
Annual cost savings	Rs	1,039,041
Investment required for Induction furnace (40 kW)	Rs	727,388
Simple payback period	Years	0.70

Note:

*** The cost of induction furnace is an indicative value gathered from discussions with furnace suppliers. It may vary according to the heating requirement and the material to be heated.*

Annexure 4

Energy saving calculation for facing, turning and drilling SPM machines

Parameter	Unit	Value
Power consumed by old manual lathe machine	kW	6.71
Production on manual lathe machine	Pcs/hr	25
Specific power consumption on manual machine	kWh/Pcs	0.27
Power consumed by SPM Machine (motor capacity 2HP) @ 60% Loading	kW	4.48
Production on SPM machine (Projected)	Pcs/hr	55
Specific power consumption on SPM machine	kWh/Pcs	0.08
Reduction in specific power consumption	kWh/Pcs	0.188
Percentage savings	%	77.9
Operating hours	Hrs	8
Annual operating days	Days	300
Annual electricity savings	kWh	25,248
Annual cost savings	Rs.	189,360
Investment required	Rs.	550,000
Simple payback period	Years	2.9

Note:

*** The cost of SPM machines is an indicative value gathered from discussions with SPM machine suppliers. It may vary from operation to operation and product to product.*

Annexure 5

Energy Saving calculation for SPM Grinding machine

Parameter	Unit	Value
Power consumed by old manual grinding machine	kW	5.968
Production on manual grinding machine	Pcs/hr	80
Specific power consumption on manual machine	kWh/Pcs	0.0746
Power consumed by SPM Machine (motor capacity 5HP) @ 70% Loading	kW	2.2007
Production on SPM machine (Projected)	Pcs/hr	150
Specific power consumption on SPM machine	kWh/Pcs	0.015
Reduction in specific power consumption	kWh/Pcs	0.060
Percentage savings	%	80.3
Operating hours	Hrs	8
Annual operating days	Days	300
Annual electricity savings	kWh	21,574
Annual cost savings	Rs.	234,900
Investment required	Rs.	650,000
Simple payback period	Years	2.77

Note:

*** The cost of SPM machines is an indicative value gathered from discussions with SPM machine suppliers. It may vary from operation to operation and product to product.*