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

Pali Textile Cluster

Baseline Energy Audit Report
Shree Rajaram Mills




Submitted to

ENERGY IS LIFE
B E E
CONSERVE IT

Submitted by

InsPIRE

InsPIRE Network for Environment

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contents

List of Tables

List of Figures

List of Abbreviations

APH	Air-preheater
BEE	Bureau of Energy Efficiency
BD	Blow Down
BOP	Best Operating Practice
BFW	Boiler Feed Water
CETP	Common Effluent Treatment Plant
CSE	Center for Science and Environment
CRS	Condensate Recovery System
FD	Forced Draft
HP	Horse Power
ID	Induced Draft
kcal	Kilo Calories
kg	Kilogram
kVA	Kilo Volt Ampere
kW	Kilo Watts
MSME	Ministry of Micro Small and Medium Enterprises
RTHPA	Rajasthan Textile and Hand Processors Association
RO	Reverse Osmosis
SEC	Specific Energy Consumption
SFC	Specific Fuel Consumption
SPC	Specific Power Consumption
SME	Small and Medium Enterprise
SO	Sulphur Oxide
TDS	Total Dissolved Solids
TFH	Thermic Fluid Heater
VFD	Variable Frequency Drive

About The Project

The project titled "BEE's National Program on Energy Efficiency and Technology Up-gradation in SMEs" supported by Bureau of Energy Efficiency (BEE), Ministry of MSME and Rajasthan Textile and Hand Processors Association (RTHPA) aims to bring down the energy demand of MSME industries located at different clusters around the country. Pali Textile Processing cluster located at Pali, Rajasthan is one such cluster, which has been selected under the program. The project aims to support the MSME units in Pali to implement Energy Efficient Technologies in the SME units.

There are more than 400 Small and Medium Enterprise (SME) textile processing units operating in the various industrial pockets of Pali. The project aims to initially diffuse energy efficient technologies in selected units in the cluster. These units will act as demonstration units for long term and sustainable penetration of energy efficient technologies in the entire cluster. InsPIRE Network for Environment, New Delhi has been appointed as the executing agency to carry out the following activities in the cluster:

- Conducting pre-activity cluster workshop in the cluster.
- Conducting initial walk through audits in 5 representative units of the cluster.
- Identify and propose BEE on energy efficient process technologies, relevant to the cluster, with highest energy saving and replication potential, and their cost benefit analysis.
- Identify local technology/service providers (LSP) for the above technologies in the cluster
- Identify SME units willing to implement and demonstrate the energy efficient technologies
- Assist BEE to enter into a contract with each of the shortlisted SME units to enable implementation and showcasing of Energy Efficient technology.
- Conduct comprehensive Baseline Energy Audits in the shortlisted SME units wherein these technologies can be implemented and document the findings in the form of a report.
- Develop technology specific case studies (Audio-Visual and print) for each technology
- Prepare Best Operating Practices (BOP) document for the top 5 energy using equipment / process in the industry cluster
- Enumeration of common regularly monitorable parameter at the process level which have impact on energy performance, and listing of appropriate instrumentation for the same with options including make, supplier, indicative cost specifications and accuracy of measurements.
- Carry out post implementation energy audit in the implemented units to verify energy savings as a result of EE technology implementation.
- Verify and submit to BEE all the relevant documents of each participating unit owner indicating his complete credentials, proof of purchasing the equipment, evidence of implementation and commissioning of the EE technology in the unit.

As part of the activities conducted under the energy efficiency program in Pali Textile cluster, detailed energy audits in 11 Textile units in Pali was conducted in the month of March and April'2016. This specific audit report details the findings of the energy audit study carried out at Shree Rajaram Mills.

Executive Summary

1. Unit Details

Unit Name	:	**Shree Rajaram Mills**
Address	:	F-338 to 342, Mandia Road Industrial Area, Pali, Rajasthan- 306401
Contact Person	:	Mr. Manish Gupta, Manager (Cell no: 9314464807)
Products	:	Cloth processing (cotton & polyester)
Production		70,000 to 80,000 meters of processed cloth per day
DIC Number		1266/STA/IMO/2005
Bank Details		Bank of Baroda, Suraj Pole, Pali, A/c No.: 09790500014855, IFSC Code: BARB0PALIXX
TIN / PAN No.	:	TIN: 08023254261 PAN: ABWPC1521H
Contract demand		300 kVA

2. Existing Major Energy Consuming Technology

Coke Based Steam Boiler & Thermopac

- Steam boiler and thermopac with no provision of monitoring and control.
- Prevailing specific fuel consumption is 0.08 kgs of coke per meter of processed cloth. High TDS in the feed water leads to frequent blow-down of boiler.

Jet Dyeing Machine and Zero-Zero Machine

- 2 Nos of Jet Dyeing machine with no provision for condensate recovery.
- Each jet machine uses steam at 200 kg/hr with a production of 1100-1200 mtrs of processed cloth per batch from jet dyeing machines (2-3 hrs time required for one batch)

Jigger Machine

- A total of 20 numbers jigger machines used for cotton dyeing at elevated temperature (60-80 ^{0}C). Jiggers are not equipped with temperature monitoring and control system.
- Each jigger machine uses 2000-2500 liters of water in each cycle.

3. Proposed Energy Saving Technologies with Cost Economics

Proposed Energy Saving Measures

- Installation of temperature based automation system in thermopac
- Installation of oxygen based automation system in steam boiler
- Installation of RO system for treatment of feed water to boiler.
- Installation of condensate recovery system for jet dyeing machines.
- Installation of temperature monitoring and control system in jigger machines

Table 1: ***Cost Economic Analysis***

Technology	Estimated Energy Savings (%)	Savings (in Rs)	Investment (in Rs)	Simple Payback period (Months)
Installation of temperature based automation system in thermopac	1	75,732	3,00,000	48
Installation of oxygen based automation system in steam boiler	18.8	5,08,846	7,00,000	17
Reverse Osmosis (RO) system in steam boiler	3	3,27,299	2,00,000	7
Condensate Recovery System (CRS) in Jet Dyeing Machine	16.67	3,03,630	5,00,000	20
Temperature Monitoring & Control in Jigger Machines (for 10 Jiggers)	5.70	4,92,252	2,50,000	6

Introduction

1.1 ABOUT THE CLUSTER

The Pali textile cluster is one of the biggest SME clusters in Rajasthan having over 350 member industries. The units in the cluster are mainly located in industrial areas namely Industrial Area Phase I & Phase II, Mandia Road Industrial Area and Punayata Industrial Area. Balotra and Bhilwara are other textile clusters in Rajasthan. These clusters also have similar processes and any intervention in Pali would benefit entrepreneurs in these clusters as well. Pollution of nearby river was a significant environmental issue. Center for Science and Environment (CSE) conducted a study to assess the situation behind the environmental issues. The units faced closure for a long time due to legal actions and decided to set up a Common Effluent Treatment Plant (CETP) for redressal the waste water related issues. The CETP is being operational under a trust managed by the entrepreneurs themselves.

Ironically, even though none of the resources required for textile processing is available locally, the textile cluster at Pali has grown despite the odds. The industrial area has no water and all the water required is transported from a distance of over 20 KM. The labour working in the cluster is mostly from outside Pali, at times from as far as Eastern UP and Bihar. Equipment suppliers are all based in Gujarat and Pali does not have enough local service providers or consultants. Even the grey (raw) cloth, dye and chemicals are brought mostly from Maharashtra and Gujarat. Coal or residual pet coke is also not available locally.

Only resource that are available locally is the entrepreneurship of the people, availability of clear sky for over 340 days in an year and good power availability. Presence of a pool of dye masters to process over 400 shades through colour recipe based on experience is another plus for Pali. Initially, Surat used to be the largest processing center for dyeing but a large portion of the job there got outsourced to Pali due to problems like Pollution, Flood, Plague etc.

1.2 ABOUT THE UNIT

M/s Shree Rajaram Mills, Pali, was established in the year 2007 and is engaged in processing of cloth (both cotton and polyester) which includes raw cloth (grey) processing, dyeing and finishing operations. The manufacturing unit is located at F-338 to 342, Mandia Road Industrial Area, Pali. The unit operation is overseen by Mr. Manish Gupta, Manager.

The raw material procured by the unit includes grey (raw cloth) purchased from various sources predominantly from Gujarat and Maharashtra. The unit operates for 24 hours per day, presently.

The daily production lies in the range of 70,000 to 80,000 meters of processed cloth per day. The major energy usage in the unit includes wet steam (generated from coke fired boiler) and electricity. The average monthly coke consumption (derived from reported date of last one year) in the unit is 1,18,344 Kgs. The average monthly electricity consumption (derived from reported date of last one year) is 90,162 kWh. ***Figure 1.1*** depicts monthly electricity consumption vis-à-vis total monthly production of the unit for last one year. ***Figure 1.2*** depicts monthly coke consumption vis-à-vis total monthly production for last one year.

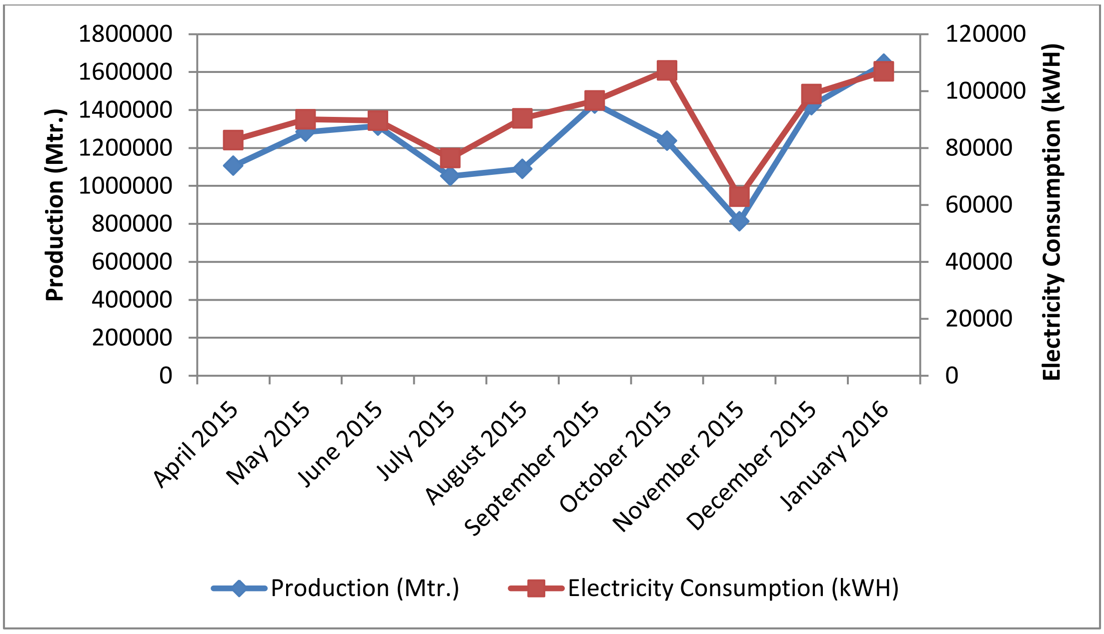

Figure 1.1: ***Monthly variation of production and electricity consumption***

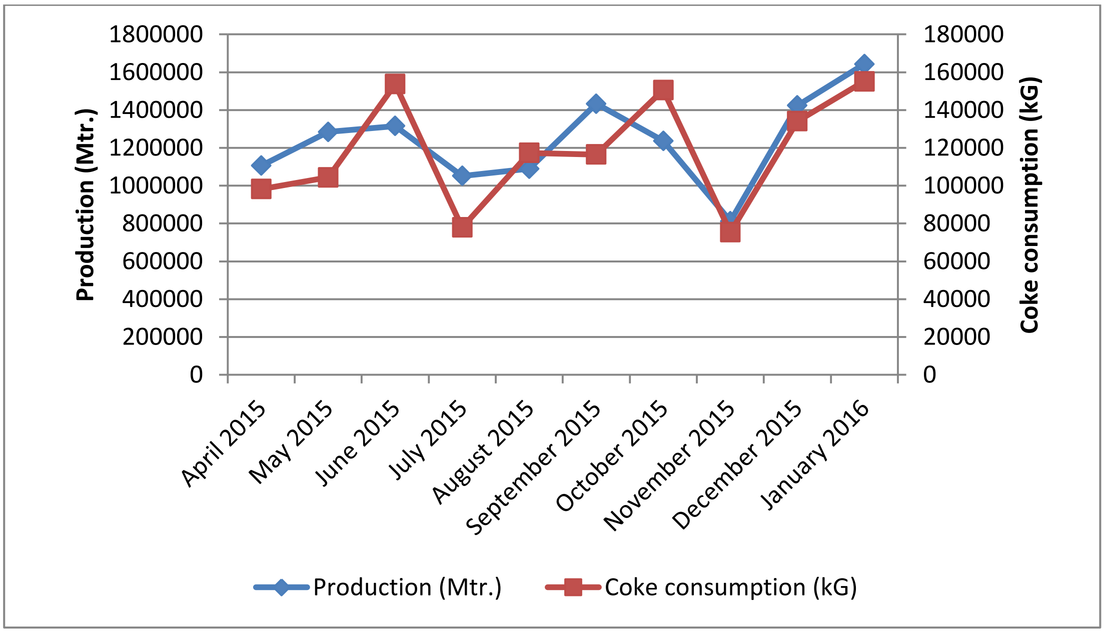

Figure 1.2. ***Monthly variation of production and coke cosumption***

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Figure 1.3 and ***Figure 1.4*** below respectively depicts the variation in specific electrical energy consumption and specific thermal energy consumption vis-à-vis the monthly production for last one year.

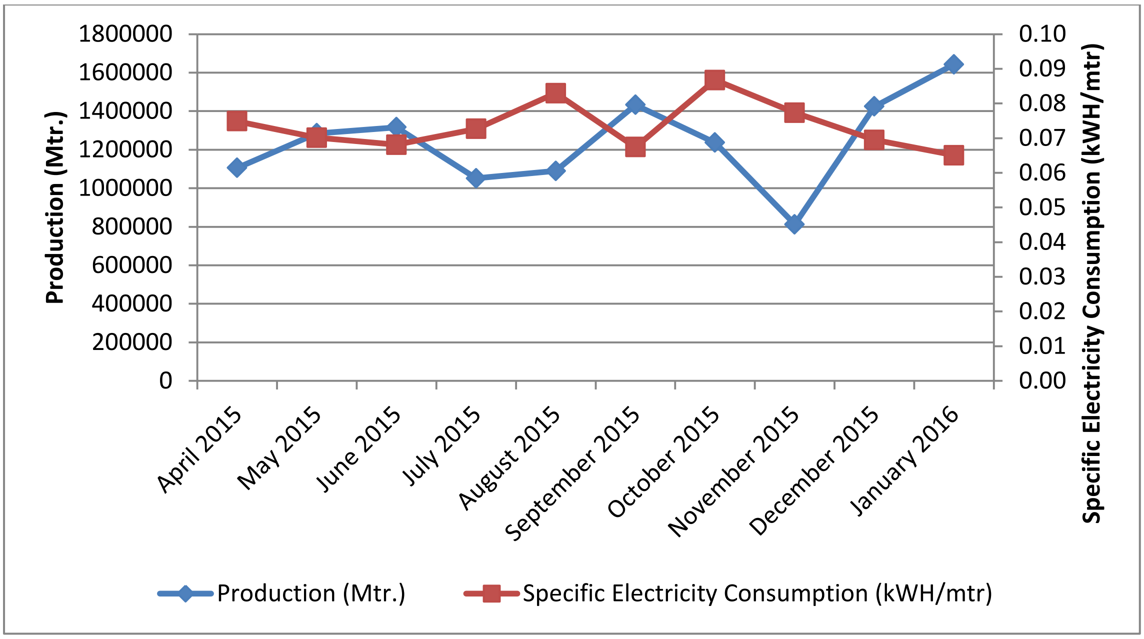

Figure 1.3: ***Variation in specific electrical energy consumption and monthly production***

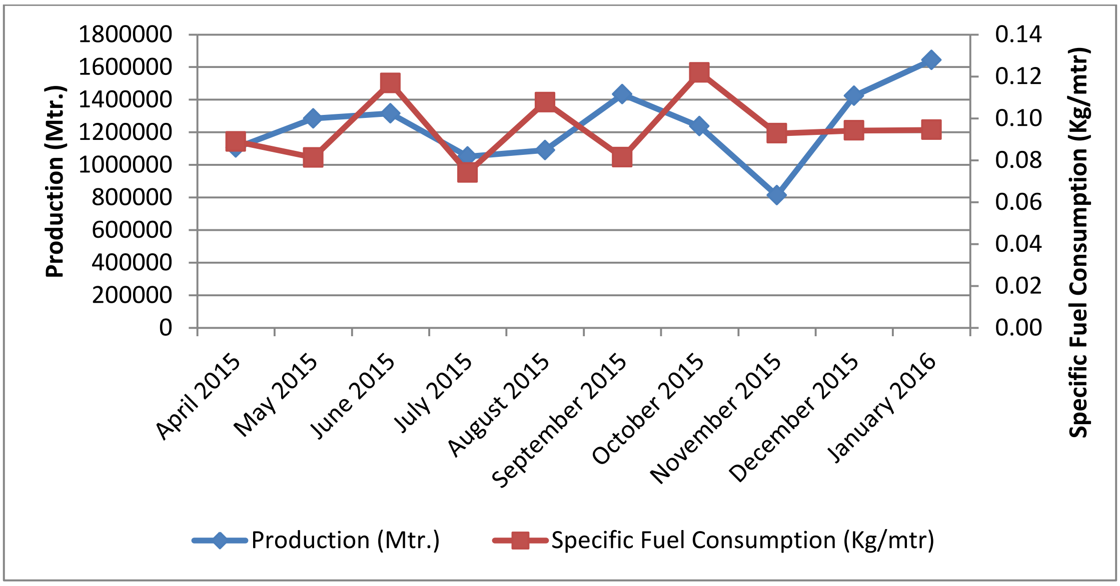

Figure 1.4.: ***Variation in specific fuel consumption (coke) and monthly production***

According to the assessment of the energy consumption data as reported by the unit (filled in questionnaire attached), the specific thermal energy consumption of the unit varies from 552 kCal/mtr to 711 kCal/mtr over a period of one year with an average of 602.40 kCal/mtr. The specific electrical energy consumption of the unit varies from 0.07 kWh/mtr to 0.09 kWh/mtr over a period of one year with an average of 0.07 kWh/kg. The unit used coke as fuel with a calorific value of 8200 kCal/mtr. The total average specific energy consumption (in kcal), based on reported data for one year, is estimated as **665.58 kCal/mtr** of product. The energy consumption pattern for the unit has been summarized below at ***Table 1.1***:

Table 1.1: ***Energy consumption details of Shree Rajaram Mills***

SN	Parameter	Unit	Value
1	Name and address of unit	Shree Rajaram Mills F-338 to 342, Mandia Road Industrial Area, Pali, Rajasthan-306401	
2	Contact person	Mr. Manish Gupta, Manager	
3	Manufacturing product	Processed cloth (Cotton/ Polyester)	
4	Daily Production	80,000 mtr per day	
Energy utilization			
5	Average monthly electrical energy consumption	kWh	90,162
6	Average monthly fuel (coke) energy consumption	kg	1,18,344
7	Average specific thermal energy consumption	kCal/mtr	602.40
8	Specific electrical energy consumption	kWh/mtr	0.07
9	Specific energy consumption[1,2]	kCal/mtr	665.58
10	Electrical energy cost[3]	Rs/mtr	0.48
11	Thermal energy cost[3]	Rs/mtr	0.71

Note:

[1]: Specific gross calorific value of Coke has been considered as 8200 kCal/kg

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

[3]: The unit operates for 25 days a month (1 shift of 12 effective hours per day).
Cost of electricity has been taken as Rs 6.50 / kWh
Cost of coke has been taken as Rs 7.5 /kg

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1.3 PRODUCTION PROCESS OF PLANT

The ***Figure 1.5*** below shows the typical process employed at processing of textile products at Shree Rajaram Mills:

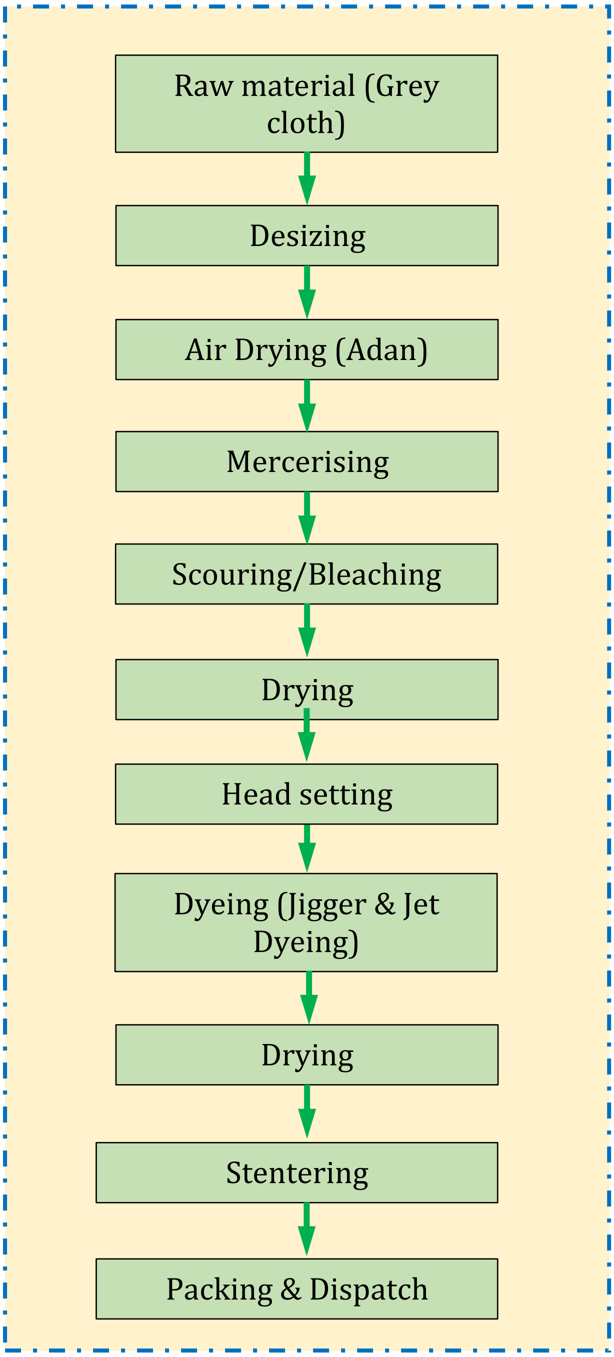


Figure 1.5: ***Production process at Shree Rajaram Mills***

1.4 ENERGY AUDIT METHODOLOGY

The primary objective of the energy audit was to quantify the existing energy consumption pattern and to determine the operating efficiencies of key existing systems. The key points targeted through energy audits were determination of specific energy consumption, various losses, operation practices like production, fuel consumption, steam utilization and losses, process temperatures, electrical energy consumptions etc. Pre – planned methodology was followed to conduct the energy audits. Data collected at all above steps were used to calculate various other operating parameters like material processing rate (mtr/hr), specific electricity consumption (kWh/kg), specific steam utilization (kg/kg), etc. The energy audit methodology is depicted in ***Figure 1.6*** below:

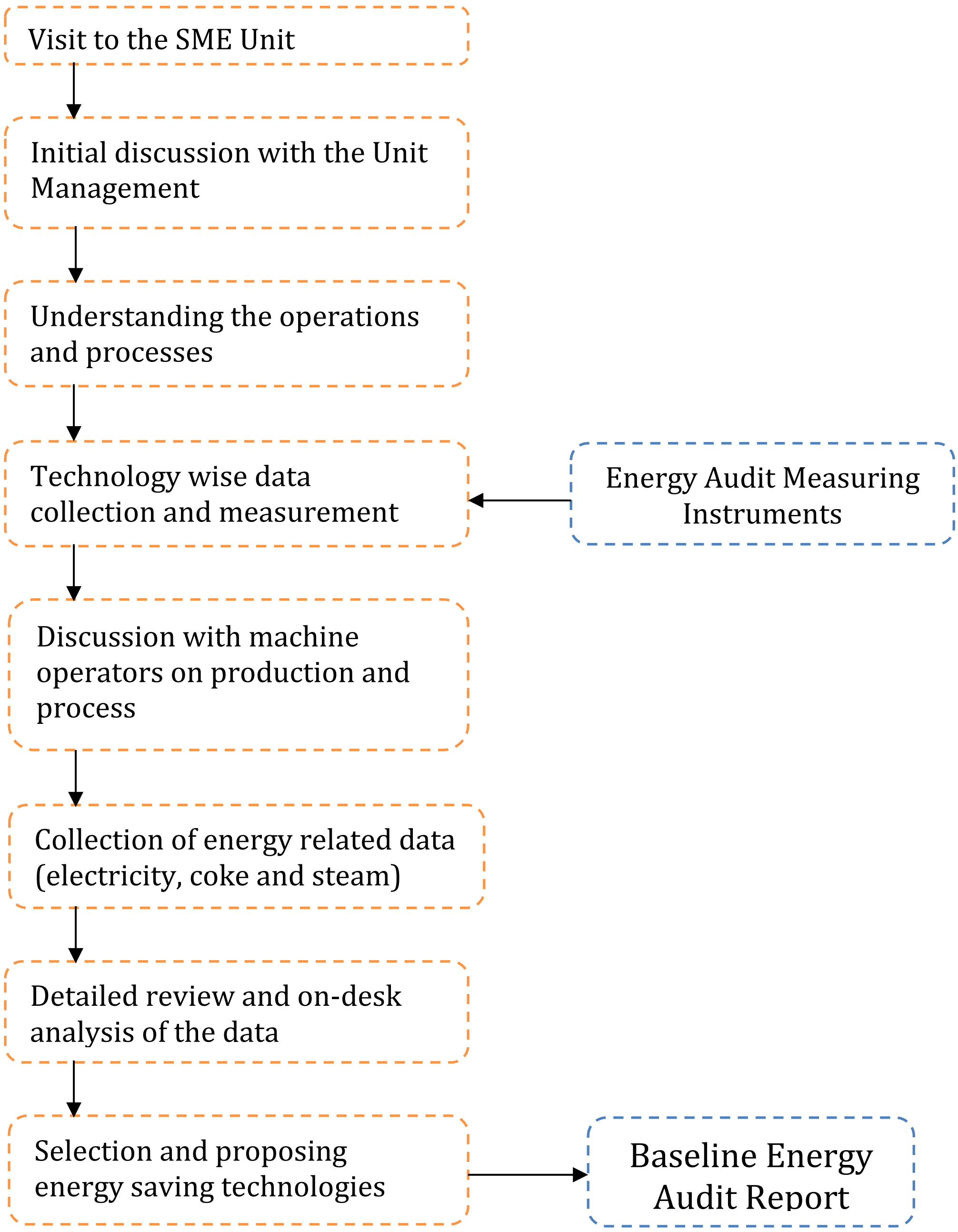
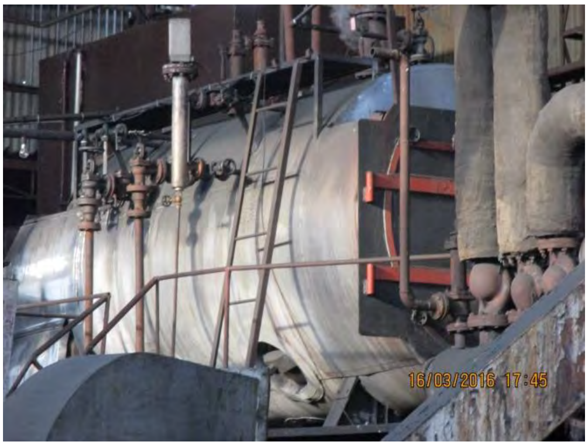


Figure 1.6: ***Energy audit methodology***

1.5 UNIT PHOTOGRAPHS



Caption: Boiler unit at Shree Rajaram Mills

Caption: Thermic-fluid heater at Shree Rajaram Mills

Caption: Cotton dyeing using jigger machines

Caption: Finishing operation

Caption: Finishing operation using Stenter

Caption: Caustic unit at Shree Rajaram Mills

Present Process, Observations and Proposed Technology

2.1 INSTALLATION OF THERMOPAC AUTOMATION

2.1.1 Present Process

Shree Rajaram Mills has a thermic-fluid heater (thermo-pac) of 1000 U capacity. Pet-coke is used as the fuel for the thermopac. The heating chamber consists of a fluidized bed of coke wherein air is supplied from bottom. The heat generated by combustion of coke and air is used to heat thermic fluid to required temperature. The heated thermic-fluid generated is used in various processes across the unit. The thermic fluid heater operates for an average of 12 hours daily.

2.1.2 Observations

The Thermic fluid (TF) temperature is dependent primarily on the following factors:

- The amount of fuel fired inside the thermopac furnace for combustion
- The amount of air going to the bed of the furnace for combustion.

Proper combustion of the fuel is very important factor in maintaining good thermopac efficiency, reliability and pollution free environment. To maintain constant thermic fluid outlet temperature the fuel firing rate should also change as per the change in the oil temperature. This leads to the requirement of combustion control system which incorporates the temperature transmitter, the temperature controller and a mechanism to maintain correct air-fuel ratio to meet the varying steam demand. The existing thermopac used at Shree Rajaram Mills does not have provisions of monitoring and control of thermic fluid temperature and thermopac combustion.

Based on the detailed study of the unit, it is proposed to install a temperature based control system for the thermopac. This can be achieved by means of a combustion controller. The combustion controller receives thermopac outlet temperature from temperature transmitter as process variable (PV) input. This input signal is used by the PID controller to control the fuel feed rate using a VFD. Thus, the air-fuel ratio remains fixed at every point during unit operations. Based on the change in forced draught (FD) speed and fuel feeding, the furnace draft will vary. This will be further controlled by secondary draft controlling loop with the help of draft transmitter and draft controller. By this process, the boiler chamber will be maintained at a slightly negative pressure.

2.1.3 Conclusion

As per the study conducted in the unit, it is suggested to install a temperature based PID control in the thermic-fluid heater. This system will be able to maintain the air-fuel ratio based on the thermic-fluid temperature and also control the furnace draught using secondary looping.

The installation of the temperature based automation in the thermic fluid heater and utilizing the same to control air-fuel ratio and furnace draught will lead to following benefits:

- Saving of fuel feed.
- Savings in electrical energy consumption
- Improvement in boiler efficiency
- Lower maintenance
- Improved environment

2.1.4 Cost Economics Analysis

The section below provides a cost benefit analysis for installation of economizer in the existing thermic-fluid heater for pre-heating boiler feed water of the unit:

Table 2.1: *Cost Economic Analysis of proposed economizer*

SN	Parameter	Unit	Value
1	Temperature in boiler chamber	°C	850
2	Temperature required	°C	800
3	Saving in energy	Kcal/h	11500
4	Saving in fuel (considering boiler efficiency of 50%)	kg/hr	3
5	Saving in specific fuel consumption	%	1
6	Annual saving in fuel	kg/annum	10098
7	Annual cost saving	Rs/yr.	75732
8	Investment	Rs/yr.	300000
9	Pay back	months	48

*Cost of fuel taken as Rs 7.5/kg

As per the detailed calculations done, it is proposed to install a temperature based automation system in the existing thermic-fluid heater. The estimated fuel saving with the installation is 10,098 kgs annually which can save an amount of Rs. 75,732 per year. Thus the cost of the system (estimated to be Rs. 3,00,000) can be recouped in 48 months.

2.2 INSTALLATION OF BOILER AUTOMATION

2.2.1 Present Process

Shree Rajaram Mills has installed a steam boiler of 3 tonnes capacity to generate wet steam required for the process. Steam is used at a working pressure of 4-5 kg/cm^2. Pet-coke is used as the fuel for the steam boiler. The heating chamber consists of a fluidized bed of coke wherein air is supplied from bottom. The heat generated by combustion of coke and air is used to heat water to form steam. The steam generated is used in various processes across the unit. The boiler operates for an average of 12 hours daily.

2.2.2 Observations

Combustion efficiency is an important parameter to determine the boiler efficiency. Combustion efficiency depends on 3 'Ts" i.e. temperature, turbulence and time. In case of

Rajaram Mills, there is not control on the fuel feeding rate and air supply to the boiler combustion chamber. Also, the unit does not have monitoring system for measuring the chamber temperature and free oxygen in the flue gas. In order to determine the combustion efficiency in the boiler chamber, oxygen percentage in the flue gas outlet was monitored in the unit using a flue gas analyzer. The oxygen percentage was observed to be 15% instead of the required level of 8%. This led to high amount of excess air in the boiler chamber thus leading to poor efficiency of the boiler.

The specific fuel consumption of coke was observed to be around 0.08 kgs of coke per meter of the processed cloth which is higher in comparison to the values for other units. It was observed that during operation, fuel supply was controlled manually without controlling the air flow rate. Further, there was no provision for measuring the temperature inside the boiler heating chamber.

Based on the detailed study of the unit, it is proposed to install an oxygen based control system in the steam boiler of the unit. The system will work based on the oxygen percentage in the flue gas, which will automatically control the forced draught (FD) and the induced draught (ID) fan. The fuel flow rate can also be monitored using an integrating a temperature based control system with the same. The correct amount of excess air maintained will lead to significant improvement in the combustion efficiency of the unit.

2.2.3 Conclusion

As per the study conducted in the unit, it is suggested to install an oxygen based automation control system in the steam boiler. This system will be able to maintain the correct oxygen and excess air percentage thus improving the boiler efficiency.

The installation of the oxygen based automation in the steam boiler will lead to following benefits:

- Saving of fuel feed.
- Savings in electrical energy consumption
- Improvement in boiler efficiency
- Lower maintenance
- Improved environment

2.2.4 Cost Economics Analysis

The section below provides a cost benefit analysis for installation of oxygen based control system in the existing steam boiler of the unit.

Table 2.2: *Cost Economic Analysis of proposed oxygen based automation system*

SN	Parameter	Unit	Value
1	Present O_2 level	% age	15
2	Theoretical air requirement	kg of air/kg of fuel	10.8
3	Excess air supply at present condition	% age	250
4	Actual mass of air supplied at present condition	kg of air/kg of fuel	37.8
5	Proposed O_2 level required	% age	8
6	Excess air supply after implementation of technology	% age	61.5
7	Reduction in sensible excess air		188.5
8	Reduction in fuel consumption	%	18.8
9	Hourly fuel consumption (present)	kg/hr	197
10	Hourly fuel consumption after installation	kg/hr	160
11	Annual fuel saving	kg/yr	67846
12	Annual monetary saving	Rs/yr	508846
13	Investment	Rs	700000
14	Payback	months	17

* With every 10% reduction in excess air leads to a saving in specific fuel consumption by 1%

It is therefore proposed to install an oxygen based automation control system in the existing steam boiler the estimated fuel saving with the installation is 67,846 kgs annually which can save an amount of Rs. 508846 per year. Thus the cost of the economizer (estimated to be Rs. 7, 00,000) can be recouped in 17 months period.

2.3 CONDENSATE RECOVERY SYSTEM IN JET DRYING MACHINE

2.3.1 Present Process:

Shree Rajaram Mills has installed 2 numbers of jet dyeing machines. These machines are used for pressurized dyeing (Colouring) process, used mainly for polyester based fabric. Steam at a working pressure of 4-5 kg/cm^2 along with water is used in the jet dyeing process. A significant amount of steam is lost during the heating operation of the jet dyeing process, as the portion of the latent heat is transferred to the equipment line resulting in condensate formation. Also, a significant amount of steam is transformed to condensate during the cooling cycle of the jet dyeing process. In addition to these, heat available in exit water generated during the process is wasted during the water recycling process. The unit has 2 numbers of jet dyeing machines, each having a capacity to use steam at 200 to 250 kg/hour. The jet dyeing operation is done in 3 batches in a day, each batch having a capacity of dyeing 1500-2000 meters of cloth per jet machine.

2.3.2 Observations

The jet dyeing process is a batch dyeing process in which dyeing is accomplished in a close tabular system, basically composed of an impeller pump and a shallow dye bath. The fabric to be dyed is loosely collapsed in the form of a rope, and tied into a loop. The impeller pump supplies a jet of dye solution, propelled by water which transports the fabric into the dyeing system, surrounded by dye liquor, under optimum conditions.

Turbulence created by the jet aids in dye penetration and prevents the fabric from touching from touching the walls of the tube, thus minimizing mechanical impact in the fabric. Steam is supplied during the heating process for better heat penetration and to create optimum dyeing conditions. Each operational cycle lasts for 2-3 hours which includes heating process, dyeing process and cooling operations. The cloths are dyed in pressurized conditions with the help of steam and water. A significant portion of steam is converted into water droplets due to condensation. When steam condenses, at the threshold or instant of phase change, the condensate temperature is the same as steam because only the latent heat has been lost, and the full amount of sensible heat remains. This condition is known as "Saturated Water". Not wasting, but rather recovering and reusing as much of this sensible heat as possible through installation of condensate recovery system.

2.3.3 Conclusion

In order to recover heat lost through condensate, it is proposed to install a condensate recovery system in the jet dyeing machines. Condensate recovery is a process to reuse the water and sensible heat contained in the discharged condensate. Recovering condensate instead of throwing it away can lead to significant savings of energy, chemical treatment and make-up water. Condensate can be reused in many different ways, for example:

- As heated feed water, by sending hot condensate back to the boiler's deaerator
- As pre-heat, for any applicable heating system
- As steam, by reusing flash steam
- As hot water, for cleaning equipment or other cleaning applications

The system includes a positive displacement condensate pump which can recover (suck) hot condensate and flash steam from the steam pipeline and feed the same into the boiler feed water tank. The pump may also be equipped with an in-built receiver for condensate which eliminates the need for a separate storage tank. The installation of the system will allow 100% recovery of condensate formed during the jet dyeing process. The technology can be suitably modified for mechanical or sensor based control.

Benefits of the condensate recovery system are:

- Reduced fuel cost
- Lower water related expenses
- Positive impact on safety and environment

2.3.4 Cost Economics Analysis

The section below provides cost benefit analysis for the installation of condensate recovery system (CRS) in the jet dyeing machine.

Table 2.3: *Cost Economic Analysis of proposed condensate recovery system in jet dyeing machine*

SN	Particular	Unit	Value
1	No. of Jet Dyeing Machine	no	2
2	Steam Consumption of Jet Dyeing M/c per hr	kg/hr	250
3	No.of Batches per day	no	5
4	Condensate recovery potential (considering heating cycle of 45 mins)	kg/day	1875
5	operating days	days	330
6	Sensible heat @ 4kg/cm^2	kcal/kg	144
7	Sensible heat @ 0.5 kg/cm^2	kcal/kg	111
8	Latent heat @ 0.5 kg/cm^2	kcal/kg	532
9	Flash steam quantity saved	kg/day	116
10	Savings with flash stem (A)	Rs	38381
11	Balance condensate stem	kg/day	1759
12	Temperature of condensate	°C	95
13	Make up water temperature	°C	35
14	Gain in enthalpy	kcal/d	105522
15	GCV of fuel	kCal/kg	8200
16	Cost of fuel	Rs/kg	7.5
17	Savings with condensate stem	Rs	79624
18	Total quantity of RO water generated per day	Ltr/day	1875
19	Cost of RO water per liter	Rs	0.3
20	Savings from Ro water per year (B)	Rs	185625
21	Total Saving (A+B)	Rs	303630
22	Cost of condensate recovery system	Rs	500000
23	Simple pay back	months	20
24	Fuel saving	kg/hr	87
25	Energy saving	%	16.67

*Cost of fuel has been taken as Rs 7.5/kg

The proposed condensate recovery system in the jet dyeing machine will lead to a saving of Rs 3, 03,630 annually. Thus the estimated investment of Rs 5,00,000 will be recouped in a period of 20 months.

2.4 BOILER FEED WATER TREATMENT

2.4.1 Present Process:

Shree Rajaram Mills has installed 1 number of steam boiler of 3 tonnes capacity. Since, Pali cluster do not have any internal source of water, water to be used in the boiler is sourced from nearby areas. Presently, the unit is not applying any kind of process treatment for the feed water to the boiler. The total dissolved solids (TDS) content in the boiler feed water intends to surplus the maximum permissible TDS of the boiler due to repeated use of water. This leads to frequent boiler blow-down operation of the boiler, where a certain amount of water is blown off and is automatically replaced by feed water thus maintaining the optimum level of total dissolved solids (TDS) in the boiler water. In Shree Rajaram Mills, boiler blow-down is carried out at a frequency of 4 hours every day. The frequency of blow-down is predominantly dependent of the high level of TDS in the boiler feed water. During each Blow-Down (BD) operation, a large quantity of energy in the form of steam is wasted into the atmosphere.

2.4.2 Observations

The TDS level of the feed water used for the steam boiler at Shree Rajaram Mills was reported to be 500 ppm, which when continuously used intends to surplus the permissible TDS level which is around 2000-3000 ppm. When feed water enters the boiler, the elevated temperature and pressure cause the components of water to behave differently. Under heat and pressure, most of the soluble components in the feed water come out of the solution as particulate solids, sometime in crystalized forms and other times as amorphous particles. When solubility of a specific component in water is exceeded, scale or deposits develop. Deposit in boilers may result from hardness contamination of feed water and corrosion products from the condensate and feed water system. Deposits and corrosion result in localized heating, efficiency losses and may ultimately result in failure of boiler tube and inability to produce steam. In order to avoid deposits or scale formation in the boiler lining, blow-down operation is carried out in the boiler. The process of blow-down involves blowing off a portion of the water and replacing it with fresh feed water.

In case of Shree Rajaram Mills, intermittent blow-down operation is practiced at frequency of 4 hours. The blow-down is done with the use of a valve fitted to discharge pipe at the lowest point of the boiler. The blow-down process is carried out for a period of 1-2 minutes. Approximately 1500-1700 liters of water is lost every day in the blow-down operation.

In order to reduce the blow-down operation in the boiler and to maintain the permissible level of TDS, it is suggested for pre-treatment of boiler feed water. This external treatment of boiler feed water can be done in a number of ways. One of the most feasible options is the 'Reverse Osmosis' processes.

2.4.3 Conclusion

In order to maintain the TDS of boiler feed water close to the permissible range, it is suggested to install a revise osmosis (RO) plant in the unit. When solution of differing concentration are separated by a semi-permissible membrane, water from less concentrated solution passes through the membrane to dilute the liquid of high concentration, which is called osmosis. If the solution of high concentration is pressurized, the process is reversed and water from the solution of high concentration flows to the weaker solution. This is known as reverse osmosis. The quality of water produced depends upon the concentration of the solution on the high-pressure side and pressure differential across the membrane. The process is suitable for waters with high TDS.

Installation of the RO system of required capacity can lead to considerable reduction in boiler blow-down, thus leading to a saving in steam. The membrane for RO system can be suitably selected based on the TDS level of the unit.

Benefits of the installation of the RO system are:

- Lower boiler blow-down
- Less make up water consumption
- Steam saving as a result of reduced blow down
- Reduced maintenance downtime
- Increased boiler life
- Reduced fuel cost

2.4.4 Cost Economics Analysis

The section below provides cost benefit analysis for the installation of RO system in the boiler feed water line:

Table 2.4: Cost Economic Analysis of proposed RO system

SN	Parameter	Unit	Value
1	Quantity of steam generated per hour	kg/hr	3000
2	Quantity of fuel used per hour	kg/hr	394
3	Quantity of fuel used to generate 1 kg of steam	kg/kg	0.131
4	**Without RO**		
5	Frequency of blow down per month	no.	75
6	No. of blow downs in a year	no.	900
7	Steam lost in each blow down	kg	533
8	Steam lost in year	kg	480000
9	Fuel used to generate lost steam	kg	63040
10	**With RO**		
11	Frequency of blow down	no.	25
12	No. of blow downs in a year	no.	300
13	Steam lost in each blow down	kg	533
14	Steam lost in year	kg	159900
15	Fuel used to generate lost steam	kg	21000.2
16	Annual saving in fuel	kg	42039.8
17	Percentage saving in fuel consumption	%	3.0
18	Annual cost saving in fuel	Rs	315298.5
19	Annual cost saving in terms of make-up water and boiler maintenance	Rs	12000
20	Annual cost savings	Rs	327299
21	Equipment cost	Rs	200000
22	Pay back	months	7

*Cost of fuel taken as Rs 7.5/kg

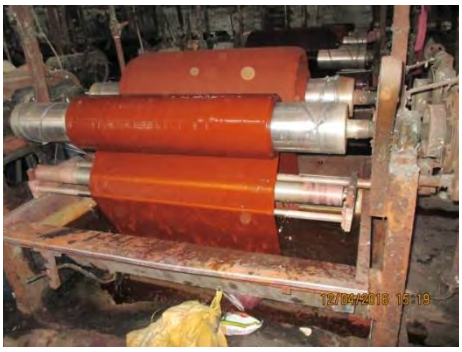
The proposed RO system will lead to an annual saving of 43,039 kgs of coke which implies to Rs 3,27,299 annual monetary benefits. The estimated equipment cost can thus be recouped in less than a year.

2.5 TEMPERATURE MONITORING AND CONTROL IN JIGGER MACHINES

2.5.1 Present Process:

Shree Rajaram Mills has installed a total of 20 Jigger machines, 16 small jiggers running with 3 HP motor each and 4 jumbo jiggers, each running with 5 HP motor. These jigger machines are used for dyeing of cotton cloth at elevated temperature of 60-80 ^{0}C depending on the type of fabric and the dye used. Steam is fed into the system for the required amount of elevated temperature. Once the dyeing process is over, the hot water is drained out of the factory. The temperature requirement for water is different for different grades of dyes and quality of fabric. However, no temperature monitoring system has been installed in the jigger machines. Monitoring and control of temperature of water is done purely based on manual interference.

2.5.2 Observations



Dyeing of cotton fabric is done with the help of a jigger machine. In this process the fabric is rotated in a shallow dip containing hot water. The temperature of the water depends on the type of dyeing agent and the quality of the fabric. Typically a temperature range between 60^{0}C to 80^{0}C is adopted based on different fabric quality and dye. Steam is used to bring amount the required temperature in the process. In case of Shree Rajaram Mills, no temperature monitors is being installed in any of the jiggers. The monitoring of water temperature and its control is purely done by manual interference. A study of the jigger water temperature showed off-shooting of temperature at certain places. Thus, a significant amount of energy in the form of steam required to heat water is being lost due to the absence of temperature monitoring and control system. It is suggested for installation of sensor based automatic temperature control and monitoring system in the jiggers.

2.5.3 Conclusion

In order to maintain the correct temperature profile in the jigger water, it is suggested to install a sensor based temperature monitoring and control system. This system can be used to monitor the temperature level of water in the jiggers and control the flow of steam by a pneumatically operated valve. This will be lead to optimum utilization of steam in the jiggers thus leading to a substantial energy savings.

Benefits of the installation of the temperature monitoring and control system in Jiggers machines are:

- Precision temperature control
- Reduced energy consumption
- Better quality of production
- Savings in terms of feed water to jiggers.

2.5.4 Cost Economics Analysis

The section below provides cost benefit analysis for the installation of temperature monitoring and control system in jiggers. For calculation purpose, it has been assumed that the system is installed in 10 nos. of jiggers.

Table 2.5: *Cost Economic Analysis of jigger water temperature monitoring and control system*

SN	Particulars	Units	Value
1	Temperature observed in Jigger	°C	95
2	Temperature to be maintained	°C	80
3	Machine Capacity	kg	200
4	Steam pressure	kg/cm^2	4
5	Steam Enthalpy @ 4 Kg /cm^2 pressure	kCal/kg	657
6	Liquor Ratio		0
7	Water Capacity	Kg	400
8	Specific heat coefficient (Cp)-water	kCal/kg °C	1
9	Specific heat coefficient (Cp)-fabric	kCal/kg °C	0.5
10	No. of batches per day	nos.	2
11	Saving of steam per batch	kg / hr	11
12	Saving of steam per day (considering 10 hrs heating period in 2 batch)	kg/day	114
13	Savings of steam per annum	kgs/annum	37648
14	Annual fuel savings	kgs	6563
15	Annual monetary savings	Rs	49225
16	Investment per jigger	Rs	25000
17	General payback period	Months	6
18	Annual fuel savings for 10 jiggers	Kgs	65634
19	Annual monetary savings for 10 jiggers	Rs	492252
20	Investment for 10 jiggers	Rs	250000
21	Pay-back	Months	6
22	Energy savings	%	5.70

*Cost of fuel taken as Rs 7.5 /kg

The proposed temperature monitoring and control system (estimated for 10 jigger machines) will lead to an annual fuel saving of 65,634 kgs of coal which means a monetary saving of Rs 4, 92,252. Thus the estimated investment of Rs 2, 50,000 can be recouped in around 6 months period.

Annexure 1

Questionnaire

Energy Audit – Questionnaire Form

BEE National Programme
On
"Energy Efficiency in SMEs – Pali Textile Cluster"

Name of the MSME unit		Shree Rajaram Mills.
Address:		F-338 to 342 Mandia Road.
Ph. No:		
Name of the respondent		Manish Gupta.
Designation:		Production Manager.
Mobile No. / Email id		93144-64807
Unit details		
Year of Establishment		2007
Type of Products		Bleaching, Dyeing, Finishing.
Installed Capacity		80,000 mtr/day.
Operating hrs per day		24 hrs.
Connected Load (kVA or kW please specify)		
Supply Voltage (Volt)		440 Volt.
Duration of electricity supply		20 - 24 hrs.

Annual Energy Consumption/ Production

Financial Year (April to March)	2013-14	2014-15	2015-16
Coke consumed (kg)			
Biomass Briquettes			
Wood			
Cost of coke (in Rs.)			
Electrical units consumed (In kWh)			
Electricity charges (in Rs.)			
LDO/HSD/ FO consumption (L)			
Fuel Cost (in Rs.)			
Production (Kg)			

Source and Calorific Value of Fuels:

Fuel	Source	Calorific Value (kCal)
Coke (Kg)		
Biomass Briquettes		

For: Shree Rajaram Mills

Manager

		Wood		
		HSD (L)		
		LDO (L)		
		FO (L)		
		Electricity (kWh)		

Monthly Energy Consumption and Production Data

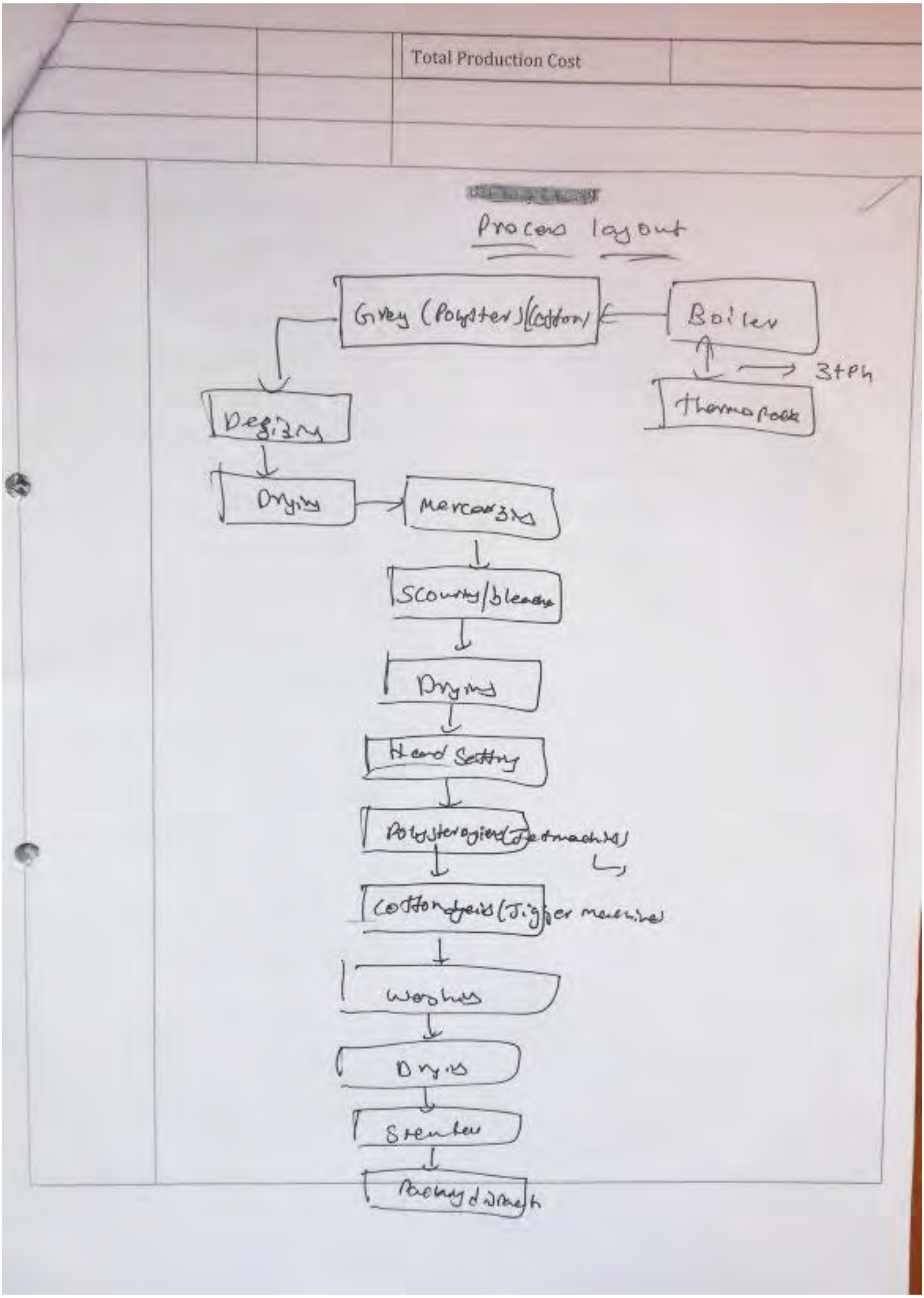
Month	Production ~~(Kg)~~ (Than)	Pet Coke consumption ~~(Kg)~~ Rs Ton	Biomass /Wood Consumption (Kg)	Electricity consumption (kWH)	HSD/LDO /FO (L)	Any other fuel (specify units)
April'15	8502	98.25		82736 ~~82736~~		
May'15	9880	104.42		90056		
June'15	10122	153.75		89580		
July'15	8088	77.89		76384		
August'15	8383	117.32		90404		
September'15	11022	116.53		96604		
October'15	9513	150.59		107240		
November'15	6248	75.38		62808		
December'15	10955	134.12		98940		
January'16	12638	155.19		106868		
February'16	8015					
March'16						

Cost variables per Kg of Production

Cost Variable	Cost/ kg of production
Electricity Cost	Rs 6.5/kwh
Coke Cost	Rs 7.5/Kg
Fuel Cost (LDO/HSD/FO) etc.	NA
Labour Cost	
Material Cost	
Other Cost	

For: Shree Raja...

Manager



Total Production Cost
Process layout
Boiler
3TPh
Thermopack
Drying
Heat Setting
Washing
Stenter

SHREE RAJA RAM MILL'S PALI

Kamal®

केमीकेल		
(1) परवा	10 नग x 7.5 H.P. प्रतिमोटर	75 HP
(2) स्टेंटरिंग	1 नग x 5 HP	5 HP
(3) मेंगल	1 नग x 7½ HP	7½ HP
(4) Auto fix	1 नग x 5 HP	5 HP
(5) चुनरी रोल	1 नग x 2 HP	2 HP
(6) ड्रायनिर	2 नग x ½ HP	1 HP
(7) हेडिंग टैंकर	1 नग x 5 HP	5 HP
(8) मैनमोटर	1 नग x 15 HP	15 HP
(9) फ्लोटर	2 नग x 3 HP	6 HP
(10) फलोमोटर	1 नग x 5 HP	5 HP
जिगर	16 जीगर x 3 H.P. प्रतिमोटर	48 HP
	4 जम्बो x 5 HP प्रतिमोटर	20 HP
सोफ्ला	1 मोटर 20 HP	20 HP
	1 कम्प्रेसर 3 HP	3 HP
	रोल 3 नग x 1½ HP प्रति	4½ HP
	पम्प 1 नग x 5 HP	5 HP
कुण्डी	2 मोटर 7½ HP प्रति	15 HP
	परवा 2 नग x 3 HP प्रति	6 HP

For: Shree Rajaram Mills

Manager

J.T.	4 × 5 HP	20 HP
पखा	4 × $1\frac{1}{2}$ HP	6 HP
कैथल	2 नग × 10 HP	20 HP
पखा	2 नग × $1\frac{1}{2}$ HP	3 HP
महाराज	1 नग × 10 HP	10 HP
	2 नग × 5 HP	10 HP
	5 नग × $7\frac{1}{2}$ HP	$37\frac{1}{2}$ HP
पम्प	1 नग × $1\frac{1}{2}$ HP	$1\frac{1}{2}$ HP
	कार्तिक 1 नग × 3 HP	3 HP
पम्प	4 नग × 5 HP (बन्द हैं)	20 HP
	2 नग × 2 HP (मिट्टी के)	4 HP

Kamal

[illegible]	
1× 7½ HP	7½ HP
4 नग × 5 HP	20 HP
पंप 1 नग × 3 HP	3 HP
थर्मीपॅक oil pump 2×15 HP – 1 चालू + 1 स्टँडबाय	30 HP
...नळी 1× 5 HP	5 HP
लिफ्ट 1× 3 HP	3 HP
ID fan 1× 7½ HP	7½ HP
FD 1× 12 HP	12 HP
1 पंप ऑइल सर्क्युलेटर 1 HP	1 HP
स्टीम बॉयलर 1 नग ID × 7½ HP	7½ HP
1 नग FD × 12 HP	12 HP
पंप 2 नग × 5 HP (1) चालू	10 HP
स्टरर 1 नग × ½ HP	½ HP
फिडर 1 नग × 1½ HP	1½ HP
पाणी टेंक (7)	
(1) 1× 7½ HP अंदर	7½ HP
1× 5 HP बाहेर	5 HP
(2) 1 पंप × 2 HP	3 HP
(3) 1 पंप × 3 HP	3 HP
R.O. 1 पंप × 7½ HP	7½ HP
(4) 1 पंप × 5 HP	5 HP
(5) 1 पंप × 5 HP	5 HP
(6) 1 पंप × 5 HP	5 HP
(7) पिण्याचे पाणी 1 पंप × 5 HP	5 HP

For: Shree Rajaram Mills

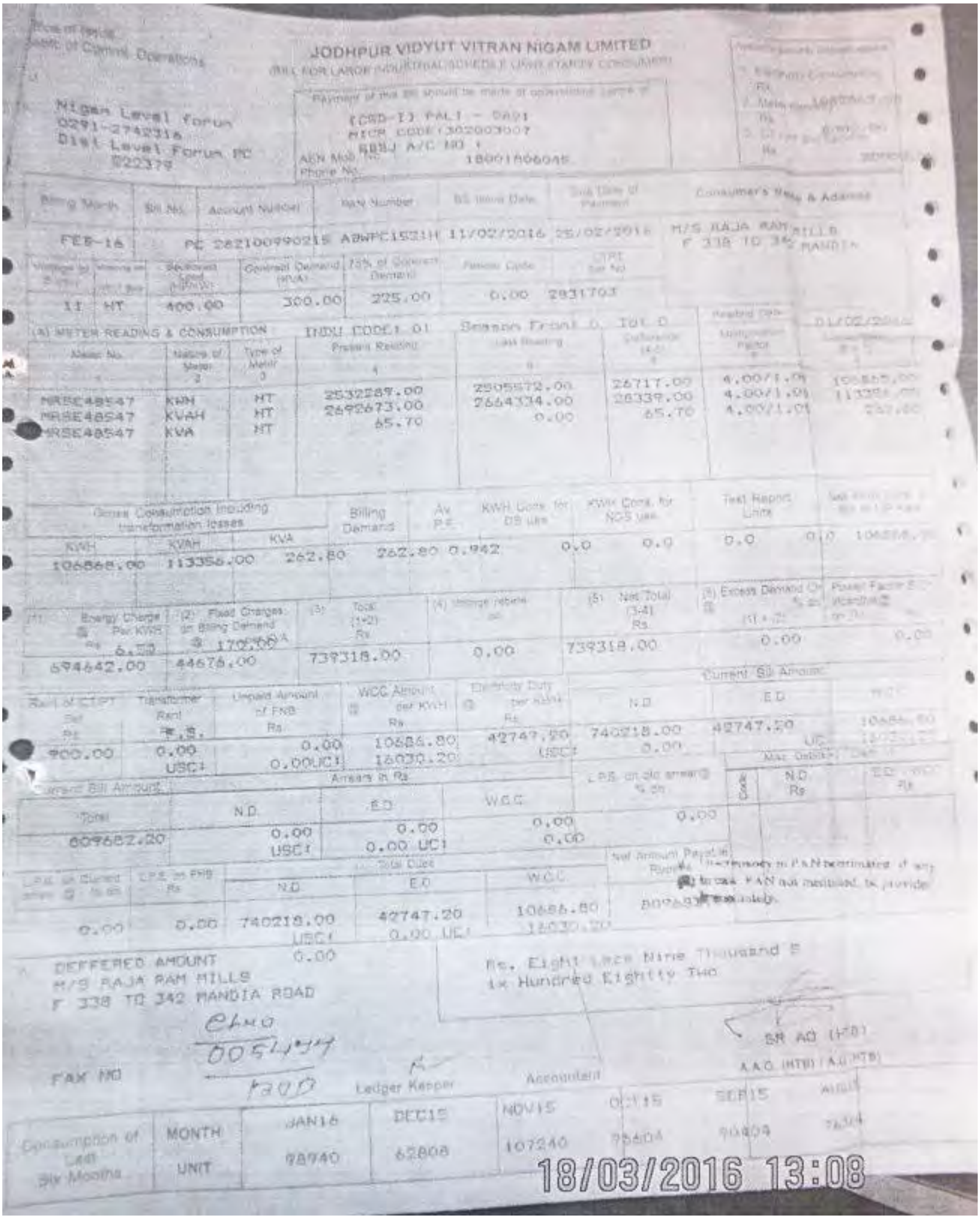
Manager

Kamal®

सोफ्ट	6 × 3 HP	18 HP
	1 × 5 HP	5 HP
कम्प्रेसर	1 × 12 HP	12 HP
	1 × 20 HP	20 HP
फ्लोराप	6 नग × $7\frac{1}{2}$ HP	45 HP
मेगाल	1 नग × 5 HP	5 HP
फ्लोटर	1 नग × 5 HP	5 HP
रेफ्रिजरेटर फैन	1 नग × 5 HP	5 HP
स्कुबिंग	1 × 5 HP चालू	5 HP
	1 × 5 HP बंद	5 HP

Kamal®

सिलिंग	1 × $7\frac{1}{2}$ HP	$7\frac{1}{2}$ HP
	4 × 3 HP	12 HP
	2 × 3 HP	6 HP
जेट	2 × $7\frac{1}{2}$ HP	15 HP
	4 × 1 HP	4 HP
डेको	1 × 5 HP	5 HP
	1 × 3 HP	3 HP
	2 × 1 HP	2 HP
पावर हाउस	1 × 5 HP	5 HP



JODHPUR VIDYUT VITRAN NIGAM LIMITED

Nigam Level Forum
0291-2742316
Dist Level Forum PC
822379

(CSD-I) PALI - 0A01
MICR CODE (302003007
SBBJ A/C NO :
AEN Mob. No. / Phone No. 18001806045

Billing Month	Bill No.	Account Number	PAN Number	Bill Issue Date	Due Date of Payment	Consumer's Name & Address
FEB-16	PC	282100990215	ABWPC1521H	11/02/2016	25/02/2016	M/S RAJA RAM MILLS F 338 TO 342 MANDIA

Voltage of Supply		Sanctioned Load	Contract Demand (KVA)	75% of Contract Demand		CT/PT Set No
11	HT	400.00	300.00	225.00	0.00	2831703

(A) METER READING & CONSUMPTION   INDU CODE1 01   Season Front 0   Tot 0

Meter No.	Nature of Meter	Type of Meter	Present Reading	Last Reading	Difference	Multiplication Factor	
MRSE48547	KWH	HT	2532289.00	2505572.00	26717.00	4.00/1.0	106868.00
MRSE48547	KVAH	HT	2692673.00	2664334.00	28339.00	4.00/1.0	113356.00
MRSE48547	KVA	HT	65.70	0.00	65.70	4.00/1.0	262.80

Gross Consumption including transformation losses KWH	KVAH	KVA	Billing Demand	Av P.F.	KWH Cons. for DS use	KWH Cons. for NDS use	Test Report Units	
106868.00	113356.00	262.80	262.80	0.942	0.0	0.0	0.0	0.0

(1) Energy Charge @ 6.50 Per KWH Rs	(2) Fixed Charges on Billing Demand @ 170.00	(3) Total (1+2) Rs	(4) Voltage rebate	(5) Net Total (3-4) Rs	(6) Excess Demand Charge	Power Factor
694642.00	44676.00	739318.00	0.00	739318.00	0.00	0.00

Rent of CT/PT Set Rs	Transformer Rent Rs	Unpaid Amount of FNB Rs	WCC Amount @ per KWH Rs	Electricity Duty @ per KWH Rs	Current Bill Amount N.D	E.D	W.C.C
900.00	0.00 USCI	0.00 0.00UCI	10686.80 16030.20	42747.20	740218.00 0.00 USCI	42747.20 UC	10686.80

Arrears in Rs

Current Bill Amount Total	N.D	E.D	W.C.C	L.P.S. on old arrear	
809682.20	0.00 USCI	0.00 0.00 UCI	0.00 0.00	0.00	

L.P.S. on Current arrear	L.P.S. on FNB Rs	Total Dues N.D	E.D	W.C.C	Net Amount Payable Rupees
0.00	0.00	740218.00 USCI	42747.20 0.00 UCI	10686.80 16030.20	809682

DEFFERED AMOUNT 0.00
M/S RAJA RAM MILLS
F 338 TO 342 MANDIA ROAD

Rs. Eight Lace Nine Thousand Six Hundred Eightty Two

FAX NO

Ledger Keeper   Accountant   SR AO (HTB)

Consumption of Last Six Months	MONTH	JAN16	DEC15	NOV15	OCT15	SEP15	AUG15
	UNIT	98940	62808	107240	95604	90404	76304

18/03/2016 13:08