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

Pali Textile Cluster

Baseline Energy Audit Report
K.B. Dyeing Mills (P) Ltd.




Submitted to

ENERGY IS LIFE
B E E
CONSERVE IT

Submitted by

InsPIRE

InsPIRE Network for Environment

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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 Palli 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 K. B. Dying Mills (P) Ltd.

Executive Summary

1. Unit Details

Unit Name	:	**K.B. Dyeing Mills (P) Ltd.**
Address	:	E-44, Mandia Road, Pali, Rajasthan- 306401
Contact Person	:	Mr. Praveen Kothari, Director (Cell no: 9414120350)
Products	:	Cloth processing (cotton & polyester)
Production		70,000 to 1,00,000 meters of processed cloth per day
DIC Number		08/020/12/00176
Bank Details		ICICI Bank, A/c No.: 684305110020, IFSC Code: ICIC0006843
TIN / PAN No.	:	TIN: 08823255664 PAN: AACCK2323F
Contract demand		280 KVA

2. Existing Major Energy Consuming Technology

Coke Based Steam Boiler

- Steam boiler with no provision for pre-heating of boiler feed water and combustion air. Also, the unit do not have boiler feed water treatment facility.
- Prevailing specific fuel consumption is 0.07 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

- 5 No's of Jet Dyeing machine and 2 Nos. of zero-zero machine with no provision for condensate recovery.
- Each jet machine uses steam at 250 kg/hr and each zero-zero 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) and 30,000 mtrs of processed cloth per day from zero-zero machine respectively.

Jigger Machine

- A total of 24 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 economizer in thermic fluid heater for boiler feed-water pre-heating.
- Installation of combustion air pre-heater in steam boiler.
- Installation of RO system for treatment of feed water to boiler.
- Installation of condensate recovery system for jet dyeing and zero-zero 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)
Economizer in Thermic fluid exit	10.43	14,73,291	3,00,000	2
Air-preheater (APH) in steam boiler	2.32	3,28,145	2,00,000	7
Reverse Osmosis (RO) system in steam boiler	3	2,91,021	2,00,000	8
Condensate Recovery System (CRS) in Jet Dyeing Machine	33.33	6,07,260	5,00,000	10
Condensate Recovery System (CRS) in Zero-Zero Machine	13.33	6,44,861	2,50,000	5
Temperature Monitoring & Control in Jigger Machines (for 10 Jiggers)	5.7	3,28,168	2,50,000	9
Total		**36,72,746**	**17,00,000**	

CHAPTER 1:

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 K.B. Dyeing Mills (P) Ltd., Pali, was established in the year 2004 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 E-44, Mandia Road, Pali. The unit operation is overseen by Mr. Praveen Kothari, Director.

The raw material procured by the unit includes grey (raw cloth) purchased from various sources predominantly from Gujarat and Maharashtra. The unit operates for 12 hours per day, presently.

The daily production lies in the range of 70,000 to 1,00,000 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 1,56,990 Kgs. The average monthly electricity consumption (derived from reported date of last one year) is 86,998 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.

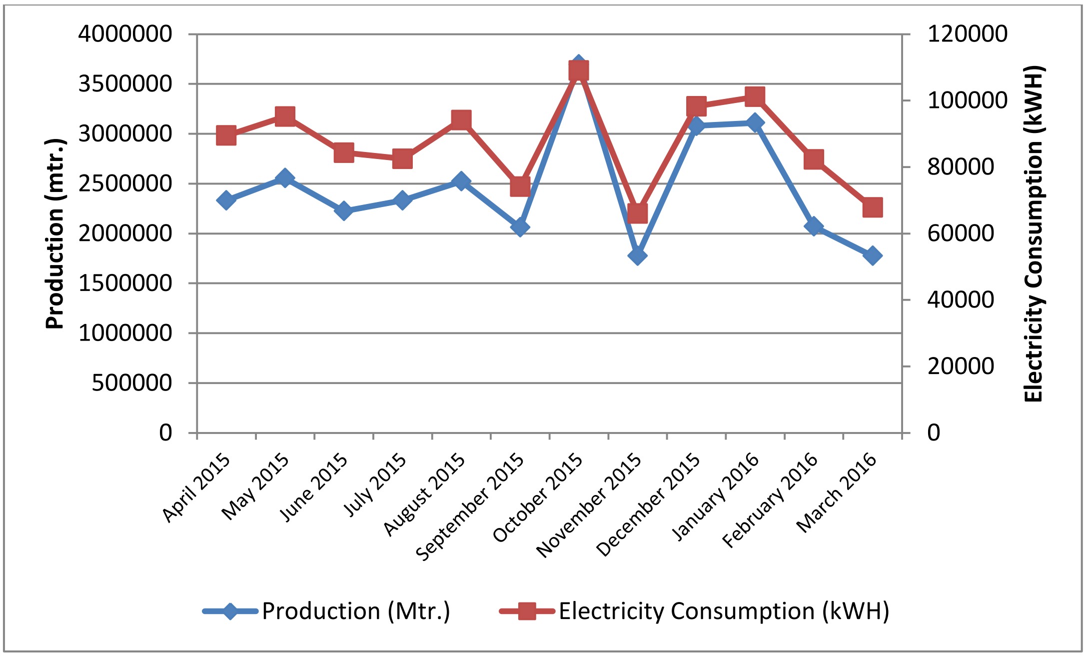

Figure 1.1: ***Monthly variation of production and electricity consumption***

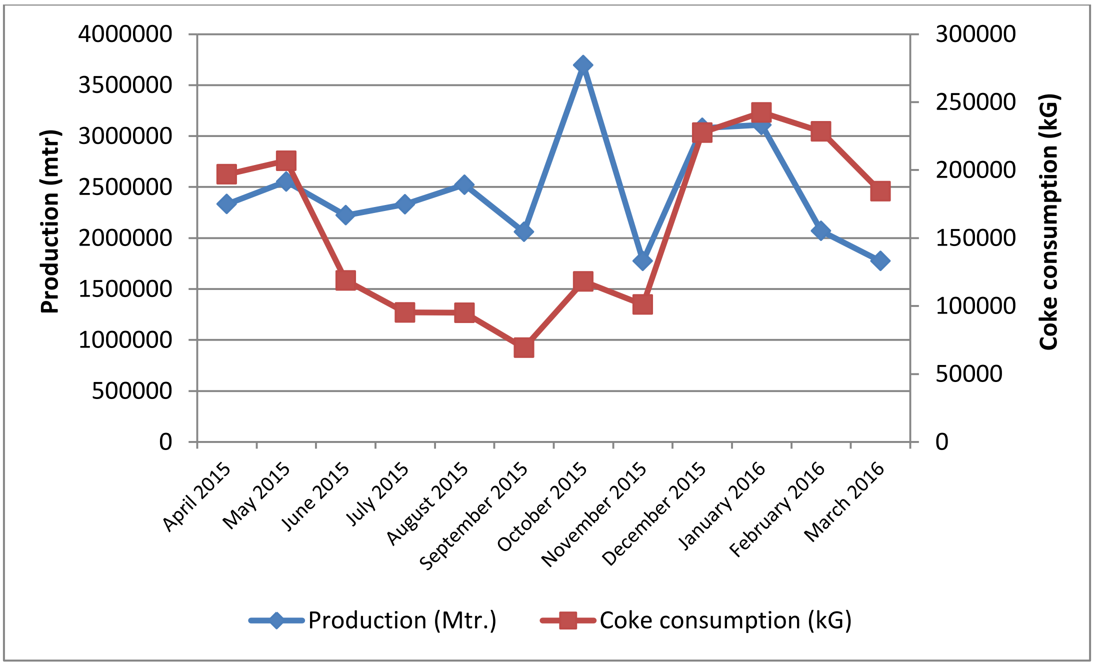

Figure 1.2: ***Monthly variation of production and coke cosumption***

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.

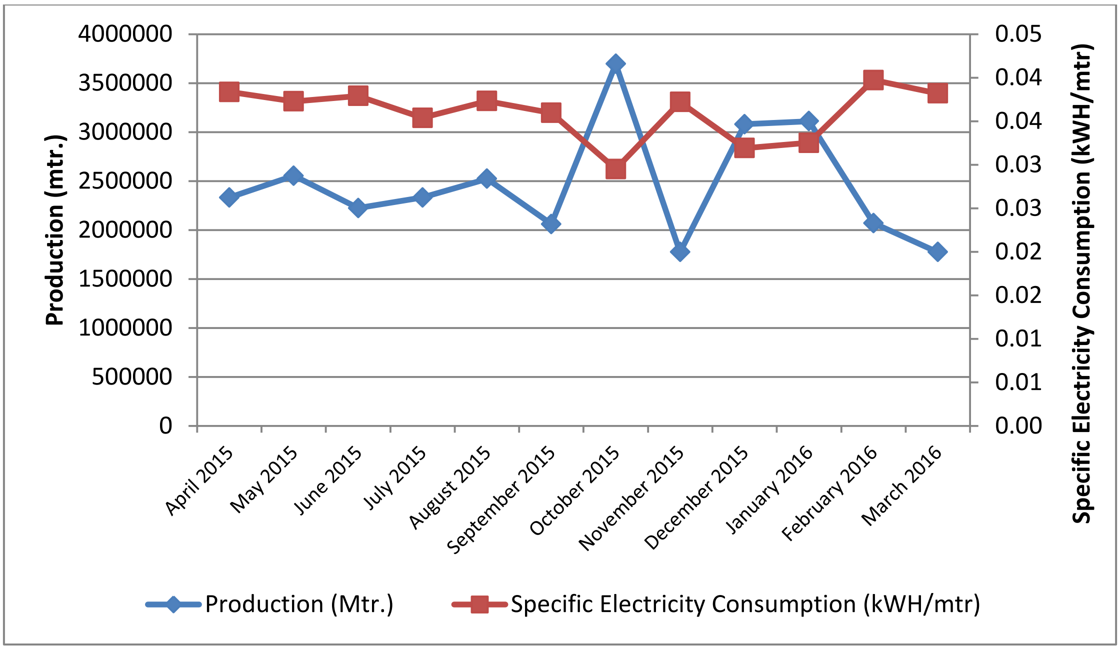

Figure 1.3: ***Variation in specific electrical energy consumption and monthly production***

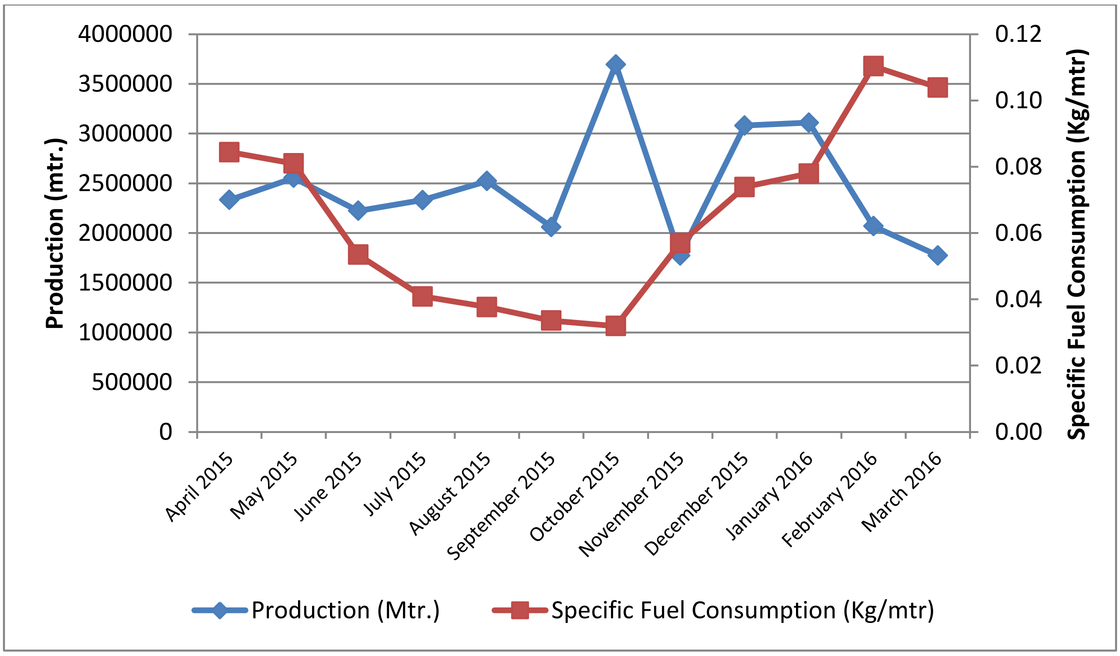

Figure 1.4: ***Variation in specific fuel consumption (coke) and monthly production***

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 241 kCal/mtr to 325 kCal/mtr over a period of one year with an average of 294 kCal/mtr. The specific electrical energy consumption of the unit varies from 0.03 kWh/mtr to 0.04 kWh/mtr over a period of one year with an average of 0.04 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 **325.56 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 K.B. Dyeing Mills (P) Ltd.***

SN	Parameter	Unit	Value
1	Name and address of unit	K.B. Dyeing Mills (P) Ltd., E-44, Mandia Road, Pali, Rajasthan-306401	
2	Contact person	Mr. Praveen B Kothari, Director	
3	Manufacturing product	Processed cloth (Cotton/ Polyester)	
4	Daily Production	70,000 to 1,00,000 mtr per day	
Energy utilization			
5	Average monthly electrical energy consumption	kWh	86,998
6	Average monthly fuel (coke) energy consumption	kg	1,56,990
7	Average specific thermal energy consumption	kCal/mtr	294.66
8	Specific electrical energy consumption	kWh/mtr	0.04
9	Specific energy consumption[1,2]	kCal/mtr	325.56
10	Electrical energy cost[3]	Rs/mtr	0.23
11	Thermal energy cost[3]	Rs/mtr	0.33

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.

1.3 PRODUCTION PROCESS OF PLANT

The ***Figure 1.5*** below shows the typical process employed at processing of textile products at K.B. Dyeing Mills (P) Ltd.:

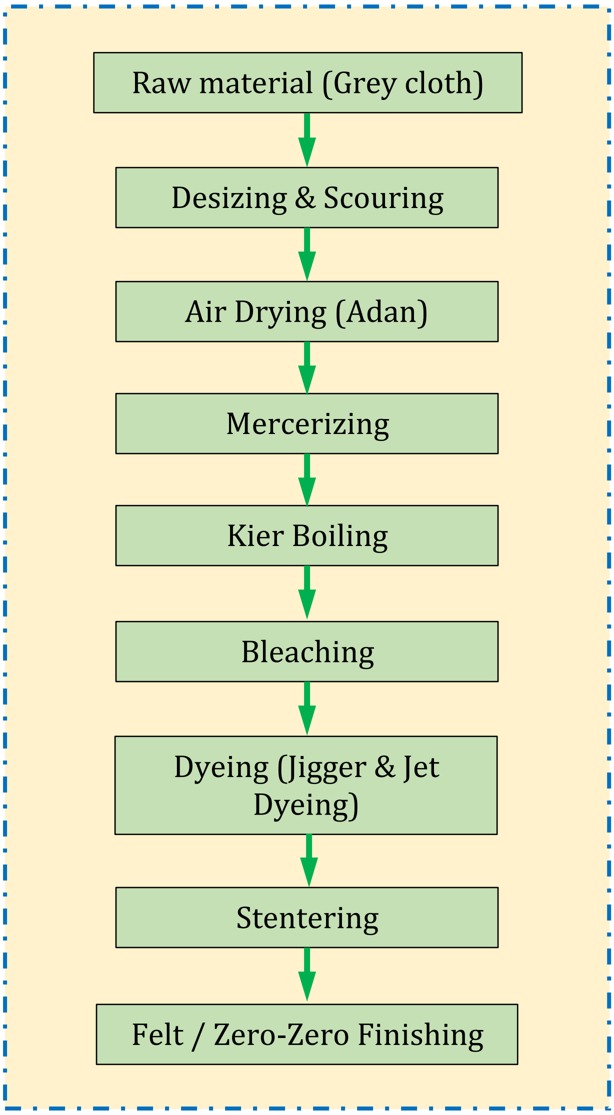

Figure 1.5: ***Production process at K.B. Dyeing Mills (P) Ltd.***

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:

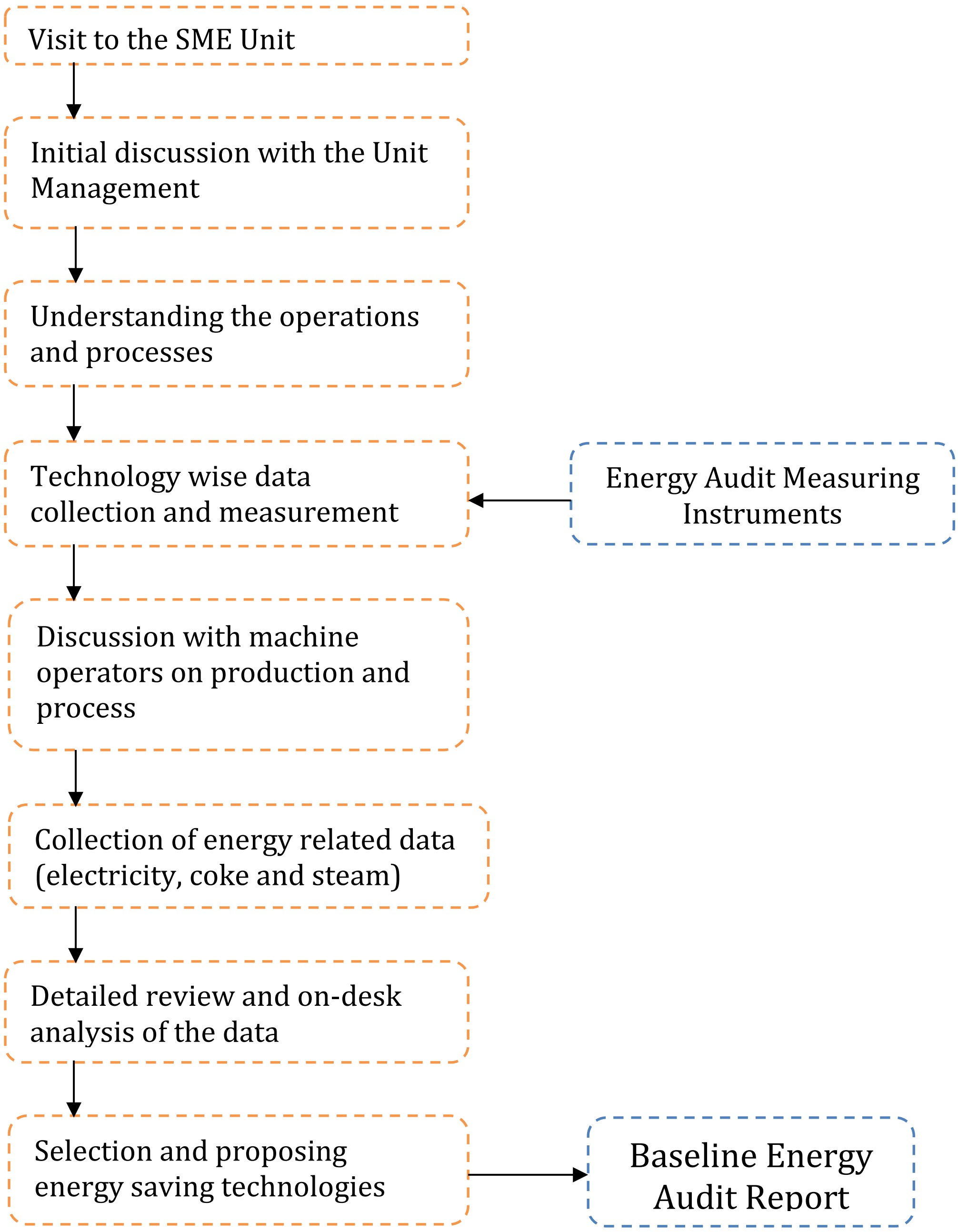

Figure 1.6: ***Energy audit methodology***

1.5 UNIT PHOTOGRAPHS

Caption: Natural drying of fabric at K.B. Dyeing Mills Pvt. Ltd

Caption: Cotton fabric dyeing using Jigger Machines

Caption: Polyester dyeing using Jet dyeing machine

Caption: Finishing operation using Stenter

Caption: Caustic processing unit at KB Dyeing

Caption: Thermo-fluid boiler unit at KB Dyeing

Present Process, Observations and Proposed Technology

2.1 INSTALLATION OF ECONOMIZER IN THERMIC-FLUID HEATER EXIT

2.1.1 Present Process

K.B. Dyeing Mills (P) Ltd. 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. The unit also has a thermic-fluid heater (thermo-pack) of 1000 U capacity. 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.

2.1.2 Observations

The steam boiler operating in the unit is a packaged boiler with fire tube design. Steam is the main agent of energy used in the textile processing unit. Thus, the boiler is the major energy utilizing source in the unit. The existing boiler used at KB Dyeing does not have provisions of waste heat recovery. The feed water to the boiler is fed at ambient temperature (35^{0}C) and the stack temperature was observed to be around 180^{0}C. Also, waste heat recovery system is not installed in the thermic-fluid heater. The flue gas temperature leaving the thermic-fluid heater was observed to be 240^{0}C. The combustion air to the boiler firing unit is also being fed at ambient temperature (35^{0}C). No monitoring is being done towards feeding of coke and air into the boiler. In order to analyse the boiler performance, a detailed study was carried out in the unit.

The specific fuel consumption of coke was observed to be around 0.07 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.

The flue gas temperature leaving at 240^{0}C from the thermic-fluid heater provides a potential for waste heat recovery. Stack temperature needs to be maintained above 120^{0}C in order avoid condensation of Sulphur oxides (SO) present in the flue gas which can cause corrosion. The available heat from a temperature difference of 120^{0}C is sufficient to rise the boiler feed water temperature by 60-65^{0}C. The increase in boiler feed water temperature can lead to substantial increase in boiler efficiency thus leading to reduction in specific fuel consumption.

2.1.3 Conclusion

As per the study conducted in the unit, it is suggested to install an economizer (boiler feed water heating system) in the thermic-fluid heater exit. This heat can be utilized to raise the boiler feed water temperature; thus pre-heating the boiler feed water.

The installation of the economizer in the thermic fluid heater and utilizing the same for pre-heating boiler feed water will lead to following benefits:

- Waste heat recovery
- Improvement in boiler efficiency
- Reduction in FD/ID fan power usage
- 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	Quantity of steam generated per hr (Q)	kg/hr	3000
2	Quantity of fuel used per hr (q)	kg/hr	523
3	Working Pressure	kg/cm^2	10
4	Temperature of feed water	^{0} C	35
5	Type of fuel		Coke
6	Calorific Value of fuel	kCal/kg	8200
7	Enthalpy of steam	kCal/kg	665
8	Enthalpy of feed water	kCal/kg	35
9	Boiler Efficiency	%	44
10	Flue gas temperature (in thermic fluid heater)	^{0} C	240
11	Steam generation per Kg of fuel	kg/kg	6
12	Flue gas quantity	kg/kg	15
13	Quantity of flue gas	kg/hr	7654
14	Quantity of heat available in flue gas	kCal/hr	211241
15	Rise in feed water temperature	^{0} C	63
16	Savings in terms of fuel from pre-heated boiler feed water	%	10.43
17	Savings in terms of fuel	kg/hr	55
18	Annual operating hrs	hrs	3600
19	Annual savings of fuel	kgs	196439
20	Annual cost savings**	Rs/yr	1473291
21	Cost of economizer	Rs	300000
22	Pay-back		2

* Every rise of 6ºC in boiler feed water temperature through waste heat recovery would offer about 1% fuel savings.

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

As per the detailed calculations done, it is proposed to install an economizer in the existing thermic-fluid heater outlet and utilizing the heat to pre-heat the boiler feed water. The estimated fuel saving with the installation is 1,96,439 kgs annually which can save an amount of Rs. 14,73,291 per year. Thus the cost of the economizer (estimated to be Rs. 3, 00,000) can be recouped in less than 4 months.

2.2 INSTALLATION OF AIR-PREHEATER FOR BOILER COMBUSTION AIR

2.2.1 Present Process

K.B. Dyeing Mills (P) Ltd. 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

The steam boiler operating in the unit is a packaged boiler with fire tube design. Steam is the main agent of energy used in the textile processing unit. Thus, the boiler is the major energy utilizing source in the unit. The existing boiler used at KB Dyeing does not have provisions of waste heat recovery. Combustion air to the boiler is fed at ambient temperature (35^{0}C) and the flue gas exit temperature was observed to be around 180^{0}C. No monitoring is being done towards feeding of coke and air into the boiler. In order to analyse the boiler performance, a detailed study was carried out in the unit.

The specific fuel consumption of coke was observed to be around 0.07 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.

The flue gas temperature leaving at 180^{0}C from the steam boiler provides a potential for waste heat recovery for combustion pre-heating. Stack temperature needs to be maintained above 120^{0}C in order avoid condensation of Sulphur oxides present in the flue gas which can cause corrosion. The available heat from a temperature difference of 60^{0}C is sufficient to rise the combustion air temperature by 100-120^{0}C. The increase in combustion air temperature can lead to substantial increase in combustion efficiency in the boiler heating chamber thus leading to reduction in specific fuel consumption.

2.2.3 Conclusion

As per the study conducted in the unit, it is suggested to install an air pre-heater (boiler combustion air pre-heat system) in the steam boiler exit. This heat can be utilized to raise the combustion air temperature.

The installation of the air preheater in the steam boiler and utilizing the same for pre-heating combustion air will lead to following benefits:

- Waste heat recovery
- Improvement in boiler efficiency
- Reduction in FD/ID fan power usage
- Improved environment

2.2.4 Cost Economics Analysis

The section below provides a cost benefit analysis for installation of air-preheater in the existing steam boiler of the unit.

Table 2.2: *Cost Economic Analysis of proposed combustion air-preheater*

SN	Parameter	Unit	Value
1	Exit flue gas temperature	^0C	180
2	Stack dew temperature	^0C	120
3	Available temperature for heat transfer	^0C	60
4	Quantity of steam generated per hour	kg/hr	3000
5	Quantity of fuel in the boiler	kg/hr	523
6	Specific heat of water	kCal/ kg ^0C	1
7	Steam generation per Kg of fuel	kg/kg	5.74
8	Flue gas quantity	kg/kg	20.69
9	Quantity of flue gas	kg/hr	10821
10	Quantity of heat available in flue gas	kCal/hr	149326
11	Rise in combustion pre-heat temperature	^0C	48.8
12	Savings in terms of fuel from pre-heated combustion air	%	2.32
13	Savings in terms of fuel	kg/hr	12.15352
14	Annual operating hrs	hrs	3600
15	Annual savings of fuel	kgs	43753
16	Annual cost savings**	Rs/yr	328145
17	Cost of air pre-heater	Rs	200000
18	Pay-back	months	7.3

* Every rise of 21^{0}C in combustion air pre-heat temperature through waste heat recovery would offer about 1% fuel savings.
**Cost of fuel taken as Rs 7.5 / kg

It is therefore proposed to install an air pre-heater in the existing steam boiler outlet and utilizing the heat to pre-heat the combustion air for the boiler. The estimated fuel saving with the installation is 43,753 kgs annually which can save an amount of Rs. 3,28,145 per year. Thus the cost of the economizer (estimated to be Rs. 2, 00,000) can be recouped in less than 8 months.

2.3 CONDENSATE RECOVERY SYSTEM IN JET DRYING MACHINE

2.3.1 Present Process

K.B. Dyeing Mills (P) Ltd. has installed 4 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 4 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 1100-1200 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	4
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	3750
5	Operating days	days	330
6	Sensible heat @ 4kg/cm2	kcal/kg	144
7	Sensible heat @ 0.5 kg/cm2	kcal/kg	111
8	Latent heat @ 0.5 kg/cm2	kcal/kg	532
9	Flash steam quantity saved	kg/day	233
10	Savings with flash stem (A)	Rs	76762
11	Balance condensate stem	kg/day	3517
12	Temperature of condensate	°C	95
13	Make up water temperature	°C	35
14	Gain in enthalpy	kcal/d	211043
15	GCV of fuel	kCal/kg	8200
16	Cost of fuel	Rs/kg	7.5
17	Savings with condensate stem	Rs	159248

SN	Particular	Unit	Value
18	Total quantity of RO water generated per day	Ltr/day	3750
19	Cost of RO water per liter	Rs	0.3
20	Savings from Ro water per year (B)	Rs	371250
21	Total Saving (A+B)	Rs	607260
22	Cost of condensate recovery system	Rs	500000
23	Simple pay back	months	10
24	Fuel saving	kg/hr	174
25	Energy saving	%	33.33

The installation of condensate recovery system in 4 nos. of jet dyeing machines will lead to a saving of Rs 6, 07,260 annually. The estimated cost of the equipment i.e. Rs 5,00,000 can be recouped in less than 10 months.

2.4 CONDENSATE RECOVERY SYSTEM IN ZERO-ZERO (FELT) MACHINE

2.4.1 Present Process:

K.B. Dyeing Mills (P) Ltd. has installed 2 numbers of felt machines. These machines are used for finishing operations wherein the fabric is rotated in circular rubber drum with blanket of steam rotating around it. Steam at a working pressure of 4-5 kg/cm^2 is used in the process. A significant amount of steam is lost during the operation, as the portion of the latent heat is transferred to the equipment line resulting in condensate formation. The unit has 2 number of zero-zero (felt) machines, each having a capacity to use steam at 200 to 250 kg/hour. Around 30,000 meters of cloth is processed in zero-zero machine every day

2.4.2 Observations

The felting or zero-zero process is carried through controlled compression shrinkage or pre-shrinking of the fabric by passing the fabric into rubber unit. This process forces the yarns closer together and the fabric becomes thicker and heavier and the dimensional stability of the fabric improves. This process is also called “sanforization”.

In the zero-zero finishing operation, fabric is passed between hot cylinder with steam in the inner line and endless rubber, heating of the cylinder takes place by steaming arrangements. Pressure is applied on the fabric between the rubber and cylinder by pressure roll. During this above operation shrinkage takes place on the fabric. During drying of fabric in the felt unit, the moisture is uniformly absorbed from the fabric by the felt blanket. And the shrinkage of the fabric is set. The unit also has a cooling cylinder which is used to further cool the fabric to normal temperature.

A significant portion of steam is converted into water droplets due to condensation in the zero-zero and felt operations. 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.

2.4.3 Conclusion

In order to recover heat lost through condensate, it is proposed to install a condensate recovery system in the zero-zero 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

2.4.4 Cost Economics Analysis

The section below provides cost benefit analysis for the installation of condensate recovery system in the zero-zero machine.

Table 2.4: *Cost Economic Analysis of proposed condensate recovery system in zero-zero machine*

SN	Particular	Unit	Value
1	No. of zero-zero machine	No	2
2	Steam consumption for zero zero machine	kg/hr	200
3	Operating hours per day	hrs	12
4	Condensate recovery potential	kg/day	4800
5	operating days	days	300
6	Sensible heat @ 4kg/cm2	kcal/kg	144
7	Sensible heat @ 0.5 kg/cm2	kcal/kg	111
8	Latent heat @ 0.5 kg/cm2	kcal/kg	532

SN	Particular	Unit	Value
9	Flash steam quantity saved	kg/day	298
10	Savings with flash stem (A)	Rs	89323
11	Balance condensate stem	kg/day	4502
12	Temperature of condensate	°C	95
13	Inlet temperature	°C	35
14	Gain in enthalpy	kcal/d	270135
15	GCV of fuel	kCal/kg	8200
16	Cost of fuel	Rs/kg	7.5
17	Savings with condensate stem	Rs	123538
18	Total quantity of RO water generated per day	Ltr/day	4800
19	Cost of RO water per liter	Rs	0.30
20	Savings from Ro water per year (B)	Rs	432000
21	Total Saving (A +B)	Rs	644861
22	Cost of condensate recovery system	Rs	250000
23	Simple pay back	months	4.65
24	Fuel saving	kg/hr	70
25	Energy saving	%	13.33

The installation of condensate recovery system in 2 nos. of zero-zero machines will lead to a saving of Rs 6, 44,861 annually. The estimated cost of the equipment i.e. Rs 5,00,000 can be recouped in less than 5 months.

2.5 BOILER FEED WATER TREATMENT

2.5.1 Present Process:

K.B. Dyeing Mills (P) Ltd. 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 KB Dyeing, 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.

2.5.2 Observations

The TDS level of the feed water used for the steam boiler at K.B. Dyeing Mills (P) Ltd. 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 KB Dyeing, 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.

2.5.3 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

2.5.4 Cost Economics Analysis

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

Table 2.5: *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	523
3	Quantity of fuel used to generate 1 kg of steam	kg/kg	0.174
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	83680
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	27875.9
16	Annual saving in fuel	kg	55804.1
17	Percentage saving in fuel consumption	%	3.0
18	Annual cost saving in fuel	Rs	418531
19	Annual cost saving in terms of makeup water and boiler maintenance	Rs	12000
20	Annual cost savings	Rs	430531
21	Equipment cost	Rs	200000
22	Pay back	months	6

*Cost of fuel taken as Rs 7.5 /kg

The proposed reverse osmosis system in the boiler feed water system will lead to an annual fuel saving of 55,804 kgs of coal with an monitory saving of Rs 4,30,531. Thus the investment for the system (estimated as Rs 2, 00,000) will be recouped in a period of 6 months.

2.6 TEMPERATURE MONITORING AND CONTROL IN JIGGER MACHINES

2.6.1 Present Process

K.B. Dyeing Mills (P) Ltd. has installed a total of 24 Jigger machines, 18 small jiggers running with 3 HP motor each and 6 jumbo jiggers, each running with 7.5 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.

2.6.2 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 KB Dyeing, 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.

2.6.3 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.

2.6.4 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 2.6: *Cost Economic Analysis of jigger water temperature monitoring and control system*

SN	Particulars	Units	Value
1	Temperature observed in Jigger	^{0}C	95
2	Temperature to be maintained	^{0}C	80
3	Machine Capacity	kg	200
6	Steam pressure	kg/cm2	4
7	Steam Enthalpy @ 4 Kg /cm2 pressure	kCal/kg	657
8	Liquor Ratio		0
9	Water Capacity	Kg	400
10	Specific heat coefficient (Cp)-water	kCal/kg ^{0}C	1
11	Specific heat coefficient (Cp)-fabric	kCal/kg ^{0}C	0.5
12	No. of batches per day	nos.	2
13	Saving of steam per batch	kg / hr	11
14	Saving of steam per day (considering 10 hrs heating period in 2 batch)	kg/day	114
15	Savings of steam per annum	kgs/annum	37648
16	Annual fuel savings	kgs	6563
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
**It has been estimated that the technology is implemented in 10 nos. of jiggers.

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

Questionnaire

Energy Audit – Questionnaire Form

(5)

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

Name of the MSME unit		K. B. DYEING MILLS (P.) LTD.
Address:		E-44, MANDIA ROAD, PALI
Ph. No:		94141-20350
Name of the respondent		PRAVEEN B. KOTHARI
Designation:		DIRECTOR
Mobile No. / Email id		SARVANKOTHARI@GMAIL.COM
Unit details		
Year of Establishment		2004
Type of Products		PROCESSING OF CLOTH
Installed Capacity		
Operating hrs per day		12 HRS PER DAY
Connected Load (kVA or kW please specify)		280 K.V.A.
Supply Voltage (Volt)		440 (VOLT)
Duration of electricity supply		24 HOURS
Annual Energy Consumption/ Production	(x130 Mtr)	see table below
Source and Calorific Value of Fuels:		see table below

Annual Energy Consumption/ Production:

Financial Year (April to March)	2013-14	2014-15	2015-16
Coke consumed (kg)	1159090/-	1469263/-	1883884/-
Biomass Briquettes	-NIL-	-NIL-	-NIL-
Wood	-NIL-	-NIL-	-NIL-
Cost of coke (in Rs.)	8072982/-	9213370/-	8744479/-
Electrical units consumed (In kWh)	846204	955584	1043976
Electricity charges (in Rs.)	5574567/-	6420308/-	7935219/-
LDO/HSD/ FO consumption (L)	6000	6600	7992
DIESEL Fuel Cost (in Rs.)	327340/-	383950/-	412984/-
THAN Production (Kg)	189047	199735	227136

Source and Calorific Value of Fuels:

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

For K. B. Dyeing Mills (P) Ltd.

Praveen

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		Wood		
		HSD (L)		
		LDO (L)		
		FO (L)		
		Electricity (kWh)	BY GOVT.	

Monthly Energy Consumption and Production Data

Month	Production (Kg) THAN (X 130 Mtr)	Coke consumption (Kg)	Biomass /Wood Consumption (Kg)	Electricity consumption (kWH)	HSD/LDO /FO (L) DIESEL (L)	Any other fuel (specify units)
April'15	17938	196800	-NIL-	89452	800	-NIL-
May'15	19646	206822	-NIL-	95184	400	-NIL-
June'15	17103	118847	-NIL-	84280	1200	-NIL-
July'15	17935	95256	-NIL-	82476	1200	-NIL-
August'15	19408	95076	-NIL-	94120	800	-NIL-
September'15	15846	69212	-NIL-	74052	800	-NIL-
October'15	28424	118089	-NIL-	109036	1192	-NIL-
November'15	13649	101074	-NIL-	66016	0	-NIL-
December'15	23695	227592	-NIL-	98276	400	-NIL-
January'16	23924	242401	-NIL-	101108	800	-NIL-
February'16	15919	228340	-NIL-	82204	0	-NIL-
March'16	13649	184377	-NIL-	67772	400	-NIL-

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.	
Labour Cost	NA
Material Cost	
Other Cost	

For K. B. Dyeing Mills (P) Ltd.

Auth. Sign./Director

Process Layout

DESIZE & SCOURING

↓

AIR DRY

↓

MERCERISE

↓

KEIR BOILING

↓

BLEACHING

↓

DYEING

↓

STANTERING

↓

COLLENDRING

For K. B. Dyeing Mills (P) Ltd.

Auth. Sign./Director

Major Energy Consuming Equipment

S. NO	Equipment	Energy Source	Make/ Supplier	Year of Installation	Technical Specification / capacity	Use	Comments
A	**BOILER STEAM**			Before 2005			
1	2 PUMP X 5 HP						
2	1 ID FAN X 20 HP (With Inverter Drive)						
3	1 FD FAN X 15 HP (With Inverter Drive)						
4	1 SCREW FIDDER X 1/2 HP						
5	1 CRASHER X 3 HP						
				Before 2005			
B	**THERMOPACK**						
6	1 PUMP X 20 HP (With Inverter Drive)						
7	1 FD FAN X 10 HP (With Inverter Drive)						
8	1 ID FAN X 20 HP (With Inverter Drive)						
9	1 SCREW FIDDER X 1/2 HP						
C	**JIGER**			Before 2005			
10	18 JIGER X 3 HP						
11	6 JIGER (JUMBO) X 7.5 HP (With Inverter Drive)						
D	**JET**			Before 2005			
12	2 MACHINE X 7.50 HP						
13	2 MACHINE X 10.50 HP						
E	**FELT**			Before 2005			
14	2 RUBBER UNIT X 15 HP						
15	2 BLANKET X 15 HP						
F	**STATENTER (2)**			Before 2005			
16	10 FAN Double Speed X 10 HP						
17	10 FAN Double Speed X 7.50 HP						
18	2 MANGLE MOTOR X 10 HP (With Inverter Drive)						

For K. B. Dyeing Mills (P) Ltd

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Major Energy Consuming Equipment

S. NO	Equipment		Energy Source	Make/ Supplier	Year of Installation	Technical Specification / capacity	Use	Comments
19	2 MAIN MOTOR	X 20 HP (With Inverter Drive)						
20	1 MOTOR	X 1/2 HP (With Inverter Drive)						
G	**MERCERIZING**				Before 2005			
21	5 MOTOR	X 10 HP WITH GEAR BOX						
H	**WATER PUMP**				Before 2005			
22	1 MOTOR	X 5HP						
23	2 MOTOR	X 7.50 HP						
I	**CAUSTIC PUMP**				Before 2005			
24	2 MOTOR	X 5 HP						
J	**KIER**				Before 2005			
25	1 PUMP	X 10 HP						

For K. B. Dyeing Mills (P) Ltd.

Auth. Sign./Director