Investigation on Energy Conservation & Energy Management Opportunities in Rubber Industries

A Project Report

Submitted by

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DEPARTMENT OF MECHANICAL ENGINEERING

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*This is to certify that **Mr. Sajineesh.G** final year ME student in Energy Engineering of Kumaraguru College of Technology, Coimbatore has successfully completed his project work entitled **"Investigation on Energy Conservation and Energy Management Opportunities in Rubber Industries"** at **Kerala State Productivity Council, Kalamassery** as a part of his curriculum under the guidance of **Mr.A.P.Jose, Deputy Director, KSPC.***

Industrial Guide

A. P. Jose

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K. M. George
Director

ABSTRACT

India now faces a formidable challenge on energy front. Load management and energy conservation are currently being considered and adopted by many industries around the world to meet the current situation of limited capacity and continuously growing demand.

The objective of Energy Management is to achieve and maintain optimum energy procurement and utilization, throughout the organization, to minimize energy costs without affecting production & quality and to minimize environmental effects.

Effective management of energy consuming systems can lead to significant cost and energy savings as well as increased comfort. A good energy management program begins with a thorough energy audit.

Industrial energy audit is an effective tool in defining and pursuing comprehensive energy management program. Energy Audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists.

The project presents the analysis, findings and recommendations for achieving energy and cost saving opportunities in rubber industries.

First a preliminary energy audit was conducted; data were collected from the past record and analyzed for specific energy consumption. Then a detailed audit was carried out at the two units of the rubber factory. For the purpose of measuring different parameters equipments like Digital power recorder, Lux meter were used.

Energy conservation opportunities were identified in different machines and payback period has been calculated for the implementation of energy efficient system.

പ്രൊജക്ട് രത്നചുരുക്കം

ഊർജ്ജ മേഖലയിൽ ഇന്ത്യ ഇന്ന് അതിഭീഷണമായ പ്രതിസന്ധി നേരിട്ടുകൊണ്ടിരിക്കുകയാണ്. ഉയർന്നു വരുന്ന ഊർജ്ജ ആവശ്യകതയും പരിമിതമായ ഊർജ്ജസ്രോതസ്സും തുടരുന്ന ഇന്നത്തെ സ്ഥിതിയിൽ ലോകമെമ്പാടുമുള്ള ഉപഭോക്താക്കൾ ഊർജ്ജസംരക്ഷണത്തിന്റെയും ഉപഭോഗ നിയന്ത്രണത്തിന്റെയും ആവശ്യകത മനസ്സിലാക്കി നിയന്ത്രണനടപടികൾ കൈക്കൊള്ളാൻ തീരുമാനിച്ചിരിക്കുന്നു.

ഈ പ്രൊജക്ട് റബ്ബർ വ്യവസായത്തിൽ കൈക്കൊള്ളാവുന്ന ഊർജ്ജ സംരക്ഷണ രീതികൾ, ചെലവുചുരുക്കൽ നടപടികൾ എന്നിവയെപ്പററിയുള്ള വിശകലനം, കണ്ടെത്തലുകൾ, ശുപാർശകൾ എന്നിവയെ വിശദമായി പ്രതിപാദിക്കുന്നു.

ആദ്യപടിയായി ഒരു പ്രാഥമിക ഊർജ്ജ ഓഡിററ് നടത്തി വിവരങ്ങൾ ശേഖരിക്കുകയും അതിൽനിന്നും നിശ്ചിത ഊർജ്ജ ഉപഭോഗം കണ്ടെത്തുകയും ചെയ്തു. പിന്നീട് വിശദമായ ഓഡിററ് നടത്തി. ഇതിനായി ഡിജിററൽ പവ്വർ റിക്കോർഡർ, ലക്സ് മീററർ തുടങ്ങിയ ഉപകരണങ്ങൾ ഉപയോഗിച്ചു.

വിവിധ ഉപകരണങ്ങളിലെ ഊർജ്ജ സംരക്ഷണത്തിനുള്ള അവസരങ്ങൾ കണ്ടെത്തുകയും അവയുടെ കാര്യക്ഷമത വർദ്ധിപ്പിക്കാനുള്ള ഉപകരണങ്ങൾക്കായുള്ള മുടക്കുമുതൽ തിരിച്ചുകിട്ടാനുള്ള സമയദൈർഘ്യം കണക്കാക്കുകയും ചെയ്തു.

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ENERGY AUDITING –AN INTRODUCTION

1.1 INTRODUCTION

Industrial sector uses about 50% of total commercial energy available in India. Indian industries are highly energy intensive and efficiency is well below that of other industrialized countries. Energy conservation has a direct impact on economic development and also environment protection .Thus the saving of energy becomes a crucial issue.

Effective management of energy consuming systems can lead to significant cost and energy savings as well as increased comfort. A good energy management program begins with a thorough energy audit. Energy audit, a successful energy conservation program, promises to achieve reduction of nearly 25% in annual energy consumption by implementation of energy efficient operation and maintenance strategies.

1.2 OBJECTIVES

The objective of my project is to conserve energy in different equipments used in rubber industries, to find out different energy management methods and to study the possibilities of utilizing solar energy as alternate energy source for the factory. The reason for choosing rubber industries is the potential for energy conservation is immense here because of the lower capacity utilization and use of obsolete technology.

1.3 ENERGY CONSERVATION

"Conservation of energy means using less energy for same level of activity and brings down cost of production, optimizes the use of limited financial resources, increases global competitiveness of the industry."

1.3.1 Energy Conservation Act

Considering the vast potential of energy saving and benefits of energy efficiency the Government of India enacted the Energy Conservation Act 2001. The Act provides for the legal framework, institutional arrangement and a regulatory mechanism at the central and state levels

1.4 ENERGY MANAGEMENT

1.4.1 Definition & Objectives of Energy Management

The fundamental goal of energy management is to produce goods and provide services with the least cost and least environmental effect.

. One definition of energy management is:

> *"The judicious and effective use of energy to maximize profits (minimize costs) and enhance competitive positions"*

The objective of Energy Management is to achieve and maintain optimum energy procurement and utilisation, throughout the organization and:

- To minimize energy costs / waste without affecting production & quality
- To minimize environmental effects.

1.4.2 Principles of Energy Management

The principles of Energy Management involve the following:

i. Procure all the energy needed at the lowest possible price
ii. Manage energy use at the highest energy efficiency
iii. Reusing and recycling energy by cascading
iv. Use the most appropriate technology
v. Reduce the avoidable losses

1.5 ENERGY AUDIT

"Energy audit is a technical survey of a plant in which the machine wise or section wise pattern of energy consumption is studied and attempts to balance the energy input correlating with production.

- Objective is to balance the total energy inputs with its use and to identify all energy streams.
- It quantifies the usage of energy according to its discrete functions
- It focuses attention on energy cost also

1.5.1 Energy Audit - Types and Methodology

Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete functions. Industrial energy audit is an effective tool in defining and pursuing comprehensive energy management programme.

As per the Energy Conservation Act, 2001, Energy Audit is defined as "the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption".

1.5.2 Need for Energy Audit

In any industry, the three top operating expenses are often found to be energy (both electrical and thermal), labour and materials. If one were to relate to the manageability of the cost or potential cost savings in each of the above components, energy would invariably emerge as a top ranker, and thus energy management function constitutes a strategic area for cost reduction. Energy Audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists.

The Energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programmes which are vital for production and utility activities. Such an audit programme will help to keep focus on variations which occur in the energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc.

In general, Energy Audit is the translation of conservation ideas into realities, by lending technically feasible solutions with economic and other organizational considerations within a specified time frame.

The primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. Energy Audit provides a " bench-mark" for managing energy in the organization and also provides the basis for planning a more effective use of energy throughout the organization.

1.5.3 Type of Energy Audit

The type of Energy Audit to be performed depends on:

- Function and type of industry
- Depth to which final audit is needed, and
- Potential and magnitude of cost reduction desired

Thus Energy Audit can be classified into the following two types.

A. Preliminary Audit

B. Detailed Audit

A. Preliminary Energy Audit Methodology

Preliminary energy audit is a relatively quick exercise to:

- Establish energy consumption in the organization
- Estimate the scope for saving
- Identify the most likely areas for attention
- Identify immediate improvements/ savings
- Set a 'reference point'
- Identify areas for more detailed study/measurement
- Preliminary energy audit uses existing, or easily obtained data

B. Detailed Energy Audit Methodology

A comprehensive audit provides a detailed energy project implementation plan for a facility, since it evaluates all major energy using systems.

This type of audit offers the most accurate estimate of energy savings and cost. It considers the interactive effects of all projects, accounts for the energy use of all major equipment, and includes detailed energy cost saving calculations and project cost.

In a comprehensive audit, one of the key elements is the energy balance. This is based on an inventory of energy using systems, assumptions of current operating conditions and calculations of energy use. This estimated use is than compared to utility bill charges.

Detailed energy auditing is carried out in three phases: Phase I, II and III.

Phase I - Pre Audit Phase
Phase II - Audit Phase
Phase III - Post Audit Phase

Phase 1 –Pre Audit Phase Activities

A structured methodology to carry out an energy audit is necessary for efficient working. An initial study of the site should always be carried out, as the planning of the procedures necessary for an audit is most important.

Initial Site Visit and Preparation Required for Detailed Auditing

An initial site visit may take one day and gives the Energy Auditor/Engineer an opportunity to meet the personnel concerned, to familiarize him with the site and to assess the procedures necessary to carry out the energy audit.

During the initial site visit the Energy Auditor/Engineer should carry out the following actions: -

- Discuss with the site's senior management the aims of the energy audit.
- Discuss economic guidelines associated with the recommendations of the audit.
- Analyse the major energy consumption data with the relevant personnel.
- Obtain site drawings where available – building layout, steam distribution, compressed air distribution, electricity distribution etc.
- Tour the site accompanied by engineering/production

The main aims of this visit are

- To identify the main energy consuming areas/plant items to be surveyed during the audit.
- To identify any existing instrumentation/ additional metering required.
- To decide whether any meters will have to be installed prior to the audit
- To identify the instrumentation required for carrying out the audit.
- To plan with time frame
- To collect macro data on plant energy resources, major energy consuming centers
- To create awareness through meetings/ programme

Phase 2- Detailed Energy Audit Activities

Depending on the nature and complexity of the site, a comprehensive audit can take from several weeks to several months to complete. Detailed studies to establish, and investigate, energy and material balances for specific plant departments or items of process equipment are carried out. Whenever possible, checks of plant operations are carried out over extended periods of time, at nights and at weekends as well as during normal daytime working hours, to ensure that nothing is overlooked.

The audit report will include a description of energy inputs and product outputs by major department or by major processing function, and will evaluate the efficiency of each step of the manufacturing process. Means of improving these efficiencies will be listed, and at least a preliminary assessment of the cost of the improvements will be made to indicate the expected payback on any capital investment needed. The audit report should conclude with specific recommendations for detailed engineering studies and feasibility analyses, which must then be performed to justify the implementation of those conservation measures that require investments.

The information to be collected during the detailed audit includes: -

1. Energy consumption by type of energy, by department, by major items of process equipment, by end-use
2. Material balance data
3. Energy cost and tariff data
4. Process and material flow diagrams
5. Generation and distribution of site services.
6. Sources of energy supply

Energy Management procedures and energy awareness training programs within the establishment

Phase 3 Energy Audit Reporting Format

After successfully carried out energy audit energy manager/energy auditor should report to the top management for effective communication and implementation. The format may be suitably modified for specific requirement applicable for a particular type of industry

CHAPTER 2

TSR RUBBER FACTORY

2.1 ABOUT THE COMPANY

TSR Rubber factory is a unit of District Cooperative Rubber Marketing Society established in 1987.The Company produces TSR rubber from field coagulant. The company is having an annual production capacity of 293000 kg with a monthly average of 41857 kg.

2.2 PRODUCTION PROCESS

The coagulated rubber from the estates are collected and transported by truck to the factory. The coagulated rubber is then fed to the ball breaker and then dipped into the water. The dirt rubber is removed by high pressure water jets. Then the material is rolled on the roller about 8 or 9 passes and formed into sheets. The finished sheet is then broken into small pieces by hammer mill. The drying is done by hot air. After dried the blocks are compressed by hydraulic press. Then packed and dispatched.

2.3 HIGHLIGHTS OF TSR FACTORY

- Quality, Consistency and Customer Satisfaction are the catchwords of this factory
- TSR Factory keeps in touch with its customers for feed back to make the best available product.
- TSR believes in Zero –defect product.
- They are the approved suppliers of raw material to almost all the tyre companies in India.

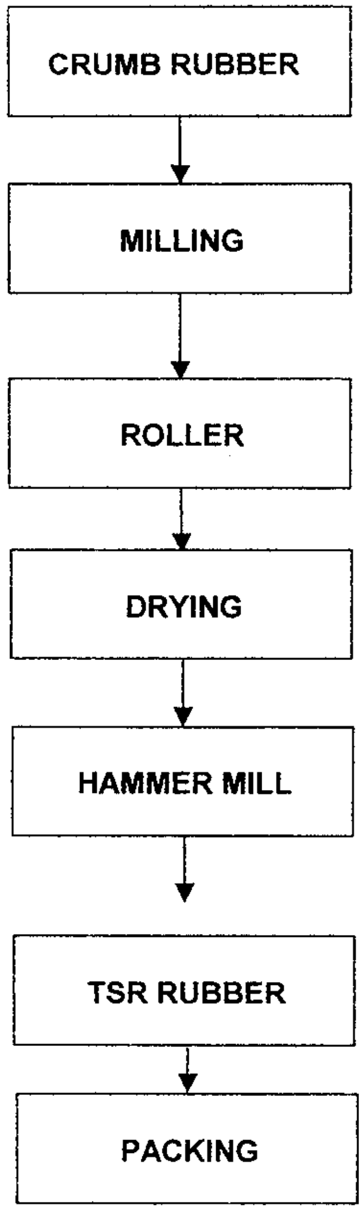

FIGURE 2.1 PROCESS FLOW DIAGRAM

TABLE 2.1 PURCHASED POWER COST AT TSR FACTORY

Contract Demand	280 KVA
75% CD	210 KVA
120% CD	336 KVA
60% of Z1 RMD	114 KVA

Consumption details	**RMD (KVA)**	**Consumption (KWH)**
Normal Period (Z1)	190 KVA	18224 KWH
Peak Period (Z2)	56 KVA	1452 KWH
Off-peak period (Z3)	47 KVA	9184 KWH
Total purchased power		28860 KWH
Self Generated power		0 KWH
Average PF		0.65

Sl. No.	Particulars	Qty.	Unit	Rate/unit (Rs.)	Amount (Rs.)
1	**Total Demand Charge**				
a)	Billing Demand Charge	210	KVA	270.00	56700.00
b)	Time of Use Charge	0	KVA	36.00	0.00
c)	Off-peak incentive	0	KVA	-22.50	0.00
d)	Excess Demand Charge	0	KVA	135.00	0.00
e)	Excess off-peak Demand	0	KVA	270.00	0.00
	Sub total (a+b+c+d+e)				56700.00
2	**Total Energy Charge**				
a)	Energy Charge	28860	KWH	3.00	86580.00
b)	Time of Use Charge	0	KWH	2.40	0.00
c)	Off-peak incentive	1247	KWH	-1.05	-1309.35
	Sub total (a+b+c)				85270.65
d)	Incentive/Penalty for PF				21317.66
	Total Energy Charge				106588.31
3	**Electricity Duty**	28860	KWH	0.10	2886.00
4	**Surcharge**	28860	KWH	0.025	721.50
5	**Duty on SG power**	0	KWH	0.012	0.00
Total Charge (1+2+3+4+5)					**Rs.166,896**
Overall energy cost per unit					**Rs.5.78**

TABLE 2.2 POWER COST CALCULATION

Power cost calculation in differential pricing method applicable to Extra High Tension/ High Tension and deemed High Tension Consumers is given below:

(Normal time set between 06.00 hrs to 18.00 hrs, peak time 18.00 hrs to 22.00 hrs and off-peak time 22.00 hrs to 06.00 hrs.)

Billing demand will be the highest of the Recorded Maximum Demand during Normal Time, Peak Time or 75 % of the Contract Demand or 50KVA.

1. Demand Charge = Normal Demand Charge + Time of Use Charge - Incentive

a) Normal Demand Charge = Billing Demand x Ruling Demand Charge/KVA

b) Time of Use Charge = Demand during peak time in excess of 60% of the demand during normal time x Ruling Demand charge/KVA x 0.8 x 4/24.

c) Incentive = Demand during off peak time (up to 105 % of the contract demand) in excess of 60 % of the demand during normal time x ruling Demand Charge/KVA x 0.25x8/24.

2. Excess Demand Charge =Excess Billing Demand x Demand Charge/KVA x 0.5 (Only if Maximum recorded Demand during normal/peak time exceeds the Contract Demand).

3. If the recorded Maximum Demand during the off peak time exceeds 120 % of the Contract Demand, the excess demand will be charged only at the ruling tariff.

4. Energy Charge = Normal Energy Charge + Time of Use Charge - Incentive.

(a)	Normal Energy Charge	=	(Normal consumption + Peak consumption + off peak consumption) x ruling energy charges/unit.
(b)	Time of Use Charge (Only if the consumption during peak period exceeds 10 % of the energy consumption during the month)	=	(Peak consumption - 10 % of the energy Consumption during the month) x ruling energy charge/unit x 0.80.
(c)	Incentive (Only if the consumption during off peak period exceeds 30 % of energy consumption during the month)	=	(Off peak time consumption – 27.5 % of the total Consumption) x ruling energy charges/unit x 0.35.

5. Power Factor Improvement

Incentive	0.15% of energy charges for each 0.01 unit increase in power factor from 0.90 p.f
Penalty	1% energy charge for every 0.01 fall from 0.90 p.f

6. **Total Monthly Charges = (1) + (2) + (3) + (4) ± (5)**

TABLE 2.3 PRODUCTION AND ENERGY CONSUMPTION DETAILS FOR THE YEAR 2005

Month & Year	Maximum Demand (KVA)	Billing Demand (kVA)	Power Consumption (kWh)	Prodn. (kg)	Fuel (Diesel) (L)	Fuel (Coconut shell) (kg)	Specific Energy Consumption (kWH/Kg Of Prodn)
Jan-05	121.0	210.0	5344.0	9075.0			0.59
Feb-05	216.0	216.0	14927.0	24275.0			0.61
Mar-05	209.0	210.0	13296.0	30100.0			0.44
Apr-05	81.0	210.0	8363.0	14200.0			0.58
May-05							
Jun-05							
Jul-05							
Aug-05	211.0	211.0	11571.0				
Sep-05	42.0	210.0	6220.0				
Oct-05	190.0	210.0	16624.0	39750.0	550.0	11675.0	0.40
Nov-o5	190.0	210.0	28860.0	84750.0	814.6	33363.0	0.34
Dec-05				90850.0	390.0	22528.0	
Monthly sum/Average	157.5	210.9	105205.0	293000.0	1754.6	67566.0	0.49
			13150.6	41857.1	584.9	22522.0	

TABLE 2.4 PANEL READINGS

Sl. No.	*Switch Board*	*Actual Load Readings*			
		KW	*I*	*V*	*PF*
1.	LC - 6	43.8	88.60	380	0.75
2.	LC - 2	28.6	52.93	382	0.82
3.	LC - 3	33.9	56.20	375	0.93
4.	LC - 4	4.0	13.02	373	0.47
5.	LC - 5	26.3	51.89	380	0.77
Total		**92.67**	**174.04**	**378**	**0.81**

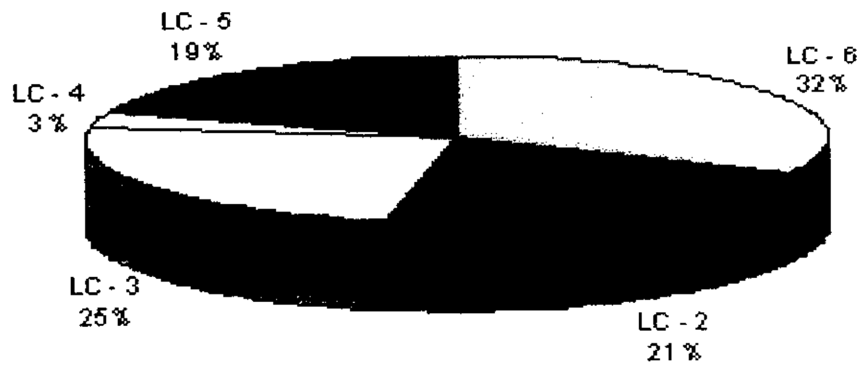

FIG 2.2 POWER DISTRIBUTION

TABLE 2.5 CONTINUOUS LOAD READINGS OF INDIVIDUAL LOADS

Time	Voltage R(V)	Current R(A)	Active Power (kW)	Reactive Power (kVar)	Apparent Power (kVA)	Power Factor	Frequency (Hz)
Creeper No.5- (30HP)							
2:39 PM	380.70	18.69	6.03	10.63	12.22	0.49	49.72
2:40 PM	381.30	17.63	4.40	10.53	11.41	0.39	49.72
2:41 PM	381.40	16.79	3.12	10.30	10.77	0.29	49.72
2:42 PM	381.60	18.12	5.14	10.66	11.83	0.43	49.72
2:43 PM	380.70	17.84	4.79	10.55	11.59	0.41	49.72
2:44 PM	345.40	14.85	4.68	7.75	9.05	0.47	49.72
Average	375.18	17.32	4.69	10.07	11.14	0.41	49.72
Creeper No.4- (30HP)							
2:46 PM	378.60	19.23	6.54	9.86	11.83	0.55	49.72
2:47 PM	378.90	19.94	7.66	9.99	12.59	0.61	49.72
2:48 PM	378.20	20.41	7.87	10.22	12.90	0.61	49.72
2:49 PM	378.40	20.45	8.14	10.02	12.91	0.63	49.72
2:50 PM	379.60	20.12	7.56	10.18	12.68	0.60	49.72
2:51 PM	380.50	19.27	6.82	10.09	12.18	0.56	49.72
2:52 PM	380.70	19.63	7.12	10.16	12.41	0.57	49.72
2:53 PM	380.60	22.05	9.41	10.40	14.02	0.67	49.72
2:54 PM	147.60	6.30	1.22	0.91	1.53	0.32	49.72
Average	353.68	18.60	6.93	9.09	11.45	0.57	49.72
Shreddor- (50HP)							
2:55 PM	185.00	13.86	3.51	2.03	4.05	0.43	49.72
2:56 PM	380.80	42.46	21.16	17.55	27.49	0.77	49.72
2:57 PM	381.30	39.61	18.63	17.52	25.58	0.73	49.72
2:58 PM	380.20	50.28	26.87	18.64	32.70	0.82	49.72
2:59 PM	378.90	50.92	27.07	18.77	32.94	0.82	49.72
3:00 PM	379.00	33.63	13.95	16.28	21.44	0.65	49.72
3:01 PM	378.10	33.46	12.88	16.92	21.27	0.61	49.72
3:02 PM	376.60	39.15	17.47	17.94	25.04	0.70	49.72
3:03 PM	292.30	33.35	16.50	2.80	16.26	0.78	49.72
Average	313.22	33.67	15.80	12.84	20.68	0.63	49.72
Prebreaker- (30HP)							
3:05 PM	168.70	12.52	5.45	3.95	3.75	0.81	49.72
3:06 PM	377.20	27.54	16.27	7.98	18.12	0.90	49.72
3:07 PM	377.10	32.85	19.68	8.73	21.53	0.91	49.72
3:08 PM	377.60	33.39	19.92	9.06	21.89	0.91	49.72
3:09 PM	377.60	27.07	15.92	8.04	17.84	0.89	49.72
3:10 PM	377.50	14.95	6.19	7.47	9.70	0.64	49.72
3:11 PM	377.20	12.26	3.00	7.20	7.80	0.39	49.72
3:15 PM	376.80	32.75	19.62	8.77	21.49	0.91	49.72
Average	351.21	24.17	13.26	7.65	15.26	0.80	49.72
SFB 1							
3:21 PM	374.60	10.16	2.94	5.59	6.32	0.47	49.72
3:22 PM	375.80	9.66	2.90	5.31	6.05	0.48	49.72
3:23 PM	181.50	3.69	1.20	0.25	1.18	0.49	49.72
Average	310.63	7.84	2.35	3.72	4.51	0.48	49.72
Creper 1							
3:30 PM	371.90	17.78	8.31	7.90	11.46	0.73	49.72
3:31 PM	372.70	18.69	8.13	8.93	12.07	0.67	49.72
Average	372.30	18.24	8.22	8.41	11.77	0.70	49.72

TABLE 2.5 CONTINUOUS LOAD READINGS OF INDIVIDUAL LOADS

Time	Voltage R(V)	Current R(A)	Active Power (kW)	Reactive Power (kVar)	Apparent Power (kVA)	Power Factor	Frequency (Hz)
Creper 2							
3:48 PM	378.20	12.48	2.93	6.57	7.19	0.41	49.72
3:49 PM	378.00	16.82	3.64	8.70	9.43	0.39	49.72
3:50 PM	377.20	19.76	6.84	9.02	11.32	0.60	49.72
3:51 PM	376.50	21.26	8.41	8.94	12.27	0.69	49.72
3:52 PM	375.30	20.67	8.10	8.66	11.86	0.68	49.72
3:53 PM	375.70	20.11	7.48	8.74	11.50	0.65	49.72
3:54 PM	376.20	19.92	7.31	8.74	11.39	0.64	49.72
3:55 PM	376.90	21.79	9.18	8.68	12.64	0.73	49.72
3:56 PM	377.10	21.63	8.91	8.93	12.61	0.71	49.72
3:57 PM	125.50	7.81	3.54	3.20	1.53	0.77	49.72
Average	351.66	18.23	6.63	8.02	10.17	0.63	49.72
Hammer							
4:03 PM	361.60	35.72	9.46	19.35	21.54	0.43	49.72
4:04 PM	371.90	31.94	4.20	18.95	19.40	0.22	49.72
4:05 PM	371.00	32.59	4.99	19.05	19.69	0.25	49.72
4:06 PM	371.50	37.40	10.81	19.95	22.69	0.48	49.72
4:07 PM	371.40	33.56	6.49	19.25	20.32	0.32	49.72
4:08 PM	371.80	37.07	11.03	19.89	22.75	0.48	49.72
4:09 PM	372.00	41.29	14.98	20.53	25.41	0.59	49.72
4:10 PM	322.40	34.59	11.74	14.20	18.42	0.56	49.72
Average	364.20	35.52	9.21	18.90	21.28	0.42	49.72
LC4- SECTION 1							
Gasifier Blower							
4:20 PM	247.90	1.81	0.31	0.66	0.73	0.38	49.72
4:21 PM	375.10	2.03	0.63	1.07	1.24	0.50	49.72
4:22 PM	375.70	2.00	0.63	1.06	1.24	0.51	49.72
4:23 PM	374.20	1.91	0.59	1.04	1.20	0.49	49.72
4:24 PM	373.50	1.84	0.82	1.21	1.46	0.56	49.72
4:25 PM	374.70	2.38	0.83	0.75	1.12	0.75	49.72
Average	353.52	1.99	0.63	0.97	1.16	0.53	49.72
SBT Pump-5HP							
4:26 PM	373.70	4.13	1.63	2.18	2.72	0.60	49.72
4:27 PM	373.80	3.31	1.31	1.74	2.18	0.60	49.72
4:28 PM	311.60	1.60	0.36	0.68	0.77	0.40	49.72
Average	353.03	3.01	1.10	1.53	1.89	0.53	49.72
Light							
4:29 PM	373.40	2.25	0.50	1.35	1.44	0.35	49.72
4:30 PM	296.80	1.91	0.59	0.12	0.58	0.83	49.72
4:31 PM	372.50	3.63	1.55	1.82	2.39	0.65	49.72
4:32 PM	372.80	3.67	1.56	1.84	2.41	0.65	49.72
4:33 PM	318.70	3.08	1.33	1.12	1.74	0.66	49.72
Average	346.84	2.91	1.11	1.25	1.71	0.63	49.72

2.4.1 Demand Management

The contract demand of the unit 280 KVA and the average Maximum demand is about 194 KVA.

For the purpose of analysis, continuous load readings were noted down fro the TOD meter for a period of 24 hours on a typical working day. From the continuous load readings it is observed that the load reaches maximum during normal period as the company is going with only single shift operation. The maximum demand occurs when all the plant activities are carried out simultaneously. The load readings and the demand profile are given in table 2.6 and figure 2.3.

From the continuous load readings it is noted that the maximum demand occurred on that particular day is only 148KVA and the maximum demand occurred during the previous month was 194KVAwhich is less than 75% of the contract demand. So in order to achieve the full advantage of the maximum demand reduction and also to avoid the excess payment for the demand, the contract demand should be rearranged so that the maximum demand should lie in between 75 to 100% of the contract demand.

The peak demand is the highest amount of power used period (30 minutes) in the metering month. In a month (720 hours), there would be 1440 measurements. In the differential pricing method, each day is divided into three time zones namely Normal time (between 06.00 hrs. to 18.00 hrs.), peak time (between 18.00 hrs. to 22.00 hrs.) and off-peak time (between 22.00 hrs. to 06.00 hrs.). The highest measurement in each zone will be chosen as its respective peak demand. The recorded maximum demand depends on simultaneous running of various loads at the peak period. But for billing purpose, the RMD during off – peak time is not considered. Billing demand will be the highest of the recorded maximum demand during Normal time, Peak time or 75% of the Contract demand or 50 KVA. It is recommended to provide a maximum demand controller to avoid any occasional rise in maximum demand.

TABLE 2.6 CONTINUOUS LOAD READINGS

Time	Active Power (kW)	Reactive Power (kVar)	Apparent Power (kVA)	Power Factor
8:30 AM	120.00	64.77	136.36	0.88
9:00 AM	104.00	61.71	120.93	0.86
9:30 AM	80.00	34.08	86.96	0.92
10:00 AM	104.00	47.38	114.29	0.91
10:30 AM	96.00	49.18	107.87	0.89
11:00 AM	76.00	36.81	84.44	0.90
11:30 AM	68.00	36.70	77.27	0.88
12:00 PM	128.00	75.95	148.84	0.87
12:30 PM	120.00	68.01	137.93	0.87
1:00 PM	104.00	50.37	115.56	0.90
1:30 PM	96.00	59.50	112.94	0.85
2:00 PM	104.00	69.89	125.30	0.83
2:30 PM	96.00	62.01	114.29	0.84
3:00 PM	108.00	55.33	121.35	0.89
3:30 PM	104.00	61.71	120.93	0.86
4:00 PM	96.00	56.96	111.63	0.86
4:30 PM	88.00	45.08	98.88	0.89
5:00 PM	56.00	57.13	80.00	0.70
5:30 PM	12.00	15.19	19.35	0.62
6:00 PM	5.00	7.02	8.62	0.58
6:30 PM	4.00	6.93	8.00	0.50
7:00 PM	3.00	4.56	5.45	0.55
7:30 PM	3.00	4.44	5.36	0.56
8:00 PM	3.00	5.06	5.88	0.51
8:30 PM	4.00	5.92	7.14	0.56
9:00 PM	4.00	5.62	6.90	0.58
9:30 PM	4.00	6.23	7.41	0.54
10:00 PM	5.00	8.43	9.80	0.51
10:30 PM	4.00	6.57	7.69	0.52
11:00 PM	4.00	6.40	7.55	0.53
11:30 PM	4.00	6.75	7.84	0.51
12:00 AM	4.00	6.93	8.00	0.50
12:30 AM	4.00	24.68	25.00	0.16
1:00 AM	4.00	21.86	22.22	0.18
1:30 AM	4.00	24.68	25.00	0.16
2:00 AM	4.00	20.67	21.05	0.19
2:30 AM	3.00	18.51	18.75	0.16
3:00 AM	3.50	23.07	23.33	0.15
3:30 AM	3.00	17.39	17.65	0.17
4:00 AM	4.00	21.86	22.22	0.18
4:30 AM	3.00	18.51	18.75	0.16
5:00 AM	3.00	16.39	16.67	0.18
5:30 AM	4.00	24.68	25.00	0.16
6:00 AM	3.00	16.39	16.67	0.18
6:30 AM	4.00	20.67	21.05	0.19
7:00 AM	4.00	24.68	25.00	0.16
7:30 AM	4.00	20.67	21.05	0.19
8:00 AM	4.00	19.60	20.00	0.20
Average	**38.95**	**29.64**	**51.46**	**0.54**
Maximum	**128.00**	**75.95**	**148.84**	**0.86**

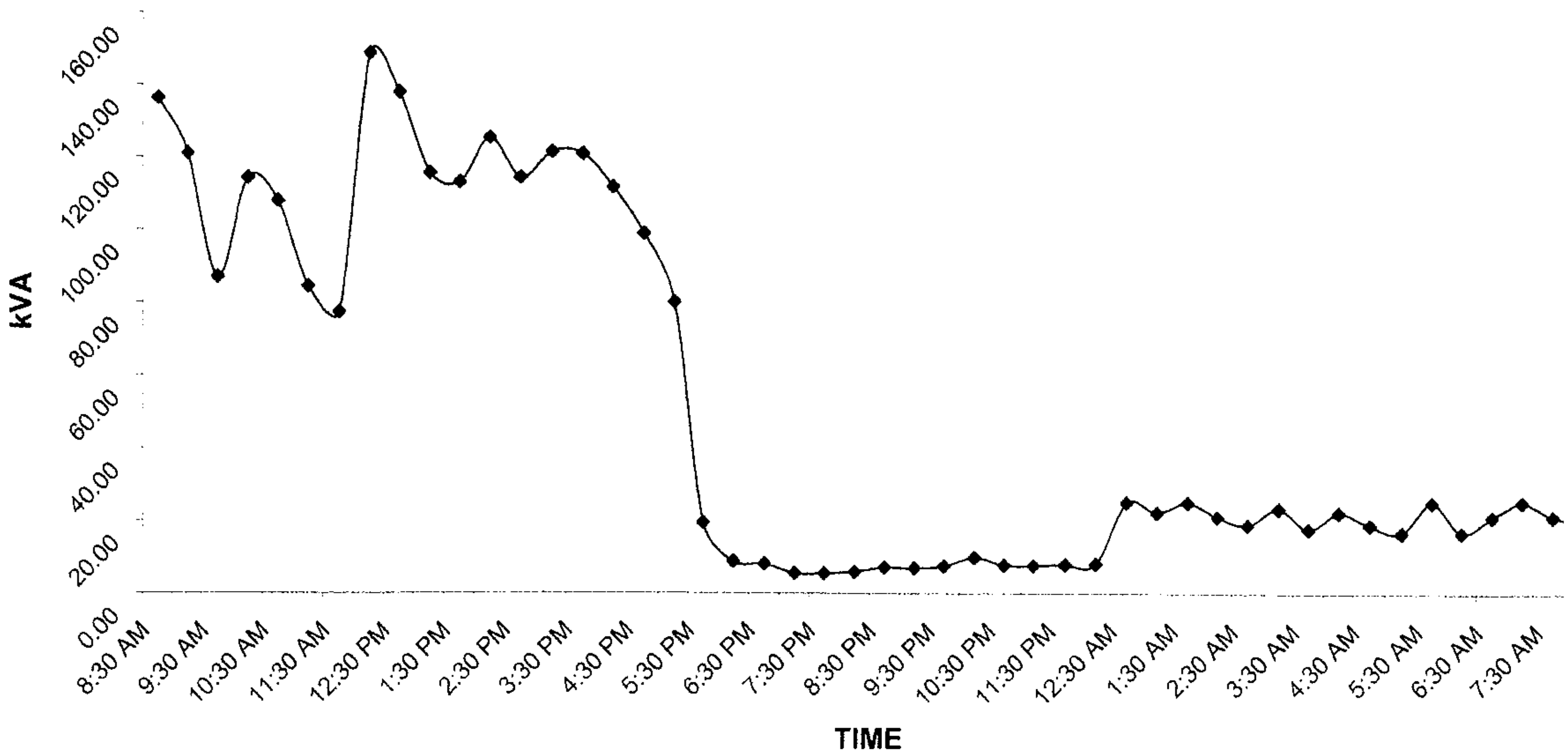

FIG 2.3 DEMAND PROFILE

2.4.2 Transformer Loading and Losses

The transformer used in this unit is of 1000 KVA capacity. The present average loading of the transformer is only 5% for a typical working day, ie. 50 KVA. The low loading of the transformer is due the single shift operation of the plant resulting no load during nighttime. From the transformer test data it is seen that the maximum efficiency at Unity Power Factor of a 1000 KVA transformer occurs at 40.45% loading with an efficiency of 99.118 .The profile of 1000kVA transformer at different load conditions is given in table 2.7 and fig 2.4.

From the average loading of the transformer is concerned, the capacity of existing transformer is much higher than the one actually required for this plant. At present the transformer loss comes about 10% of the total power consumption of the plant with an average per day loss of about 44 kWh.

For a distribution transformer the maximum efficiency occurs when the transformer is loaded between 30 – 40% of its rated capacity. So by taking account of this and also any future expansion of the plant, it is recommended to replace the existing transformer with a suitable size transformer, say 630KVA, so that the per day transformer losses can be reduced to 30 kWh with a loading of 8%. The profile of 630KVA transformer at different load conditions is given in fig 2.5. . By replacing the transformer, the company can achieve an annual cost saving of around Rs.29,367/-. The detailed saving calculations are given.

TABLE 2.7 EFFICIENCY OF 1000 KVA TRANSFORMER AT DIFFERENT LOAD CONDITIONS

% Load	kVA	Iron Loss (W)	Cu Loss (W)	Total Loss (kW)	Efficiency at UPF (%)	Efficiency at 0.9 PF (%)	Efficiency at 0.65 PF (%)
5	**50**	**1800**	**28**	**1.83**	**96.474**	**96.097**	**94.676**
10	100	1800	110	1.91	98.126	97.922	97.145
15	150	1800	248	2.05	98.653	98.506	97.943
20	200	1800	440	2.24	98.892	98.771	98.306
25	250	1800	688	2.49	99.015	98.907	98.492
30	300	1800	990	2.79	99.079	98.977	98.589
35	350	1800	1348	3.15	99.109	99.011	98.635
40.45	**404.5**	**1800**	**1800**	**3.60**	**99.118**	**99.021**	**98.649**
45	450	1800	2228	4.03	99.113	99.015	98.642
50	500	1800	2750	4.55	99.098	98.999	98.619
55	550	1800	3328	5.13	99.076	98.975	98.586
60	600	1800	3960	5.76	99.049	98.945	98.545
65	650	1800	4648	6.45	99.018	98.910	98.497
70	700	1800	5390	7.19	98.983	98.872	98.444
75	750	1800	6188	7.99	98.946	98.831	98.388
80	800	1800	7040	8.84	98.907	98.787	98.328
85	850	1800	7948	9.75	98.866	98.742	98.266
90	900	1800	8910	10.71	98.824	98.695	98.202
95	950	1800	9928	11.73	98.781	98.647	98.136
100	1000	1800	11000	12.80	98.736	98.598	98.069

TABLE 2.8 EFFICIENCY OF 630 KVA TRANSFORMER AT DIFFERENT LOAD CONDITIONS

% Load	kVA	Iron Loss (W)	Cu Loss (W)	Total Loss (kW)	Efficiency at UPF (%)	Efficiency at 0.9 PF (%)	Efficiency at 0.65 PF (%)
5	32	1200	19	1.22	96.275	95.878	94.382
8	**50.4**	**1200**	**48**	**1.25**	**97.583**	**97.322**	**96.330**
10	63	1200	75	1.28	98.016	97.801	96.980
16	101	1200	192	1.39	98.637	98.488	97.919
20	126	1200	301	1.50	98.823	98.694	98.201
25	157.5	1200	470	1.67	98.951	98.836	98.395
30	189	1200	676	1.88	99.017	98.909	98.496
35	220.5	1200	921	2.12	99.047	98.943	98.542
40.0	**251.7**	**1200**	**1200**	**2.40**	**99.056**	**98.952**	**98.555**
45	283.5	1200	1522	2.72	99.049	98.945	98.544
50	315	1200	1879	3.08	99.032	98.926	98.519
55	346.5	1200	2273	3.47	99.008	98.898	98.481
60	378	1200	2705	3.91	98.977	98.865	98.435
65	409.5	1200	3175	4.38	98.943	98.827	98.383
70	441	1200	3682	4.88	98.905	98.785	98.325
75	472.5	1200	4227	5.43	98.864	98.740	98.264
80	504	1200	4810	6.01	98.822	98.692	98.199
85	535.5	1200	5430	6.63	98.777	98.643	98.131
90	567	1200	6087	7.29	98.731	98.592	98.061
95	598.5	1200	6782	7.98	98.684	98.540	97.989
100	630	1200	7515	8.72	98.636	98.486	97.916

TRANSFER LOSS REDUCTION BY REPLACING THE 1000kVA TRANSFORMER WITH 630kVA TRANSFORMER

Present case (Distributing load through one 1000.kVA transformer)

The rating of the transformer	=	1000 kVA
Average load of the plant	=	50kVA
Average loading of the transformer	=	5%
Loss of the transformer(cu.loss & hyst.loss) at this loading	=	1.83 kW
Annual transformer loss (300 days/year)	=	(1.83 x 24 x 365)
	=	16031 kWH
Present energy cost at TSR	=	Rs.5.78
Annual cost due to transformer loss	=	**Rs.92,658**

Proposed case (Replace the 1000kVA Transformer with 630kVA Transformer)

Average load per transformer	=	50 kVA
Average loading per transformer	=	8.0%
Loss of the transformer(cu.loss & hyst.loss) at this loading	=	1.25 kW
Annual transformer loss (300 days/year)	=	(1.25x 24 x 365)
	=	10950 kWH
	=	**Rs.63,291**
Annual reduction in transformer loss	=	5080.8 kWH
Annual cost saving	=	**Rs.29,367**

2.5 POWER FACTOR CORRECTION

2.5.1 Power Factor

The cosine of the angle between voltage and current in an AC system is called power factor.It is represented in fig 2.6.

In all industrial electrical distribution systems, the major loads are resistive and inductive. Resistive loads are incandescent lighting and resistance heating. In case of pure resistive loads, the voltage (V), current (I), resistance (R) relations are linearly related, i.e.

$$V = IR$$

$$P = VI \ \ W$$

$$P = (VI/1000) \ \ KW$$

Typical inductive loads are A.C. Motors, induction furnaces, transformers and ballast-type lighting. Inductive loads require two kinds of power: a) active (or working) power to perform the work and b) reactive power to create and maintain electro-magnetic fields.

Active power is measured in kW (Kilo Watts). Reactive power is measured in kVAr (Kilo Volt-Amperes Reactive).

The vector sum of the active power and reactive power make up the total (or apparent) power used. This is the power generated by the EBs for the user to perform a given amount of work. Total Power is measured in kVA (Kilo Volts-Amperes)

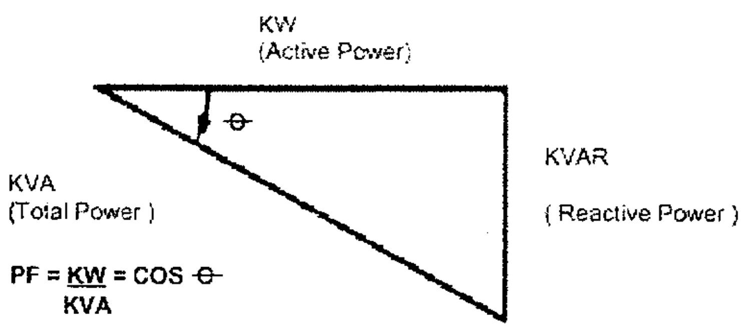

FIGURE 2.6 POWER FACTOR ILLUSTRATION

The active power (shaft power required or true power required) in kW and the reactive power required (kVAr) are 90^0 apart vectorically in a pure inductive circuit i.e., reactive power kVAr lagging the active kW. The vector sum of the two is called the apparent power or kVA, as illustrated above and the kVA reflects the actual electrical load on distribution system.

The ratio of kW to kVA is called the power factor, which is always less than or equal to unity. Theoretically, when electric utilities supply power, if all loads have unity power factor, maximum power can be transferred for the same distribution system capacity. However, as the loads are inductive in nature, with the power factor ranging from 0.2 to 0.9, the electrical distribution network is stressed for capacity at low power factors

2.5.2 Power Factor Correction

For the purpose of power factor correction, the company has adopted Central compensation as well as group compensation methods. A total of 150kVAr is connected in the system of which 100 kVAr (12.5kVArx4, 10kVArx4, 5kVArx2) is connected at the main panel with APFC and 50 kVAr (25kVARx2) is connected at the load centre. Details are given in table 2.9.

It is noted that at present the capacitors with APFC is operated manually throughout the day and this leads to over compensation during low load and nights under no load conditions. From the log book recording the TOD meter readings, it is noted that the capacitor is overcompensated during night time. During day time the company is maintaining a power factor of 0.82 - 0.9 when all the capacitors switched on and the power factor falls less than 0.5 during night time. During night time as well as no load time, the system is over compensated due to the presence of over capacitors resulting again poor pf at these periods.

TABLE 2.9 CAPACITOR RATINGS

Rating of Capacitor	Rated KVAr	MEASURED VALUE				% Capacitance
		Voltage	Current	P f	KVAr	
12.5kVArx4, 10kVArx4, 5kVArx2	100	380	87.2	.023	57.4	57%
25kVArx1(LC-2)	25	382	28	.021	18.5	74%
25kVArx1(LC-3)	25	380	25	.023	16.5	66%

In order to get the maximum benefit of capacitor addition, a power factor controller is essential and it must be operated automatically. It controls the power factor of the installation by giving signals to switch on or off power factor correction capacitors. Relay is the brain of control circuit and needs contactors of appropriate rating for switching on/off the capacitors.

The main advantages of connecting an APFC are as follows:

a. The capacitors are switched on only when required and results in increased life of capacitors.

b. Controller with flexible switching program reduces continuous operation of a capacitor.

c. Other advantages like sophisticated protection for the expensive capacitors, In-built digital power factor meter etc.

The present average system power factor is 0.65. Even though the company is maintaining a power factor in between 0.82 to 0.9 during daytime when the plant is in full swing operation, the power factor at nighttime comes below 0.50. During nighttime transformer become the major inductive load resulting low power factor. So the net average pf will be less than the expected one. But here in TSR in order to compensate the low pf during nighttime, the company is switched on the 100kVAr with APFC in manual mode resulting leading power factor. As far as the demand is concerned, it will be having the same effect for leading as well as lagging power factor. From the analysis the main reason for the low pf during nighttime is found to be the over compensated capacitors.

To assess the effect of over compensated capacitors during nighttime, the TOD meter readings were noted down from 6 PM to 6 AM at an interval of one hour. For a period of first 6 hrs, the readings were taken with 100kVAr capacitor with APFC is switched on manually and the rest of the readings were taken without the capacitor. From this it is found that the power factor was leading during the first period with an average pf of around 0.50 due to the presence of excess capacitors in the system. During the second period with capacitor in the switched off position, the power factor was lagging with an average pf of around 0.15. Hence to avoid the low pf due to the transformer action, a 50 kVAr capacitor is required to connect at the main panel exclusively for the transformer compensation throughout the day.

So by reducing the excess capacitors during nighttime, the average system pf can be improved and hence the penalty due to the low pf less than 0.90. The present maximum demand of the company is 190kVA with a power factor of 0.88 which is less then 75% of the contract demand. By adding a 66 kVAr capacitor with APFC to the total system during daytime, the MD will reduce by 21 kVA and the new maximum demand will be 169kVA. So the net reduction in kVA below 75% of the contract demand is 41kVA. The saving due to reduction in Maximum Demand will be obtained only after reducing the Contract demand. It is recommended to lower the CD to 225 KVA to minimise the payment of excess demand charges. If the unit is having any concrete plan for capacity addition in the near future, it should also be taken into consideration while re-fixing the contract demand.

The investment required for 66 kVAr capacitor with APFC is comes about Rs.118,000/- and the annual savings by reduction in MD will be Rs.68,400/-. The savings obtained by avoiding the penalty due to low pf is about Rs.2,55,000/- and through incentive for power factor above 0.9 is Rs.13,800/- and therefore the total saving is Rs.3,38,000/- per annum. Therefore the investment will be paid back in.

4 months. The detailed calculation of kVAR requirement, investment required, savings and payback is given

The additional capacitor requirement of 66 KVAR may also be connected at the load end of the major motors to improve the power factor and to minimise the cable loss.

Maximum benefit of capacitors is derived by locating them as close as possible to the load. At this location, its kVArs are confined to the smallest possible segment, decreasing the load current. This, in turn, will reduce power losses of the system substantially. Power losses are proportional to the square of the current. When power losses are reduced, voltage at the motor increases; thus, motor performance also increases.

2.5.3 Advantages of PF Improvement by Capacitor Addition

Reactive component of the network is reduced and so also the total current in the system from the source end. I^2R power losses are reduced in the system because of reduction in current. Voltage level at the load end is increased.

KVA loading on the source generators as also on the transformers and lines upto the capacitors reduces giving capacity relief. A high power factor can help in utilizing the full capacity of your electrical system.

Cost benefits of PF improvement

While costs of PF improvement are in terms of investment needs for capacitor addition the benefits to be quantified for feasibility analysis are:

a) Reduced KVA (Maximum demand) charges in utility bill

b) Reduced distribution losses (KWhr) within the plant network

c) Better voltage at motor terminals and improved performance of motors

d) A high power factor eliminates penalty charges imposed when operating with a low power factor

Investment on system facilities such as transformers, cables, switchgears etc for delivering load is reduced

POWER FACTOR IMPROVEMENT

The present average power factor	=	0.65
Contract Demand	=	280 KVA
75% of Contract Demand	=	210 KVA
The present Recorded Maximum Demand	=	190 KVA
Power factor at Maximum Demand	=	0.88
Therefore the average max. load	=	190 x 0.88
	=	167 KW
Recommended PF	=	0.99
RMD at improved PF	=	167 / 0.99
	=	169 KVA
Reduction in KVA	=	190 - 169
	=	**21 KVA**
Reduction in kVA due to pf improvement	=	**21**
Total reduction in kVA by reducing the CD to 225kVA	=	**210 - 169**
	=	**41**
Annual Saving due to reduction in RMD	=	41 x 270 x 12
	=	**Rs.68,400**
Total Energy Charge	=	Rs.85,270
Annual Incentive due to pf improvement above 0.9	=	**Rs.13,814**
Annual Saving by improving PF from 0.65 to 0.9	=	**Rs.255,810**
Annual Saving due to pf Improvement	=	**Rs.338,024**
Additional KVAr requirement	=	KW x (Tan f1-Tan f2)
	=	167 x (0.540 - 0.142)
	=	66 KVAr

Investment Required

66 kVAR capacitors including installation charge	=	66 x 1800
		Rs.118,000
Simple Payback period	=	118000 / 338024 x12
	=	4.2
		Say 4 months

2.6 ELECTRIC DRIVES

The major part of power consumption in the factory is by electric motors. All the LT motors above 5 HP and few low HP motors were analyzed for loading, power factor and efficiency related aspects. From the measurements and readings taken it was observed that almost all the motors of the machines used in the plant are loaded above 50%. Instantaneous readings were taken for the motors of steady load and continuous analysis of load readings were done for motors of varying load. The list of motors, measured parameters, and the capacitor requirement are given in table 2.10.

2.6.1 Optimization of Motor Size

AC motors are widely used as drives in Industries. But they have an inheritant drawback wherein their Efficiency drops if they are operated under low loads. This is because the power factor of such motors falls sharply with reduction in load. So for efficient operation of induction motors, care should be taken to choose the motor size to match the load.

2.6.2 Energy Efficient Motors

It is generally believed that the efficiency motors is high and as such no improvements are possible. However, when the losses in a standard motor is reduced to the extent of about 25%, it can be called an Energy Efficient Motor. Energy Efficient Motors are presently available, having efficiency exceeding 91%. Energy Efficient Motors have became a suitable product for energy conservation even at a higher cost, because of steeply escalating cost for electric power. In general the efficiency of small motors is less than the efficiency of large motors. The efficiency of energy efficient motors is generally 3% to 4% higher than the ordinary motors. Energy efficient motors result from design

TABLE 2.10 SUMMARY OF MOTOR DRIVE READINGS

Sl. No.	Machine	Rating		Actual reading				%ge Loading	kVAR Requir
		HP	KW	KW	I	V	PF		
1.	CREEPER NO 5	30.0	22.4	4.7	17.80	381	0.40	18%	8
2.	CREEPER NO 4	40.0	29.8	7.6	20.14	379	0.58	22%	8
3.	SHREDDOR	50.0	37.3	17.3	36.19	380	0.73	39%	12
4.	PREBREAKER	30.0	22.4	13.8	25.03	377	0.84	52%	6
5.	CREEPER 1	30.0	22.4	10.5	21.6	332	0.84	40%	5
6.	CREEPER 2	30.0	22.4	7.0	19.4	377	0.55	27%	8
7.	HAMMER	30.0	22.4	8.9	35.65	370	0.39	34%	15
8.	GASIFIER BLOWER	3.0	2.2	0.7	2.03	375	0.53	27%	1
9.	SBT PUMP	5.0	3.7	1.5	3.72	374	0.61	33%	1
10.	BLOWER 1	15.0	11.2	7.9	14.25	385	0.83	60%	4
11.	BLOWER 2	15.0	11.2	5.7	12.1	380	0.72	44%	4
12.	BLOWER 3	12.5	9.3	6.7	16.20	383	0.63	61%	6
13.	BLOWER 4	12.5	9.3	6.3	12.0	383	0.79	58%	4
14.	CHAIN PUSHER	2.0	1.5	0.1	1.01	382	0.21	8%	0
15.	RIVER PUMP	15.0	11.2	11.8	21.92	373	0.83	90%	6
16.	GLT PUMP	10.0	7.5	8.0	14.40	385	0.83	91%	4
17.	COOLING FAN	3.0	2.2	2.0	3.62	384	0.81	74%	1
18.	PRESSING MOTOR	7.5	5.6	3.3	7.5	376	0.67	50%	3
	Total								95.

characteristics, selection of materials, sometimes more copper and iron, and from tighter and more expensive manufacturing production methods. Depending on motor design for any motor, maximum motor efficiency will be at a load varying from 85-125% of motor rating. Equipment designers will often select a motor with peak efficiency at 85% of driven load since the designer expects most machine operation to be at this motor load. So when replacing the present motors the energy efficient motors may considered.

In most cases the payback period for the additional investment made is less than 3 years. Hence it is recommended to go for energy efficient motors as a replacement for the present ordinary motor as and when it is due for replacement.

2.6.3 Rewinding of Motors

The factory now has a number of motors which are rewinded once or twice. It is beneficial to go for a new motor if go for a forth rewinding. On rewinding the motor efficiency decreases. The company must taken a policy decision to replace all the ordinary motors with energy efficient motors after the third rewinding.

2.7 LIGHTING SYSTEM

The total lighting load of the TSR factory including office building is less than 1kW. The general lighting consists of tube light fittings either of the single or double type.

The following table 2.11 gives the details of the different types of light fitting and their lumen outputs. The continuous load reading for the lighting system is given in table 2.12.

TABLE 2.11 TYPES OF LIGHTING SYSTEM

Type of Lamp	Lumens / Watt		Typical Application	Typical Life (hours)
	Range	Avg.		
Incandescent	8-18	14	Homes, restaurants, general lighting, emergency lighting	1000
Fluorescent Lamps	46-60	50	Offices, shops, hospitals, homes	5000
Compact fluorescent lamps (CFL)	40-70	60	Hotels, shops, homes, offices	8000-10000
High pressure mercury (HPMV)	44-57	50	General lighting in factories, garages, car parking, flood lighting	5000
Halogen lamps	18-24	20	Display, flood lighting, stadium exhibition grounds, construction areas	2000-4000
High pressure sodium (HPSV) SON	67-121	90	General lighting in factories, ware houses, street lighting	6000-12000

TABLE 2.12 LIGHTING POWER CONSUMPTION

Time	Voltage R(V)	Current R(A)	Active Power (Kw)	Reactive Power (kVar)	Apparent Power (kVA)	Power Factor	Power Integral (KWh)
1/2/2006 17:10	383.40	0.28	0.60	0.22	0.64	0.94	0.15
1/2/2006 17:55	386.40	0.18	0.35	0.15	0.38	0.92	0.43
1/2/2006 18:10	378.10	0.96	0.27	0.36	0.46	0.60	0.50
1/2/2006 18:25	365.80	1.54	0.41	0.51	0.66	0.63	0.61
1/2/2006 18:40	356.90	1.80	0.42	0.60	0.73	0.57	0.71
1/2/2006 18:55	355.50	2.22	0.76	0.40	0.85	0.89	0.90
1/2/2006 19:10	358.60	2.15	0.74	0.41	0.84	0.87	1.08
1/2/2006 19:25	361.90	1.96	0.68	0.41	0.79	0.85	1.25
1/2/2006 19:40	366.80	2.00	0.69	0.44	0.82	0.84	1.43
1/2/2006 19:55	373.10	2.07	0.72	0.48	0.86	0.83	1.61
1/2/2006 20:10	377.00	2.15	0.75	0.51	0.90	0.83	1.79
1/2/2006 20:25	380.10	2.19	0.77	0.53	0.93	0.82	1.99
1/2/2006 20:40	383.10	2.39	0.84	0.55	1.01	0.84	2.20
1/2/2006 20:55	387.10	2.91	1.04	0.58	1.20	0.87	2.46
1/2/2006 21:10	388.30	2.85	1.05	0.49	1.16	0.91	2.72
1/2/2006 21:25	391.30	2.77	1.04	0.49	1.15	0.90	2.98
1/2/2006 21:40	393.10	2.72	1.03	0.49	1.14	0.90	3.24
1/2/2006 21:55	384.20	2.62	0.97	0.43	1.06	0.91	3.48
1/2/2006 22:10	383.90	2.60	0.97	0.42	1.06	0.92	3.72
1/2/2006 22:25	387.20	2.64	0.99	0.44	1.08	0.91	3.97
1/2/2006 22:40	391.30	2.68	1.01	0.48	1.11	0.90	4.22
1/2/2006 22:55	393.60	2.70	1.02	0.50	1.13	0.90	4.47
1/2/2006 23:10	397.30	2.48	0.94	0.51	1.07	0.88	4.71
1/2/2006 23:25	398.80	2.63	1.05	0.42	1.13	0.93	4.97
1/2/2006 23:40	399.70	2.56	1.03	0.42	1.11	0.93	5.23
1/2/2006 23:55	402.80	2.60	1.04	0.45	1.14	0.92	5.49
1/3/2006 0:10	326.20	2.09	0.83	0.38	0.74	0.91	5.70
1/3/2006 0:25	402.80	2.60	1.05	0.47	1.15	0.91	5.96
1/3/2006 0:40	400.50	2.60	1.04	0.46	1.14	0.92	6.22
1/3/2006 0:55	400.30	2.60	1.04	0.46	1.13	0.92	6.48
1/3/2006 1:10	401.00	2.60	1.04	0.45	1.13	0.92	6.74
1/3/2006 1:25	402.80	2.61	1.04	0.46	1.14	0.91	7.00
1/3/2006 1:40	403.50	2.61	1.05	0.46	1.14	0.92	7.26
1/3/2006 1:55	405.60	2.63	1.06	0.47	1.16	0.91	7.53
1/3/2006 2:10	405.10	2.63	1.06	0.47	1.16	0.91	7.79
1/3/2006 2:25	405.00	2.62	1.06	0.47	1.15	0.91	8.05
1/3/2006 2:40	406.00	2.63	1.06	0.48	1.16	0.91	8.32
1/3/2006 2:55	407.30	2.64	1.07	0.49	1.17	0.91	8.58
1/3/2006 3:10	408.10	2.64	1.07	0.49	1.17	0.91	8.85
1/3/2006 3:25	407.30	2.64	1.07	0.48	1.17	0.91	9.12
1/3/2006 3:40	407.10	2.64	1.07	0.48	1.17	0.91	9.38
1/3/2006 3:55	404.70	2.64	1.06	0.48	1.16	0.91	9.65
1/3/2006 4:10	403.80	2.64	1.05	0.47	1.15	0.91	9.91
1/3/2006 4:25	403.60	2.61	1.05	0.46	1.14	0.92	10.17
1/3/2006 4:40	402.10	2.60	1.04	0.45	1.13	0.92	10.43
1/3/2006 4:55	399.30	2.57	1.03	0.43	1.12	0.92	10.69
1/3/2006 5:10	399.20	2.57	1.03	0.43	1.11	0.92	10.95
1/3/2006 5:25	394.20	2.53	1.00	0.39	1.08	0.93	11.20
1/3/2006 5:40	386.80	2.47	0.97	0.35	1.03	0.94	11.44
1/3/2006 5:55	382.90	2.41	0.93	0.34	0.99	0.94	11.67
Average	**389.81**	**2.37**	**0.92**	**0.45**	**1.02**	**0.88**	

2.7.1 Use of natural daylight

Natural daylight is the most abundantly and freely available source of illumination. Proper utilization of this source is very beneficial to the unit as it will to a great extent reduce the dependence on the artificial lights during the day and also reduces the energy consumption.

The translucent sheets may provide in the processing area in day time to avoid burning of some tube lights. The natural daylight is the most abundantly and freely available source of illumination. Proper utilisation of this source is very beneficial to the unit, as it will to a great extent reduce the dependent on the artificial light during daytime and also reduces the energy consumption. The processing area having roofing sheets which make it all the more easier to adopt natural day light for plant lighting. The natural daylight can be used by selectively replacing some of the Aluminum sheets from the roof with translucent sheets.

2.7.2 Energy Savings from Day Light

Total No of fluorescent tubes burning during day time in the plant= 22

Average power consumption per tube including choke = 55W

Average burning hours	= 10 hrs
Average power consumption per day	= (22 x 55 x 10)/1000
	= 12.1 kWh
Annual power consumption (300 days/year)	= 12.1 x 300
	= 3630 kWh
Average cost of power /unit	= Rs. 5.78
Total cost saving per annum	= 3630 x 5.78
	= Rs . 20, 981
Investment required for translucent sheets	= Rs. 25,000
Simple payback period	= (25000/20981) x 12
	= 14.3 months

2.7.3 Electronic Ballast

The efficiency of fluorescent tube increases when working at a high frequency of 20 to 30 KHz, than at normal 50 Hz frequency. The electronic ballast is a device, which converts the 50 Hz supply to 25 to 30 KHz.

The basic circuit of electronic ballast converts the input AC to DC and then inverts it to AC to run the lamp at a high frequency. Fluorescent tubes operating at high frequencies have a higher efficiency than those driven at normal frequency by virtue of low reactive circuit components and they have practically no losses.

Brief Description: - The electronic ballast or solid state choke does not require starters or capacitors to be used with it. It consumes only one to two watt of power compared to 15 to 20 Watts of power in conventional choke. Efficiency of lighting improves by 10%. The power factor is improved. The electronic ballast offers a rapid start to the system, which lights in less than a second. **Stroboscopic effect** otherwise known as flickering effect is produced due to the periodic fluctuations in the light output of the lamp caused by cyclic variation of the frequency on an AC circuit. The flickering effect is more pronounced in conventional ballasts which are operated at lower frequencies of 50 Hz. Flickering effect is totally eliminated in electronic ballasts as they operate at high frequency. The tube life also is increased as compared to the tubes using conventional chokes.

2.7.4 Energy Efficient Lighting System

It is observed that ordinary tube lights of 40 Watts are used in almost all fittings. Proven results show that 40 Watt conventional tube light and 36 Watts slim tube light give the same lighting level. Hence by replacing the 40 watt conventional tube light with the 36 watt slim tube light, 4 watts per single fitting can be saved.

It is recommended to use only 36 watt slim tubes in all fittings. This may be implemented at the time of replacement due of the present 40 watt conventional tube light. Light output comparison is given in table 2.13.

TABLE 2.13 COMPARISON OF LIGHT OUTPUT

Sl .No	Length	Diameter	Rating	Lumens	Efficacy
1	1200 mm	112	40 W	2850 lm	71
2	1200 mm	T8	36 W	2600 lm	72

Luminous efficacy = Light output / Power input

2.6.5 Savings from Energy Efficient Lighting System

Power consumption of a fluorescent tube with ordinary choke : 55 W

Power consumption of electronic ballast with slim tube : 38 W

Savings per tube set by replacing with electronic ballast : 17 W

Total number of tube fittings in the company : 30

No of tubes burning 24 hrs / day : 25

Power savings after replacement / day : 17 x 25 x 24 /1000

= 10.2 kWh

No of tubes burning 14 hrs / day : 5

Power savings after replacement / day : 1.19 kWh

Total power savings/ day : 11.39 kWh

Annual savings : 11.39 x 300

	= 3417 kWh
Cost of power at the company	: Rs. 5.78
Annual cost savings	: Rs. 19,750
Cost of electronic ballast with tube	: Rs. 300
Total investment required	: Rs. 9,000
Simple pay back period	: (9000/19750) x 12
	= 5.46 months.

2.8 SOLAR ENERGY AS ALTERNATE SOURCE

The total lighting load of the company is 1kW.Nature has bestowed on us abundant sunlight. Electricity can be produced from the solar energy by Photo Voltaic Cells.

2.8.1 Working Principle

Electricity is directly generated by utilizing solar energy by the Photo-Voltaic process. When photons from the sun are absorbed in a semiconductor they create free electrons. Thus an electric current is produced in the external circuit. A solar cell module which is commercially available is having a voltage rating of 6V and current rating of 0.5 Amps. Using these modules a SPV panel could be designed to produce an out put of 1kW so that this could replace the conventional supply for the lighting system.

2.8.2 Solar Panel Connections

To achieve the required power the cells may be connected in series parallel combination. By combining a number of solar cells in series the required voltage can be obtained. Cells can be connected in parallel to get the required current. There may be tracking arrays or fixed arrays. A tracking array keeps the solar array line perpendicular to solar radiation so that it can absorb the maximum sunlight. A fixed array is oriented towards Southside in order to absorb maximum solar radiation.

2.8.3 Design of Solar Cell Array for Lighting System

Total lighting load	= 1kW
Voltage rating of single solar module	= 6V
Current rating of single solar module	= 0.5A

To calculate the No of modules to be connected ,first the value of current is to be calculated

Power	= Voltage x Current
Power	= 1kW
Voltage	= 230 V
1000	= 230 x I
I	= 4.34 A

No of cells to be connected in parallel to produce 4.34 A = 4.34 / 0.5 =9 rows

No of cells to be connected in series to produce 230 V = 230 / 6 =39 cells

2.8.4 Photo voltaic System for Power Generation

A basic SPV system interconnected with grid is shown

It consists of

1. Solar Array: which converts the solar energy to DC power.
2. A blocking Diode: which lets the DC flow only towards the battery or grid.
3. Battery Storage: in which the generated electric power may be stored. The common lead acid storage batteries are not ideal for this purpose, but they are probably the best presently available.Extensive research in progress
4. Inverter/Converter: usually solid state which converts the battery bus voltage to AC of frequency and phase to match that needed to integrate with the utility grid.
5. Switches and Circuit Breakers: to permit isolating parts of the system .

2.8.5 Advantages of Solar Energy

1. No fuel cost
2. No pollution
3. Transmission loss are avoided because the SPV system could be installed near to load centers.
4. Low maintenance cost.

2.8.6 Pay back Period Calculation

Total lighting load	=1Kw.
Cost required for producing 1W	=Rs. 200
Cost required for attaining 1 KW out put	=Rs. 2,00,000

According to Industrial tariff the cost required for the lighting system annually

=33,000

Simple pay back period = 2,00,000 / 33,000 = 6 years

CHAPTER 3
LATEX FACTORY

3.1 ABOUT THE COMPANY

Latex factory is a unit of District Cooperative Rubber Marketing Society established in 1989. The company produces Centrifuge Latex (CENEX) and bye product as Skim coagulant. This factory is having an installed production capacity of 10000 Liters of CENEX per day.

3.2 PRODUCTION PROCESS

Fresh field latex collected at various collection centers is bulked and ammoniated to about 1%. The preserved field latex thus obtained is packed in barrels and transported to the factory. On arrival at the factory, the latex is tested for DRC, ammonia content, magnesium content and volatile fatty acids (VFA). The latex is poured into large desludging tanks after sieving and the sludge is allowed to settle. Calculated quantity of diammonium hydrogen phosphate (DAHP) is added to fasten settling.

After a settling time of about 12-16 hours, the latex is fed to the centrifuging machine which separates it into concentrate and the skim. One centrifuging machine can process about 3,000 litres of field latex per day in three shifts. After having 3 to 4 hours of continuous working, the bowl is taken out and cleaned.

The latex concentrate is collected in bulking tanks, ammonia content is made up drc is adjusted and, if necessary, MST is boosted up. After thorough homogenisation, a sample is drawn and tested for complete parameters. The latex is then filled in barrels and marketed.The skim latex is collected in shallow tanks for deammoniation and coagulated using sulphuric acid. The coagulum is transported to company's crepe factory.

3.2.1 Quality Control of Centrifuged Latex

The properties of centrifuged latex are assessed by a set of parameters. The ISO and other national standard organisations have formulated their specifications. In India, the Bureau of Indian Standards (BIS) has formulated a set of specifications for quality control and is published in IS 5430-1981.

3.3 ENERGY UTILISATION

The Latex Factory, utilises electrical energy as the main energy input for the plant activities. The power requirement of the units is met with the Electrical energy purchased from the Kerala State Electricity Board as well as generated using diesel generators during supply interruptions, low voltage conditions and power cuts. The total power consumption of the plant during the year 2005 was about 165835 kWH with monthly average consumption of 13820 kWH.

The present KSEB charge for the unit is Rs.3.25/kWH for both power and light. The overall cost of power including duty, fixed charge etc. is about Rs.3.69/ KWH for the month of November 2005.

The production and power consumption details of the unit for the year 2005 was analysed and are represented in graphical form to indicate the variations in power consumption, production, diesel consumption etc... The details of production and power consumption of the plant are given in table 3.1.

The energy and cost distribution chart for the year 2005 is given in table 3.2

TABLE 3.1 ENERGY CONSUMPTION DETAILS FOR THE YEAR 2005

Month & Year	PM	LM	ENERGY CONSUMPTION(KWH)			Diesel consumption (Ltrs.)	Hrs of operation (Hrs.)		Cenex DRC (Kg)	Skim (Kg)	Specic Energy Consumption (kWH/Kg of Cenex)
			KSEB	Self Generation	Total		DG 83KVA	DG 63KVA			
JAN '05	12727	485.0	13212.0	1716.4	14928.4	613.0	53.8	3.0	115831.2	18327.7	0.13
FEB	10532	451.0	10983.0	4482.8	15465.8	1601.0	129.3		115089.0	19174.0	0.13
MAR	11135	503.0	11638.0	2819.6	14457.6	1007.0	72.0	4.0	111185.4	19610.8	0.13
APR	10333	471.0	10804.0	4496.8	15300.8	1606.0	133.0		120909.3	19876.6	0.13
MAY	11063	560.0	11623.0	4099.2	15722.2	1464.0	121.0		132029.7	24527.7	0.12
JUN	9666	441.0	10107.0	5482.4	15589.4	1958.0	157.0		94010.1	16033.3	0.17
JUL	9723	449.0	10172.0	5188.4	15360.4	1853.0	147.0		160957.49	30399.99	0.10
AUG	3161	199.0	3360.0	33.6	3393.6	12.0	3.0		MAINTENANCE		
SEP	7230	454.0	7684.0	1674.4	9358.4	598.0	42.5	2.5	66238.9	15068.04	0.14
OCT	11855	453.0	12308.0	2175.6	14483.6	777.0	61.3		102800.8	21504.89	0.14
NOV	13845	528.0	14373.0	781.2	15154.2	279.0	20.0		120453.6	21138.14	0.13
DEC	15272	559.0	15831.0	789.6	16620.6	282.0	23.4		35183.6	23763.1	0.47
TOTAL	**126542**	**5553**	**132095**	**33740**	**165835**	**12050**	**963**	**10**	**1174689**	**229424**	
MONTHLY AVERAGE	**10545**	**463**	**11008**	**2812**	**13820**	**1004**	**80**	**3**	**106790**	**20857**	0.14

TABLE 3.2 ENERGY & COST DISTRIBUTION 2005

Energy inputs	Unit	Annual Consumption	Energy		Cost/Unit (Rs.)	Total Cost	
			kWH	%ge		Rupees	%ge
Purchased Power (KSEB)	(KWH)	132095	132095	79.7%	3.69	487298	55%
Diesel (DG Set)	(Ltrs)	12050	33740	20.3%	33	397650	45%
Total			**165835**	100.0%		**884948**	100%

3.4 ELECTRICAL SYSTEM

The 440 V supply from the nearby distribution transformer having a capacity of 100kVA is utilized for the activities of the plant and come under LT IV tariff. From the LT main panel, distribution of load for different section is through the sub-switch boards located at each section. The power distribution pattern of the plant is given in table 3.3.

The connected load of the plant is 68kW and from the continuous load readings taken for a period of 24hrs on a typical working day, it is found that the maximum load of the plant occurred was 42kW with an average load of 25 kW. The low average load is due to the fact that on the day of energy audit one centrifuge machine was in maintenance up to 10 PM.

By considering the loading of the transformer, the power factor of the plant and hence the demand must be taken into account. At present average loading of the transformer is found to be 30%, i.e. 30kVA with a average power factor of around 0.81 and the maximum demand of the plant occurred was 58kVA, i.e. 58%, at around 2:30PM when the majority of the plant operations were carried out simultaneously. The continuous load readings of the plant is given in table 3.4.

For a distribution transformer the maximum efficiency occurs when the transformer is loaded between 30 – 40% of its rated capacity. So before going for any future expansion of the plant, it should also be taken in to account. It is noted that the company is going to implement additional loads which comes around 54HP, i.e. 40kW, as a part of capacity expansion of the plant. By taking these additional loads the average load of the transformer will be around 75kVA ie. 75%, for an average power factor of 0.81. At maximum demands, the loading of the transformer may go above 90% of the transformer capacity and as a result of this the losses in the will be more as compared to the previous case and it will affect the transformer life also. So it is recommended to go for a suitable capacity

TABLE 3.3 PANEL READINGS

Sl. No.	**Switch Board**	**Actual Load Readings**			
		KW	***I***	***V***	***PF***
1.	SSB - 4	10.7	16.72	371	1.00
2.	SSB - 2	12.5	20.20	375	0.95
3.	Cevtrifuge M/c(I&II)	16.1	32.25	375	0.77
Total		**28.54**	**52.45**	**375**	**0.84**

TABLE 3.4 KSEB TOTAL

Time	Voltage (V)	Current (A)	Active Power (kw)	Reactive Power (kvar)	Apparent Power (kva)	Power Factor	Frequency (Hz)
5:00 PM	380.00	15.45	10.61	6.25	12.32	0.86	49.76
5:30 PM	381.30	15.83	8.61	7.72	11.56	0.75	49.76
6:00 PM	366.40	15.60	8.62	8.45	12.07	0.71	49.76
6:30 PM	329.10	34.16	12.77	15.31	19.94	0.64	49.76
7:00 PM	322.30	18.65	8.41	6.59	10.68	0.79	49.76
7:30 PM	335.20	19.20	8.87	7.25	11.45	0.77	49.76
8:00 PM	341.30	18.74	8.62	7.57	11.47	0.75	49.76
8:30 PM	349.80	22.84	9.85	10.41	14.34	0.69	49.76
9:00 PM	357.30	18.53	8.77	7.82	11.75	0.75	49.76
9:30 PM	367.70	30.23	12.28	15.10	19.46	0.64	49.76
10:00 PM	382.00	32.41	15.94	13.69	21.02	0.76	49.76
10:30 PM	372.90	33.64	16.62	12.94	21.07	0.79	49.76
11:00 PM	388.80	32.51	16.20	13.81	21.28	0.76	49.76
11:30 PM	402.10	22.12	11.17	10.37	15.24	0.74	49.76
12:00 AM	403.10	33.71	17.47	14.66	22.81	0.77	49.76
12:30 AM	405.50	35.40	18.62	15.09	23.97	0.78	49.76
1:00 AM	410.20	23.88	10.61	13.08	16.84	0.63	49.76
1:30 AM	408.30	31.82	17.10	14.66	22.52	0.76	49.76
2:00 AM	409.90	32.00	16.49	14.83	22.17	0.74	49.76
2:30 AM	411.10	32.88	17.38	15.02	22.97	0.76	49.76
3:00 AM	410.00	38.91	17.34	21.30	27.46	0.64	49.76
3:30 AM	412.00	31.39	15.88	14.83	21.73	0.73	49.76
4:00 AM	410.20	28.77	13.84	14.49	20.04	0.69	49.76
4:30 AM	406.00	30.85	15.50	14.31	21.09	0.73	49.76
5:00 AM	398.60	31.35	16.57	13.80	21.56	0.77	49.76
5:30 AM	388.10	31.87	16.44	13.38	21.20	0.78	49.76
6:00 AM	366.10	43.86	22.01	16.12	27.28	0.81	49.76
6:30 AM	364.70	43.70	21.21	17.20	27.31	0.78	49.76
7:00 AM	360.50	48.40	23.49	15.63	28.21	0.83	49.76
7:30 AM	364.70	40.22	18.19	15.17	23.69	0.77	49.76
8:00 AM	364.80	47.32	23.36	15.99	28.31	0.83	49.76
8:30 AM	362.20	52.54	25.43	16.57	30.35	0.84	49.76
9:00 AM	361.20	63.21	33.86	18.94	38.79	0.87	49.76
9:30 AM	367.10	57.66	32.52	19.17	37.75	0.86	49.76
10:00 AM	381.30	68.87	36.63	19.84	41.66	0.88	49.51
10:30 AM	380.60	72.32	38.07	19.62	42.82	0.89	49.51
11:00 AM	379.90	71.95	37.77	19.60	42.55	0.89	49.51
11:30 AM	380.30	68.84	36.63	19.42	41.46	0.88	49.51
12:00 PM	379.10	68.73	36.42	19.49	41.31	0.88	49.51
12:30 PM	379.80	74.27	38.69	19.01	43.11	0.90	49.51
1:00 PM	379.40	74.68	39.07	18.61	43.27	0.90	49.51
1:30 PM	381.50	60.33	31.31	13.62	34.15	0.92	49.51
2:00 PM	380.60	59.97	30.97	13.35	33.73	0.92	49.51
2:30 PM	372.10	97.70	41.82	40.88	58.48	0.72	49.51
3:00 PM	380.50	59.73	30.69	13.48	33.52	0.92	49.51
3:30 PM	380.20	60.66	30.99	13.46	33.79	0.92	49.51
4:00 PM	379.40	63.93	32.13	13.28	34.77	0.92	49.51
4:30 PM	380.10	61.47	31.20	13.44	33.97	0.92	49.51
5:00 PM	380.10	62.59	31.59	13.51	34.35	0.92	49.51
Average	**385.26**	**49.40**	**25.06**	**16.30**	**30.19**	**0.81**	**49.66**
Maximum	**372.10**	**97.70**	**41.82**	**40.88**	**58.48**	**0.72**	**49.51**
Minimum	**322.30**	**18.65**	**8.41**	**6.59**	**10.68**	**0.79**	**49.76**

transformer, say 160kVA, so that the average loading of the transformer should lie less than 50% of its capacity.

At present the DG sets are operated during low voltage conditions. The DG sets are operated around 5 months in a year with an average operating time of around 5hrs/day which costs around Rs.2,47,500/- per annum. So it is recommended to go for step up transformer so that the cost due to the operation of DG sets during low voltage conditions can be avoided. The savings calculation is given in table 3.5. below.

TABLE 3.5 DG SET SAVING

Consumption	12 Lts/hr
Average operating time/day	5hrs
Monthly consumption	12 x 5x 25 = 1500 Lts
Diesel cost/month	1500 x 33 = Rs. 49500
Number of months DG operates due to low voltage	5
Annual diesel charge	49500 x 5=Rs.2,47,500

Also, at present, of the two generators, the 82.5kVA DG set is connected to the bus bar at the bottom of the main panel which is isolated from the KSEB bus and 62.5kVA DG set is connected to the top bus bar which is common to both 62.5kVA DG set and KSEB supply. At low voltage conditions the ETP is operated through 82.5kVA DG set and the rest of the load is supplied from KSEB. The average fuel consumptions of 82.5kVA and 62.5kVA DG sets are 12ltrs/hr and 8ltrs/hr respectively. So it is recommended to interchange the DG sets at the main panel so that only the 62.5kVA DG set is only need to operate during low voltage conditions for the ETP. Hence the company can save around 4ltrs/hr with an annual cost saving of around Rs.82,500/-.

3.4.1 Power Factor Correction

For the purpose of power factor correction, the company has adopted load compensation method. It is noted that capacitors are connected for loads like centrifuge machines, aerator, river pumps etc.. But it is found that the capacitors connected to the centrifuge machines and aerator is not working and is recommended to replace.

3.5 ELECTRIC DRIVES

The major part of power consumption of Latex Factory, is by centrifuge latex machines, Lab and ETP. All the loads having more operating hours were analyzed for loading, power factor and efficiency related aspects. From the measurements and readings taken it was observed that on the whole the motor loading is good. The list of motor drives and the measured parameters are given in table 3.6. The power consumption details of individual loads of the plant are given in table 3.7.

3.5.1 Centrifuge Latex Machine

The company has two centrifuge latex machines having a capacity of 450ltrs/hr each with a rated load of 15HP. The average time for one batch of processing is around 3hrs and the total capacity of the plant is around 100 barrels/day.

The power consumption of each machines for one batch of processing were analyzed using the digital power recorder and for the first machine the

TABLE 3.6 SUMMARY OF MOTOR DRIVE READINGS

Sl.	Machine	Rating		Actual reading				%ge Loading	kVAR Required for 0.99 PF
No.		HP	KW	KW	I	V	PF		
1.	Centrifuge 1	15.0	11.2	7.6	15.42	369	0.77	57%	5
2.	Centrifuge 2	15.0	11.2	8.5	16.83	382	0.77	65%	5
3.	Aerator	15.0	11.2	4.7	9.76	369	0.76	36%	4
4.	River Pump	5.0	3.7	4.5	7.97	365	0.90	103%	1
5.	Recycling Pump	1.0	0.7	0.6	1.0	367	1.00	72%	0

TABLE 3.7 POWER CONSUMPTION DETAILS

Machine	Average Load (kW)	Average Operating Hours	Average power consumption/day (kWH)
Present Power consumption of the plant			
Centrifuge Machine 1	7.56	22	166
Centrifuge Machine 2	8.53	22	188
Aerator	5.07	24	122
Lab	13.19	8	106
River Pumps (5HP+1HP)	5.59	6	34
Light+fan	1.15	24	28
Power consumption/day			**642**
Power consumption of additional equipments to be implemented			
10 HP compressor for deammonisation	7.5	8	60
10 HP compressor for latex pumping	7.5	8	60
5HP lab	3.5	8	28
15HP C L machine	9.0	22	198
5HP ETP	3.5	8	28
9HP Stirrer	6.0	8	48
Power consumption/day			**422**
Total consumption/day after implementing the addl. Equipments			**1,064**

TABLE 3.8 CENTRIFUGE 1

Time	Voltage R(V)	Current R(A)	Active Power (kW)	Reactive Power (kVar)	Apparent Power (kVA)	Power Factor	Frequency (Hz)	Power Integral (KWh)
10:15 AM	390.60	59.75	15.98	37.21	40.50	0.39	49.51	0.30
10:20 AM	365.20	45.67	17.54	23.01	28.94	0.61	49.51	1.62
10:25 AM	373.50	14.90	7.64	5.94	9.68	0.79	49.51	2.68
10:30 AM	372.70	14.65	7.52	5.97	9.60	0.78	49.51	3.31
10:35 AM	366.40	14.57	7.48	5.75	9.43	0.79	49.51	3.93
10:40 AM	363.80	14.81	7.36	5.87	9.41	0.78	49.51	4.55
10:45 AM	366.90	15.24	7.54	6.01	9.64	0.78	49.51	5.17
10:50 AM	371.60	15.14	7.52	6.03	9.64	0.78	49.51	5.80
10:55 AM	375.90	15.22	7.51	6.12	9.68	0.78	49.51	6.43
11:00 AM	374.50	15.00	7.45	6.11	9.63	0.77	49.51	7.05
11:05 AM	362.40	14.80	7.33	5.60	9.22	0.79	49.51	7.67
11:10 AM	360.50	14.85	7.32	5.72	9.29	0.79	49.51	8.27
11:15 AM	364.20	15.05	7.30	5.81	9.33	0.78	49.51	8.88
11:20 AM	362.80	15.29	7.35	5.84	9.38	0.78	49.51	9.48
11:25 AM	366.50	15.40	7.45	6.03	9.59	0.78	49.51	10.11
11:30 AM	365.20	15.48	7.39	5.98	9.51	0.78	49.51	10.72
11:35 AM	365.60	15.38	7.51	5.96	9.59	0.78	49.51	11.34
11:40 AM	368.30	15.08	7.44	5.91	9.50	0.78	49.51	11.96
11:45 AM	367.60	15.18	7.49	5.98	9.59	0.78	49.51	12.58
11:50 AM	365.80	15.16	7.49	5.91	9.54	0.79	49.51	13.21
11:55 AM	366.50	15.24	7.52	5.93	9.58	0.79	49.51	13.83
12:00 PM	366.90	15.30	7.62	6.02	9.71	0.78	49.51	14.46
12:05 PM	367.60	14.99	7.53	5.98	9.61	0.78	49.51	15.09
12:10 PM	367.80	15.19	7.51	6.06	9.65	0.78	49.51	15.72
12:15 PM	366.40	15.11	7.47	6.08	9.64	0.78	49.51	16.35
12:20 PM	366.70	15.06	7.38	6.02	9.52	0.78	49.51	16.97
12:25 PM	366.60	15.06	7.51	6.00	9.61	0.78	49.51	17.59
12:30 PM	368.30	14.86	7.40	5.96	9.50	0.78	49.51	18.21
12:35 PM	367.30	14.96	7.41	6.05	9.56	0.77	49.51	18.83
12:40 PM	366.30	15.15	7.47	6.05	9.61	0.78	49.51	19.44
12:45 PM	367.20	15.16	7.50	6.03	9.63	0.78	49.51	20.06
12:50 PM	367.30	15.37	7.48	6.02	9.60	0.78	49.51	20.68
12:55 PM	374.90	15.21	7.43	6.28	9.72	0.76	49.51	21.31
1:00 PM	376.90	15.18	7.47	6.34	9.79	0.76	49.51	21.93
1:05 PM	377.10	15.62	7.70	6.49	10.07	0.76	49.51	22.56
1:10 PM	376.40	15.68	7.78	6.45	10.11	0.77	49.51	23.20
1:15 PM	376.80	15.82	7.95	6.51	10.27	0.77	49.51	23.86
1:20 PM	378.10	16.20	8.33	6.53	10.58	0.79	49.51	24.54
1:25 PM	379.10	16.42	8.37	6.61	10.67	0.78	49.51	25.24
1:30 PM	379.60	16.55	8.44	6.66	10.75	0.79	49.51	25.93
1:31 PM	381.20	11.84	6.07	4.95	7.83	0.78	49.51	26.03
1:32 PM	384.60	0.66	0.45	0.22	0.50	0.90	49.51	26.04
1:33 PM	380.40	16.62	4.19	10.28	11.11	0.39	49.51	26.11
Average	**370.70**	**16.60**	**7.71**	**7.12**	**10.64**	**0.76**	**49.51**	**26.11**

TABLE 3.9 CENTRIFUGE 2

Time	Voltage (V)	Current (A)	Active Power (kw)	Reactive Power (kvar)	Apparent Power (kva)	Power Factor	Frequency (Hz)	Power Integral (KWh)
11:35 AM	360.30	47.64	12.24	27.20	29.82	0.41	49.70	0.34
11:40 AM	396.60	43.67	18.57	23.69	30.10	0.62	49.70	1.56
11:45 AM	398.80	13.75	7.30	5.92	9.40	0.78	49.70	2.64
11:50 AM	367.30	14.36	7.46	5.05	9.01	0.83	49.70	3.27
11:55 AM	372.90	14.95	7.64	5.42	9.37	0.82	49.70	3.90
12:00 PM	370.70	14.73	7.82	5.37	9.48	0.82	49.70	4.54
12:05 PM	370.30	14.52	7.64	5.36	9.34	0.82	49.70	5.19
12:10 PM	369.00	14.95	7.85	5.45	9.55	0.82	49.70	5.83
12:15 PM	368.40	15.03	7.83	5.50	9.56	0.82	49.70	6.49
12:20 PM	364.50	15.34	8.02	5.36	9.65	0.83	49.70	7.15
12:25 PM	364.60	15.59	8.16	5.35	9.76	0.84	49.70	7.83
12:30 PM	365.60	15.82	8.27	5.38	9.87	0.84	49.70	8.51
12:35 PM	364.60	15.83	8.19	5.48	9.86	0.83	49.70	9.20
12:40 PM	363.50	16.11	8.36	5.44	9.97	0.84	49.70	9.89
12:45 PM	362.60	16.35	8.49	5.44	10.08	0.84	49.70	10.59
12:50 PM	364.50	16.48	8.54	5.66	10.24	0.83	49.70	11.29
12:55 PM	368.20	16.22	8.58	5.58	10.23	0.84	49.70	12.00
1:00 PM	376.50	15.82	8.58	5.85	10.38	0.83	49.70	12.72
1:05 PM	377.80	16.06	8.65	6.10	10.58	0.82	49.70	13.43
1:10 PM	377.10	16.43	8.61	5.98	10.48	0.82	49.70	14.15
1:15 PM	377.80	16.25	8.66	6.03	10.55	0.82	49.70	14.87
1:20 PM	379.90	15.86	8.51	5.94	10.38	0.82	49.70	15.58
1:25 PM	381.50	16.03	8.61	6.06	10.53	0.82	49.70	16.30
1:30 PM	382.50	16.17	8.68	6.19	10.66	0.81	49.70	17.02
1:35 PM	383.80	15.96	8.50	6.08	10.45	0.81	49.70	17.74
1:40 PM	383.80	15.97	8.47	6.18	10.48	0.81	49.70	18.45
1:45 PM	384.30	16.12	8.63	6.19	10.62	0.81	49.70	19.16
1:55 PM	426.70	14.80	9.00	6.82	11.29	0.80	49.70	20.48
2:00 PM	424.30	14.64	8.89	6.64	11.10	0.80	49.70	21.22
2:05 PM	422.10	14.53	8.77	6.65	11.01	0.80	49.70	21.96
2:10 PM	421.50	14.59	8.79	6.57	10.97	0.80	49.70	22.69
2:15 PM	420.60	14.06	8.69	6.37	10.77	0.81	49.70	23.41
2:20 PM	423.50	0.65	0.49	0.27	0.56	0.88	49.70	23.98
Average	**382.91**	**16.83**	**8.53**	**6.87**	**11.09**	**0.80**	**49.70**	**23.98**

eddy current losses. A change in the air gap may affect power factor and output torque.

The impact of rewinding on motor efficiency and power factor can be easily assessed if the no-load losses of a motor are known before and after rewinding. Maintaining documentation of no-load losses and no-load speed from the time of purchase of each motor can facilitate assessing this impact. For example, comparison of no load current and stator resistance per phase of a rewound motor with the original no-load current and stator resistance at the same voltage can be one of the indicators to assess the efficacy of rewinding.

3.5.5 Energy Efficient Motors

It is generally believed that the efficiency motors is high and as such no improvements are possible. However, when the losses in a standard motor are reduced to the extent of about 25%, it can be called an Energy Efficient Motor. Energy Efficient Motors are presently available, having efficiency exceeding 91%. Energy Efficient Motors have became a suitable product for energy conservation even at a higher cost, because of steeply escalating cost for electric power. In general the efficiency of small motors is less than the efficiency of large motors. The efficiency of energy efficient motors is generally 3% to 4% higher than the ordinary motors.

Energy efficient motors result from design characteristics, selection of materials, sometimes more copper and iron, and from tighter and more expensive manufacturing production methods. Depending on motor design for any motor, maximum motor efficiency will be at a load varying from 85-125% of motor rating. Equipment designers will often select a motor with peak efficiency at 85% of driven load since the designer expects most machine operation to be at this motor load.

The design improvements in energy-efficient motor to reduce intrinsic motor losses are :

- By using low loss steels

- Increasing the active material by incorporating a longer core length
- Using thinner laminations
- Reducing the air gap between the stator and rotor
- Using copper bars in the rotor instead of aluminium.
- By using superior bearings and smaller fans etc.

Hence it is recommended to go for energy efficient motors as a replacement for the present ordinary motor as and when it is due for replacement.

3.6 LIGHTING SYSTEM

The lighting power consumption of the latex factory is very low, less than 5%, as compared to the total power consumption of the factory. Natural lighting is also made available at possible areas to reduce lighting power consumption during daytime. The overview of the lighting system gives an impression of an energy efficient system.

The following table 3.10 gives the characteristics of the different types of lighting. While selecting lamp types for various purposes, these points may also be considered along with the initial and running cost:

TABLE 3.10 COLOUR RENDERING INDEX

Sl.No.	Type of Lamp	*Efficacy (lm/W)	Lamp Life Hrs.	Colour rendering index
1	Fluorescent	60	8000	75
2	Incandescent Lamp	15	1000	100
3	HPMV Lamp	55	15000	45
4	HPSV Lamp	100	15000	40
5	LPSV Lamp	150	18000	45

***Efficacy** - Ratio of light out put from a lamp to the electric power it consumes and is measured in lumens per watt (lm/W).

3.6.1 Electronic Ballast For Energy Saving In Fluorescent Lamps

The efficiency of the fluorescent tube is increases when it is working at a high frequency of 20 to 30 kHz, than at the normal 50Hz frequency. The electronic ballast is a devise which converts the conventional 50 Hz supply to 20 to 30 kHz supply.

The basic circuit of electronic ballast converts the input AC to DC and then inverts it to AC to run the lamp at high frequency. Florescent lamp operating at high frequencies has a higher efficiency than those driven at normal frequencies by virtue of low reactive circuit components and they have practically no losses.

The electronic ballast or solid-state choke does not require starters or capacitors be used with it. It consumes only one to two watts of power compared to 15 to 20 watts of power in conventional choke. Efficiency of lighting is improved by 10%. The power factor is also improved. The electronic ballast offers a rapid start to the system, which lights in less than a second. Stroboscopic effect otherwise known as the flickering effect is produced due to the periodic fluctuations in the light out put of the lamp caused by cyclic variation of the frequency on an ac circuit. The flickering effect is more pronounced in the conventional ballasts which are operated at a lower frequency of 50Hz. Flickering effect is totally eliminated in the electronic ballasts as they operate at high frequency. The tube life is also increased as compared to the tubes using conventional chokes.

It is recommended to replace conventional chokes by electronic ballasts. This may be implemented at the time of replacement of present conventional choke. Cost of electronic ballast varies from Rs.225/- to Rs.325/-per unit for a single tube.

3.6.2 Energy Efficient Tube Light

It is observed that ordinary tube lights of 40 Watts is used everywhere in the plant. Proven results show that 40 Watts conventional tube light and 36 Watts slim tube light gives same lighting level. Hence by replacing the 40 Watts conventional tube light with 36 Watts slim tube light, 4 watts per single fitting can be saved.

It is recommended to use only 36 Watts slim tubes in all fittings. This may be implemented at the time of replacement of present 40 watts conventional tube light.

CHAPTER 5

LIMITATIONS OF THE PROJECT WORK

One of the major problems I have identified is the lack of previous year's energy consumption and production data. Thus a comparative study of the specific energy consumption could not have been done. Another limitation is the high investment cost for energy efficient system. The two units are working under rubber board so that for the implementation of energy efficient system, they have to get permission from the board. Before the implementation of the energy efficient system the company s capacity expansion plan also have to be considered.

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