Notes

Chapter - 11

Pulp & Paper

11.1 Introduction

The Indian pulp and paper industry is over a hundred years old. First mill in the country was commissioned in 1812 in Serampur (W. Bengal). Over the years, the installed capacity has grown from a paltry 0.15 million tonnes in the early fifties to the present level of 8.3 million tonnes.

However, the growth of the industry has been uneven and as a result, the Indian paper industry is a mix of large integrated plants based on wood based raw material and medium and small size paper plants based on waste paper. The capacities of the mills range from 500 tonnes/annum to 2.0 lakh tonnes/ annum.

There are about 700 units, which manufacture pulp, paper, paperboard and newsprint paper, out of which nearly 570 are in operation. The total installed capacity is nearly 83 lakh tonnes out of which 11 lakh tonnes are lying idle due to closure of many units.

Based on the raw material utilized, the paper units can be classified into three broad categories as:

- Wood based (Bamboo, hardwood etc.)
- Agro-based (Bagasse, jute, rice & wheat straw)
- Waste paper based

The Indian scenario on production of paper and paperboard, import and export during the last 4 years is given below in Table 11.1

Table 11.1 : Installed Capacity, Production, Import & Export of Paper

(In Lakh Tonnes)

Year	Installed Capacity	Production	Imports	Exports
2004-05	74.0	58.90	1.95	2.70
2005-06	76.0	59.00	2.85	2.92
2006-07	78.0	61.40	3.47	3.39
2007-08	78.0	41.58 (Upto November, 2007)	0.64 (upto May, 2007)	N.A.

(Source: CPPRI & CMIE)

11.2 Manufacturing Process

A variety of processes are in use in the paper industry depending on the type of raw material used and the end product desired. Among these, Kraft (Sulphate) process, Semi-Mechanical process and Sulphite process are the most popular ones. In the Indian pulp and paper industry, the Kraft process dominates the wood/bamboo pulping. Paper making essentially consists of following stages:

- Preparation of pulp
- Stock preparation
- Sheet formation & water removal

11.2.1 Preparation of pulp

11.2.1.1 Wood preparation

Hard wood logs are debarked by wet or dry process depending upon the size of the logs handled. Small diametric logs are debarked by dry process by friction. In wet process, debarking of larger logs of wood is done by drum or pocket barkers.

Hydraulic barking uses high-pressure water jets to separate bark and log. Energy requirement for friction barking is lower than that for hydraulic barking. In India, most of the mills are not doing debarking as they receive either debarked wood or use them with bark due to difficulty in debarking of some hardwoods. The logs are chipped to size suitable for pulping using chippers. Dise and drum chippers are used for chipping. The oversized chips are rechipped, as under sized chips are rejected.

11.2.1.2 Pulp making

Predominantly, pulp making is done either by mechanical or chemical means. In mechanical process, the wood is reduced to small particles by rubbing against huge grindstones revolving at high speeds. Groundwood mechanical process is the most commonly used and most of the Newsprint paper production is undertaken through groundwood pulp process. In India, chemi - mechanical pulping (CMP) is done by only one newsprint paper mill. In CMP, the wood chips are subjected to a mild chemical treatment prior to mechanical separation using a refiner. In the chemical process, the cellulose fibers of the wood are separated from the non-cellulose components by chemical action.

Three primary chemical processes are in use, viz., Kraft or sulphate (alkaline), Sulphite (acidic) and Neutral Sulphite Semi Chemical (NSSC). As mentioned earlier, all large Pulp & Paper mills in India use the Kraft sulphate chemical process for pulping. In this process, the raw material (almost any kind of wood - soft or hard) is cut and chipped to produce chips of 0.5-1" size. These chips are fed into digesters, reacted with white liquor (80:20 NaOH and Na_2S) and steamed for about two to three hours at high temperature and pressure (162 - 168 °C and 7-8 kg / cm^2). Digesters may be batch or continuous type, the latter offering advantages such as increased throughput, reduced labour and better energy utilization. Continuous digesters are also very useful in agro fiber pulping. Many mills using agro residue use Pandia Continuous Digesters. The pulp is then washed to make the pulp free from soluble impurities and removal of black liquor through usual 3 or 4 stages of counter current washing using rotary drum filters. The washed pulp is sent for bleaching to increase the brightness of the pulp and the dilute black liquor is sent to evaporators. The treated pulp then goes for stock preparation. The black liquor after concentration is fired in recovery boilers. The residue "green liquor" is treated with lime to get white liquor for reuse.

In Soda process, which is mostly used for pulping of agricultural residues, Sodium Hydroxide (NaOH) is the main cooking chemical. Other cooking parameters are almost same as Kraft process.

11.2.1.3 Bleaching Process

Pulp when it comes from digester, contains residual coloring matter. This unbleached pulp may be used for making heavy wrapping paper or bags. However, paper to be used for printing, writing or paper which is to be dyed, must first be bleached. The main object in bleaching is to remove residual lignin from the wood pulp fibers as well as to destroy or remove remaining colouring matter. Now a days, various bleaching agents are used to bleach the pulp like chlorine, chlorine dioxide, hydrogen peroxide, oxygen & calcium hypo chlorite

11.2.2 Stock preparation

Stock preparation is undertaken to give the pulp various desired qualities through refining. It is mostly accomplished in either double disk or conical refiners. A more vigorous and special type of refiner, known as Jordan, is used in mechanical pulp preparation method, in which a conical plug rotates in conical shell. The stock then undergoes addition of sizing, filling, and coloring agents. A final screening & centricleaning is carried out prior to paper making for removing the contaminants as they may lead to defects in paper.

11.2.3 Sheet formation & water removal

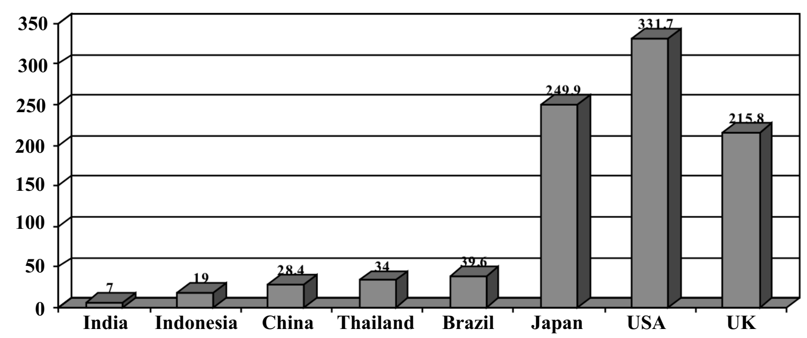
The feed to the paper machine consists of combination of refined pulp together with additives, such as fillers and wet end chemicals, having requisite stock consistency. Either Fourdrinier or cylindrical mould machines form the above feed into a sheet. Mills producing cultural and newsprint paper use high-speed fourdrinier and twin wire sheet formers. Mills producing packaging paper & board mainly use cylindrical mould machines. At wet end of paper machine, water is first removed by gravity, then by suction, then by pressing the sheet and lastly by drying by steam heated cylinders.

11.3 Per Capita Consumption

The per capita consumption of paper in the different parts of the world are depicted below:

Figure - 11.1

Per Capita Consumption (kg/year)



Source : CII - IREDA & CPPRI

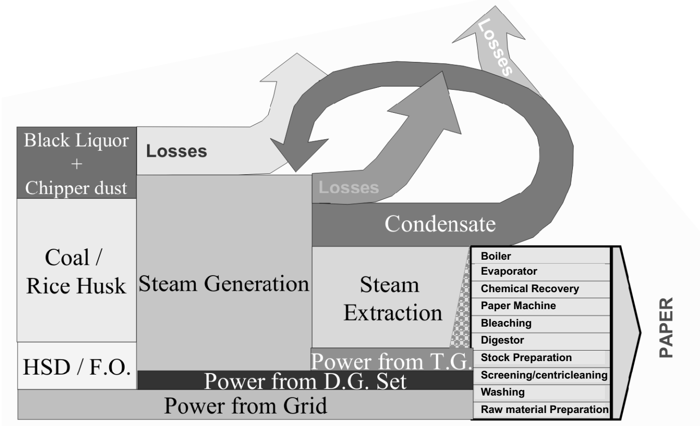
The Indian per capita consumption of paper is 7 kg, in comparison to the Asian average of 21 kg, World average of 55 kg and US average of 331.7 kg. So the Indian pulp and paper industry has got a tremendous growth potential estimated at about 8% per year.

11.4 Energy Profile

The share of energy costs in the total manufacturing cost is close to 25%. Coal and electricity are the two major energy sources used in the paper production. Other fuels, such as low sulphur heavy stock (LSHS), furnace oil, etc. are also used to fire boilers. Light diesel oil (LDO) and high-speed diesel (HSD) are also used for captive power generation in diesel generator sets in plants. The Steam and Electricity generated by energy facilities as shown in figure 11.2 are used by various production facilities. Steam and electricity consumption per tonne of paper is 11-15 tonnes and 1500-1700 kWh respectively in Indian mills. The total specific energy consumption of Indian pulp and paper industry ranges from 31 to 52 GJ (Giga joules) per tonne of product, which is roughly double the norms compared to North American and Scandinavian units. The overall energy conservation and utilization efficiency in Indian Pulp & paper mills is very low compared to mills in developed countries.

It shows that there is immense potential of energy savings in this sector.

Figure - 11.2: Conversion & Utilisation of Energy in Paper Industry



Source: CPPRI

The energy consumption pattern varies according to type of raw material and the technology used by a particular mill.

11.5 Energy Intensity

The paper industry is highly energy intensive and is the sixth largest consumer of commercial energy in the country.

Large paper plants generate part of their own power through cogeneration, while smaller plants depend exclusively on purchased power.

The energy cost, as a percentage of manufacturing cost, which was about 15% a few decades earlier is presently about 25%. This is mainly due to the increase in energy prices.

The expenditure on energy ranks only next to the raw material in the manufacture of paper. With the ever-increasing fuel prices and power tariffs, energy conservation is strongly pursued as one of the attractive options for improving the profitability in the Indian pulp and paper industry.

The specific energy consumption comparison of Indian paper industry vis-à-vis the international trends is as follows (Table -11.2):

Table 11.2: Comparison of Specific Energy Consumption

Parameter	Units	Norm	Indian Mills	International Mills
Steam	MT/ MT of FNP	Avg. Best	11-14 7.5	6.5-8.5 6.0
Power	KWh/ MT of FNP	Avg. Best	1500-1700 1200-1300	1150-1250 900-1000
Water	m^3/ MT of FNP	Avg. Best	150 75	50 25
Total energy	GCal/ MT of FNP	Avg. Best	52 31	28 18

Source: CII-IREDA & CPPRI

The typical break-up of steam and power of the various Indian mills vis-à-vis the international mills is shown in Table 11.3 (a) & (b):

Table 11.3 (a) : Consumption of Section wise Steam consumption

(MT/MT of FNP)

Section	Indian Mills	International Mills
Digester	2.50-3.90	1.9-2.3
Bleach Plant	0.35-0.40	0.20-0.25
Evaporator	2.50-4.00	1.50-2.30
Paper Machine	3.00-4.00	0.70-2.00
Soda Recovery Plant	0.50-1.10	0.30-0.50
Total	**11.0 - 14.0**	**6.5 - 8.5**

Source: CII-IREDA & CPPRI

Table 11.3 (b) Comparison of Section wise Power Consumption (kWh/MT of FNP)

Section	Indian Mills	International Mills
Digester	58-62	43-46
Bleach Plant	88-92	66-69
Paper Machine	465-475	410-415
Soda Recovery Plant	170-190	127-135
Stock Preparation	275-286	164-172
Utilities & Others	246-252	160-165
Chippers	112-128	92-98
Washing & Screening	145-155	116-123
Total	1500-1700	1150-1250

Source: CII-IREDA & CPPRI

11.6 Energy Saving Potential

The various energy conservation studies conducted by PCRA and feedback received from the various industries through questionnaire survey and plant visits indicate an energy savings potential of 20%.

This is equivalent to an annual savings potential of about Rs.3000 million. The estimated investment required to realize this savings potential is Rs.5000 million.

The pulp and paper industry has an attractive cogeneration potential of over 100 MW, in addition to the existing cogeneration plants.

11.6.1 Major factors affecting energy consumption in paper mills

The major factors that affect energy consumption in the Indian pulp and paper industry are:

- Low level of capacity utilisation
- Quality and type of paper produced
- Number and multiplicity of machinery
- Paper machine renewability and down time
- Finishing losses
- Boiler type & pressure levels
- Level of cogeneration
- Power generation

Section-wise details of factors, which affect energy efficiency, are given below:

- Type of raw material preparation section
  - Type of chippers/ cutters
  - Type of conveying system
- Digesters system
  - Type of pulping technology (RDH and extended dezincification preferred using oxygen dezincification)
  - Installation of blow heat recovery
  - Optimal bath liquor ratio
- Washing section
  - Utilisation of advanced washers, such as, flat belt wire washers, double wire press, DD washer and Twin drum washer
- Screening section
  - Installation of advanced screening equipment
- Stock Preparation
  - Type of refiners
  - Type of centri-cleaners (use of low pressure drop centri- cleaners reduce the pumping power consumption)
- Paper machine
  - Type of press
  - Percentage moisture after press section
  - On-line moisture control
  - Type of hood system
  - Type of siphon for condensate removal
- Evaporation section
  - Type of evaporator and number of stages
  - Steam economy achieved (minimum should be 6)
  - Extent of condensate recovery

- Other Factors
  - Type of river water pumping system and overall water consumption
  - Levels of instrumentation
  - Extent of utilisation of variable speed drives, such as, variable frequency drives (VFD), variable fluid couplings (VFC), DC drives, dyno - drives etc.

Apart from the above factors, optimized operation and proper maintenance are also very important for energy efficiency.

11.6.2 Target specific energy consumption figures

The overall specific energy consumption norms for large integrated paper plants, producing writing and printing paper, using 100% chemical bleached pulp and operating on sulphate process, should be as highlighted below:

- Steam = 9.00 MT/MT of finished paper
- Power = 1300 kWh/MT of finished paper
- Water = 100 m^3/MT of finished paper

The break-up of the target specific steam, specific power and specific water consumption figures in the different sections of the plant are given in table 11.4 (a), 11.4 (b) and 11.4 (c)

Table 11.4 (a): Specific Steam Consumption break-up (MT/MT of FNP)

Section	Steam
Pulping & washing	1.2
Bleaching	0.4
Black Liquor Evaporation	2.4
Chemical recovery boiler	0.8
Recausticising & Lime kiln	0.5
Paper machine	2.0
Deaerator	1.4

Source: CII-IREDA & CPPRI

Table 11.4 (b): Specific Power Consumption break-up (kWh/ MT of FNP)

Section	Power
Chippers	30
Digester house	55
Washing and Screening	105
Bleaching plant	105
Stock preparation, Paper m/c and Finishing	500
Power boilers	170
Intake well + Water treatment plant	60
Recovery (Evaporator, recovery boiler, causticisers and lime kiln)	175
Effluent treatment plant	60
Lighting and workshop etc.	50
Total	1300

Source: CII-IREDA & CPPRI

Table 11.4 (c): Specific water consumption break-up (100 m^3/MT of FNP)

Section	Water
Pulp Mill	30
Paper machine	20
Boilers incl. WTP and Cooling tower	30
Chemical recovery area	10
Miscellaneous	10
Total	100

Source: CII-IREDA & CPPRI

11.7 Technologies for Energy Conservation

11.7.1 Recovery of Chemicals from Spent Liquor Obtained from Counter Current Washing of Unbleached Pulp

Technology Description

The chemical recovery systems (evaporators, recovery boilers etc.) are an integral part of any large integrated paper plant. The black liquor can be fired in the soda recovery boilers to generate steam. The sodium salts recovered in the process is reused in the digesters. The installation of such chemical recovery systems in the medium size paper plants is generally considered financially unattractive. Installation of Fluidized Bed Reactor to recover chemicals in medium size paper plant offers an attractive option. The reactor recovers chemicals from spent liquor and converts them into sodium carbonate pellets. These pellets are commercially sold, resulting in additional revenue generation.

Advantages

- Recovery of Chemicals (Sodium Carbonate) from spent liquor results in saving of power and savings of chemicals like Urea and DAP in the effluent treatment plant.

Case Study 1: Recovery of Chemicals from Spent Liquor Obtained from Counter Current Washing of Unbleached Pulp in a Medium Size Paper Mill

Brief

Before Improvement	*After Improvement*
In an agro-based medium size paper plant, the spent liquor obtained from the counter current washing of unbleached agro-pulp, was getting mixed with wastewater and let out to effluent treatment plant. This increases the load on the effluent treatment plant, as it is not possible to bring down the Sodium ratio in the effluent.	*A chemical recovery plant, to recover the chemicals from spent black liquor, obtained from the counter current washing of the unbleached agro-pulp, was installed.* *The following benefits were achieved on the installation of chemical recovery system:* • *Chemical recovery (Sodium Carbonate)* • *Savings in power at the effluent treatment plant* • *Savings in Urea and DAP at the effluent treatment plant*

Energy savings

Annual savings : Rs. 6.2 Million
Investment Required : Rs. 12.6 Million
Payback period : 24 months

11.7.2 Waste heat recovery from waste sludge in pulp and paper industry

Technology Description

An efficient technology for processing of sludge including waste-to-energy aspect and energy recovery has been developed by University Department of Chemical Technology, Mumbai and Paper & Pulp Technology Department, Sant Gadgebaba Amaravati University, Amaravati. The retrofit has been realized in two stages. The waste sludge is burnt in a multiple hearth incinerator with a fluidized bed chamber. The different stages of retrofit, can be characterized as "waste-to-energy", where heat from flue gas is utilized for generating the steam, drying the sludge, pre-heating air for combustion & fluidization and water preheating for steam generation. Off-gas cleaning system consists of a filter for particulate removal and a three-stage scrubber system is attached for cleaner stack.

Advantages

- The technology is favourable both economically and environmentally.

11.7.3 Seven Effect Free Flow Falling Film (FFFF) Evaporator

Technology Description

Multiple effect evaporators are installed in the liquor line between the brown stock washers and the soda recovery boiler to efficiently remove large amounts of water from the liquor, so that, the recovery boiler produces steam from this liquor economically. The multiple effect evaporator is fed black liquor at 12-14% solids concentration and concentrated to 40-55% solids. Most of the paper plants use the short tube or long tube vertical evaporators, having five to seven effects, the first two effects being contained in one evaporator body. The latest trend among the large integrated paper plants is the installation of free flow falling film evaporators. They are characterised by higher steam economy and better operational performance.

Advantages

- The installation of 7-effect FFFF evaporator resulted in achieving steam economy of 6 tons of water evaporation per ton of steam.

Case Study 2: Installation of Seven Effect Free Flow Falling Film (FFFF) Evaporator

Brief

Before Improvement	*After Improvement*
A large integrated paper plant had a conventional quintuple effect short tube vertical evaporator system for the concentration of black liquor. The black liquor flow rate was about 2500 m^3/h. The steam economy achieved was 2.8 tons of water evaporation per ton of steam. These evaporators had frequent operational problems, leading to increase mechanical down time. Also the chemical losses were more due to the frequent water boiling.	*The latest 7 - effect free flow falling film evaporator, was installed in place of the conventional short tube vertical evaporator.* *The installation of 7-effect FFFF evaporator resulted in achieving a steam economy of 6 tons of water evaporation per ton of steam. A net saving of about 9700 MT of low-pressure steam was achieved as a result of this modification.*

Energy savings

Annual savings @ Rs. 3.00 per kg of steam : Rs. 29.1 Million
Investment required : Rs. 36.9 Million
Investment required : 15 months

11.7.4 Use of Variable Frequency Drives (VFD's) in Washer Drum Drives

Technology Description

One step in paper manufacturing process is washing of pulp to remove free soluble impurities and black liquor, thereby recovering maximum amount of spent chemicals. The washing is done using rotary drum washers driven by variable speed systems to achieve desired speed variation, according to the throughput of the plant. The dyno-drives used for the purpose, though have lesser maintenance problems, are inefficient at lower speeds. The variable frequency drives (VFDs) are more efficient at lower/all speeds and require lesser maintenance, in comparison to the dyno-drive.

Advantages

- VFDs are more energy efficient at all speeds and enable precise control of speed.

Case Study 3: Replacement of Dyno-drives with Variable Frequency Drives (VFD's) in Washer Drum Drives

Brief

The contents of the digester, after cooking, are blown down to a blow tank. The blown pulp is then washed, to remove the dissolved lignin and chemicals. Usually, washing is practiced in counter current fashion, involving 3 or 4 stages of washing, using rotary drum washers. The washed pulp is then sent for bleaching and further processing. The rotary drum washers are operated under vacuum, utilizing a barometric column. These drum washers are driven by a variable speed system, to achieve the desired speed variation, according to the throughput of the plant.

Before Improvement	*After Improvement*
In one of the old integrated paper plant, the washer drum drives were fitted with dyno-drives. The washers were operating at 50 - 60% of the rated speed for majority of the time. The dyno-drives are very inefficient at lower speeds.	*The dyno-drives of the washers were replaced with variable frequency drives (VFD's).* *The replacement of dyno-drives with VFD's resulted in a net reduction in power consumption. The net power saving achieved was 36,024 units/year (equivalent of 5.23 kW). The other major advantage is, the precise speed variation, which can be achieved.*

Energy savings

Annual savings @ Rs. 4.5/kWh : Rs. 0.16 Million per year.
Investment required : Rs 0.25 Million
Payback period : 19 months

11.7.4 Sonic Soot Blowers in Place of Steam Soot Blowers for Coal Fired Boilers

Technology Description

Coal fired boilers are installed to meet the steam requirements of the paper plant. The boiler water tubes get frequently coated with soot deposits, as a result of combustion of coal in coal-fired boilers. The cleaning of tubes has to be carried out

to ensure better heat transfer. Steam soot blowers do this normally. The steam consumption of the steam soot blowers is very high and results in drop in efficiency of the boilers. Replacing steam soot blowers with Sonic (Acoustic) blowers, offers a viable option for reducing steam consumption and maintenance cost.

Advantages

- Savings in steam consumption
- Less maintenance cost

11.7.6 Conversion to Fluidised Bed Boilers

Technology Description

The paper plant is a major consumer of thermal energy in the form of steam. This steam requirement is met by a battery of boilers fired by a solid fuel (coal) and also partly by the Soda Recovery Boiler (SRB) in the integrated plants. In the older paper plants, the conventional stoker boilers were in use. These boilers gave higher unburnts in ash and lower thermal efficiency. The latest trend is to install the fluidized bed boilers or conversion of the existing chain / spreader stoker boilers. The Fluidized Bed Combustion (FBC) boiler also enables the use of saw dust, which is generated in the chipper house.

Advantages

- Coal having high ash content / low calorific value can be used
- Biomass fuels can also be used
- Lesser unburnts in ash
- Higher thermal efficiency

Case Study 4: Conversion of Spreader Stoker Boilers to Fluidised Bed Boilers

Brief

Before Improvement	*After Improvement*
A large integrated paper plant had four numbers of spreader stoker boilers, operating to meet steam requirements of the plant. *The steam generation was only 14 TPH, as against the design rating of 30 TPH. The boiler efficiency achieved was only 65 per cent.*	*Two of the four spreader stoker boilers were converted to fluidized bed combustion boilers. This conversion to fluidized bed combustion boilers enabled the use of sawdust, which is generated in the chipper house.* *Steam generation - 27 TPH* *Efficiency - 78%* *Coal Saving - 9239 T*

Energy savings

Annual savings @ Rs. 1.25/kg of coal : Rs. 11.5 Million
Investment required : Rs. 27.0 Million
Payback period : 28 months.

11.7.7 Conversion of MP Steam Users to LP Steam Users to Maximize Cogeneration

Technology Description

The paper industry is a major consumer of power and steam. In all the integrated plants and in a few medium sized plants, the co-generation system is installed to meet the power and steam needs of the plant simultaneously. The paper plant should make every effort to increase the co-generation power to the extent possible. The generation of power from the turbine depends on the pressure level of the extraction. The lower the pressure, the higher will be the generation of power per unit of steam extracted. Hence, efforts should be made to replace the HP (HighPressure) / MP (Medium Pressure) steam with LP (Low Pressure) steam to the highest extent possible.

Advantages

- Increase in co-generation power.

11.7.8 Deinking Process

Technology Description

Stringent guidelines for environmental protection and the social obligations of providing a clean environment is forcing paper mills to explore alternate raw materials and cleaner technologies for long term survival. Deinking process has emerged very promising in these aspects. Old Newsprints (ONP) and Old Magazines (OMG) form the raw materials for deinking. The process involves detachment of ink from the surface of the fibre and its removal through washing and floatation. Unit operations in deinking include Pulping, Screening, Floatation, Fine Cleaning, Slot Screening, Thickening, Dispersing, Bleaching & Final Storage. The waste paper is slushed with warm water and chemicals like Hydrogen peroxide, caustic, soaps etc. in the pulper and cleaned through "Contaminex" followed by HD cleaners before feeding to Floatation cell. The main task of floatation cell is to improve the cleanliness and brightness of the pulp stock. Air in the form of very fine bubbles is sparged through the stock. The ink particles stick to the air bubbles and float. The stock from floatation is pumped to the centri-cleaners for fine screening and further thickened in a Disk Filter. The stock is dewatered in a screw press to a consistency of 28% for final storage. Hindustan Newsprint Ltd. (Kerala) has successfully implemented this technology.

Advantages

- Lesser energy and water consumption, less pollution.

11.7.9 Pressure screens

Technology Description

The function of a pressure screen in a paper machine thin-stock recirculation system is to remove shives (fiber bundles) and other large, hard contaminants from the furnish. Conventional pressure screens use baskets with either slots or holes to admit the fibrous "accepts" flow and reject the contaminants. Slotted screens usually have a sculptured pattern that helps fibers to become aligned and pass through the screen. Pressure screens are equipped with various types of rotors to continuously redisperse any fibers that start to accumulate on the screen surface. Because fibers can pass through a slotted screen individually, but not as fiber flocs, papermakers sometimes choose to add retention aids ahead of pressure screens in order to achieve a favorable balance of formation uniformity and adequate retention of fine particles.

Advantages

- Reduced energy consumption, investment costs and improved cleaning efficiency.

11.7.10 Installation of Refiners (DDR/TDR)

Technology Description

In paper manufacturing process after thorough washing, bleached pulp is collected in a storage tank and finally pulp is refined through DDR (Double Disc Refiners) and TDR (Tri Disc Refiners) to make pulp suitable for paper making and to impart better fiber bonding condition which improves the physical strength of the paper. Installation of TDR in place of DDR is observed to give fine quality refining and is energy efficient. The technology has been successfully installed in ITC, Bhadranchalam.

Advantages

- Energy saving of about 150 kW can be achieved.

11.7.11 Black Liquor Recycling in Agro Based Mills

Technology Description

In the agro based mills, although chemical recovery system has been installed in few mills, but due to unfavourable properties of black liquors, the chemical and thermal recovery efficiencies are much lower than in wood based mills. One of the major constraints while processing the agro-based liquors in the chemical recovery section is the low solids concentration of the weak black liquors in comparison to the wood/bamboo liquors. This results in substantial quantities of additional steam requirements during black liquor evaporation in the chemical recovery to remove that extra quantity of water present in the agro based black liquors. Recycling of black liquor during pulping results in improved black liquor solids concentrations. In the recycling process certain portion of the fresh water is replaced with the black liquor during cooking of the agro based raw materials.

Advantages

- Improves the pulp yield by 1.0-1.5%, without bringing about any significant change in kappa values (A measure of the amount of lignin remaining in pulp after cooking) of the pulp.
- The net energy savings per tonne of pulp varies form 13-72 tonnes steam per day for a 100 tpd mill depending on the rise in solids concentrations.
- Black liquor recycling can be practiced in mills using wet cleaning systems by using improved dewatering devices.

11.7.12 High Capacity Chippers in the Chipper House and Mechanical Conveying in Place of Pneumatic Conveying.

Technology Description

Mills installed before 1980's have many small capacity disc chippers and the wood chips are transported from the chipper house located at the ground floor to the top of the digester house (at a height of about 12-15 m) for pulping operations. Conventionally, the chips were being transported pneumatically. The pneumatic conveying, though simple and easy to install, consumes more energy. Mechanical conveying is more energy efficient and consumes only about 25-30% of energy consumed by pneumatic conveying. Installation of a high capacity drum chippers belt conveyor can be taken up in those plants where the horizontal distance between the digester and chipper is sufficiently large. In case, if the horizontal distance is less and the inclination of conveying required is more, then a belt conveyor will not be suitable. In such cases, modified systems such as the crated belt conveyors can be installed.

Advantages

- Lower specific power consumption
- Mechanical feeding, leading to higher throughput
- Uniform Chips size.

Case Study 5: Installation of High Capacity Chippers in the Chipper House

Brief

The recent technological advancements have led to the development of high capacity chippers. These chippers are provided with mechanical feeding mechanisms, enabling consistent feed to the chipper and high throughput from the chippers. This results in lower specific energy consumption of the chippers.

Before Improvement	*After Improvement*
A 750 TPD plant had 5 numbers of older, low capacity disc chippers in operation, with specific energy consumption of 12 kWh/tonne.	*Two numbers of high capacity drum chippers having lower specific energy consumption (about 7 kWh/ tonne) were installed in place of the earlier 5 numbers of the chippers.*

Energy savings

Annual savings @Rs.4.5/kWh	*:Rs. 5.9 Million*
Investment required	*:Rs. 24.0 Million*
Payback period	*:49 months.*

11.7.13 Dry Mechanical boosters in place of steam ejector

Technology Description

Steam ejectors find wide use in vacuum pumping applications such as in Vapour extraction, Chemical processing, Evaporative Cooling, Vacuum distillation, Vegetable oil de-odourization, Vacuum Refrigeration, Drying etc. In spite of the fact that steam ejectors have poor overall efficiency and relatively high-energy consumption, they are popular in vacuum applications because of their simplicity and ease of operation. Dry Mechanical Vacuum Booster offers an efficient replacement to steam ejector, for most of the applications as they overcome major drawbacks associated with steam ejectors.

Advantages

- Mechanical Vacuum Boosters are more energy efficient.
- Minimum of auxiliary equipment is needed; unlike for steam ejectors, which need large condensers, cooling towers, re-circulation pumps etc.
- Mechanical Vacuum Boosters are dry pumping system and don't give rise to water and atmospheric pollution.
- Startup time for mechanical booster is very low, making them ideal for Batch process operation where immediate startup and shut down is essential for energy conservation.
- Operating costs for mechanical vacuum systems are low, resulting in extremely short payback period.

11.7.14 Xylanases as Pre - Bleaching Agents During Paper Making

Technology Description

Concern for environment-friendly technologies has lead to refocusing on the chemical route of paper bleaching in pulp and paper industry. The use of Chlorine as a bleaching agent is causing concern as this produces dioxin and other chlorinated organic compounds, which contributes to AOX (absorbable organic halides) in the recipient streams. In the technology developed in IIT, Delhi, an enzyme prepared from a thermophilic fungus has been shown to act as an effective pre-bleaching agent on soft and hard woods. The level of chlorine was reduced by 15%. AOX release was also less. Pilot scale runs have been planned in collaboration with two paper mills.

Advantages

- The level of chlorine was reduced by 15% and lower AOX release was demonstrated.

11.7.15 High-Efficiency River Water Turbine Pumps for Raw Water Intake

Technology Description

Water is an essential commodity for pulp & paper industry, from both energy and environmental point of view. The overall water consumption of the Indian pulp and paper industry varies from 125 to 175 m3/ton of finished paper (depending on the product) in large integrated paper plants.

Advantages

- Efficiency of 87% possible.
- Reduction in pumping power.

Case Study 6: Installation of High-Efficiency Turbine Pumps for Raw Water Intake

Brief

Water is an essential commodity for the pulp & paper industry from both energy and environmental point of view.

The overall water consumption of the Indian pulp and paper industry varies from 125 - 175 m^3/ton of finished paper (depending on the product) in large integrated paper plants.

Before Improvement

In one integrated paper plant, six pumps were installed at the raw water intake well to meet the raw water requirements of the entire plant. The pumps were of the following specification:

Three Pumps		***Three Pumps***	
Capacity	*= 772 m^3/h*	*Capacity*	*= 522 m^3/h*
Head	*= 35 m WC*	*Head*	*= 35 m WC*
Motor rating	*= 25 HP*	*Motor rating*	*= 75 HP*
Design efficiency	*= 86.5%*	*Design efficiency*	*= 80%*

On detailed analysis of the pumps, it was observed that the three 125 HP pumps were operating very close to the design efficiency. On the other hand, the two 75 HP pumps were operating much below their best efficiency points. The design efficiencies were not being achieved, on account of ageing and wear out of impellers.

The total power consumption (measured by a common energy meter) of the 5 pumps in operation, before modification, was on an average 8000 units per day.

After Improvement

Three new high-efficiency, 125 HP turbine pumps were installed, in place of the old 75 HP turbine pumps. Substantial energy savings can be achieved by the installation of high efficiency turbine pumps.

After the installation of new high efficiency turbine pumps for raw water intake, the total power consumption (measured by a common energy meter) of the four pumps in operation was on an average about 7000 units/day.

Energy savings

There was a net reduction in power consumption by an average of 1000 units/day (equivalent to 41.7 kW).

Annual savings @ Rs. 4.5/ kWh	*= Rs. 1.6 Million*
Investment required	*= Rs. 1.5 MIllion*
Payback Period	*= 1 month*

11.8 Case Studies

Case Study 7: Replacement of Suction Couch Roll by Solid Couch Roll in the Paper Machine

Brief

The paper machine performs the important function of converting the low consistency pulp to dry paper. The water removal is initially done by high-speed drainage, suction through flat vacuum boxes, suction couch & mechanical presses and drying in steam cylinders.

The latest paper machines have been installing the modern presses and reducing the load on the steam drying section. Another project, which has been taken up by some of the plants, is the replacement of the suction couch with the solid couch.The concept of this project is based on utilising the method, which removes the maximum quantity of water, with the least quantity of energy. This is particularly applicable to plants based on long fibre agro-pulp, which have a low drainage.

Before Improvement	After Improvement
In a medium size agro-based paper plant, the major portion of water from the wet end is removed by suction couch roll. The moisture removal is effected by a vacuum pump of 200 kW rating. This is a highly energy intensive process. *The quantity of water removed by the suction couch is very low and the energy consumption was disproportionately high.*	*The suction couch roll was replaced by a solid couch roll for the efficient removal of moisture in the wet end of the paper machine.* *The operation of the 200 kW vacuum pump was completely avoided with the implementation of this proposal.*

Energy savings

Annual savings @ Rs. 4.5 / kWh	*: Rs. 7.6 Million*
Investment required	*: Rs. 2.0 Million*
Payback period	*: 3 months*

Case Study 8: Utilisation of Bamboo Dust along with Coal Firing in the Coal Fired Boilers

Brief

Coal is used conventionally as the basic fuel for combustion in the boilers for steam generation. The steam requirements of the entire plant are met by steam generated in these coal-fired boilers. This is supplemented by steam generation from the soda recovery boilers.

Before Improvement	After Improvement
In an integrated paper plant, two coal-fired boilers met the majority of the steam requirements of the entire plant.There was lot of bamboo dust generated in the chipper house, which was being sold-off to outside parties.	*Chipper dust was used to supplement the coal firing on a continuous basis except during the rainy season, due to the higher moisture content in the chipper dust. .* *With the use of bamboo dust as supplementary fuel to the coal firing in the coal-fired boilers, there was a net annual reduction in coal consumption by 3312 MT.*

Energy savings

Annual savings @ Rs. 1.25/kg of Coal	*: Rs. 4.14 Million*
Investment Required	*: Minimal*
Payback period	*: Immediate*

Case Study 9: Installation of Centralised Compressed Air System

Brief

A centralized compressed air system has a single large / multiple number of compressors at one location. On the other hand, a decentralised compressed air system has multiple numbers of compressors, distributed over various locations. Centralised compressor system is preferred in cases where a large capacity requirement is needed at identical pressure levels.

Before Improvement	After Improvement
A large integrated paper plant had two compressed air units catering to the compressed air requirements of the entire plant. These units were located at two different locations (decentralized). The decentralized system necessitates the operation of multiple compressor units. This leads to increase in both power consumption and mechanical maintenance problems.	*The old compressed air pipelines were replaced with new pipelines, to reduce the leakage losses and line friction losses. Further, the compressors were located at one central location for ease of operation and maintenance.* *There was a substantial reduction in the leakage losses and significant savings of power. There was a net reduction in power consumption by 53 kW*

Energy savings

Annual savings @ Rs.4.5/kWh	*: Rs. 2.0 Million*
Investment required	*: Rs. 1.0 Million*
Payback period	*: 6 months*

Case Study 10: Installation of Heat of Compression (HOC) Air Dryers

Brief

Compressed air is an important utility in process and engineering industries. Instrumentation applications require dry air. Any moisture present in the *compressed air will condense at the point of utilisation causing damage to the instrumentation valves. Drying of compressed air is achieved through various methods. However, the latest trend is to install heat of compression (HOC) dryers.*

Heat of compression dryer is a major technological improvement, having the following distinct advantages:

- *Utilizes the heat in compressed air for regenerating the desiccant*
- *Electrical heaters are eliminated*
- *No purge air losses*
- *Low atmospheric dew point is achieved depending on the desiccant used.*

Before Improvement	***After Improvement***
A large integrated paper and board plant had compressed air requirements of about 112 m^3/ min. About 50 m^3/min of the compressed air was being dried using heater reactivated (lambda) type air dryer. The heater was rated for 32 kW heating capacity. The purge air loss in the dryer was about 10% of the total quantity of air being dried. This type of air dryer in addition to being highly energy intensive, also leads to substantial quantity of compressed air losses.	*An HOC dryer was installed alongside the existing dryer and utilised for drying of compressed air. The desiccant used was activated alumina, which can give an atmospheric dew point of - 40°C. Power savings achieved on account of the elimination of heater operation was 0.075 Million kWh/yr. Also, compressed air losses were totally avoided, as there are no purge losses in HOC dryers with savings of 0.08 Million kWh/yr.*

Energy savings

Annual savings @ Rs. 4.5/kWh	*: Rs. 0.7 Million*
Investment required	*: Rs. 1.48 Million*
Payback period	*: 25 months*

Case Study 11: Installation of Blind Drilled Rolls (Dri-Press Rolls) instead of Conventional Press Rolls in Press Section of Paper Machine

Brief

The press section has a very important role in the drying process and hence, steam consumption of paper machine depends upon the extent of mechanical dewatering. Many of the old paper plants, in general, have conventional press rolls for de-watering. This led to non-uniform moisture removal, which in turn affected the throughput through the system. This resulted in very high specific steam consumption in the paper machine.

The recent technological advancements in water removal and increased runability of paper machines have led to the development of the blind-drilled rolls (or Dri-Press rolls).

Before Improvement	***After Improvement***
In a large integrated paper plant, the press section had the conventional press roll. The dryness achieved with the press roll was about 40-42%. *This system had the following disadvantages:* • *Lower throughput* • *Increased de-watering requirement* • *Higher downtime due to higher breakages at wet end* • *Higher purging requirements* • *High specific steam consumption*	*The plant replaced the conventional press rolls with blind-drilled rolls in the two paper machines in phases.* *The dryness with blind-drilled rolls (for writing & printing paper) improved to 44-46%, as compared to 40-42% with conventional press rolls, thereby, achieving 2-6% improvement in dryness.* *This results in equivalent savings of 307 Tonne of steam consumption. Besides, there was tremendous improvement in machine run ability.*

Energy savings

Annual savings @ Rs. 3.00/kg of steam	*: Rs. 0.9 Million*
Investment required	*: Rs. 2.4 Million*
Payback period	*: 32 months*

Case Study 12: Installation of Extended De-lignification Pulping Process instead of Conventional Pulping

Brief

In a large integrated paper plant, the digester house had conventional vertical stationary digesters, having a combined capacity of 250 Tons of BD pulp/day.

The plant replaced the conventional vertical digesters with 3 new digesters of 80-tons/ day of BD pulp capacity, based on rapid displacement heating pulping process.

	Before Improvement	***After Improvement***
Steam consumption	*1.42 tons / ton of FNP*	*0.70 tons / ton of FNP*
Batch time	*6 hours (avg. time)*	*4 hours (avg. time)*
Kappa number	*21-22*	*12-13*
Yield	*45.3%*	*46%*
Washing loss	*16 kg/ ton of pulp (as sodium sulphate)*	*10 kg/ ton of pulp (as sodium sulphate)*
Black liquor conc.	*14.2%*	*16%*
Ash retention	*7%*	*10%*
Paper breakage	*3.3%*	*1.5%*

The reduction in chemical consumption was about 50%.

Energy savings

Annual savings	*: Rs. 140 Million*
Investment required	*: Rs. 500 Million*
Payback period	*: 42 months*

Case Study 13: Improved Paper Machine Design to Improve Production

Brief

The success of a paper mill is determined not only on the basis of quality and quantity of paper produced, but also on productivity. Efficiency of paper machine plays a vital role in achieving runability and hence, productivity.

Before Improvement
In an agro-residue based paper mill, renewable agro-waste, such as, wild grasses and straws were being used for making high quality writing & printing paper. *A critical study was conducted to modify its paper machine to improve its efficiency in terms of quality and productivity.*

After Improvement
The plant team applied various modifications, right from head box to dryer part in paper machine. The details of the modifications are as follows: • Energy efficient rotary showers installed in head box, in place of stationary showers • Wire circuit provided with an additional roll to improve wrap on FDR (Felt Drilled Roll) • Motor used for wire return roll removed. Diameter of dandy rolls increased to 1200 mm to increase speed of paper machine, enhance production and provide for watermarks • Ceramic tops installed in place of HDPE tops in paper machine • Suction pick-up roll modified to suction cum BDR (Blind Drilled Roll) to avoid shadow marking and ensure better sheet dryness • Speed difference between wire and pickup roll reduced, resulting in improved life of pickup felt life • SLDF (Spiral Linked Drier Fabric) screen replaced with woven screen for better sheet flatness and prevent screen marking • Static current remover installed between calendar and pope reel

Energy savings

Annual Savings : Rs. 18.3 Million
Investment required : Rs. 5.0 Million
Payback period : 3 months

Case Study 14: Replacement of metallic blades with Fibre Reinforced Plastic (FRP) blades in cooling towers

Brief

Before Improvement	After Improvement
A well-known paper manufacturing company had one centralized cooling tower consisting of 3 cells. The cells are fitted with fans having aluminium blades. The 3 cells of the cooling tower operate continuously. The fans are fitted with 55 kW motors. Metallic blades are heavy & consume more power.	Replacement of aluminium blades with lightweight FRP blades reduced the load on cooling tower fan motors & brought down energy consumption. With 3 nos of fan, total power consumption was 124.3 kW. After replacement, power consumption reduced to 98.7 kW with an annual total energy savings of 0.197 Million kWh.

Energy savings

Annual savings @ Rs.4.5 / kWh : Rs. 0.9 Million
Investment required : Rs. 1.52 Million
Payback period : 20 months

Case Study 15: Use of lighting voltage controller to reduce lighting energy consumption

Brief

Before Improvement	After Improvement
A paper manufacturing plant has a connected lighting load of nearly 370 kW. This consists of fluorescent fittings, HPSV, HPMV & CFL lamps for plant, office and area lighting. The lighting load is fed from 3.3 kV bus by 4 nos. of LT transformers. These transformers have lighting loads apart from other loads. Each transformer is connected to a Lighting circuit Distribution box. The total actual load varies between 300 to 350 kW during night. Meters are fitted at each DB to measure power consumption. The voltage levels at lighting DBs vary between 225 & 240 V.	The plant lighting voltages were at a level, which could be brought down further. The installation of lighting voltage controllers, of different kVA, on each DB brought down the lighting consumption by 20%. The output voltages were set at 210 V. 4 No. of DB lighting circuits had a total power consumption 338 kW. After installation, total power consumption came down to 275 kW with an annual total energy savings of 0.245 Million kWh.

Energy savings

Annual savings @ Rs. 4.5/kWh : Rs. 1.1 Million
Investment required : Rs. 1.2 Million
Payback period : 13 months

Case Study 16: Replacement of desiccant (adsorption) type dryer with refrigerated dryer in compressed air systems

Brief

Before Improvement	After Improvement
A paper manufacturing plant has 5 reciprocating compressors. The compressed air is generated at 7.4-7.6 kg/cm^{2}g. The compressed air in the plant is used primarily for instrumentation needs. The compressed air is needed to be dry for this usage and a desiccant type dryer was in use at the plant. The disadvantage with the desiccant type dryer is that energy is needed to drive off the moisture adsorbed by the desiccant. Though a much lower dew point (dryer air) can be obtained by this type of dryer, in this case, the dryer was over designed to provide much drier air than needed and was consuming energy unnecessarily. kW/1000m^3/h: 20.7 Dew Pt. °C: -20 Purge: 10-15%	The dryer was replaced with a refrigerant type dryer, which consumes much less energy, as there is no desiccant to be dried. In the refrigerant type dryer, the air stream is cooled to nearly 0°C. In the process, it loses moisture to maintain the dew point. kW/1000m^3/h: 2.9 Dew Pt. °C: 2 - 10 Purge: Nil Energy savings per hour by replacement of dryers: 37.75 kWh Operating annual hours: 8000 Annual energy savings: 3.02 lakh kWh

Energy savings

Annual savings @ Rs. 4.5/kWh : Rs. 1.4 Million
Investment required : Rs. 1.0 Million
Payback period : 9 months

Case Study 17: a) To conserve the electrical and thermal energy

b) To reduce the cost of production to compete and survive in the paper manufacturing field.

Brief

Before Improvement	*After Improvement*
It is observed that the paper machine efficiency can further be improved to get more production with less power consumption per tonne of paper. *a)The Vacuum pump used in the paper machine was found to be less efficiency and more power consuming.* *b)The water consumption was seen to be in the higher side in the pulp mill.* *c)The used steam in the paper machine coming out after passing through a series of dryer cylinders was found to be have more heat value for reuse. The vent out steam from dryer cylinder was measured as 600 kg/hour.*	*The "Kakati" vacuum pumps were purchased and replaced. The driving motor was also replaced from 75 HP to 50 HP.* *Flowbox of the paper machine was pressurized. The production of paper increased from 33 MT/day to 40 MT/day and power consumption was reduced drastically from 720 kWh/MT to 640 kWh/MT.* *A new Thickener in the pulp mill was installed. It was found that the 5 HP motor was stopped due to recycling of thickener water.* *A "Forbes Marshall" make Thermo compressor system was installed. It was found that the steam consumption came down drastically from 2.6 MT/Tonne of paper to 2.2 MT/Tonne of paper.*

Energy savings

Increase in productivity : 33 MT/day to 40 MT/day
Power Consumption reduction : 720 kWh/MT to 640 kWh/MT.
Steam Consumption reduction : 2.6 MT/Tonne of paper to 2.2 MT/Tonne of paper.

Case Study 18: Revamping of Paper Mill with new machinery, retrofitting & capacity enhancement

Brief

Before Improvement	*After Improvement*
Specific energy consumption of a 200TPD plant was 16.44 % of total mill power consumption. *High effluent treatment load and high consumption of resources.* *Low steam economy in Evaporator.* *Use of elemental chlorine for bleaching which is not environmental friendly and a power guzzler technology.*	*Pulp Mill capacity enhanced to 300 TPD. Specific energy consumption improved to 14.93% of total mill consumption, a saving of 34.96 lakh units.* *Free Flow Falling Film (FFFF) black liquor evaporators of 125TPH water evaporation capacity was installed.* *Soda recovery boiler of 625 TPD solid firing capacity was installed.* *New effluent free R8 process chlorine dioxide generation plant of 7 TPD capacity was installed.* *Recausticizing and limekiln of 130TPD lime production capacity was installed.*

Energy savings

Annual savings : Rs. 516 Million
Investment required : Rs. 2030 Million
Payback period : 46 months

Case Study 19: Replacement of 4" pipeline by 6" pipeline for supplying Hot Water to Wood Brown Stock Washers

Brief

Before Improvement	*After Improvement*
In Pulp Mill Brown Stock Washers (BSW) were used for washing the cooked pulp. For this purpose hot water is used. Two pumps were provided each with the rating of 30 kW - one in service and the other as standby for supplying hot water to the washers. The wash water was supplied through 4" pipeline. As pulp production increased from 100 TPD to 140 TPD, more quantity of water was required for washing. To maintain the production level, both the pumps were put into operation consuming about 34 kW.	*Since the volumetric flow rate increased, the pressure drop was also higher in the 4" line. A 6" line replaced the 4" line and the pressure drop was reduced. The same quantity of water could be handled by single pump since the pump had the required capacity. There was a power saving of about 11.5 kW*

Energy savings

Annual savings @ Rs. 4.5/kWh : Rs. 0.43 Million
Investment required : Rs. 0.19 Million
Payback period : 5 months

Case Study 20: To down size Saveall Shower Water Pump impeller in MF Machine

Brief

Before Improvement	*After Improvement*
MF 3 Paper Machine has a Polydisc Saveall for recovery of fillers and fines in the water and reuse of excess white water. The Polydisc Saveall has discs mounted with synthetic wire mesh that needs to be cleaned with high-pressure water. For this purpose a separate high-pressure pump is used. It was found that the high-pressure pump was oversized, as the system head was lower than the design head of the pump. This resulted in throttling of the valve at the delivery by about 35% to achieve the required flow rate and pressure.	*The performance curves of the pump were studied and it was found that the required duty conditions could be achieved by installing a lower diameter impeller.* *It was found that by replacing the impeller a saving of about 12 kW could be achieved.*

Energy savings

Annual savings @ Rs. 4.5/kWh : Rs. 45 Million
Investment required : Rs. 0.1 Million
Payback period : 3 months

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