Implementation Of Cogeneration Technique In Textile Industry For Energy Conservation

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Abstract

Energy means any form of energy derived from fossil fuels, nuclear substances, Hydro-electricity and includes electricity generated from renewable sources of energy or biomass connected to grid. Energy conservation is the reduction of quantity of energy used. Energy conservation supports the eco friendly lifestyle by providing energy, which saves the money and at the same time saves the earth. A vast majority of the Asian countries has yet to tap the existing cogeneration potential to the maximum. Considering the rapid industrial growth in many parts of the region, one would expect many more new process industries and commercial buildings to be added to the existing stock within a short span of time [1]. Owners of existing as well as new industries and commercial buildings will benefit from these schemes by having access to low-cost and more reliable energy supplies. This paper deals with a comparison study on the aspects of energy economics in textile industry using conventional system and cogeneration system.

Keywords: - Energy, Cogeneration, Energy Economics, Energy Conservation

I. Introduction:

Energy is one of the critical inputs for economic development of any country. Developing countries like India accounts for only 40 % of world's total energy consumption, while constituting 80 % of world's total population. The Government of India has planned to double its installed capacity by 2020 to meet the exponentially increasing power requirement. Energy conservation and Energy efficiency are presently the most powerful tools in our transition to a clean energy future [2]. Energy is mainly required to run manufacturing units, factories, machines, automobiles, homes (for example, electricity for heating and lighting) and so on. This energy is provided by fuel such as coal and oil [3]. Producing energy is expensive. Producing energy from fuels such as coal and oil is also harmful to the environment because it leads to pollution and climate changes (such as global warming). Therefore it is essential to adopt an approach that encourages the production and consumption of the minimum amount of energy to meet man's urban lifestyle. Such an approach that leads to efficient energy usage is called Energy Conservation. Energy Conservation leads to lower costs but it also helps to promote a healthy environment. By opting and adopting encon measures, it is possible to tap a huge potential of surplus energy at comparatively lower cost.

II. Cogeneration:

The simultaneous generation of electricity and heat in the form of steam, typically where the need for both arises for industrial or commercial purposes and where the steam is generated by utilizing the waste heat from electricity generation [2].

III. Why Cogeneration?

Thermal power plants are a major source of electricity supply in India. The conventional method of power generation and supply to the customer is wasteful in the sense that only about a third of the primary energy fed into the power plant is actually made available to the user in the form of electricity. In conventional power plant, efficiency is only 35% and remaining 65% of energy is lost. The major source of loss in the conversion process is the heat rejected to the surrounding water or air due to the inherent constraints of the different thermodynamic cycles employed in power generation. Also further losses of around 10-15% are associated with the transmission and distribution of electricity in the electrical grid. In a conventional fossil fuel fired power plant, maximum fuel efficiency of about 35% is achieved. Maximum heat loss occurs by way of the heat rejection in a steam condenser where a straight condensing steam turbine is used[1]. Some improvement in the efficiency could be attained through extraction-cum-condensing steam turbine instead of straight condensing. The steam so extracted could be supplied to either process consumer or to heat the feed water before it enters into boiler. The rejected heat energy from the steam turbine is most efficiently used to meet the thermal energy requirement for cogeneration system. The overall efficiency of around 80-85%.

IV. Merits of Cogeneration:

1. Cogeneration results more efficient use of fuel, and corresponding reductions in the emissions of SO2, NOx and CO_2.
2.One often misleadingly compares the efficiency of cogeneration around 85% with the efficiency of power generation facilities (i.e. condensing power plants) in the order of 40%. For a correct comparison, one must take the weighted average of the efficiency of power and heat production and compare it with the efficiency of cogeneration.
3.With separate production of heat in modern boilers, efficiency will be significantly above 85%, and with condensing gas boilers even close to 100%. For condensing power stations, such as gas-fired combined-cycle plants, whose market share can only increase, efficiency approaches 60%. As a result, the advantages of cogeneration have a tendency to decrease.
4.With a proper comparison between separate or combined production of heat and power in modern facilities, the energy advantage amounts to 15-20%, which is still significant from an ecological viewpoint? Where feasible, this advantage should be exploited.

V. Implementation of Cogeneration System in Textile Industry:

A. Overview

The Indian textile Industry is currently one of the largest and most important sectors in the economy in terms of output, foreign exchange earnings and employment in India. Textiles account for 20 per cent of India's industrial production and around 35 per cent of its export earnings.

The total production of fabrics in all the three sectors combined was around 42 billion square meters, with 59 % of the total fabric production produced by the power loom sector, 19 % by the handloom sector, 17 % by the knit yarn sector, and the rest by the organized mill sector [2]. The textile industry is a self -reliant industry from the production of raw materials to the delivery of final products with considerable value addition at each stage of processing.

B. Contribution to Economy:

It accounts for 9% of GDP, for nearly 20% of the total national industrial production and 35% of the export earnings, making it India's largest net foreign exchange industry. This industry contributes less than 1.5 % to the gross import bill of the country. It directly employs 35 million workers and has widespread forward and backward linkages with the rest of the economy, thus providing indirect employment to many more millions.

VI. Types of Textile Sectors:

The textile industry has three main sectors

- Organized Mill sector (Traditional weaving and spinning)
- PowerLoom sector (Mechanized Looms)
- HandLoom sector.

It also includes the sub-sectors which are common in industries

- Spinning
- Weaving
- Knitting
- Garmenting

Manmade fibres account for around 40 per cent share in a cotton-dominated Indian textile industry. India accounts for 15% of world's total cotton crop production and records largest producer of silk. It is the second largest employer after the agriculture sector in both rural and urban areas. India has a large pool of skilled low-cost textile workers, experienced in technology skills. Almost all sectors of the textile industry have shown significant achievement. The sector has shown a 3.66 per cent CAGR over the last five years. Cost competitiveness is driving the penetration of Indian basic yarns and grey fabrics in international commodity markets.

VII. Textile Production:

Fiber processing Involves

- Spinning
- Weaving
- Knitting machines
- Dyeing and printing
- Other finishing process

A. Spinning:

It is the Process of twisting the fiber. The amount of twist given the yarns determines various characteristics. Light twisting yields soft-surfaced fabrics, whereas hard-twisted yarns produce hard-surfaced fabrics, which provide resistance to abrasion and are less inclined to retain dirt and wrinkles. Hard twisted yarns are used in producing hosiery and crepes.

Fig. 1: Spinning Section

B. Weaving:

Two sets of yarns, called the warp and the woof (more commonly filling, or weft) are used in weaving, which is carried out on a mechanism known as a loom. Warp yarns run along the length of the loom; filling yarns run across it. Different patterns and textures are achieved by varying the number of warp yarns and by altering the sequence in which they are raised or lowered.

Fig. 2: Weaving Section

C. Dyeing and Printing:

The fabrics can be dyed after weaving or knitting is completed (piece-dyed).The loose fibers can be dyed in a vat (stock-dyed) or the yarn or filament can be dyed before weaving (yarn-dyed).

D. Types of Fiber:

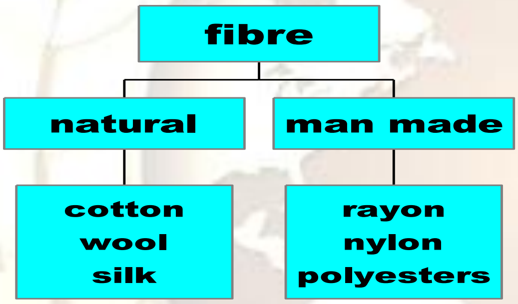

Fig. 3: Fiber Classification

E. Process Involved in Rayon Fiber Manufacture

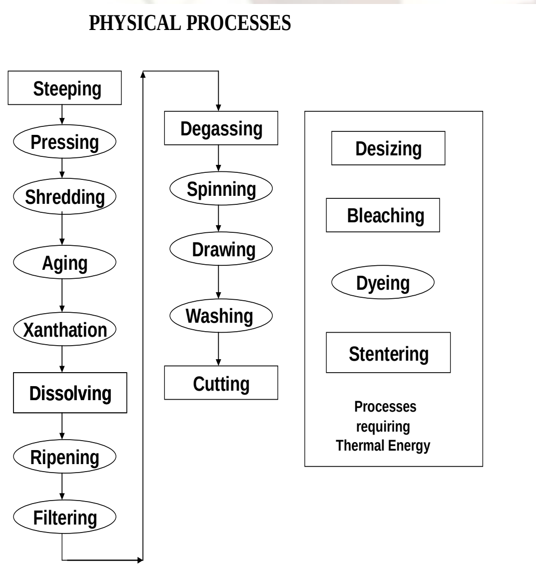

Fig. 4: Physical Process

SHREDDING

The pressed alkali cellulose is shredded mechanically to yield finely divided, fluffy particles called "crumbs". This step provides increased surface area of the alkali cellulose, thereby increasing its ability to react in the steps that follow**.**

AGING

`The alkali cellulose is aged under controlled conditions of 18-30°C in order to depolymerize the cellulose to the desired degree of polymerization. In this step the average molecular weight of the original pulp is reduced by a factor of two to three

XANTHATION

In this step the aged alkali cellulose crumbs are placed in vats and are allowed to react with carbon disulphide under controlled temperature (20 to 30° C) to form cellulose xanthate viscous orange colored solution called "viscose", which is the basis for the manufacturing process is produced

DISSOLVING

The yellow crumb is dissolved in aqueous caustic solution. The large xanthate substituents on the cellulose force the chains apart, reducing the interchain hydrogen bonds and allowing water molecules to solvate and separate the chains

RIPENING

The viscose is allowed to stand for a period of time to "ripen". Two important processes occur during ripening .Redistribution and loss of xanthate groups.

FILTERING

The viscose is filtered to remove undisclosed materials that might disrupt the spinning process or cause defects in the rayon filament.

DEGASSING

Bubbles of air entrapped in the viscose must be removed prior to extrusion or they would cause voids, or weak spots, in the fine rayon filaments

SPINNING

spin bath containing *Sulphuric acid, Sodium sulphate, Zinc sulphate* -for acidification - to impart a high salt content for coagulation of viscose,- exchange with sodium xanthate to form zinc xanthate, to cross-link the cellulose molecules respectively. Slow regeneration of cellulose and stretching of rayon will lead to greater areas of crystallinity within the fiber, as is done with high-tenacity rayon.

DRAWING

The rayon filaments are stretched while the cellulose chains are still relatively mobile. This causes the chains to stretch out and orient along the fiber axis. Washing the freshly regenerated rayon contains many salts and other water soluble impurities which need to be removed

CUTTING

If the rayon is to be used as staple, the group of filaments (termed "tow") is passed through a rotary cutter to provide a fiber which can be processed in much the same way as cotton
The Process which require heat energy are

Bleaching

This operation is done to remove the natural colouring pigments. Cloth is maintained at steam pressure of 2 to 3 atm

Dyeing

In this process cloth is passed through the dye which is all time maintained at 60°C

Drying

Here the cloth before passed on to the printing process is dried in drying ranges which are kept hot by 3.5 atm steam

Stentering

Here the dimensions of the cloth are stabilised. Cloths are passed through hot chamber and the cloth is pulled to the required dimension with 4 atm steam.

VIII : Results & Discussion:

Annual Production: 200000 mtrs of rayon
Electricity Requirement : 800 kW
Process Heat Requirement
For Dyeing &Bleaching : 7.5Tonnes/hr @3 bar/150°C
Drying : 5.5 Tonnes/hr@7bar/200°C

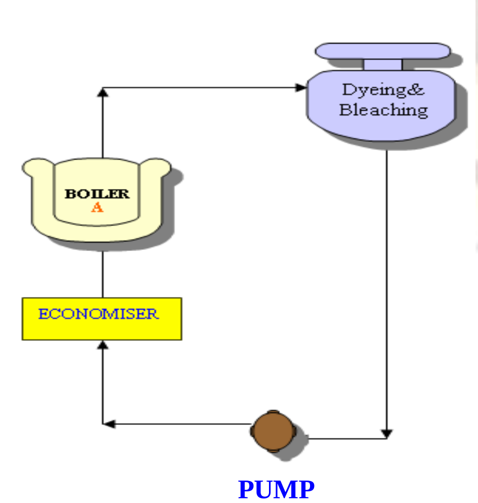

Fig. 5: *7T/hr @ 3 bar/150*°C

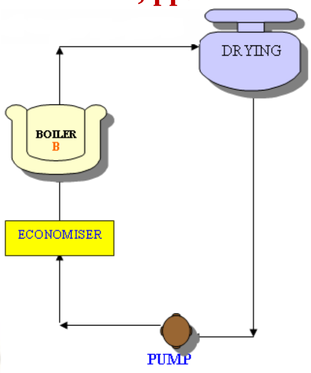

Fig. 6: *5.5T/hr @ 7 bar/200*°C

A. Conventional system:

Assumption

Efficiency of Boiler = 75%
Calorific value of firewood = 3500 kcal/kg
Cost of firewood = Rs.700/tonne
Operating days = 330 days

Boiler 1

Outlet condition = 3bar/150°c
Steam requirement = 7.5tonnes/hr
Cost = Rs.7000000/Mw

Boiler 2

Outlet condition = 7bar/200°c
Steam requirement = 5.5tonnes/hr
Cost = Rs.6000000/Mw

Heat output from boiler 1

$$= \frac{7.5\times10^3\,(2760.4 - 546.3)}{3600}$$

$$= 4.612 \text{ MW}$$

Heat output from boiler 2

$$= \frac{5.5\times10^3\,(2844.2 - 546.3)}{3600}$$

$$= 3.510 \text{ MW}$$

Total output = 8122 kW

Heat input to boiler $= \frac{8122}{0.75}$

= 10.829 MW

Mass flow rate of fuel $= \frac{10829}{3500\times4.186}$

= 0.7391kg/sec

Mass of fuel/annum

= 0.7391x3600x24x330
= 21073219 kg/annum

Fuel cost = 700 x 21073219
= Rs.1.47crores

Capital investment cost

Cost of boiler 1 = 7000000 x 4.612
= Rs.3.23 crores
Cost of boiler 2 = 6000000 x 3.510
= Rs.2.10 crores
Total investment cost = Rs.5.33 crores

Utility cost

Interest @ 12% = Rs.0.6396 crores
Depreciation@ 10% = Rs.0.533 crores
Operating& Maintenance cost@5%

= Rs.0.2665 crores

Utility cost = Rs. 1.44crores

Total expenditure

Total expenditure = Fuel cost + Utility cost

= 1.47 + 1.44

= Rs.2.9 crores

B. Cogeneration System:

Assumption

Outlet condition = 70 bar/ 450ºc

Efficiency of Boiler = 75%

Cost of boiler = Rs.8000000/MW

Efficiency of Turbine = 88%

Cost of Turbine = Rs.1 crore/ MW

Calorific value of firewood = 3500 kcal/kg

Cost of firewood = Rs.700/tonne

Operating days = 330 days

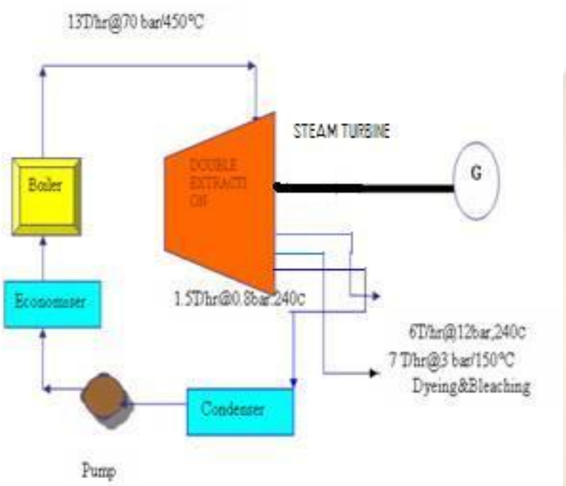

Fig. 7: Topping Cogeneration Cycle

Power output from turbine

Input = Output

$m_1h_1 = (p / 0.88) + m_2h_2 + m_3h_3 + m_4h_4$

$\frac{13x10^3}{3600}$ (3285) = (p / 0.88)+ $\frac{6.0x10^3}{3600}$ (2762)+ $\frac{5.5x10^3}{3600}$ (2724) + $\frac{1.5x10^3}{3600}$ (2665)

Power output = 1.75 MW

Electricity produced / annum

= 1750x24x330

= 13860000kWh

Heat output from boiler

= $\frac{13x10^3}{3600}$ (3285-546.3)

= 9893kW

= 9.893 MW

Heat input to boiler

= $\frac{9893}{0.75}$

= 13.19 MW

Mass flow rate of fuel

= $\frac{13190}{3500x4.186}$

= 0.9002 kg/sec

Mass of fuel/annum

= 0.9002x3600x24x330

= 25666502 kg/annum

Fuel cost = 700 x 25665.5

= Rs.1.79 cr

Unit Cost

Unit Cost = $\frac{17900000}{13860000}$

= Rs 1.3

Capital investment cost

Cost of boiler = 8000000 x 9.893

= Rs.7.9 crores

Cost of turbine = 10000000 x 1.75

= Rs.1.75 crores

Total investment cost = Rs.9.33 crores

Utility cost

Interest @ 12% = Rs.1.1196 crores

Depreciation@ 10% = Rs.0.933crores

Operating& Maintenance cost@5%

= Rs.0.4665 crores

Utility cost = Rs.2.52crores

Total expenditure

Total expenditure = Fuel cost + Utility cost

= Rs.4.31 crores

Savings

Total power produced = 1750 kW

Power required = 800 kW

Excess power available = (1750 – 800)

= 950 kW

Cost savings if purchased from E.B

= 800x24x330(4.75–1.3)

= Rs2.19 crores

Cost savings if sold to E.B

= 950x24x330x2.5

= Rs. 1.88 crores

Total savings through electricity

= 2.19 + 1.88

= Rs4.07 crores

Increase in expenditure3600

= (Total expenditure in cogeneration) – (Total expenditure in conventional system)

= 4.31 – 2.91

= Rs.1.4 crores

Net savings = (Savings through Electricity) – (Increase in expenditure)

= 4.07 – 1.4

= Rs.2.67crores

Increase in investment = (Investment in Cogeneration) – (Investment in conventional System)

= 9.33 – 5.33

= Rs 4 crores

Simple payback = $\dfrac{\textbf{Increase in investment}}{\textbf{Net savings}}$

$= \dfrac{4.00}{2.67}$

$= 1.5$

= 1 year & 6 months

IX. Conclusion:

Conservation and efficient utilization of energy resources play a vital role in narrowing the gap between demand and supply of energy. Energy conservation is the quickest, cheapest and most practical method of overcoming energy shortage. Many communications consider the development of cogeneration, next to more use of renewable energy as one of the most important instrument for CO2 reduction. Decentralized cogeneration is considered of paramount importance. The feasibility of installing Cogeneration in a Textile mill with processing capability is studied and the results favor the setting up of a cogeneration facility with a payback period of 2 to 3 years. This study clearly shows that in the economical point of view and the energy saving potential point o f view the proposal system satisfies the entire requirement and hence the setting up of Cogeneration facility is recommended. It is encouraging to note that there are already a large number of cogeneration plants which have been commissioned in some Asian countries in the last decade or so. Considering the developments that can be expected, decentralized cogeneration facilities are unlikely to play the role attributed to them by 2020 in many studies.

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