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Use of Energy in Textile Industry: A Case Study on Ethiopian Textile Industry

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Abstract:
Energy is essential for the creation of wealth and improvement of social welfare; this means that adequate and reliable supply of energy is required to ensure sustainable development.The textile industry is one of the major energy consuming industries and retains a record of the lowest efficiency in energy utilization but energy consumption is in increasing trend, due to modernized machines and continuous usage of the equipments in inefficient operating parameters. The energy cost is around 15 % to 20 % over the production cost and it stands next to raw material cost. So now a day's area of focus is towards energy consumption at load end and by optimizing the efficiency of the mills. Most of the textile mills have several common features and therefore if the key features for conserving energy are identified then it is quite possible that these can be replicated to the other plants as well. In our research paper we investigated the comprehensive overview of the present energy management strategies in the Ethiopian textile industry and the Implementation Strategies and barriers of Energy Conservation Management Technologies and the driving forces for the implementation of energy efficiency measure.

Key words- *Energy Efficiency, Implementation Strategies, Textile mills*

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I. Introduction

Energy is one of the most important ingredients in any industrial activity. The availability is not infinite however. Energy crisis globally, as well as high cost of fuels resulted in more activities to conserve energy to maximum extent. Energy crisis globally, as well as high cost of fuels resulted in more activities to conserve energy to maximum extent[1]. The textile industry is one of the major energy consuming industries and retains a record of the lowest efficiency in energy utilization. About 23% energy is consumed in weaving, 34% in spinning, 38% in chemical processing and another 5% for miscellaneous purposes[3]. In general, energy in the textile industry is mostly used in the form of electricity, as a common power source for machinery, cooling & temperature control system, lighting, equipment etc.; oil as a full for boilers which generate steam, liquefied petroleum gas, coal. And this has made pathway to conservation of energy which can be affected through process and machinery modifications and implementation of technological advancements relating to process. Optimization as well as development of newer methods to meet the challenge of substantial energy saving in textile mills.

High Energy Intensive Area	Annual Energy saving Potential(MWH)	Values in Birr
Cement Factory	15,432.20	58,444,970.00
Steel Factory	773.00	426,740.80
Textile Factory	5,211.90	3,988,592.45

Fig. 1 Energy Saving Potential in Ethiopia, Source::https://www.energystar.gov

Energy is essential for the creation of wealth and improvement of social welfare; this means that adequate and reliable supply of energy is required to ensure sustainable development [4]. However, the use and conversion of primary energy most of the time results in waste and emission; they are harnessed from limited resources which are considered environmentally unsustainable. The increasing rate of environmental problems related to energy use has led to a growing interest in issues of sustainable development thereby leading to a challenge of decoupling of economic growth and energy use. To achieve this requires the judicious use of resources, technology, appropriate incentives and strategic policy planning [2]. Energy management refers to the strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems. Energy efficiency on the other hand is defined as a ratio between an output of performance, service, goods or energy, and an input of energy [3.] Thus energy efficiency improvement basically refers to the reduction of energy input for a given service, goods or output. Notably, these two concepts advocate for the use of energy resources in a manner that will save energy and ensure minimal wastage, consequently promoting environmental sustainability. In response to the wave of challenges related to energy use, some industries around the world have reduced energy intensities by adopting and developing energy efficient technologies and management strategies [6].

II. Use Of Energy In Textile Industry

In general, energy in the textile industry is mostlyused in the forms of electricity, as a common powersource for machinery, cooling and temperaturecontrol systems, lighting, office equipment, etc[11].

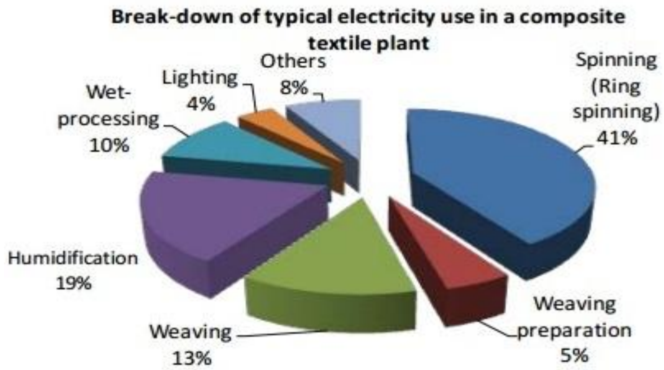

Fig. 2. Electricity consumption in textile Plant, Source::https://www.energystar.gov

The major consumption of electricity in spinning is 41%.So if the consumption in spinning is higher so saving potential is also in spinning section [21]. Thermal energy is major for chemical processing while power dominates consumption pattern in spinning/weaving. Thermal energy in textile mills is mainly consumed in heating of water and drying of water[15]. Thermal energy in the form of steam is supplied to the various equipments through pipe. The average steam consumption in unit operations and stages of wet processing are seen in figure 3.

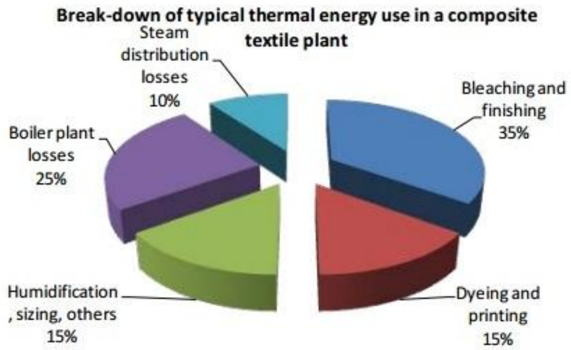

Fig. 3. Break Down of Thermal Energy use, Source::https://www.energystar.gov

III. Energy Use Pattern in Ethiopia

In the current study an energy management system was analyzed in a Bahir Dar textile plant(BDTSC). The main energy sources used in the plant were power and steam. BDTSC is one of Ethiopia textile factories, manufacturing 100% cotton products, including yarns and fabrics. We analyzed the energy usage pattern of BDTSC and we can divide the consumption in two major portion, first in the factory and secondly in Boiler operations. The main usage of electrical energy in the textile industry is in the manufacture of yam and cloth.

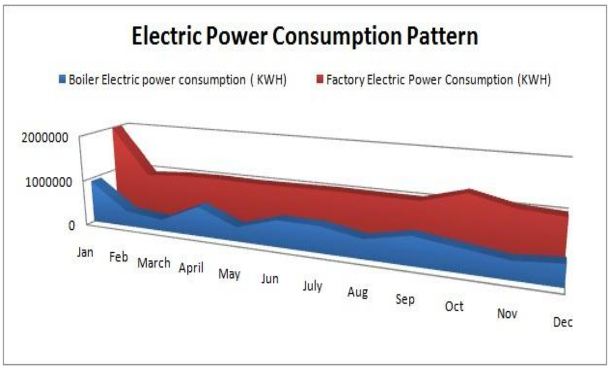

Fig. 4. Electrical Power Consumption in BDTSC

The figure 4 gives us information about how much average electricity spent in 2016. According to the figure there were upward trends in both the segment. But in the boiler variation is high but in factory the electricity consumption not very much fluctuates [16].

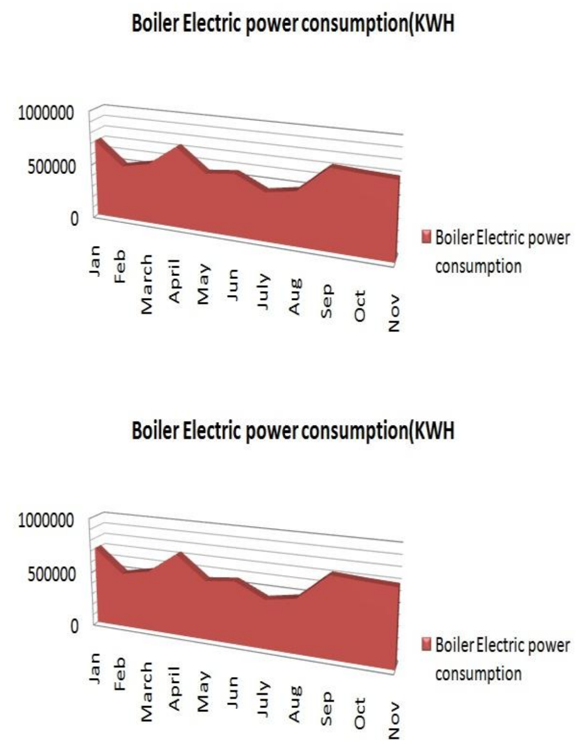

Fig. 5 Electrical Power Consumption in Boiler section in BDTSC

IV. Focus Areas for Energy Conservation

A. Thermal Energy

Thermal energy is major for chemical processing while power dominates consumption pattern in spinning/weaving. Thermal energy in textile mills is mainly consumed in two operations. They are heating of water and drying of water [23, 24]. The following table indicates the department wise Percent steam consumption in a composite textile mill. Thermal energy in the form of steam is supplied to the various equipments through pipe. The average steam consumption in unit operations and stages of wet processing are seen in the following figure.

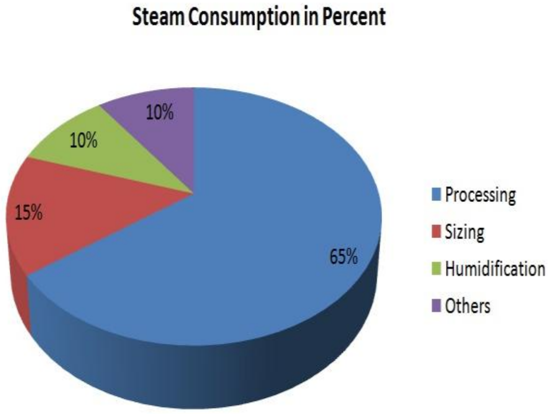

Fig. 5 Steam consumption in different processes

B. Electrical Energy

The wet processing of textiles consumes around 15%of the total electrical energy mainly only for runningthe various processing machineries. Electricity is the major type of energy used in spinning plants, especially in cotton spinning systems. If the spinning plant just produces raw yarn in a cotton spinning system, and does not dye or fix the produced yarn, the fuel may just be used to provide steam for the humidification system in the cold seasons for preheating the fibers before spinning them together. Therefore, the fuel used by a cotton spinning plant highly depends on the geographical location and climate in the area where the plant is located.

V. Energy Management Strategies

Energy management strategies basically applicable in two main form of energy. The first applicability in electrical energy, the electric energy used in industry for production and utility, amounting to nearly 3/4th or 4/5th of the total power requirement in a textile mill, where as hardly 15 to20% of electrical power is consumed for running various machines in textile wet processing [25].

- One bath bleaching may enable to save around70% electrical inputs.
- Reduced number of ends / turns jiggers may helpin saving around 20% electrical inputs.
- Elimination of curing in printing saves 100%Electrical inputs for curing step.
- Combined drying - cum - curing in resinfinishing saves around 35% electrical inputs.
- Use of high efficiency motors in place ofstandard motors with proper application willsave 2 to 4%.
- Replacement of under size and over size motors,saving depending upon the percentage of loading on the motors.

Investigation of exact burning reason, rewinding as per original technical data. Motors convert electricity into mechanical energy to drive machinery. Throughout this conversion, some energy is lost. Current motors feature improved styles and incorporate the most recent developments in materials technology[27]. The foremost efficient of these motors are termed High Efficiency Motors (HEMs).

Other benefits of HEMs besides energy savings are:

- Higher power factor,
- Longer lifespan and fewer breakdowns,
- Run cooler and less susceptible to voltage and
- load fluctuations, and
- Produce less waste heat and noise.

Apart from electrical energy textile mill requires substantialquantities of thermal energy in the form of steam as asource of heating. The various ways and means bywhich a substantial portion of huge quantities ofthermal energy consumed during the course of textilewet processing can be saved include the following[30].

1. Since most of the thermal energy is wasted in removal of water, different attempts have been made to reduce the energy as follows.

   - Efficient removal of water using heavy squeezing enables 15-20% reduction in energy requirement for drying.

- Vacuum impregnation squeezes out the air from the cloth 'and provides better dye or chemical impregnation and more uniform application and this process enables 60-65% fuel saving compared to conventional system.
- Vacuum roll extractor enables 70-75% saving in energy.

2. Some developments relating to increased in Efficiency of drying and setting units.
    - The heating up time on conventional stenter and hot flue driers are 10-20 sec. and 40-60 second respectively but by employing sieve drum drier which reduces the time of heat up to 1-3 second and gives almost 60-70% energy saving [31].
    - Radio frequency is used for uniform heating throughout the mass of the material which gives60% saving in energy.
    - Use of heat transfer fluids (thermo pack) like hydro-carbon of enabling temperatures up to300°C. This process gives 80% savings in energy.
3. Some developments relating to techniques based on reduced liquor- to- material ratio in the operations.
    - Foam application technique gives almost. 50-60% savings in energy for low wet pick-up applications.
    - Use of low M. L. R. jet dyeing machines saves40-60%fuel.
    - Azeotropic / emulsion based system of processing saves 60-70% fuel considerably because of significantly low water content of the system.
4. Some developments relating to process Developments and old process modifications.
    - Reduction in pressure kier time by kier modification from 6-8 hrs. enables 60-65% energy saving.
    - By using reducing agents like Anthraquinne the scouring time can be reduced to 3-4 hrs from 6-8hrs. This process enables 40- 50% savings in energy.
    - By solvent scouring process 60-80% energy can be saved.
5. Cold bleaching by activating sodium chloride by Hypochlorite use no thermal energy and hence 80-90% energy saving is possible.
6. Hot mercerization enables the combining of scouring and mercerization’s and saves energyaround 30- 40%.
7. Du –Pont’s two minutes bleaching uses hydrogen Peroxide at very high pH value with a special formulation to prevent undue decomposition of peroxide and damage to the fabric. An energy saving around 80-85% is possible with this process.
8. Combined one step hypochlorite bleaching and scouring at R. T. enables almost 100% energy saving.
9. Combined one step desizing, scouring and bleaching by redox system reduces almost 60%energy requirement
10. Use of solar energy for de-sizing and scouring enables almost 40-50% energy saving.
11. Cold pad batch method for reactive dyeing by Sodium silicate for fixation of the dyestuff gives 100% energy saving.
12. Low temperature curing of pigment prints by using highly active catalysts like ammonium chloride, ammonium sulphates etc. save 30-40% energy.
13. Use of flash agers for reactive color printed and dried goods. The printed and dried cloth is padded with alkaline solution of high electrolyte content and steamed for about 30-60 minutes. This method saves almost 50% steams.
14. Dyeing cum sizing of denim warps enables almost 40% saving in energy.

VI. Barriers of Energy Conservation Management Technologies

Barrier to energy efficiency can be defined as a postulated mechanism that inhibits a decision or behaviour that appears to be both energy efficient and economically efficient [34].

Risk- The short paybacks required for energy efficiency investments may represent a rational response to risk. This could be because energy efficiency investments represent a higher technical or financial risk than other types of investment, or that business and market uncertainty encourages short time horizons.

Imperfect Information-Lack of information on energy efficiency opportunities may lead to cost-effective opportunities being missed. In some cases, imperfect information may lead to inefficient products driving efficient products out of the market.

Hidden Costs- Engineering-economic analyses may fail to account for either the reduction in utility associated with energy efficient technologies, or the additional costs associated with them. As a consequence, the studies may overestimate energy efficiency potential. Examples of hidden costs include overhead costs for management, disruptions to production, staff replacement and training, and the costs associated with gathering, analyzing and applying information [41].

Access to Capital -If an organization has insufficient capital through internal funds, and has difficultyraising additional funds through borrowing or share issues, energy efficient investments may be prevented from going ahead. Investment could also be inhibited by internal capital budgeting procedures, investment appraisal rules and the short-term incentives of energy management staff [40].

Split Incentives-Energy efficiency opportunities are likely to be foregone if actors cannot appropriate the benefits of the investment. For example, if individual departments within an organization are not accountable for their energy use they will have no incentive to improve energy efficiency [42].
Bounded Rationality -Owing to constraints on time, attention, and the ability to process information, individuals do not make decisions in the manner assumed in economic models. As consequence, they may neglect opportunities for improving energy efficiency, even when given good information and appropriate incentives

VII. Conclusion

Energy is one of the main cost factors in the textile industry. Especially in times of high energy price volatility, improving energy efficiency should be one of the main concerns of textile plants. There are various energy-efficiency opportunities in textile plants, many of which are cost-effective. However, even cost-effective options often are not implemented in textile plants due mainly to limited information on how to implement energy-efficiency measures. These plants in particular have limited resources to acquire this information. Know-how regarding energy-efficiency technologies and practices should, therefore, be prepared and disseminated to textile plants. This research paper provides information on energy-efficiency technologies and measures applicable to the textile industry with barriers.

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