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Energy Efficiency Improvement Scopes Analysis in the Jute Processing Industry of Bangladesh

Md.Saleh Ebn Sharif[1], Mohammad Shakil Khan[2] and Ahmad Fahad Tayab[3]

[1]Department of Electrical and Electronic Engineering,
Bangladesh University of Engineering and Technology, Bangladesh
[2]Institute of Energy, University of Dhaka, Bangladesh
[3]School of Aerospace, Mechanical and Manufacturing Engineering, RMIT University, Melbourne, Australia
saleh.ebn.sharif@gmail.com

ABSTRACT

Energy efficiency improvement and energy saving are major industrial concerns now-a-days. This paper mainly aims at focusing key issues for reducing energy wastage and subsequent reduction of excessive energy consumption due to inefficient machinery and unplanned electrical system. In order to improve the energy consumption pattern, particularly jute processing industry of Bangladesh is considered as case study; several energy saving scopes and way of improvement have been identified. The objective is to addresses utilization strategy through mathematical analysis to maximize machine efficiency leads to greater production, financial profit by reduction of energy bill as well as trapping carbon emission. In addition, to attain the target of improving energy efficiency of Bangladesh Government's Sustainable Development Goal (SDG), this strategy can contribute by decarbonizing industrial operation and supply chains thorough improved energy efficiency. Also tend to reduce the carbon footprint of jute products, services and processes. This leads to setting ambitious emissions reductions targets in line with development of green industry; also scaling up potential investment scope as Clean Development Mechanism (CDM) projects in the development of innovative low-carbon products and services.

Key words: Power Factor, Machine, Energy Efficiency, CDM, Power Consumption

INTRODUCTION

Bangladeshi jute is known as 'golden fibre' because of the quality of jute it produced. For centuries, Bangladeshi Jute dominates the world market for its higher quality fibres. Jute was the single most important export item of Bangladesh till the end of 1980s. Still jute is one of the largest export oriented industries in Bangladesh and its contribution to the national economy is significant. According to the Bangladesh Jute Mills Corporation, major destinations of Bangladesh's jute goods export are Middle East, African Countries, European countries, South East Asia, Australia and USA. With fast growing demand of jute and up growing export opportunity Bangladesh has 205 jute mills at different location of this country. Among them 81 units are under Bangladesh Jute Spinners Association (BJSA), 97 units are under Bangladesh Jute Mills Association (BJMA) and 27 units are under Bangladesh Jute Mills Corporation (BJMC) [5]. The average production of jute goods in BJSA mills is 3, 60,500 Metric Tons, BJMA mills is 1,56,500 Metric Tons, BJMC mills is 1,46,000 Metric Tons, which sums up to 6,63,000 Metric [1]. At present average internal consumption of jute goods are 89,000 Metric tons (yarn/ twine and sacking hessian) [2]. These industries use old and primitive machineries to process jute products and hence consume lots of electricity as wastage.

JUTE PROCESSING SCENARIO

In a jute industry several machineries are used to complete the overall production process. The processing chain is start with softener machine which is used to Softening and Splitting up of raw jute at the initial stage. Then extraneous matters are removed from the jute fibre by carding machine. At next drawing machines are used to blending and equalizing silver of the fibre in three stages. Spinning machines are used then to Slivers elongate and fibres are twisted into yarn. Then windings machines spool the yarn and cops for beaming and weaving operations where wrapping and weft of yarn are done respectively. At the final stage of this process cutting and bundling of yarn are done by calendaring machines. The chain of the process is shown in Fig. 1.

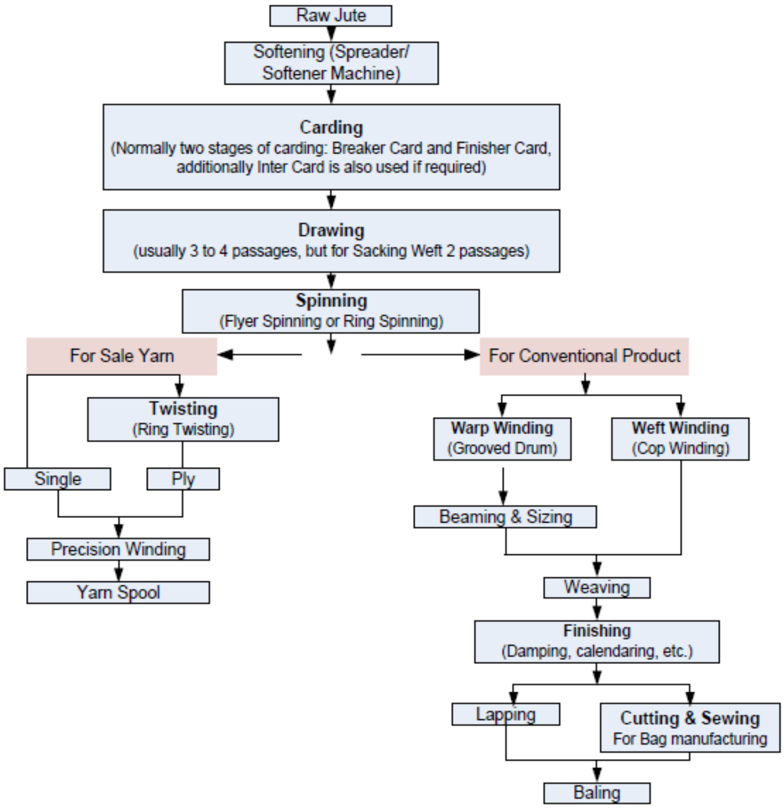

Fig.1 Jute Processing Stages

Table -1 Energy Requirement of Jute Processing Machine

Machines	Energy Requirement per Production
Softener	30 kWh
Carding	120 kWh
Drawing(1^{st},2^{nd},3^{rd})	160 kWh
Spinning	110 kWh
Winding	15 kWh
Beaming	26 kWh
Weaving	22 kWh
Calendaring	112 kWh

ENERGY SCENARIO

The production chain for jute processing is comprises with series of machines run by electricity. These machines are motive load which consume high amount of electricity.

*A. **Energy Requirement***

The processing of raw jute is started with softener machines which are known as spreader machines consume 30kWh of electricity. This mainly consumes energy for softening raw jute for further process of making it to yarn. Then carding machines which is comprises with high capacity motor requires 120kWh of energy for each production. Drawing machines have three particular stages 1^{st}, and 3^{rd} drawing machines consume maximum energy of entire machines of the production chain that is 160kWh approximately. Spinning machines consumes 110kWh of energy for to twist fibre into yarn. Winding, beaming and weaving machines requires comparatively small electricity of 12kWh, 26kWh and 22kWh respectively. The calendaring machine consumes 112 kWh of electrical energy which is 18% of total requirement for one batch of production. [3] The energy requirement of each machine is shown in Table -1.

*B. **Energy Wastage Field***

The analysis shows us various sectors where electrical energy is simply wasted. The reason of using old and inefficient machines cause large amount electrical energy to complete the entire process. Also less efficient motor drive, transmission of motion, spindle an assembly and building mechanism creates the major energy wastage in jute industry. Moreover, this high demand of electricity can't be met by grid supply. Hence, Lack of uninterrupted electricity supply tends to set up back captive power in jute processing industry. This result a huge amount of financial investment and ultimately raise the price of the processed goods [12].

C. ***Energy Efficiency Improvement Scopes***

In our assessment several efficiency improvement scopes have been identified and related analysis to get optimistic result. Most specifically we have concentrated on machines which are active as captive load to reduce the demand of electricity and can possibly increase the production.

1) *Pf Improvement*: From our observation, last six months' average power factor of Jute mill is 0.8608 – provided by electricity billing personnel. It is also observed that for low power factor Jute mill is going through extra surcharge or adjustment for power factor. Actually the utility charges according to the KW demand and add a PFC (Power factor correction) charge to adjust power factor [4]. For adjusting PF multiplier is taken in to consideration with KW demand. Based on 0.90 power factor a formula is shown below for billing [5]:

$$KWDemand \times \left(\frac{0.90}{ActualPowerFactor}\right)$$

From our real case scenario, for Power factor 0.86 Utility will charge a bill 1.046 times of actual KW demand, as shown in following formula:

$$KWDemand \times \left(\frac{0.90}{0.86}\right) = 1.046\ (multiplier)$$

For energy efficient measure it is recommended to add power factor improving arrangement to raise power factor up to 0.98. Capacitor with automatic control arrangement is recommended to install at sub-station. In order to increase power factor to 0.98 Jute mill has to add 200 KVAr capacitor (considering Jute mill's load 1205 KW) [5]. According to Bangladesh Power Development Board's Electricity Tariff Guideline 2015, it is found that the maximum demand of the consumer's service will be determined by the following percentage factors [4]:

100% for the first 75 KW of connected load.
85% for the next 75 KW of connected load.
75% for the next 75 KW of connected load.
65% for the next 75 KW of connected load.
60% for the rest of the connected load.

Annual demand charge for actual 1205 KW load is calculated in following table.

Table -2Demand Charge Before PF Improvement

Utility Demand charge percentage factors	*Demand Charge (Per KW)*	*1205 KW load's break down*	*Billing at each stage (BDT)*	*Monthly billing (BDT)*
100% for the first 75 KW	40	75	3000	31470
85% for the next 75 KW	34	75	2550	
75% for the next 75 KW	30	75	2250	
65% for the next 75 KW	26	75	1950	
60% for the rest KW	24	905	21720	

After Power Factor raised to 0.98 new Load will be = (1205 x 0.90)/0.98 = 1106 KW

Table -3Demand Charge after PF Improvement

Utility Demand charge percentage factors	**Demand Charge (Per KW)**	**1106 KW load's break down**	**Billing at each stage (BDT)**	**Monthly billing (BDT)**
100% for the first 75 KW	40	75	3000	29094
85% for the next 75 KW	34	75	2550	
75% for the next 75 KW	30	75	2250	
65% for the next 75 KW	26	75	1950	
60% for the rest KW	24	806	19344	

After installing capacitor, it is possible to save (31470 – 29094) = 2,376 BDT extra demand charge per month and annually it is possible to save = 2,376 x 12 = 28,512 BDT.

2) *Machines Up gradation:* In our analysis we have found significant rate of production can be possible if some energy savings technology can be incorporated with the machines. If conveyer belt is used in the softener machines. This can increase the efficiency of the softener machine to 21% [6]. For carding machine roll-feed breaker can be used to improve the performance. The efficiency of three stage drawing machine can be improved by superior grade gear box, which can improve 5% efficiency. Accordingly, adjusting baxter flyer in the spinning frame and installation of variable frequency drives (VFD) for winding machines can increase the efficiency 3-11% sequentially [7]. In the process of warping yearn and weft of yarn 12% efficiency can be increased by using PLC controlled inverter drive and standard looms [8]. Using corrosion and abrasion less machines performance of calendaring machines can be improved up to 42%.

3) *Parallel Cabling:* During Jute mill visit we have found that most of the mills are equipped with approximately 150 meter one aluminium armoured 3 core, 500 V, 300 Amp, 0.0825 Ω / core/ km undergroundcable. Cable length is estimated from Substation area to Jute mill's weaving bus unit. It is found that Jute mill is running with single aluminium armoured 3-core cable. But as per energy conservation measures, to reduce power loss in cable it is suggested to equip similar cable in parallel with the existing cable [10].

In this section we will analysis the energy loss inside cable considering two cases, energy cost due to power loss in cable and cable cost investment payback period. We considered 150-meter cable for our analysis and calculation. Existing single 3-core cable's resistance is 0.825 Ω/ core/ km. We considered 80% operational hours in a year to calculate energy loss for single 3-core cable. Considering 250 Amp rated current, energy loss in single cable annually is 36093 KWh.

On the other hand, after installing parallel cable with existing one and considering same 80% operational hour in a year, calculation shows 18,047 KWh energy loss which is almost half of previous energy loss. Calculation reveals that after installing parallel cable it is possible to save 18046 KWh which leads to savings of 136,608.22 BDT. Investment for installing additional cable is 500,000 BDT. Our analysis shows return on investment is 2.4 % per month.

Table -4Energy Loss Calculation in Power Cable

Energy loss in One 3-Core Cable		
S. No.	Attributes	Calculation
1	length of cable	150 m
2	Total resistance of cable	(3 x 150 x 0.825)/1000 Ω
3	Load current	250 Amp
4	Operation hours in a year [Considering 80% operation hours]	0.80 x 24 x 365 = 7000 hrs
5	Energy loss in one core cable for one year	250² x 0.0825 x 7000Wh=36093 KWh
Energy Consumption in two parallel cable		
1	Current in each cable	250/2 = 125 Amp
2	Power consumption in each cable	125² x 0.0825 =1.289 KW
3	Total Power consumption for both cable	1.289 x 2= 2.57 KW
4	Total Energy Loss [Considering 80 % operation hour]	2.57 x 7000 = 18,047 KWh
Energy savings and cost optimization		
1	Savings of energy	36093 -18047 = 18046 Kwh
2	Industrial Electricity tariff	7.57 BDT/ KWh
3	Energy cost saving in a year	136,608.22 BDT
4	Cost for additional 150 m cable	500,000 BDT
5	Payback period	(500,000/136,608.22) x 12=43 months
6	Return on investment	1/43=2.4 % per month

Table -5Energy Conservation from Production Process by Efficiency Measures

Machines	Energy Savings per Production
Softener	1.05 kWh
Carding	0.25 kWh
Drawing(1st,2nd,3rd)	0.15 kWh
Spinning	0.15 kWh
Winding	0.55 kWh
Beaming	0.6 kWh
Weaving	0.11 kWh
Calendaring	2.1kWh

Table -6 Improvement of Production Process by Efficiency Measures

Machines	Improvement of Production
Softener	10-406 kg
Carding	31-103 kg
Drawing (1^{st},2^{nd},3^{rd})	5-61 kg
Spinning	0.7-57 kg
Winding	41-209 kg
Beaming	10-240 kg
Weaving	0.8-5 kg
Calendaring	790-1187 kg

ENERGY EFFICIENCY IMPROVEMENT BENEFIT

The measures we have taken into our analysis reflect in the energy efficiency that can be achieved. The Upgradation of the machines, enhancement in the production chain add extra value in energy savings, increasing amount of production and smoothing the overall process operation.

Electricity Conservation

Our analysis shows that around 30-40% energy requirement can be reduced only by the implementation of various steps to improve the condition of electricity use. This mainly results in the softener and calendaring machines, the forward and end set of the jute process chain. Other optimistic outcomes are in the winding and drawing machines where 15-20% electrical energy consumption could be diminished. Carding and beaming machines which consumes comparatively less energy during the processing operation, consumes significant amount of less energy (10-15%) when efficiency improvement measures are being implemented. Electrical energy consumption reduction in each production process can be as follows: The impact of electricity saving trend can be depicting by a graph which is in Fig. 2.

Increase of Production

The improvement of machines progressively improves the production of jute processing. Most positive impact is on end site where cutting and bundling of yarn can be increased up to 1200kg in amount. This is comparatively huge addition to the entire production amount with the efficiency improvement measures. Also large amount of output can be results from the carding, winding and beaming machines also. This can hugely impact on the payback of the investment on the efficiency measures that could give a return within a year. The production increase trend to get the actual impact on production improvement can be depicted from below shown trend graph:

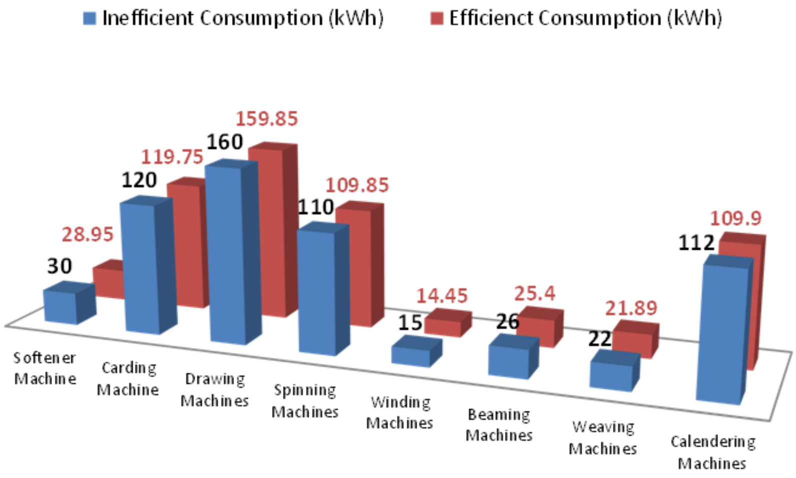

Fig.2 Graph represents the deviation of Electricity Consumption by efficient machines use

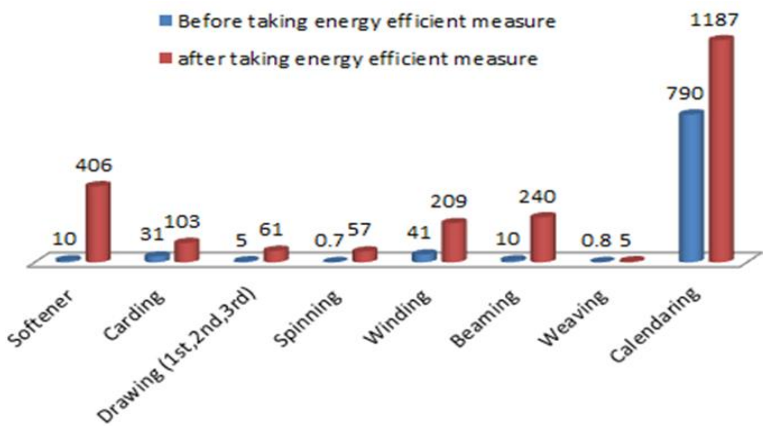

Fig.3 Graph represents the deviation of Production by efficient machines use

CDM Project Benefit

The analysis shows us at least 1-5% of overall electricity and other fuel costs have been reduced if the energy efficiency measures are taken into account. The efficient use of electricity accounts saving bill up to BDT 12 million per year. (In case of national grid supply) and for using gas-based generators would save range between BDT 3.4 million to BDT 6.3 million (In case of Captive Power Generation). This has broad impact on production cost as well investment payback. Also this saving creates a new idea of making a Clean Development Mechanism for Bangladesh in Jute processing sector. The energy conservation project can be an opportunity of earning carbon credit by reduction of CO2equivalent emission, which is approximately 1671ton/year and earning green industry badge through energy savings up to 2924MWh/year. This can open a new financial source that can earn saleable certified emission reduction (CER) credits, (1 CER is equivalent to one tonne of CO2reduction), means of achieving 1671 CER and 1.4 million BDT per year (1 Euro= 84.9340 BDT). This additional income can be utilized for investment as revival of jute processing sector which is now facing financial trouble. Not the less this CDM project can help Bangladesh to attain the SDG goal 7 where energy efficiency and carbon emission reduction are important tools for its achievement.

Annual Savings of consumers

Improvement of power factor brings economical and technical success for both consumer and power generation station. Industrial consumer has to pay electricity charge along with demand charge. Improving power factor allows consumer to reduce maximum KVA and consequently there will be annual economical savings which may lead to profit. Moreover, from technical aspects, improving power factor also reduce I^2R and voltage drops in long cable. Along with Eliminate the penalty of low power factor from the Electric Supply Company it also extends equipment life time, reduce electrical burden on cables and electrical components.

CONCLUSIONS

In this paper authors aimed at investigating electrical energy consuming sides of jute industries and recommending proper solutions to overcome economic losses due to energy wastage and inefficient demand side management. Several action plans are mentioned and recommended with mathematical analysis. Result of implementation of action plans are summarized as

- Up to 5 KWh per production electrical energy savings machine up gradation.
- By installing parallel cable, it is possible to reduce energy loss due to cable resistance up to half of energy loss of single cable.
- Enhancement of jute production after taking energy efficient plan can cover up the investment cost.
- Nationwide up to 1-5% savings of electricity by energy efficient mechanism programs in jute mills.
- Reduction of fossil fuel usage in electricity generation will lead to reduction of CO_2 equivalent emission, which is approximately 16

Moreover, implementation of energy saving measures can be implemented in different types of industries. However, implementation of energy efficient measures totally dependent on industries authorities' decision. Authors have presented enormous potentials of energy saving in industrial sector. In the end, The Government may formulate norms, establish standards, codes & regulation and promote energy efficient measures nationwide.

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REFERENCES

[1] *Annual Report 2015*, Bangladesh Jute Spinning Association (BJSA), **2015**.

[2] *Annual Report 2015*, Ministry of Textiles & Jute, Bangladesh, **2015**.

[3] *Ecological and Economic Attributes of Jute and Natural Fibre for Sustainable Eco-Management*, Dhaka, Bangladesh, **2015**. [Online]. Available: www.jutegeotech.com/html/html/5

[4] *Electricity Tariff*, Bangladesh Power Development Board, **2015**. [Online]. Available: http://www.bpdb.com

[5] *Power Factor Correction: A Guide for the Plant Engineer*, Technical Data SA02607001E, 2014.

[6] Dalia MM Yacout, MA Abd El-Kawi and MS Hassouna, Applying Energy Management in Textile Industry, Case Study: An Egyptian Textile Plant, *International Energy Journal*, **2014**, 14, 87-94.

[7] Nissanga Nishad Rasanajan Mendis and Nisal Perera, Energy Audit: A Case Study, *Proceedings of International Conference on Information and Automation,* Shandong, **2006**,45-50.

[8] Muhammad FurqanKhurshid, Muhammad Asad, Atif Ali Khan, Muhammad Ashraf Chaudhry and Ammanullah, Investigation of Specific Energy Consumption and Possible Reduction Measures of Textile Spinning Mills, *The Journal of American Science*, **2012,** 8(6), 535-542.

[9] RS Chandra, On Energy Auditing: An Experience with a Jute Mill, *International Journal on Recent and Innovation Trends in Computing and Communication*, **2011**, 2 (10), 31-34.

[10] MHA Miah, Why the Performance of the Jute Industry in Bangladesh has Been Declining Gradually? *International Journal of Management and Business Studies*,**2012**, 2 (1),14-22.

[11] *Annual Report 2015*, Bangladesh Jute Mills Corporation Report (BJMC), Ministry of Jute, Government of the People's Republic of Bangladesh, **2015**.

[12] Industrial Energy Efficiency Opportunities and Challenges in Bangladesh – Final Reports, Asian Development Bank, **2014**.

[13] K Chandran and P Muthukumaraswamy, SITRA Energy Audit–Implementation Strategy in Textile Mills, *The South India Textile Research Association*, Coimbatore, India, **2002**.

[14] *Challenges of Development: World Development Report,* Oxford University Press, Washington, USA World Bank, **2006**.