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Effect of Variable Frequency Drive on Energy Optimization: A Case Study of Lokmangal Sugar Ethanol and Co-Generation Industries Ltd., Bhandarkawathe, Solapur

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ABSTRACT: Industrial sector plays important role in energy consumption. Sugar industries by its inherent nature consume considerable amount of energy for production of sugar viz generate the energy as co-generation. There is a need to promote recycle economy, energy generation, facilitating technological progress, reduce consumption, and protect the environment. Hence, energy efficiency and conservation should be viewed as new source of energy along with energy co-generation. Co-generation in sugar industry to produce excess power is a need of an hour. Sugarcane is an Energy rich crop and one ton of cane contains about 4500 MJ energy. This paper brings out an effect of increase in load factor due to Variable Frequency Drive (VFD) at Lokmangal Sugar Ethanol and Co-generation Industries Ltd. (LSECIL) having energy generation capacity of 31.5 MW.

KEY WORDS: *Milling plant, Load factor, Energy, Bagasse, Variable Frequency Drive (VFD).*

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I. INTRODUCTION

The Indian sugar industry, one of the oldest industrial sectors is the second largest producer of sugar in the world, having the market share of about 14.75% and manufacturing nearly 15 million tons of sugar from cane, every year. There have been unique problems of sugar industry which are availability and costs of sugar cane, increasing energy cost, decrease in sugar prices, increasing cost towards pollution control, etc. In contrast to other industries, sugar industry by its inherent nature can generate surplus energy though other industries are only consumers of energy. Sugar mills conventionally co-generate their own requirements of steam and power during the operational season of 150-200 days (Sonaje and Kulkarni, 2015) by using bagasse, the residue of sugarcane generated after crushing.

Indian sugar industries have acknowledged importance of implementing high efficiency grid connected co-generation power plants for generating exportable surplus power. This surplus energy becomes an excellent source of revenue to the sugar industry to become one of important way of achieving long term sustainability. It has been observed that there is about 3000 MW to 3500 MW un-tapped potential (Nangare and Kulkarni, 2012 and APPCB, 2004). The un-tapped surplus energy generation of the sugar industries, can aid in partly mitigating the scarcity of power.

Sugar industry is identified as one such nonconventional energy source due to use of renewable sugar cane crop as a raw material, which gives capital fuel (bagasse) with appreciable calorific value.

Sugar industry consumes a considerable amount of energy for production of sugar. But the awareness on energy efficiency in Sugar Industries in India is still lowered compared to that in the developed countries. Less importance is given to energy efficiency in sugar industries, because they are self sufficient in fuel and power. By knowing the sugar manufacturing process and co-generation equipment's consumption of energy and by evaluating their operating efficiencies, energy efficiency of these equipment's can be improved, which results in the reduction of energy consumption for the same amount of sugar production. Energy optimisation measures can be adopted for new plants starting from the design stage and also can be done as a retrofit for existing plants.

The main source of energy for sugar industries is steam and electricity. Bagasse is being used as fuel to the boilers to generate high pressure steam which in turn drives the turbine to generate both electricity and low pressure steam. The low pressure steam is used for the sugar production process. Hence in a sugar industry with a co-generation plant, the energy consumed can be sub classified (Lavarack B. P., et.al, 2004) as follows,

- Energy consumption by process equipment's

- Energy consumption by cogeneration auxiliaries

Considering the above situation, this paper has tried to analyse the efforts taken by Lokmangal Sugar Ethanol and Co-generation Industries Ltd. (LSECIL), Bhandarkavthe, Dist: Solapur, Maharashtra in case of energy optimisation measures. LSECIL has been established in the year 2008 with crushing capacity of 2500 TCD with energy generation capacity of 15 MW. Over the period of time the crushing capacity and energy generation capacity has been increased upto 6000 TCD and 31.5 MW (Deshmukh G K and Sonaje N P, 2017) during the year 2009 including captive power of 10 MW and co-generation of 21.5 MW.

This co-generation power project is operating mainly on mill bagasse (Deshmukh G.K. and Sonaje N.P, 2017) during 160 season days of the sugar mill. All steam and power requirement of the sugar mill, co-generation auxiliaries and colony, both during season and off-season periods, are met internally from the co-generation power plant. Industry employs high pressure and temperature configuration boiler and steam turbine as well as electrostatic precipitator for emission control and distributed control for efficient operation.

The major machineries involved with high electrical consumption are cane choppers, cane levellers, fibrizor, mill drives, GRPF drives. As such the LSECIL has taken some measures for energy consumption for GRPF drives and hence only GRPF drives are considered while presenting the data in this paper.
The Grooved Roller Pressure Feeder (GRPF) drives has been installed with five drive motors are as details below,

Table 1: Details of GRPF Drive Motors.

S. N.	Motor Name	Rated Power (KW)	RPM	Current (I)	Voltage (V)
1	Mill GRPF 0	325	1000	235	660
2	Mill GRPF 1	250	1000	192	660
3	Mill GRPF 2	250	1000	175	660
4	Mill GRPF 3	250	1000	164	660
5	Mill GRPF 4	250	1000	181	660

The voltage and current of the motors used for above machineries are recorded during actual observations taken from the industry from the control panel for the period of 24 hours duration from 21 Dec 2014 to 20 Jan 2015 and peak values are considered in above table. While taking these observations, no energy consumption measures been considered.
The actual power consumption, its losses and load factors are calculated as below for each machinery unit.

$$P = \sqrt{3}\, V\, I \cos(\varphi)$$

Where,
P = Actual power consumption,
V = voltage supplied
I = current supplied
cos (φ) = power factor = 0.85

Sample calculation for power consumption for Zero Mill GRPF has been shown as below,

$P = \sqrt{3}\, V\, I \cos(\varphi)$

$= \sqrt{3} \times 660 \times 235 \times 0.85$

= 228345 W

= 228.345 KW

Load factor for Zero Mill:
Load factor is a ratio of actual power consumption to rated power.

LF = 228.345/325

= 0.7025

= 70.25%

Table 2: Load Factor

S. N.	Motor name	Current (I) Amp	Voltage (V)	Rated Power (KW)	Actual Power Consumption (KW)	Losses (KW)	Load Factor%
1	Mill GRPF 0	235	660	325	228.34	96.66	70.25
2	Mill GRPF 1	192	660	250	186.56	63.44	74.62
3	Mill GRPF 2	175	660	250	170.04	79.96	68.02
4	Mill GRPF 3	164	660	250	159.34	90.66	63.74
5	Mill GRPF 4	181	660	250	175.87	74.13	70.35

During the study in LSECIL, it is observed that due to frequent variation in the crushing of sugarcane, the loading most of equipment varies, resulting in inefficient operation. The Mill drives are running on fixed frequency and voltage with high starting current. Similarly the load on these drives are varies as per the crushing of sugarcane and are running on the same speed. The motors utilised may be of oversized to cope with a maximum demand which rarely occurs. All these factors summing together reflects more energy consumption than required. It is noted in the literature that slowing down a drive from 100 to 80% can reduce motor energy use by up to 50% (http://www.eskom.co.za). The load factors of all five GPRF drives which is about 70% which is in need to improve and hence it is essential to put some device like Variable Frequency Drive (VFD) to be used so that the efficacy of the motor can be increased and losses can be reduced. (G R Narasimha, *et. al.*, 2012)

Variable Frequency Drive

Keeping the above things in a background the LSECIL has applied VFD (Variable Frequency Drive) to optimize the energy efficiency of GPRF drives to adjust the frequency to regulate and adapt motor speed to match the actual demand while adjusting torque. This VFD works on the principle that they convert incoming electricity, which is at a fixed frequency and voltage, into variable frequency and voltage. When a VFD starts a motor, it initially applies low frequency and voltage, which avoids the high starting current that occurs. The applied frequency and voltage are increased at a controlled rate to increase the speed of the motor (load) without excessive current being drawn.

Status of Energy Consumption after installation of VFD

At present status, VFDs are installed at GRPF drives and actual output voltage and current is measured. Load factor is calculated for GRPF drive and it is observed that load factor is improved with considerable amount as shown below.

Table No. 5.1: Load Factor after VFD's installation

S. N.	Motor name	Current (I) Amp	Voltage (V)	Rated Power (KW)	Actual Power Consumption (KW)	Losses (KW)	Load Factor % before VFD	Load Factor % after VFD	Improvement in Load Factor
1	Mill GRPF 0	269	660	325	261.38	63.62	70.25	80.42	10.17
2	Mill GRPF 1	203	660	250	197.25	52.75	74.62	78.90	4.28
3	Mill GRPF 2	179	660	250	173.93	76.07	68.02	69.57	1.56
4	Mill GRPF 3	175	660	250	170.04	79.96	63.74	68.02	4.28
5	Mill GRPF 4	186	660	250	180.73	69.27	70.35	72.29	1.94

II. CONCLUSION

It is revealed from the analysis that due to application of VFD, the energy losses can be reduced and load factor can be improved. From the above observations it is suggested that the VFDs can be used at cane carrier drives, feeder table drives, milling plant drives juice and cooling pumps to minimize power consumption as well as to reduce breakdown, for achieving smooth working and energy optimization.

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