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Energy Audit: Case Study of a Flex Manufacturing Company

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***Abstract*— Growing concerns arise about energy consumption and its adverse environmental impact in recent years in India, which cause manufactures to establish energy management groups. The purpose of the Audit is to identify the performance of Energy Guzzlers and set the Energy Baseline for the facility. For finding out the energy baseline various testing has been performed. As per the current pattern there are numerous recommendations which will help facility to reduce their energy baseline[1]. in future. The results from the Energy audit of flex manufacturing company have been presented in this paper.**

I. INTRODUCTION

The flex manufacturing[2] company integrated manufacturer of Flex Banner, PVC Foam Sheet and self-adhesive vinyl. The factory is spread in large area where have multiple production lines for flex banner, foam sheet, vinyl and reinforcement fabric.

It is having a 33 kV connection for fulfilling their power needs. In case of power failure they are having 4 DG sets of 1250x2, 625x1 & 125x1 kVA capacity. It is having a total connected load of 8069 kW, for which a connection of 2600 kVA has been sanctioned from Power Corporation limited of respected area. Incoming supply voltage is 33 kV which is further stepped down to 380 V with the help of 2 transformers located in different sections.

Unit charges depend on the load factor. Manufacturing company having an average load factor of 66.66%, hence they are paying the energy charges at a rate of Rs 3.6 kVAh for normal hours, Rs 5.4/kVAh for peak hours & Rs 3.24 /kVAh for off peak hours. Average unit consumption of the plant is 11.82 Lakhs kVAh unit /month, while total consumption of the plant is 141.95 Lakhs kVAh units.

II. INTRODUCTION ABOUT THE PLANT

Pioneer is India's first and one of the world's largest integrated manufacturers of Flex Banner, PVC Foam Sheet and self-adhesive vinyl. The machines and technology are imported from Taiwan, Germany, Korea and China. The factory is spread over 10 acres of land where we have multiple production lines for flex banner, foam sheet, vinyl and reinforcement fabric.

With production capacity of 300 containers of flex banner and 50 containers of Foam Board and 30 containers of vinyl per month, it is one of the world's biggest producers of advertising media. Major raw material is sourced from world renowned suppliers.

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Products

- Coated/laminated fabric with plastic
- impregnated or non-impregnated non-woven
- flexible films/fold of plastic
- foot wear and components
- Footwear & components
- Coated/laminated fabric

A. Major Energy Use Areas

The major energy used areas identified in the plant were as follows:

S.No.	Description	Load KW
1	Cooling Towers Load	47
2	Compressors load	191
3	Chillers load	212
4	Motors and Load	6735
5	Lighting Load	51
6	Boilers load	340
7	AHU's & Air washers load	142
8	Blowers load	247
9	Others	100
	TOTAL	**80**

Table I. Energy Description

B. Process Flow Diagram

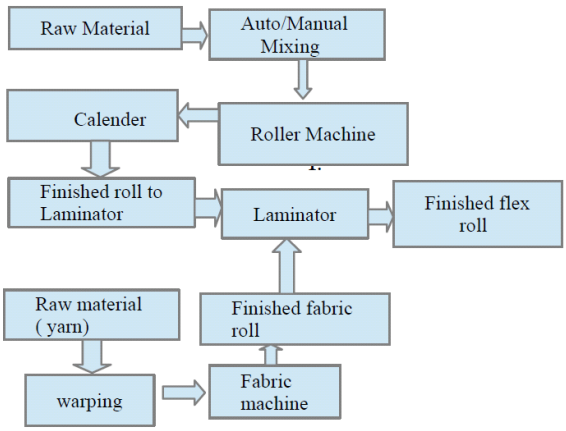

Fig. 1. Process Flow

C. Summary of Observations

- Maintenance department is doing a great job by maintaining the power factor within the range of 0.99-1.
- Average unit consumption of the plant is 11.82 Lakhs kVAh unit /month, while total consumption of the plant is 141.95 Lakhs kVAh units /Annum. Maximum and minimum units are consumed in the month of Mar-14 & Dec-14 respectively.
- Average Load factor of the plant is 66.66%, while variation is in the range of 47%-74% depending upon the production based on consumer demand.
- For fulfilling production needs plant have been paying Rs 46.79 lakhs/Month for unit charge only, while annually it is Rs 561.54 Lakhs/Annum.
- Unit consumption in normal hours is having a maximum share while maximum peak hours are having a minimum share in the unit consumption.
- Demand charges are at the rate of Rs 270 /kVA. Demand charges are levied on the maximum contribution in between the maximum demand & 75% of the contract demand.
- By Using power at 33 kV they are getting a rebate of 2.50% in the energy bill. But for getting the continuous supply they have to spend 15% charge on the energy bill.
- Total units generated to fulfill the power failure gap through the DG sets are 5.04 Lakhs kVAh/Annum. To generate these units a total of 1.37Lakhs Liters/Annum of Diesel has been used.
- Thermic fluid is used as a heating medium to cater to the heating needs of calendar & lamination machines. Thermic fluid is heated with the help of rice husk/pet coke fired boiler. Supply temperature of the fluid is 250 degree C while it returned at a temperature of 232 degree C after transferring the heat to the machines. Heat requirement of the machines is in the range of 172- 210 degree C.
- There are 3 boilers to heat up the thermic fluid.
- There are total 6 No's of compressors installed in the plant to cater to the compressed air requirement of the plant. Out of which only 3 are running at a time rest are in the standby mode. All compressors are connected in a ring system. Compressed air required for the pneumatic applications of the machines. Set pressure points for the plants are 5.6-6.4 bar. Chilled water is used for the Machine cooling, product cooling. Each section is equipped with the separate Chiller. Required chilled water temperature for the machines is in the range of 11 - 13. There are total 8 chillers installed in the plant.
- Cooling Water/Tower used to cool down the machines during the operations. For this plant is having a total of 9 cooling towers.
- The fixed energy consumption of the plant is 337514 units per month. This is irrespective of production. The energy consumption is lower in May rises steeply further but again lowers in October. The higher energy consumption in the month of march and July. It needs to be further investigated.
- The SEG calculated for DG no. 1 & 2 is 3.82 and 3.69 kWh/ Liter. This is in optimum range.
- However it was observed that the DG sets were overloaded. The recommended Loading of Generators should not be more than 80% for constant loading, 10% overload for 1 hour duration in 12 hour period and 50% overload for not more than 15 seconds.
- It was observed that the DG sets were overloaded for a larger period. It is recommended to the Load pattern analysis on the DG sets and reduce the overload. It is also recommended to run the DG sets based on kVA connected rather than current.
- The efficiency of the boiler is assessed to be 91 %.
- The damper of the FD fan 2 was found ineffective and considerable amount of air was leaking out in the atmosphere. Also the Damper of Fan 1 (in operation) was found to be set at 90%.
- The performance analysis (free air delivery test, FAD) was conducted on 5 compressors. One compressor was found non-operational during audit.
- The moisture drain from the receiver tanks was manual. The drain valves were always open leading to constant loss of compressed air.
- During audit, it was observed that the chiller was closed during winter , the trial run conducted and found the chilled water from the chillers were mixing in a common tank and the chilled water lines were uninsulated.

III. ENERGY DESCRIPTION IN THE UTILITY

A. *Energy Consumption Pattern*

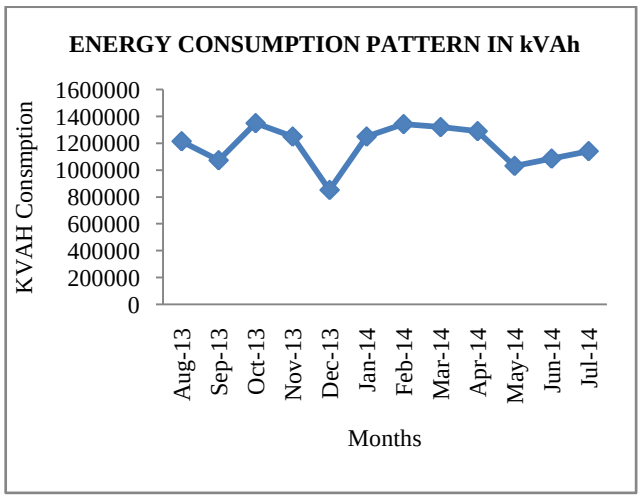

Fig. 2. KVAH Consumption Pattern

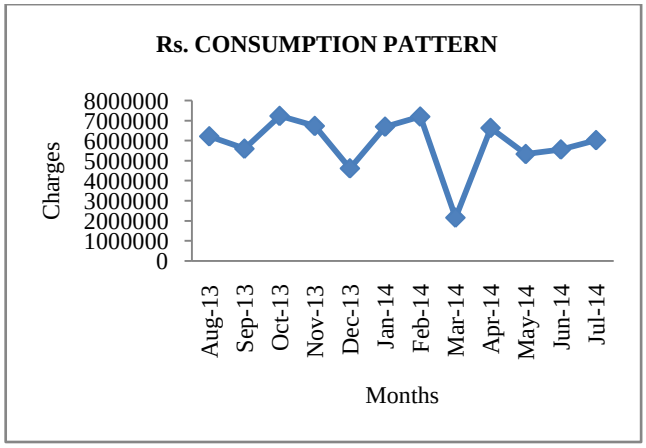

Fig. 3. Rs. KVAH Consumption Pattern[3]

B. *Boiler Details*

Thermic fluid is used as a heating medium to cater the heating needs of calendar & lamination machines. Thermic fluid is heated with the help of rice husk/pet coke fired boiler. Supply temperature of the fluid is 250 degree C while it returned at a temperature of 232 degree C after transferring the heat to the machines. Heat requirement of the machines is in the range of 172- 210 degree C.

There are 3 boilers to heat up the Thermic fluid. Details of boilers are as follows:-

BOILER DETAILS			
S no	*Description*	*Make*	*capacity kcal/kg*
1	Boiler 1	Thermopac	20 lakhs
2	Boiler 2	Thermopac	20 lakhs
3	Boiler 3	Thermopac	30 lakhs

Table II. Boiler Details

IV. ANALYSIS

After thorough analysis, calculations and trial runs (during audit), following energy conservations opportunities have been identified:

A. *Savings in Boiler*

It is recommended to reduce the range of Thermic fluid temperature by 5 ^{o}C i.e. from 250 ^{o}C to 245 ^{o}C. This would reduce the rate of fuel fired in the combustion chamber and result in immediate savings. The annual fuel usage reduction and cost savings is as follows:

Savings due to reduced Thermic fluid heating temperature			
Parameter	*Units*	*Values*	*Remarks*
Fuel Firing rate to maintain temperature at 250	kg/min	6.5	observation during audit
Fuel Firing rate to maintain temperature at 245	kg/min	5.7	observation during trial run
Reduction in fuel input	kg/min	0.8	Calculated
Savings	kg/annum	380160	Calculated
Cost of fuel	Rs/ kg	11	Given
Annual cost savings	Rs/annum	4181760	Calculated
Investment	Rs	0	
Payback period	Years	immediate	Calculated

Table III. Savings in Boiler [4].

B. *Savings in Insulation of Thermic Fluid Line*

It is recommended to insulate all flanges and control valves in the Thermic fluid distribution pipes at boiler plant and in manufacturing plant.

Heat Lost through Uninsulated area : Thermography		
Boiler room		
Description	*Units*	*Value*
Type of fuel		
Average surface temperature	C	200
Ambient temperature	C	35

Heat loss allowable surface temperature	C	45
Average area of flange	m^2	0.38
No of flanges	Nos	37
Average Effective Heat loss Area	m2	14.06
Total Effective Heat loss Area	m2	14.06
Heat loss of Steam surface line	kcal/hr m2	2751
Total Heat loss through Steam surface line	kcal/hr	38683
Fuel calorific value	kcal/kg	8200
Fuel equivalent to heat loss	kg/h	5
Energy Savings: (Using Mineral wool and Aluminum sheet)		
Boiler Efficiency	%	92%
Fuel equivalent to heat loss	kg/h	5.15
Annual working days	h	7920
Annual Fuel savings	kg	40749
Cost Savings		
Fuel price	Rs/kg	11
Annual Cost Savings	Rs	448242
Annual Cost Savings	Rs. Lakhs	4.48
Payback Period		
Total Investment	Rs. Lakhs	3.00
Payback Period	month	8.0

Table IV. Energy Savings through Insulation

C. *Energy Conservation Summary*

ENCON TABLE						
S.NO.	*Energy Conservation measures*	*Units*	*Energy Savings*	*Monetary savings Rs(lakhs)/annum*	*investment*	*Payback Period (years)*
savings with immediate payback						
1.	Energy Savings By Proper Closing of FD fan 2 Damper.	kWh/year	22308.26	1.22	0	immediate
2.	Savings due to dismantle of 1 light from 2x18w fixture	kWh/year	7632	0.42	0	immediate
3.	Savings due to reduced Oil heating temperature & Process Optimization	Kg of Fuel/year	380160	41.82	0	immediate
savings with minimum payback period						
4.	Monetary Saving by using automatic drain valves for Air receiver	kWh/year	162032	8.83	3	0.34
5.	Energy Savings By Using 2 different tanks for process cooling	kWh/year	322027	17.56	9	0.51
6.	Energy Savings By Flange Insulation in Thermal Fluid Oil Distribution	Kg of Fuel/year	110434	12.15	9	0.74
savings with Higher payback period						
7.	Savings due to the replacement of T8 lamps with LED lamps	MWh/year	22739	1.24	4	3.13
Total savings				83.23	24.88	0.3

Table V. Energy Conservation Summary

V. CONCLUSION

From the overall literature review it is concluded that there are so many ways to reduce the energy consumption, energy cost reduction etc. which we are getting from energy auditing. [5].

- During audit, it was observed that there was considerable leakage of combustion air from the damper of FD Fan 2 as only FD Fan 1 was in operation. This increases the power consumption of the FD fan motor as it has to deliver more air to fulfill the combustion air requirements of the combustion chamber. Closing the Damper completely and ensuring no leakage of air to surrounding atmosphere can result in immediate savings as it results in reduced power consumption of the motor either by impeller trimming. The automation of FD fan would significantly reduce the power consumption. This saving would be Rs 1.21Lakhs/Annum with immediate payback.
- It is recommended to optimize the process & reduce the range of Thermic fluid temperature by 5 Deg.C i.e. from 250 Deg.C to 245 deg.C. This would reduce the rate of fuel fired in the combustion chamber and result in a saving of Rs 41.20 Lakhs/annum with immediate payback.
- It is recommended to insulate all flanges and control valves in the Thermic fluid distribution pipes at boiler plant and in manufacturing plant. This will lead to a saving of Rs 12.15 Lakhs/Annum with a investment of 9 lakhs.
- It is recommended to use different insulated tanks for storing chilled water out from chillers and the water out from the process. Currently the water from chillers and process is getting mixed in the storage tank. This is reducing the effectiveness of the chillers. Separating the tanks would increase the loading on chillers resulting in improved

efficiency and reduced Specific energy consumption of the chillers. This will lead to a saving of Rs 17.55 Lakhs/annum with a investment of Rs Rs 9.00 Lakhs.

- It is recommended to install automatic moisture drain valves in the compressors. This will lead to a saving of Rs 8.83 lakhs /Annum.
- It is recommended to dismantle the 1 light from the 2 light fixture of CFL. This will lead to saving of Rs 0.41 lakhs/annum without any investment.
- The Annual energy savings is 30,371 kWh per Annum with monetary savings of Rs. 1.65 Lakhs/Annum.

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