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Power Factor Improvement in a Sugar Mill: An Analysis

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Abstract—To reduce losses in the distribution system, and to reduce the electricity bill, power factor correction, usually in the form of capacitors, is added to neutralize as much of the magnetizing current as possible..To improve the power factor in sugar mill, it is required to install the capacitors of required capacitor ratings as near to the load as possible. This paper reports a case of sugar mill where the induction motors having a power factor of 0.8 has a potential to improve the power factor to 0.95, by installing suitable power factor improvement capacitors.

Index Terms— Distribution losses, induction motors, inductive load, power factor, sugar mill

I. INTRODUCTION

Power factor improvement may be defined as the ratio of the real power to the apparent power. It is a dimensionless quantity whose value lies between 0 and 1.

Inductive loads such as (transformers, electric motors etc.) lowers the power factor and draws a major portion of power in a sugar industry. Electric motors require reactive power to set up the magnetic field while the active power produces the useful work (shaft horsepower). Total Power is the vector sum of the two.

- **Working /Active Power:** Normally measured in kilowatts (KW). It does the "work" for the system--providing the motion, torque, heat, or whatever else is required.
- **Reactive Power:** Normally measured in kilovolt-amperes-reactive (KVAR), doesn't do useful "work." It simply sustains the electromagnetic field.
- Apparent Power: Normally measured in kilovolt-amperes (KVA). Working Power and Reactive Power together make up apparent power.

Reactive power (KVAR) required by inductive loads increases the amount of apparent power (KVA) in distribution system. The increase in reactive and apparent power causes the power factor to decrease [2].

In an electric power system, a load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. The higher currents increase the energy losses in the distribution system, and require larger wires and other equipment. Because of the costs of larger equipment and wasted energy, electrical utilities will usually charge a higher cost to industrial or commercial customers where there is a low power factor [3].

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II. PROBLEM DEFINITION

The inductive loads in a sugar mill are to be analysed for low power factor for finding out the distribution losses. After analysing the low power factor, capacitor bank is required to improve the power factor. By improving the power factor, distribution losses are reduced in distribution system. Improvement in power factor will result in increasing the efficiency as well as the electrical energy saving. Recommendations for retrofitting of capacitor are to be made accordingly.

III. METHOD

In this report the subject of investigation is a 24 MW cooperative sugar mill. First of all the whole plant is studied thoroughly and the electrical energy distribution systems found. These are a 66KV substation, a 24MW steam power plant, DG sets 1010 KVA and a sugar manufacturing plant. During plant study, many inductive loads are identified motors.

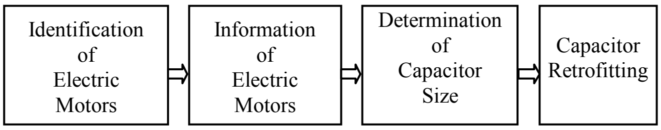

Fig1. Procedure to Analyze the Inductive Load

After studying the plant, few of the electric motors are selected for power factor improvement. The saving in electrical energy is found by analysing these inductive loads and looking for capacitor retrofit to improve the power factor. The procedure to analyze the load for power factor improvement is shown in Figure 1.

IV. RESULTS AND DISCUSSIONS

In the plant, the saving in electrical energy is found by analysing some of the electrical motors and looking for capacitor installation to improve the power factor of the loads and increase the efficiency of the motors. Sample parameters of one of the electrical motor are given in Table 1, which include rated and measured parameters of 10 HP induction motor.

Table1: Rated and Measured Parameters of 10 HP Motor

Measured parameters	**Ratings**
Power Drawn, P (KW)	6.5
Present Power Factor, PF	0.7
Required Power Factor, PF	0.95

Calculated Parameters [4]:

Phase angle of the present power factor (PF1),

$\phi 1 = \text{Cos}^{-1}(\text{PF1}) = \text{Cos}^{-1}(0.7) = 45.6^{\circ}$

Phase angle of the present power factor (PF2),

$\phi 2 = \text{Cos}^{-1}(\text{PF2}) = \text{Cos}^{-1}(0.95) = 18.19^{\circ}$

KVAR rating of the required capacitor $=P\times(\tan\phi 1 - \tan\phi 2)$

$= 6.5 \times((\tan(45.6^{\circ}) - \tan(18.19^{\circ}))$

$= 4.485$ KVAR

Reduction in distribution loss $= (1-(PF1/PF2)^2)*100$

$= (1-(0.7/0.9)^2)*100$

$= 46\%$

Analysis done on few electrical types of 10 HP electrical motors for power factor improvement are shown Table 2.

Table 2: Power Factor Improvement on 10 HP motor

Rated Power (KW)	Power Drawn (KW)	Present Power Factor	Required Power Factor	Req. Cap. (KVAR)	Reduction in Distribution Losses (%)
7.5	6.5	0.7	0.95	4.485	46
7.5	6.7	0.76	0.95	3.484	36
7.5	6.6	0.78	0.95	3.08	32.6
7.5	6.4	0.7	0.96	4.416	46.9
7.5	6.2	0.72	0.95	3.906	42.6

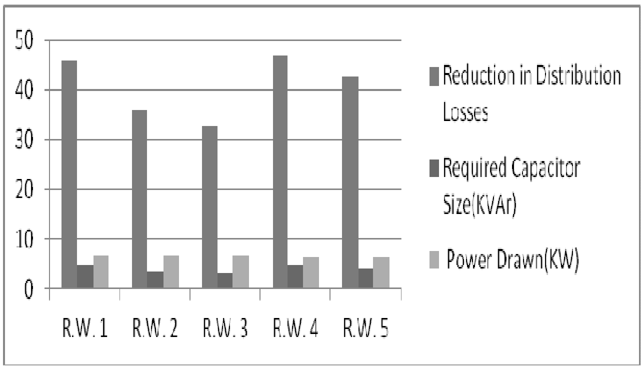

Fig2. Power Factor Improvement on 10 HP motor

Analysis done on few electrical types of 20 HP electrical motors for power factor improvement are shown Table 3.

Table 3: Power Factor Improvement on 20 HP motor

Rated power (KW)	Power Drawn (KW)	Present Power Factor	Required Power Factor	Req. Cap. (KVAR)	Reduction in Distribution Losses (%)
15	15.60	0.72	0.95	9.828	42.6
15	16	0.73	0.95	9.6	41
15	15.63	0.7	0.95	10.63	45.7

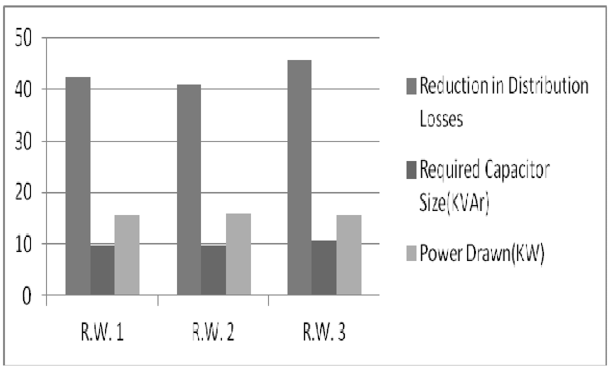

Fig3. Power Factor Improvement on 20 HP motor

Analysis done on few electrical types of 75 HP electrical motors for power factor improvement are shown Table 4.

Table 4: Power Factor Improvement on 75 HP motor

Rated power (KW)	Power Drawn (KW)	Present Power Factor	Required Power Factor	Req. Cap. (KVAR)	Reduction in Distribution Losses (%)
55	46.75	0.75	0.95	25.7	37.7
55	45.13	0.78	0.95	21.21	32.6
55	44.21	0.76	0.95	22.9	36

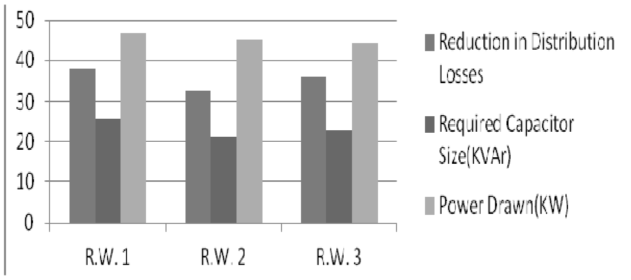

Fig4. Power Factor Improvement on 75 HP motor

Analysis done on few electrical types of 100 HP electrical motors for power factor improvement are shown Table 5.

Table 5: Power Factor Improvement on 100 HP motor

Rated power (KW)	Power Drawn (KW)	Present Power Factor	Required Power Factor	Req. Cap. (KVAR)	Reduction in Distribution Losses (%)
75	52.4	0.9	0.97	12.05	13.9

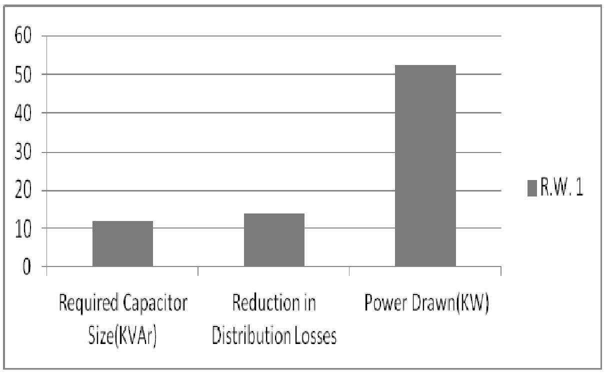

Fig5. Power Factor Improvement on 100 HP motor

This analysis shows that by connecting a capacitor of a determined size, power factor of the inductive loads in the thus lead to large reduction in distribution loss of the system and save large amount of electrical energy.

V. CONCLUSION AND FUTURE SCOPE

A sugar mill has major electrical load in the form of induction motors. Power factor of typical motor is in the range of 0.75 to 0.85 and the average of the selected load is 0.8. After installing capacitor, this power factor becomes 0.95. This analysis also shows that power factor improvement finds a great scope to save electrical energy by reducing the distribution losses. Future scope exists in the terms of reduction in Total Harmonic Distortion on account of non-linear load.

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