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Power Factor Improvement in a Textile Plant: An Analysis

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Abstract: Any inductive load requires magnetisation current that leads to a power factor that is lesser than unity. This not only attracts penalty from the utilities supplying electrical power but also results in higher distribution loss. It is therefore recommended that for the inductive loads in any plant, suitable power factor improvement capacitors be installed as near to the load as possible. This paper reports a case of textile plant where the average power factor of 0.8 in selected load has a potential to improve to 0.95, by installing suitable power factor improving capacitors.

Keywords: Power factor, induction motors, textile plant, inductive load, distribution losses.

1. INTRODUCTION

The power factor (PF) of an Alternating Current (AC) electric power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit, and is a dimensionless number between 0 and 1[1].

Inductive loads (such as transformers, electric motors, and high-intensity discharge lighting) lower the power factor and these loads draw the major portion of the power in a textile industry. The total or apparent power required by an inductive device is a composite of the following:

- Real power (measured in kilowatts, kW), is the capacity of the circuit for performing work in a particular time,
- Reactive power, the nonworking power caused by the magnetizing current, required to operate the device (measured in kilovars, kVAR)

Reactive power required by inductive loads increases the amount of apparent power (measured in kilovolt amps, kVA) in the 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].

2. PROBLEM DEFINITION

The inductive loads in textile plant under study are to be analysed for lower power factors in order to get their distribution losses. The sizes of the capacitor banks, required to improve the power factor, are then determined to bring the power factor as close to unity as possible. Improving the power factor will reduce the distribution losses in the distribution system, thus increasing the efficiency of the equipment and saving the electrical energy. Recommendations for retrofitting of capacitor are to be made accordingly.

3. METHOD

In this report the subject of investigation is a major textile plant. First of all the whole plant is studied thoroughly and the electrical energy distribution systems found. These are a 33KV substation, a 6MW steam power plant, a diesel plant and a fiber manufacturing plant. During plant study, many inductive loads are identified (such as transformers, motors etc.)

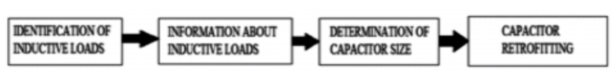

Figure 1: Procedure to Analyse the Inductive Load

After studying the plant, few of the inductive loads 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.

4. RESULTS AND DISCUSSIONS

In the plant, the saving in electrical energy is found by analyzing some of the inductive loads and looking for capacitor installation to improve the power factor of the loads and increase the efficiency of the loads. Sample parameters of one of the inductive load are given in Table 1.

Table1
Rated and Measured Parameters of an Inductive Load[3]

Measured Parameters	*Ratings*
Power Drawn, P (KW)	13
Present Power Factor, PF1	0.76
Required Power Factor, PF2	0.95

Calculated Parameters [4]:

Phase angle of the present power factor (PF1), $\phi 1 = \text{Cos}^{-1}(\text{PF1}) = \text{Cos}^{-1}(0.76) = 40.5^0$

Phase angle of the required power factor (PF2), $\phi 2 = \text{Cos}^{-1}(\text{PF2}) = \text{Cos}^{-1}(0.95) = 18.20^0$

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

$= 13 \times (\tan(40.5) - \tan(18.20)) = 6.8$ kVAR

Reduction in distribution loss

$$= \left(1 - \left(\frac{PF1}{PF2}\right)^2\right) \times 100 = \left(1 - \left(\frac{0.76}{0.95}\right)^2\right) \times 100 = 36\%$$

Analysis done on few electrical types of inductive loads for power factor improvement is shown Table 2.

Table 2
Analysed Parameters for Power Factor Improvement

Rated Power (KW)	*Power Drawn (KW)*	*Present PF*	*Target PF*	*Calculated Capacitor Size (KVAR)*	*Available Capacitor Size (KVAR)*	*Improved PF*	*Reduction in Lossess (%)*
15	13	0.76	0.95	6.8	7	0.95	36
15	13.5	0.85	0.95	3.9	4	0.95	19.9
15	14	0.79	0.95	6.26	7	0.96	32.3
20	17	0.79	0.95	7.6	8	0.95	30.8
20	17.5	0.75	0.95	9.7	10	0.95	37.7
50	41	0.82	0.95	15.14	16	0.96	27.03

Table 2 shows capacitor rating required for power factor improvement and the resulted reduction in the losses after improving power factor, while Figure 2 shows the analysis done on few inductive loads (or motors) for their power factor improvement.

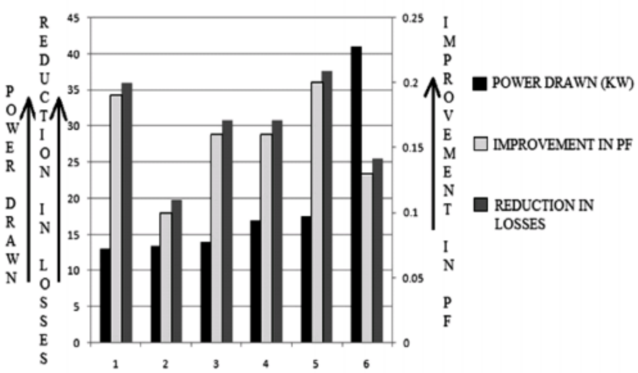

Figure 2: Power Factor Improvement Analysis

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

5. CONCLUSION AND FUTURE SCOPE

A textile plant 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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