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1. REACTIVE POWER

An electrical system when it supplies energy to a distribution system consisting of transformers, motors, fluorescent chokes and other appliances require a magnetic field for its operation. The energy which is used to establish the magnetic field is called as reactive power.

The consumer cannot extract this reactive power as energy. It leads to increase in the current that flows in the system and hence contributes to the system losses. This supply of additional unwanted reactive power to the loads leads to system instability because of the limited capability of the State Electricity Boards.

1.1 Power Factor

The power factor of a circuit or system is a measure of its effectiveness in utilizing the apparent power it draws from the system. Mathematically, it can be expressed as the ratio of the active power (kW) to the apparent power (kVA) drawn by a load.

$$\text{pf (cos}\phi\text{)} = \text{kW} / \text{kVA}$$

1.2 Reactive Power (kVAr) vs Power (kW), Apparent Power (kVA) and Current (A)

From the numerous field level studies conducted by SITRA on the influence of reactive power compensation over power consumption and power cost exclusively in textile industry, the following case studies are discussed:

2. CASE STUDIES

2.1 Case Study – 1

A study conducted in a textile mill is being presented here where a feeder has been studied with and without capacitors for 'pf' improvement. The results are tabulated below.

Power Source : It is supplied from a 380-kVA generator.

Connected Load : Two feeders namely SSB2 and SSB3 are connected and the load details are given in Table 1.

Table 1 : List of Connected Machines

Machines Connected in SSB2	Connected Power
Ring frames-7 nos. Autoconer 1No. Capacitor: 50 kVAr	209 hp
Machines Connected in SSB3	Connected Power
Ring frames –12 nos. Borewell Motor 5hp-1no. Welding transformer-1No. Capacitor – 50 kVAr	256.8 hp+ 6kVA

Table 2 : Test - 1 All (100 kVAr) Capacitors “OFF”

Phase	Hz	Voltage	Current	pf	kVA	kW @
R	49.5	240	419	0.84	101.0	80.5
Y	49.5	240	418	0.83	100.5	82.0
B	49.5	241	417	0.83	99.0	81.0
Total					300.5	243.5

Table 3 : Test – 2 50 kVAr Capacitor “ON” (in SSB2)

Phase	Hz	Voltage	Current	pf	kVA	KW @
R	49.4	241	390	0.90	94	82.5
Y	49.4	240	385	0.90	94	81.0
B	49.4	240	380	0.90	92	80.5
Total					280	244

Table 4: Test - 3 All -100 kVAr Capacitors “ON” (both SSB2 & SB3)

Phase	Hz	Voltage	Current	pf	kVA	kW @
R	49.4	241	366	0.96	87.5	81.5
Y	49.5	241	360	0.95	87.8	81.0
B	49.5	240	356	0.95	86.5	80.0
Total					261.8	242.5

@ - Measured at SSB (Load end)

Table 5 : Findings of the Case Study - 1

Condition	Apparent power (kVA)		Real Power (kW)	
	Difference		Difference	
	kVA	%	kW	%
All capacitors 100 kVAr 'off'	--	--	--	--
Capacitor 50 kVAr 'on'	-20.5	-6.8	+0.5 kW	+0.20
All capacitors 100 kVAr 'on'	-38.7	-12.9	-1.0 kW	-0.42

Comments:

Tables 2,3 & 4 depict the details of the test results conducted in the Textile mill 1. From the Table 5, it is found that

- ❖ Variations exist to the extent of about -0.42% to +0.2% in the measured kiloWatt
- ❖ Reduction in apparent power to the extent of 6.8% to 12.9% in the measured kVA.

2.2 Case Study – 2

A study conducted in another textile mill is being presented here where a feeder has been studied with and without capacitors for 'pf' improvement. The results are tabulated below.

Power Source : APTRANSCO supply.

Connected Load : A feeder supplying to ring spinning frames and the load details are given in Table 6.

Table 6 : List of Connected Machines

Machines Connected	Connected Power
Ring frames-3 nos. Overhead cleaners 3 Nos. Electronic yarn clearer 1 No. Capacitor: 20 kVAr	162 hp

Table 7 : Test - 1 20 kVAr Capacitor "OFF"

Phase	Hz	Voltage	Current	pf	kVA	kW @
R	47.9	230	122	0.82	28.1	23.0
Y	47.9	230	133	0.81	31.0	25.0
B	47.9	236	132	0.78	31.0	24.5
Total					90.1	72.5

Table 8 : Test - 2 20 kVAr Capacitor "ON"

Phase	Hz	Voltage	Current	pf	kVA	kW @
R	47.9	232	110	0.91	25.5	23.5
Y	47.9	232	119	0.90	27.8	25.0
B	47.9	237	120	0.86	28.1	24.5
Total					81.4	73

@ - power measured at SSB (Load end)

Table 9 : Findings of the Case Study - 2

Condition	Apparent power (kVA)		Real Power (kW)	
	Difference		Difference	
	kVA	%	kW	%
Capacitor 20 kVAr 'off'	--	--	--	--
Capacitor 20 kVAr 'on'	-8.7	-9.7%	+0.5	+0.69

Comments:

Tables 7 & 8 furnish the details of test results conducted in the textile mill 2. From the Table 9, it is found that

- ❖ Increase in power consumption of about 0.69% in the measured kiloWatt
- ❖ Reduction in apparent power to the extent of 9.7% in the measured kVA.

3. CONCLUSIONS

The following are the conclusions from the above case studies conducted at mill level on the effect of power factor:

- ❖ If 'pf' is improved by adding capacitors at utility (load) end, there is no difference in power consumption by the utilities (drives, appliances etc.,). The variations found in power consumption are very minimal and the inherent load fluctuations itself would have contributed to this.
- ❖ Due to reduction of magnetising current in the cables, there is reduction in the transmission line losses (I^2R losses) in the cables.
- ❖ Because of the reduction in apparent power (kVA), the MD reached in an industry will come down. If the tariff rates are based on MD reached, it is cost effective. As the tariff rates are different for SEBs (State Electricity Boards), the economics will vary.