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POWER FACTOR MANAGEMENT IN MARBLE INDUSTRY

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Abstract-Indian industry is paying one of the highest power tariffs in the world. This will get worse due to dependence on imported fuel, escalation in fuel prices and depreciation of Indian rupee. Also the gap between supply and demand is expanding leading to poor and lower quantity of power resulting in loss of production and profits. Recent advancements for higher power generation, lesser transmission and distribution cost and saving of energy can benefit significantly by improving the power system through energy efficiency at all levels. India has witnessed a phenomenal growth of industrial and IT establishment in recent past. The growth has resulted into increased level of power demand due to large usage of induction motor and drives (lagging loads) and non-linear loads. Thus electrical power system slowly started getting corrupted by introducing low power factor problems in the system. This clearly indicates that there is large need of electrical energy saving.

A survey conducted in the Udaipur district of Rajasthan (India) revealed the poor condition of power quality in large number of marble, soft stone and mineral industries .Motivated by the outcome of the survey, the investigator adopted one marble industry for investigating the power quality. The measurements in Arihant Marble industry, Udaipur showed that the average monthly power factor of the plant was maintained at 0.75. Automatic power factor controller (APFC) was designed at Hercules Controls Panel Pvt. Ltd., Udaipur (India) and commissioned at Arihant Marble Industry, Udaipur (India). The measurements were again carried out. It was found that the average monthly power factor of the plant was maintained at 0.95.The results have been also show considerable the kVA saving and energy bill reduction/month. The application of proposed APFC thus showed many fold improvements in the power system.

Key words – Power Factor Management, APFC, Marble Industry, Payback period.

I INTRODUCTION

Indian industry paid the highest power tariffs in the world due to the poor quality and lack of power generation, transmission and distribution management. The gap between supply and demand is expanding that leading to resulting in loss of production and profits [2]. There is very less awareness in India regarding low power factor and harmonic pollution. Traditionally, more emphasis was given on the solutions to improve the power factor. The incentive schemes and imposition of penalty for maintaining the PF by Electricity Board's has drawn user's attention toward the PF improvement. Thus there is large need of energy saving in electrical systems i.e. there is need to improve system power factor for several different benefits like lower utility fees by reducing peak kW billing demand and eliminating the power factor penalty, increased system capacity and reduced system losses in electrical system and increased voltage level in electrical system and cooler, more efficient motors.

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II POWER FACTOR

Power factor directly reflects how efficiently industries/organizations use electricity. Power factor compares the amount of useful electrical energy with the total amount of electrical energy supplied. It is expressed as the ratio of the actual power to the apparent power. It is also defined as the cosine of the angle between the supply voltages

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and the resulting current. As the angle gets larger (caused by increasing reactive power) the power factor gets smaller. The power factor can vary from zero to unity and can be either inductive (lagging) or capacitive (leading) in nature.

$$Cos\emptyset = \frac{Apparent\ Power}{Active\ Power} = \frac{kW}{kVA} ----- (1)$$

kW is the Working Power (also called Actual Power or Active Power or Real Power).It is the power that actually powers the equipment and performs the useful work.
kVAR is the Reactive Power. It is the power that the magnetic equipment (transformer, motor, relay etc.) needs to produce the magnetizing flux.
kVA is the Apparent Power. It is the "vectorial sum" of kVAR and kW.

III ENERGY SAVING TECHNIQUES

In the areas for improvement in electrical systems resulting in energy conservation/saving are:

(i) **Power factor management**
(ii) Demand side management
(iii) Improvement in quality of power (Reduction in harmonics)

IV POWER FACTOR IMPROVEMENT TECHNIQUES AND EQUIPMENTS

Normally the power factor of the whole load on a small and large industrial/commercial region is in the range of 0.4 to 0.8 due to large inductive (lagging) loads. This range is sometimes very low and in such cases it is desired to take special steps to improve the power factor. This can be achieved by following equipments:

(i) Static Capacitors.
(ii) Synchronous Condenser.
(iii) Phase Advancers
(iv) Automatic Power factor Controller.

In which recent trends are used Automatic Controller thus investigator concerns only automatic (intelligent) power factor controller in this paper.

Fig.1 shows the flow of power without and with power factor correction.

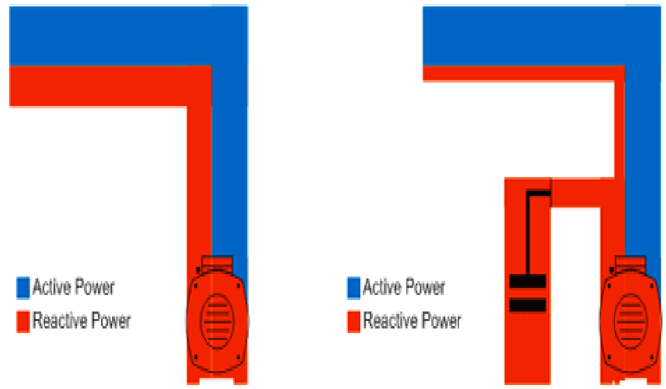

Fig.1 Flow of Power without and with Power Factor Corrections

V AUTOMATIC POWER FACTOR CONTROLLER DESIGN

This system is specially suited for high fluctuating loads. Switching of capacitors is done through relays/thyristor. This system reduces kVA demand which in turn reduces electricity bill costs & provides payback in investment leading to cost effectiveness of inputs [2]. APFC can be designed for any required specification. Fig.2 shows the Automatic power factor controller.

Fig.2- Metal Case Automatic Power Factor Controller

In this paper investigator did a survey about the power factor condition and power quality in Arihant

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Marble Pvt. Ltd industry at Udaipur, Rajasthan (India).

Step-1 Measurement of Electrical Data at Marble Industry

In Arihant marble plant the investigator collected the electrical data from electricity bill, electrical log book and discussion with electrical supervisor using digital voltmeter, ammeter, clamp meter and power factor meter in power room of plant and is tabulated in Table-1.

Table.1

Electrical parameters measured at the marble plant

Sr.No	Parameters	Minimum Value	Maximum Value
1	Load Range (Hp)	38	57
2	Load Range (kW)	28.348	42.522
3	Power Factor	0.76	0.84
4	Load (kVA)	34.435	50.62
5	Existing Number of Capacitors	0	0
6	Additional kVAR Recommended	16.88	20.21
7	Expected Power Factor	0.99	0.99

Step-2 Calculation of Capacitor for Power Factor Improvement (kVAR)

The calculation for the capacitor value has been done as below, where the maximum demand of load range is taken from Table 1

Maximum demand = 57 Hp

The value of the capacitor in terms of kVAR can be calculated by Thumb rule. Thumb rule gives the kVAR value by taking 1/3 rd of the total maximum demand used by plant.

kVAR by thumb rule =1/3rd of Hp

= (1/3) x 57Hp

= 19kVAR

= Say **20 kVAR**

(For fine control always use extra 5% capacitor) and then Capacitor divided into sectors of capacitors

=1kVAR+2kVAR+3kVAR + 5kVAR +10kVAR

= 20kVAR.

Step-3 Designing and installation of APFC Panel

After design and fabrication of APFC at Hercules Panels Pvt. Ltd. Udaipur, Rajasthan (India). Complete APFC panel was installed at Arihant Marble plant on 1July2012. Fig.3 shows the designed and commissioned APFC at Arihant Marble Industry.

Fig.3- Designed and Commissioned APFC at Arihant Marble Industry

The electrical data were measured on same day before install the panel. After one month on 30 July 2012 again investigator measured all the electrical data from APFC panels.Reading before and after installingthe APFC panel are tabulated as inTable 2.

Table.2: Electrical data before and after installing the APFC panel

S.No.	Parameters	Values Without APFC on 1July 2012	Values With APFC on 30July 2012
1	Maximum load demand	57 Hp	57Hp
2	Maximum load	42.522 kW	42.522 kW
3	Maximum load current	74.82Amp	62.26 Amp
4	Frequency	49.6 Hz	49.8 Hz
5	Voltage (phase R)	242.0 V	248.0 V
6	Voltage (phase Y)	238.6 V	244.2 V
7	Voltage (phase B)	242.5 V	236.2 V
8	Line current (phase R)	20.10 A	15.9 A
9	Line current (phase Y)	14.7 A	11.7 A
10	Line current (phase B)	40.73 A	33.2 A
11	Monthly average pf	0.79	0.95
12	C.T Ratio	50/5	50/5
13	kVAh	0	28520.2
14	kWh	0	24574.8

Step-4 Results for Power Factor Improvement
Various APFC panel data are tabulated in Table.2.

a) Penalty on low pf

In Rajasthan (India) if pf is less than 0.90, penalty levied is as follows: Low pf penalty
= (kWh x Rs.3.5) x difference in pf ------------ (2)
In case of an Arihant marble customer the details were as follows:
Number of units consumed in the month of July 2012 = 24574 kWh
Average monthly pf maintained
= 0.79 lag
Above two values are obtained from Table 1, where the value of number of units consumed per month and the average monthly pf is without APFC.

- In Arihant marble for 39.9898 kW load they are using an extra 8.08 kVA

Since, the pf was below 0.9, penalty was levied from according to equation (2)
Penalty imposed = (24574x3.5) x (0.95-0.79)
= Rs.13762/-

b) Calculation of kVA at 0.79 and 0.99 PF

- kVA utilized for loading at 0.79 PF from table 2
  = 50.62 kVA (max) x 0.79
  = 39.9898 kW
- kVA utilized for loading after pf correction to 0.99 pf
  = 50.62 kVA (max) x 0.95
  = 48.07 kW
- As per Electricity Board norms in north India the charges for kVA is Rs.300/-

Therefore monthly saving on kVA (if pf maintained at 0.99) will be = 8.08 x 300/-
= Rs.2424/-

c) Calculation of PF Incentive

•The incentive for if maintained above 0.95 for every 0.01 improvement there is a 1% reduction on the kWh.

•If the ARIHANT marble PF is maintained at 0.99 then the reduction in bill will be
= 0.99-0.95
= 0.04
= 4%
= 4% of 24574 units
= Rs. 982/-

d) Pay back Calculation

•Total saving achieved by using IPFC
= Penalty on low pf + Monthly saving on kVA + pf incentive ------------------------- (3)
= Rs 13761.44+Rs.2424+Rs.982
= Rs16167.44/-

•Total investment on APFC panel that is paid by Arihant marble industry to HerculesControl Panel Ltd = Rs. 56282.00/-

•Payback period: Less than 4 months

VI CONCLUSION

From installation of APFC panel at Arihant Marble Industry following conclusions were made:

i) Overall average monthly PF improved from 0.79 to 0.95 and obtained incentive from Electricity Boards

ii) Overall kVA utilization is improved from 39.98 kVA to 48.07 kVA and can increase the load upto 8.08 kVA without increasing the transformer kVA.

iii) Their monthly saving is around Rs.16167/- by APFC panel and payback period was 4 month.

iv) The overall efficiency of the plant increases and overall maintenance cost of plant reduces.

v) Generator and transformer heating issues were resolved.

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REFERENCES

[1] Govindan K.R., “Power factor improvement”, Energy and Fuel user’s Journal, association of India, 1-4, 2002.

[2] Mukund Bapat, “Power Factor Improvement and Energy Conservation through Use of Intelligent Power Factor Controller”, Water and Energy Abstracts, Indian journals, Vol. 18, 2008.

[3] Shwedhi M.H., Sultan M.R., “Power Factor Correction Capacitors; Essentials and Cautions”, Power Engineering Society Summer Meeting, IEEE, Vol. 3, pp 1317-1322, 16-20, 2000.

[4] Aware M.V., Kothari A.G. and Bhatt S.S., “Power Factor Improvement Using Active Filter for Unbalanced Three-Phase Non-Linear Loads” International Journal on Energy Technology and Policy, Vol. 4, pp 103-117,2006.

[5] Abhijit D. Pathak, Ralph E. Locher, Himanshu S. Mazumdar, “3-Phase Power Factor Correction, Using Vienna Rectifier Approach and Modular Construction for Improved Overall Performance, Efficiency and Reliability” Proceedings of Power Electronics Conference in Long Beach, CA,2003.

[6] S. Khanmohammadi, M. Tarafdar Hagh, M. Abapour, “ Fuzzy Logic Based SVC for Reactive Power Compensation and Power Factor Correction” Proceedings of 8th International Power Engineering Conference, pp 1241-1246,2007.

[7] Klaus Raggl, Thomas Nussbaumer, Gregor Doerig, Juergen Biela, and Johann W. Kolar, “Comprehensive Design and Optimization of a High-Power-Density Single-Phase Boost PFC” IEEE Transactions On Industrial Electronics, Vol. 56, No. 7, pp 2574- 2587, July 2009.

[8] Marlar Thein Oo and Ei Ei Cho, “Improvement of Power Factor for Industrial Plant with Automatic Capacitor Bank” Proceedings Of World Academy Of Science, Engineering And Technology, Volume 32, pp-695-701, August 2008.

[9] M.V. Aware, A.G. Kothari and S.S. Bhat, “Power factor improvement using active filter for unbalanced three-phase non-linear loads” proceeding of International Journal Energy Technology and Policy, ,Vol. 4, Nos. 1/2, pp 103-117, 2006.

[10] Taufik, A. Hernadi, R. Rudianto, M. Anwari, “Performance Study of Power Factor Correction Circuits”, Proceedings of the International Conference on Electrical Engineering and Informatics Institut Teknologi Bandung, Indonesia, pp 419-422, June 17-19, 2007.

[11] K.D. Gusseme, D.M. Van de Sype, A.P.M. Van den Bossche, and J.A. Melkebeek, “Digitally controlled boost power-factor-correction converters operating in both continuous and discontinuous conductionmode,” IEEE Transactions on Industrial Electronics, Vol. 52, Issue 1, pp.88 – 97, Feb. 2005.

[12] K. Matsui, I. Yamamoto, T. Kishi, M. Hasegawa, H. Mori, and F. Ueda, “A comparison of various buck-boost converters and their application to PFC,” Proceeding of IEEE 28th Annual Conference on Industrial Electronics Society, Vol. 1, pp. 30 – 36, Nov. 2002.

[13] K. Sangsun and P.N. Enjeti, “A parallel-connected single phase power factor correction approach with improved efficiency,” Proceeding of 17th Annual IEEE Applied Power Electronics Conference and Exposition,Vol. 1, pp. 263 – 269, March 2002.

[14] T. Tanitteerapan and S. Mori, “Soft-switching boost power factor correction converter with negative slope ramp carrier control,” Proceeding of International Symposium on Circuits and Systems, Vol. 3, pp. III-272–III 275, May 2003.

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