ECONOMY THROUGH ENERGY MANAGEMENT

Vijayant Sharma

Dept. of Electrical Engg., Vaishno College of Engg. (Hp)

***Abstract*—** This paper provides an overview of energy management measures that can be commonly recommended for an industrial facility. The combination of high electricity prices, limited generation capabilities and the economic situation requires case to case study to improve overall efficiency. In addition to using energy saving appliances

***Keywords*—** Diversity factor, power factor capacitor banks

I. INTRODUCTION

Energy management in industry in India at present is one of the most taxing problems because there is difference of about 25% in its demand and supply. Therefore the efficient use of electricity by the end users will have a multiplying effect in the saving of national economy [2, 3]. As major areas of use of electricity in modern industries are lighting, air conditioning, electrical motors etc. [1]. In order to efficiently manage electricity in the above categories, electrical energy management opportunities in these fields have been discussed in details [6, 7]. One of the most important aspects of energy management programme is electrical load analysis [5, 8]. The important parameters of electrical load analysis such as connected load, diversity factor, power factor, importance of reactive compensation using capacitor banks, capacitors for reactive compensation etc have also been taken into considerations [4]. In this paper, energy auditing of nitric acid plant is done.

II. PLANT LAYOUT

The total load of the plant is 1950KW. Where 1855 KW of machine load and 18 KW of light and other type of load as shown in Table 1.The segmental view of load distribution of industry is as shown in Fig. 1.

Table 1: Category wise load of various plants

Sr. No.	Category of load	Load in kW	Percentage value
1	Filtration plant	312	16
2	Vaporization plant	137	7
3	Cooling and absorption plant	351	18
4	Bleaching plant	332	17
5	Water treatment and workshop plant	429	22
6	Ammonia plant	195	10
7	Compression plant	175	9
8	Miscellaneous load	100	5

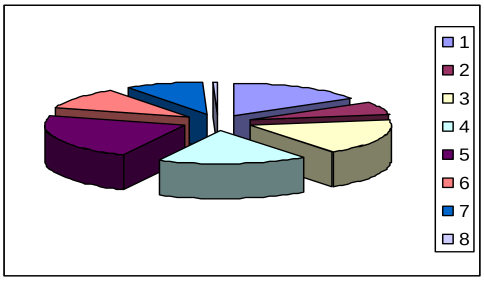
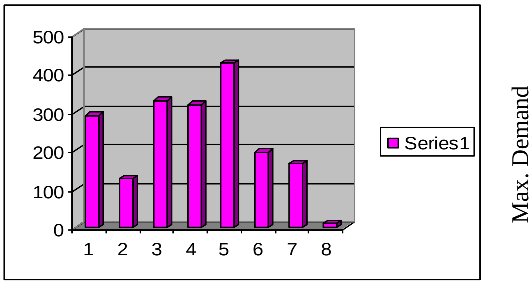


FIG. 1: SEGMENTAL VIEW OF LOAD DISTRIBUTION OF INDUSTRY IN PERCENTAGE AS PER TABLE 1

Maximum Demand of different sections is as shown in Fig. 2:



Sections of plant

Fig. 2: Maximum demand of different load

The bar chart for different loads as for the sections (1) 295 KW, (2) 127 KW, (3) 327 KW, (4) 318 KW, (5) 427 KW , (6) 192 KW , (7) 166 KW, (8) 10 KW (varies in 24 hours).

Miscellaneous load includes light fan AC which varies time to time Maximum and minimum demand of these load is as follows

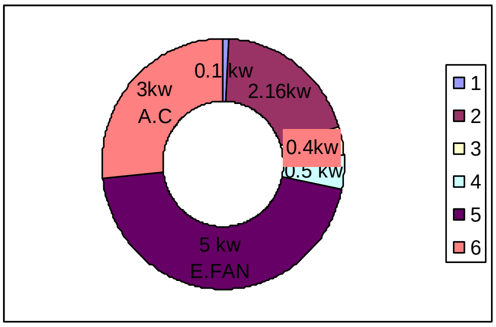


Fig. 3: Miscellaneous load

Section one to compressor remains fixed for 24 hours but the light and other load varies in 24 hours. Energy auditing can be done by replacing florescent tubes by CFL lamps , by installing capacitor bank , by installing voltage stabilizers, by reducing load up to the required level, Halogens (spot lights) are replaced with infra read coating halogens ,Replacement of the magnetic ballast from electronic ballast etc. The energy can also be saved by installing capacitor bank near to the load. By this measure reactive current will be reduced and thus energy loss can be reduced. By installing capacitor the paper browses on installing capacitor bank on machine under three schemes as follows.

III. PROBLEM FORMULATION

From technical considerations it is always desirable to improve the P.F. of an installation to unity. For the given load, improvement in P.F. would reduce maximum KVA demand and hence the fixed charges. This saving however can be effected by the installation of P.F.. improvement plant, which requires annual expenditure. Consumer will therefore improve P.F. . to that value for which he is able to get maximum saving in annual expenditure. For this three different locations are analysed (scheme I, II and III) for the placement of capacitor banks and to get most economical P.F.

a) Calculation: Let a consumer is supplied load P at P.F.. $\cos\varphi_1$ with maximum KVA demand S_1. Let it is improved to $\cos\varphi_2$ with max KVA demand S_2. If consumer is to pay maximum demand charge of Rs A/KVA per annum, then the annual savings affected by his P.F. Improvement plant

$$=A\ (S_1 - S_2) \qquad (1)$$
$$= A\ \ [P/\cos\emptyset_1 - P/\cos\emptyset_2] \qquad (2)$$

Reactive KVA rating of . P.F. improvement plant is given by

$$RKVA = P\left(\tan\emptyset_1 - \tan\emptyset_2\right) \qquad (3)$$

P.F. improvement plant costs Rs B/KVA/Annum then annual expenditure on P.F.. improvement

$$Plant = BP\ (\tan\emptyset_1 - \tan\emptyset_2) \qquad (4)$$
$$For\ Maximum\ saving = ds/d\varphi_2 = 0$$
$$Net\ annual\ savings\ (S) = AP\ \left[\frac{1}{\cos\emptyset_1} - \frac{1}{\cos\emptyset_2}\right]$$
$$BP\ (\tan\emptyset_1 - \tan\emptyset_2)$$
$$Ds/d\varphi_2 = -AP\sec\emptyset_2 \, Tan\emptyset_2 + BPsec^2\,\emptyset_2 = 0 \qquad (5)$$

Or $AP\sec\emptyset_2\, Tan\emptyset_2 = BPsec^2\emptyset_2$

Or

$$\frac{A\sin\emptyset_2}{\cos^2\emptyset_2} = \frac{B}{\cos^2\emptyset_2} \qquad (6)$$

$$\sin\varphi_2 = \frac{B}{A} = \frac{\text{Annual expenditure per KVA of phase Advancing plant}}{\text{Annual fixed charges per KVA of max Demand}}$$

b) Methodology: The following methodology has been adopted:

For this different three locations for the capacitor bank have been selected.

(i) At LT panel (ii) at distribution board (iii) at the load

For Scheme I Total Cost = 1, 97, 000+35.89xTx cost per unit of energy

For Scheme II Total Cost = 2, 41,500+27.97xTx Cost per unit of energy

For Scheme III Total Cost=4, 35,000+16.011xTx Cost per Unit of energy

i) Study of technical and economical aspects has been be done

ii) Comparison has been be done between the three schemes

iii) Break even analysis has to be done and optimum location has to be selected

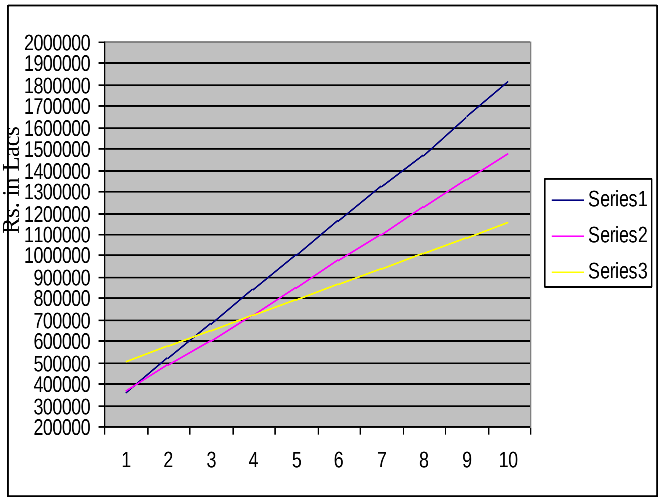
c) Comparison: Following are the comparison done of three schemes of installing capacitor bank.

Table 2: Comparison of installation cost and energy saved in the three schemes

1)	Scheme I	Scheme II	Scheme III
Installation Cost	1,97,000/-	2,41,500/-	4,35,000/-
Distribution Losses (in kW)	35.89	27.971	16.011
Energy lost in day (24 Hours in units	861.36	669.6	384.26
Energy lost in a Month(in units)	25840.8	20088	11527.8
Cost of energy wasted in a month (@ Rs 4.50/ unit in Rs.)	116283.6	90396	51875.1
Cost of energy lost in one year	1395403.2	1084752	622501.2

Amount of money saved in one year if scheme II is adopted as compared to scheme I= Rs. 310651.2
Amount of money spent in excess of scheme I if scheme II is adopted = Rs. 44, 500/-
If scheme III is adopted, amount of money spent on installation in excess of scheme II is 1, 93,500/-

Amount of money saved in one year due reduction in losses = Rs. 4, 62,250.8



Time in hrs x 1000
Fig. 4: Break Even Analysis

Total cost= Installation cost + Cost of energy lost

= Installation cost + Power lost x Operating hours x Cost of one Unit of Energy . Where T represents total operating hours of plant Total costs (Installation + Cost of energy) for different working hours for the three schemes have tabulated as below:

Table 3: Total cost for different working hours for three schemes

Working Hours	Scheme I 1,97,000+35.89 xTxCost of electricity per unit	Scheme II 2,41,500+27.97x Tx cost of electricity per unit	Scheme III 4,35,000+16.011xTx cost of electricity per unit
1000	358505	367365	507045
2000	520010	493230	579090
3000	681515	600150	651135
4000	843020	725700	723180
5000	1004525	851250	795225
6000	1166030	976800	867270

IV RESULTS AND DISCUSSIONS

Scheme1

Cost of installing capacitor bank of 790 KVAR at LT panel = Rs. 1, 97,000/-

Scheme 2

Total cost of installing capacitor banks in scheme II= Rs. 2, 41,500/

Scheme 3

Total cost in scheme III=Rs. 4, 35, 000/

Amount of money saved in one year if scheme II is adopted as compared to scheme I
= Rs. 3, 10,651.2/-

Amount of money spent in excess of scheme I if scheme II is adopted = Rs. 44, 500/-

If scheme III is adopted, amount of money spent on installation in excess of scheme II is 1, 93,500/-

Amount of money saved in one year due to reduction in losses = Rs. 4, 62, 250.80/-

Amount of money saved in one year if scheme II is adopted as compared to scheme I
= Rs. 3, 10,651.2

Therefore the additional expenses occurred in construction of central panels for connecting capacitor banks at the load points are recoverable in a period, which is less than one year.

Break even Analysis when the scheme II and III are compared with scheme I, shows that cost of scheme II equalized with cost of scheme I after 2000 working hours, after which the cost in scheme II is less, which shows, that if working life of the plant is more than 2000 hours, the scheme II will be beneficial. The cost of scheme III equalizes with the cost of scheme I between 3000 to 4000 working hour after which scheme III costs less, therefore if the operating life of the plant is more than 4000 working hours, scheme III will be beneficial over scheme I.

When scheme II is compared with scheme III, It is found that the costs of the two equalizes at between 4000 to 5000 hour of operation after which the operating costs of scheme III will be less than that of scheme II. Therefore scheme III must be followed for the plant if its working life is more than 5000 hours.

V CONCLUSIONS

Energy saving by connecting Power factor improvement equipment near to load instead of connecting at LT Panel

- In scheme I distribution losses are 35.89 kW
- In scheme II distribution losses are 27.971 kW
- In scheme III distribution losses are 16.011 kW
- So if one will adapt the method used in Scheme II instead of method used in Scheme I, one can save 7.919 kW.
- And if one will adapt the method used in Scheme III, instead of method used in Scheme I, one can save 19.879 kW.
- As power run on 24 hour basis, total unit of energy saved in one year are 19.879 x 24 x 365 = 174131.28 KWH
- If cost of energy is Rs. 4.5 per unit, it will save Rs. 783463.50 annually.

Total Industrial load in India at present is 80,000 MW which will rise to 100,000 MW by the end of this century. If 2% of energy is saved by following the Principles discussed 2% saving in energy would mean saving of 2000 MW of Power, the cost of which comes out to be Rs. 90,00,000.00 Lacs. So it is concluded that in addition to using energy saving appliances if capacitor bank has to be installed at proper location then optimum economy energy efficiency can be achieved.

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