

A Paper on Power Factor Improvement

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ABSTRACT: *There are different ways in which the efficiency of the system is improved and the cost of the system is decreased. Here in this paper to decrease the losses and to improve the efficiency of the system, power factor calculation analyzed. Power factor plays an important role to improve the power system generation, transmission and distribution. There are different ways in which the power factor has been improved. There are different benefits of the improvement of the power factor. Here in this research paper capacitor is used for the improvement of the power factor. The rating of the capacitor has been calculated and analyzed and the power factor of different equipment has been calculated and analyses. The calculation has been done before and after the improvement of power factor by using a capacitor and it is found that after adding the capacitor, the power factor of the system is improved and analyzed the capacitor value for this system is 7000 μ F. The cost of the system is also calculated.*

KEYWORDS: *Apparent power, Capacitor, Power factor (Pf), Reactive power, Efficiency, Corrections.*

INTRODUCTION

The ratio of active power to the apparent power is called the power factor. It is represented by $\cos\phi$. The value of power factor should not be more than one. Power factor is also the ratio which measures the effective electricity [1]. The value of power factor should not be more than one. In ideal case the value of power factor is one but the desired value of power factor is between 0.95 to 0.99.

The benefits of high factors are as follows:

- The cost of equipment decrease.
- The value of current decreases.
- The losses of system decrease.
- The efficiency of the system gets improved.
- Voltage regulation improves.

1. Relation between power factor and efficiency

The power factor and the efficiency of the system are directly proportional to each other. As the power factor of the system is near unity, the output of the system will be maximum so, the efficiency of the system will improve [2]. Similarly, if the power factor is less, the output of the system will decrease and the efficiency of the system will decrease.

2. Efficiency is important in power generation

The power generation is done in “kWh” fuel is used to generate the power, which is used as input to the system. In small input to the system, the output is more so the system cost will decrease and efficiency of the system will increase [3].

3. How to improve power factor

Power factor plays big role in generating the electricity. There are different ways in which the power factor improves. The most important device used to improve the power factor is capacitor bank, in which different combination of capacitor used to improve the power factor. By adding capacitor, the reactive power will increase [4]. So the angle between the real power and the apparent power will decrease and $\cos\phi$ will increase, where $\cos\phi$ represents power factor.

4. Lead- lag point

The lead and lag of the power factor depends upon the lead and lag angle of current and voltage. If current lead the voltage, then it is leading angle. If the current lag the voltage, then it is lagging angle [5]. Current leads the voltage when capacitor is used in the system. The use of capacitor bank depends upon the system.

5. Power triangle explain with diagram

Power triangle includes three power are Real power, Reactive power and Apparent power. The power triangle is shown in Figure 1 where the horizontal part of power triangle is real power, the vertical part of the power triangle is reactive power and square root of real power and apparent power is apparent power [6]. Where angle between the real power and apparent power represents the power angle.

6. Role of capacitor to improve power factor

The capacitor is used in system with different forms. It can be used as single capacitor or as a capacitor bank. If capacitor is connected to the system, reactive power gets increases, due to an increase in reactive power, the power angle between the real power and apparent power decreases, so the power factor $\cos\phi$ increases [7].

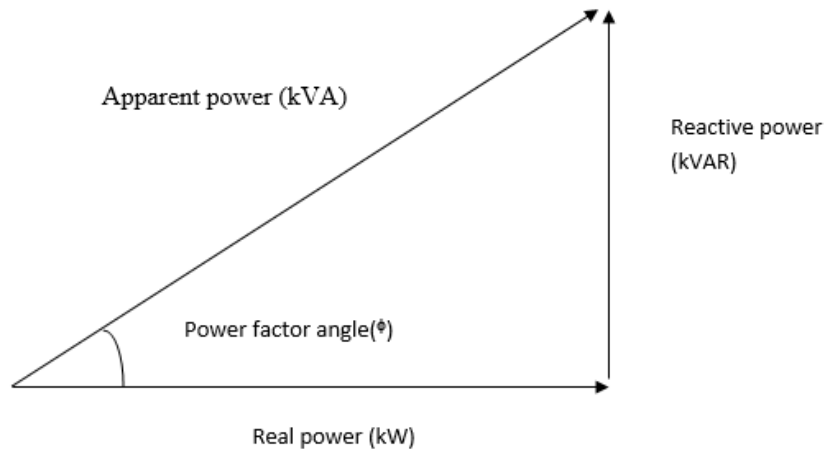


Figure 1: Power triangle for power factor angle ‘ Φ ’

Research Questions

- Why the improvement of power factor is important?
- What is the role of a capacitor in improving power factor?

LITERATURE REVIEW

There are different researches related to “Improvement of power factor” In which the following are some description:

As in “Study of power factor correction techniques” author Sanjay L. Kurkute et.al analyzed the power factor by using different techniques like PLC, FPGA etc. to get better power factor.

As in “A review paper on automatic power factor correction.” Author Saurabh kumar sharma et.al analyzed the power factor in this research paper where analysis has been done with software and theoretically by taking a circuit into consideration [8].

As in “Research and simulation of active power factor correction” author Wang su et.al analyzed the control method and fundamental study for active power factor correction. Matlab and Simulation is also used for the analysis purpose in this research paper.

As in “Modelling and Simulation of power factor corrected AC-DC converters” author Ashish Pandey et.al presented the introduction of power electronics. This research paper contains deep learning of converters and its performance on power factor correction techniques has been modelled and simulated [9].

METHODOLOGY

1. Design:

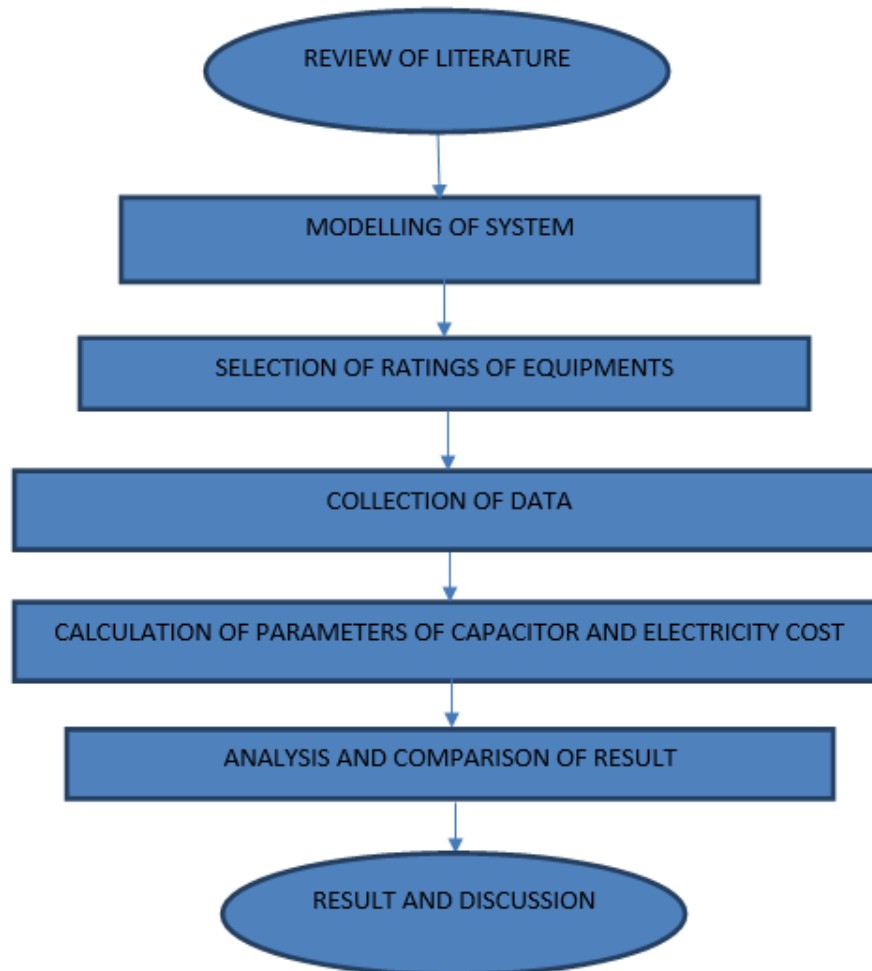


Figure: 2 Methodology

The methodology of power factor improvement is shown in figure 2.

2. Sample:

The instruments used in this research are at rated calculated value, according to the calculation of capacitor for improvement of power factor. Above the rating, equipment may burn. Some measuring instruments are also used for this experimental research.

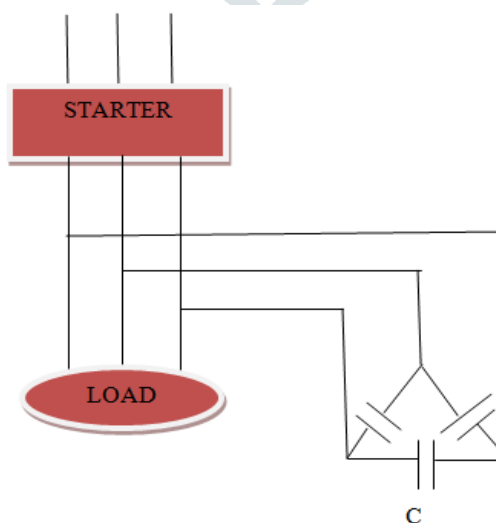


Figure 3: Connection of combination capacitor

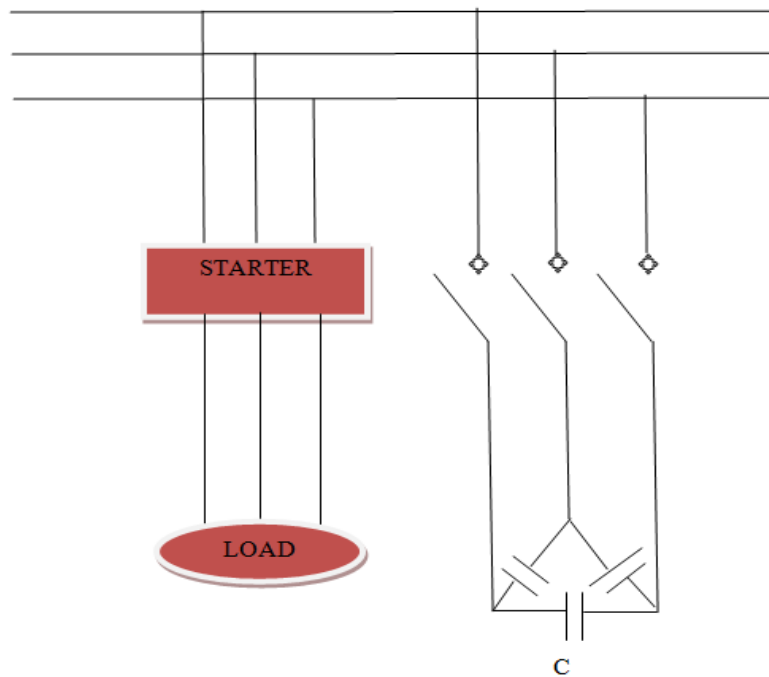


Figure 4: Connection of combination of capacitor

3. Instrument:

In this Research, the main role is of capacitor in the system to improve the power factor. Other than capacitor used for improvement of power factor other equipments are also used like capacitor in different combination, starter and Motor is used as a load [10]. Input is connected to grid side and relay and circuit breaker used to protect other equipment from the fault.

4. Data Collection and Analysis:

For the analysis of improvement of power factor two circuit diagrams are taken into consideration. Figure 3 shows the combination of capacitor connected with the circuit and Figure 4, shows the different combination of capacitor with the circuit.

Table 1: Data collection

Sl. No.	Types of Equipments	kVA	kW	kVAR	Actual pf	Current	Time(hr)
1.	A1	784.7	565	544.5	0.72	670.79	7
2.	B1	982.35	668	720.2	0.68	691.01	8
3.	C1	1116.1	692	875.6	0.62	601.07	6
4.	D1	1173.4	751	901.0	0.64	104.15	6
5.	E1	1171.6	785	869.7	0.67	167.07	8
6.	F1	1620.6	940	1320.2	0.58	419.36	7

Table 2: Data collection

Sl. No.	Types of Equipments	kVA	kW	kVAR	Desired kVAR	Desired pf	Current	Time (hr)
1.	A1	588.54	565	164.6	379.9	0.96	550	7
2.	B1	695.8	668	194.7	525.5	0.96	543	8
3.	C1	720.8	692	201.7	673.9	0.96	563	6
4.	D1	782.2	751	218.7	651	0.96	591	6
5.	E1	817.7	785	228.9	640.8	0.96	604	8
6.	F1	979.1	940	273.9	1046.3	0.96	713	7

Table 1 and Table 2 shows the data collection which is collected by the different sources. According to the desired value of reactive power, capacitor is used. To find the value of capacitor to fulfil the requirement of reactive power voltage is considered as 415V.

$$\text{Capacitor} = \frac{\text{Reactive power}}{w \times V \times V}$$

$$\text{Capacitor (A1)} = \frac{126.6 \times 1000}{314.1 \times 415 \times 415} = 2340 \mu \text{ F}$$

$$\text{Capacitor (B1)} = \frac{175.1 \times 1000}{314.1 \times 415 \times 415} = 3236 \mu \text{ F}$$

$$\text{Capacitor (C1)} = \frac{224.6 \times 1000}{314.1 \times 415 \times 415} = 4152 \mu \text{ F}$$

$$\text{Capacitor (D1)} = \frac{217 \times 1000}{314.1 \times 415 \times 415} = 4011 \mu \text{ F}$$

$$\text{Capacitor (E1)} = \frac{213.6 \times 1000}{314.1 \times 415 \times 415} = 3948 \mu \text{ F}$$

$$\text{Capacitor (F1)} = \frac{348.76 \times 1000}{314.1 \times 415 \times 415} = 6447 \mu \text{ F}$$

5. Calculation of Electricity:

Electricity using equipments = kW × hr (Hour)

Sl. No.	Types of Equipments	kW	hr	kWh	Energy price	Total cost
1	A1	565	7	3955	9rps/unit	35595/-
2	B1	668	8	5344	9rps/unit	48096/-
3	C1	692	6	4152	9rps/unit	37368/-
4	D1	751	6	4506	9rps/unit	40554/-
5	E1	785	8	6280	9rps/unit	56520/-
6	F1	940	7	6580	9rps/unit	59220/-

RESULTS & DISCUSSION

Analysis has been done by considering the different pieces of equipment and the active power, reactive power and apparent power has been calculated for the same types of equipment where for the analysis of the system two power factors are considered. One is taken as the actual power factor and the other is the desired power factor. The data has been collected from different sources. By analysis of the system at different power factor, different values of reactive power achieved, which is very useful for operating any system. The value of a capacitor is calculated for reactive power improvement. It is found by calculation that for this system 7000μF capacitor will be suitable. And the cost of the generation of this system is also calculated.

CONCLUSION

This research analyzed by the designing system and calculation approaches. From the above research, it is found the calculation of capacitor has been done by taking different values of power from the collected data, input voltage considered as 415V with 50Hz frequency. After calculation of the capacitor, it is analyzed that the selected rating of capacitor for improvement of power factor of this system is 7000μF. According to energy improved, the cost of electricity has been calculated.

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