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Design, Manufacturing and Testing of Capacitor Bank for Power Factor Improvements

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ABSTRACT

Now days, increasing the need of electricity hence we required a different types of capacitors. In a power system along with constant power it is important to maintain the quality of power electronics devices for industrial, commercial and residential application with increasing non-linear load. Usually the electrical power supply companies impose a penalty, if the average power factor over a stipulated period falls below a certain value. A large part of load of bulk consumers are inductive in nature because of use of induction motors. This causes low power factor (lagging because of predominately inductive loads). Capacitors, on the other hand, constitute leading power factor load; thus compensating a major part of the inductive loads and result in power factor close to unity but still lagging in nature. This improvement of power factor fulfills the requirements of the utility. The main purpose of providing capacitor bank in case of power system is to supply reactive power to the system and they are installed at the receiver end, this is also called as VAR Compensation. The capacitor banks are called Static VAR Compensator.

I. INTRODUCTION

Now a days, increasing the need of electricity hence we required a different types of capacitors. In a power system along with constant power it is important to maintain the quality of power electronics devices for industrial, commercial and residential application hence increasing the non-linear load. Hence due to non-linear load decreases the power quality. This reduces the efficiency of power and results into financial losses. In current situation more than 90% of load is inductive. That's why power factor is lagging then by using the capacitor bank we can make power factor near to unity.

Capacitors are electronic components that store, filter and regulate electrical energy and current flow and are one of the essential passive component used in circuit board. Capacitors are primary used for storing electrical charges, conducting alternative currents (AC) and blocking or separating different voltages levels of direct current(DC) source.

A capacitor is a passive two terminals electrical component that store potential energy in an electrical field. The effect of capacitors is known as capacitance. While some capacitance exists between any two electrical conductors in proximity in a circuit, a capacitor is a component designed to add capacitance to a circuit. The capacitors were originally known as a conductance or compensator.

Figure 1. Capacitor banks for PF correction

The physical form and construction of practical capacitors vary widely and many capacitors types are in common use. Most capacitors contain at least two electrical conductors often in the form of metallic plates or surface separated by a dielectric medium. A conductor may be a foil, thin film, sintered bead of metal, or an electrode. The non conducting dielectrics act to increases the capacitors charge capacity. Materials commonly used as dielectrics include glass, ceramic, plastic film, mica and oxide layers. Capacitors are widely used as parts of electrical circuits in many common electrical devices.

Capacitor is defines as the ratio of the electric charge on each conductor to the potential different between them. The unit of capacitance in the International System of Units (SI) is the Farad (F), defines as one coulomb per volt (1C/V). The capacitance of a capacitor is proportional to the surface area of the plates (conductor) and inversely reduced to the gap between them. In practice, the dielectrics between the plates passes a small amount of leakage current. It has an electric field strength limits, known as the breakdown strength.

Film capacitors consists of two metal foil electrodes made of aluminium foil separated by a piece of plastic film. The plastic film is made by alternating two pieces of aluminium foil with two layers of plastic film. These interleaved layers are wound around a spindle in a manner that prevents the metal layers from touching. Film capacitors can wound in two different ways- inductive an non inductive.

II. IMPORTANT PARAMETERS FOR DESIGNING OF CAPACITORS

1) Nominal capacitance (C) :

The nominal value of the capacitance of a capacitors is the most important of all the capacitor characteristics. This value measured in pico farad, nano farad. Smaller capacitors can have a nominal value as low as one pico farad, while larger electrolytic can have a nominal capacitance value of up to one farad. All capacitors have a tolerance rating from -20% to as high as +80% for aluminium electrolytic affecting its actual or real value.

2) Working voltage :

The working voltage is another important capacitor characteristic that defines the maximum continuous voltage either DC or AC that can be applied to the capacitor without to the capacitors without failure during its working life. DC and AC voltage value are usually not the same for a capacitor as the AC voltage value refer to the rms value and not the maximum or peak value which is 1.414 times greater. The specified DC working voltage is valid within a certain temperature range, normally -30^{0}C to +70^{0}C.

3) Tolerance :

The tolerance value is the extent to which the actual capacitance is allowed to vary from its nominal value can range anywhere from -20% to –
80%. Thus a 100 micro farad capacitors with $\pm$20% tolerance could legitimately vary from 80 micro farad to 120 micro farad and still remain within tolerance. The most common tolerance variation for capacitors is

5% or 10% but some plastic capacitors are rated as low as +1%.

4) Leakage current :

Capacitor leakage current is an important parameter in amplifier coupling circuits or in power supply circuits. Electrolyte type capacitors on the other hand may have very high capacitors, but they also have a high leakage current due to their poor isolation resistance, and are therefore not suited for storage or coupling application. Also,the flow of leakage current for aluminium electrolytic increases with temperature.

5) Working temperature :

Change in temperature around the capacitor effect the value of the capacitance because of change in the dielectrics properties. If the air or surrounding temperature becomes to hot or to cold the capacitors value of the capacitors may changes so much as to effect the correct operation of the circuits.

6) Polarization :

Capacitor polarization generally refers to the electrolytic type capacitors but mainly the aluminium electrolyte, with refers to their electrical connection. The majority of electrolytic capacitors are polarized types that are the voltage connected to the capacitors terminals must have the correct polarity, i.e. positive to positive and negative to negative.

III. MANUFACTURING PROCESS

1) Winding :

Slit anode and cathode foils after slitting process are stitched wit lead tabs and wound into cylindrical element together with spacer paper. Spacer paper is to contain liquid electrolyte that works as real cathode are restores damaged dielectric film, as well as maintaining the distance between anode and cathode foils contact to prevent short circuits.

Figure 2. Winding and casing for capacitor banks

Di electric material: POLYPROPYLENE

Conductor: ALUMINIUM FOIL

2) Pressing :

A 4 kg pressure is applied to the stacked layers of the dielectrics sheets to crimp and form them. As a rule, the processes so far are undertaken in a clean room. The voltage applied for breakdown capacity of capacitors is 40 kv.

3) Measurement and packing :

Finally, the completed chips are checked to verify that they have the prescribed electrical characteristics, after which they are tapped or packed in some other forms and shipped. As per the requirements we design the winding.

Example: star delta, delta star or star star, etc.

4) Removing moisture :

There are drying ovens reaching vacuum upto 0.005 mm of Hg. Also vacuum drying of oil whereby last traces of trapped air and moisture removed.

5) There testing section :

AC and DC high voltage upto 100 kv& 300 kv. An impulse voltage generator. Scearing bridges for LV & HV capacitors along with CO2/SF6 reference electrode. A variety of shunts reactor which enables

us to carry on thermal endurance tests on all types of capacitors and reactors.

6) Process inspection and packing :

Capacitors finished with aging are packed through electrical sceening and appearance inspection.

7) Outgoing inspection :

Outgoing inspection is conducted based on our sampling plan and criteria.

IV. TESTING OF THE PRODUCT

1) Visual examination :

Examine the capacitor for finish, workshop, marketing and dimension wise.

Figure 3. Winding and casing for capacitor banks

2) Insulation resistance test :

Apply a stabilised voltage of 1000 volts D.C. applied between all the terminals and contained using 1 KV Megger.

Insulation resistance should be>50 mega ohms.

3) Output test :

Measure the capacitance with the help of digital capacitance meter. Calculate the value of KVAR and note down these values in the testing register.

Figure 4. output test for capacitor banks

4) Tan delta :

Measure the Tan Del with the help of schearing bridge. Note down the value in the register.

5) Voltage test between terminals :

Applying proscribed DC voltage between terminals .

Figure 5. Voltage test of capacitors

6) Test for efficiency of discharge devices :

Apply the DC voltage between the terminals and allow the capacitor to discharge through its discharge device. Measure the voltage after 30 sec.

7) Sealing test for leakage of oil :

Keep the capacitor in the oven at 70^0C for 12 hours.

V. CALCULATION

5KVAR, 3 Phase, 50Hz, AC Delta connected, 440V supply

KVAR=$KV^2 * 2\pi fc$

$\frac{5}{3}=(440 * 10^{-3})^2 * (2\pi * 50 * 10^{-3})c$

C=$\frac{1.67}{(0.44)^2 * 0.314}$

C=27.47$\mu fd/ph$

Table 1. System Parameters

Description	Symbol	Value
Capacitance	C	27.47 $\mu fd/ph$
Length of film	L	10.24m
No. of Turns	N	50
Voltage Stress	V	36.7V/μ

VI. CONCLUSION

In this project we learn about Design, manufacturing process and testing of capacitor. While designing of capacitor practical value and theoretical value is different because of different types of losses also gain the knowledge of "how to work on high voltage.

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