AFE BABLOLA UNIVERSITY

ADO-EKITI, EKITI STATE, NIGERIA

NAME: EGBONODJE CHRISTOPHER

DEPARTMENT OF MECHANICAL ENGINEERING

MATRIC NUMBER: 17/ENG06/028

SUBMITED TO

ELECTRICAL ELECTRONICS DEPARTMENT

COLLEGE OF ENGINEERING ABUAD

Course Title: Electrical Machines

Course Code: EEE 326

APRIL 2020

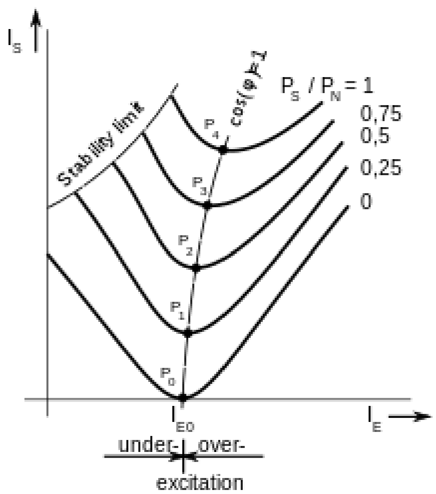
1. **How is Power factor correction done by using a synchronous motor?**

Firstly, a **synchronous** electric **motor** is defined as an AC **motor** in which, at steady state, the rotation of the shaft is synchronized with the frequency of the supply current; the rotation period is exactly equal to an integral number of AC cycles

A **Synchronous Machine** when used for **power factor correction** has two circuits, A Stator Circuit which is connected to the grid and a rotor circuit which is called Field winding/Excitation Winding. The field winding is controlled by a solid state voltage and frequency regulator.

Increasing the device's field winding excitation results in its furnishing reactive power (VARs) to the system and decreasing the field winding excitation causes absorption of reactive power from the system (VARs). Hence, it acts as a capacitor in over excited mode and an as inductor in under-excited mode.

The variations of *I* with excitation are known as **V** curves because of their



shape.

A synchronous condenser operates at nearly zero real power as the machine passes from under-excited to overexcited, its stator current passes through a minimum.

2. **What is meant by power factor when it come to synchronous motor?**

POWER FACTOR generally is defined as the ratio of the actual electrical power dissipated by an AC circuit to the product of the r.m.s (root mean squared). values of current and voltage. The difference between the two is caused by reactance in the circuit and represents power that does no useful work.

Synchronous motors are designed to operate at unity (1.0) power factor or 0.8 leading power factor. By varying the DC excitation of the motor, the power factor of the motor can be varied widely. Overexcited synchronous motors operate at leading power factor and provide reactive **kVAR**-like capacitors.

3. How do synchronous motors improve power factors?

An over-excited synchronous motor has a leading power factor. This makes it useful for **power factor correction** of industrial loads. Both transformers and induction motors draw lagging (magnetizing) currents from the line. On light loads, the power drawn by induction motors has a large reactive component and the power factor has a low value. The added current flowing to supply reactive power creates additional losses in the power system. In an industrial plant, synchronous motors can be used to supply some of the reactive power required by induction motors. This improves the plant power factor and reduces the reactive current required from the grid.

A synchronous condenser provides step-less automatic power factor correction with the ability to produce up to 150% additional vars. The system produces no switching transients and is not affected by system electrical **harmonics** (some harmonics can even be absorbed by synchronous condensers). They will not produce excessive voltage levels and are not susceptible to electrical **resonances.** Because of the rotating **inertia** of the synchronous condenser, it can provide limited voltage support during very short power drops.

4. Why there is better power factor in synchronous motor as compared to that of an equivalent induction motor?

Higher PF means low requirement of MMF for energy transfer , hence low magnetizing current requirement.
synchronous machine have separate DC excitation which reduces machine's excitation dependency on main supply, hence better PF.
whereas IM(induction motor) have no such provisions, hence low PF .

5. How can a power factor be controlled in synchronous motors?

The power factor of a synchronous motor is dependent on the power, the reactance, and generally, with a change the excitation. When the excitation of the motor is increased, the power factor changes from lagging to unity and then to a leading power factor. This property of the motor is utilized to improve the power factor of the leads, having a low lagging power factor. Normally, when the motor is utilized in this way to improve the factor, the synchronous motor is run without any mechanical load. The excitation is adjusted in such a manner that it works at a leading power factor. The synchronous motor is then referred to a synchronous condenser.

6. What happens when synchronous motor operates on no load?

A synchronous motor running on no-load with leading power factor will act as synchronous condenser. This is not truly a no-load operation since the motor, while behaving as a condenser is actually feeding a part of reactive load of the system to which it is connected.

The same motor when operated with lagging power factor on no-load will draw a reactive current from the system depending upon the system voltage.

However, this does not mean that the motor can be operated on no-load regardless of the armature current that flows in the motor. The capacity of the motor to run as synchronous condenser or as synchronous motor, whether on load or no-load is dictated by its V-curve (Armature current vs. field current).

7. Why is a synchronous motor not used for developing power factors?

A synchronous motor is not used for creating power factor due to the equality in synchronous speed of the stator movement to the rotor movement. The power factor which is a result in a ratio of the actual electrical power dissipated by an AC circuit to the product of the r.m.s (root mean squared). Hence: Power factor correction is done at receiving end, where we cannot use synchronous generator for power factor correction as we need some prime mover to drive the generator shaft. Hence extra machine is needed as the prime mover at receiving end also. So instead of a synchronous generator, synchronous motor at leading pf is preferred which is used for power factor correction and/or for load demand.

Moreover, synchronous generators are used at generating stations which also can provide electricity at desired pf. Hence pf can be maintained from both the ends.

8. Why is the efficiency of the synchronous motor greater than the induction motor?

Synchronous motor always rotates with **synchronous** speed, irrespective of the loading conditions. So, the effective output is not reduced, compared to **induction motor**. So, more **efficiency** is observed in this case. Also, the operating power factor is constant in **synchronous motors**. It is also a doubly excited machine, unlike **induction motor**.

In an **induction motor**, some part of the power is spent to generate the magnetic field in the **motor**. The **synchronous motors** have a fixed magnetic field due to the presence of permanent magnets. So their **efficiency** is higher.

9. Why is a fixed power factor used in a motor?

As power factor is the ratio of the actual electrical power dissipated by an AC circuit to the product of the r.m.s. values of current and voltage, fixed power factor refers to a constant and unchanging value of both the actual electrical power and the value of the root mean squared current and voltage in a circuit analysis.

Power factor of synchronous motors might be fixed. Usually such motors r huge and therefore their reactive power causes huge losses. It's a question of efficiency and economic reasons probably.

the motor manufacturers mention a P F value, which they need to assess the performance of their manufactured products, so as to comply with standards and specifications.

In an actual / practical situation, neither the manufacturer / end user has any control over the supply voltage P F, which is commonly dictated by all of the other consumers of (perhaps) the same power!

10. If a synchronous motor has a leading power factor, does this motor consume or supply reactive power? Does this motor consume or supply real power...

If a synchronous motor has a leading power factor, does this motor consume or supply reactive power? Does this motor consume or supply real power? Whenever a synchronous machine (either motor or generator) is being operated at leading power factor(PF), it always shed out its leading Reactive VARs (Volta-ampere reactive) for such machine which is deficient with leading VARs (operating at lagging PF) and thus the VARs deficient machine will absorb that leading VARs supplied and tend to improve its lagging PF to unity. /

Now, when this machine is done with improvement of its PF from lagging to unity and still being fed with Leading VARs in excess, it will eventually start acting like a source of Leading VARs for some other Leading VARs deficient machines connected in the power system.

Synchronous condensers (phase modifiers) are the best examples for this kind of practices. Phase modifier is nothing but an un loaded synchronous motor operated at leading PF and without load.

11. **We use multiple MV synchronous AC motors from 350hp to 2000hp. What is a ballpark efficiency of these motors? I'm trying to estimate operation...**

You have a tough job on your hands. Large synchronous motors have adjustable power factor. They can even have leading power factor. They are often set this way compensate for all the other induction motors. This can affect the efficiency of the motor depending on load. With the system tuned to near unity the entire distribution system benefits. It is a good way to go. There is not just one type of synchronous motor but they most often do better than standard induction motors.

12. **Why is the efficiency of a synchronous motor greater?**

The Efficiency of a synchronous motor and induction motor is dependent on slip and losses in general. The efficiency of a synchronous motor is greater than of an induction motor of the same output and voltage rating because there is neither loss related to slip nor the additional losses due to magnetizing current.
With synchronous motors, there is no difference of speed between air gap rotating magnetic field and rotor.

13. **Which motor can operate at a high power factor?**

Synchronous motor has a unity (1.0) power factor which is the highest power factor as can be. This implies that the r.m.s (root mean squared) voltage and current is equal to the actual electrical power dissipated.

A synchronous electric **motor** is an **AC motor** in which, at steady state, the rotation of the shaft is ... In **higher** power industrial sizes, the **synchronous motor** provides two important functions. First, it is a highly ... energy **to work**. Second, it **can operate** at leading or unity **power factor** and thereby provide **power-factor** correction.

14. **How is the power factor considered in an induction motor?**

Power factor is a number which in very small length tells us about the efficiency of an AC machine like induction motor. As we know, in an inductive load current lags the voltage by a certain angle. Higher the lag, lesser will be the power factor. In case of DC current, voltage and current are inphase but in case of AC, at a given instant the current lags the voltage. As a result, the actual or active power to the machine is product of Voltage and cosine component of current. cosine of the angle between Voltage and Current is called power factor. If this factor is low, the line current will have to increase to transfer required power. This increase in current will cause Voltage drop and unnecessary heat loss thus decreasing efficiency.

15. How does a synchronous motor work as a power factor corrector?

In electrical engineering, a **synchronous condenser** (sometimes called a **synchronous capacitor** or **synchronous compensator**) is a DC-excited synchronous motor, whose shaft is not connected to anything but spins freely.[1] Its purpose is not to convert electric power to mechanical power or vice versa, but to adjust conditions on the electric power transmission grid. Its field is controlled by a voltage regulator to either generate or absorb reactive power as needed to adjust the grid's voltage, or to improve power factor. The condenser’s installation and operation are identical to large electric motors and generators.

Increasing the device's field excitation results in its furnishing reactive power (measured in units of var) to the system. Its principal advantage is the ease with which the amount of correction can be adjusted. The kinetic energy stored in the rotor of the machine can help stabilize a power system during rapid fluctuations of loads such as those created by short circuits or electric arc furnaces. Large installations of synchronous condensers are sometimes used in association with high-voltage direct current converter stations to supply reactive power to the alternating current grid.

Synchronous capacitors are an alternative to capacitor banks for power factor correction in power grids. One advantage is the amount of reactive power from a synchronous condenser can be continuously adjusted. Reactive power from a capacitor bank decreases when grid voltage decreases, while a synchronous condenser can increase reactive current as voltage decreases. However, synchronous machines have higher energy losses than static capacitor banks.Most synchronous condensers connected to electrical grids are rated between 20 MVAR (megavar) and 200 MVAR and many are hydrogen cooled. There is no explosion hazard as long as the hydrogen concentration is maintained above 70%, typically above 91%

An over-excited **synchronous motor** has a leading **power factor**. This makes it useful for **power factor correction** of industrial loads. Both transformers and **induction motors** draw lagging (magnetising) currents from the line. ... This improves the plant **power factor** and reduces the reactive current required from the grid.