14 M

Unit-2: Energy Conservation in Electrical Machines

Need of Energy Conservation in Induction Motor :

- India is a growing economy and economic growth of any country largely depends on industrialisation and energy consumption.
- The 3-ph I.M consume about 70% of electricity used in industry.
- I.M have low pf more losses & loss efficiency.
- There is also losses due to ~~low~~ poor material quality.
- So manufacturer started use of good & thin steel lamination material having low losses and improve η.
- To save energy consumption in process plant to use of energy efficiency motor are choosen over Standard Induction motor.
- The motor having high efficiency, good power factor and ~~fewer~~ minimum losses are called energy efficient motor.
- Motor must work at higher η so reducing losses.
- The cost of electricity is increasing so, energy conservation is needed.
- So economic as well as environmental aspects necessity to conservation in Electric Motor.
- following table shows the shares of electrical energy used by motor in various sector :

Sector	Share (in %)	Applications
Industrial	70	Process and material Handling Equipment
Commercial	38	Mainly HVAC
Agricultural	25	Agriculture Pumps & fan
Residential	22	Refrigerator / HVAC
Transport	60	Railways

Need of Energy Conservation in Transformer :

- Transformer is most important equipment in pow System which play significant role in generatio Transmission & Distribution of Electrical Energy
- T/F operating efficiency directly effect the cos & benifits of whole system.
- According to statical data the total power loss generated by T/F approximately 10% of total operation capacity therefore energy conservation of T/F is necessary.
- All electrical power consumer receives passes through T/F at each T/F there is energy losses obvious.
- A modern distribution of Transformer operates at high efficiency [95% to 98%] at the range of 98.99%.
- However the total no. of transformer used in transmission, distribution, commercial, rural, industrial is very large.
- So, even small amount of losses in every T/F. Contribute a significant energy loss as well as (Heat produce) global warming & climate change.
- Thus, even small improvement in T/F η will lead energy conservation.

Energy Conservation Techniques in Induction Motor :

- There are various techniques of energy conservation in Induction Motor.

1) By Improving Power Quality
2) By Motor Survey
3) By Matching Motor
4) By Minimizing Idle and Redundant Running of motor
5) By Operating in star mode
6) By Rewinding of Motor
7) Replacement by energy efficient motor
8) Periodic Maintenance

1. IMPROVING POWER QUALITY :

- Due to poor quality of power, induction motor affected badly it consumed more energy above the rated value.
- To reduces these losses there are many aspects of the term power quality such as Voltage unbalance, and Harmonic distortion.

Parameter	Permissible Variation (in %)
Voltage	±5 to ±10
Frequency	±3
Combined	±6

(1) Voltage Unbalance : In a condition of voltage unbalance voltages in three phase becomes unequal which may lead motor to significant problems such as: Excess heating Vibration

Voltage unbalance can be minimized by:
- Equal distribution of single phase loads on all three phases.

② Harmonic Distortion: The presence of unwanted frequencies in addition to fundamental frequency of 50 Hz causes harmonic voltage distortion.
- Undisirable effects of higher frequencies related with harmonic voltage distortion causes ↑sed Iron & Copper losses.
- Due to this it increases operating temperature and increased motor heating.

2. MOTOR SURVEY:

- In large industrial plants, the population of inductions motor is too large that needs attention. So, it necessary to develop and maintain a motor management plan.
- ~~This demands the Surveying of motor with respect to load by applying Some methodology~~
- Motor Survey is important aspect in energy Conservation. A motor ~~Methodology~~ Survey should begin by reviewing the nameplate information on motor to be obtained the parameter such as rating of motor, rated speed, ~~Recording of motors Measurements Analysis~~ efficiency, full-load current, etc. ~~of Electrification.~~ The motor nameplate is the 1st ~~Field Parameters Observation~~ step of a motor survey. It ~~gives~~ obtained high efficiency above 80% of full load torque.

3. By Matching Motor :

- If the Same rating of ~~motor~~ Equipment drawn by Same rating of motor ~~supply~~ it said to be well match. e.g. A 10 KW fan drawn by 10 KW motor it said to be well match.
- If the motor over size it causes lower η,

Lower power factor and higher initial cost.
- Reasons for unmatching of motor :
① Use of large motor for high starting torque, instead of using specially designed motor.
② Large motor even at low voltage designing the output to be maintained.

4. MINIMIZING THE IDLE & REDUNDANT RUNNING MOTOR :

(Not engaged in Activity)

- Motor is said to undergoing Idle operation when it continues to run even through it is not supplying useful work
Typical Example of Idle operation are :
① Continuation of unloaded conveyor belts.
② Running exhaust fans even it not needed.
- If minimizing the Idle condition then 100% saving of the power consumed can be achieved.
- Redundant operation means equipment operate without any significant effect on production neither quality nor quantity.
Example of Redundant operation are :
① Operation of an air conditioning unit even when desired temperature is achieved
② Air conditioning runs also as good as redundant if windows is open.

5. OPERATING IN STAR MODE :

- If the loads operating at less than 30% of the full load i.e, at light loads, operation of 'Delta' connected motor but in 'Star' connection can save energy.

- In many cases, the load is below 30% most of the time, but sometimes the load exceeds 50% in this condition automatic Star - Delta changover switches can be installed. This can save upto 5 to 15% of the existing power consumption.

6. REWINDING OF MOTOR :

- The most common problem occurs when heat is applied to strip old winding the lamination can be damaged, thereby increasing eddy current losses.
- A change in air gap may affect power factor and o/p torque
- Efficiency can be improved by changing the winding of motor.

7. REPLACEMENT BY ENERGY EFFICIENT MOTOR

- Energy efficient motor improved design & high quality material in order to reduce losses therefore It has higher efficiency than conventional motor.
- Due to more losses occurs in Conventional motor, so it can be replaced with the energy efficient motor to increase the efficiency of motor, as well as Reduces Consumption of energy.

8. PERIODIC MAINTENANCE :

- Periodic maintenance program of the Induction motor is may ~~change~~ depending upon type of machines & its applicatio

- Weekly maintenance include :
① Loose connection
② Oil in bearing
③ Brushes

- Half Yearly Maintenance include :
① Clean dirt from winding.
② Wipe Commutator & Brushes
③ Clean Brush Holder

- Yearly Maintenance :
① Ensure proper connection bet^n Commutator & Armature Coils.
② Check insulation

Energy Conserwation Techniques in TRANSFORME

① Parallel Operation of Transformer :
② Load Sharing
③ Isolating Transformer

1. Parallel Operation of Transformer :

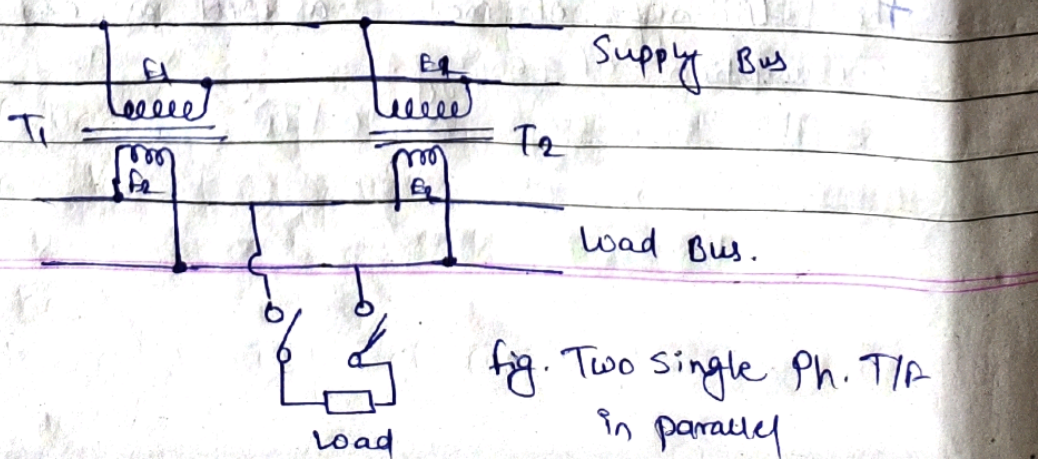


fig. Two single Ph. T/F in parallel

- When primary winding are connected to a common voltage & secondary winding are connected to a common load then that TF said to be in parallel operation.
- The connection diagram of parallel operation of TF is shown in above fig.
- Most of the cases power TF gives max. η at full loa
- ~~If one no. of TF are in parallel then one can switch on only those TF which will give the total demand by running nearer to its full load rating for that time.~~
- When load increases, one can s/witch on one by one one other TF connected in ||el to ~~fulfill~~ fulfil the total demand
- In this way one can run the system with max. efficiency. condn for ||el operation : ①Same V& Ratio & curr ②Same polarity ③ Same phase sequence ④ Same kVA Rating

2. Load Sharing :

- The problem like overloading, Variation in V& f heating are very common in x'mer.
- It takes a lot of time for its repairing & maintena & also involves high cost.
- Load sharing protects the transformer under overload condition.
- Due to overload excessive amount of heat is produce & secondary winding of transformer may burn.
- To minimize this losses load sharing of TF is needed to conservation of energy.

3. Isolating Transformer :

- Isolation is defined as cutting of electrical supply to the system in order to ensure the safety of those working on the equipment
- An isolator is a mechanical device which is operated manually & used to open or close a circuit off load. An isolater s/w must be provided & close to supply point, so that the transformer can be safe for maintenance.
- Certain level of protection against electrical shock is provided by insulation betn the primary & secondary winding.
- In this way we can isolating transformer to ~~reduce~~ avoid str. danger shock & losses of transfor for reducing energy consumption.

4. Replacement by Energy Efficient T/F :

* Energy Efficient T/F are very important means to reduce transmission & distribution loss.
- Silicon steel is a soft magnetic material that is used in electrical power transformer, motor & generator. It increases the electrical resistivity of iron & therefore reduces eddy current losses.
- With the improvement of silicon steel properties the losses of a T/F can be reduces.
- So, the an energy efficient transformer is giving its non-stop operation & 25 years service life, therefore it can be easy for energy conservation by replacement of energy efficient T/F.

Advantage of Energy efficient T/F :

1. They have less operating losses
2. Less heat is generated due to less losses
3. They have longer life.
4. High electrical Resistivity of core material reduces eddy current loss.

Energy Conservation Equipment :

1) Soft Starters
2) Automatic star delta Converter
3) Variable frequency Drives (VFD)
4) Automatic P.F Controller (APFC)
5) Intelligent P.f. Controller (IPFC)
6) Active Harmonic filters (AHF)

1) Soft Starter :

- Soft Starter is a device which controls the acceleration of an electric motor by controlling the applied voltage.
- In technical terms as starter is any device that reduces the torque applied to the electric motor.
- It increase the i/p vtg of motor gradually so that motor speed increase slowly.
- Soft starter protect the motor from mechanical jerking due to sudden supply of the full vtg.
- The torque is proportional to the square of the starting current, Thus, the torque & current can be adjusted by reducing the voltage at the time of starting the motor.

* Advantage of Soft Starter :

(1) It starts the motor smoothly as compaire to Conventional starter.
(2) Mechanical stress & jerk not occurs.
(3) Reduction in starting current.
(4) Soft starter reduces the overheating of motor.

* Application :

(1) Cement industries
(2) Sugar plants
(3) Conveyer belt motor
(4) Steel industries

(ASD Starter / Converter)

2. Automatic Star Delta Converter :-

- All motors of higher capacity (generally ≥10hp) are provided with Star / Delta ~~st~~ winding.
- During the initial start up the motor is connected in Star mode to reduced the initial value of current.
- Once the motor achieves the required speed, it switches to the Delta mode, after which the motor can be loaded.
- Whenever the load on the motor is less than 40% it switches the motor to Star mode & as soon as the load ↑se >40% it switches the motor to Delta mode.
- With the help of this equipment the saving are near about 10-40% depending on the motor load & the load changes.

3. Variable Frequency Drives :- (VFD)

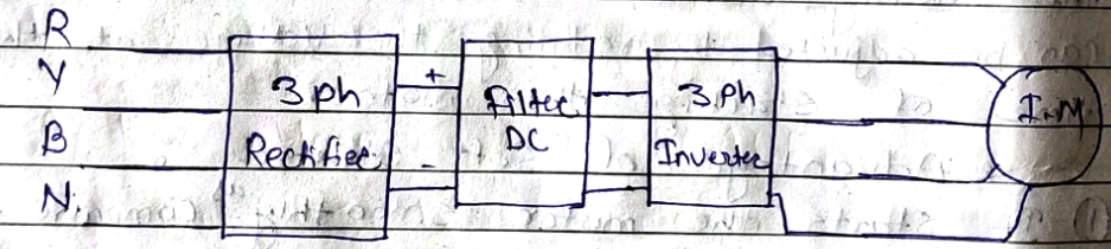


fig. VFD

- The basic function of VFD is to changes the frequency of supply voltage to vary the speed of motor.
- By adjusting the motor speed in such a way that matching of motor o/p to load can be achieved which results in energy saving.
- As shown in above fig. rectifier converts AC supply into DC supply. DC ~~link~~ filter is used to filter out ripple from rectified output.
- Inverter is used to convert rectified DC supply into AC supply.

- As per application if the speed control is required above rated speed then by increasing the frequency it is possible.

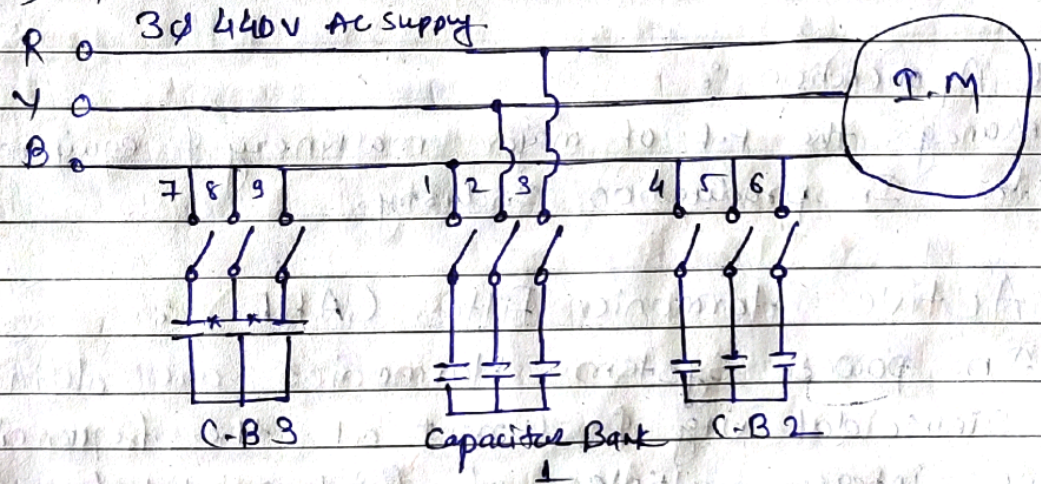
4) ~~Automatic Power Factor Controller~~ (APFC)
Application & Benefits

(1) Motor driven centrifugal pumps & fans.
(2) Conveyers, machine tools & other protection line equipment.

* Benefits of VFD

(1) Energy Saving
(2) Cost Saving
(3) Increased productivity
(4) Less Maintenance cost.

4) Automatic Power factor Controller :



- The P.F Controller is used to check Maintain the p.f at unity across the lines it is connected.
- In A.P.F.C panel, the switching procedure of the capacitors bank is stepwise. as well as smooth & better P.F control is possible.
- If P.F is above reference value then UP will not takes any action, but when P.F falls below reference value ~~value~~ then it will ~~spen~~ send signal to relay will connect respective capacitive bank across the load.
- Due to this the motor run efficiently & E.C is takeplace.

5) Intelligent P.F Controller (I.P.F.C) :-

- During the operation of A.P.F.C in first hour, intelligent P.F.C the capacitance to be added at each step & stores these value in the memory
- It avoids the problem of which occurs during capacitor switching.

* Features of I.P.F.C :-

① It is continuously monitor the power factor in real time.
② It has decision making capability due to MC based system.
③ It is also helps to balance the load in the entire system.

* Disadvantage of IPFC :-

① These systems can be costly
② The installation & configuration can be complicated.

* Application :-

① Manage the P.F of major machinery & equipment
② In production Industry

6) Active Harmonic Filter (AHF) :-

- In power system, Harmonics are defined as a sinusoidal wtg & current at the frequencies that are integer multiples of fundamental frequency and these create major distortion in main wtg & load current.
- There are two types of Harmonics
① Current Harmonics
② Voltage Harmonics.

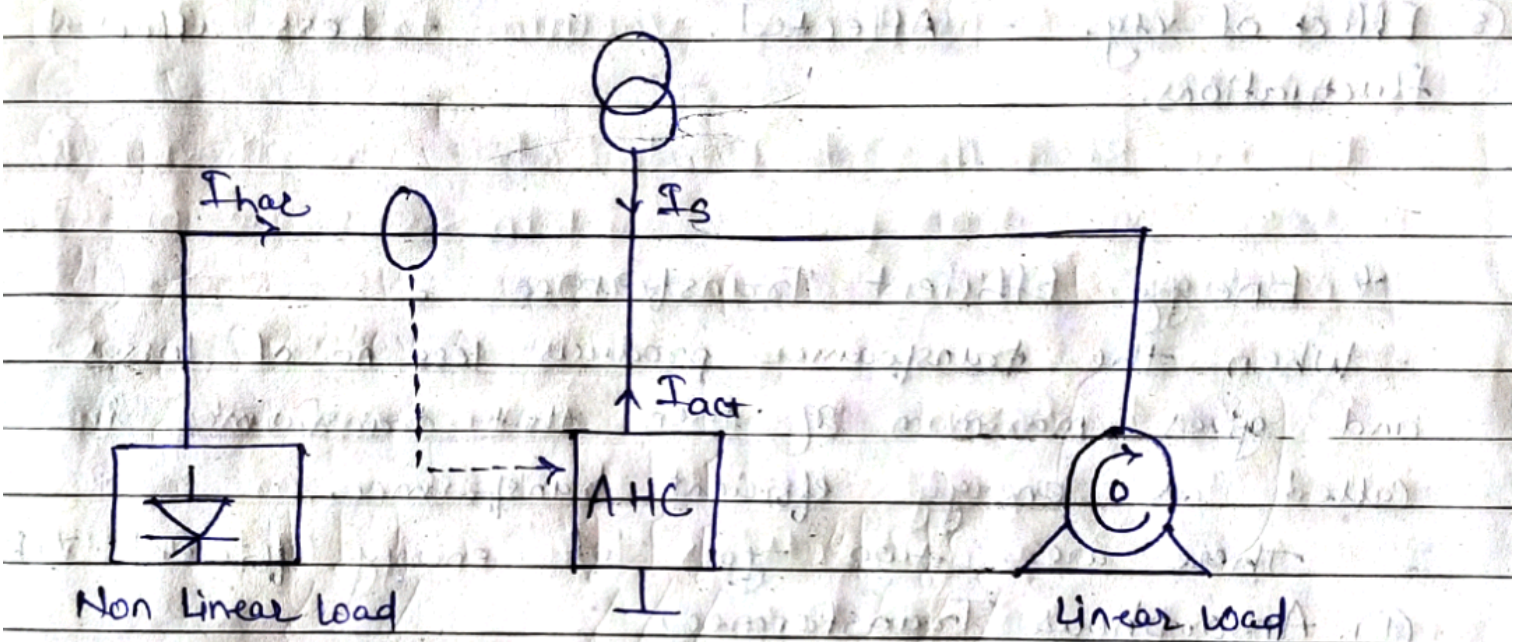
① Current Harmonics :- The current Harmonics induced by the non-linear load such as VSDs (Variable Speed Drives.) so, that the is not in a perfect sinusoidal waveform. in p/w line.

② Voltage Harmonics :- When the non-sinusoidal vtg drop at the source impedance, then results as the distorted vtg produced at load terminal.

- Harmonic filters are used to protect costly electrical equipment from distorted power supply ~~caused~~ due to Harmonics. there are two types of H. filters
① Passive filters ② Active filters.

① P.F :- Passive filters consist of simple component such as resistor, Inductor & capacitor.

② Active filter :- A.F. consist of mainly p/w electronic components such as BJT, MOSFET, etc.



Is - Source current
Iact - Active harmonic filter current.
I_H - Harmonic current.

* Comparison bet^n Standard conventional motor & Energy efficient motor :

Parameter	Standard M.	Energy efficient M.
(1) Noise	- More noise while operation.	- less noise while operation.
(2) Cost	- less cost as Com-pair to energy eff. m.	- cost is higher, th standard m.
(3) Energy Cons.	- Less	- More
(4) Efficiency	- Efficiency is low due to the losses.	- It has high η due to less losses.
(5) Effect of v^{tg}. fluctuations	- Affected.	- Less affected.

* Energy Efficient Transformer :

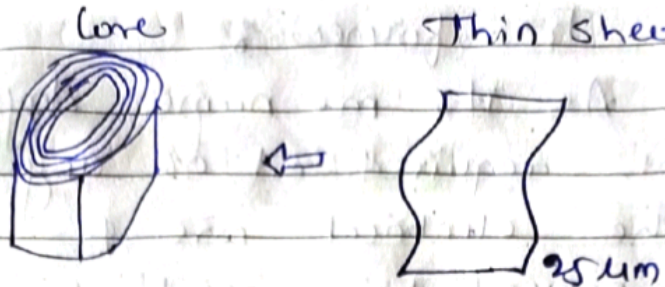
- When the transformer produces less no. of losses and gives maximum η then that transformer is called as energy efficient transformer.
- There are two types of energy efficient TFs
  (1) Amorphous Transformer
  (2) Dry type Transformer.

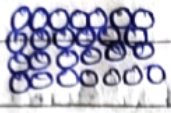
1) Amorphous Transformer :

- Conventional transformer use the core of silicon steel laminations with an uniform crystalline structure.
- Amorphous x'mer use the core of amorphous steel which has lower hysterisis losses.
- Due to this we can save energy near about 70% to 75% of energy.

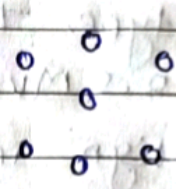
H.M. Sign.

Teacher's Sign.





Crystalline structure



Amorphous structure

Amorphous alloy :

- In amorphous alloy the metal have crystalline structure with a neat arrangement of atoms.
- When a metal in a liquid form at high temp. & is it rapidly cooled then metal retains its liquid structure for solidification.
- It results in a non-crystalline alloy which contains randomly arranged crystals called as amorphous alloy.

Advantage :

1. Lowest Hysteresis loss
2. Low Eddy current loss
3. Less Maintenance cost
4. Up to 75% energy saving using amorphous metal than conventional metal.
5. Better overload capacity
6. Easy Repair

2) Dry Type Transformer :

- As its name dry type means it does not required oil or any other liquid to cool the electrical core & coil. The purpose is served by normal air ventilation
- In India, Dry type TF in the range up to 11 kV & capacity 2.5 MVA are manufactured.
- The popular design in Dry type construction are :
  ① Epoxy Resin Impregnated (Vacuum Pressure (VPI)
  ② Cast Resin

1) Epoxy Resin Impregnated :

- It is also termed as Vacuum Pressure Impregnated (VPI).
- Epoxy Resin has high dielectric strength which makes the transformer sustain extreme operating conditions.

2) Cast Resin : Cast resin are dry type TF. The magnetic circuit & winding are not immersed in an insulating liquid but are cast with an epoxy resin mixture.

- The Cast Resin process minimises the pollution & corrosive particles.