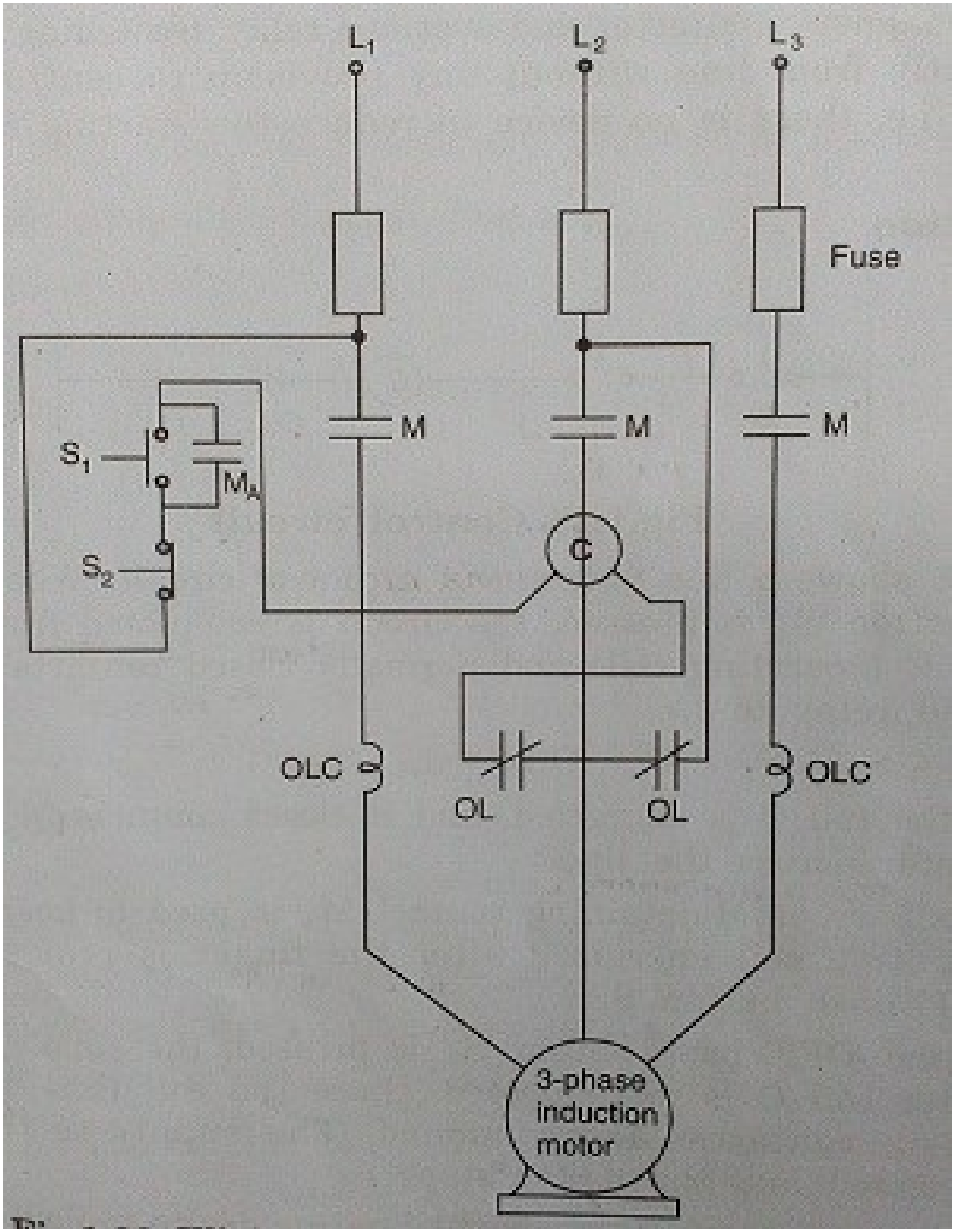
- **Function and necessity of A.C starter:**
- **Necessity:**
- Rotor current at standstill, I2 = E2/Z2
- The magnitude of E2 depends upon the flux linking with the rotor conductors and its relative speed.
- The strength of the rotor flux depends upon the applied voltage.
- At the instant of applying rated voltage to the stator winding, rotor is stationery and as such the slip is unity.
- So if full rated voltage is given to the stator winding, then magnitude of the emf induced in the rotor conductors will be high, because the relative speed between the rotor conductors and of the revolving flux is very high.
- Further the rotor conductors are short circuited and thus have low impedance.

- Hence, the current drawn by the stator winding or motor is very large, approximately 5 to 7 times the full load current.
- **Effect of high starting current:**
- The copper losses occurring in the stator and rotor windings due to high starting current are extremely large, which produce a lot of heat inside the machine and may damage the insulation of the windings.
- Moreover, there will be a dip in the supply voltage.

- **The starting current drawn by the motor can be reduced to a permissible value by**
- Applying reduced voltage to the stator winding.
- Inserting the resistance in the stator circuit.
- Inserting the resistance in the rotor circuit.

- **Methods of starting 3-phase induction motor:**
- **For squirrel cage i.m:**
- D.O.L starter
- Primary resistance starter
- Auto transformer starter
- Star delta starter
- **For slip ring:**
- Rotor resistance starter

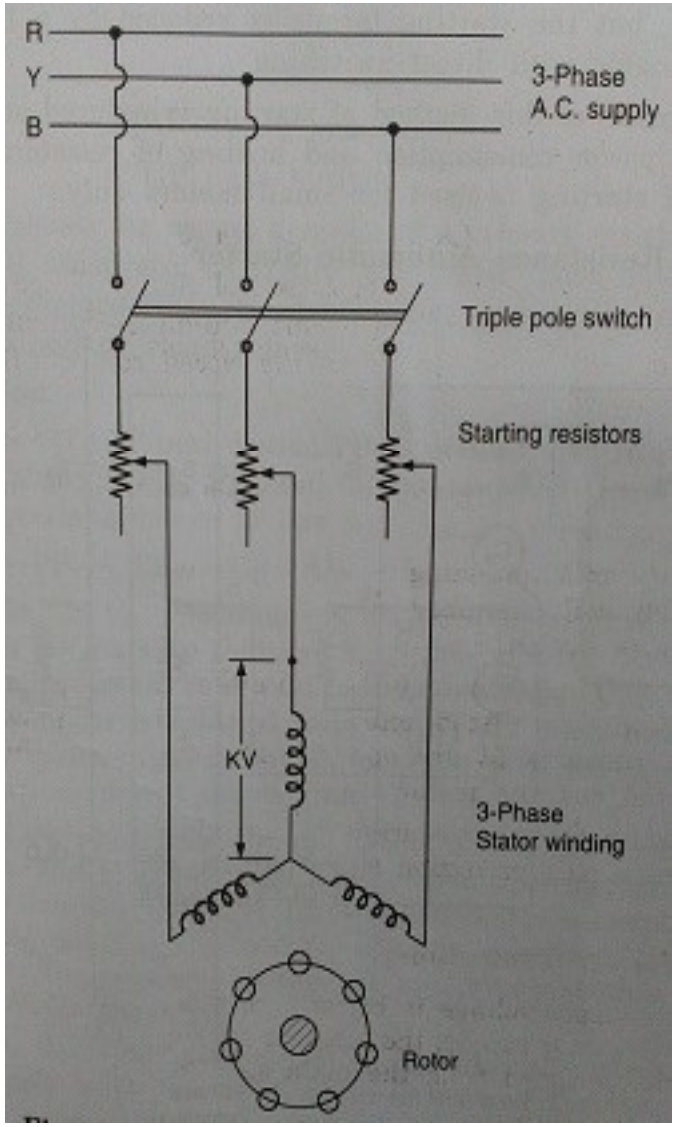
- **L1, L2,L3** lines
- **M**= main contacts
- **MA**= Auxiliary or maintaining contact
- **S1**= START push button
- **S2**= OFF push button
- **OLC**= overload relay coil
- **OL**= overload relay contact
- **C**= magnetic coil or operating coil.



- In this method of starting, the rate of temperature rise is high and motor may get damaged if the starting period, which may be due to excessive load or excessive voltage drop in the supply lines.
- So small size squirrel cage induction motors up to 5kW may be started by this method.

Manual and Automatic primary resistance starter

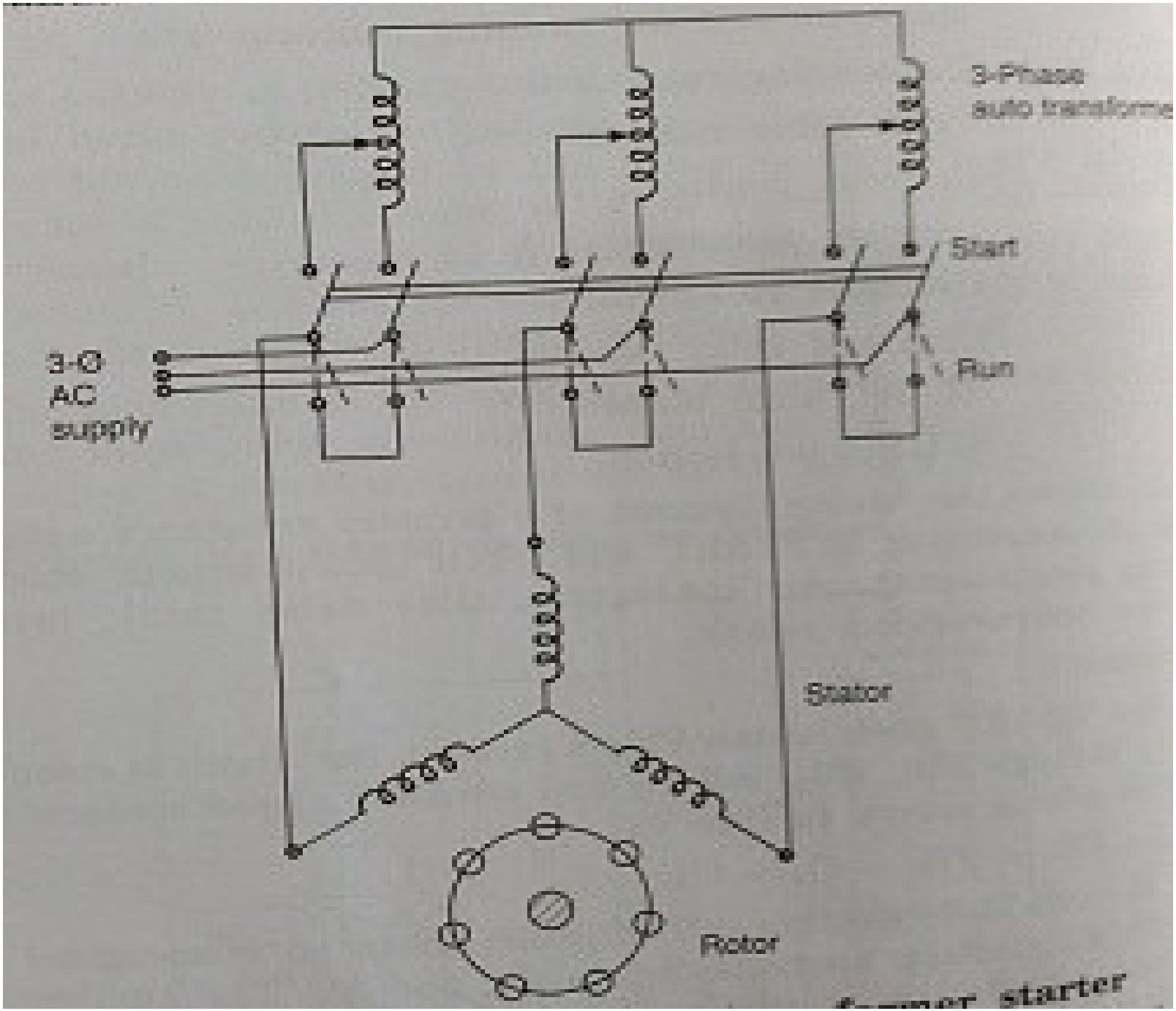
- In this method of starting of 3-phase IM motor, primary resistance are connected in all the three phases of the stator winding
- As a result the applied voltage across the stator winding at the instant of starting is reduced to a fraction K of the rated voltage of the motor.



- Therefore the initial high starting current will also reduced by the same fraction.
- The purpose of primary or starting resistor is to drop some voltage and hence reduced the voltage applied across the motor terminals.
- The torque developed by the motor is directly proportional to the square of applied voltage, so if the voltage applied across the motor terminals is reduced by fraction K
- Starting current is reduced by fraction K,
- But the starting torque is reduced by a fraction K^2 of that obtainable with direct switching.

- The drawbacks of this method of starting is torque and large power consumption and heating of resistors.
- This method of starting is used for small motors only.

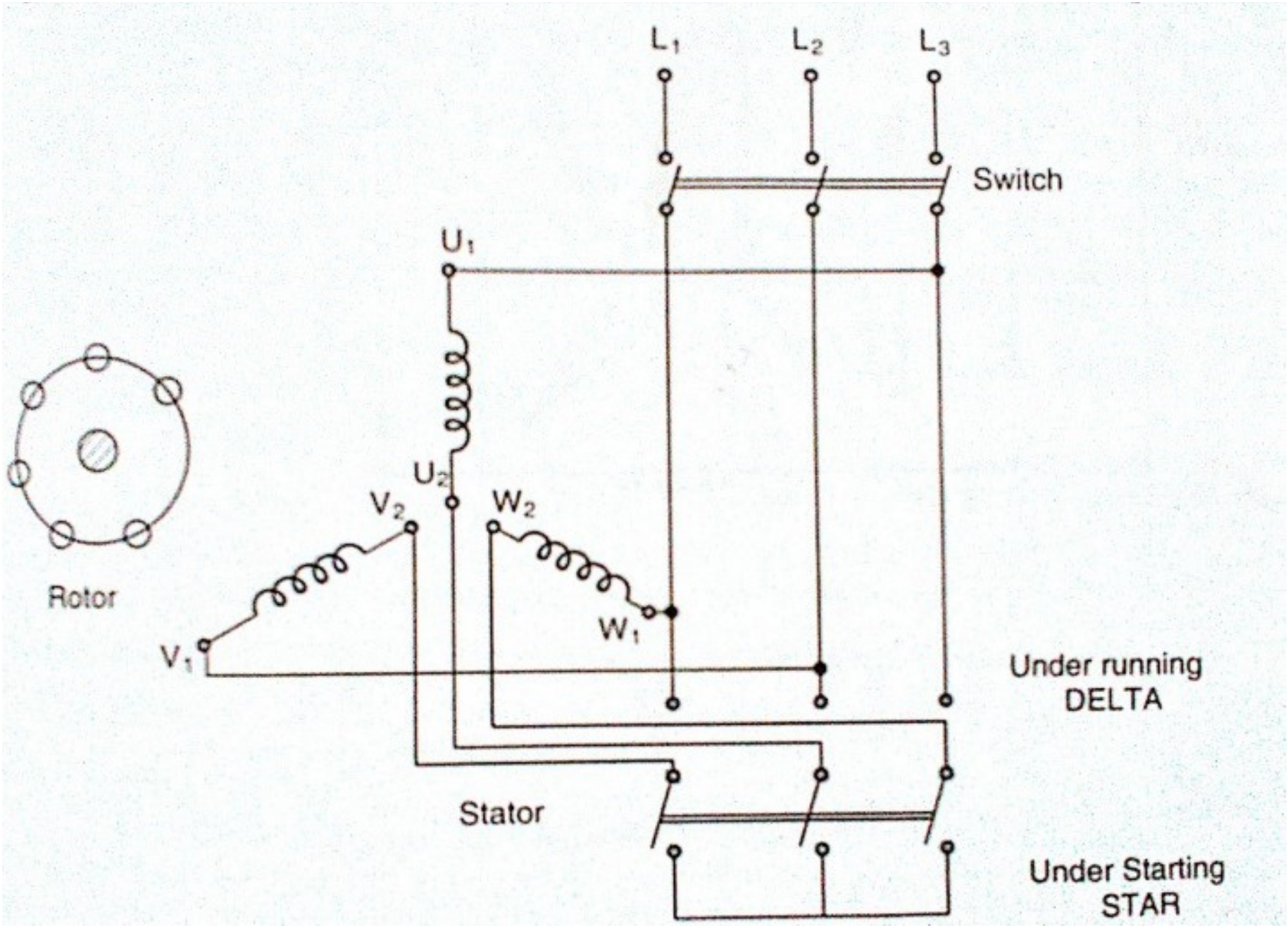
- **Manual auto transformer:**
- In this method, 3-phase auto transformer with fixed tapings is used to obtain reduced voltage for staring the 3-phase IM.
- Normally 50% to 60% tapings can be used to obtain a safe value of starting current.
- Thus, 50 to 60% of the rated voltage is applied at starting and the auto transformer is cut out of the motor circuit, when the motor has picked up the speed about 70% to 80% of the normal speed.
- Hence, during normal running condition, the voltage across the stator winding is of rated value.


3-Phase
auto transforme
Start
Run
3-Φ
AC
supply
Stator
Rotor

- **Problem:** occurs with a primary resistor starter is that all the voltage that is dropped through the resistors is turned into heat.
- The amount of heat may become very large and cause problem.

- An auto transformer starter can be used for both star and delta connected motors.
- This method of starting is used for starting large motors as the cost of auto transformer is high.

- **star delta starter:**
- At starting, the 3 phase stator winding is connected in star, therefore the applied voltage to each phase of the winding is $1/\sqrt{3}$ of the rated voltage of the motor.
- When the motor has picked up the speed the phases of the stator winding are connected in delta.
- Now full supply voltage is applied across the stator winding.


L1
L2
L3
Switch
U1
U2
V2
W2
W1
V1
Rotor
Stator
Under running
DELTA
Under Starting
STAR

- **Features of star-delta starting**
- For low- to high-power three-phase motors.
- Reduced starting current
- Six connection cables
- Reduced starting torque
- Current peak on changeover from star to delta
- Mechanical load on changeover from star to delta

- **Application of Star-Delta Starter:**
- The star-delta method is usually only applied to **low to medium voltage and light starting Torque** motors.
- The received starting current is about **30 %** of the starting current during direct on line start and
- the starting torque is reduced to about **25 %** of the torque available at a D.O.L start.
- This starting method only works when the application is light loaded during the start.
- If the motor is too heavily loaded, there will not be enough torque to accelerate the motor up to speed before switching over to the delta position

- **Soft starter:**
- With the development of computer technology and power electronic technology, electronic starters are implemented in order to achieve the softly starting IM
- Among these, thystorized soft starters which are commonly used, apply reduced voltage to the motor are cheap, simple, reliable and occupy less volume.

- Soft starter is a technology used to start IM motor gently.
- Starting accelerates the motor more smoothly than direct on line starting or other form of reduced voltage starting.
- Starter works by controlling the amount of current delivered to the motor while it is starting.
- this prevents current transients and supply disturbances.
- Soft starting also limits the level of starting torque extending the acceleration period and enabling the motor to build up to full speed more gently.

- **Benefits of soft start:**
- **Electrical benefits:**
- Controls the current surge at start, preventing voltage dips and surges on the electricity supply.
- It can reduce electricity charges by reducing the demand peak associated with DOL motor starting.

- **Mechanical benefits:**
- Prevent torque transients.
- Reduces excessive wear on components including pipes, valves, coupling and bearing.
- Economical benefit:
- Reduced electrical and mechanical strain on the motor
- Reduced the risk of damaged
- Reduce the amount of maintenance required, minimizing maintenance cost and production downtime.

- **Advantages:**
- Simple and flexible control over starting current and torque.
- Smooth control of voltage and current, free from steps
- Capable of frequent starting
- Capable of handling changing start condition

- **Energy efficient motor:**

- **Losses:**
- **Fixed losses:**
- **Variable losses:**