

**1) Define Drive and Electric Drive.****ANS:****DRIVE**

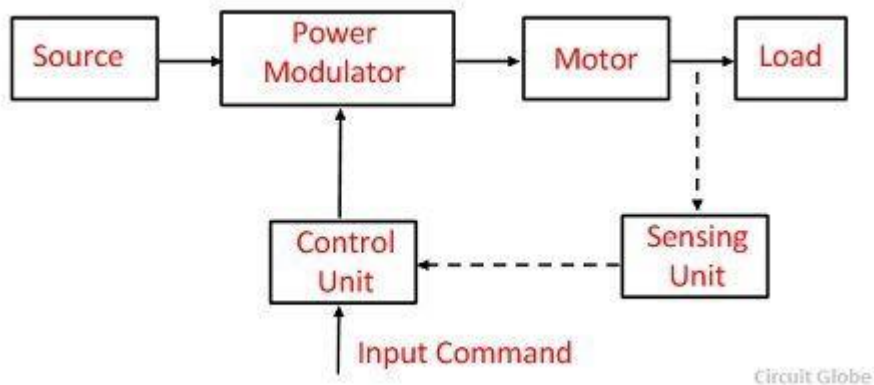
A combination of prime mover, transmission equipment and mechanical working load is called a drive.

**ELECTRIC DRIVE**

Electric drive: An Electric Drive can be defined as an electromechanical device for converting electrical energy to mechanical energy to impart motion to different machines and mechanisms for various kinds of process control

The system which is used for controlling the motion of an electrical machine, such type of system is called an electrical drive. In other words, the drive which uses the electric motor is called electrical drive. The electrical drive uses any of the prime movers like diesel or a petrol engine, gas or steam turbines, steam engines, hydraulic motors and electrical motors as a primary source of energy. This prime mover supplies the mechanical energy to the drive for motion control.

The block diagram of the electrical drive is shown in the figure below. The electrical load like fans, pumps, trains, etc., consists the electrical motor. The requirement of an electrical load is determined regarding speed and torque. The motor which suited the capabilities of the load is chosen for the load drive.



**2)List out some examples of prime movers.**

**ANS:**

1 a: an initial source of motive power (such as a windmill, waterwheel, turbine, or internal combustion engine) designed to receive and modify force and motion as supplied by some natural source and apply them to drive machinery

b: a powerful tractor or truck usually with all-wheel drive

2: the self-moved being that is the source of all motion

3: the original or most effective force in an undertaking or workeducation is ... a prime mover of cultural and societal change

Example of prime movers are Petrol engines, Diesel engines, gas or steam turbines, steam engines, hydraulic motors, and electric motors.

**3)List out some advantages of electric drives.**

**ANS:**

**Advantages of Electrical Drives**

- Enough overload capacity without loss of life of machine.
- Four quadrant operation.
- Modifiable torque-speed characteristics.
- No requirement of warming up period.
- Higher efficiency.
- Easy control.
- Clean operation, no pollution.
- Wide range of speed control.

**4)Give some examples of Electric Drives**

**ANS:**

Mechatronic systems comprise a large variety of electrical drives. ... Electrical power-generating machines, which are used to drive power-consuming machines, and electrical actuators (control motors, servo drives), which are employed to drive control valves, are typical example

series-wound motors; - shunt-wound motors; - permanent-field motors. - induction motors (asynchronous motors); - synchronous motors. - commutator motors (universal motors); - squirrel cage motors.

**5)What are the types of electric drives?**

**ANS:**

**Types of Electrical Drives**

- AC Motor drives.
- DC Motor drives.
- Individual.
- Multi Motor.
- Group Drive.
- Constant Speed drive.
- Variable Speed drive.
- Vector Control Drive.

**6)Classify electric drives based on the means of control.**

**ANS:**

**Manual,**

**Semiautomatic,**

**Automatic**

**Speed Control and Drive Classification:**

Speed Control and Drive Classification are the Drivers where the driving motor runs at a nearly fixed speed are known as Constant Speed or Single Speed Drives. Multi-speed drives are those which operate at discrete speed settings. Drives needing stepless change in speed and multispeed drives are called Variable Speed Drives. When a number of motors are fed from a common converter, or when a load is driven by more than one motor, the drive is termed as multi-motor drive.

Speed range of a variable speed drive depends on the application. In some applications it can be from rated speed to 10% of rated speed. In some other applications, speed control above rated speed is also desired, and the ratio of

maximum to minimum speed can be as high as 200. There are also applications where the speed range is as low as from rated speed to 80% of rated speed.

A variable speed drive is called constant torque drive if the drive's maximum torque capability does not change with a change in speed setting. The corresponding mode (or region) of operation is called Constant Torque Mode. It must be noted that the term 'Constant Torque' refers to maximum torque capability of the drive and not to the actual output torque, which may vary from no load to full load torque. The Constant Power Drive and Constant Power Mode (or region) are defined in the same way.

Ideally it is desired that for a given speed setting, the motor speed should remain constant as load torque is changed from no load to full load. In practice, speed drops with an increase in the load torque. Quality of a speed control system is measured in terms of speed-regulation which is defined as

$$\text{Speed regulation} = \frac{\text{No load speed} - \text{Full load speed}}{\text{Full load speed}} \times 100\% \quad (3.1)$$

If open-loop control fails to provide the desired speed regulation, drive is operated as a closed-loop speed control system.

## 7)What is a Group Electric Drive (Shaft Drive)?

**ANS:**

If several group of mechanisms or machines are organized on one shaft and driven or actuated by one motor, the system is called a group drive or shaft drive.

This drive consists of single motor, which drives one or more line Shafts supported on bearings. The line shaft may be fitted with either pulleys & belts or gears, by means of which a group of machines or mechanisms may be operated.

The Group Drive system uses a high powered motor which drives an overhead shaft called the main shaft by means of chain or belt. The main shaft runs across the workshop from one end to other ends. The main shaft drives another shaft called counter shaft. Finally, the countershaft drives the group of machines through belting and pulleys.

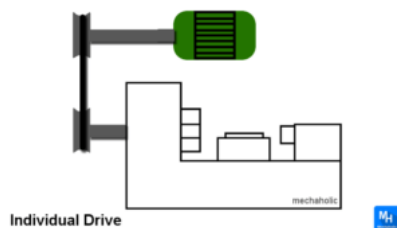


## 8)What is an individual electric drive?

**Ans**

If a single motor is used to drive or actuate a given mechanism and it does all the jobs connected with this load , the drive is called individual drive. ... Each motor is driven by its own separated motor with the help of gears , pulleys etc

In the Individual Drive system, each machine tool has its own electric motor which drives the machine through belt, chain, gearing or by direct coupling. The system is also called as a self-contained drive.



**9)What is a multi motor electric drive? Give some examples**

**ANS:**

a group of electric motors that are interconnected by a common control system and drive the working members of a machine or installation (for example, rolling mills, paper machines, composite metalworking machines, and walking excavators).

**10)What are the types Drive systems?**

**ANS:**

Types of Drives, Features and Principles (Motors And Drives)

**Mechanical.**

Mechanical variable-speed drives were probably the first type of drive to make their way into the industrial environment

**Hydraulic Drives.**

Hydraulic drives have been, and continue to be, the workhorse of many metals processing and manufacturing applications. The hydraulic motor's small size makes it ideal for situations where high power is needed in very tight locations..

**Eddy-Current Drives.**

Eddy-current drives have their roots in the heavy machinery part of industry. Grinding wheels are prime candidates for eddy-current drives. This system uses an AC-to-DC power-conversion process, which allows variable shaft speeds, depending on the amount of power converted

**Rotating DC Drives**

This system dates back to the mid 1940s. The system also gained the name M-G set, which stands for motor-generator set

**Electronic Drives (DC)**

DC drives have been the backbone of industry, dating back to the 1940s. At that time, vacuum tubes provided the power conversion technology. Vacuum tubes led to solid-state devices in the 1960s. The power conversion device, called the silicon controlled rectifier (SCR), or thyristor, is now used in modern electronic DC drives

## **Electronic Drives (AC)**

Basically, three types of AC drive technologies are currently available. Though each type differs in the way power is converted, the end result is the use of a variable-speed AC induction motor. All AC drives take AC input, convert it to DC, and change DC to a variable AC output, using a device called an inverter (i.e., inverts DC back to AC voltage). For purposes of this section, we will confine our discussion to a generic AC drive.

### **11)How heating occurs in motor drives?**

#### **ANS:**

The heating of motor due to losses occurring inside the motor while converting the electrical power into mechanical power and these losses occur in steel core, motor winding & bearing friction.

Your electric motor is a complex machine and requires a careful balance of environmental and supportive factors to run smoothly. Overheating in an electric motor can happen for a variety of reasons.

The most common causes of overheating include:

**An unsuitable motor:** Motors come in a range of sizes. Choose a motor that can cope with the preferred voltage and performance level necessary for your project. A motor that's too large can waste expensive energy, and a motor that's too small will be unable to handle an excessive workload — leading to greater stress and heat.

**The wrong voltage supply:** Too many volts or too few volts can be damaging to a motor. When your motor doesn't have the right voltage support, it needs to work harder to perform, which causes parts to overheat.

**A poor surrounding environment:** A motor needs room to breathe so it can perform at its best. If your machine is running in a hot environment, it will struggle to cool down quickly. Give the motor plenty of space to operate.

**Improper use:** Some motors can run consistently, whereas others are intended for intermittent use. Make sure that you only use your motor according to its specifications. If you attempt to run an intermittent duty motor for too long, it won't have the time it needs to cool down between cycles.

**Altitude:** The location of your company can have an impact on your motor performance. Your machine might not cool as efficiently at higher elevations because the air is thinner. It's important to choose a motor that's rated for your workshop's location.

**A lack of ventilation:** If there is something blocking the ventilation holes for your electric motor, then hot air won't escape and will build up within the system, causing damage. Scheduling regular maintenance on your motor can help reduce this risk.

**12)What are the classes of duties?**

**ANS**

Continuous duty.

Short time duty.

Intermittent periodic duty.

Intermittent periodic duty with starting.

Intermittent periodic duty with starting and braking.

Continuous duty with intermittent periodic loading.

Continuous duty with starting and braking.

**13)How will you classify electric drives based on the method of speed control?**

**ANS:**

Electrical Drives are classified into two types based on running speed namely Constant speed drives & changeable speed drives.

Constant speed drive consists essentially of a hydraulic transmission with mechanical controls governing the output rotation speed. The transmission is capable of either adding to or subtracting from the speed received from the gearbox in order to provide constant output speed to keep the generator on frequency

Variable speed drives (VSDs), also called adjustable speed drives (ASDs), are devices that can vary the speed of a normally fixed speed motor. In HVAC systems, they are used primarily to control fans in variable air volume systems instead of other devices such as inlet vanes and discharge dampers.



**14)What is meant by “short time rating of motor”?**

**ANS:**

A short time rating of an electric motor can be defined as the extrapolated overload rating of the motor which it can supply for the specified short time without getting overheated. ... Sometimes it may be required to estimate the time of operation of a given motor of continuous rating  $P_r$  to drive the load  $P$ .

**15)What is meant by “load equalization”?**

**ANS:**

It is desirable to smooth out the fluctuating load, otherwise during intervals of peak load it will draw a heavy current from the supply either producing large voltage drop in the system or requiring cables and wires on heavy section. The process of smoothing out the fluctuating load is known as load equalization.

**16) Explain the factors governing the selection of motors.**

**ANS:**

Nature of electric supply

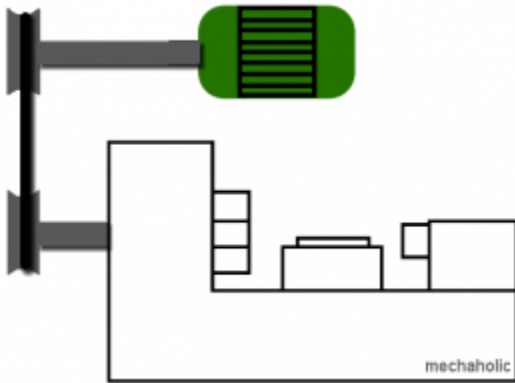
Whether supply available is A.C. (single phase or three phase) or D.C. (pure D.C. or rectified A.C.)to be utilized for motor.



Nature of electric supply

Nature of the drive

Whether motor is to drive individual machine or a group of machines.



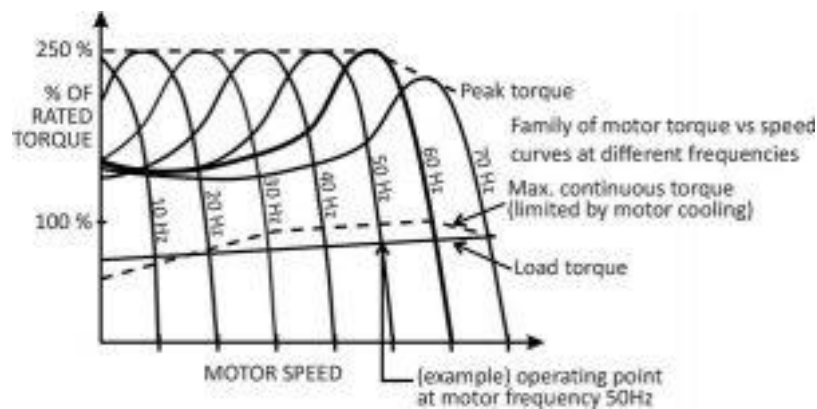
Individual drive

Nature of load

Whether the load requires light or heavy starting torque.

Whether load torque increases with speed or remains constant.

Whether load has heavy inertia, which may required long starting time.



Motor speed

Electrical characteristics of motor

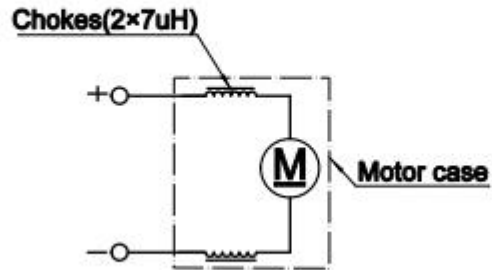
Starting characteristics.

Running characteristics.

Speed control.

Braking characteristics.

Motor Circuit:



Electrical characteristics of motor

Size and rating of the motor

whether motor is to run continuously intermittently or on load cycle.

Whether over load capacity and pull torque are sufficient.



Motor

Mechanical considerations

Type of enclosures.

Type of bearings.

Transmission of drive

Noise level



Mechanical considerations (motor-maintenance)

Cost

Capital cost.

Running cost.

**17) Write a brief note on classes of duty for an electric motor.**

**ANS:**

Now a days, in almost every applications, electric motors are used, and to control them electrical drives are employed. But the operating time for all motors are not the same. Some of the motors runs all the time, and some of the motor's run time is shorter than the rest period. Depending on this, concept of motor duty class is introduced and on the basis of this duty cycles of the motor can be divided in eight categories such as

### **Continuous duty**

It denotes the motor operation at a constant load torque for a duration long enough for the motor temperature to reach steady-state value. This duty is characterised by a constant motor loss. Paper mill drives, compressors, conveyers, centrifugal pumps and fans are some examples of Classes of Motor Duty in Electrical Drives.

### **Short time duty**

In this, time of drive operation is considerably less than the heating time constant and machine is allowed to cool off to ambient temperature before the motor is required to operate again. In this operation, the machine can be overloaded until temperature at the end of loading time reaches the permissible limit. Some

examples are: crane drives, drives for household appliances, turning bridges, sluice-gate drives, valve drives, and many machine tool drives for position control.

**Intermittent periodic duty**

It consists of periodic duty cycles, each consisting of a period of running at a constant load and a rest period. Neither the duration of running period is sufficient to raise the temperature to a steady-state value, nor the rest period is long enough for the machine to cool off to ambient temperature. In this Classes of Motor Duty in Electrical Drives, heating of machine during starting and braking operations is negligible. Some examples are pressing, cutting and drilling machine drives.

**Intermittent periodic duty with starting**

This is intermittent periodic duty where heat losses during starting cannot be ignored. Thus, it consists of a period of starting, a period of operation at a constant load and a rest period; with operating and rest periods, being too short for the respective steady-state temperatures to be attained.

In this duty, heating of machine during braking is considered to be negligible, because mechanical brakes are used for stopping or motor is allowed to stop due to its own friction. Few examples are metal cutting and drilling tool drives, drives for fork lift trucks, mine hoist etc.

**Intermittent periodic duty with starting and braking**

This is the intermittent periodic duty where heat losses during starting and braking cannot be ignored. Thus, it consists of a period of starting, a period of operation with a constant load, a braking period with electrical braking and a rest period; with operating and rest periods being too short for the respective steady state temperatures to be attained.

Billet mill drive, manipulator drive, ingot buggy drive, schrewdown mechanism of blooming mill, several machine tool drives, drives for electric suburban trains and mine hoist are some examples of this duty.

**Continuous duty with intermittent periodic loading**

It consists of periodic duty cycles, each consisting of a period of running at a constant load and a period of running at no load, with normal voltage across the excitation winding. Again the load period and no load period being too short for the respective temperatures to be attained. This Classes of Motor Duty in Electrical

Drives is distinguished from the intermittent periodic duty by the fact that a period of running at a constant load is followed by a period of running at no load instead of rest. Pressing, cutting, shearing and drilling machine drives are the examples.

### **Continuous duty with starting and braking**

Consists of periodic duty cycle, each having a period of starting, a period of running at a constant load and a period of electrical braking; there is no period of rest. The main drive of a blooming mill is an example.

### **Continuous duty with periodic speed changes**

Consists of periodic duty cycle, each having a period of running at one load and speed, and another period of running at different speed and load; again both operating periods are too short for respective steady-state temperatures to be attained. Further there is no period of rest.

## **18) Explain in detail about the various types of electric drives**

**ANS:**

### **Classification of Electrical Drives**

Usually, these are classified into three types such as group drive, individual drive, and multi-motor drive. Additionally, these drives are further categorized based on the different parameters which are discussed below.

- Electrical Drives are classified into two types based on supply namely AC drives & DC drives.
- Electrical Drives are classified into two types based on running speed namely Constant speed drives & changeable speed drives.
- Electrical Drives are classified into two types based on a number of motors namely Single motor drives & multi-motor drives.
- Electrical Drives are classified into two types based on control parameter namely stable torque drives & stable power drives.

**19) Explain the different types of loading of drives**

**ANS:**

It is very important that you consider the type of load that is being put on each electric motor, as this can affect the opportunity for energy saving.

The three main electric motor load types are:

Variable-torque loads - eg fans and pumps where the speed varies. With this type of load, reducing the speed of the motor by even a small amount can save a lot of energy.

Constant-torque loads - eg conveyors, screw and reciprocating compressors, and crushers. With these loads, the amount of power consumed is in direct proportion to the useful work done. So halving the speed will halve the energy consumed.

Constant-power loads - eg machine tools and centre winders. With these loads, the power is constant so there will rarely be energy savings when the speed is reduced.

**20) Why a single phase induction motor does not self start?**

**ANS:**

When single-phase AC supply is given to stator winding. It produces alternating flux. ... It is not synchronously revolving (or rotating) flux, as in case of 3 phase stator winding, the field cannot produce rotation. Hence single phase induction motor is not self-starting.

**21) What is meant by plugging?**

**ANS:**

Induction motors are one of the major power-consuming load on the planet today and are widely used for all industrial and domestic applications. Plugging is one of the braking technique performed in the induction motors. Dynamic braking and regenerative braking are the other two braking methods.

Plugging is the method of inducing negative torque in the rotor of an induction motor to rapidly bring its speed of rotation to zero. This is done by reversing the supply connection at the stator terminals.

**22) Give some applications of DC motor**

**ANS:**

DC series motor is suitable for both high and low power drives, for fixed and variable speed electric drives. This type of motor has simple construction. Also, it is easy for design and maintenance.

Because of its high starting torque, this motor uses in the cheap toys and automotive applications such as,

Cranes

Air compressor

Lifts

Elevators

Winching system

Electric traction

Hair drier

Vacuum cleaner and in speed regulation application

Power tools

Sewing machine

Electric footing

**23) What are the different types of electric braking?**

**ANS:**

The electric braking of a DC motor is of three types, (i) Rheostatic or dynamic braking, (ii) Plugging or reverse current braking and (iii) Regenerative braking.

**(i) Rheostatic or dynamic braking:**

In case of DC shunt motors, armature is disconnected from the supply and a rheostat (variable resistor) is connected across it. The field winding is left connected across the supply. Obviously, now armature is driven by the inertia and hence machine starts acting as a generator. Thus the machine will now feed the current to the connected rheostat and heat will dissipate at the rate of  $I^2R$ . Braking



effect is controlled by varying the resistance connected across the armature. In case of DC series motor, motor is disconnected from the supply and field connections are reversed and a rheostat is connected in series. The field connections are reversed to make sure that the current through field winding will flow in the same direction as before.

### **(ii) Plugging or Reverse current braking:**

In this method, armature connections are reversed and hence motor tends to run in opposite direction. Due to reversal of the armature terminals, applied voltage  $V$  and back emf  $E_b$  starts acting in the same direction and hence the total armature current exceeds. To limit this armature current a variable resistor is connected across the armature. This is similar for both series and shunt wound methods. Plugging gives greater braking torque as compared to rheostatic braking. This method is generally used in controlling elevators, machine tools, printing presses etc.

### **(iii) Regenerative braking:**

Regenerative braking is used where, load on the motor has very high inertia (e.g in electric trains). When applied voltage to the motor is reduced to less than back emf  $E_b$ , obviously armature current  $I_a$  will get reversed, and hence armature torque is reversed. Thus speed falls. As generated emf is greater than applied voltage (machine is acting as a DC generator), power will be returned to the line, this action is called as regeneration. Speed keeps falling, back emf  $E_b$  also falls until it becomes lower than applied voltage and direction of armature current again becomes opposite to  $E_b$ .

**24) Define synchronous speed****ANS:**

A definite speed for an alternating-current machine that is dependent on the frequency of the supply circuit because the rotating member passes one pair of poles for each alternation of the alternating current

Or

The synchronous speed is the speed of the revolution of the magnetic field in the stator winding of the motor. It is the speed at which the electromotive force is produced by the alternating machine

**25) Why a single phase induction motor does not self start?****ANS:**

When single-phase AC supply is given to stator winding. It produces alternating flux, i.e. which alternates along one space axis only. It is not synchronously revolving (or rotating) flux, as in case of 3 phase stator winding, the field cannot produce rotation. Hence single phase induction motor is not self-starting.

To overcome this problem and to make the motor self-starting, it is temporarily converted into two-phase motor during starting. For this purpose, the stator of 1 phase motor is provided with extra winding known as starting winding in addition to the main winding. These two windings are placed across the single phase supply.

This winding is so arranged that the phase difference between the currents in the two stator windings is very large. Hence motor behaves like a two-phase motor. The two currents produce a revolving flux and this makes the 1  $\phi$  motor self-starting.

**26)Mention the Starters used to start a DC motor.****ANS:**

There are various types of dc motor starters, such as 3 point starter, 4 point starter, no-load release coil starter, thyristor controller starter etc. The basic concept behind every DC motor starter is adding external resistance to the armature winding during starting.

**3 Point Starter**

When the connected dc motor is to be started, the lever is turned gradually to the right. When the lever touches point 1, the field winding gets directly connected across the supply, and the armature winding gets connected with resistances  $R_1$  to  $R_5$  in series. During starting, full resistance is added in series with the armature winding. Then, as the lever is moved further, the resistance is gradually is cut out from the armature circuit. Now, as the lever reaches to position 6, all the resistance is cut out from the armature circuit and armature gets directly connected across the supply. The electromagnet 'E' (no voltage coil) holds the lever at this position. This electromagnet releases the lever when there is no (or low) supply voltage.

It can be seen that, when the arm is moved from the position 1 to the last position, the starter resistance gets added in series with the field winding. But, as the value of starter resistance is very small as compared to the shunt resistance, the decrease in shunt field current may be negligible. However, to overcome this drawback a brass or copper arc may be employed within a 3 point starter which makes a connection between the moving arm and the field winding, as shown in the figure of 4 point starter below.

When the motor is overloaded beyond a predefined value, 'overcurrent release electromagnet' D gets activated, which short-circuits electromagnet E and, hence, releases the lever and the motor is turned off.

### **4 Point Starter**

The main difference between a 3 point starter and a 4 point starter is that the no voltage coil (electromagnet E) is not connected in series with the field coil. The field winding gets directly connected to the supply, as the lever moves touching the brass arc (the arc below the resistance studs). The no voltage coil (or Hold-on coil) is connected with a current limiting resistance  $R_h$ . This arrangement ensures that any change of current in the shunt field does not affect the current through hold-on coil at all. This means, electromagnetic pull of the hold-on coil will always be sufficient so that the spring does not unnecessarily restore the lever to the off position. A 4 point starter is used where field current is to be adjusted by means of a field rheostat for the purpose of operating the motor above rated speed by reducing the field current.

### **DC Series Motor Starter**

Construction of DC series motor starters is very basic as shown in the figure. The start arm is simply moved towards right to start the motor. Thus, maximum resistance is connected in series with the armature during starting and then gradually decreased as the start arm moves towards right. This starter is sometimes also called as a 2 point starter.

The no load release coil holds the start arm to the run position and leaves it when the voltage is lost.

### **27)Mention the Starters used to start an Induction motor.**

**ANS:**

Starting methods of Induction motor include: Direct –On– line (DOL) starters for less than 10 Kw motors. Star–Delta starters for large motors. The stator winding is initially connected in a star configuration and later on changed over to a Delta connection, when the motor reaches rated speed.

### **28)Why motor take heavy current at starting?**

**ANS:**

At start, the reactance of the rotor is high because the slip of the motor is equal to unity. The value of  $R_r/s$  increase as the slip gets decrease. When the induction motor is started the rotor reactance is more than the rotor resistance and because of the large  $X_r/R_r$  ratio the motor takes large inductive current.

**29)What are the 3 ways of field control in DC series motor?**

**ANS:**

Resistance variation in the armature circuit: This method is called armature resistance control or Rheostat control.

Variation of field flux  $\Phi$  This method is called field flux control.

Variation of the applied voltage.

**30)Give the Limitation of field control**

**ANS:**

Field controlled DC motors are easy and hassle-free, which makes them a popular choice for motor operators and manufacturers. On the other hand, there are certain cases when a different motor control method may be more effective.

Disadvantages of field control include:

Limits on speed: If your application requires you to adjust the motor below the normal speed, you may be better off choosing an armature controlled method. Field controlled DC motors can only operate above the normal speed. Higher speeds can also result in less torque.

Reduced stability: The field control method allows operators to obtain higher speeds than the norm. Yet its overall range can be lowered due to a lack of stability. With a weaker field, you may only be able to safely exceed certain speeds.