GOVT CO-ED POLYTECHNIC

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LAB MANUAL

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CONTENTS

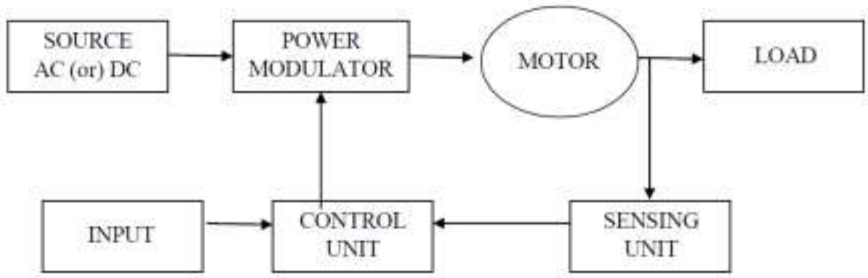
Experiment No: 1

AIM: To identify different drives used in material handling system.

Theory:

Materials handling is the movement and storage of materials at the lowest possible cost by using proper methods and equipment. In any industry, be it big or small, involving manufacturing or construction type work, materials have to be handled as raw materials, intermediate goods or finished products from the point of receipt and storage of raw materials, through production processes and up to finished goods storage and dispatch points.

The basic block diagram for electrical drives used for the motion control is shown in the following figure



1. **Load:** usually a machinery to accomplish a given task. E.g.-fans, pumps, washing machine etc.
2. **Power modulator:** modulators (adjust or convert) power flow from the source to the motion
3. **Motor:** actual energy converting machine (electrical to mechanical)
4. **Source:** energy requirement for the operation the system.
5. **Control:** adjust motor and load characteristics for the optimal mode.

The choice of the electric drives can be done on the following grounds:

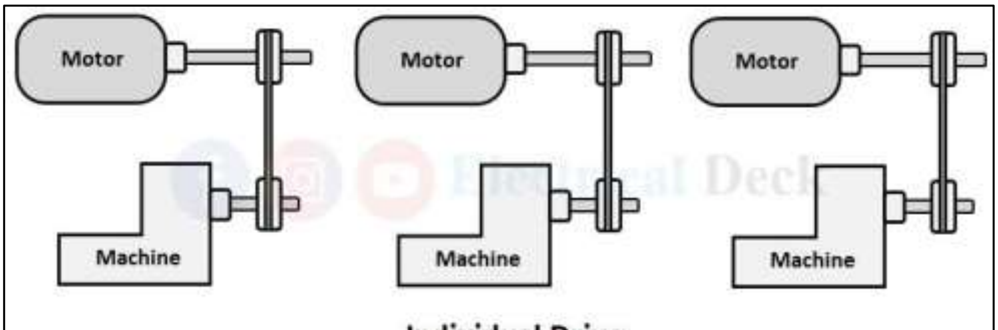
1. Group drive
2. Individual drive
3. Multi-motor drive

1. **Group drive:** One motor is used as a drive for two or more than machines. The motor is connected to a long shaft. All the other machines are connected to this shaft through belt and pulleys.
2. **Individual drive:** In this drive, there will be a separate driving motor for each process equipment. One motor is used for transmitting motion to various parts or mechanisms belonging to signal equipment. Ex: Lathe, as one motor used in lathe which rotates the spindle, moves feed with the help of gears and imparts motion to the lubricating and cooling pumps.

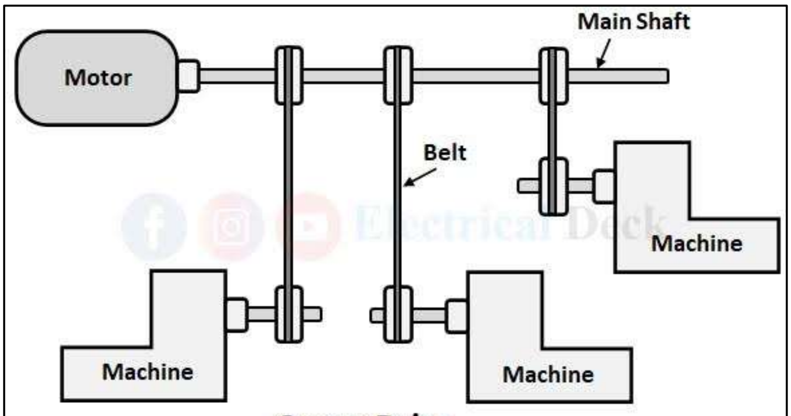
3. **Multi-motor drive:** In this type of drive, separate motors are provided for actuating different parts of the driven mechanism. Ex: cranes, drives used in paper mills, rolling mills etc., In cranes, separate motors are used for hoisting, long travel motion and cross travel motion.

Classification of Loads

- Torque dependent on speed (Ex-hoists, pumping of water or gas against constant pressure)
- Torque linearly dependent on speed (Ex- motor driving a DC generator connected to a fixed resistance load [generator field value is kept constant])
- Torque proportional to square of speed (Ex- fans, centrifugal pumps, propellers)
- Torque inversely proportional to speed (Ex-milling and boring, machines)



Individual Drive



Group Drive

Result:

Thus, different drives used in material handling system has been studied successfully.

Experiment No: 2

AIM: To determine Torque/speed and Torque/current characteristics of DC motor.

Theory:

The performance of a DC motor is given by the relation among the armature current, torque and speed. These relations are given graphically in the form of curves, which are called as characteristics of DC motors. These characteristics show the behavior of the DC motor under different load conditions.

Speed and Torque Characteristics
The graph plotted between the speed (N) and the armature torque (τ_a) for a DC motor is known as the speed-torque characteristics. It is also known as mechanical characteristics of DC motor.

Torque and Armature Current Characteristics
It is the graph plotted between the armature torque (τ_a) and the armature current (I_a) of a DC motor. It is also known as electrical characteristics of the DC motor.

Characteristics of DC Shunt Motor

The shunt motors are the constant flux machines i.e. their magnetic flux remains constant because their field winding is directly connected across the supply voltage which is assumed to be constant.

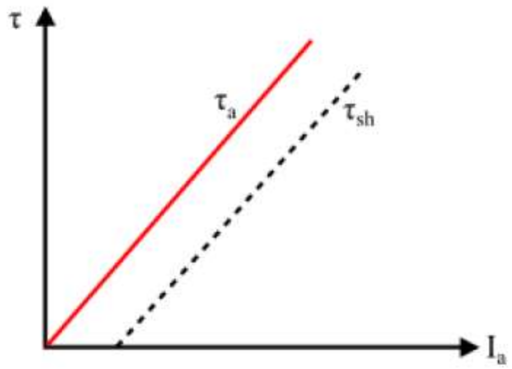
Torque and Armature Current Characteristics
The armature torque in a DC motor is directly proportional to the flux and the armature current, i.e.,

$$\tau_a \propto \varphi I_a$$

In case of a shunt motor, the flux is also constant. Therefore,

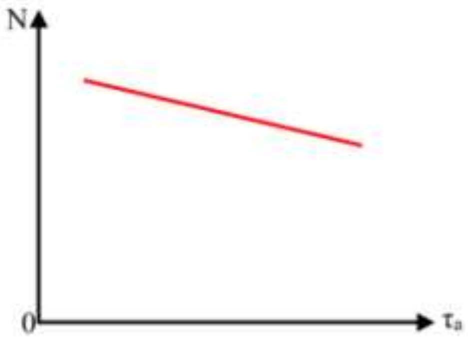
$$\tau_a \propto I_a$$

Hence, the torque and armature current characteristics of DC shunt motor is straight line passing through the origin (see the figure). The shaft torque is less than the armature torque which is represented by the dotted line.
From the characteristics, it can be seen that a very large current is required to start a heavy load. Thus, the shunt motor should not be started on heavy loads.



Speed and Torque Characteristics

This is the curve plotted between the speed and the torque for various armature currents. It can be seen that the speed of the shunt motor decreases as the load torque increases.



Characteristics of DC Series Motor

In a DC series motor, the field winding is connected in series with the armature and hence carries the full armature current. When the load on shaft of the motor is increased, the armature current also increases. Hence, the flux in a series motor increases with the increase in the armature current and vice-versa.

Torque and Armature Current Characteristics

The armature torque in a DC motor is directly proportional to the flux and the armature current, i.e.,

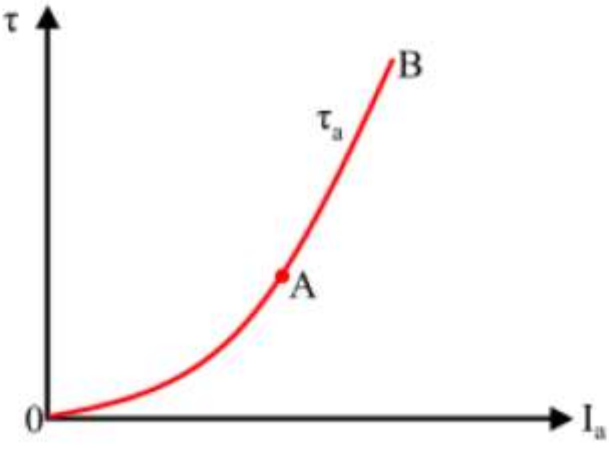
$\boldsymbol{\tau_a \propto \varphi I_a}$

Upto magnetic saturation, $\boldsymbol{\varphi \propto I_a}$

so that $\boldsymbol{\tau_a \propto (I_a)^2}$

After magnetic saturation,

$\boldsymbol{\Phi}$ becomes constant, so that, $\boldsymbol{\tau_a \propto \varphi I_a}$



Therefore, up to magnetic saturation, the armature torque is directly proportional to the square of the armature current. Hence, the torque versus armature current curve up to magnetic saturation is a parabola (part OA of the curve).

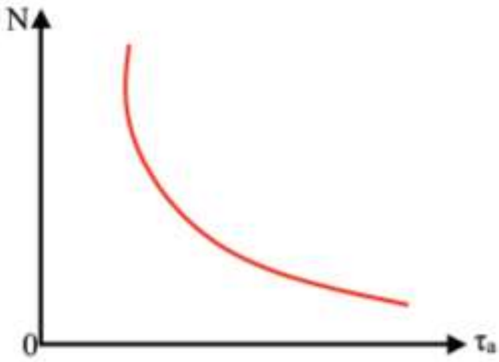
After the magnetic saturation, the armature torque is directly proportional to the armature current. Hence, torque versus armature current curve after magnetic saturation is a straight line(Part AB of the curve).From the torque versus armature current curve, it is clear that the starting torque of a DC series motor is very high.

Speed and Torque Characteristics

The speed torque characteristics of a DC series motor can be obtained from its speed-armature current and torque-armature current characteristics as follows

For a given value of I_a determine τ from the torque-armature current curve and N from the speed-armature current curve. This will give a point (τ ,N) on speed-torque curve. Repeat this procedure for different values of armature current and determine the corresponding values of speed and torque (τ , N), (τ , N) etc.

When these points are plotted on the graph, we obtain the speed and torque characteristics of a DC series motor as shown in the figure below.



It is clear from the characteristics that the series motor has high torque at low speed and vice versa. Thus, the series DC motor is used where high starting torque is required.
At no-load, the armature current is very small and so is the flux. Hence, the speed increases to a dangerously high value which can damage the machine. Therefore, a series motor should never be started on no-load.

Result:

Thus, the torque v/s speed and torque v/s current characteristics of DC motor has been studied successfully.

Experiment No: 3

AIM: To determine Torque/speed and Torque/slip characteristics of three phase induction motor.

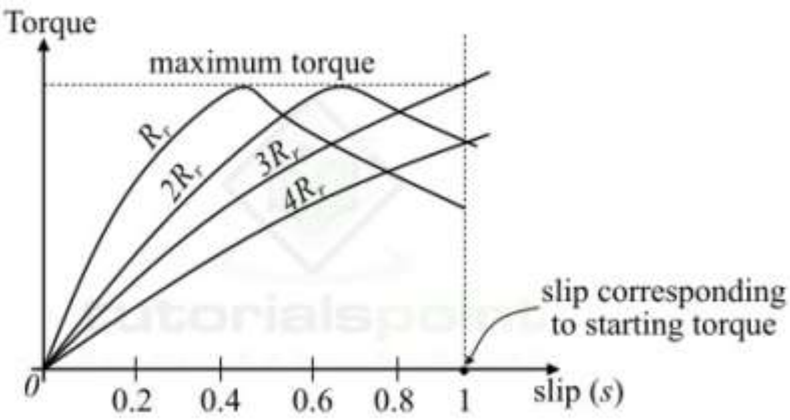
Theory:

The operating performance of a three-phase induction motor can be explained with the help of the following two characteristics namely,

- Torque-Slip Characteristics
- Torque-Speed Characteristics

Torque-Slip Characteristics

The **torque-slip characteristics** of a three-phase induction motor is the curve drawn between the motor torque and slip for a particular value of rotor resistance. Figure below shows different torque-slip characteristics of a typical three-phase induction motor for a slip range from *s* = 0 to *s*= 1 for various values of rotor resistance.



For a three-phase induction motor, the relation between the motor torque and slip under running condition is given by,

$$\tau_r = \frac{KsR_r}{R_r^2 + s^2 X_r^2} \quad \text{…………….. (1)}$$

Where, K is a constant, *s* is the slip, R_r is the per phase rotor resistance, and X_r is the standstill rotor reactance per phase.

From Equation-1, we may conclude the following points –

Case 1: If *s* = 0, then $\tau_r = 0$. Therefore, the torque-slip curve starts from the origin.

Case 2: At normal speed of the motor, the slip is small, and thus sX_r is practically negligible as compared to R_r.

$$\therefore \tau_r \propto \frac{s}{R_r}$$

Since for a given motor *Rr* is also constant.

$$\therefore \tau_r \propto s$$

Thus, the torque-slip curve is a straight line from zero slip to a slip that corresponds to full load.

Case 3: If slip value exceeds the full-load slip, then torque increases and becomes maximum when $R_r = sX_r$. This maximum torque in a three-phase induction motor is known as **breakdown torque** or **pull-out torque**. The value of the breakdown torque is at least double of the full-load torque when the induction motor is operated at rated voltage and frequency.

Case 4: When the slip value becomes greater than that corresponding to the maximum torque, then the term $(sX_r)^2$ increases rapidly so that $(R_r)^2$ may be neglected.

$$\therefore \tau_r \propto \frac{s}{s^2 X_r^2}$$

As $(X_r)^2$ is practically constant, then

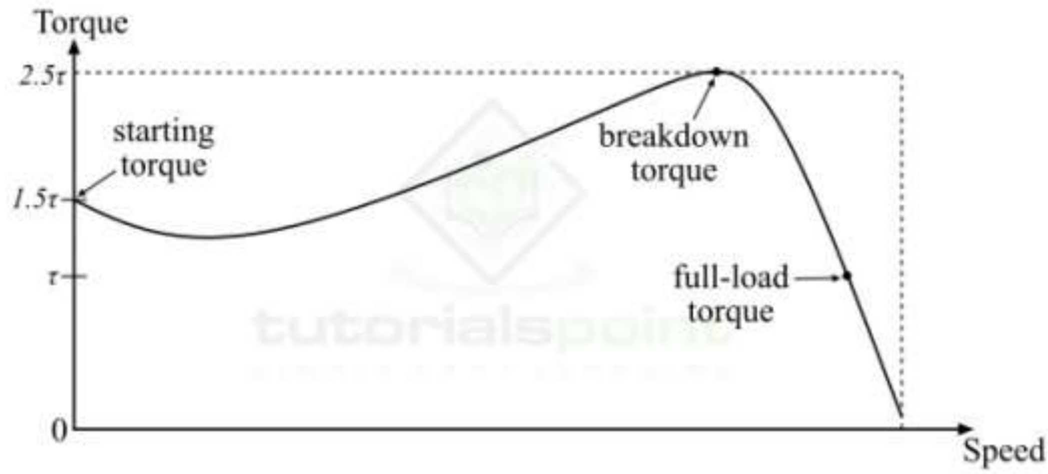
$$\tau_r \propto \frac{1}{s}$$

Hence, the torque is now inversely proportional to the slip. Thus, the torque-slip curve is a *rectangular hyperbola*. Therefore, from the above analysis of torque-slip characteristics of a three-phase induction motor it is clear that the addition of resistance to the rotor circuit does not change the value of maximum torque, but it only changes the value of slip at which the maximum torque occurs.

Torque-Slip Characteristics

For a three-phase induction motor, the motor torque depends upon the speed and following points may be noted from this characteristic curve

- If the full-load torque is **τ,** then the starting torque is 1.5τ and the maximum torque (or breakdown torque) is 2.5τ.



- At full-load, if speed of the motor is N, and if the mechanical load on the shaft increases, the speed of the motor will drop until the motor torque is again equal to the load torque. Once the two torques are equal, the motor will run at a constant speed but lower than the previous. Although, if the motor torque becomes greater than 2.5τ (i.e. breakdown torque), the motor will suddenly stop.

- For a three-phase induction motor, the torque-speed curve is essentially a straight line between the points of no-load and full-load. The slope of the curve line depends upon the resistance of the rotor circuit, i.e., greater the resistance, the sharper the slope.

Result:

Thus, Torque v/s speed and Torque v/s slip characteristics of three phase induction motor have been studied successfully.

Experiment No: 4

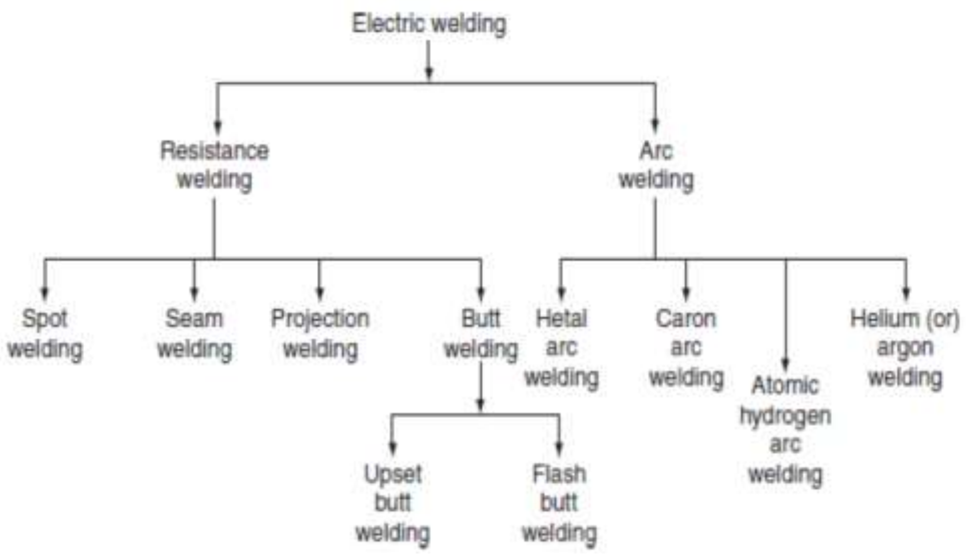
AIM: To compare various types of supply required for different types of welding.

Theory:

Welding is the process of joining two pieces of metal or non-metal together by heating them to their melting point. Filler metal may or may not be used to join two pieces.
The physical and mechanical properties of a material to be welded such as melting temperature, density, thermal conductivity, and tensile strength take an important role in welding. Depending upon how the heat applied is created; we get different types of welding such as thermal welding, gas welding, and electric welding.

ELECTRIC WELDING

It is defined as the process of joining two metal pieces, in which the electrical energy is used to generate heat at the point of welding in order to melt the joint. The classification of electric welding process can be shown below



The classification of each welding type is discussed below:

<u>RESISTANCE WELDING</u>

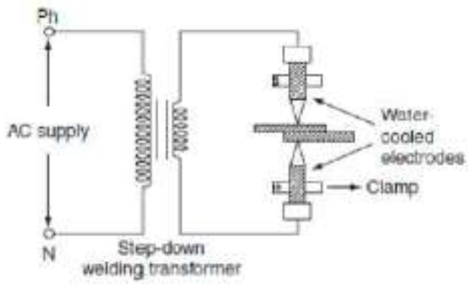
Resistance welding is the process of joining two metals together by the heat produced due to the resistance offered to the flow of electric current at the junctions of two metals. The heat produced by the resistance to the flow of current is given by:

$$H = I^2 Rt$$

Where, I is the current through the electrodes, R is the contact resistance of the interface, and t is the time for which current flows.

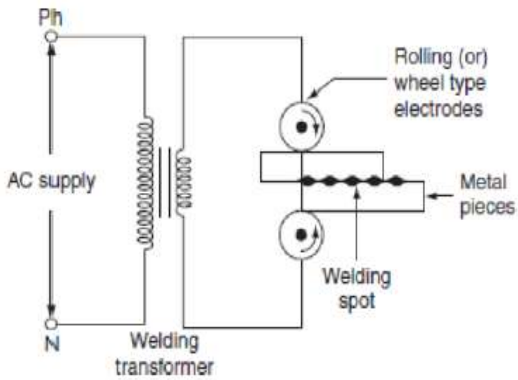
Depending upon the method of weld obtained and the type of electrodes used, the resistance welding is classified as:
1. Spot welding.
2. Seam welding.
3. Projection welding.

1. **Spot Welding**



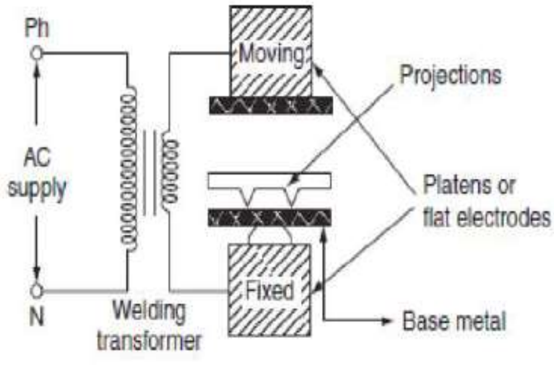
Spot welding means the joining of two metal sheets and fusing them together between copper electrode tips at suitably spaced intervals by means of heavy electric current passed through the electrodes. (See in Figure)
This type of joint formed by the spot welding provides mechanical strength and not air or water tight, for such welding it is necessary to localize the welding current and to apply sufficient pressure on the sheet to be welded. The welding current varies widely depending upon the thickness and composition of the plates. It varies from 1,000 to 10,000 A, and voltage between the electrodes is usually less than 2 V.

2. **Seam Welding**



Seam welding is nothing but the series of continuous spot welding. If number spots obtained by spot welding are placed very closely that they can overlap, it gives rise to seam welding. In this welding, continuous spot welds can be formed by using wheel type or roller electrodes instead of tipped electrodes. When these wheel type electrodes travel over the metal pieces which are under pressure, the current passing between them heats the two metal pieces to the plastic state and results into continuous spot welds.

3. **Projection Welding**



In the projection welding, both current and pressure are localized to the welding points as in the spot welding. But the only difference in the projection welding is the high mechanical pressure applied on the metal pieces to be welded, after the formation of weld. The electrodes used for such welding are flat metal plates known as platens.

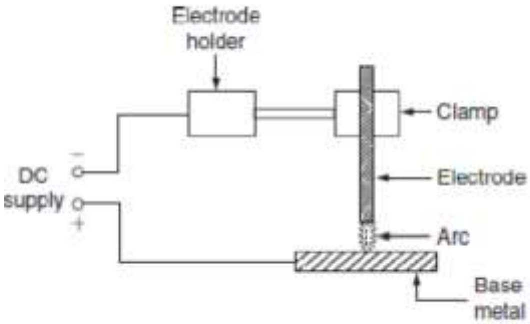
ARC WELDING

Electric arc welding is the process of joining two metallic pieces or melting of metal is obtained due to the heat developed by an arc struck between an electrode and the metal to be welded or between the two electrodes as shown In this process, an electric arc is produced by bringing two conductors (electrode and metal-piece) connected to a suitable source of electric current, momentarily in contact and then separated by a small gap, arc blows due to the ionization and give intense heat. This type of welding is also known as *'non-pressure welding'.*

Depending upon the method of weld obtained and the type of electrodes used, the electric arc welding is classified as:
1. Carbon arc welding.
2. Metal arc welding.
3. Atomic hydrogen arc welding.

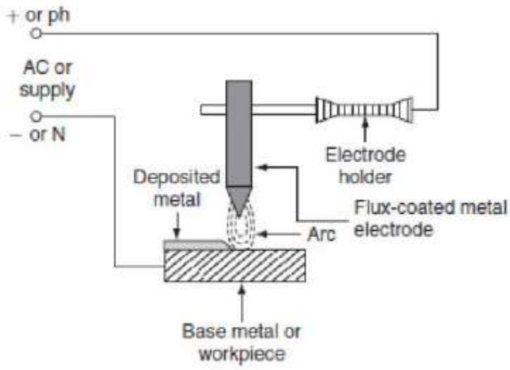
1. Carbon arc welding.

In this process of welding, two carbon electrodes are placed in an electrode holder used as negative electrode and the base metal being welded as positive. Unless, the electrode is negative relative to the work, due to high temperature, there is a tendency of the particles of carbon will fuse and mix up with the base metal, which causes brittleness; DC is preferred for carbon arc welding since there is no fixed polarity maintained in case of AC.



2. Metal arc welding

In metal arc welding, the electrodes used must be of the same metal as that of the work-piece to be welded. The electrode itself forms the filler metal. An electric arc is stuck by bringing the electrode connected to a suitable source of electric current, momentarily in contract with the work-pieces to be welded and withdrawn apart. The circuit diagram for the metal arc welding is shown in Figure.



<u>Comparison Between Resistance & Arc Welding</u>

Resistance Welding	***Arc Welding***
The source of supply is AC only	The source of supply is either AC (1-ø , 3-ø) or DC
The head developed is mainly due to flow of current through contact resistance.	The head developed is mainly due to striking of arc between electrodes or an electrode and the work-piece.
The temperature attained by the workpiece is not so high.	The temperature of the arc is so high, so proper care should be taken during the welding.
External pressure is required.	No external pressure is required hence the welding equipment is more simple and easy to control.
Filler metal is not required to join two metal pieces.	Suitable filler electrodes are necessary to get proper welding strength
It cannot be used for repair work; it is suitable for mass production	It is not suitable for mass production. It is most suitable for repair works and where more metal is to be deposited
The power consumption is low	The power consumption is low
The operating power factor is low	The operating power factor is high
Bar, roller or flat type electrode are used (not consumable)	Coated or bare electrodes are used (consumable or non-consumable)

Result:

Thus, various types of welding and their source of supply for welding have been studied successfully.

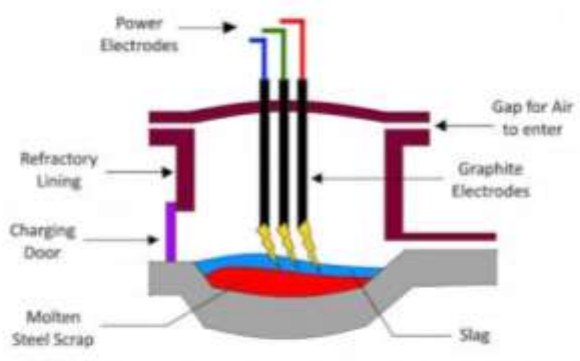
Experiment No: 5

AIM: To draw the basic circuit for electric arc furnace showing the arrangements of OCBs, control panels, CTs through relays, furnace transformer and arrangement of electrode movement.

Theory:

An electric arc furnace is a furnace that heats a material by means of electric arc. In electric arc furnace the charged material heating is directly exposed to an electric arc and the current from the furnace terminals passes through the charged material. Arc furnaces differ from the induction furnaces, in which the charge is heated instead by eddy currents.

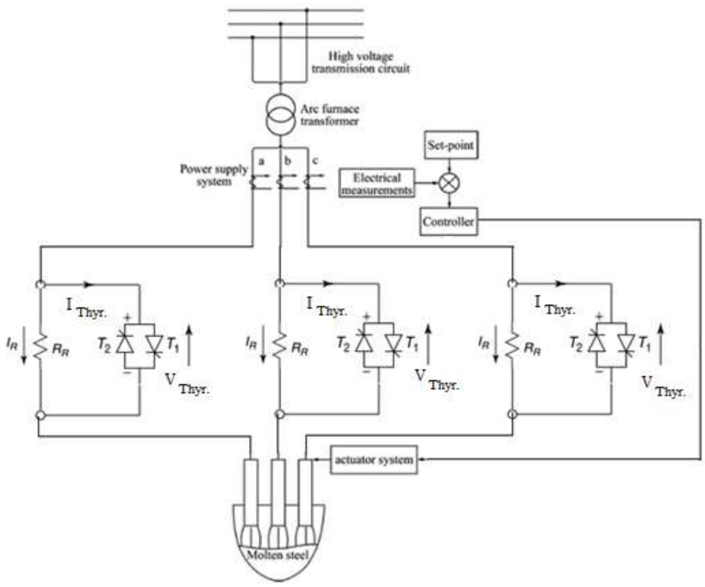
An electric arc furnaces used for steelmaking consists of a refractory-lined vessel, usually water cooled in larger sizes.



Process:

- The charge is put into the furnace.
- A powerful electric current arc developsbetween the electrodes that produces intense heat.
- The charge melts and chemical reactions produces steel.
- Alloying materials are added.
- The furnace is tipped to pour out the motion steel.

Circuit Diagram:



Result:

Thus, the basic circuit for an electric arc furnace has been studied successfully.

Experiment No: 6

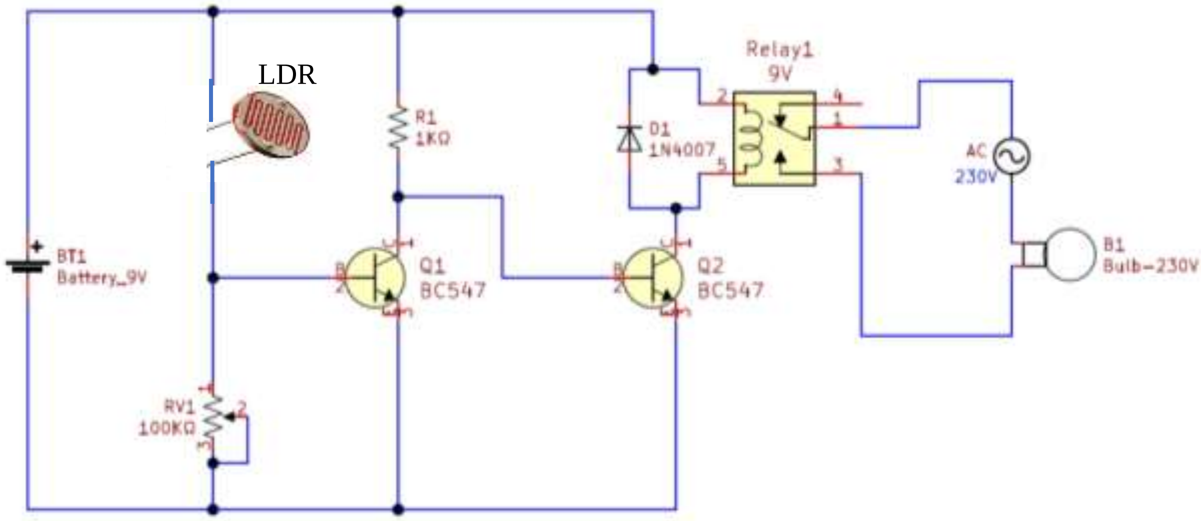
AIM: Draw automatic illumination control circuits using LDR's.

Theory:

Study of illumination engineering is necessary not only to understand the principles of light control as applied to interior lighting design such as domestic and factory lighting but also to understand outdoor applications such as highway lighting and flood lighting. Now a day, the electrically produced light is preferred to the other source of illumination because of an account of its cleanliness, ease of control, steady light output, low cost, and reliability.

In this experiment, a circuit is drawn which controls the illumination of an ac bulb depending on the light of surrounding environment. The circuit acts automatically as they are controlled by photon activated sensors viz Light Dependent resistor (LDR). Such circuit finds application in automatic street lamp illumination, as the sensor detects low intensity of light during the dusk, it activates the relay of circuit which consequently turns the ac bulb ON.

The circuit for illumination control can be shown in figure below.



Result:

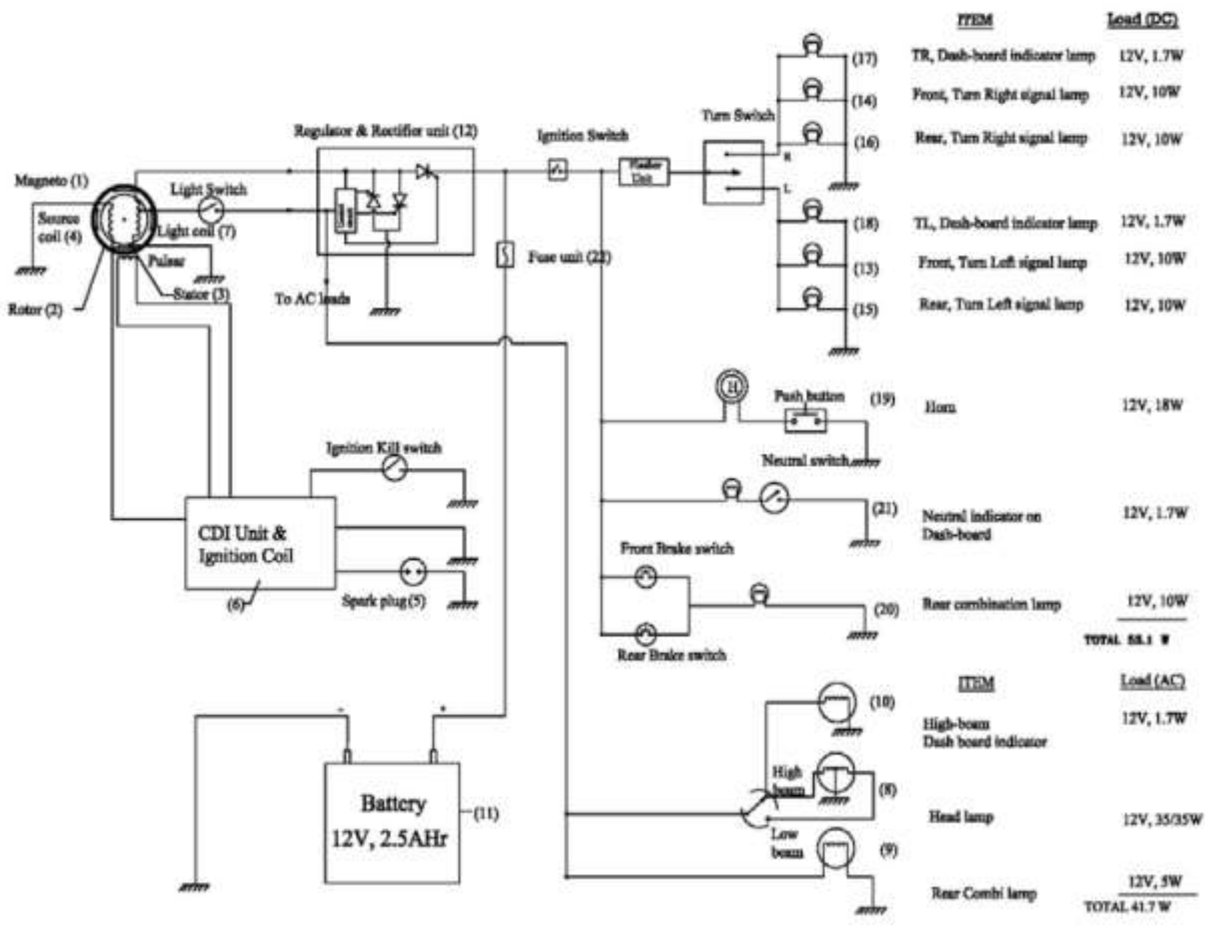
Thus, an automatic illumination control circuit using LDR, has been drawn and studied successfully.

Experiment No: 7

AIM: Draw the circuit diagram of a lighting of a two-wheeler.

Theory:

Two-wheelers are an integral part of life in developing countries like India, China, SE Asia, etc. These are fitted with Lead-acid Battery to meet intermittent loads such as Horn, direction indicators and Brake Light. In addition to headlights, tail lights and turn signals, some motor cycle owner used to add accessory lights onto their bike.
With modern technology, the owner gets to choose among three kinds of light bulbs, for example either halogen, LED or Xenon HID, owing to its brighter illumination and longer lifetime.
In this experiment, we will try to draw and study about the wiring diagram of a two-wheeler. The figure below shows a schematic diagram for lighting system of a two-wheeler.



Result:

Thus, the circuit diagram of a lighting system for a two-wheeler has been drawn and studied successfully.

Experiment No: 8

AIM: To draw the power diagram of A.C locomotive and its equipment.

Theory:

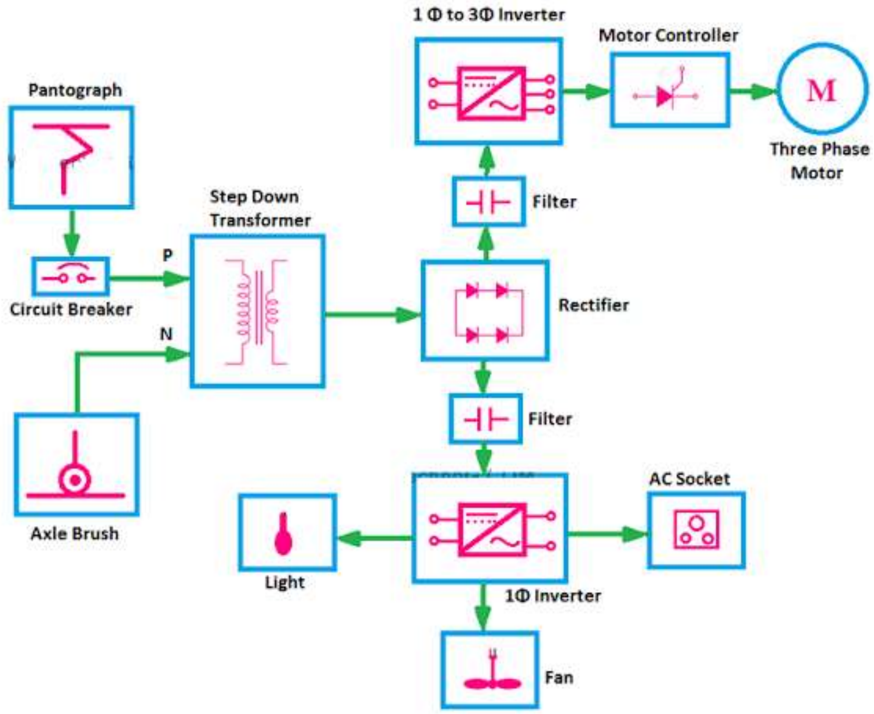
A system that causes the propulsion of a vehicle in which that driving force or tractive force is obtained from various devices such as electric motors, steam engine drives, diesel engine drives, etc. is known as traction system.
A traction system which develops the necessary propelling torque, by involving the use of electrical energy at any stage to drive the traction vehicle, is known as an electric traction system.

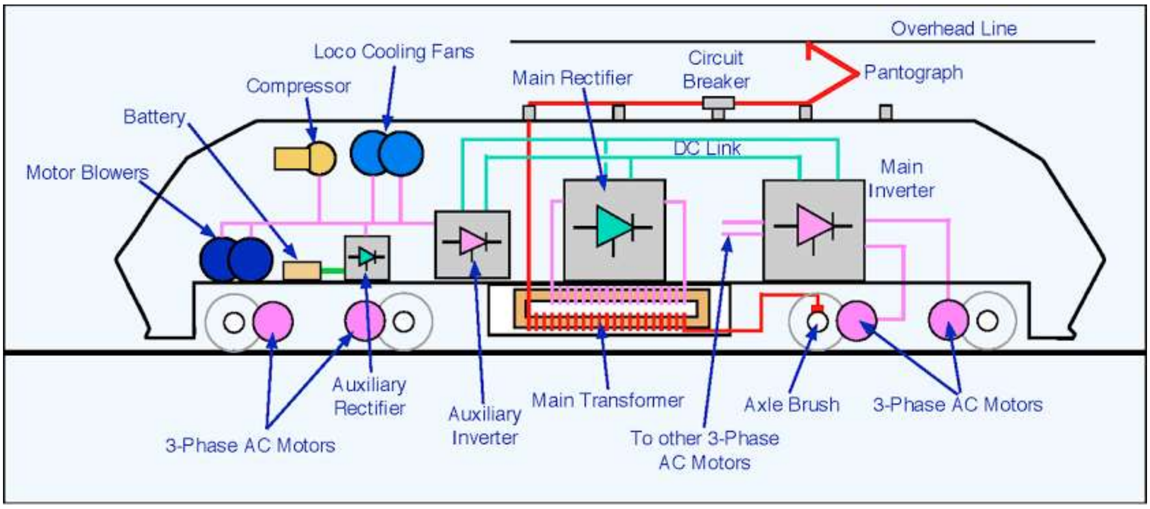
Three-phase AC system
In this system of track electrification, 3- ϕ induction motors are employed for getting the necessary propelling power. The operating voltage of induction motors is normally3,000‐ 3,600-V AC at normal supply frequency. Usually 3- ϕ induction motors are preferable because they have simple and robust construction, high operating efficiency, provision of regenerative braking without placing any additional equipment, and better performance at both normal and reduced frequencies. In addition to the above advantages, the induction motors suffer from some drawbacks; they are low-starting torque, high-starting current, and the absence of speed control. The main disadvantage of such track electrification system is high cost of overhead distribution structure. This distribution system consists of two overhead wires and track rail for the third phase and receives power either directly from the generating station or through transformer substation. Three-phase AC system is mainly adopted for the services where the output power required is high and regeneration of electrical energy is possible.

AUXILIARY EQUIPMENT
A traction system comprises of the following auxiliary equipment in addition to the main traction motors required to be arranged in the locomotive are discussed below.
Motor–generator set - Motor‐generator set consists of a series motor and shunt generator. It is mainly used for lighting, control system, and the other power circuits of low voltages in the range 10‐100V. The voltage of generator is effectively controlled by automatic voltage regulator.
Battery - It is very important to use the battery as a source of energy for pantograph, to run auxiliary compressor, to operate air blast circuit breaker, etc. The capacity of battery used in the locomotive is depending on the vehicle. Normally, the battery may be charged by a separate rectifier.
Rectifier Unit - If the track electrification system is AC motors and available traction motors are DC motors, then rectifiers are to be equipped with the traction motors to convert AC supply to DC to feed the DC traction motors.

Transformer or autotransformer - Depending on the track electrification system employed, the locomotive should be equipped with tap-changing transformers to step-
down high voltages from the distribution network to the feed low-voltage traction motors. Driving axles and gear arrangements All the driving motors are connected to the driving axle through a gear arrangement, with ratios of 4:1 or 6:1.

The block diagram of an AC locomotive is shown below





Result:

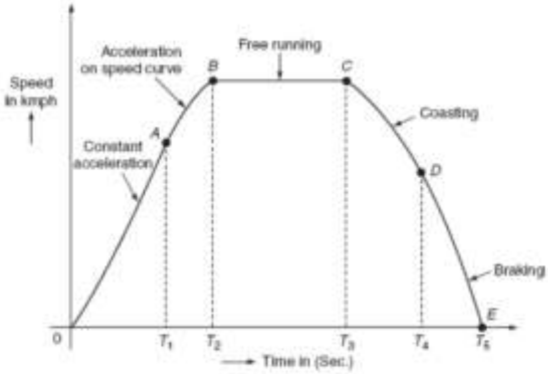
Thus, the power diagram of A.C locomotive and its equipment has been drawn and studied successfully.

Experiment No: 9

AIM: Calculate tractive power and energy consumption for a basic electric traction system.

Theory:

The movement of trains and their energy consumption can be most conveniently studied by means of the speed–distance and the speed–time curves as shown in figure. The motion of any vehicle may be at constant speed or it may consist of periodic acceleration and retardation. The speed–time curves have significant importance in traction.



If the frictional resistance to the motion is known value, the energy required for motion of the vehicle can be determined from it. Moreover, this curve gives the speed at various time instants after the start of run directly.

Power output from the driving axle:

Let F_t is the tractive effort in N and ν is the speed of train in kmph.

∴ The power output (P) = rate of work done

$$= \text{Tractive effort} \times \frac{\text{distance}}{\text{time}}$$

$$= \text{Tractive effort} \times \text{speed}$$

$$= \frac{F_t \times \nu \times 1{,}000}{3{,}600} \text{W}$$

$$= \frac{F_t \times \nu}{3{,}600} \text{kW}.$$

If 'ν' is in m/s, then P = $F_t \times \nu$ Watts. If 'η' is the efficiency of the gear transmission, then the power output of motors,

$$P = \frac{F_t \nu}{3{,}600\eta} \text{kW}$$

SPECIFIC ENERGY CONSUMPTION:

The energy input to the motors is called the *energy consumption. This is the energy* consumed by various parts of the train for its propulsion. The energy drawn from the distribution system should be equals to the energy consumed by the various parts of the train and the quantity of the energy required for lighting, heating, control, and braking.

This quantity of energy consumed by the various parts of train per ton per kilometer is known as specific energy consumption. It is expressed in watt hours per ton per km.

$$\therefore \left.\begin{matrix}\text{Specific energy}\\ \text{consumption}\end{matrix}\right\} = \frac{\text{total energy consumption in W} - \text{h}}{\text{the weight of the train in tons} \times \text{the distance covered by train in km}}$$

The specific energy consumption is inversely proportional to the distance between stations. Greater the distance between stops is, the lesser will be the specific energy consumption. The typical values of the specific energy consumption is less for the main line service of 20–30 W*hr/ton*km and high for the urban and suburban services of 50–60 W*hr/ton*km.

For a given schedule speed, the specific energy consumption will accordingly be less for more acceleration and retardation.

For a given distance between the stops, the specific energy consumption increases with the increase in the speed of train.

Result:

Thus, tractive power and energy consumption for a basic electric traction system has been calculated successfully.

Experiment No: 10

AIM: To calculate the energy recovered during regenerative braking.

Theory:

The method in which no energy is drawn from the supply system during braking period and some energy is fed back to the supply system is known as regenerative braking. Such method is employed to stop any AC or DC motor while it is a part of a locomotive.

When the train is accelerated up to a certain speed, then it acquires energy, (known as **Kinetic energy**), corresponding to that speed and this kinetic energy is given by

$$KE = \frac{1}{2} m v^2$$

During coasting period, a part of this stored energy is utilized in propelling the train against frictional and other resistances to motion and hence the speed of the train falls. Under ideal conditions, i.e., no resistances to motion of the train, the speed of the train would have not decreased.

In the similar way, when the train going down the gradient or moving on a level track, the speed of the train remaining the same or reduced. Under this condition, the stored energy can be converted into electrical energy and fed back to the supply system.

The amount of electrical energy returned to the supply system depends upon the following factors –

- The initial and final speeds of the train during regenerative braking.
- The resistance to the motion of the train.
- The gradient of the track in case the train is moving down the gradient.
- Efficiency of the traction system.

Now, let

V_1 = Initial speed of train in kmph

V_2 = Final speed of train in kmph

W_e = Equivalent weight of train

Then, the kinetic energy stored in the train at the initial speed (V_1) is given by,

$$KE_1 = \frac{1}{2} \times \frac{1000\, W_e}{9.81} \times \left(\frac{1000\, V_1}{3600}\right)^2 \quad \text{kgm}$$

$$\Rightarrow KE_1 = \frac{1}{2} \times 1000\, W_e \times \left(\frac{1000\, V_1}{3600}\right)^2 \text{ Watt seconds}$$

$$\Rightarrow KE_1 = \frac{1}{2} \times 1000\, W_e \times \left(\frac{1000\, V_1}{3600}\right)^2 \times \frac{1}{3600} \text{ Watt hours}$$

$$\therefore KE_1 = 0.01072\, W_e\, V_1^2 \text{ Wh}$$

Similarly, the kinetic energy at the final speed (V_2) is given by,

$$KE_2 = 0.01072\, W_e\, V_2^2 \text{ Wh}$$

Therefore, the amount of energy available during regeneration is

$$KE_1 - KE_2 = 0.01072\, W_e \left(V_1^2 - V_2^2\right)$$

Also, some of the energy is lost to overcome the resistance to motion and the losses in the traction system including traction motors.

Result:

Thus, the energy recovered during regenerative braking has been calculated successfully.