Chapter-1

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Polar curve and their uses

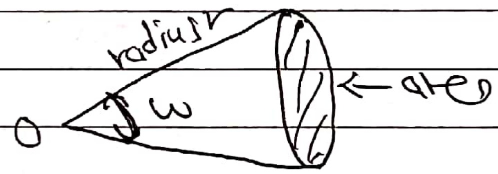
The luminous intensity in most

Solid Angle → (16\S, 14F, 14S)

Solid Angle is generated by the surface passing through the point in space & the periphery of the area. It is denoted by ω. , expressed in steradian

→ It is given by the ratios of the area of the surface to the square of the distance betn the area & point.

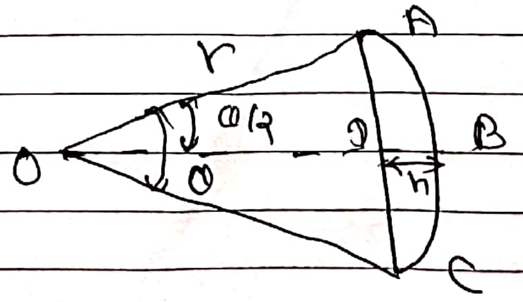
$$\omega = \frac{\text{area (A)}}{(\text{radius})^2}$$



→ The largest solid Angle subtended at a point is due to sphere at it's centre and is equal to $\frac{4\pi r^2}{r^2} = \frac{\text{area of surface}}{r^2}$

$= 4\pi$ Steradian.

→ Relationship betn ω & θ



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consider a curved surface of spherical segment ABC of height 'h' & radius r.

Surface area of segment ABC $= 2\pi r h$

Here, $BD = h = OB - OD$

$= r - r\cos\theta/2$

$= r(1 - \cos\theta/2)$

$\therefore$ surface area of segment ABC $= 2\pi r^2 (1 - \cos\theta/2)$

Hence, ~~$2\pi r^2($~~

solid angle $(\omega) = \dfrac{\text{surface area}}{(\text{radius})^2}$

$$= \frac{2\pi r^2 (1 - \cos\theta/2)}{r^2}$$

$$\boxed{\omega = 2\pi(1 - \cos\theta/2)}$$

#

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Color Rendering Index (CRI) - 155, 145, 135

→ Color Rendering Index describes how a light source makes the color of an object appear to human eyes and how well subtle variation in color shades are revealed.

→ The CRI is a scale from 0 to 100 percent indicating how accurate a given light source is alternrendering color when compared to a reference light source.

→ The higher the CRI, the better the color rendering ability. Light sources with a CRI of 80 to 90 are considered good at color rendering. It is important to note that CRI is independent of color tempr.

→ The CRI measures the ability of a light source to accurately render all frequencies of the colour specturm when compared to a perfect reference light of similar type.

* Incident lamp → CRI of 100
* Tungesten Halogen - " " 95
* Metal Halide - " " 85
* Triphosphore fluoresent → " " 85

(2019F)

Arc lamp- defn (next copy)

Advantages

① Flexible lamp lengths, typically 3" to 60".
② low cost of purchase

Disadvantages

1) o/p decreases with time due to striking arc
2) lamp operating tempr are high
3) ~~Mercury is hazardous & requires pr~~

Application

→ Followspots
→ Projectors
→ Search light
→ early motion pictures.

Neon light →

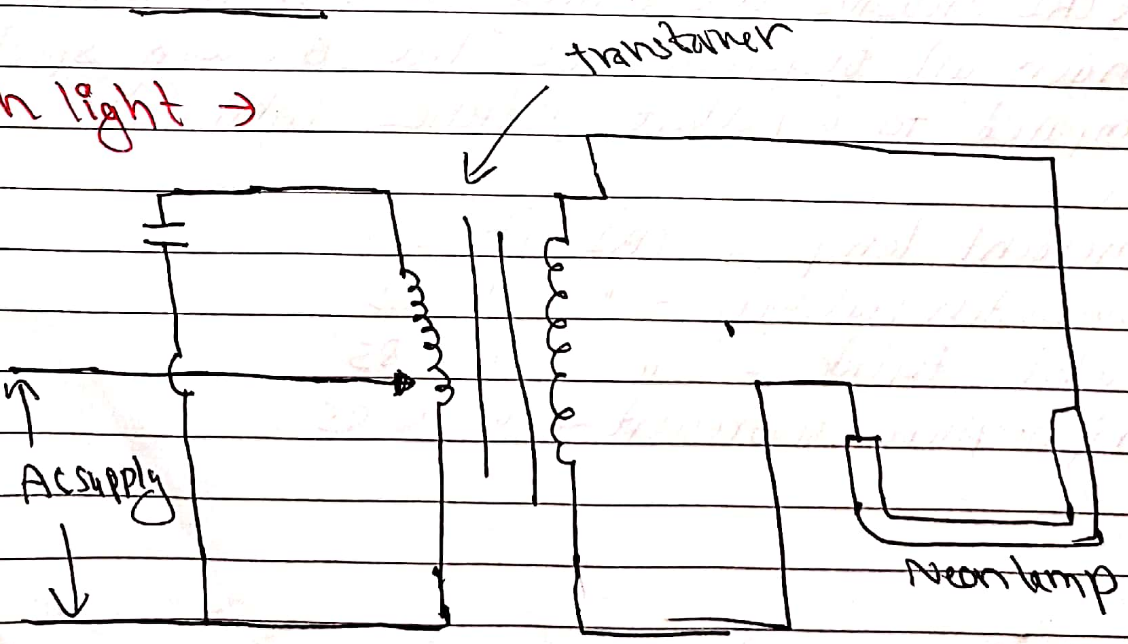

Fig- Neon lamp

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Advantages

1. Very low Power consumption
2. Very long life
3. No threat to environment
4. wide operating range i,e DC or AC
5. More reliable than LEDS for airport runway landing light
6. Easy to setup
7. High visibility

Disadvantages

→ low light o/p for input power
→ expressive to be used as signs & display
→ Shape of tube is limitation
→ Diffused light.

16/11/8F

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Ultra-violet lamp →

Ultra-violet ~~lamp~~ is form of electromagnetic radiation with wavelength shorter than visible light but longer than x-rays.

→ UV radiation is present in sunlight.

→ It is also produced by electric arc, mercury vapour lamp & black light.

→ Ultra-violet lamp are usually housed in a quartz or special glass that transmitts UV radiation more easily than ordinary glass.

→ It is also used for medical purpose.

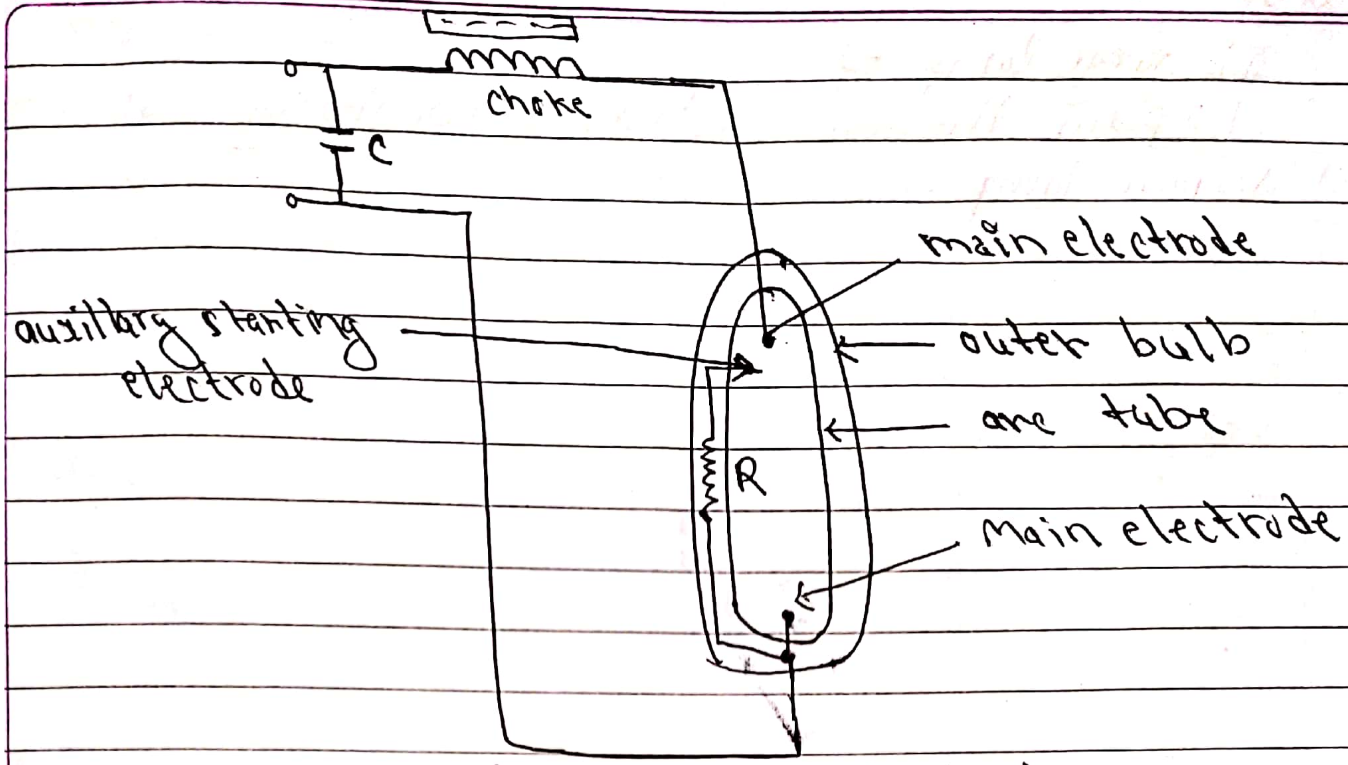

fig - Ultra-violent lan

It consist of two bulb-an-arc tube containing the electric discharge and outer bulb which protects the arc tube from changes in tempr. The inner tube & arc tube is made of quartz (or hard glass) and outer bulb of hard glass.

The arc tube consist of small amount of mercury and argon gas. In addition to two main electrode an auxillary starting electrode connected through a high resistance, is also provided. The main electrode consist of tungesten coals with electrons-emitting coating or element of thorium metal.

(2016F)

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Difference betn luminous efficiency & luminous efficacy →

luminous efficiency	luminous efficacy
1) luminous efficiency measures the amount of visible light produced by a light source relative to the power consumed.	1) luminous efficacy measures the amount of visible light produced by a light source per unit of power consumed.
2) It indicates how effectively a light source converts electrical energy into visible light.	It quantifies the efficiency of a light source of a light source in terms of visible light o/p per unit of electrical power input.
3) It's unit is lumens per watt (lm/w).	3) It's unit is lumens per watt (lm/w).
4) It is used to evaluate the efficiency of individual light source.	4) It is used to compare the efficiency of different light source or lighting system.
5) It helps to assess the efficiency of a light source in terms of light o/p for a given power input.	5) It enables comparison betn different light sources to identify the most energy efficient options.

a) Typical values vary depending on the type of light source.	
6) eg. Incandescent bulbs have lower luminous efficiency compared to LED bulbs.	6) eg. LED bulbs generally have higher luminous efficacy compared to incandescent or fluorescent ~~car~~ bulbs.
7) luminous efficiency $(\eta v) = \frac{\text{Total luminous flux (in lumens)}}{\text{Total power input (watt)}}$	luminous efficacy $= \frac{\text{luminous flux } (\phi v)}{\text{Radiant power } (\phi e)}$.

* Define sensitivity of human eye (13F)

– Spectral sensitivity is the relative efficiency of detection of light or other signal as a function of the frequency or wavelength of the signal.

→ Spectral sensitivity of eye is influenced by light intensity.

→ Sensitivity of human eyes to light increase with the decrease in light intensity.

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Define Intensity of light →

light intensity refers to the strength or amount of light produced by a specific lamp source. It is the measure of the wavelength weighted power emitted by a light source.

→ Intensity of light is directly related to brightness more brightness means more intensity of light.

2021S

1.(a) What do you mean by polar curve ? Explain the types of polar curve with their application and also explain how you can obtain the mean spherical candle power from the polar curve.

⇒ There are different type of polar curve
1) Limacons
2) cardioids
3) Rose curve
4) Archimedean spirals
5) Logarithmic "

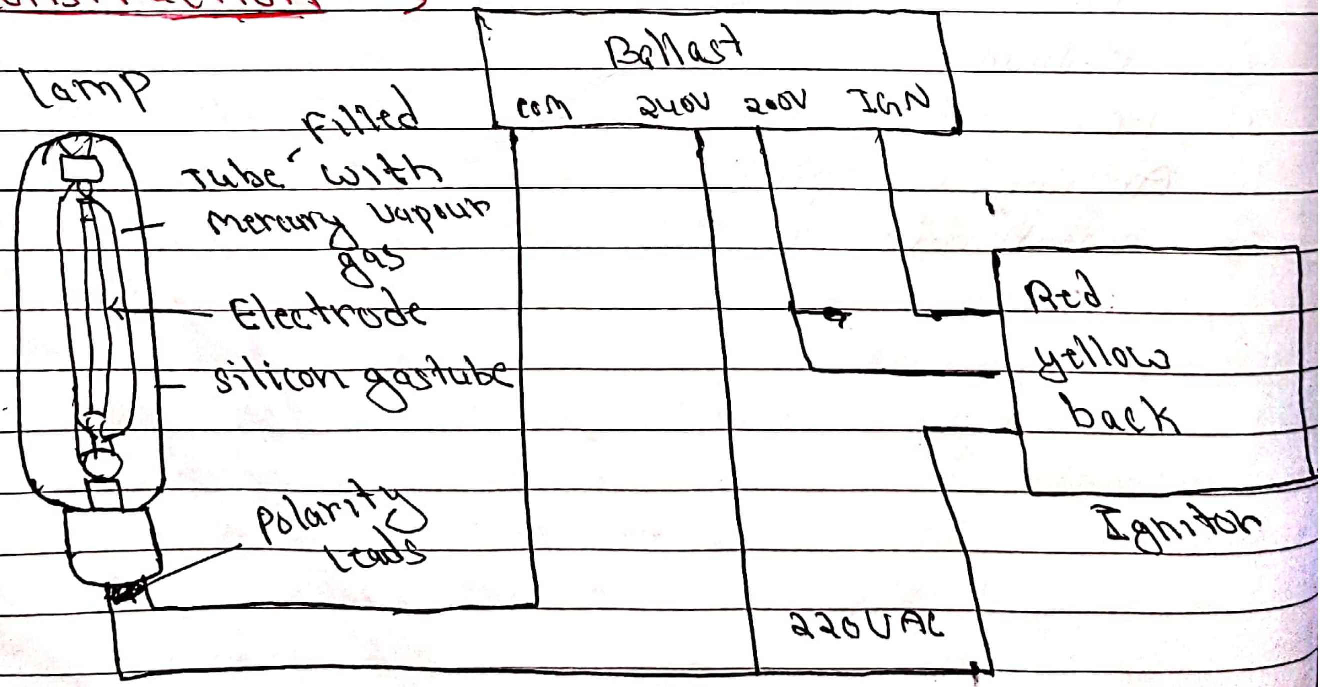
Explain the working & construction of Mercury Vapor lamp?

A lamp that consist of vapourized mer-cury to generate light by using an electric arc is known as mercury vapour lamp.

Basically, this lamp discharges gas when heated or cooled. The mercury which is present inside the tube is in liquid form which is ionized before generating light.

It's wavelength at low pressure ranges between 184 nm & 253 nm.

Construction →



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It consist of a electrode made up of an alloy of tungsten which is placed together in a medium containing mercury vapour & 25-50 torr of pure argon gas. These electrode are enclosed in an elliptically shaped glass tube made up of silica.

Working of Mercury Vapor lamp →

The mercury vapour and neon gas (pink in color) present in the ~~bub~~ bulb requires high voltage at the starting to illuminate light.

When high voltage is appiled, we can observe that the neon gas which was originally in pink color will changes into orange color by heating. It is similar to a 100 watt glowing bulb and it takes 5 to 7 min to turn on completetly.

→ The ignitor which is present internally consist of bimetallic strip and capacitor, which provides high starting voltage.

→ When the bimetallic strip expands on heating it will short-circuit then the lamp will be turned on., when this metallic strip cools, it disconnect the connection & turns off the lamp.

CS CamScanner

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→ Hence, by connecting the ballast and ignitor to this lamp, the mercury vapour and neon gas get heated up & expands the bulb inside to illuminate the light.

Advantages

→ It provides with high intensity
→ The o/p is clear white light
→ Rated life of 24,000 hrs
→ It can be available in different colors, shapes, sizes & ratings.

Disadvantages

→ Maintenance of lumen is poor.
→ They are voltage sensitive
→ The cooling time is 5 to 6 min.

Application
→ Industrial areas
→ Street lights
→ Security
→ Stair wells
→ Home appliances like ~~gara~~ garages.

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* Specific Energy consumption ⇒

Specific energy consumption is defined as the energy consumed (wh) per tonne mass of the train per km length of the run

$$E_{spc} = \frac{\text{Total energy consumed}}{\text{Train mass (tonne)} \times \text{run length (km)}}$$

$$= \frac{\text{Specific energy o/p}}{\eta}$$

where, $\eta \rightarrow$ overall efficiency of transmission motor & gear

$= \eta_{motor} \times \eta_{gear}$

Chapter-6 Electric Transtion

22F, 20F, 10F

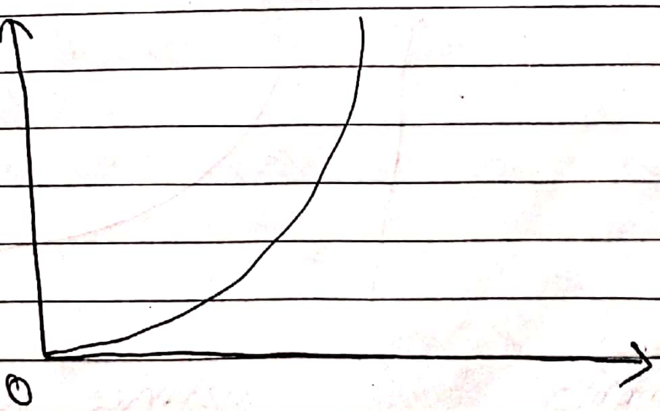
Factors affecting specificic energy consumption of electrical transction operationg on a given schedule speed are - 12S, 16F

1) Acceleration →
It consists of two part known as
→ Constant accleration or acceleration during notc -hing up:
→ speed curve running or acceleration on the speed curve.

2) Retardation →
For a given run & a given schedule speed, the specific energy consumption is lower the higher the acceleration and retordation since with this a longer coasting period can be obtained and for a smaller period, the supply is switched on.

3) Maximum speed → From the expression for specific energy consumption it is clear that this quantity increase with increase in maximum speed. A typical curve shows the variation.

watt-hr/tonne-km



0 max. speed

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4) Gradient →

The higher the gradient of the track, more will be energy consumption even though part of energy during this period can be feedback to the system through regenerative breaking. When the train is moving down the gradient.

⑤ Train resistance →

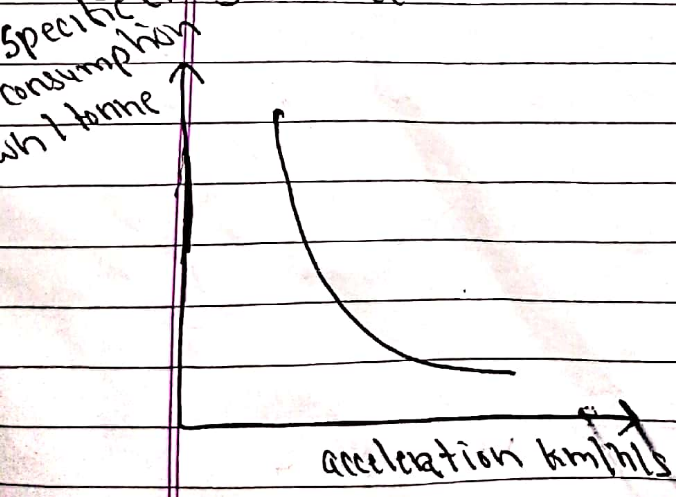
In general, higher the train resistance, higher will be the specific energy consumption.

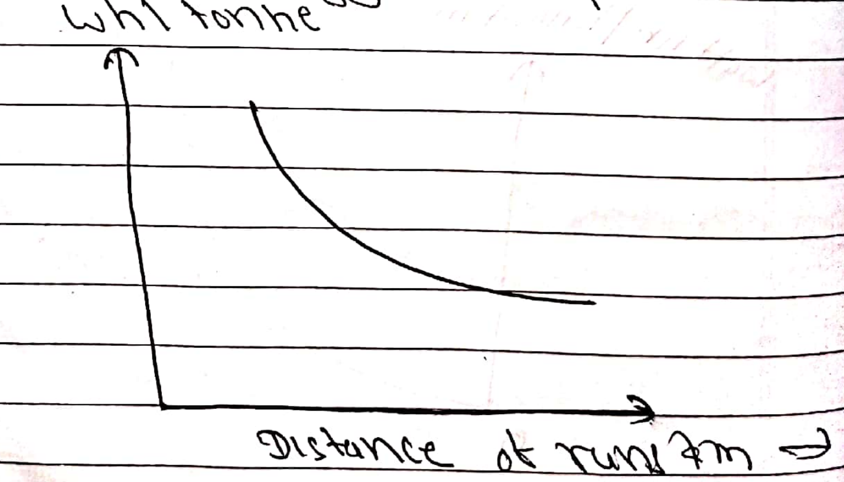
⑥ Type of train equipment →

The higher the overall efficiency of the train equipment the lesser will be the specific energy consumption for a particular specific energy o/p at the axles.

⑦ Distance between stops →

The greater the distance, the smaller will be the specific energy consumption i.e for surban service, it is higher as compared to the main line service.





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Typical values of specific energy consumption at

→ For suburban service — — 50-75 wh/tonne-km
→ For main line — — 20-30 " " "

18L

What are the methods of approximation of speed time curve?

⇒ Methods of approximation of speed time curves:
→ calculation by trapezoidal speed time curve
→ " " quadrilateral " " "

21S, 21F, 16F

Hybrid Vechiles (16F)

→ A hybrid vechiles is a conventionally fueled & operated vehicle that has been equipped with a power train capable of implemen-ting atleast the first three of the following 4 hybrids functions:

- Engine shutdown when power demand is zero or negative.
→ Engine down-size for improved thermal efficiency
→ Regenerative breaking for recovery & reverse of braking energy.
→ Enginee-off propulsion at low power (when engine is inefficient).

Power sources for hybrid vehicles include

- → Wind
- → solar
- → Flywheel
- → Hydrogen
- → Petrol or Diesel fuel
- → Electromagnetic field, radio waves
- → overhead electricity
- → compressed or liquified natural gas
- → Electric batteries & capacitors
- → Hydraulic accumulator

→ Mechanical connection - - electrical connection

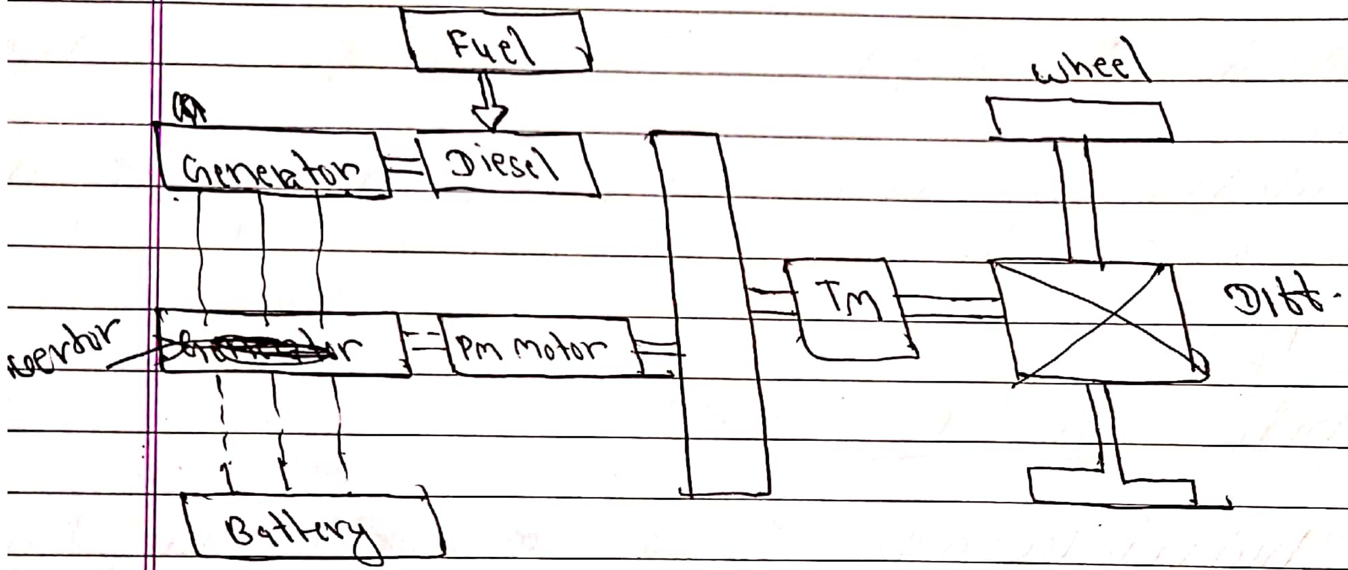

Fig- series Hybrid vechile

→ In series hybridization following operation modes can be found

- → Pure Enginee mode
- → Power split "
- → Battery charging "
- → Regenerative braking mode

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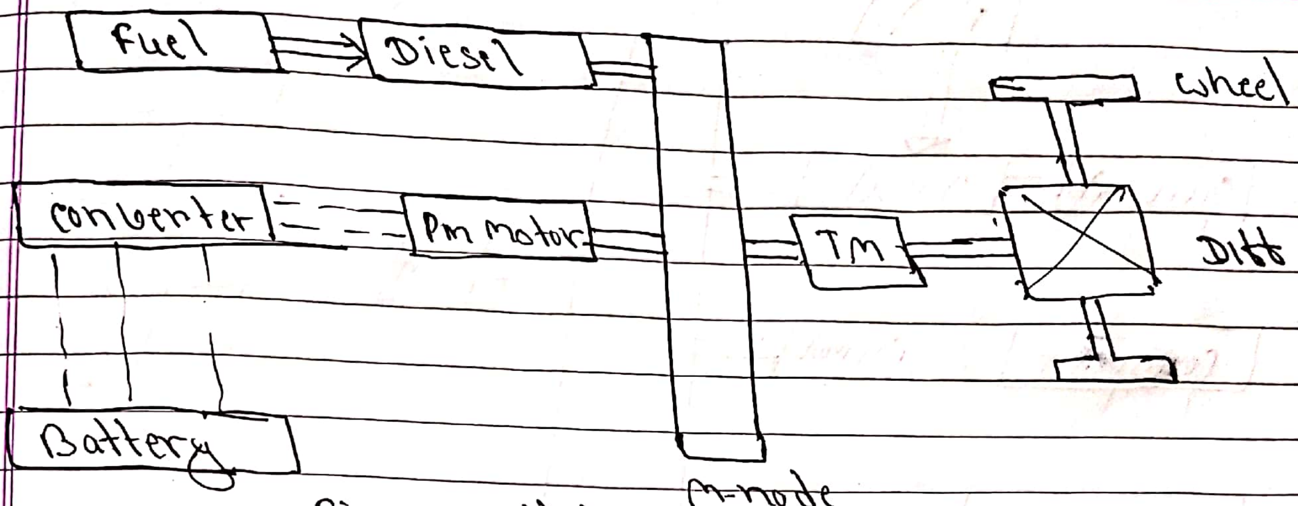

Fig - parallel HEV

→ In parallel HEV, it parallel the mechanical power o/p from the electric motor & the ICE are utilized to provide total tractive effect.

→ In this situation, the vehicle is powered by the either engine, electrical motor or both and the coupling are mechanical.
In parallel hybridization, following operating modes can be found.

→ Motor alone mode
→ Engine " "
→ power split "
→ Regenerative braking

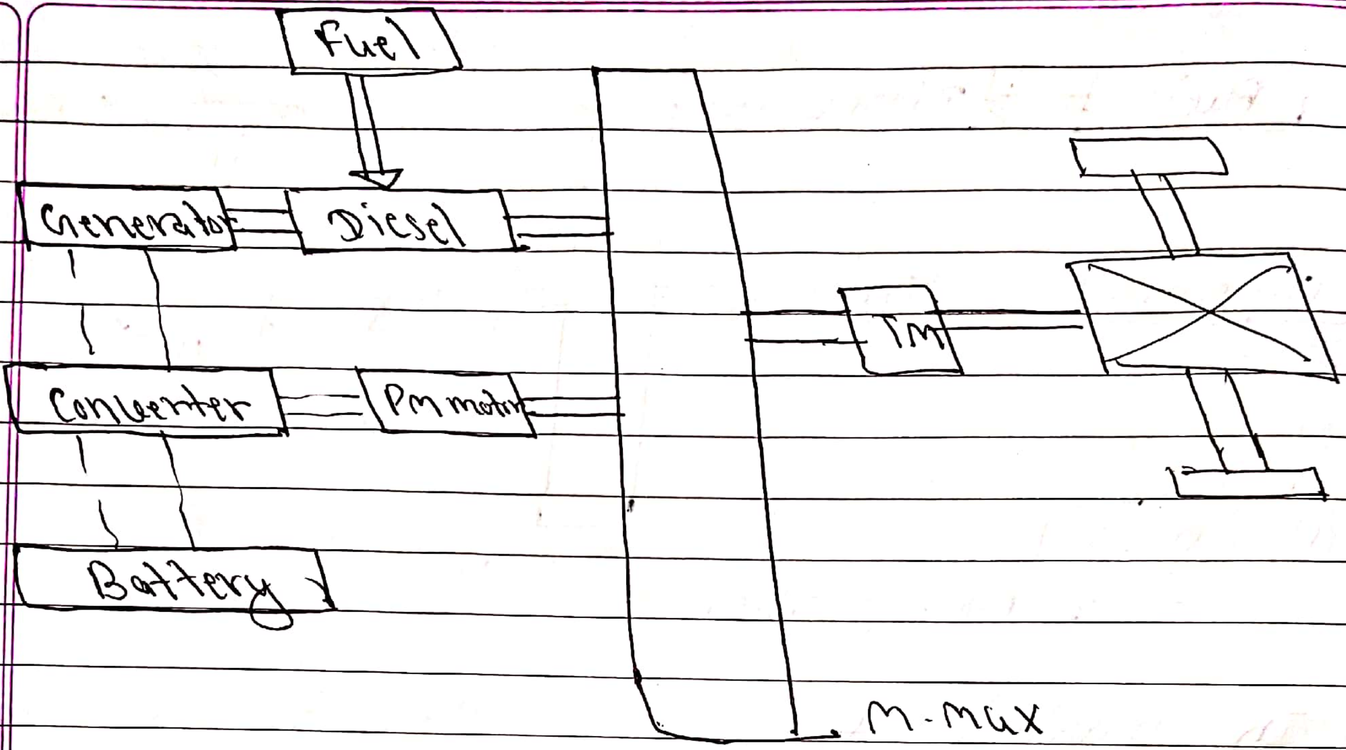

Fig - Mixed hybridization

20F

Advantages

→ lower emission & better mileage
→ reliable & comfortable
→ Much cleaner cars than normal vehicle
→ Reduced energy dependence
→ Noise pollution & emission of CO_2 are considerably reduced.
→ Financial benefit
→ Regenerative braking system
→ Improved acceleration
→ Hybrid vehicle uses no energy during idle state, they turn off & use less than petrol engines at low speeds.

12FIS, 13F

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Advantages & Disadvantages of electric transction system.

Advantages

1. cleamliness
2. cheapness
3. less maintaince cost
4. High starting torque
5. Breaking - regenerative braking is used which feeds back 40% of the energy.
6. Saving in high grade coal
7. less Noise pollution
8. lower power loss at higher altitudes
9. lower running cost of locomotive & multiple unit
10. Higher practical limit of power
11. " limit of speed
12. " hauling capability

Disadvantages

i) High initial expenditure
ii) Interference with telegraphs and telephone line
iii) Failure of supply is a problem
iv) For braking & control, additional equipment required.
v) Upgrading brings significant cost
vi) Increased maintenance cost of the lines.

vii) Electric locomotive can be use only on those routes which have been electrified.

18F

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8 (a) Write significant features of traction drive & desirable properties of transection motors

=) Significant features of transaction drive are :

1) During start and acceleration, large torque is required for accelerating the heavy mass.

2) During acceleration & when negotiating up-gradients, the motor is subjected to torque overloads.

3) In AC traction, single phase supply is used due to economic reasons.

4) When the locomotive crosses from one supply section to another, there is a sharp voltage fluctuations in the supply.

5) The power factor should not be allowed to be lower than 0.8.
" " " never be allowed to be leading to avoid voltages.

6) Both in AC & DC transection, the injection of harmonics can lead to mal-operation of signal and interference in the lines.

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7) Dynamic braking is widely used. However, when the train is stationary mechanical breaks are also provided.

8) Regenerative braking is employed when the energy saved is large enough to justify the additional cost of drive & transmission line.

9) In a locomotive, more than one motors are fed from a converter. The load sharing betn motors is more uniform when the motors have a large speed regulation.

Significant feature of traction motor

(a) Electrical characteristics →
→ Higher starting torque
→ sample speed control
→ self recivoing property
→ Better commutation
→ capability to operate in parallel
→ Possibility of dynamic or regenerative braking
→ capability to take heavy loads without flashover
→ " " withstand temporary interruption of supply.
→ " " " voltage fluctuation

(b) Mechanical characteristics
→ Minimum weight
→ Must be small in overall dimension specially in it's
→ Transction motor must be robust & capable to withstand continous vibrations.

Explain the term simplified speed time curve

In order to study the performance of various speed - time curves for a particular criterion. eg. the energy requirement, schedule speed for a particular service, preliminary calculations are required.

It is to be noted that at this stage the exact characteristics of the series motor are not known.

Therefore, the actual speed time 'curve are replaced by approximate curves. The simplified curves have simple geometric & hence relationship betn the acceleration retardation, average speed & distance can be deduced by simple mathematical evaluations.

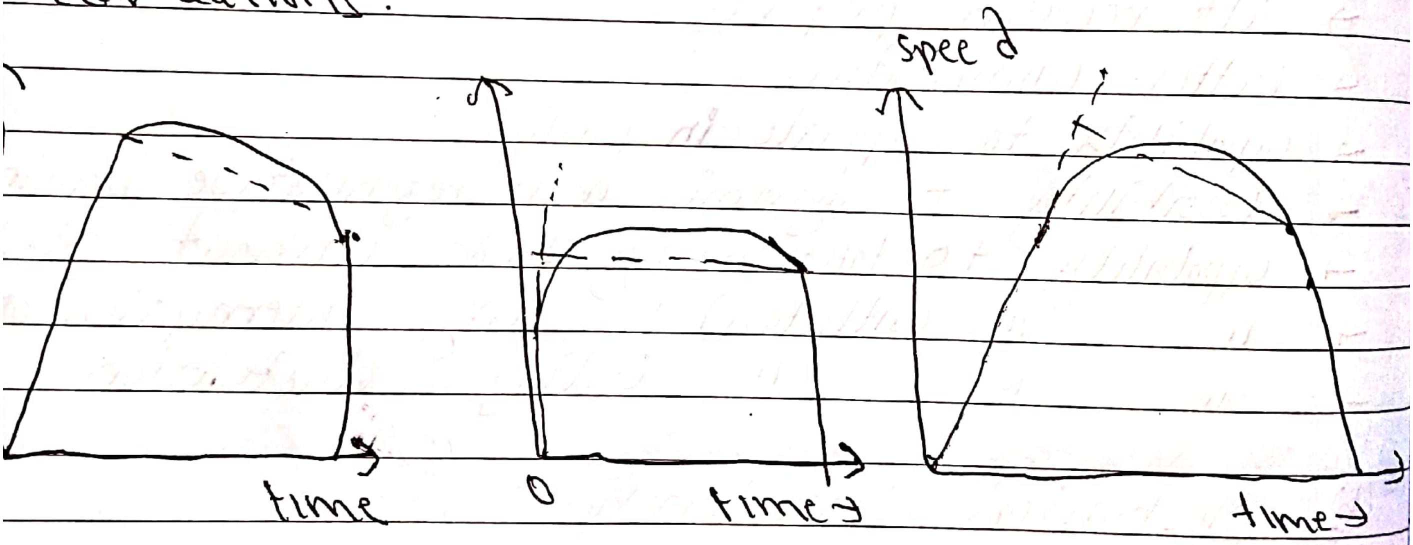

Fig - approximate speed time curve

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The speed time curve of an urban services can be replaced by an equ speed time of simple quadrilateral shape.

The speed time curve of a main line service is best & most easily replaced by a trapezoid.

Since the area of speed time curves represents the total distance travelled hence the areas of the two curve should be same.

The area under the approximated curve & the actual speed time curve is the same.

The values of acceleration and retardation are kept same as those of the original speed time curve.

Electrical Drive : 16S | 14F | 10F

A form of machine equipment designed to convert electrical energy into mechanical energy and to provide electrical control of it's process is known as electrical drive.

An electrical drive has the following point
- load
- Power modulator
- Motor
- control unit
- power service.
- source

(Q.N) 16S What are the losses of electrical drive system? Explain method to reduce it.

⇒ Losses in Electrical Drive system.

Energy conservation in electrical drive is achived by reduction of losses in it's various parts. Typical losses include the following:

1) Electrical transmission losses → The losses depend on the drive power factor and harmonics in the line current.

2) Conversion losses in the power modulator (or Converter)
The semi-conductor converter usually has low conversion losses.

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3) Electric Motor losses to convert electric power into mechanical power →
These are determined by choice of motor (quality of it's design and selection of right rating) & quality of supply (voltage variation, unbalance, frequency variation & harmonics).

4) Mechanical losses → Mechanical losses in the parts of the transmission system such as bearing, gears, clutches & belts.

5) losses in the load → load is a machine required to perform a specified task such as fan, pump & train.

6) losses caused by throttling or by other means that control material flow by absorbing or by passing excess o/p.

7) Mechanical transmission losses, such as friction loss to move material from one location to another. losses in pipe line carrying fluid.

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Methods to reduce losses in Electrical Drive →

We can increase the energy efficiency of an electrical drive by reducing the total losses in Electrical Drive.

a) Improvement of conventional solutions →
This can be achived by means of using new high quality active materials in electric machines & by optimization of their power circuit.

b) systematic apporach to designing and taking into account →
(the combined work of all the component of an electrical drive):
In this case, improvement entails development of a new-type of electric drive, such as switched reluctances drive, electric drive with a field-regulated reluctances machine, & others.

c) Improvement of both the existing solutions & taking into account the combined work of a semiconductor converter & Motor.

(17F, 16S, 15S, 14S)

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Functional Block Diagram of Electric Drive

The very basic block diagram of an electric drive is shown below. The load in the figure ~~department~~ represents various types of equipment which consist of electric motor, like fans, pumps etc.

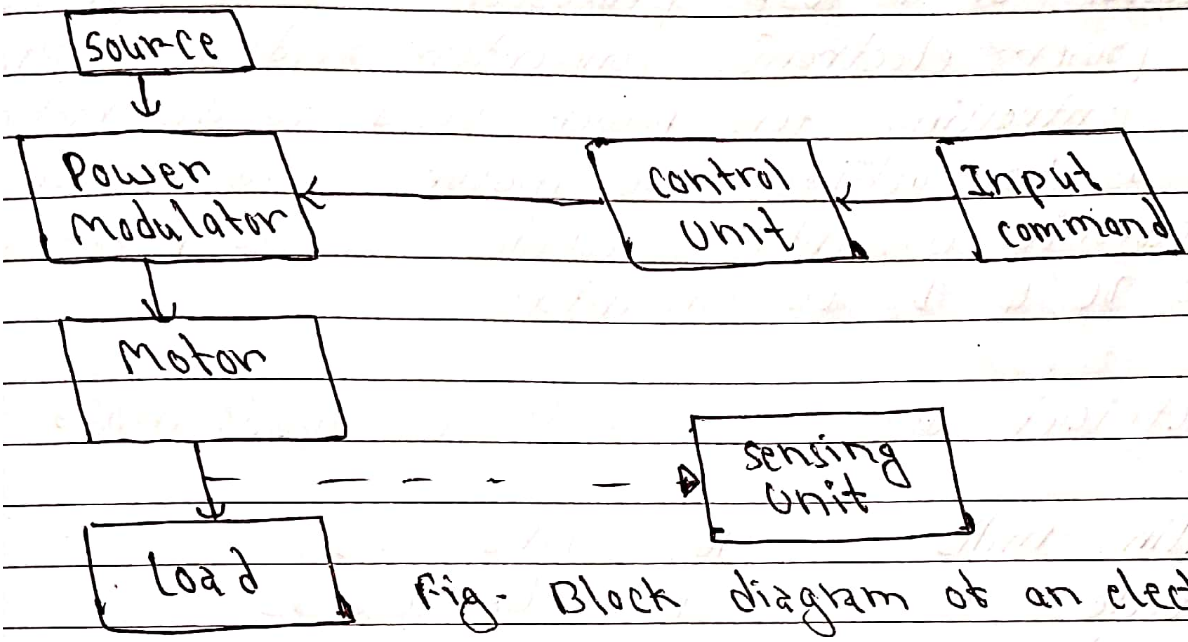

fig- Block diagram of an electrical drive

In the above block diagram, of an electric drive system, electric motor, power processor (power electronic converter), controller, sensors (eg: PID controller) & the active load or apparatus are shown as the major component included in the drive.

The electric motor is the core component of an electrical drive that converts electrical energy into mechanial energy (that drive the load). The motor can be DC Motor or AC Motor depend on the type of load.

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The controller tells the power processor, how much power it has to generate by providing the reference signal to it after considering the input command & sensor inputs.

The controller should be a microcontroller, a micro-processor or a DSP processor. Power processor is power electronic converter and is responsible for controlling the power flow to the motor so as to achive the motor. The power electronic converters includes AC-AC, DC-AC, AC-DC & DC-DC convertors.

Electrical drives for different application→

Rolling mills
Textile ″
cement ″
paper ″
coal mining
Domestic appliences
lifts
lathe, grinding and milling machines
Cranes & hoist work
Machine tool drive
Drilling machine
Air compressor
Electric traction
PumPs
Refrigration & air conditioning
16) Breweries
17) Excavators
18) Belt conveyors
19) wood working machinary
20) woolen mills
21) Quarrying.

Multimotor Electrical Drive : (16S, 14F, 16F)

→ It consists of several individual drives each of which serves to operate one of many working member or mechanisms in some production cost.

eg. in travelling cranes, there are three motors : one for hoisting, another for long travel motion & the third one for cross travel motors.

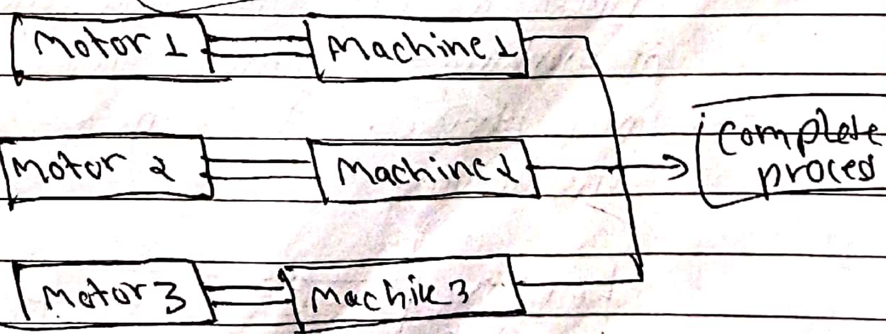
→ such drive is essential in complicated metal-cutting machine tools, paper making machines, rolling mills, rotary printing machine & similiar other type of other machinary.

→ The use of individual and multimotor drives has enabled introduction of automation in production process which in turn has considerablly increased the productivity of various industrial organization.

→ complete or partial automation helps to operate various mechanism at optimum conditions and to increase reliability & safety of operation

Disadvantages

→ High initial cost



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Advantages

1) There is a flexibility in the installation of different machines.

2) Absence of belts and line staff greatly reduce the risk of a accident to the operating personnel.

3) Machine not required can be shut down and also replaced with a mimum of dislocation.

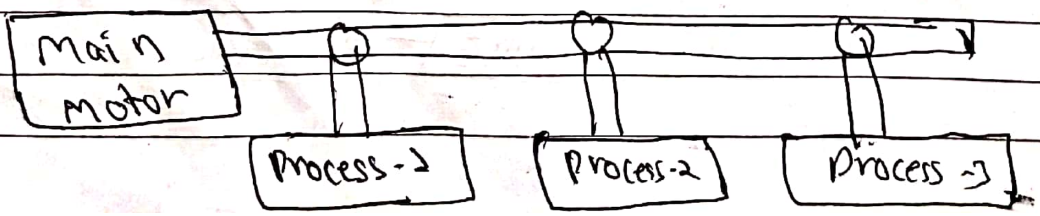
4) Each machine is driven by a separated motor, It can be run or stopped on desired.

5) In the case of motor fault, only it's connected machine will stop where as other will continue working undisturbed.

Classification of Electrical drive → 14R

① Group Drive → 14F/13S / 12F / 10F / 16F / 18

A drive in which a single electric motor drives a line staff by means of which an entire group of working machines may be operated is called group drive. It is also sometimes called the line staff drives.



Advantages →

→ Saving in initial cost

→ efficiency & Power factor of a large group drive motor will be large, provided it is operated fairly near. It's rated load.

Disadvantages →

→ Noise level at the working site is quite high.

→ Group drive doesn't give good appearance

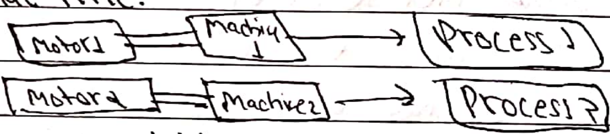
→ This system is unreliable since any fault in driving motor renders all the driven equipment idle.

→ Group drive can't be used where constant speed is needed as in paper and textile industry.

(2) Individual Drive → ((14F, 13S, 12S, 12F, 10F, 16F)

In Individual drive, each machine is driven by it's own separate motor with the help of gears, pulley etc.

eg. single-phase drilling machine.



Advantages

→ Flexibility in the installation of different machine.

→ Machines not required can be shut down and also replaced with a minimum of dislocation.

→ The maintenance of line ~~shaft~~ shafts, bearings, pulleys, and belt etc is eliminated.

→ Each operator has full control of the machine which can be quickly stopped if an accident occurs.

Disadvantages → High cost

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Multimotor drive → (Already describe).

Types of load → 15F | 12F | 10F

Load torque are classified into the following two categories.

Active loads →

The loads which are due to the forces of gravity, tension or compression in a spring or any electric body are called active loads. The active or potential torque may be +ve & -ve depending upon whether they aid or resist the rotation of the drive. Such torque retain their signs irrespective of the direction of rotion of the drive.

Active torque act in one direction only. Active torque comes to play for hoists, lifts, elevators, railway locomotive on gradients.

Positive Torques →

These torque are due to friction, cutting & defores-tation of inelastic bodies.

They always oppose the motion of drive & change their sign when the direction of rotation of drive is changed. eg. The frictional torque always acts in a direction opposite to that of driving torque.

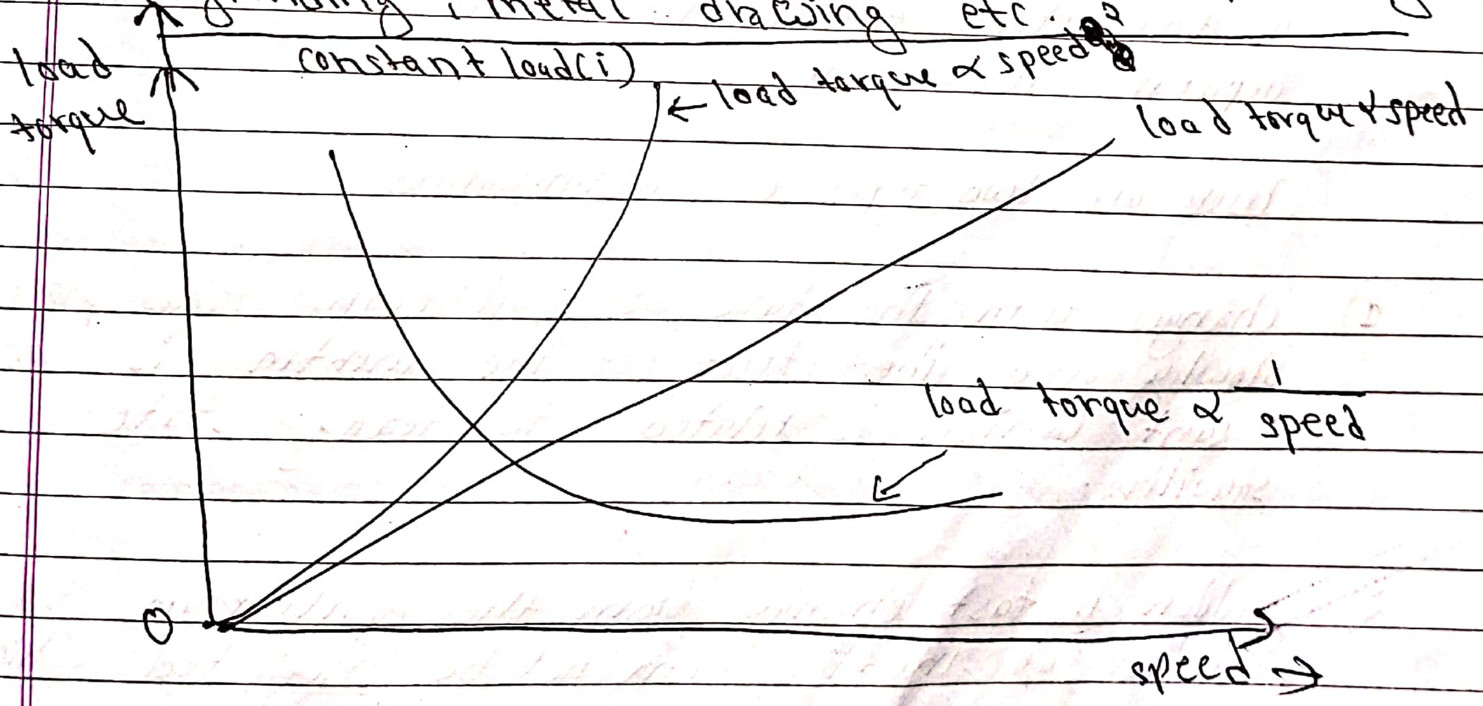
Speed torque characteristics → ISF

1) constant load torque → It is independent of the speed and occurs in case of cranes, hoists etc

2) load torque ∝ speed →
The torque increases linearly with speed & occurs in case of field friction where lubricant is used.

3) load torque ∝ speed^2 →
The torque increases as a square of speed & occurs in case of air & fluid friction such as, in fans, water, wheels etc.

4) load torque ∝ 1/speed →
The torque varies inversely as the speed & occurs where determination of material takes place. eg. in grinding, metal drawing etc.



24 # Block diagram of DC drive

22F | 21R-SN | 20F | 18F | 16F | 14F | 13F

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Describe steady state & transient state stability of electrical drive system.

→ The drive is said to be in equilibrium if the torque developed by the motor is exactly equal to the load torque & the corresponding speed is called equilibrium speed.

→ If the drive comes out of the state of equilibrium due to some disturbance, it comes back to steady state for stable equilibrium but for unstable equilibrium the speed of the drive increases uncontrollably or decreases to zero.

* stability →

If the stability of the motor load combination is defined as the capacity of the system which enables it to develop forces of such a nature as to restore equilibrium after any small depature therefrom.

There are two types of disturbances

1) Changes from the state of equilibrium takes place slowly and the effect of the inertia is insignificant which is related to steady state stability.

2) sudden & fast change from the equilibrium state so effect of inertia can not be neglected which is

related to dynamic or transient stability.

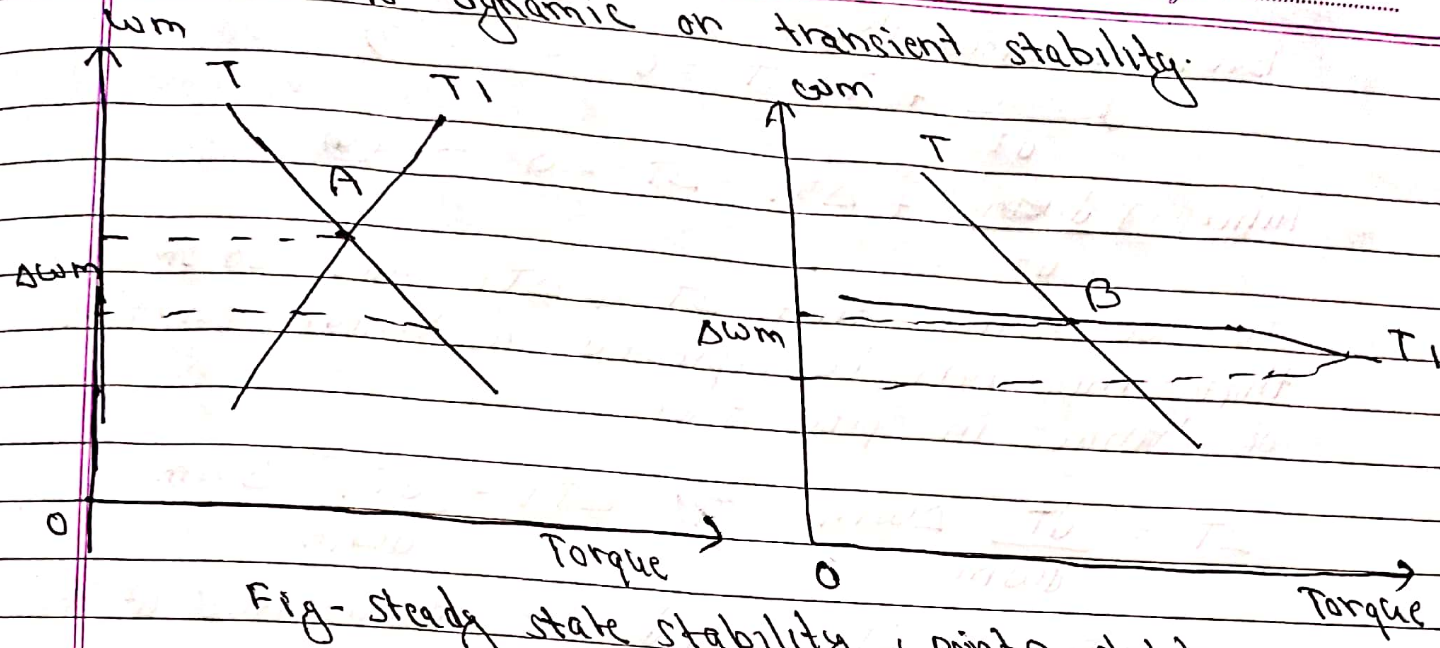

Fig- Steady state stability, point A - stable, Point B - unstable

Hence we can say that an equilibrium point will be stable when an increase in speed causes load torque to exceed the motor torque

$$\frac{dT_1}{d\omega_m} > \frac{dT}{d\omega_m} \quad \text{——— (1)}$$

Eqn (1) is the criteria for steady state - stability and it can be derived mathematically as below. After a small displacement from the equilibrium the torque equation becomes,

$$J\frac{d\omega_m}{dt} + J\frac{d}{dt}(\Delta\omega_m) + T_1 + \Delta T_1 - T - \Delta T = 0 \text{ — (2)}$$

where, $\Delta\omega_m$ = a small displacement in motor speed from equilibrium

ΔT_1 = a small displacement in load torque from equilibrium

ΔT = a small displacement in motor torque from equilibrium

But, we know that,

$$J\frac{d\omega m}{dt} + T_1 - T = 0 \quad --- (3)$$

Hence,

$$J\frac{d(\Delta\omega m)}{dt} + \Delta T_1 - \Delta T = 0 \quad - (4)$$

If we assume that ΔT & ΔT_1 are so small that they can be expressed as linear function of change in speed then

$$\Delta T = \frac{dT}{d\omega m}\Delta\omega m \quad \& \quad \Delta T_1 = \frac{dT_1}{d\omega m}\Delta\omega m$$

where $\frac{dT}{d\omega m}$ & $\frac{dT_1}{d\omega m}$ indicates derivative at the point of equilibrium.

Substituting these values in eqn (4)

$$J\frac{d}{dt}(\Delta\omega m) + \left[\frac{dT_1}{d\omega m} - \frac{dT}{d\omega m}\right]\Delta\omega m = 0 \quad - (5)$$

Solution of eqn (5) is

$$\Delta\omega m = (\Delta\omega m)_0 e^{-t/\tau} \quad --- (6)$$

where,

$$\tau = \frac{J}{\left(\frac{dT_1}{d\omega m} - \frac{dT}{d\omega m}\right)}$$ is called mechanical time constant.

where,

$(\Delta\omega m)_0$ is initial value of derivation in speed.

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Based on the value of exponent, there are three cases:

1. Exponent > 0 ⇒ unstable system
2. Exponent < 0 ⇒ Stable "
3. Exponent = 0 ⇒ Eqn is insufficient to discuss about stability

The exponent will always be negative if

$$\left(\frac{dT_1}{d\omega_m} - \frac{dT}{d\omega_m}\right) > 0$$

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Write the essential part of electrical drive? What are the function of power modulators

⇒

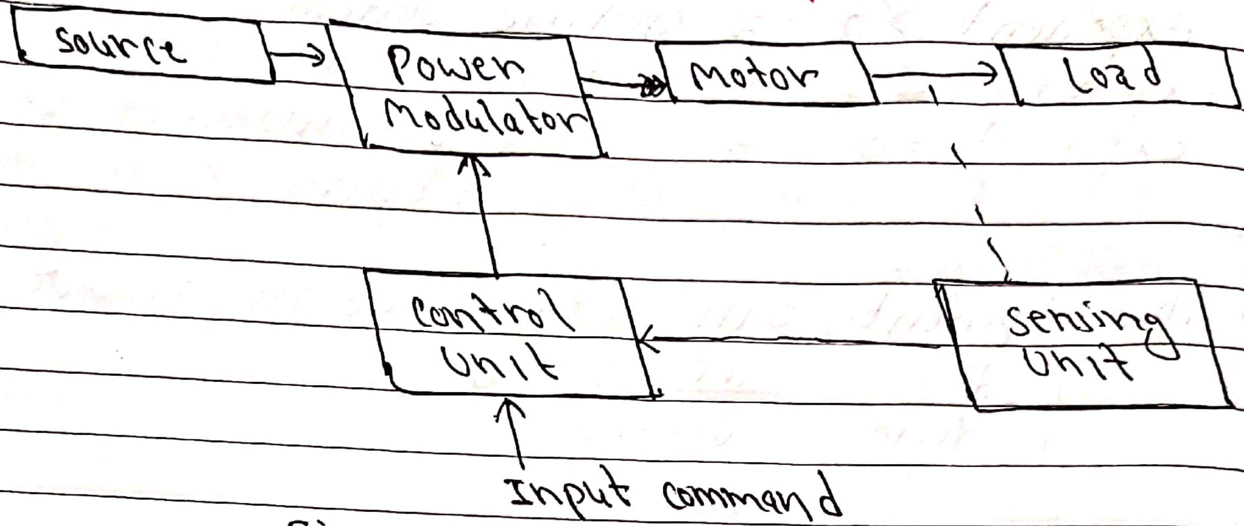

Fig- Functional Block diagram of electric drive.

Essential part of electrical drive

1. Source
2. Power Modulator. 3. Motor.
4. Control unit
5. Sensing unit

1) Source → It can be either ac source or dc source.

2) Power Modulator →

In the electric drive system, the power Modulator can be any one of the following

1) Controlled rectifier (ac to dc converters)
2) Invertors (dc to ac ")
3) ~~Dc chopper (dc to dc~~ Ac voltages controller (ac to ac
4) Dc choppers (dc to dc ")
5) Cyclo converters (frequency ")

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Function of Power Modulators

→ It regulates the output power from the source according to the load requirement.

→ It converts the energy according to the requirement of motor.

→ It also selects the mode of operation of motor.

→ During transient operation it restricts source & motor current within permissible.

(3) Control unit →

→ It operates the power modulator as desired.

→ It generates the command for power modulator according to the input command & o/p from the sensing unit.

(4) Sensing Unit →

→ senses the certain drive parameters like motor current & speed.

→ It is mainly required either for protection or for close loop operation

(5) Motor → Aagadi

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	Feature	Individual Drive	Group Drive	Multimotor drive
1)	control	Independent	centralized	centralized
2)	Motor Connection	one Motor	Multiple Motors	Multiple Motors
3)	Synchronization	Not synchronized	partially synchronized	Fully synchronized
4)	complexity	simple	Moderate	complex
5)	scalability	limited	Moderate	High
6)	cost	lower	Moderate	Higher
7)	Redundancy	NO	partial	Yes
8)	Fault Tolerance	low	Moderate	High
9)	speed	It is used where constant speed is require.	It can't be used where constant speed is required.	
10)	space Utility	less space is required	More space is required in case of group drive.	
11)	PF & Efficiency	Efficiency & PF is good	Efficiency & PF is not good.	

2019F 3(a) | 16F

Compare individual drive, group drive & Multimotor drive

Flywheel sizing → (19F/15S) - SN

Let, T_{load} = load torque

T_{fw} = flywheel torque

T_0 = No load "

T_{motor} = motor torque at any instant

ω_0 = motor speed on no load, rad/s

ω = " " at any instant, rad/s

$S = (\omega_0 - \omega)$ = rotor slip

t = time second

J = moment of inertia of flywheel, kg-m²

Case-I) Load Increasing (flywheel decelerating):

During the period the flywheel decelerates & gives up a part of stored energy in it. The torque required to be suppiled by the motor

$$T_{motor} = T_{load} - T_{fw} \quad \text{--- (1)}$$

energy given out by the flywheel when it's speed is reduced from ω_0 to ω

$$= \frac{1}{2} J(\omega_0^2 - \omega^2) = J\left(\frac{\omega_0+\omega}{2}\right)(\omega_0-\omega)$$

But $\frac{\omega_0+\omega}{2} = \omega$ = mean speed

and, $\omega_0 - \omega = $ slip (s)

energy given out $= J\omega s$

The power is given out by the flywheel

= rate of energy given up

$= \frac{d}{dt} (J\omega s)$

$= J\omega \, ds/dt$

Flywheel torque, $T_{fw} = \frac{Power}{\omega}$

$= J\omega \cdot \frac{ds/dt}{\omega}$

$= J \cdot ds/dt$ — (11)

eqn (1) becomes,

$T_{motor} = T_{load} - J \cdot \frac{ds}{dt}$

As for value of slip upto 10%, the slip is proportional to the torque i.e $S = K T_{motor}$

$T_{motor} = T_{load} - JK \cdot \frac{dT_{motor}}{dt}$

or $T_{load} - T_{motor} = JK \cdot \frac{dT_{motor}}{dt}$

or $\frac{dT_{motor}}{T_{load} - T_{motor}} = \frac{1}{KJ} dt$

or $-\log_e (T_{load} - T_{motor}) = \frac{t}{KJ} + C_1$

or $\frac{-t}{KJ}$ ~~$t = \log_e [T_{load}$~~

From initial condition, when $t = 0$, $T_{motor} = T_0$

$C_1 = -\log_e (T_{load} - T_0)$

~~Flywheel sizing~~

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$$-\log_e (T_{load} - T_{motor}) = \frac{1}{KJ} \cdot t - \log_e (T_{load} - T_0)$$

$$-\frac{1}{KJ} t = \log_e \left[\frac{T_{load} - T_{motor}}{T_{load} - T_0} \right]$$

$$e^{-t/KJ} = \frac{T_{load} - T_{motor}}{T_{load} - T_0}$$

$$T_{motor} = T_{load} - (T_{load} - T_0)\, e^{-t/KJ} \quad \text{— (iii)}$$

Case-2 : load decreasing (Flywheel accelerating)

When load decreases, the motor accelerates the ~~motor~~ flywheel to it's normal speed, slip is therefore decreased & $\frac{ds}{dt}$ is -ve.

$$T_{motor} = T_0 + T_{fw}$$

$$T_{motor} = T_0 - J \cdot \frac{ds}{dt}$$

solving —

$$\boxed{T_{motor} = T_0 + (T_{motor} - T_0)\, e^{-t/KJ}}$$

(18F, 13F)

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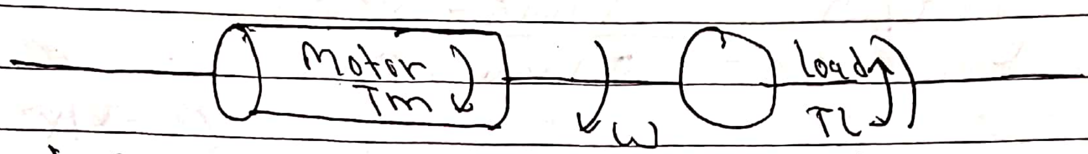
Write the eqn describing the dynamics of motor load combination & prove that the condition for steady state stability.

The motor and the load that it drives are represented by the rotational system.



The basic eqn of the motor load system is

$$T_m = T_L + J \cdot d\omega / dt$$

T_m & T_L is motor & load torque respectively in Nm.

$J \rightarrow$ Moment of inertia

$\omega \rightarrow$ Angular velocity in rad/sec

Motor torque is the applied torque & load torque is the resulting torque.

If $T_m > T_L$, $(d\omega/dt > 0)$: The drive will be accelerating in particular picking up speed of reach rated speed.

If $T_m < T_L$ $(d\omega/dt < 0)$: The drive will be decelerating & particular, coming to rest.

If $T_m = T_L$ $(d\omega/dt = 0)$: The motor will continue to run at same speed, if it were running or continue to be at rest, if it were not running.

→ As $T_m > T_L$, the drive accelerates & when $T_m < T_L$ the drive accelerates is true only for the passive load.

→ The term $J(d\omega/dt)$ represents the inertia or dynamic torque, which is available during transient condition.

→ During acceleration, the dynamic torque is directed against the motion & during the breaking it will help motion of the drive

$$\pm T_m = \pm T_L + J \cdot d\omega/dt$$

→ The different loads connected to the motor will have different speed, to select the motor it is desirable to refer all mechanical quantities like load torque, inertia etc at one single axis mostly the o/p shaft of the motor.

chapter-4 Starting of Electric Motor

(18S), (22F)

Methods of reducing energy losses during starting - 17S | 13F | 15F | 12F

The following methods are commonly used to reduce the loss in energy during starting of motor

1) Reducing the moment of inertia of the rotor →

we have,

Energy lost during starting, when the motor changes it's speed from zero to no load, ω_0 will be

$$W_{st} = J\omega_2^2 - \frac{J}{2}\omega_2^2 = \frac{J\omega_0^2}{2}$$

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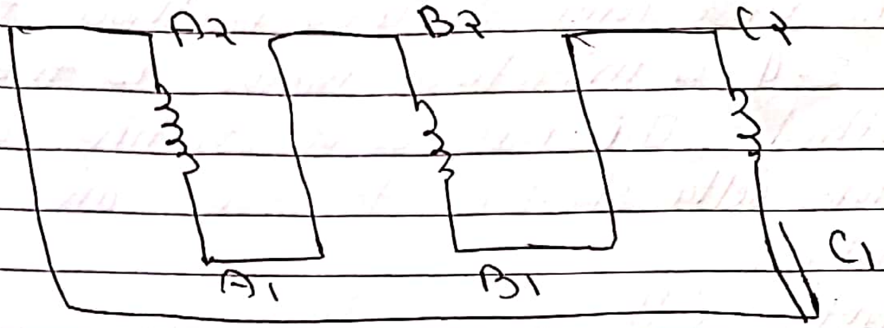
start-delta starter at remaining

When the motor picks up the speed, about of it's rated speed, the switch s is immediately put into the Run position. As a result, a stator winding which was in star connection is changed into delta connection now



~~Start delta starter at remaining~~

If motor is started with delta connection by direct switching

$$I_{LD} = \frac{\sqrt{3} V_P}{Z}$$

If the motor is started with star connection by direct switching

$$I_{LS} = \frac{V_P/\sqrt{3}}{Z}$$

So, $\frac{I_D}{I_S} = \frac{I_{LD}}{I_{LS}} = \frac{\sqrt{3} V_P/Z}{V_P/\sqrt{3}Z} = 3$

$$\boxed{I_S = I_{LS} = \frac{1}{3} I_{LD}} \qquad \boxed{I_{LS} = \frac{1}{3} I_{LD}}$$

~~Since the~~ since the developed torque is proportional to the square of the voltage applied to an induction motor, star delta starter reduces the starting torque to 1/3 that is obtained by direct delta starting.

18F||17F

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Describe the short start delta starter, Autotransformer starter, Reactor starter & rotor resistance starter of Induction motor.

1) Start-delta starter →

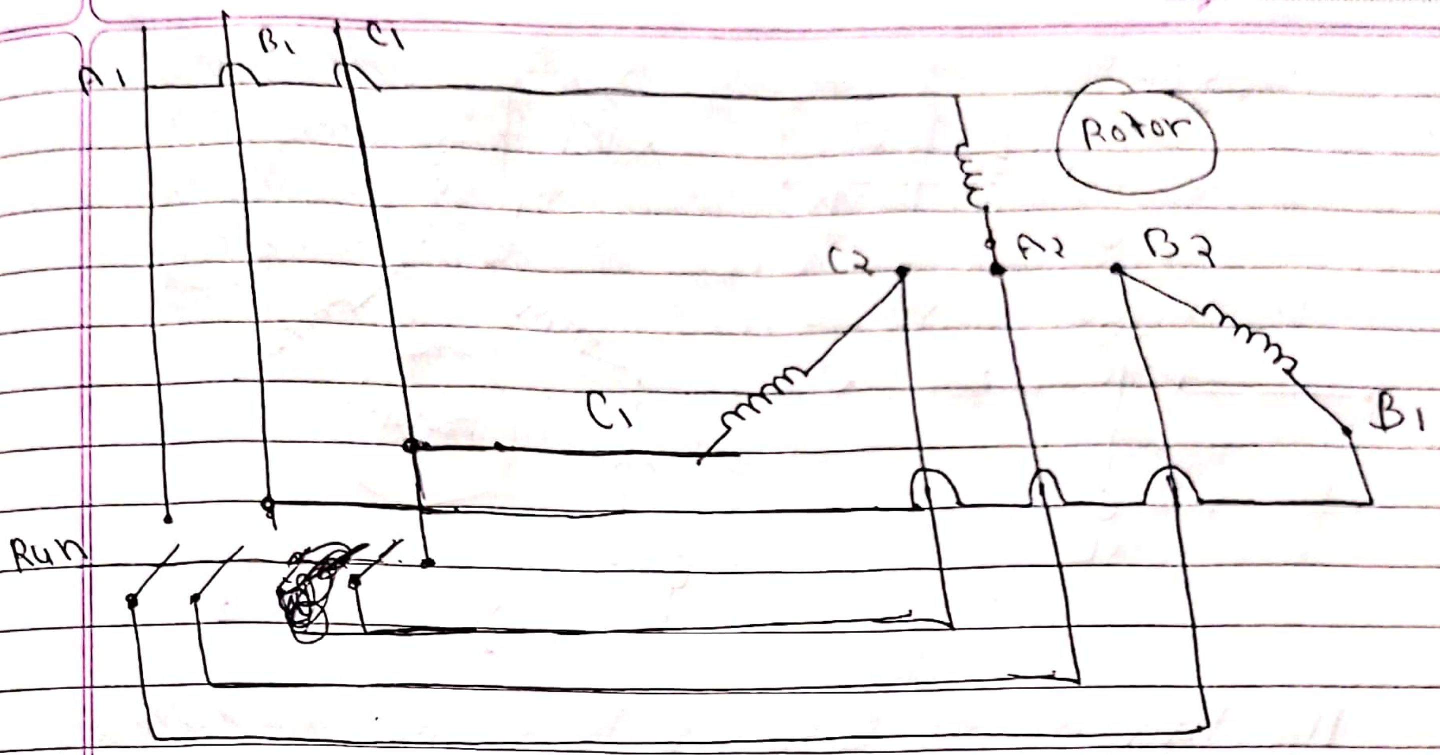
The most commonly used method for starting of 3-ϕ induction motor is the star-delta method. This method of starting applies a star delta starter to start an induction motor.

Starter delta starter is a type of reduced voltage reduced. We use it to reduce starting current without using any external device or apparatus. The major application of motors with star delta starters are fans, pumps, centrifugal chillers in AC etc.

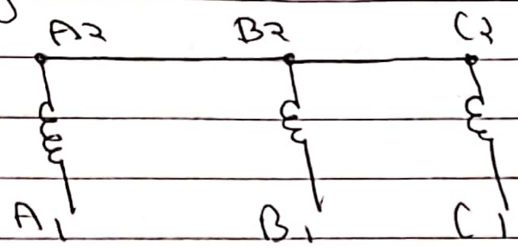
In the star delta starter, the initial connection of the stator winding is in the form of star. If V_L is the line voltage, & V_P is the phase voltage, then the voltage at each stator phase is given by

$$V_P = \frac{V_L}{\sqrt{3}}$$

As the motor accelerates & gains speed, the stator winding are disconnected from the stator ~~wind~~ configuration & connected in the form of delta.



When the switch s in start position, the stator winding are connected in the star



② Auto-transformer starter →

An auto-transformer, starter is suitable for both star & delta connected motors. In this method, the starting current is limited by using a 3-ϕ autotransformer to reduce the intial stator appiled voltage.

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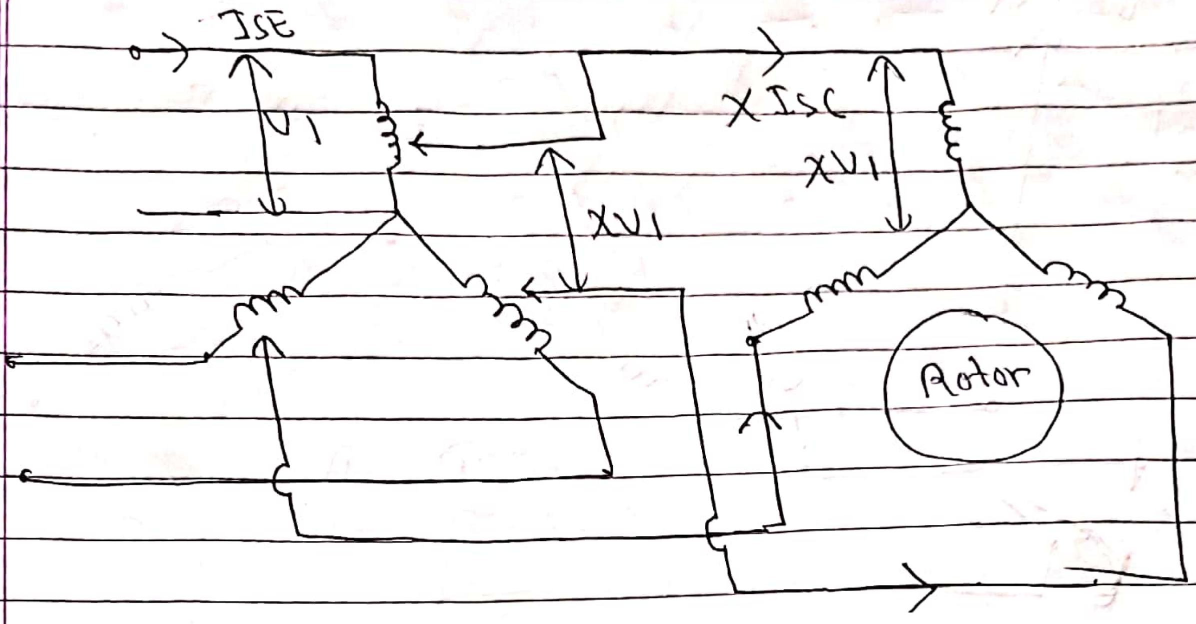
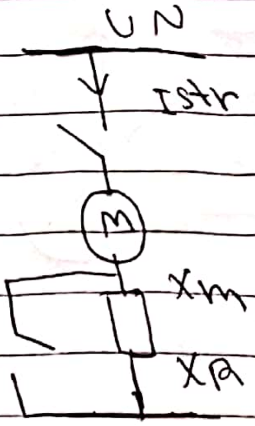


The transformer is a step down transformer hence it reduces the per phase supply voltage from V_1 to XV_1. The reduction in voltage reduces current from Is to XIs. After the motor reaches to it's ~~need~~ normal operating speed, the autotrans-former is disconnected & then full voltage (line) is appiled.

3) Reactor starter →

By connecting a coil with an iron core (a reactor) in series with the motor during start, the starting current is limited in proportion with the voltage.

However, this also means a quardatic eqn in the avaliable starting torque. The advantages of this method is it's low cost in comparison with other method.



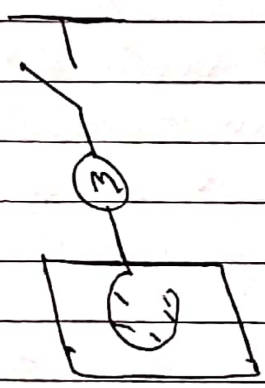
UN = Rated net voltage
Ist = start current at full voltage
XR = reactor reactance
Xm = motor "
IstR = starter current at red voltage

$$I_{stR} = \left(\frac{U_N}{X_m + X_R} \right), \quad T_{stR} = \left(\frac{I_{stR}}{I_{st}} \right)^2 T_{st}$$

4) Rotor resistance starter (Rheostant starting) →

To limit the rotor current which consequently reduces the current drawn by the motor from the supply, the resistance can be inverted in the rotor circuit of start.

Rheostant starting can only be used with slip ring motors. On these motor, the resistance of the other circuits can be increased with an external resistor



UN = Rated net voltage.

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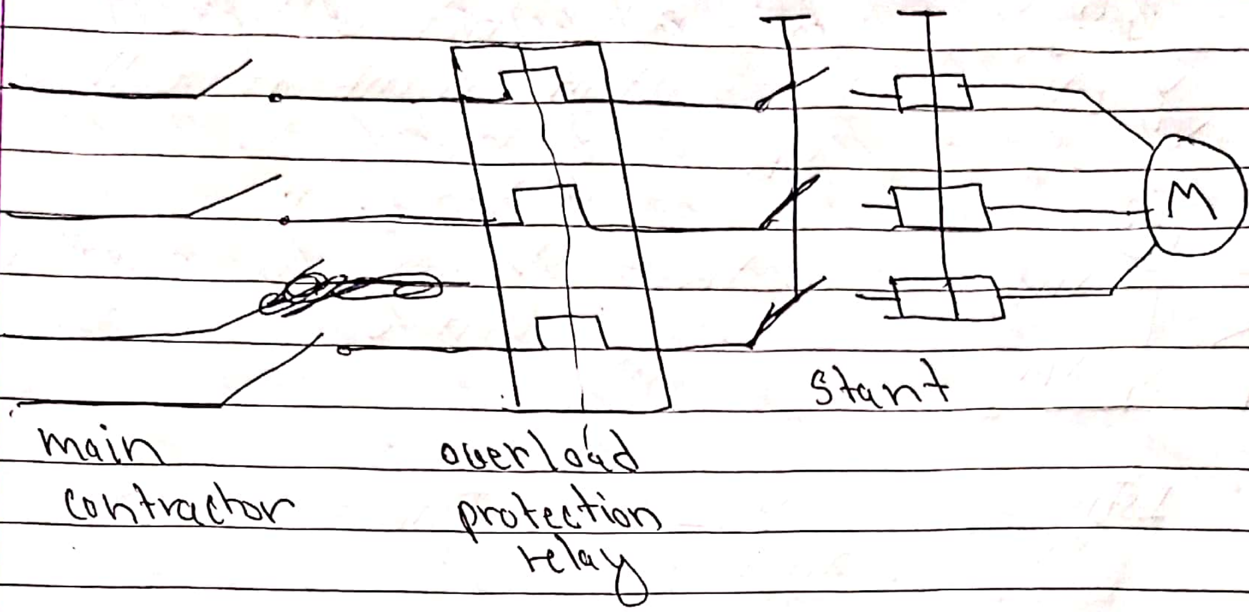

High torque is produced at low speeds, when the external resistance is at it's higher value. The high resistance limits starting current & allows the motor to start safely against high load.

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Energy losses during transient operation of DC motor ~~⊕~~ 3a
shunt

⇒ An expression of the form given below may be obtained for the energy last in the armature of a DC shunt motor

The voltage eqn of the dc motor is

$$V = E + I_a R_a$$

$$I_a R_a = V - E$$

For the shunt motor,

$$I_a R_a = V - K\omega \quad \text{——} \ (I)$$

Above eqn is valid for a separately excited motor also. The eqn of motion on no load will be

$$T_m = K \cdot I_a = J \cdot \frac{d\omega}{dt} \quad \text{——} \ (II)$$

Multiplying eqn (I) by (II), we get

$$I_a^2 R_a = J \cdot V/K \frac{d\omega}{dt} - J\omega \frac{d\omega}{dt} \quad \text{——} \ (III)$$

On no load, the $I_a R_a$ in the motor will be negligibly small & hence $V = K\omega_0$

ω_0 = no load speed of shunt motor

Put, $\frac{V}{K} = \omega_0$ in eqn (III)

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$I_a^2 R_a \cdot dt = J \cdot \omega_0 \, d\omega - J\omega \, d\omega$ —— (11)

If the motor speed were to change from ω_1 to ω_2 from t_1 to t_2, energy dissipated in the armature ckt is given by,

$$W = \int_{t_1}^{t_2} I_a^2 R_a \, dt$$

$$= J\omega_0 \int_{\omega_1}^{\omega_2} d\omega - J \int_{\omega_1}^{\omega_2} \omega \cdot d\omega$$

$$= J\omega_0 (\omega_2 - \omega_1) - \frac{J}{2} (\omega_2^2 - \omega_1^2)$$

Hence, energy lost during starting, when the motor changes it's speed from zero to no load speed ω_0 will be

$$W_{st} = J\omega^2 - \frac{J}{2}\omega_2^2 = \frac{J\omega_0^2}{2}$$

Thus, energy lost in the armature of a dc motor during starting on no load will be equal to the K.E absorbed by the armature while accelerating from standstill to no load speed. Further, this energy loss is independent of the armature circuit resistance. If the motor were started with a constant load torque T_L the energy lost during starting could be determined as follows

$T_m = K \cdot I_a = T_L + J \cdot d\omega/dt$ —— (12)

Multiplying (1) by (5)

$$I_a^2 R_a = J \cdot \frac{V}{K} \frac{d\omega}{dt} - J\omega \frac{d\omega}{dt} + \frac{V}{K} T_L - T_L \cdot \omega \quad \text{--- (VI)}$$

If the motor speed were to change from ω_1 to ω_2, the energy lost would be given by,

$$W = \int_{t_1}^{t_2} I_a^2 R_a \cdot dt$$

$$= \frac{J \cdot V}{K} \int_{\omega_1}^{\omega_2} d\omega - J \int_{\omega_1}^{\omega_2} \omega \cdot d\omega + \frac{V}{K} T_1 \int_{t_1}^{t_2} dt - \int_{T_1}^{t_2} \omega(t)\, dt * T_L$$

$$= J \cdot \frac{V}{K} (\omega_1 - \omega_2) - \frac{J}{2} (\omega_2^2 - \omega_1^2) + \frac{V}{K} T_L (t_2 - t_1)$$

$$- T_L \int_{t_1}^{t_2} \omega(t) \cdot \omega \cdot dt \quad \text{--- (VII)}$$

$\frac{V}{K}$ in eqn (VII) can be replaced by ω_0, the no load speed. Hence, energy lost during starting on load, when speed changes from zero to ω_r will be

$$W_{st} = J\omega_0 \cdot \omega_r - \frac{J}{2} \omega_r^2 + T_L \cdot \omega_0 \cdot t_{st}$$

$$- T_L \int^{t} \omega(t)\, dt$$

$$= J\left(\omega_0\omega_r - \frac{\omega_r^2}{2}\right) + T_L\left(\omega_0 t_{st} - \int_0^t \omega(t)\,dt\right) \quad \text{--- (VII)}$$

Where,

t_{st} = accelerating time

The second term in eqn (VII), shows that the energy lost during starting depends so both on the accelerating time & on the nature of speed variation with time during acceleration.

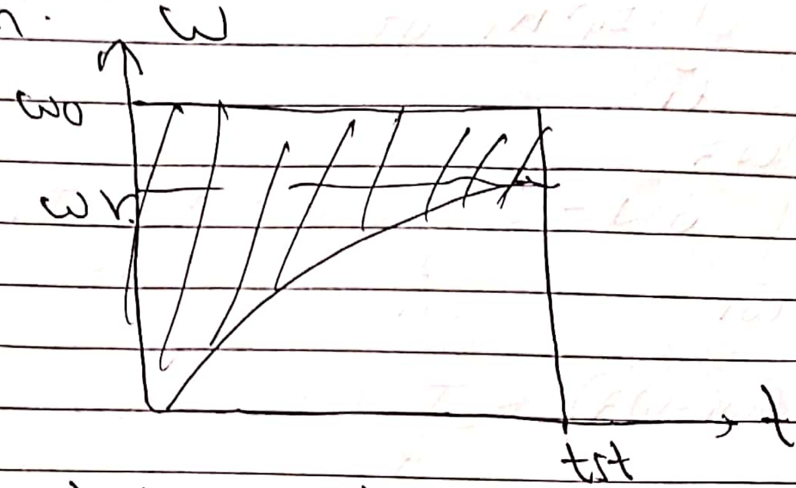

Fig - speed figure during starting of a dc shunt motor

$\left(\omega_0 t_{st} - \int_0^t \omega(t)\,dt\right)$ can be determined as the standard.

Chapter-5 Electrical Breaking

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Braking is the process to reduce the speed of any moving or rotating equipment.

Types of Braking

(a) Mechanical Braking
(b) Electrical "

18F1 17 S16S

Electrical Breaking

In electrical braking, the braking energy is converted into electrical energy instead of converting it into heat energy at the brake shoes (as in mechanical braking) and either dissipated in the resistances or returned to the supply.

Types of Electrical Braking

1. Plugging or reverse current braking (3rd supply)
2. Rheostatic or dynamic braking ~~No ext~~ (supply)
3. Regenerative braking. No supply supp (~~No~~ ext supp)

1) Regenerative Braking →

→ In this method, the motor is not disconnected from the supply.

→ It remains connected to it & feeds back the braking energy or KE to the system.

→ As no energy is wasted in this method & it is suppiled back to the system thus overall energy

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is saved. Hence it is better than plugging and rehostatic braking.

→ Mostly used when the load on the motor has overhauling characteristics as in the lowering of hoist or downward motion of an electric train.

Advantages

1) Reduced energy consumption
2) Higher speeds are possible while going down the gradients.
3) Relatively small amount of brak block dust formed which increases the life of bearnings.
4) Higher value of braking retardation is obtained.
5) Ease & safety with which heavy loads can be halved over step gradients.
6) Improved performances
7) ~~Disadvantages~~ smaller Accessories
8) Reduction in Engine Wear
9) ~~fct~~ Emission reduction
9) Increase of overall energy efficiency of a vehicle.

Disadvantages

→ Friction brakers are still necessary
→ Added weight - extra components can increase weight.
→ Cost of component, engineering, manufacturing & installation is high.
→ Complexity - depend on control necessary for operation of regenerative braking system.

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2) Rheostatic or Dynamic Braking → (13F, 15F)

→ In this method of braking, the motor is disconnected from the supply & operated as a generator driven by the kinetic energy of the rotating part of motor & it's driven machines.

→ Thus the KE of rotation is converted into electri-cal energy, which is dissipated in the external resistance connected across the motor at the braking instant.

→ The advantage of this method is that no energy is required from the supply to break the motor.

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3) Plugging or Reverse current braking →

→ simple method of electric braking.

→ In this method, the torque of the motor is reversed by reversing the supply connection.

→ It makes the motor & the driven machine to standstill condition.

→ A special device is required to cut off the supply as soon as motor comes to rest

→ Better braking torque than rheostatic braking.

17F, 15F, 18F, 16S

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Regenerative braking for Dc shunt motor →

⇒ This type of braking in dc shunt motor is possible when the overhauling load act as a prime mover & so drives the machine as a generator.

⇒ In this case, back emf is greater than supply voltage.

⇒ To stop the machine at the point when back emf is equal to supply voltage we have to cut off the supply line.

→ Mechanical breaks required in order to hold the motor at standstill condition.

→ All the dc shunt motors are provided with regeneration capability.

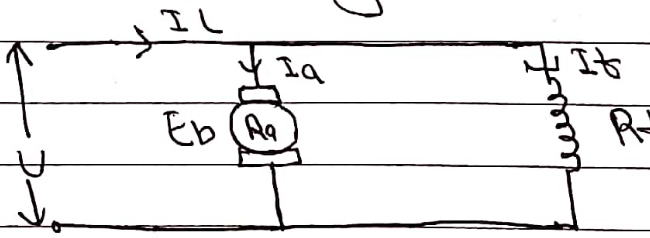

Fig - ckt diagram of dc shunt motor

The armature current of dc shunt motor is given as

$$I_a = \frac{V - E_b}{R_a}$$

During regeneration, $E_b > V$

$$\therefore (I_a)_{reg} = -I_a$$

In motoring mode, $E_b < V$

we have,

$$E_b \propto \phi \omega$$

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For constant field current, ϕ = constant when $\omega \uparrow$, $E_b \uparrow$

After $E_b > V$, regenerative braking starts. Then I_a reverse, torque reverse, speed falls & E_b falls.

when $E_b < V$, motoring mode starts to stop at the point when $E_b = V$, cut off supply.

During regeneration,

$$(I_a)_{reg} = -I_a$$

so,

$$I_a = -\left(\frac{E_b - V}{R_a}\right) = -\left(\frac{K\phi\omega - V}{R_a}\right)$$

$$T_b = -K\phi I_a = K\phi\left(\frac{K\phi\omega - V}{R_a}\right)$$

or, $$K\phi\omega - V = \frac{T_b \cdot R_a}{K\phi}$$

a $$K\phi\omega = V + \frac{T_b \cdot R_a}{K\phi}$$

a $$\omega = \frac{V}{K\phi} + \frac{T_b \cdot R_a}{K^2\phi^2} \quad \text{--- (1)}$$

which represents eqn of st. line with slope $\frac{R_a}{K^2\phi^2}$.

The first term in eqn (1) represents the no load speed when $T_b = 0$ which is equal to

$$\omega_0 = \frac{V}{K\phi}$$

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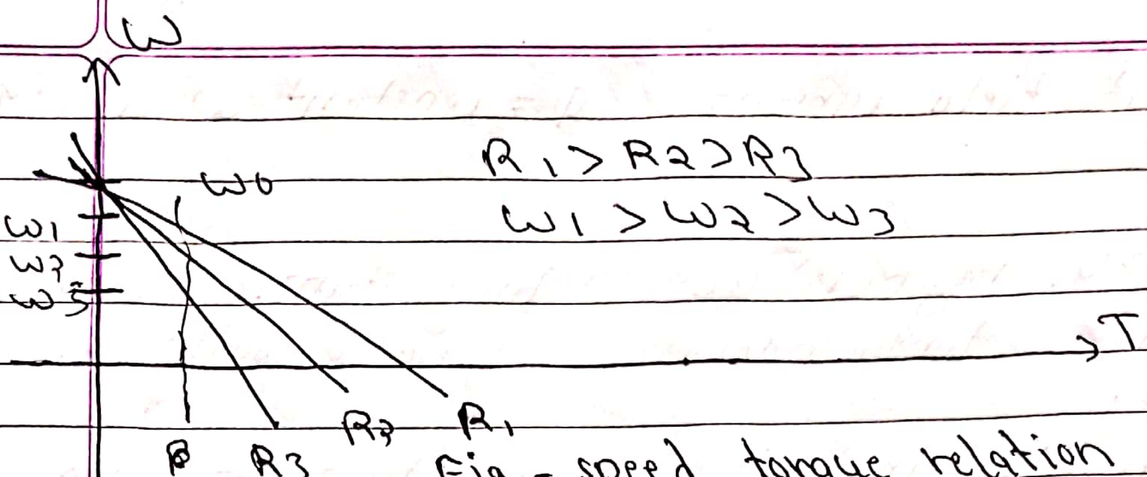

Fig - speed torque relation during regenerative braking of dc shunt motor

Hence higher the resistance of armature circuit to provide a particular braking torque higher is the speed required.

The other ways to apply regenerative braking for constant speed are
1) Increase the excitation i.e field current
2) Decrease the supply voltage.

(W13, 14F, 15F, 16S, 10F)

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Regenerative Braking for Induction Machine →

Regenerative braking can take place only when the rotor rotates in the same direction as that of the stator magnetic field but with a speed greater than the synchronous speed. Such a state occurs during any one of the following process.

Switching over to a low frequency supply in frequency controlled induction motor in order to reduce the speed of operation of the drive.

Downward motion of the loaded hoisting mechanism

Switching over to a larger pole number operation from a smaller one in multispeed squirrel cage motor.

In all above cases, the slip and the torque developed becomes negative & thus the machine acts as a generator, reciving mechanical energy and giving it back to the supply as electrical energy.

During switching over from smaller pole or number to larger or from high frequency to low frequency of supply, the change in speed from a higher value to a lower one takes place as per the speed torque curve.

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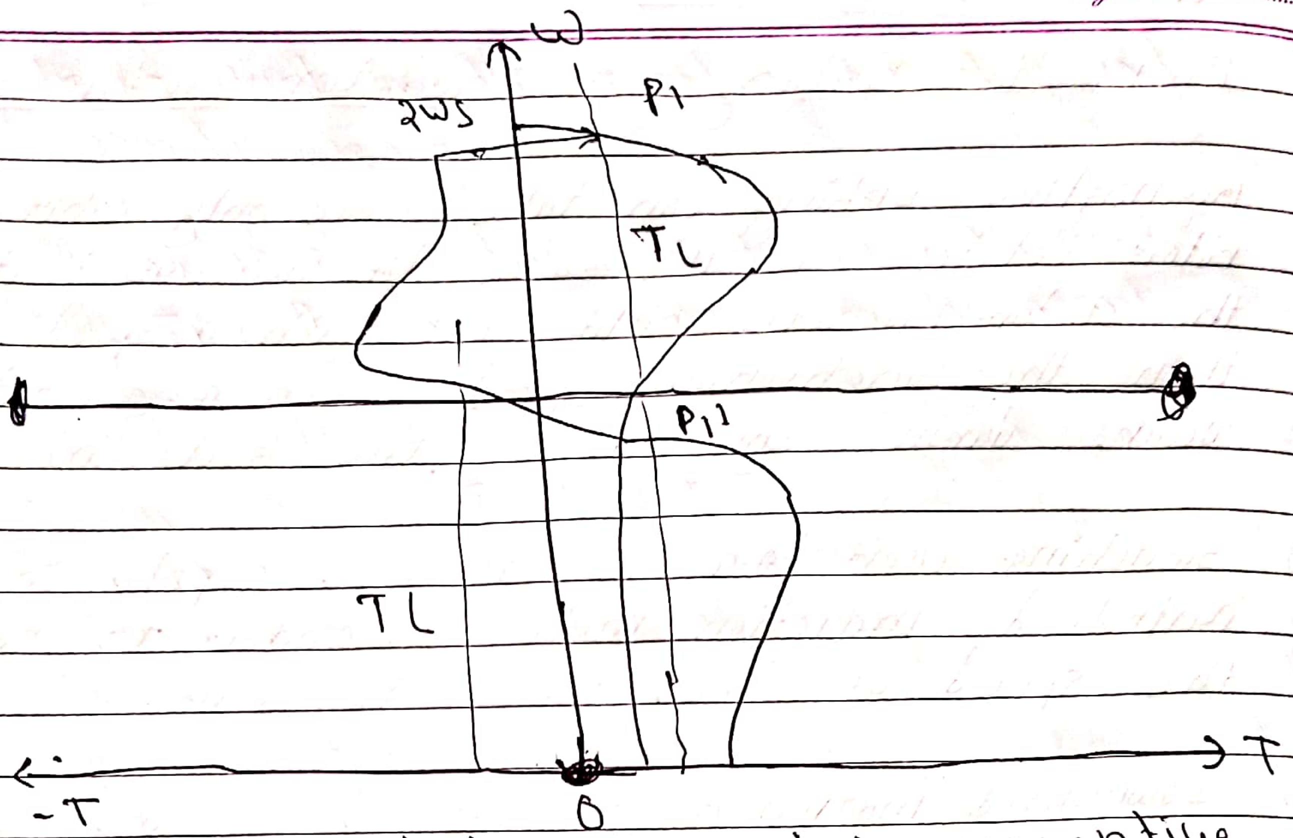

Fig - speed torque curve during regenerative braking of induction motor

→ By varying the resistance in the rotor circuit, it is possible to operate at any speed higher than the synchronous speed during braking.

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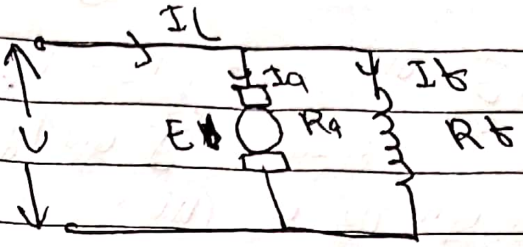
Derive the energy loss expression during starting & plugging of dc shunt motor.

Energy loss / consumption during starting of DC shunt motor :

For a dc motor



$$V = E + I_a R_a$$
$$= k\omega + I_a \cdot R_a$$
$$I_a R_a = V - k\omega$$

on load condition, $V = k\omega_n$ as the drop $I_a R_a$ is negligibly small

$$I_a R_a = k(\omega_n - \omega) \quad \text{--- (I)}$$

Now, on no load, the eq^n $J \cdot \frac{d\omega}{dt} = T_e - T_L$ becomes,

$$J \cdot \frac{d\omega}{dt} = T = kI_a \quad \text{--- (II)}$$

Multiplying eq^n (I) by I_a, we have

$$I_a^2 R_a = k I_a (\omega_n - \omega) \quad \text{--- (III)}$$

From eq^n (II) & (III)

$$I_a^2 R_a = J(\omega_n - \omega)\, d\omega/dt$$

Now,

energy loss during starting is

$$E_s = \int I_a^2 R_a \cdot dt = J\int_0^{\omega_n} (\omega_n - \omega)\frac{d\omega}{dt} \cdot dt$$
$$= \frac{1}{2} J\omega_n^2 \quad \text{--- (IV)}$$

Eq^n (IV) shows that the energy consumed by armature of dc shunt of separately excited motor equals

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the KE stored by the armature & is thus independent of armature resistance.

whereas, if the motor were started with constant load torque T_L, the energy consumed in the armature ckt is

$$J \cdot d\omega/dt = T_e - T_L \quad \text{--- (4)}$$

$$T_e = KI_a = J\, d\omega/dt + T_L \quad \text{--- (V)}$$

from eqn (V) & (III)

$$I_a^2 R_a = (\omega_n - \omega)\left[J \frac{d\omega}{dt} + T_L\right]$$

$$E_S = \int_0^t I_a^2 R_a \cdot dt$$

$$= \int_0^t (\omega_n - \omega)\left[J \cdot \frac{d\omega}{dt} + T_L\right] dt$$

$$E_S = J\omega_n \int_0^{\omega_n} d\omega + \int_0^t \omega_n \cdot T_L \cdot dt - J \int_0^{\omega_m} \omega \cdot d\omega - \int_0^t \omega T_L\, dt$$

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Energy loss during plugging for dc shunt motor →

let us suppose that the braking take place with no load on the motor. The energy loss during braking is given by,

$$E_{bss} = \int I_a^2 R_a \cdot dt$$

we have,

$$E_b + I_a R_a = V_t$$

$$I_a R_a = V_t - k\omega \quad [\because E_b = k\omega]$$

Now,

$$T_a = -J \cdot d\omega/dt = kI_a$$

$$I_a = -\frac{J}{K}\cdot\frac{d\omega}{dt}$$

Now, at no load, $V_t = K\omega_0$

$$\frac{V_t}{K} = \omega_0$$

$$\therefore \quad I_a^2 R_a = (I_a \cdot R_a)\cdot I_a = (V_t - K\omega) \times \left(-\frac{J}{K}\cdot\frac{d\omega}{dt}\right)$$

$$I_a^2 R_a\, dt = -\frac{V_t}{K} J\, d\omega + J\omega\, d\omega$$

$$= -J\omega_0\, d\omega + J\omega\, d\omega$$

Where,
brake is applied at no load, $\omega = 0$

$$E_{loss} = \int_{\omega_0}^{0} -J(\omega_0 - \omega)\, d\omega$$

$$= \left[J\cdot\left(\omega_0\omega - \frac{\omega^2}{2}\right)\right]_{\omega_0}^{0}$$

$$E_{loss} = \frac{J\omega_0^2}{2}$$

= ~~KE~~ energy of the armature at the start of braking

Now,
If motor reverses, it's direction of rotation & the speed changes from $+\omega_0$ to $-\omega$, the energy lost by armature will be $4\left(\frac{J\omega_0^2}{2}\right)$

$$= 2J\omega_0^2 \quad \#$$

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Prove that during dynamic braking energy dissipated in breaking resistor $E = \frac{1}{2} J \omega_0^2$ & during plugging energy dissipated in braking resistor $E = \frac{3}{2} J \omega_0^2$.

⇒ Soln,

let us suppose that the braking takes place with no load on the motor.

We have, eqn of motor on no load is

$$T_m = K \cdot I_a = J \cdot \frac{d\omega}{dt}$$

Multiplying above eqn by, $I_a R_a = V - K\omega$

we get, ~~$I_a^2 R_a = VI - K\omega I$~~

$$I_a^2 R_a = \frac{JV}{K} \frac{d\omega}{dt} - J\omega \cdot \frac{d\omega}{dt}$$

On no load, the $I_a R_a$ in the motor will be negligible, and hence $V = K\omega_0$

ω_0 = no load speed of the shunt motor

Put, $V/K = \omega_0$

Then,

$$I_a^2 R_a \, dt = J\omega_0 \, d\omega - J\omega \, d\omega \quad \text{---} (1)$$

The energy dissipated in the armature ckt during rehostat braking is determined using eqn (1). It must be noted that during rheostatic braking $V = 0$ & braking takes place from speed ω_0 to standstill.

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Hence,

$$W_{br(rhe)} = \int_{\omega_0}^{0} -J\omega \, d\omega$$

$$= \int_{0}^{\omega_0} J\omega \cdot d\omega$$

$$= \frac{J \cdot \omega_0^2}{2}$$

And,

During reverse current braking / plugging, the applied voltage V is of the opposite polarity and hence ω_0 in eq^n (1) will change it's sign while determining the loss.

The speed limits are ω_0 & zero.

$$\omega_0(rv) = \frac{3}{2} J \cdot \omega_0^2$$

If the motor reverses it's direction of rotation i.e. if the speed changes from $+\omega$ to $-\omega_0$, the energy loss in the armature ckt will be

$$W_{rev} = \frac{4}{2} J \cdot \omega_0^2$$

$$\therefore \boxed{W_{rev} = 2 \cdot J \cdot \omega_0^2}$$

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Q.N) Energy losses & stopping time calculation during dynamic breaking & plugging of 3-ϕ induction motor →

For no load

We have, energy loss in rotor circuit during starting is

$$\omega = -J\omega_s^2 \int_1^{0.05} s\,ds \quad --- (1)$$

Energy loss in rotor circuit during plugging (braking) will be

$$\omega_p = J\omega_s^2 \int_2^1 s\,ds \quad ---- (2)$$

[∵ $s_p = 2-s$, s at normal running condition is very small. so s_p at the instant of braking is taken as 2]

$$\omega_p = 3/_2 J\omega_{ms}^2 \quad --- (3)$$

For constant load torque T_L

Energy loss in rotor circuit during starting is

$$\omega = -J\omega_s^2 \int_1^{0.05} \left(1 + \frac{T_L}{T_M - T_L}\right) s\,ds \quad --- (4)$$

Energy loss in rotor circuit during plugging will be

$$\omega_p = J\omega_s^2 \int_2^1 \left(1 + \frac{T_L}{T_M - T_L}\right) s\,ds \quad --- (5)$$

Stopping time calculation during braking of induction motor

we have, $dt = \frac{-\tau_m}{2}\left(\frac{s}{s_m} + \frac{s_m}{s}\right) ds$ --- (1)

where, $\tau_m = J\frac{\omega_{ms}}{T_m}$ = mechanical time constant of motor

Time required to start an induction motor on no load is 0.05

$$t_s = \frac{-\tau_m}{2}\int_{1}^{0.05}\left(\frac{s}{s_m} + \frac{s_m}{s}\right) ds$$

$$t_s = \tau_m\left(\frac{1}{4s_m} + 1.5s_m\right) \quad \text{--- (2)}$$

Time required for stopping by plugging when initially running at no load can be expressed as

$$t_b = \frac{-\tau_m}{2}\int_{2}^{1}\left(\frac{s}{s_m} + \frac{s_m}{s}\right) ds$$

$$= \tau_m\left(0.345\,s_m + \frac{0.75}{s_m}\right) \quad \text{--- (3)}$$

Time required for speed reversed by plugging when running on no load is given by

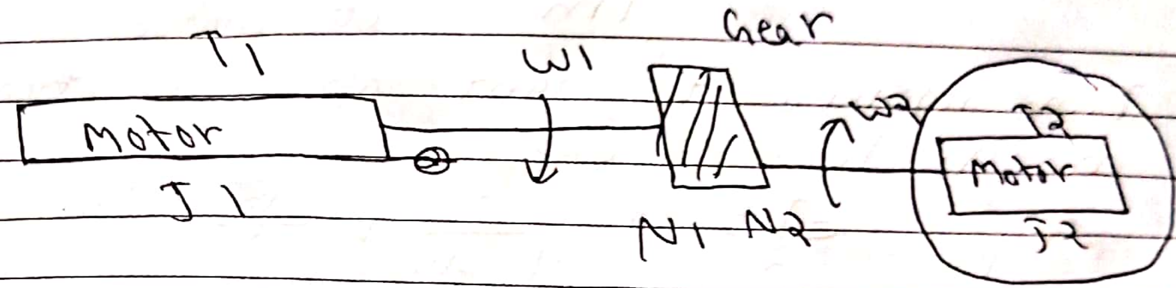
$$t_r = \frac{-\tau_m}{2}\int_{2}^{0.05}\left(\frac{s}{s_m} + \frac{s_m}{s}\right) ds$$

$$= \tau_m\left(3.69\,s_m + \frac{1}{s_m}\right) \quad \text{--- (4)}$$

2021 3(b) 18S

18S 3(b) Two motors having torque T_1 & T_2 with moment of inertia J_1 & J_2 are coupled with a gear having ratios of $N_1 : N_2$. Compute the moment of inertia & torque referred to first motor M_1. Assume figure if necessary.

⇒



let us consider a motor (M_1) coupling with gear ratios $N_1 : N_2$ & $\frac{N_1}{N_2} = a$ & motor speed 'ω_1' moment of inertia J_1, torque T_1 also another motor is coupling with gear ratios (α), motor speed ω_2, moment of inertia J_2 & torque T_2 are as shown in figure:

Now, gear ratios $= \frac{\omega_2}{\omega_1} = \frac{N_1}{N_2} = a$ — — (i)

where a is gear tooth ratios of the losses in transmission are neglected the KE due to equivalent inertia must be the same as KE of various moving parts thus

$$\frac{1}{2} J_1 \omega_1^2 = \frac{1}{2} J_2 \omega_2^2 \quad \text{— — (ii)}$$

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From eqn (I) & (II), we get

$$J_1 = a^2 J_2$$

Power at the two motors must be same, if transmission efficiency of the gear be η then

$$T_1 N_1 = \cancel{\frac{T_2 \omega_2}{\eta}} \quad \frac{T_2 \omega_2}{\eta} \quad \text{--- (III)}$$

Where, Hence m_1 is the main motor so, total equivalent torque referred to the motor shaft. T_1 from eqn (I) & (II), we get

$$\boxed{T_1 = a \frac{T_2}{\eta}}$$

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Q.N) Explain Breking characteristics of DC shunt motor with Torque speed characteristics.

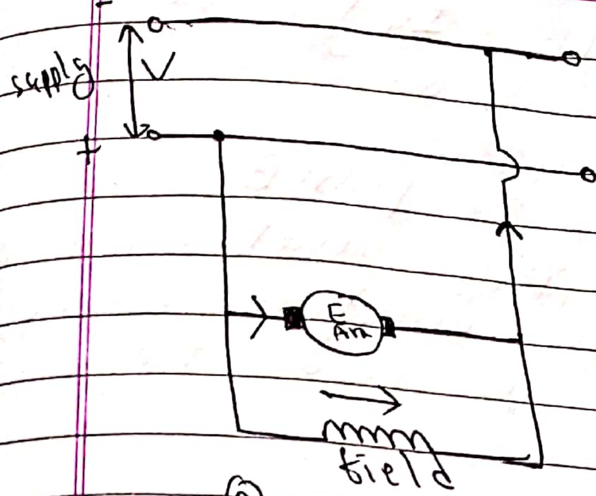
13S/14F OR Discuss in brief the various types of electric breaking system employed to reduce speed of a dc shunt motor. Explain regenerative breaking & it's application.

⇒ Various types of electrical breaking are as follow:
1) Plugging or counter current Braking
2) Dynamic (or Rehostatic) Braking
3) Regenerative breaking

1) Plugging Braking →

~~In this case~~ Figure shown the normal running condition of DC shunt motor. In this case also Eb opposes the supply voltage. When break is appiled, the armature connection are reversed. The torque in opposite direction will be produced. It will reduce the speed of the motor & when the motor stops, DC supply is cut off.

Figure (b) shows the braking condition of the shunt motor. In this case, back emf is helping the supply voltage and to limit heavy brush of current, a resistance R is connected in series with the armature of the motor.



Fig(a) - Normal running

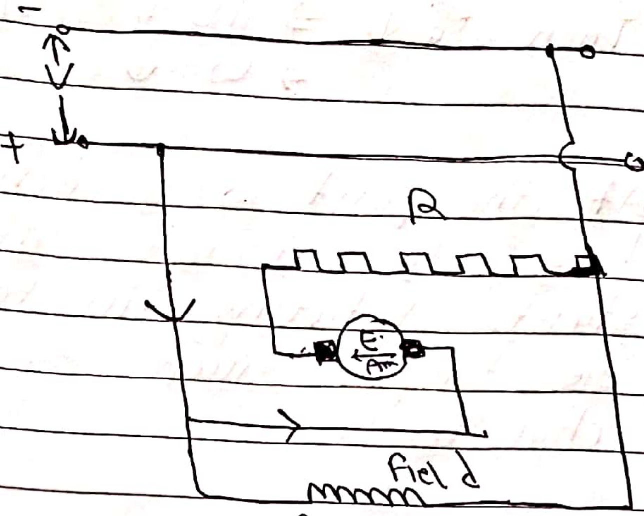


Fig-(b) Plugging

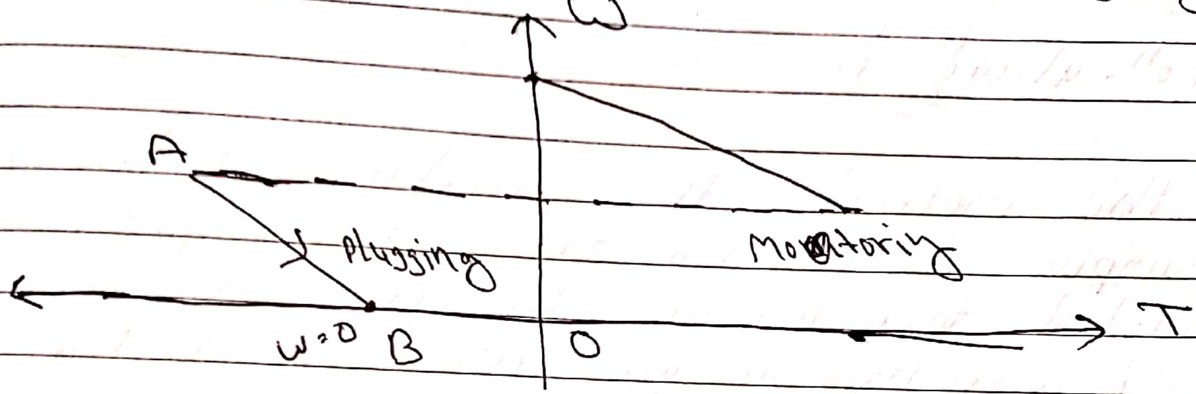


Fig - speed torque characteristics of during motor

During plugging,

$$V - I_a R_a + E_b = 0$$

$$\Rightarrow I_a = \frac{V + E_b}{R_a}$$

→ I_a is in opposite direction to that of monitoring mode so motor develops torque in opposite direction which denotes point A in above speed torque characteristics.

→ Now speed falls because of which E_b also falls ($E_b \propto \omega$)

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→ Then $I_a \downarrow \Rightarrow T_b \downarrow$ $\quad [\because T_b \propto I_a]$
$\Rightarrow \omega \downarrow$

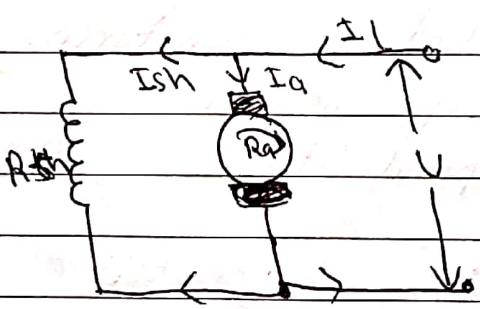
At the point $\omega = 0$ denoted by point B we have to cut off the supply otherwise motor starts rotating in reverse direction because of torque given by OB in speed torque characteristics

2) Dynamic or (Rehostant Breaking) → 19F-long

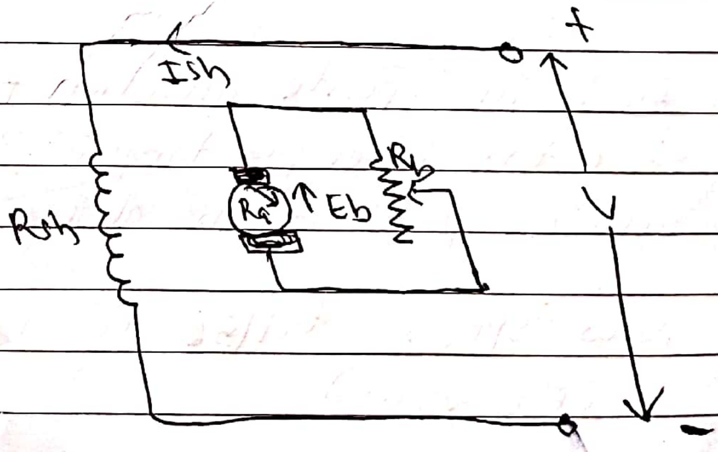
Defn - already described.

In this method, the armature of the motor is simply disconnected from the supply and is connected to a resistance in series with it, the field winding remains connected to the DC supply.

Both running & braking condition of DC motor are shown in fig (a) and figure (b) below. The braking torque can be adjusted suitably by varying the resistance in the armature circuit.



Motoring



During dynamic breaking

armature current $(I_a) = -E_b / R_b$

where, R_b = external braking resistance insented in armature ckt

∴ The braking torque developed

$$T_{db} = K\phi I = -K\phi\, E_b/R_b$$

$$= -K^2\phi^2 \frac{\omega}{R_b} \quad [\because E_b = K\phi\omega]$$

since, ϕ is constant

$$T_{db} = -C^2 \frac{\omega}{R_b} \quad \text{where, } C^2 = K^2\phi^2$$

$$\omega = -T_{db} \frac{R_b}{C^2} \quad \text{--- (1)}$$

⇒ Eqn (1) shows that the dynamic braking characteristics of motor is a straight line with negative slope $(-R_b/C^2)$ passing through the origin & lying in 2nd quardant as shown in fig below

→ The steepness of the st. line increases with increase in external resistance. Hence the magnitude of braking torque can be controlled by controlling the magnitude of braking resistance.

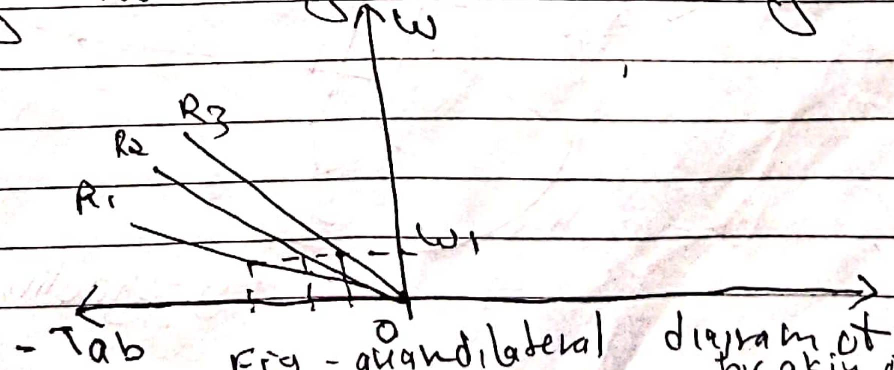


Fig - quandilateral diagram of dynamic breaking of dc shunt

21F Breaking Mechanism of DC Series Motor
20F - DB of IM | Regenerative Break of IM (3-ϕIM)

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3) Regenerative breaking -
already described.

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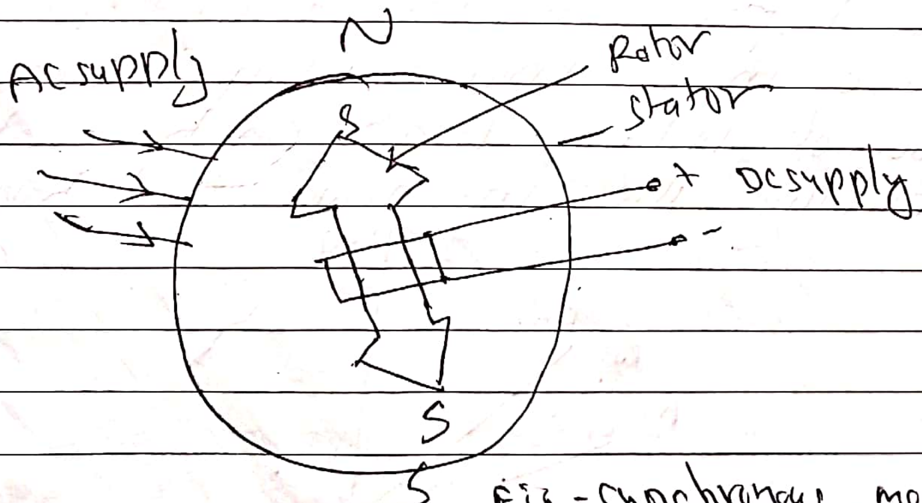
21-SN | 21F-SN

Breaking of synchronous motor (Machine)

→ only dynamic Breaking

→ Plugging can't be applied because if the supply is reversed than stator field is also reversed but the rotor is rotating in the same direction because of inertia. Hence the relative speed betn stator field & rotor field is not zero & no torque is produced. It can also applied by using damper winding.

→ Regenerative braking can't be applied as it need speed greater than synchronous speed which is not possible in synchronous machine because relative speed betn stator field & rotor field is not zero in that case consequently no torque is produced.



S fig - synchronous motor

(a) Dynamic Breaking of synchronous motor →

→ Dynamic Breaking is appiled by disconnecting the motor from supply and reconnecting the motor across three phase resistor keeping the field excitation constant. At this moment the motor act as an synchronous ~~motor~~ generator & energy is dissipated in the resistors.

→ For higher braking torque, field excitation can be increased.

Mathematical analysis of dynamic braking

The braking current at an speed ω of rotor is

$$I_{br} = \frac{\omega L_{af} I_f}{\sqrt{2}\sqrt{r^2 + \omega^2 L_s^2}} \qquad \text{—— (1)}$$

where, $\frac{\omega L_{af} I_f}{\sqrt{2}}$ = E_{rms} = induced emf/phase in stator due to field current I_f & rotational speed ω

L_{af} = mutual inductance/phase betn stator winding & field winding

I_f = field current

r = magnitude of braking resistance / phase including stator resistance

L_s → synchronous inductance / phase

excitation ... constant speed & constant

→ braking current (Ibr) is constant

→ $I_b^2 R$ losses or power mode available for braking hence remains constant throughout the braking process.

∴ Braking torque (Tbr) produced by these losses in the breaking resistance increases as speed decreases

Since $\left(T_{br} = \frac{P_{br}}{\omega} \right)$

The speed at which max. braking torque is developed can be determined as

$$\frac{dT_{br}}{d\omega} = 0$$

$$T_{br} = \frac{P_{br}}{\omega} = \frac{3 I_{br}^2 r}{\omega} = \frac{3 L_{af}^2 I_f^2 r}{2} \cdot \frac{\omega}{r^2 + \omega^2 L_s^2}$$

$$T_{br} = K_2 \cdot \frac{\omega}{r^2 + \omega^2 L_s^2} \quad \text{———} \; (2)$$

where, $K_1 = \frac{3 L_{af}^2 I_f^2 r}{2}$ = motor constant

Differentiating eqn (2) w.r.to ω & equating to zero for max^m temp^r

$$\omega_m = \frac{r}{L_s} \Rightarrow \omega_m L_s = r$$

$$(X_s)_m = r$$

i.e max braking torque occurs at that speed for which the machine reactance is equal to the value of braking resistance.

speed of rotor magnetic field with respect to rotor $= N_{rm} = \frac{120 f_r}{P} = \frac{120 sf}{P}$

$$= \frac{120\left(\frac{N_s - N_r}{N_s}\right) f}{P}$$

$$= \left(\frac{120 f}{P}\right) \times \left(\frac{N_s - N_r}{N_s}\right)$$

$$= N_s \left(\frac{N_s - N_r}{N_s}\right)$$

$$= N_s - N_r$$

∴ speed of rotor magnetic field w.r.to stator

$$= N_{rm} + N_r$$

$$= N_s - N_r + N_r$$

$$= N_s$$

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Breaking Mechanism of DC series Motor

1) Plugging appiled to DC series Motor.

→ In D.C. series motor while plugging the field current is also reversed. This result the production of the torque in the same direction as it was working normally.

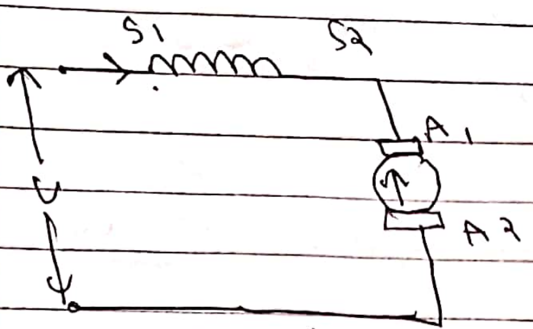


Fig - Normal condition

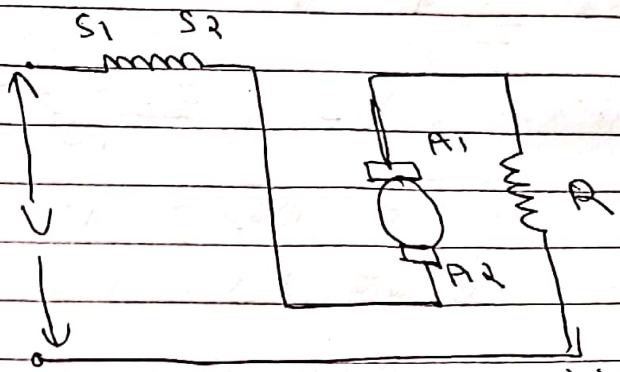


Fig - During Braking

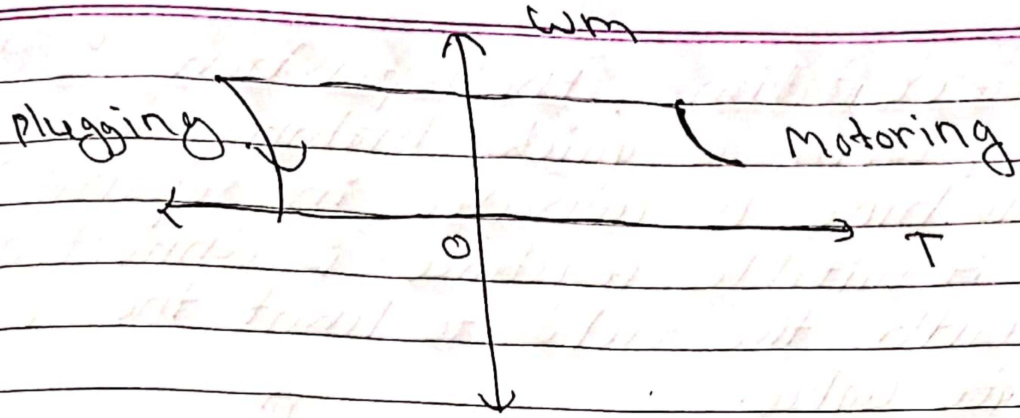
→ Therefore in order to develop torque in reverse direction, the direction of field current should remain unchanged.

→ The direction of field current remains unchanged whereas direction of armature current gets reversed.

→ Now, a total voltage $(V + E_b)$ is available across the armature terminal i.e near by twice of supply voltage.

→ It causes heavy current to flow around the ckt.

→ Hence, the additional resistance R is connected in series to limit the current.



2) Dynamic braking in dc series motor →

↳ For Dynamic braking, the series motor is disconnected from the supply. A variable resistance resistance R_b as shown in the figure below is connected in series & the connections of the field winding are reversed.

→ The field connections are reversed so that the current through the field winding flows in the same direction as before i.e from S_1 to S_2 so that the back emf produces the residual flux. The machine now starts working as a self-excited series generator.

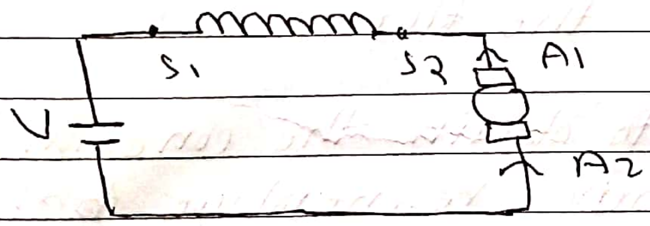
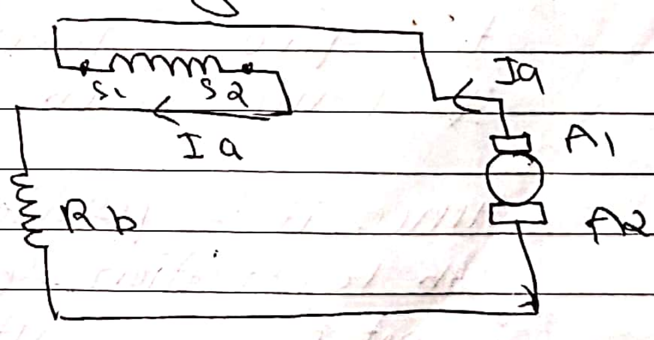


fig- motoring



Breaking with self excitation

→ In self-excitation, the operation is slow. Hence, when a quick braking is required, the machine is connected in separate-excitation mode. A suitable resistance is connected in series with the field to limit the current to a safe value.

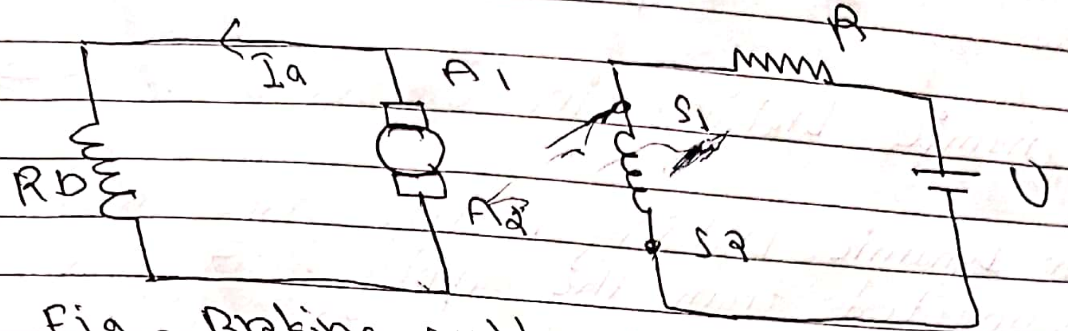


Fig - Braking with separate excitation.

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c) ~~Why~~ For Regenerative Braking →

Q-N) Why regenerative braking is not possible for dc series dc motor

→ For a dc series motor, we know that higher the speed, lower is the armature current & hence lower is the flux.

Hence it is possible to obtain the condition E>V for regeneration & hence regenerative braking is not possible with normal operating condition.

Hence, in electric transction, regenerative braking is being used for such motor by reconnecting the machine as separatedly excited machines.

→ During regeneration, the current through the armature reverses & since the excitation has to be maintained, the field connection must be reversed, if a short circuit condition is to be avoided.

Plugging of induction motor

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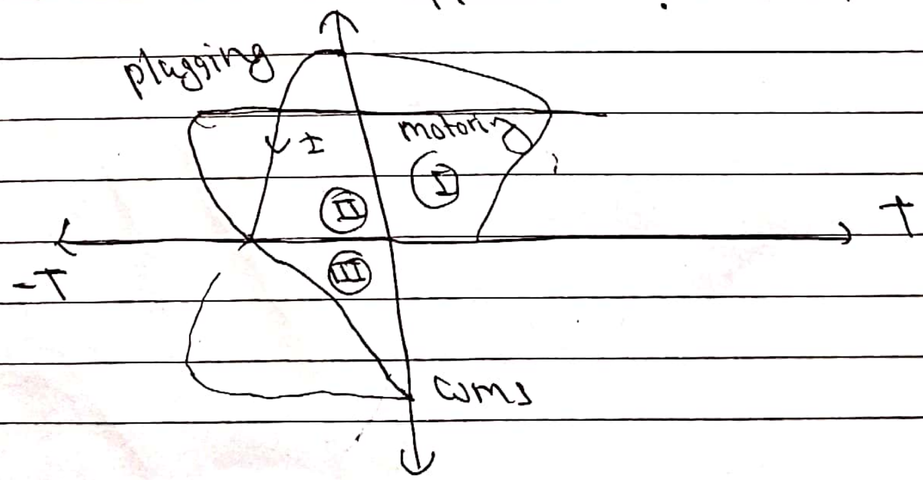
(Q.N) ~~Why regenerat~~ During plugging operation of wound rotor induction motor, usually external resistance is into, the rotor circuit. Why? Why it is necessary to disconnect it from supply when speed reaches close to zero? 17F))

⇒ Plugging induction motor braking is done by reversing the phase sequence of the motor. Plugging braking of induction motor is done by interchanging connections of only two phases of stator with respect of supply terminals. & with that the operation of motoring shifts to the plugging braking.

The external resistance from the rotor circuit is need to disconnect from supply when speed reaches close to zero because the torque is not zero at zero speed.

The motor is connected to rotate in the reverse direction and the torque is not zero or any other speed & as a result the motor first deacceleration to zero at zero & then smoothly accelerates in the opposite direction.



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1) Natural characteristics
2) With external resistance in rotor

During plugging operation of wound rotor induc-tion motor, usually external resistance is put into the rotor circuit because by varying this resistance, it is possible to change the speed during braking. Addition of rotor resistance has another advantages of reducing stator current.

During plugging, both the electrical energy consumed from the supply and the mechanical energy appiled at the ~~start~~, are spent as heat developed in the windings of the motor toge-ther with any external resistance connected in series with the other.

Methods of electric Heating Element →

Heat can be generated by passing the current through a resistance or induced current. The ~~induction of~~ indication of an arc beth two electrode also develops heat. The bombardment by some heat energy particles such as α, γ, β & X-rays or accelerating ion can produce heat on the surface.

~~method~~ of Electrical heating can be broadly classified as follow →

① Direct resistance Heating →

In this method, the electric current is made to pass through the charge or substance to be heated. This principle of heating is employed in electrode boiler.

2) Indirect resistance Heating → In this method, electric current is made to pass through a wire or high resistance heating element, the heat so developed is transferred to change from the heating element by convection or radiation. This method of heating is employed in ~~Hare~~ immersion water heater.

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iii) Infrared or radiant heating →

In this method, the heat energy is transferred from source (incandescent lamp) and focused upon the body to be heated up in the form of electromagnetic radiations. Normally, this method is used for drying clothes in the ~~that~~ textile industry and to dry the wet points on an object.

iv) Direct Arc heating → In this method, by striking the arc between the charge and the electrode or electrode, the heat so developed is directly conducted & taken by the charge. The furnance operating on this principle is known as arc furnance.

v) Indirect Arc heating → In this method, arc is established betn the two electrode, the heat so developed is transferred to charge or substance by radiation. The furnance operating on this principle are known as indirect arc furnances. This method is generally used in the melting of non-ferrous metals.

Direct Induction, Heating →

In this method, the current are induced by electromagnetic action in the charge to be heated. These induced emf induced current are used to melt the charge in induction furnance.

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vii) Indirect Induction Heating →

In this method, eddy currents are induced in the heating element by electromagnetic action. Thus, the developed heat in the heating element is transferred to the body or charge to be heated by radiation or convection.

viii) Dielectric Heating →

In this method, the heat developed ing non-metalic material due to inter automatic friction, known as dielectric loss. This principle of heating usually employee for preheating of plastic, performs braking boundary cores etc.

Induction Heating & It's type (15F, 14F, 18P)

The induction heating process makes use of the correct induces by the electromagnetic action in the material to be heated. To develop sufficient amount of heat, the resistance of material must be low.

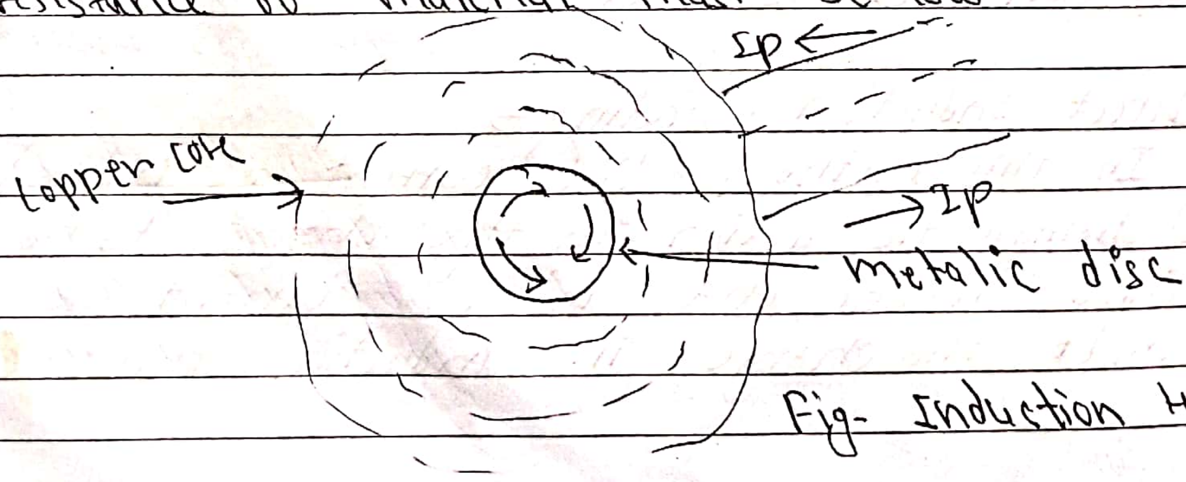

Fig- Induction Heating.

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Heat developed in the disc is depending upon the following →

1) Primary coil current
2) supply frequency
3) no. of turns of coil
4) High electrical resistivity of the disc
5) magnetic coupling betn the coil & disc.

The depth of penetration of induced current into the disc

$$d = \frac{1}{2\pi}\sqrt{\frac{\rho \times 10^9}{\mu f}}$$

where,

ρ = Specific resistance in Ωcm
f = frequency in Hz
μ = permeability of the charge

→ There are typically two types of induction furnance
1) Core type or low frequency induction furnance
2) Coreless " or High " " "

① Core type Furnance →

The operating principle of the core type furnance is the electromagnetic induction. This furnance is operating just like a transformer. It is further classified as:

→ Direct core type
→ Indirect " "
→ Vertical " "

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(a) Direct core type induction furnance →

The core type furnance is essentially a transformer in which the charge to be heated from single turn secondary ckt & is magnetically coupled to the primary by an iron core as shown in figure:

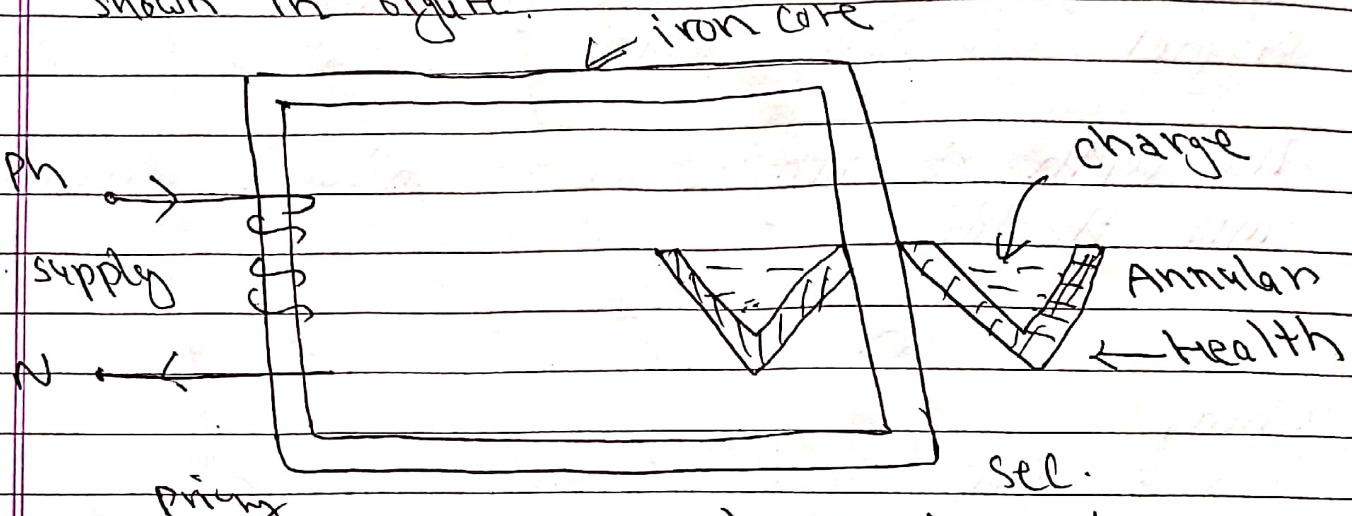

Fig - Direct core type furnance

Advantages

1) Energy Efficiency
2) Fast Heating
3) Precise tempr control
4) clean & Enviromentally friendly
5) Versatility
6) compact size

Disadvantages

1) Initial Investment cost
2) Electricity demand
3) Limited capacity
4) Dependence on power supply.

(AJAX Wyatt)

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(b) Vertical core type Induction Furnance →

It is an ~~important~~ improvement over the direct core type furnance for overcome. It consist of transformer with ~~Some of~~ core and vertical channel for the horizontal secondary is formed by the charge itself.

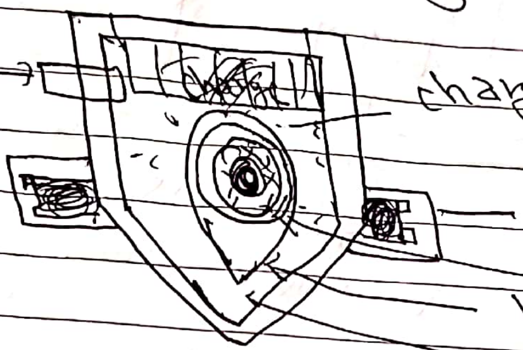


Fig - Ajax - Wyatt Induction Furnance.

Advantages

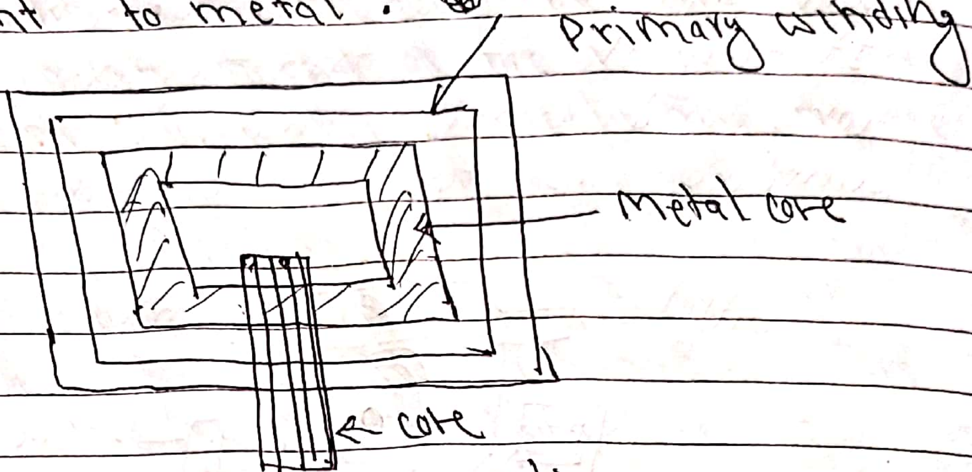
1. Efficient Heating
2. Precise tempr control
3. compact design
4. Flexibility
5. Reduced oxidation
6. Faster melting

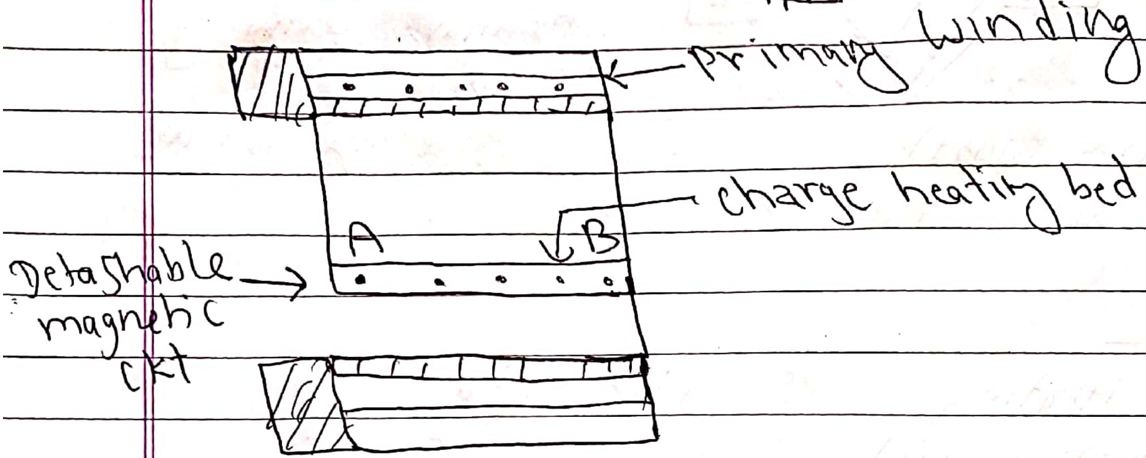
Disadvantages

1) limited capacity
2) complex maintenance
3) limited pouring control
4) Risk of inclusions
5) Dependence on power supply.

(i) Indirect core type Furnance →

This type of furnance is used for providing heat treatment to metal.





→ It consist of magnetic circuit AB is made up of a special alloy & is kept inside the chamber of the furnance. This magnetic ckt losses it's magnetic properties of certain tempr & regains them again when it is cooled to the same tempr.

Advantages

1) Improved safety
2) versatility
3) controlled Atmosphere
4) Eaiser maintenance
5) Reduced contamination
6) Better pouring control

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Page: ....

Disadvantages

1) Lower efficiency
2) longer melting point
3) High initial cost
4) potential maintenance challenges.

22E

(II) Coreless type Induction Furnance (High frequency " ") → 15F, 14F, 13F, 13S, 12S, 12F, 10F, 18F

→ It is a simple furnance with absence of core. In this furnance, heat develops in the charge due to eddy current flowing through it.

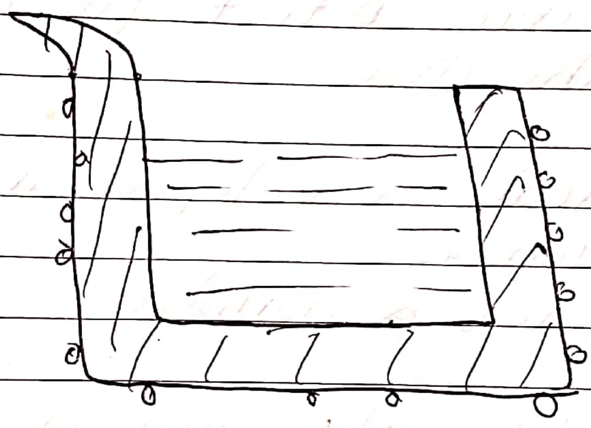

Fig- coreless induction furnance

→ The furnance consist of refractory or ceramic crucible cylindrical in shape enclosed within a coil that forms primary of the transformer. The furnance also contains a conducting or non conducting material that act as secondary.

→ If the conductor is made up of conducting material, charge can be conducting or non-conducting, whereas if the container is made up of non-conducting material, charge taken should have conducting materials.

→ When primary coils are excited by an alternating sources, the flux set up by these coils induce the eddy current in the charge. The direction of the resultant eddy current is in direction opposite to the current in the primary coil. The currents heat the charge to melting point & they also set up electro-magnetic forces that produce a stiring action to the charge.

→ The eddy currents developed in any magnetic ckt are given as

$$W_e \propto B_m^2 f$$

where,

B_m = max flux density

f = frequency

W_e = eddy current loss.

→ Minimum stray magnetic field is maintained when designing coreless furnance, otherwise there will be considerable eddy current loss. The selection of a suitable frequency of the primary current can be given by Peterson's formula,

$$t = \frac{1}{2\pi}\sqrt{\frac{\rho \times 10^9}{\mu f}}$$

Where,

t = thickness upto which current in the metal has penetrated

ρ = resisticvity in Ωcm

μ = permeability of the material

For efficient operation, the ratios of diameter of the charge (d) to the depth of the penetration of current should be more than 6,

$$d/t = 8$$

Hence, $f = \frac{16 \times \rho \times 10^9}{\pi^2 \mu \cdot d^2}$

Advantages

High melting efficiency.
Uniform Heating
Versatility
Easy Maintenances
Fast Melting speed
Precise Tempr control.

Disadvantages

High initial cost
High power consumption
Limited capacity
Need for crucible lining
(5) Risk of Retractory wear
(6) susceptibility

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2015

Electric welding →

Electric welding is defined as the process of joining two metal piece in which the electrical energy is used to generate heat at the point of welding in order to melt the joint.

Electric welding

Resistance welding
→ spot ''
→ seam ''
→ projection ''
→ Butt — upset butt ''
→ Flash '' ''

Arc welding
→ metal arc ''
→ carbon '' ''
→ Automatic hydrogen ''
→ Helium / argon ''

2015 **Principle of Electric winding →** (Arc welding & Resistanc की तरह)

2018

Merits of Electrical windings

1) versatility
2) strong & Double joints
3) Efficiency
4) Automation capabilities
5) joint customization
6) wide range of wield thickness

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Demerits of Electrical welding.

1) Equipment cost
2) skilled labour cost
3) Energy consumption
4) sensitivity to External factors
5) Safety Hazard
6) Joint preparation.

Principle of Electric winding →

The principle of Electric winding involves creating a high intensity electrical arc or electrical resistance to join two or more metal pieces together. There are two primary method ∴ arc welding & resistance welding.

1) Arc welding →

→ In arc welding, an electric current is passed through an electrode and the base metal to be welded. The electric current creates an intense heat that melts the electrode & the base metal, forming a weld pool.

→ The heat generated by the arc fuses, the base metal & the electrode creating a strong bond when molten metal sodities.

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→ The electrode used in arc welding can be consumable (consumed during the welding process process) or non - consumable (doesn't melt).

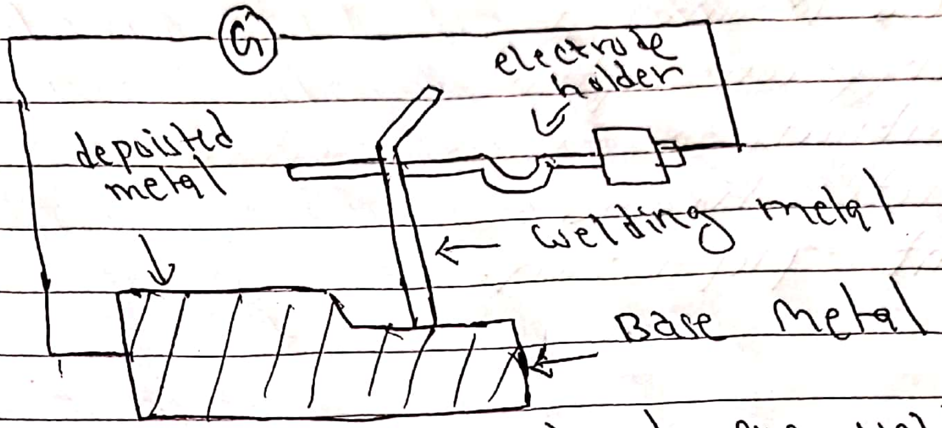

Fig - Arrangment of arc welding metal

↳ When the supply is given across the conductors separated by some distance apart, the air gap present betn the two conductor gets ionized, as the arc welding is in process, the ionization of the arc path & it's surrounding area increase This increase in ionization decrease the resistance of path. The current increases with the decrease in voltage of arc.

↳ ~~Electric arc welding is extensively used for the joint~~

Various types of electric arc welding
1) Carbon arc welding
2) Metal " "
3) Atomic hydrogen "
4) Inert gas "
5) Submerged " "

17F

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Write down the properties of Good Heating Element →

The materials used for heating element should have following properties.

1) High specific resistance → Materials should have high specific resistance so that small length of wire may be required to provide given amount of heat.

2) High melting point → It should have high melting point so that it can withstand for high tempr, a small increase in tempr will not destroy the element.

3) Low tempr coeff. of resistance →
The radiant heat is proportional to fourth power of the tempr, it is very efficient heating at high tempr. For accurate tempr control, the variation of resistance with the operating tempr should be very low. This can be obtained only if the material has low tempr coeff of resistance.

4) Free from oxidation → The element material shouldn't be oxidized when it is subjected to high tempr, otherwise the formation of oxited layer will shorten it's life.

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5) High mechanical strength →
The material should have high mechanical strength and should withstand for mechanical vibrations.

6) Non - corrosive →
The element shouldn't corrode when exposed to almosphere or any other chemical fumes.

2) Resistance welding → 14F | 12F | 10F

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

$$H = I^2 R \cdot t$$

where,

I = current through electrode

R = contact resistance of the interface

t = time for which current flows,

Here, the total resistance offered to the flow of current is made up of

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→ Resistance of current path in the work.
→ Resistance betn the contact of the parts being welded.
→ " " " electrode & the surface of parts being welded.

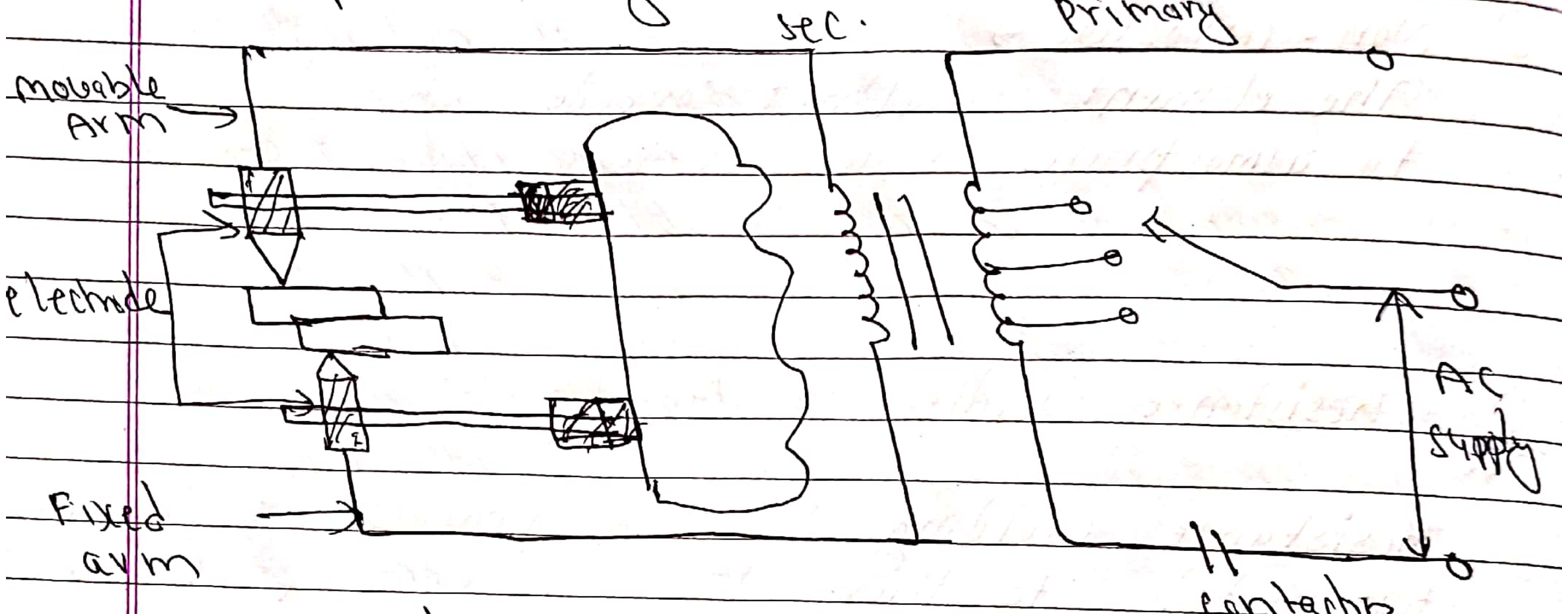

Fig - electric ckt for resistance welding

→ In this process of welding, the heat developed at the contact area betn the pieces to be welded reduces the metal to plastic state or liquid state, then the pieces are pressured under high mechanical pressure to complete the weld.

→ The electric voltage input to the welding varies in betn 4 to 12V depending upon thickness, area, composition etc. & usually power ranges from about 60 to 180 W for each mm^2 of area.

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Advantages

- Maintenance cost is less
- It can be employed for mass production
- welding process is rapid & simple
- localized heating is possible, if required
- No need of using filler metal
- Both similar & dissimilar metal can be welded.
- comparatively lesser skill is required.

Disadvantages

- Initial cost is high
- ~~length~~
- The workpiece with heavier thickness can't be welded, since it requires high input current.

Application

- Used for manufacturing of tubes & similar structural sections.
- Used by many industries manufacturing products made up of thinner gauge metals.

18F | 16K

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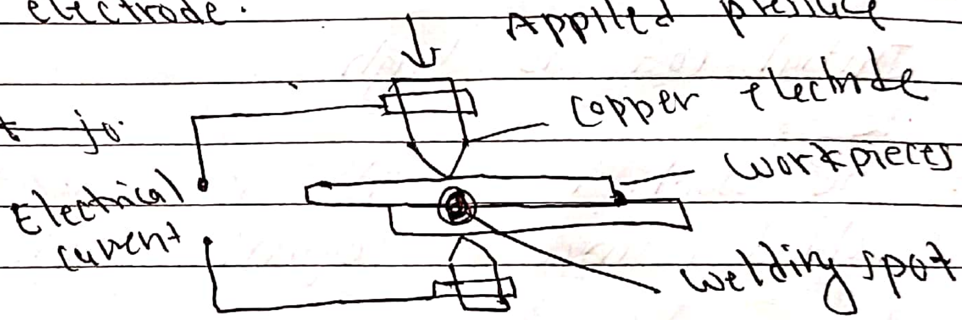
Types of resistance welding

1) spot welding
2) seam "
3) Butt "
4) Projection "

1) spot welding →

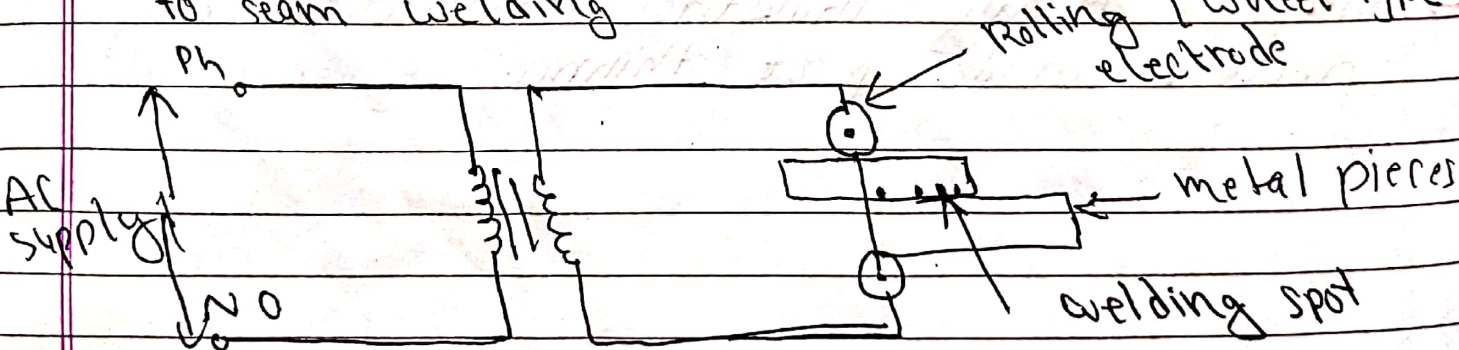
spot welding means the joining of two metal sheets and fusing them together beth copper electrode tips at suitably spaced interval by means of heavy electric current passed through the electrode.

~~This type of jo~~



2) seam welding →

seam welding is nothing but the series of continous spot welding. If no. of spots obtained by spot welding are placed very closely than they can overlap, it gives rise to seam welding.



Seam welding is very important as it provides leak proof joints. It is usually employed in welding of pressure tanks, transformers, condenser evaporators, air craft tanks etc.

3) Projection welding → It is modified from of spot welding. In projection welding, both current & pressure are localized to the ~~winding~~ welding point as in the spot welding. But the only difference in projection welding is the high mechanical pressure applied on the metal pieces to be welded after the formation of weld.

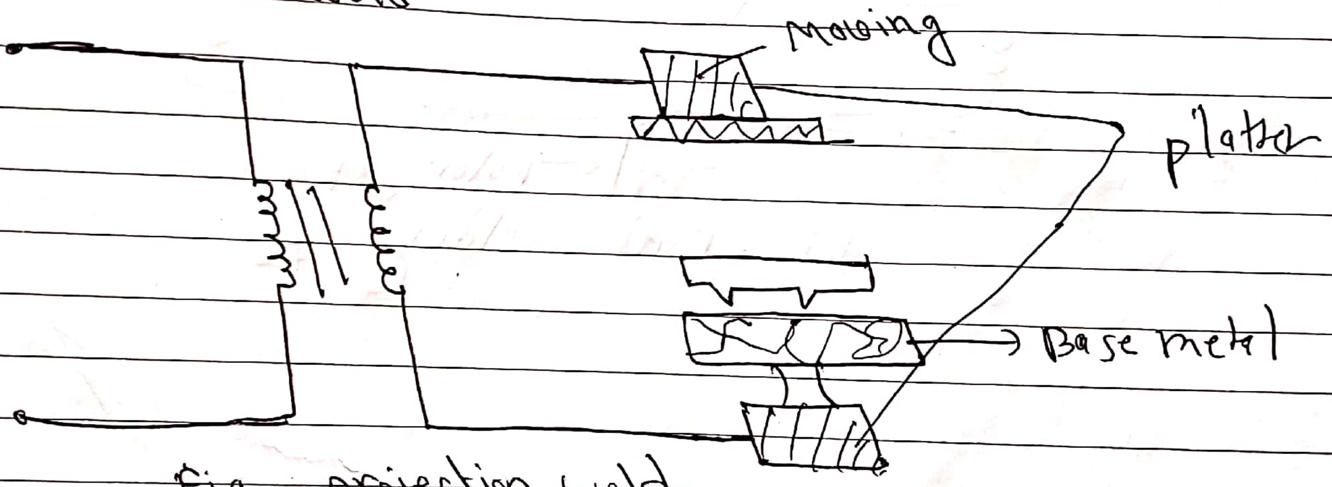


Fig - projection weld.

Advantages

→ simplicity in welding process
→ It is easy to weld some of the parts where the spot welding is not possible.

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4) Butt welding →

Butt welding is similar to the spot welding, however the only difference is in butt budding, instead of electrodes, the metal parts that are to be joined or butted together are connected to the supply.

The three basic types of butt welding process are :

→ Upset butt welding
→ Flash " "
→ Precusion " "

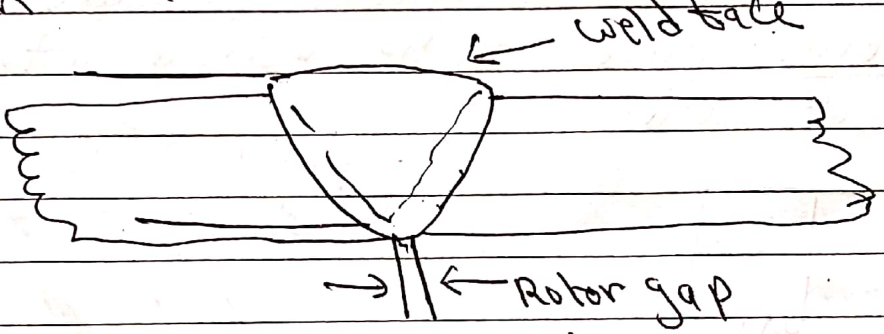

Fig - Butt welding

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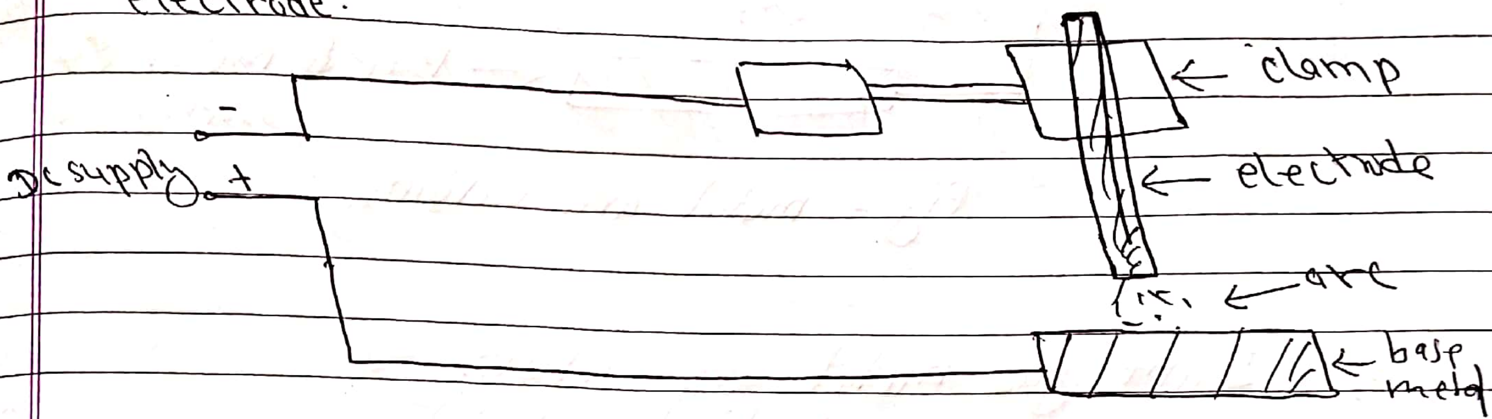
Types of Arc winding

1) Carbon Arc welding → 17F1116F

It is the one of the process of arc welding in which arc is stuck between two carbon electrode or the carbon electrode & the base material. In the carbon arc welding, carbon or graphite rods are used as electrode.



Advantages

1) It is quite clean, simple & less expensive
2) Eairly adoptable for automation
3) The heat developed during the welding can easily controlled by adjusting the length of the arc.

2) Metal arc welding →

In metal arc welding, the electrodes used must be of same metals as that of the work piece to be welded. The electrode itself forms the filler metal. An electric arc is stucked by brigging the electrode connected to a suitable source of electric current.

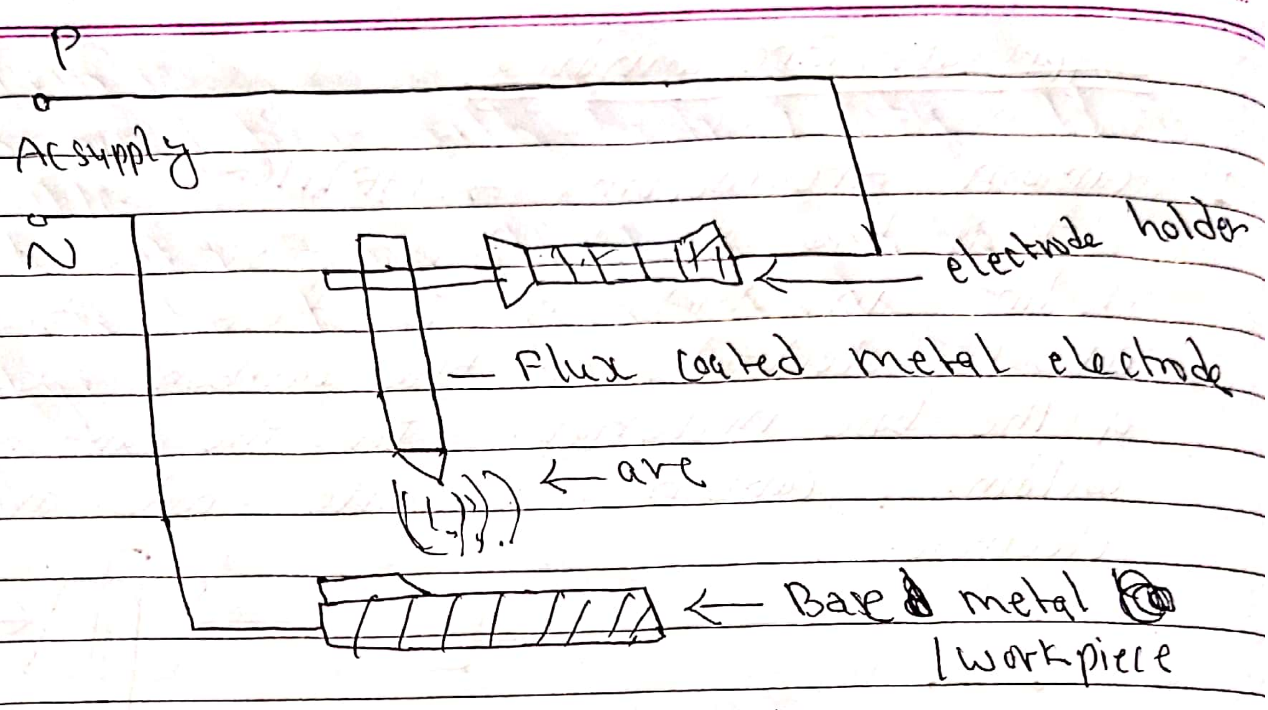


Fig - metal arc welding

3) Inert gas metal arc welding →

It is a gas shielded metal arc welding, in which an electric arc is stuck betn tungesten electrode & workplace to be welded. Filter ~~mag~~ metal may be introduced separately into the arc it required.

A welding gum which carries a nozzle, through this nozzle, inert gas such as belgillum or argon is blown around the arc & onto the weld. As both beryllium & argon are chemically inert, so the molten metal is protected from the action of the atmosphere by an envelop of chemically reducing or inert gas.

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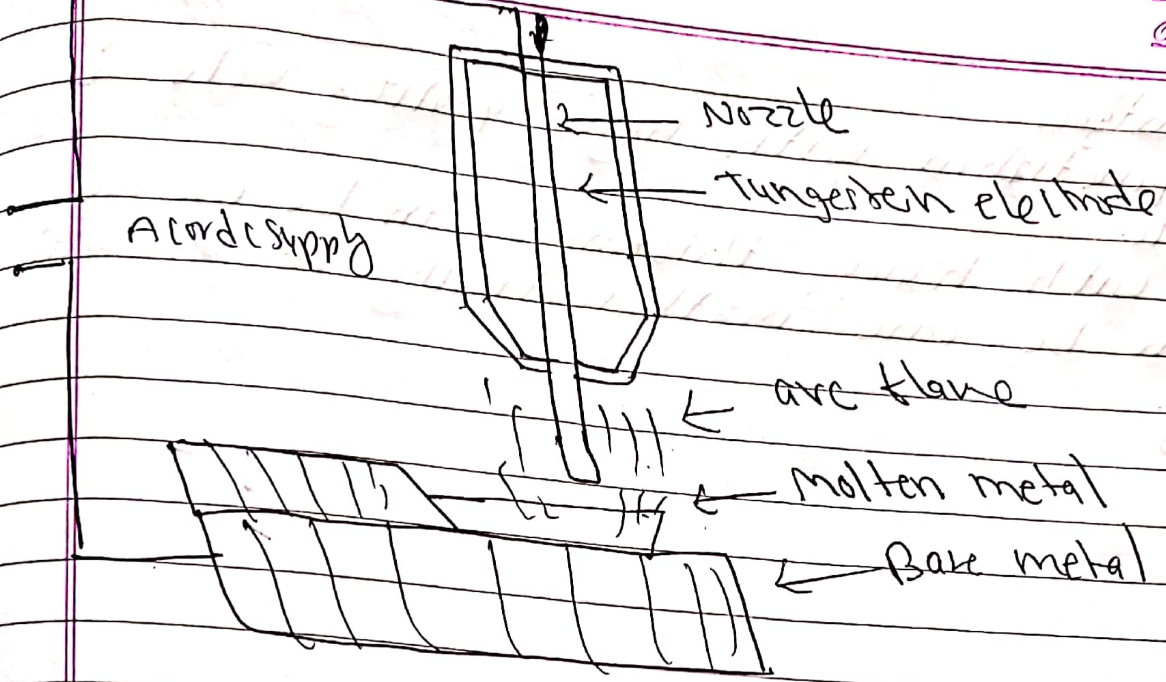
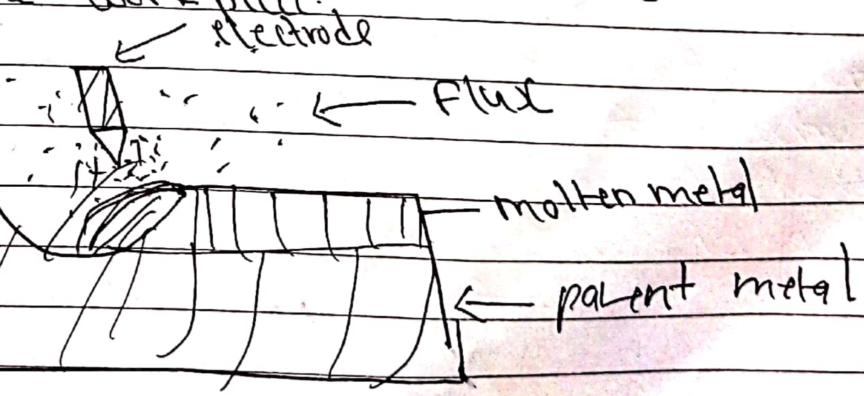


Application

→ welding for light alloys, stainless steel.
→ welding of non ferrous metal such as coppers, Al etc.

4) Submerged Arc welding →

It is an arc welding process, in which the arc column is established betn above metal electrode & workpiece. Electric arc & molten pool are shielded by blanket of granular flux on the work piece.



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Adwantges

i) Deep penetration with high quality weld is possible.
ii) Job with heavy thickness can be welded
iii) It can be done mathematically or automati-cally.