ELECTRICAL MACHINE

4th Sem,

AE & I

FACULTY NAME - PADMINI PRADHAN

ELECTRICAL MACHINE

unit-1 ELECTRICAL MATERIAL

1.1 Properties & uses of different conducting material.
1.2 Properties & use of various insulating materials used electrical engineering.
1.3 Various magnetic materials & their use.

unit-2 DC GENERATOR

2.1 construction, principle & application of DC Generator.
2.2 Classify DC generator including voltage equation.
2.3 Derive EMF equation & simple problems.
2.4 Parallel operation of DC generators.

unit-3 DC MOTOR

3.1 Principle of working of a DC motor.
3.2 concept of development of torque & back EMF in DC motor including simple problems.
3.3 Derive equation relating to back EMF, current, speed and Torque equation.
3.4 classify DC motors & explain characteristics, application
3.5 Three point & four point stator/starter of DC motor by solid state converter.
3.6 Speed of DC motor by field control and armature control method.
3.7 power stages of DC motor & derive Efficiency of a DC motor.

unit-4 AC CIRCUITS

4.1 Mathematical representation of phasors, significant of operator "j".
4.2 Addition, subtraction, multiplication & Division of phasor quantities.
4.3 AC series circuits containing resistance, capacitance, conception of active, Reactive and apparent power and Q-factor of series circuits & solve related problems.
4.4 Find the relation of AC parallel circuits containing Resistance, inductance and capacitance Q-factor of parallel circuits.

unit-5 TRANSFORMER

5.1 Ideal transformer

5.2 construction & working principle of transformer

5.3 Derive of EMF equation of transformer, voltage transformation ratio.

5.4 Discuss flux, current, EMF components of transformer and their phasor diagram under no load condition.

5.5 Phasor representation of transformer flux, current EMF primary and secondary voltage under load condition.

5.6 Types of losses in single phase (1-ϕ) Transformer.

5.7 open circuit & short circuit test (simple problems)

5.8 Parallel operation of Transformer.

5.9 Auto Transformer

unit-6 INDUCTION MOTOR

6.1 construction feature, types of three phase induction motor.

6.2 Principle of development of rotating magnetic field in the stator.

6.3 Establish relationship between synchronous speed, actual speed and slip of induction motor.

6.4 Establish relation between torque, rotor current & power factor

6.5 Explain starting of an induction motor by using DOL and star-delta starter. state industrial use of induction motor

unit-7 SINGLE PHASE INDUCTION MOTOR

7.1 construction features and principle of operation of capacitor type & shaded pole type of single-phase induction motor.

7.2 Explain construction & operation of AC series motor.

7.3 concept of alternator & its application.

coverage of Syllabus upto Internal Exams
chapter 1, 2, 3, 4

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Electrical Material

Properties & uses of Different conducting material

Electrical Material :- The material which conduct electricity due to flow of free electrons when an electric difference is applied across them is called as electric material.

Conducting material

The materials which are used for commercially for conducting electricity is known as conducting material. It has low resistivity as compared to other material.

Properties

a) Low temp^r co-efficient :-

- It means change of resistance with change in temp^r should be low.
- Low resistive materials should have low temp. co-efficient.

Ex- In case of hot summer, the resistance of long transmission line will increase, so, it will increase voltage drop & also power loss. So, it should have low temp. co-efficient. If it has high temp^r co-efficient, it has more power loss.

b) Sufficient mechanical strength :-

- In the case of windings of transformer & overhead line conductors used for transmission line conductors used for transmission & distribution of electric power, the conducting material is subjected to mechanical stress. Therefore to with stand the mechanical the conducting material should passes

c) Ductility :-

- The conducting material should be ductile enough to enable itself being drawn into different size & shapes.

d) Solderability :-

- Conductors have often to be joined, the joint should offers minimum contact resistance, so, if the joint is soldered, then min^m contact resistance happend.

e) Resistance to corrosion :-

- The conducting material should be such that it is not corroded, when it is used in outer atmosphere.

Electrical conducting material

1) Low resistivity, high conducting materials

Copper

- Copper can be drawn into very thin wires sheets & bars of various thickness can be made.
- Hard drawn coppers are used in overhead conditions, high voltage underground cables & bus bars.
- Annealed Cu is used for insulated condⁿ. in low voltage power cable, windings wire for electrical machine & T/F & flexible wires in making coils.

Alluminium

- It can be used in overhead transmission lines, bus bars, squirrel cage I.M rotor bars

Silver

- This alloy is used in commutator segment of small DC motor.
- Its good corrosion resistance property makes its alloy very much useful as contact material.

Steel :-

- It is easily corroded when exposed to moisture, when a zinc coating is provided on its surface:
- It does not corrode galvanised steel wires are used as over head telephone wires & earth wire.

ACSR (Aluminium conductors steel reinforced)

- It is used in over head transmission lines.

Brass

- It is used in plug points, socket outlet, switches, lamp holder etc.

Bronze

- It is used for contacting conductors & commutator segments.

High resistivity materials & their applications

→ Manganin - It is used in shunt for measuring instruments, resistance boxes, coils for precision electrical measuring instruments.

→ Nichrome has high working temp^n (1100°c) in addition to its high value of resistivity. It can be drawn into thin wires & is mechanically strong.
- It is used for electric furnance, electric irons electric ovens, room heaters.

→ Tungsten - It is used for making fillaments more thinner greater is its tensile strength.

→ Carbon are used in applications like brushes for electric machines & apparatus, electrodes, for electrode arc furnace non wire resistance battery cell element, arc lamps, arc welding etc.

→ Mercury is used as mercury arc rectifiers; gas filled tubes. as liquid contact materials. in electrical switches etc. It is used for making and breaking contact in Buchholz relay used for transformer protection.

Properties & uses of various insulating materials used electrical Engineering

Properties

1) Visual properties

These are the following visual properties
a) Appearance
b) Colour
c) Crystalinity

- These counts to some extend towards the customer selection of the insulating material.

2.) Mechanical properties

→ High impact strength
→ High tensile strength
→ Hardness
→ Flexibility
→ Absorption

The mechanical properties of an insulatorea are
a) Temp^re :- Due to the generation of heat in the conductor; temp^r may rise which can affect the insulating material. While selecting insulating materials, it must be ensured that they can with stand high temp^r.

b) Humidity - In order to overcome the effect of humidity on mechanical strength, non hygroscopic material should be selected as insulating material.

c) Viscosity - Viscosity is an important property of liquid dielectric. It mainly affects the manufacturing process of dielectrics.

d) Porosity - The moisture holding capacity of high porosity materials is also high which is not desirable in case of insulating material.

e) Density - On the basis of volume, insulating materials are selected for various applications. For small portable equipment, low density insulating material are used.

Thermal properties

a) Melting point - Melting point of dielectric materials should be very high so that they can withstand high temp^n without melting.

b) Thermal Expansion - Thermal expansion due to temp^n change will lead to various mechanical affects. It should be as low as possible in case of insulators.

c) Thermal Conductivity - Heat can be produced in the system due to cu loss & dielectric loss. In order to dissipate this heat to the atmosphere thermal conductivity of the insulating material should be high.

d) Thermal Aging - Dielectric which are operated at high temp^n for a long time, their mechanical & electrical properties are decreased. This effect should be the least in case of good insulating material.

e) Heat Resistance - An insulator should withstand temp^n changes without changing its other properties. This type of insulating materials can handle more power.

Magnetism :- Magnetism is a phenomenon by which a material exerets either attractive or repulsive force on another.

Magnetic dipoles :-

Magnetic dipoles are found to exist in magnetic materials, analog to electric dipoles.

i) A magnetic dipoles is a small magnet composed of north & south poles insted of positive & negative charge.

ii) magnetic forces are generated by moving electrically charged particles. These forces are in addition to any electronic forces that may already exists.

iii) It is convenient to think magnetic forces in terms of distributed field, which is represented by imaginary lines. These lines also indicate the direction of the force.

iv) Type of magnetism :- A material is magnetically characterized based on the way it can be magnetized.

v) This depends on the material's magnetic susceptibility - its magnitude & sign.

vi) Three basic magnetism are :-

a) Dia-magnetism
b) Para-magnetism
c) Ferro-magnetism

[A] Diamagnetic Materials :-

Diamagnetic materials are those materials that are freely magnetized when placed in the magnetic field. However, the magnetization is in the direction opposite to that of the magnetic field. The magnetism that is shown by these materials is known as a diamagnetism.

Properties of Diamagnetic materials :-

i) very week; exists only in presence of an external field, non-peremanent.

ii) Applied external field acts on atoms of a material, slightly unbalancing their orbiting electrons, and creates small magnetic dipoles within atoms which oppose the applied field. This action produces a negative magnetic effect known as diamagnetism.

iii) The induced magnetic moment is small, and the magnetization (m) direction is opposite to the direction of applied field (H).

iv) Materials such as Cu, Ag, Si, and alumina are diamagnetic at room temperature.

[B] Paramagnetic materials :-

Paramagnetic materials are materials that tend to get weakly magnetized in the direction of the magnetizing field when placed in a magnetic field. Paramagnetic materials have a permanent dipole moment or permanent magnetic moment. However if we remove the applied field the materials tend to lose their magnetism. This is because thermal motion randomizes the spin orientation of the electron.

* Properties of paramagnetic Materials

i) When the net atomic dipole moment of an atom is not zero, the atoms of paramagnetic substances have permanent dipole moment due to unpaired spin.

ii) The substance are weakly attracted by the magnetic feild.

iii) In the non-uniform external magnetic field, paramagnetic substances move from week field region to a strong field region.

iv) A paramagnetic rod sets itself parallel to the field because the field is strongest near poles.

v) The relative permeability is slightly greater than 1. The field inside the material is greater than the magnetizing field.

vi) Magnetic field lines become denser inside paramagnetic substance

vii) Magnetization of paramagnetic substances is inversely proportional to absolute temperature.

viii) The magnetic dipole moment of paramagnetic substances is small & parallel to the magnetizing field.

c) Ferromagnetism :-

Ferromagnetism gets its name from the word "ferreous" which means iron which was the first metal known to show attractive properties to magnetic field. Ferromagnetism is a unique magnetic behaviour that is exhibited by certain materials such as iron, cobalt, alloy, etc. It is a phenomenon where these materials attain permanent magnetism or they acquire attractive attractive power. It is also described as a process where some of the electrically uncharged materials attract each other strongly.

Properties of ferromagnetic material :-

i) The atoms of ferromagnetic substances have permanent dipole moment present in domains.

ii) Atomic dipoles in ferromagnetic substances are oriented in the same direction as the external magnetic field.

iii) The magnetic dipole moment is large & is in the direction of the magnetizing field.

iv) The intensity of magnetization (M) is very large & positive & varies linearly with the magnetizing field (H). Hence saturation depends on the nature of the material.

v) Ferromagnetic substance are strongly attracted by the field. So in a no. of uniform field, they tend to stick at the poles where the field is strongest.

vi) If a ferromagnetic powder is placed in a watch glass placed on two poles piece which are sufficient apart then powder accumulates at sides & shows depression in the middle because the field is strongest at poles.

vii) When a ferromagnetic substance is liquified, it loses ferromagnetic properties due to higher temperature.

Unit-2

DC GENERATOR

2.1 construction, Principle & application of DC Generator.

- An electric generator is a machine that converts mechanical energy to electrical energy.

Generator principle

- An electric generator is based on the principle that whenever flux is cut by a conductor, an emf is induced which will cause a current to flow if the conductor circuit is closed.
- The direction of induced emf is given by fleming right hand rule.

Fleming's Right hand rule

Stretch the thumb, fore-finger & middle finger of your right hand so that they are right angles to each other, if the fore finger points in the direction of magnetic field, thumb in the direction of the motion of the conductor, then middle finger will point in the direction of induced emf.

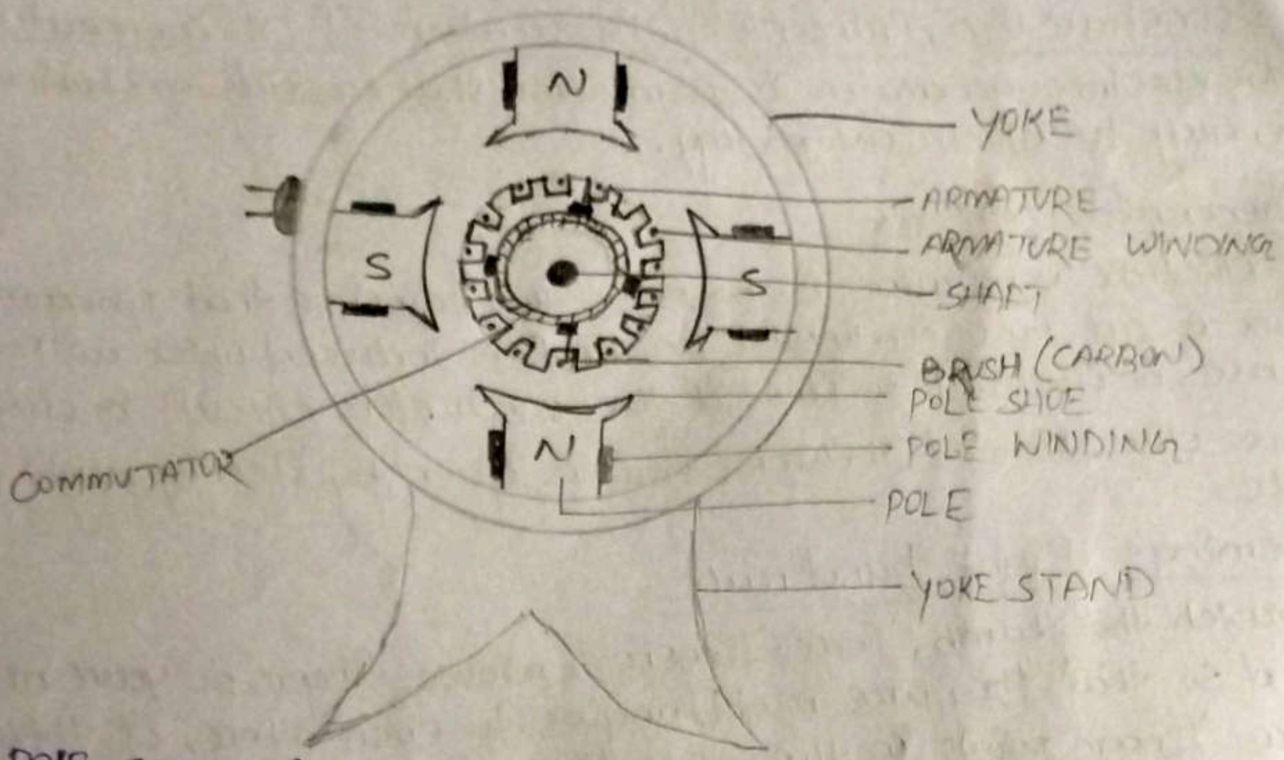
Construction of DC Generator

A D.C Generator consists of the following essential parts.

1) magnetic frame or yoke.
2) pole core and pole shoes.
3) pole coils
4) Armature core
5) Armature winding
6) Commutator
7. Brushes & Bearings.

1. YOKE

- It is made of cast iron but for large machine usually cast steel or rolled steel is employed.
- It provides mechanical support for the poles & acts as a protecting cover for the whole machine.
- It also carries the magnetic flux produced by the pole.



2. POLE CORES & POLE SHOE

- The field magnet consists of pole cores & pole shoes.
- The pole core itself may be a solid piece made of either cast iron or cast steel.
- The pole face is known as pole shoe which is made large than the main body.
- Pole core basically carries a field winding which is necessary to produce the magnetic field in the machine & pole
- Shoes spread out the flux in the air gap & being of larger cross-section reduced the reluctance of magnetic path.

3. POLE COILS

- The pole coils consists of Cu wire or strip.
- The field coils are mounted on the poles.
- The field coils are connected in such a way that adjacent pole have opposite polarity.
- When current is passed through these coils, they electromagnet the poles which produce the necessary flux that is cut by revolving armature conductor.

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4. ARMATURE CORE

- Armature core consists of slotted soft iron lamination that are stacked to form a cylindrical core.
- It houses the armature conductors or coils & causes them to rotate & hence cut the magnetic flux of the field magnet.
- It is a cylindrical or drum shaped & is built up of usually circular sheet steel discs. It is keyed to the shaft.

5. ARMATURE WINDING

- The slots of the armature core hold insulated conductors that are connected in a suitable manner. This is known as armature winding.
- This is the winding in which the working emf is induced.
- The armature conductors are connected in series-parallel. The conductors being connected in series so as to increase the voltage & in parallel path so as to increase the current.
- The armature winding of a DC machine is a closed circuit winding.

6. COMMUTATOR

- It is a mechanical rectifier which converts the alternating voltage generated in the armature windings into direct voltage across the brushes.
- The commutator is made of copper segments. Insulated from each other by mica sheets & mounted on the shaft of a machine.

7. BRUSHES

- The function of the brushes is to collect current from commutator & to ensure the electrical connections betn the rotating commutator & stationary external load circuit.
- The brushes are made of carbon & rest on the commutator and are in the shape of a rectangular block.

8. Bearing

- Bearing is a device which gears break & smooth rotation to the armature.
- Ball bearing are usually used as they are more reliable but for heavy duty machins, roller bearing are preferable.

9. EYE BOLT :- The eye bolt is provided by the body generally on the top for lifting the machine.

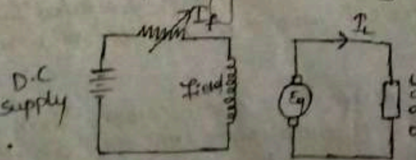
10. COOLING FAN :- It is used in cooling tower made up of cast iron & is also fitted on the opposite side of the commutator + shaft.

Types of Generator

- DC Generator
  - Separately excited dc generator
  - Self excited dc generator
    - Series generator
    - Shunt generator
    - Compound generator
      - Long shunt
      - Short shunt

Separately Excited DC generator

- A DC generator whose field magnet winding is supplied from an independent external dc source (by a battery etc) is called a separately excited dc generator.

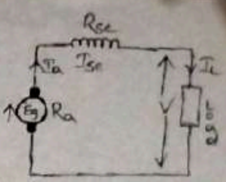


Self excited D.C generator

- Self excited d.c generator are those whose field magnets are energised by the current produced by the generators themselves. There are 3 types of self excited generator depends upon the manner in which the field winding is connected to the armature.

(A) Series generator

In a series wound generator, the field winding is connected in series the armature winding.



- The whole armature current flows through the field winding as well as load.
- Since the field winding carries the whole of load current, it has a few turns of their wire having low resistance.

In this figure,

E_g = Generated emf
R_a = armature resistance
I_a = armature current
R_{se} = Series field resistance
I_{se} = Series field current
I_L = Load current
V_L = Terminal Voltage / Load voltage

Here, $I_a = I_{se} = I_L$

Then, $V_L = E_g - I_aR_a - I_{se}R_{se} - 2BD$

$\Rightarrow V_L = E_g - I_aR_a - I_aR_{se} - 2BD$ ($\because$ series connection $= I_a = I_{se}$)

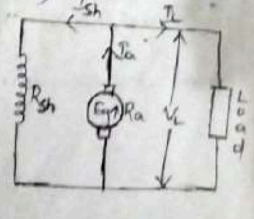
$$\Rightarrow \boxed{V_L = E_g - I_a(R_a + R_{se}) - 2BD}$$

power developed in armature $= E_gI_a$

power delivered to load $= V_LI_L$

B) Shunt generator (parallel generator)

- In a shunt generator the field winding is connected in parallel with the armature winding so that the terminal voltage is applied across it.
- The shunt field winding has many turns of fine wire having high resistance.



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In shunt generator,

I_{sh} = shunt field current

R_{sh} = shunt field resistance

$$I_{sh} = \frac{V_L}{R_{sh}}$$

Armature Current, $I_a = I_{sh} + I_L$

Terminal voltage, $V_L = E_g - I_aR_a - 2B.D$

power developed in armature = E_gI_a

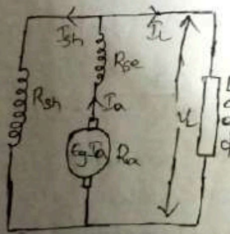
power delivered to load = V_LI_L

c) Compound generator

In a compound wound generator, there are two sets of field winding on each pole, one is in series & other in parallel with the armature

i) Long shunt

In long shunt DC generator the shunt field winding is in parallel with both series field & armature winding



Shunt field current, $I_{sh} = \frac{V_L}{R_{sh}}$

Armature current, $I_a = I_L + I_{sh}$

voltage across the load;

$V_L = E_g - I_aR_a - I_{se}R_{se}$

$\Rightarrow V_L = E_g - I_aR_a - I_aR_{se}$ ($\because I_a = I_{se}$)

$\Rightarrow V_L = E_g - I_a(R_a + R_{se})$

power generated, $P_g = E_g \times I_a$

power delivered to the load, $P_L = V_L \times I_L$

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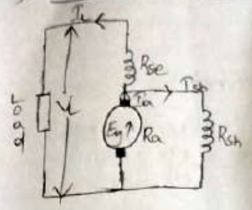
ii) Short shunt compound wound DC generator



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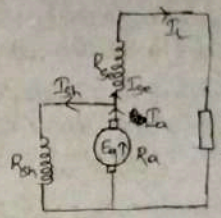

- Short shunt compound generator are generators where only the shunt field winding is in parallel with the armature winding.

Series field current, $I_{se} = I_L$ $\quad I_a = I_{sh} + I_L$ ($\because I_L = I_{se}$)

Shunt field current, $I_{sh} = \frac{V_L + I_{se}R_{se}}{R_{sh}}$

Terminal voltage, $V_L = E_g - I_aR_a - I_{se}R_{se}$

power developed in armature, $P_g = E_gI_a$

power delivered to load, $P_L = V_LI_L$

NOTE POINT

Brush contact drop - It is the voltage drop over the brush contact resistance when current passes from commutator segment to the brushes & finally to the external load.

Generated EMF or EMF Eq^n of a Generator

Let, ϕ = flux/pole in webber

Z = total no. of armature conductor

= No. of slots × No. of conductors/slot

P = No. of generator poles

A = No. of parallel paths in Armature

N = Speed of armature in rpm

E_g = emf of the generator

Avg. emf generated/conductor = $\frac{d\phi}{dt}$ volt

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Now, flux cut/conductor in one revolution,

$d\phi = \phi P$ weber

No. of revolution/second $= \frac{N}{60}$

Time for one revolution, $dt = \frac{60}{N}$ second.

Hence, according to Faraday's laws of Electromagnetic induction, emf generated/conductor $= \frac{d\phi}{dt}$

$= \frac{\phi P N}{60}$ volt

Emf of generator, E_g = emf per parallel path

$= (\text{emf}/\text{cond}^n) \times$ No. of cond^n in series per parallel path

$= \frac{\phi P N}{60} \times \frac{Z}{A}$

$$\Rightarrow \boxed{E_g = \frac{ZN\phi}{60} \times \frac{P}{A}}$$

where, $A = 2$, for wave winding

$A = P$, for lap winding

Parallel operation of D.C Generator

In a DC power plant, power is usually supplied from several generator of small ratings connected in parallel instead of from one large generator. This is due to following reasons.

i) Continuity of service :- If a single large generator is used in the power plant, then in case of its breakdown the whole plant will be shut down. So, if power is supplied from a no of small units operating in parallel then in case of failure of one unit, the continuity of supply can be maintained by other healthy units.

ii) Efficiency :- Generator run most efficiently when loaded to their rated capacity. Usually the load in electrical power plant fluctuates between its peak value sometimes during the day & its minimum during the last night hours. Therefore, when load demand in power plant decreases, one or more generators can be shut down & the remaining units can be efficiently loaded.

iii) Maintenance & repair :- Generators generally require maintenance & repair. Therefore if generators are operated in parallel, the routine or emergency operations can be performed by isolating the affected generators while load is being supplied by other units. This leads to both safety & economy.

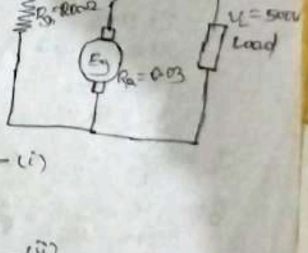
iv) Increasing plant capacity :- In the modern world of increasing population, the use of electricity is continuously increasing. When added capacity is required, the new unit can be easily paralleled with old units.

v) Non-availability of single large unit :- In many situations a single unit of desired large capacity may not be available. In that case a no. of smaller units can be operated in parallel to meet the load requirement. Generally a single large unit is more expensive.

PROBLEM

Q.1. A 4 pole long shunt lap wound generator of 25 kW & terminal voltage of 500 V, armature resistance 0.03 Ω, $R_{se} = 0.04\,\Omega$, $R_{sh} = 200\,\Omega$. Find E_g.

Sol^n → Given data,



$P_L = 25\text{ kW} = 25000\text{ W}$

$V_L = 500\text{ V}$

$R_a = 0.03\,\Omega$

$R_{se} = 0.04\,\Omega$

$R_{sh} = 200\,\Omega$

$I_{sh} = \frac{V_L}{R_{sh}} = \frac{500}{200} = 2.5\text{ A}$. ——— (i)

$P_L = V_L I_L$

$\Rightarrow I_L = \frac{P_L}{V_L} = \frac{25000}{500} = 50\text{ A}$. ——— (ii)

So $I_a = I_L + I_{sh}$

$= 50 + 2.5 = 52.5\text{ A}$.

Then $E_g = V_L + I_a(R_a + R_{se})$

$= 500 + 52.5\,(0.03 + 0.04)$

$= 500 + (52.5 \times 0.07) = 500 + 3.675$

$= 503.675\text{ V}$ (Ans)

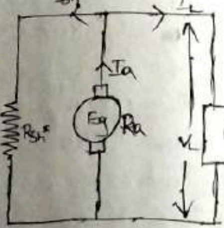
Q2. A 4 pole generator having wave wound armature winding has 51 slots each slot containing 20 conductors, then what will be the voltage generated in a machine when driven in 1500 rpm assuming the flux per pole to be 7.0 mwb.

sol^n →
$P = 4$
$Z = 20 \times 51 = 1020$
$A = 2$
$N = 1500$ rpm
$\phi = 7.0 \times 10^{-3}$ wb

$$E_g = \frac{ZN\phi}{60} \times \frac{P}{A} = \frac{1020 \times 1500 \times 7 \times 10^{-3}}{60} \times \frac{4}{2}$$
$$= \frac{102 \times 15 \times 7 \times 2}{60} = 357V.$$

Q3. An 8 pole DC shunt generator with 778 wave connected armature conductors & running at 500 rpm supplies a load of 12.5 resistance at terminal voltage of 50 V. The armature resistance is 0.24 Ω & field resistance is to 250 Ω. Find armature current, the induced emf & flux per pole.

sol^n → given,
$P = 8$ $\quad R_a = 0.24\,\Omega$
$A = 2$ $\quad R_{sh} = 250\,\Omega$
$Z = 778$
$N = 500$ rpm
$R_L = 12.5$
$V_L = 50V$



$$I_L = \frac{V_L}{R_L} = \frac{50}{12.5} = 4A$$
$$I_{sh} = \frac{V_L}{R_{sh}} = \frac{50}{250} = 0.2A$$

i) $I_a = I_{sh} + I_L = 0.4 + 4 = 4.2A$.

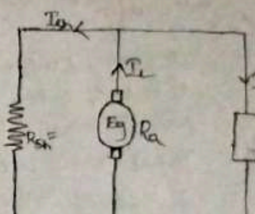
ii) $V_L = E_g - I_a R_a \Rightarrow E_g = V_L + I_a R_a = 50 + (4.2 \times 0.24) = 51.056V$

iii) $E_g = \frac{ZN\phi}{60} \times \frac{P}{A} \Rightarrow \frac{778 \times 500 \times \phi}{60} \times \frac{8}{2}$

$\Rightarrow \frac{51.056 \times 60}{778 \times 500 \times 4} = \phi \Rightarrow \phi = 0.001951 = 1.951$ mwb.

Q4. A 4 pole DC shunt generator with a shunt field resistance of 100 Ω & $R_a = 1\,\Omega$ has 378 wave connected conductor in armature, the flux per pole is 0.02 wb. If a load resistance of 10 Ω is connected across a armature terminals terminal & the generator is driven at 1000 rpm. Calculate the power absorbed by the load.

sol^n → $P = 4$ $\quad R_L = 10\,\Omega$
$A = 2$ $\quad N = 1000$ rpm
$R_{sh} = 100\,\Omega$
$R_a = 1\,\Omega$
$Z = 378$
$\phi = 0.02$ wb



$$E_g = \frac{ZN\phi}{60} \times \frac{P}{A} = \frac{378 \times 1000 \times 0.02}{60} \times \frac{4}{2}$$
$$= 252V$$

$E_g = V_L + I_a R_a$

$I_L = I_a - I_{sh}$

$R_a = 1\,\Omega$, $R_L = 10\,\Omega$

$I_a = I_{sh} + I_L$
$$= \frac{V}{R_{sh}} + \frac{V}{R_L} = \frac{V}{100} + \frac{V}{10} = \frac{V + 10V}{100} = \frac{11V}{100}A.$$

$E_g = V_L + I_a R_a$

$\Rightarrow V = E_g - I_a R_a = 252 - \frac{11V}{100} \times 1$

$\Rightarrow V = \frac{25200 - 11V}{100}$

$\Rightarrow 100V + 11V = 25200$

$\Rightarrow 111V = 25200$

$\Rightarrow V = \frac{25200}{111} = 227$ V.

$I_L = \frac{227}{10} = 22.7$

$P_L = V_L + I_L = 227 \times 22.7 = 5153$ w.

Q5. A 4pole lap wound dc shunt generator has a useful flux per pole of 0.07 wb. The armature winding consists of 220 turns each of 0.004 Ω resistance. Calculate the terminal voltage when running at 900 rpm if the armature current is 50A. Also calculate power output in KW for the generator.

Sol^n → $P = 4$

$A = P = 4$ (lap winding)

$\phi = 0.07$ wb

No. of turns = 220

Total no. of conductors

$Z = 220 \times 2 = 440$

No. of turns per parallel path = 220/4 = 55

Resistance per parallel path = $55 \times 0.004 = 0.22\ \Omega$.

$R_a = \frac{0.22}{A} = \frac{0.22}{4} = 0.055\ \Omega$.

$E_g = \frac{ZN\phi}{60} \times \frac{P}{A} = \frac{4 \times 0.07 \times 440 \times 900}{60 \times 4} = 462\ V$

$E_g = V + I_a R_a$

$\Rightarrow 462 = V + 50 \times 0.055$

$\Rightarrow V = 462 - 50 \times 0.055 = 459.25$ volts.

output $VI = 459.25 \times 45.42 = 20814 w = 20.814 KW$.

$I_L = I_a - I_{sh} = 50 - 4.58$ $\left(I_{sh} = \frac{459.25}{45.42}\right)$

$= 45.42 A$.

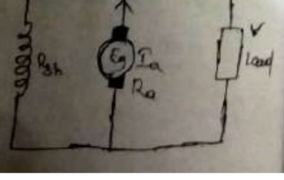
Q.6. A 30 KW 300 V DC shunt generator has armature & field resistance of 0.05 Ω & 100 Ω resp. Calculate total power developed by the armature when it delivers full load output.

Ans → $P_L = 30 KW = 30 \times 10^3 w$.

$V = 300V$

$R_a = 0.05$

$R_{sh} = 100\ \Omega$



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$P_L = V I_L$

$\Rightarrow I_L = \frac{P_L}{V} = \frac{30 \times 10^3}{300} = 100 A$.

$I_{sh} = \frac{V}{R_{sh}} = \frac{300}{100} = 3 A$.

$I_a = I_{sh} + I_L = 100 + 3 = 103 A$

$E_g = V + I_a R_a$

$= 300 + (0.05 \times 103)$

$= 300 + 5.15 = 305.15$ V.

$P_g = E_g I_a = 305.15 \times 103$

$= 31430.45 = 31.430$ KW.

Uses of DC Generator

1. They are used as portable electric supply system.
2. They are used in DC welding as DC supply.
3. They are used in labs for testing purpose because they can give variable output voltage.
4. They are used for battery charging in various places like industries & power stations.
5. They are used to give excitation power supply to the alternators.
6. They are used as boosters to compensate the voltage drop in the electric feeders in various types of distribution systems such as railway service.
7. In some special cases they are also used for electrical breaking. Like they are used for supplying field excitation current in DC locomotives for regenerative breaking.

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