Q.2 a. An iron has 15cm diameter and 10 cm^2 cross-sectional area, wound with 200 turns of wire. For flux density of 1 Wb/m^2 and permeability of 500, find the exciting current.

Answer:

$D = 15$ cm, $a = 10$ cm^2, $N = 200$, $B = 1$ Wb/m^2, $\mu_r = 500$,

$$l_i = \pi D = \pi \times 15 \times 10^{-2} = 0.4712 \text{ m}$$

$$S = \frac{l_i}{\mu_0 \mu_r a} = \frac{0.47123}{4\pi \times 10^{-7} \times 500 \times 10 \times 10^{-4}} = 750 \times 10^3 \text{ AT/Wb}$$

$$\phi = B \times a = 1 \times 10 \times 10^{-4} = 10 \times 10^{-4} \text{ Wb}$$

$$\phi = \frac{\text{M.M.F.}}{S} = \frac{NI}{S} \quad \text{i.e.} \quad 10 \times 10^{-4} = \frac{200 \times I}{750 \times 10^3}$$

$$I = \frac{10 \times 10^{-4} \times 750 \times 10^3}{200} = \mathbf{3.75\ A}$$

b. What is meant by Self Induced EMF? Derive an expression for the coefficient of self induction.

Answer:

Self induction is that phenomenon in which a change in electric current in a coil produces an induced emf in the coil itself.

MATHEMATICAL REPRESENTATION:

Self induced emf in a coil is directly proportional to the rate of change of electric current in the coil.i.e.

Emf = – DI/Dt

Or emf = -L DI/Dt

Where, L = self inductance of the coil.

SELF INDUCTANCE

Self inductance of a coil is defined as the ratio of self-induced emf to the rate of change of current in the coil.

Self inductance = emf/ DI/Dt

It is denoted by ‘L’ and it depends upon the physical characteristics of the coil.

Unit of self inductance is Henry

Expressions for Coefficient of Self Inductance (L)

$$L = \frac{N\phi}{I} \quad \ldots (1)$$

But $\phi = \frac{\text{m.m.f.}}{\text{Reluctance}} = \frac{NI}{S}$

$\therefore$ $L = \frac{N.NI}{I.S}$

$$\therefore \quad \boxed{L = \frac{N^2}{S} \text{ henries}} \quad \ldots (2)$$

Now $S = \frac{l}{\mu a}$

$$L = \frac{N^2}{\left(\frac{l}{\mu a}\right)}$$

$$\therefore \quad \boxed{L = \frac{N^2 \mu a}{l} = \frac{N^2 \mu_0 \mu_r a}{l} \text{ henries}} \quad \ldots (3)$$

Where l = length of magnetic circuit

a = area of cross-section of magnetic circuit through which flux is passing.

Q.3 a. Define voltage regulation of a transformer. Deduce an expression for voltage regulation.

Answer:

The **Voltage Regualtion** of a transformer is defined as the arithmetic difference in the secondary terminal voltage between no load and full rated load at a given power factor with same value of primary voltage for both rated load and no load . It is expressed as either a per unit (p.u) or a percentage (%) of full rated load.

Percent age voltage regulation at full load = $V_{nl} - V_{fl} / V_{fl}$ X 100

Percentage regulation (%) = (Terminal voltage on no load – terminal voltage on load) / Terminal voltage on no load X 100

b. A 250 KVA, 1100 V / 400 V, 50 Hz single-phase transformer has 80 turns on a secondary. Calculate:

a) the approximate values of the primary and secondary currents.

b) the approximate number of primary turns.

c) the maximum values of flux (8)

Answer:

a) Full — load primary current

$$= \frac{250 \times 1000}{1100} = \mathbf{22.7\ A}$$

and full — loaded secondary current

$$= \frac{250 \times 1000}{400} = \mathbf{625\ A}$$

b) Number of primary turns

$$= \frac{80 \times 11000}{400} = \mathbf{2200}$$

c) From expression ,

$$E_2 = 4.44\ N_2\ f\ \Phi_m \text{ volts}$$

$$400 = 4.44 \times 80 \times 50 \times \Phi_m$$

$$\mathbf{\Phi_m = 22.5\ mWb}$$

Q.4 a. What is starter? Explain the necessity of starter for a dc motor.

Answer:

at the starting instant the speed of the motor is zero, (N = 0). As speed is zero, there cannot be any back e.m.f. as $E_b \propto N$ and N is zero at start.

$\therefore$ E_b at start = 0

The voltage equation of a d.c. motor is,

$$V = E_b + I_a R_a$$

So at start, $V = I_a R_a$ ... as $E_b = 0$

$$\therefore \quad I_a = \frac{V}{R_a}$$

Generally motor is switched on with normal voltage and as armature resistance is very small, the armature current at start is very high.

Such high current drawn by the armature at start is highly objectionable for the following reasons :

1. In a constant voltage system, such high inrush of current may cause tremendous line voltage fluctuations. This may affect the performance of the other equipments connected to the same line.
2. Such excessively high armature current, blows out the fuses.
3. If motor fails to start due to some problems with the field winding, then a large armature current flowing for a longer time may burn the insulation of the armature winding.
4. As the starting armature current is 10 to 15 times more than the full load current, the torque developed which is proportional to the I_a will also be 10 to 15 times, assuming shunt motor operation. So due to such high torque, the shaft and other accessories are thus be subjected to large mechanical stresses. These stresses may cause permanent mechanical damage to the motor.

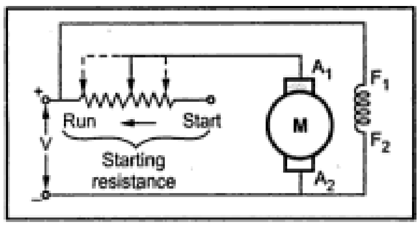

Fig. Basic arrangement of a starter

To restrict this high starting armature current, a variable resistance is connected in series with the armature at start. This resistance is called **starter** or **a starting resistance**. So starter is basically a current limiting device. In the beginning the entire resistance is in the series with the armature and then gradually cut off as motor gathers speed, producing the back e.m.f. The basic arrangement is shown in the Fig.

In addition to the starting resistance, there are some protective devices provided in a starter. There are two types of starters used for d.c. shunt motors.

a) Three point starter

b) Four point starter

b. A 240-V, 20 HP, 850 r.p.m., shunt motor draws 72A when operating under rated conditions. The respective resistance of the armature and shunt field is 0.242 Ohm and 95.2 Ohm, respectively. Determine the percent reduction in the field flux required to obtain a speed of 1650 r.p.m., while drawing an armature current of 50.4 A

Answer:

Given V = 240V

P_i = 20hp = 20 x 735.5 watt = 14.71 kW

Find Change in flux =?

I_{sh} = V/ R_{sh} = 240 / 95.2 = 2.5 Amp

N_1 = 850 rpm ; I_L = 72 Amp. At rated load

R_a = 0.242, R_{sh} = 95.2Ω

N_2 = 1650 rpm , I_{a2} = 50.4 Amp

$E_{b1} = V - I_{a1} R_a$

= 240 – 69.47 x 0.242 = 223.19 volt

and $E_{b2} = V - I_{a2} R_a$

= 240 – 50.4 x 0.242 = 227.80 volt

$E_{b1} / E_{b2} = N_1 \Omega_1 / N_2 \Omega_2$

Therefore, $\Omega_1 / \Omega_2 = (E_{b1} / E_{b2}) \times (N_2 / N_1)$

= (223.19 / 227.80) x (1650 / 850) = 36826.35/19363

Ω_1 / Ω_2 = 1.90/1 = 19/10

Therefore, change in flux $\Delta\Phi = (\Omega_1 - \Omega_2)/ \Omega_1 \times 100$

= 9/19 x 100 = **47.37%**

Q.5 a. Write the expression for the induced emf and torque of a dc machine using standard symbols. What is machine constant?

Answer: Refer Page No. 478-179 from Text Book

b. A 4-pole dc machine has an armature radius of 14.5 cm and active length 21 cm. The pole area is 70% of pole pitch. Average flux density under poles is 0.8T. The armature has 33 slots, 33 coils with a turn/coil. Determine the following:

(i) The armature constant K_a

(ii) The armature induced emf E_a

(iii) The conductor current when the armature carries a current of 240A

(iv) The torque and mechanical power developed at the armature current of 240A

Answer: Refer Example 10.2 (Page 481) from the Text Book

Q.6 a. Discuss the working principle of three phase induction motor.

Answer:

Working principle of 3 Ø induction motor :

In A.C. motors, rotor does not receive electric power by conduction but by induction in exactly the same way as the secondary of 2-wdg transformer receives its power from the primary. So such motors are known as induction motors. The principle of a 3Ø 2 pole stator having 3 identical wdg placed 120o apart. The flux (assumed sinusoidal) due to 3 Ø wdg is shown. Let Ø m be maximum value of flux due to any one of the 3Ø . The resultant flux Ør at any instant, is given by vector sum of individual fluxes Ø 1 Ø 2 Ø 3 due to 3 Ø. Let us consider values of Ør at four instants 1/6th time period apart corresponding to points marked 0,1, 2 and 3.

(i) When $\theta = 0^o$ i.e. corresponding to points 0

Hence $\varnothing_1 = 0$, $\varnothing_2 = \frac{\sqrt{3}}{2}\varnothing_m$, $\varnothing_3 = \frac{\sqrt{3}}{2}\varnothing_m$,

$\varnothing_r = 2 \times \frac{\sqrt{3}}{2}\varnothing_m$, $\cos\frac{60^o}{2} = \sqrt{3} \times \frac{\sqrt{3}}{2}\varnothing_m = \frac{3}{2}\varnothing_m$,

(ii) When $\theta = 60^o$ i.e. corresponding to point 1

Here $\varnothing_1 = -\frac{\sqrt{3}}{2}\varnothing_m$

$\varnothing_2 = \frac{\sqrt{3}}{2}\varnothing_m$,

$\varnothing_3 = 0$

(iii) when $\theta = 120^o$ corresponding to point 2

Here $\varnothing_1 = -\frac{\sqrt{3}}{2}\varnothing_m$; $\varnothing_2 = 0$, $\varnothing_3 = -\frac{\sqrt{3}}{2}\varnothing_m$

$\varnothing_r = \frac{3}{2}$

(iv) when $\theta = 180^o$ corresponding to point 3

$\varnothing_1 = 0$, $\varnothing_2 = \frac{\sqrt{3}}{2}\varnothing_m$; $\varnothing_3 = -\frac{\sqrt{3}}{2}\varnothing_m$

Hence
1. Resultant flux is 3 Øm i.e. 1.5 times the maximum value of flux due to any phase.
2. Resultant flux rotates around stator at synchronous speed given by
Ns = 120 f/p

b. The power input to the rotor of a 3-phase, 50 Hz, 6 Pole induction motor is 80 kW. The rotor emf makes 100 complete alternations per minute. Find :
(i) the slip
(ii) rotor frequency
(iii) the mechanical power developed by the motor (6)

Answer:
Given Pi = 80 kW ; 50Hz
P = 6
Rotor frequency f´ =(100/60) = 5/3 = 1.67 Hz
S = f´ / f = (5/3) / 50 = 0.033
Mechanical Power developed by motor = (1-S) Pi
= (1- 1/30) x 80 kW = **77.33kW (8)**

Q.7 a. Why single phase induction motors are not self starting?

Answer:
Single phase induction motors set up pulsating torque, instead inidirectional and continuous torque. This is because force experienced by the current carrying conductors depends upon the direction of current and the magnitude of the flux. As an alternating current, direction and magnitude is changing so varying force is experienced by the conductors. Once in one direction, say clockwise, then in other direction, i.e. anticlockwise. The change is so quick that neither it moves in a clockwise direction nor in

an anticlockwise direction. However, if the motor is rotated by some means in any direction it will continue to rotate, even though the starting means have been withdrawn due to resultant torque in that direction. Hence we can say single phase motors are not self starting and certain means have to be used for starting single phase induction motors

b. Explain AC Series motor or Universal motor in brief.

Answer: Refer Page No. 607 from Text Book

Q.8 a. What is the concept of power transmission? Develop the circuit model of 3-phase transmission line.

Answer: Refer Page Nos. 676-677 from Text Book

b. What are different levels of voltages used for generation, transmission and distribution of electric power?

Answer:
Different Levels Of Voltages For Generation, Transmission And Distribution:
- The generation voltage is upto 30 KV AC rms (line to line).
- The long distance high power transmission is by EHVAC lines 220 kV, 400 kV & 760 kV Ac. In special cases, HVDC line is preffered. The rated voltages of HVDC lines are ±250 kV, ± 400 kV, ± 500 kV & ± 600 kV.

- The backbone transmission system is done by EHV AC transmission lines (400 kV AC & 200 kV AC).
- Distribution is at lower AC voltage between 132 kV AC and 3.3 kV AC.
- Utilization is at the low voltages upto 1kV and medium voltage upto 11 kV.
- The industrial substations receive power at distribution voltage such as 3.3 kV and step down it to 440 V AC. Larger industries receive power at 132 kV and internal distribution at 3.3 kV to 440 volt AC.

Q.9 Write notes on any TWO of the following:-
(i) Types of Wiring
(ii) Types of Indicating Instruments
(iii) Various methods of measurement of Electronic components

Answer:

(i) Refer Pages 705-706 from Text Book I

(ii) Refer Page 614 from Text Book I

(ii) Refer Pages 639-640 from Text Book I

TEXT BOOK

I. Basic Electrical Engineering, D.P. Kothari and I.J. Nagrath, Tata McGraw-Hill Publishing Company Limited, Third Edition, 4th Reprint 2011.