EMF EQUATION OF AN ALTERNATOR:-

Let

Z = no of conductors / phase

$Z = 2T$; T = no of turns / phase.

P = no of poles.

f = frequency of induced emf in Hz.

ϕ = flux / pole in wb.

N = rotor speed in rpm.

K_d = distribution factor.

K_c (or) K_p = coil span factor (or) Pitch factor.

K_f = form factor = 1.11

Time taken to complete one revolution is

$$dt = \frac{60}{N} \text{ seconds.}$$

In one revolution of rotor, each stator conductor is cut by a flux = $d\phi = P\phi$ webers.

$$\text{Average emf induced / conductor} = \frac{d\phi}{dt} = \frac{P\phi}{60/N} = \frac{P\phi N}{60}$$

We know that $N = \frac{120f}{P}$

On substituting the value of N

$$\text{Average emf / conductor} = \frac{P\phi}{60} * \frac{120f}{P} = 2\phi f \text{ volts.}$$

There are Z conductors in series/ph, then average value of emf/phase $= 2f\phi * Z = 2\phi f * 2T$ $(\because Z = 2T)$

Average emf/phase $= 4f\phi T$ volts.

Rms value of emf/ph = form factor * average value

$= 1.11 * 4f\phi T$

Rms value of emf/ph = $\boxed{4.44 f \phi T \text{ volts}}$

* This is the actual value of emf if coil is full pitched and concentrated.

* But if the wdgs are distributed and the coils are short pitched then, the emf equation is multiplied by two factors K_c and K_d.

$\therefore$ Emf/ph $= 4.44 * K_c * K_d * f\phi T$ volts

(or)

$E = 4 K_f K_c K_d f \phi T$ volts

where

$K_d = \dfrac{\text{emf in distributed wdg}}{\text{emf in concentrated wdg}}$.

$K_d = \dfrac{\sin m\beta/2}{m \sin \beta/2}$

m = no of slots / pole / phase.

β = angular displacement between slots.

$$\beta = \frac{180}{n} \quad ; \quad n = \frac{\text{slots}}{\text{Pole}}$$

$$k_c = \cos\frac{\alpha}{2}$$

α = 180 – Actual coil span of coils.

(or)

α = β * no of slots by which the coils are short pitched.

Advantages of short pitch coils.

(i) Less copper is required

(ii) Eliminates high frequency harmonics. Waveform is more sinusoidal.

(iii) Eddy current and hysteresis loss is minimised. This increases the efficiency.

PROBLEMS:

Pblm 1:-

The armature of a 3ϕ alternator has 120 slots. The alternator has 8 poles. Calculate its distribution factor.

m = ?; no of slots = 120; poles = 8.

k_d = ? ; $k_d = \frac{\sin m\beta/2}{m \sin \beta/2}$; m = slots/pole/ph = 120/8/3

m = 5

$\beta = \frac{180}{n}$; n = slots/pole = $\frac{180}{8}$ = 15

β = 180/15 = 12

$\therefore k_d = \frac{\sin 5 \times 12/2}{5 * \sin 12/2} = 0.9566$