Basic Concepts in Rotating Electrical Machines

3

Introduction

❑ Electromagnetic torque

- Also called interaction torque.

$T_e \propto$ (Stator field strength) (Rotor field strength) $\sin\delta$

where, δ = Torque angle

❑ Electrical and Mechanical degrees

$$\theta_{elec} = \frac{P}{2}\theta_{mech}$$

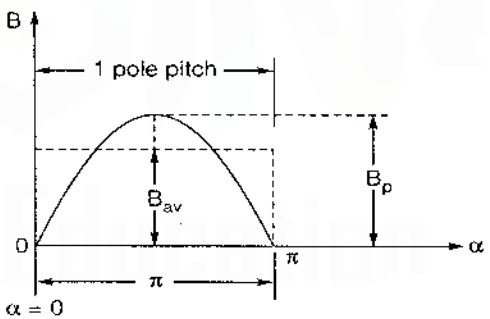
where, θ_{elec} = angle in electrical degree
θ_{mech} = angle in mechanical degree
P = number of poles

❑ Pole pitch

The peripheral distance between adjacent poles is called pole pitch. is always equal to 180 electrical degree.

❑ Average value of flux density wave over one pole-pitch

$$B_{av} = \frac{2}{\pi}B_p$$



where, B_p = Maximum flux density

❑ Total flux per pole

$$\phi = \frac{4}{P}B_p r l$$

where, l = Axial length of the armature core
r = Radius of armature core

❑ Generated emf in a full-pitched coil

$$e = N\omega_r \phi \sin\omega_r t$$

where, N = Number of turns in single full pitched coil
ϕ = flux per pole
ω_r = relative velocity between field flux wave and armature coil

❑ Rms value of generated emf in a full-pitched coil

$$E = 4.44 f_r N \phi$$

where, f_r = rotational or speed frequency

❑ Rotational frequency

$$f_r = \frac{P n_r}{2} \text{ Hz}$$

where, n_r = relative speed between armature coil and flux-density wave in rps.

❑ Generated emf in a short-pitched coil

$$E = 4.44 k_p f N \phi$$

where, k_p = coil pitch factor or coil-span factor or pitch factor

❑ Pitch factor

$$k_p = \cos\frac{\varepsilon}{2}$$

where, ε = Angle of chording (or pitching) for fundamental flux wave.

Note:

For n^{th} space field harmonic, chording angle becomes $n\varepsilon°$ electrical.

$$k_{pn} = \cos\frac{n\varepsilon}{2}$$

❑ Distribution factor

$$k_d = \frac{\sin\left(\frac{q\gamma}{2}\right)}{q\sin\left(\frac{\gamma}{2}\right)}$$

where, q = No. of slots per pole per phase

γ = Angular slot pitch

$$\gamma = \frac{180\,P}{\text{Total no. of slots}} \text{ electrical degree}$$

- **Distribution factor for n^{th} harmonic**

$$k_{dn} = \frac{\sin\left(\frac{qn\gamma}{2}\right)}{q\sin\left(\frac{n\gamma}{2}\right)}$$

- **Winding factor**

$$k_w = k_p \times k_d$$

- **Phase spread**

$\sigma = q\gamma$ ... in electrical space degrees

- **Synchronous speed**

Speed at which rotating magnetic field revolves is called synchronous speed

$$n_s = \frac{120f}{p} \text{ r.p.m.}$$

■■■■