1-10 Skewing effect

Rotor conductors are skewed because of these main reasons:

Primarily to prevent the cogging phenomenon. It is a phenomenon in which, if the rotor conductors are straight, there are chances of magnetic locking or strong coupling between rotor & stator.

To avoid crawling. Crawling is a phenomenon where harmonic components introduces oscillations in torque

Other reasons include increasing effective rotor resistance, to improve the starting torque & starting power factor, increasing effective magnetic coupling between stator & rotor fluxes.

$ks = \sin\frac{\gamma}{2} / \frac{\gamma}{2}$

ɤ=skewing angle

$Es = Erms = 2.22\ F\ Ks\ \emptyset$

Harmonic Effect

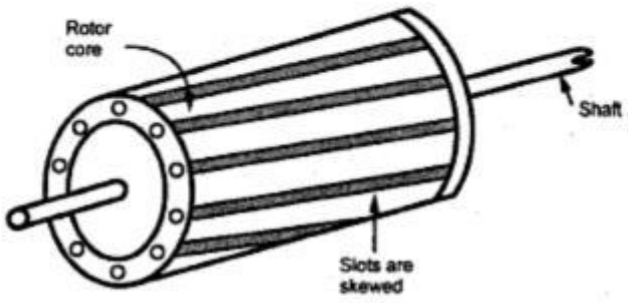
N=harmonic order=1,2,3,4, ……∞

N=2km±1=1,2,3,4   k=0,1,2,……..

N=4km± 1=1,3,5,7….   Wave positive &negative area eque

N =6k ±1 =1,5,7,11,13,…..3Ø machines

M, no.of phase



$En = E1\ \frac{Bn}{B1} emf\ induced\ harmonic\ field$

$E = (E1^2 + E3^2 + \cdots \ldots . En^2)½ \quad resultant\ \ induced\ emf$

1-11 Pitch factor: is the ratio of the voltage induced in a short-pitch winding to the voltage that would be induced if the winding were full pitch

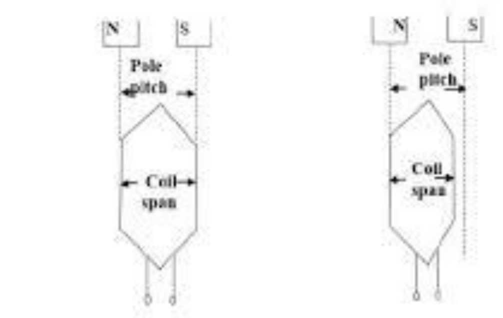
In short pitched coil, the induced emf of two coil sides get vectorially added and give resultant emf of the loop. In short pitched coil, the phase angle between the induced emf of two opposite coil sides is less than 180° (electrical). But we know that, in full pitched coil, the phase angle between the induced emf of two coil sides is exactly 180° (electrical). Hence, the resultant emf of a full pitched coil is just the arithmetic sum of the emfs induced on both sides of the loop. We well know that vector sum or phasor sum of two quantities is always less than their arithmetic sum. The pitch factor is the measure of resultant emf of a short-pitched coil in comparison with resultant emf of a full pitched coil.

$$K_p = \frac{Resultant\ emf\ of\ short\ pitch\ coil}{Resultant\ emf\ of\ full\ pitch\ coil}$$

ec emf induced in turn side.

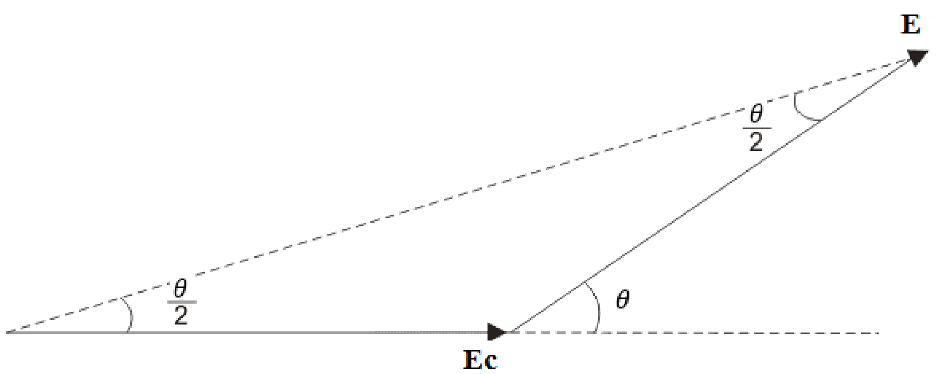
e. total emf induced in turn

e=2ec   for full.pitch turn



$$\sin\frac{\gamma}{2} = \frac{ad}{\mathrm{ab}} = \frac{\frac{e}{2}}{\mathrm{e1\ or\ e2}}$$

$$or\ E = 2Ec\ \sin\frac{\gamma}{2}$$



$$\mathrm{E} = 2\mathrm{Kp\ Ec} \qquad \mathrm{Kp} = \sin\frac{\gamma}{2}\ or\ \ Kp = \cos\frac{\theta}{2}\quad in\ Similar\ way$$

$Et = emf\ \ induced\ \ in\ single\ \ turn$

$Et = 4.44\ F\ Kp\ \emptyset$

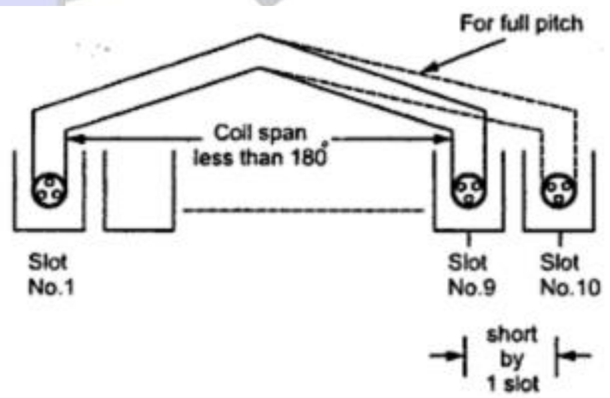
$Kp = 1\ FOR\ Full\ pitch\ windings$

$Kp < 1\ FOR\ Chorded\ winding$

$\theta = y\ \alpha\ \ ,\qquad \gamma = 180 - \theta$

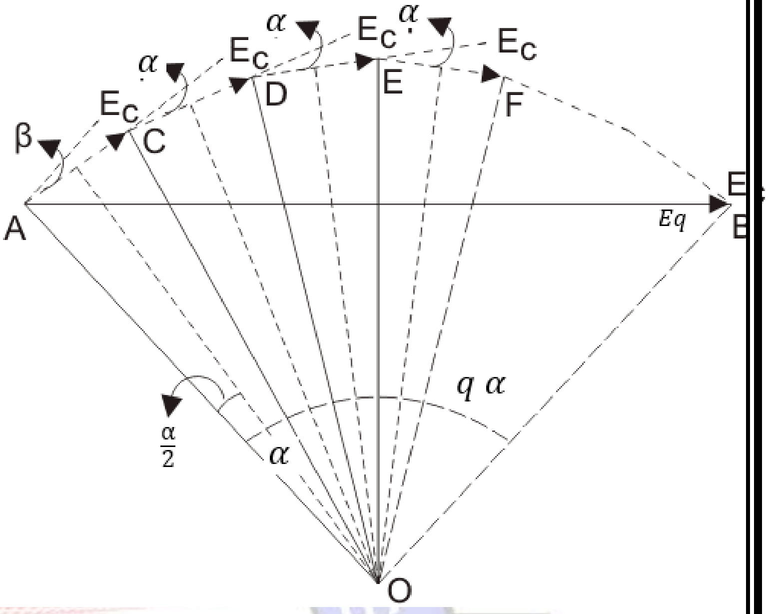
$Ec = emf\ induced\ in\ acoil\ with\ Tc\ turns$

$Ec = 4.44\ F\ KP\ Tc\ \emptyset$



$$KPn = \sin\frac{n\gamma}{2} = \cos\frac{n\theta}{2}$$

1-12 Distribution Factor:



$$k = \frac{Phasor\ sum\ of\ component\ emfs}{Arithmetic\ sum\ of\ component\ emfs}$$

$$q\ Ec = 3Ec = E1 + E2 + E3$$

$$Kd = \frac{AB}{q\ Ec} = \frac{Eq}{q\ Ec}$$

$$AB = Eq = Kd(q\ Ec)$$

$$= 2R\ \sin\frac{q\ \alpha}{2} = \left(\frac{\sin\frac{q\alpha}{2}}{q\sin\frac{\alpha}{2}}\right)(q\ Ec)$$

$$R = \frac{ab}{2\sin\frac{\alpha}{2}} = \frac{Ec}{2\sin\frac{\alpha}{2}}$$

$$\therefore kd = \frac{\sin\frac{q\alpha}{2}}{q\sin\frac{\alpha}{2}} \rightarrow kdn = \frac{\sin\frac{qn\alpha}{2}}{q\sin\frac{n\alpha'}{2}}$$

$$kw = kp\ kd$$

$$Eq = 4.44\ F\ Kw\ (q\ Tc)\emptyset\ , \qquad Ts = pq\ Tc$$

$$Eph = 4.44\ F\ Kw\ Ts\ \emptyset$$

$$EL = \sqrt{3}Eph \quad for\ \lambda\ connected\ winding$$

$$EL = Eph\ \ for\ \Delta connected\ winding$$

1-13 Produced m.m.f

$$i = IM\ \sin wt$$

$Fc = iT = \sqrt{2}I\ Tc\ \sin wb$

$F = \frac{Fc}{2} = \pm\frac{iTc}{2} = \pm\frac{\sqrt{2}ITc}{2}\sin \mathrm{wt} = \pm \mathrm{Fm}\ \sin \mathrm{wt}$

$Fm = \frac{\sqrt{2}I\ Tc}{2}; F1 = \frac{4}{\pi}Fm$

$\boldsymbol{or}\ F1 = \frac{2\sqrt{2}}{\pi}I\ Tc = 0.9ITc$

$Fn = {}^{F1}/_{n} = 0.9\frac{I\ Tc}{\mathrm{n}}$

For distributed coils(q=2)

f1m=f2m=fm

Kd=fqm/qfm=f1/qfm

F1=qkdfm=0.9i(q Tc)kd   single layer

F2= qkwfm=1.8i(q Tc)kw   double layer

I=Iph/a ;Ts=pqTs

Single-layer Ts=pqTc/a

Double-layer Ts=2pq Tc/a

IphTs=aI 2pq Tc/a=2p(IqTc)

Fn=0.9 IphTs Kw/n p   for single phase

For 3Ø f1=m/2f1=3/2f1=1.35 iphTs kw/p

(fn)3Ø=1.35 IphTs kw/np

In general

(fn)m=m/2 fn=0.45 m iphkwnTs/np

*for uniform syn. System (f) is constant and rotating with syn. speed.

*if the reluctance constant ,the flux and mmf form is the same the mmf direction of rotation depends on the phase sequence.

*slot skewing has no effect of mmf value.

*mmf wave form is sinusoidal if s=∞(lowest harmonic)

*if the field under both poles is the same,then the horizontal axis will divide the mmf waveform in two equal areas.

*in poly phase machines ,the mmf resultant phase or (f) is varying in time and rotating is same.

*if the phasor value is always constant ,then the rotating field is circular otherwise if is ellipsoid for single phase it is pulsating

Ex. 1:- a 6-pole,generator having (108) slots on the stator find the pitch factor for the fundamented,1st harmonic when the coil is chorded by(3)slots.

Sol:-

$s = 108 \ \ , 2P = 6 \ , \quad P = 3 \ \ , y = 3$

$Q = \frac{S}{P} = \frac{108}{3} = 36 \ \ , \ \ \propto = \frac{2\pi}{Q} = \frac{360}{36} = 1\mathring{0} \ , \theta = y\alpha = 3 \times 1\mathring{0} = 30 - Charding\ angle$

$\Upsilon = 180 - \theta = 180 - 30 = 150° \ coil\ span\ angle$

$kp1 = \sin\frac{\Upsilon}{2} = \sin 75° = 0.962$

$or\ kp1 = \cos\frac{\theta}{2} = \cos 15 = 0.962$

Ex.2) a 3-phase ,16pole,Y-connected generator ,its air gap flux is 60 mwb/pole sinusoidally the stator having(96)slots in each(4)conductors, and the coil span is(150).find the line emf induced at no load, when the generator is running at 375rpm

Sol:- $\Upsilon = 150° \ , s = 96 \ , \ 2P = 16 \ \ , \emptyset = 60 \times \frac{10^3 wb}{pole} \ \ , Ns = 4 \ \ , n = 375rpm \ F = \frac{nP}{60} = \frac{375\times 8}{60} = 50HZ \ \ , q = \frac{s}{2Pm} = \frac{96}{16\times 3} = 2$

$Ts = \frac{sNs}{2m} = \frac{96\times 4}{2\times 3} = 64 \ , \propto = \frac{60°}{2} = 30° \ , kp = \sin\frac{150}{2} = 0.966 \ , \ kd = \frac{\sin\frac{q\propto}{2}}{q\sin\frac{\propto}{2}} = \frac{\sin 30°}{2\sin 15°} = 0.962$

$E = 4.44Fkp\ kd\ Ts\ \emptyset = 4.44 \times 50 \times 0.966 \times 0.962 \times 64 \times 0.06 = 792.2V$

$E = \sqrt{3E} = \sqrt{3} \times 792.2 = 1375\ v$

Ex. 3) a 3-phase, 50Hz generator running at 1500 rpm, the stator inside diameter is (0.5m) and its length is (1.2m)find the induced emf in each conductor. if the maximum air gap flux density is(0.62T) and it is sinusoidally distributed.

Sol:-

$$F = 50 \quad , n = 1500rpm \, , D = 0.5m \quad , L = 1.2m \quad Bm = 0.62T$$

$$P = \frac{60F}{n} = \frac{60 \times 50}{1500} = 2 \qquad 2P = 4$$

$$\tau = \frac{\pi D}{2P} = \frac{\pi \times 0.5}{4} = 0.3925M \rightarrow Pole\ pitch$$

$$Bav = \frac{2}{\pi} Bm = \frac{2}{\pi} \times 0.62 = 0.392T \quad \rightarrow avarage\ flux\ density$$

$$\emptyset = Bav(\tau L) = 0.392 \times 0.3925 \times 1.2 = 0.187wb$$

Then emf induced in one conductor is:-

$$Econ = 2.22F\emptyset = 2.22 \times 50 \times 0.187 = 20.7v$$

Emf induced in one turn

$$Et = 2Econ = 41.4v$$