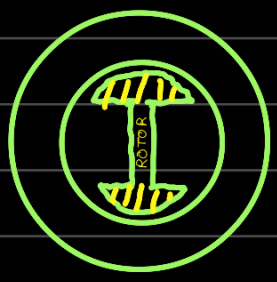
Day-21

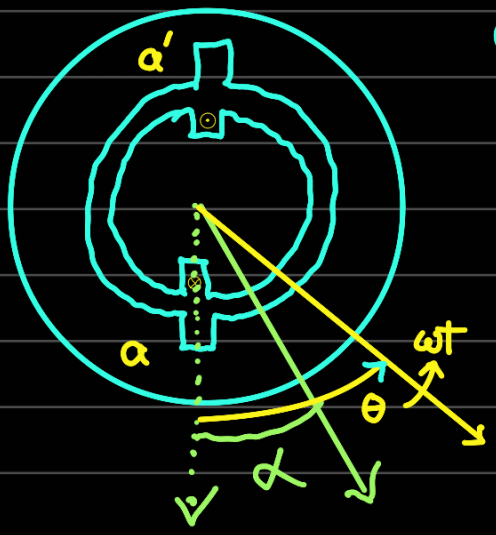
→ Synchronous machine:

Cylindrical rotor/ Non-Salient pole SM	Salient pole SM
	
Uniform air gap	non-Uniform air gap

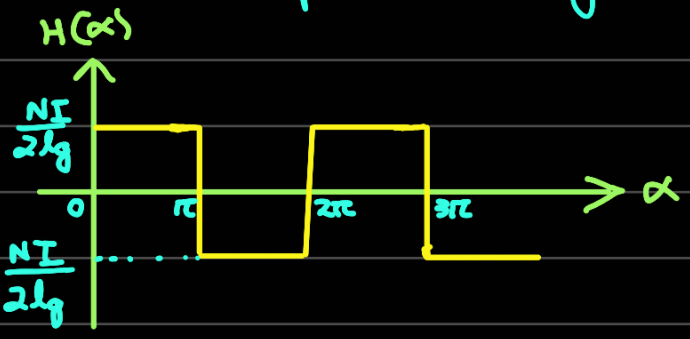
→ Analysis of cylindrical rotor SM-

Length of rotor = l
Radius of rotor = r
Air gap = l_g

Rotor/field winding has N turns and carries DC current I



'α' is a spatial angle



$$e(\omega t) = N\frac{d\phi(x)}{dt}$$

$$H(\alpha) = \begin{cases} -\frac{NI}{2l_g}, & \alpha \in [0, \theta) \\ \frac{NI}{2l_g}, & \alpha \in (\theta, \pi+\theta) \\ -\frac{NI}{2l_g}, & \alpha \in (\pi+\theta, 2\pi] \end{cases}$$

Strictly speaking, $H(\alpha)$ is not defined for $\alpha = \theta$ and $\pi+\theta$, as that is the transition point

$$l_{aa'}(\omega t) = N \frac{d\Phi(\omega t)}{dt}$$

$$\Phi = \iint_S \vec{B} \cdot d\vec{S}$$ → can be seen clearly in the air gap ($\vec{B}$ is radial there)

$$= \int_{\alpha=0}^{\pi} |\vec{B}|\,|d\vec{S}|$$

$$= \frac{\mu_0 NI}{2l_g} \int_0^{\pi} r\,d\alpha\, l$$

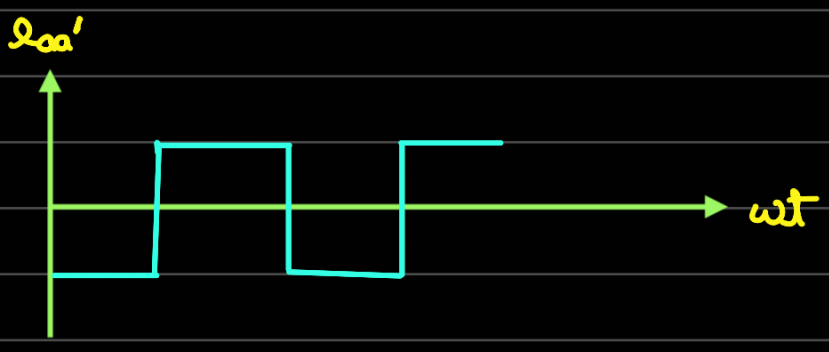
$$= \underbrace{\frac{\mu_0 NI}{2l_g} \times \pi r l}$$

Flux-linked by coil aa' at $\theta = \omega t = 0$

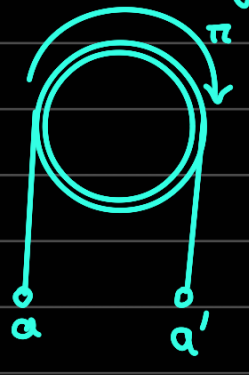
$$\Phi_{aa'}(\theta) = \int_0^{\theta} -B\,ds + \int_{\theta}^{\pi} B\,ds \qquad (\theta = \omega t)$$

$$= \left[\frac{-\mu_0 N I}{2g}\theta + \frac{\mu_0 N I}{2g}(\pi-\theta) \right] r l$$

$$= \frac{\mu_0 N I r l}{2g}(\pi - 2\theta)$$



So far we saw concentrated winding (2 slots, all windings in it)



coil pitch (C.P) $= 180^\circ$ (Full-pitched winding)

If C.P. $< 180^\circ$

↓

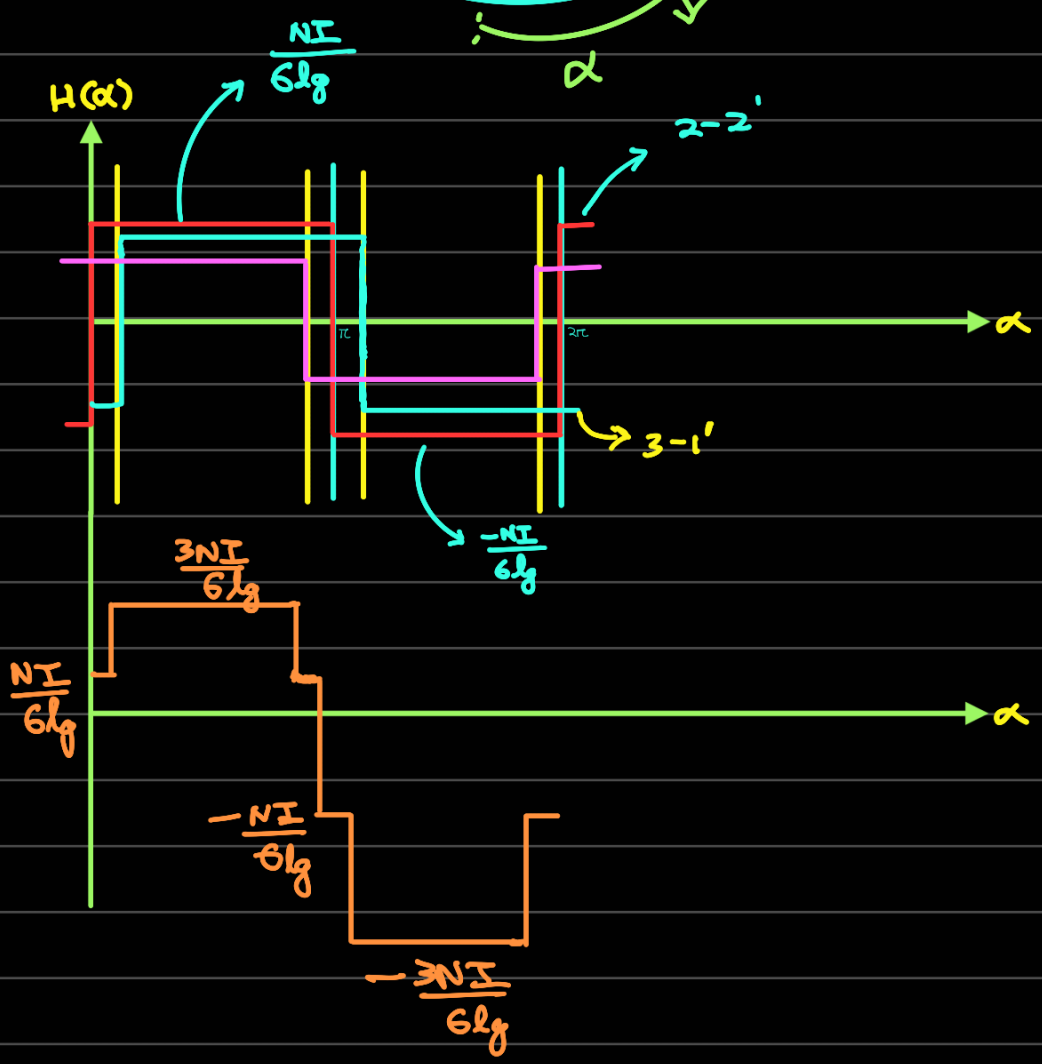
Short-pitched winding

We don't want square wave! We go for distributed winding.

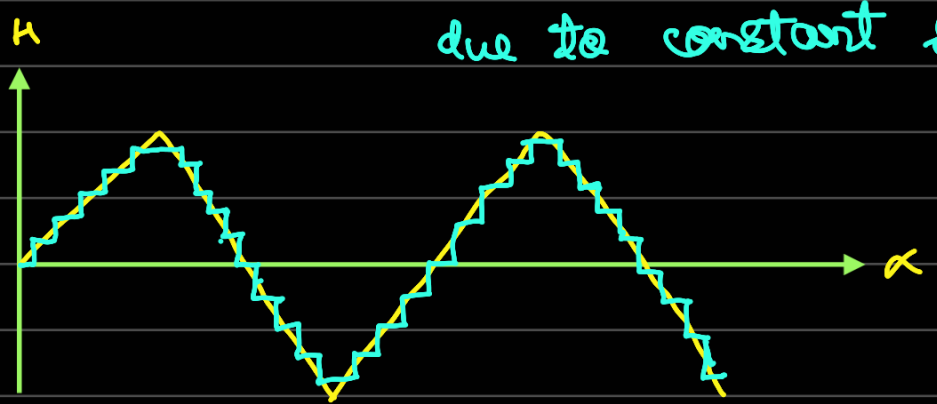
↓

Superposition of square waves giving sinusoidal wave!

Total N turns, assuming equal distribution on slots, one slot has $\frac{N}{3}$ turns



↓ approaches triangular wave due to constant step size



For non-constant step size, we go for sinusoidal distributed windings.