SNS COLLEGE OF ENGINEERING

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AN AUTONOMOUS INSTITUTION

Approved by AICTE, New Delhi and Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

POWER SYSTEM ANALYSIS
UNIT – III
STEPPER MOTOR

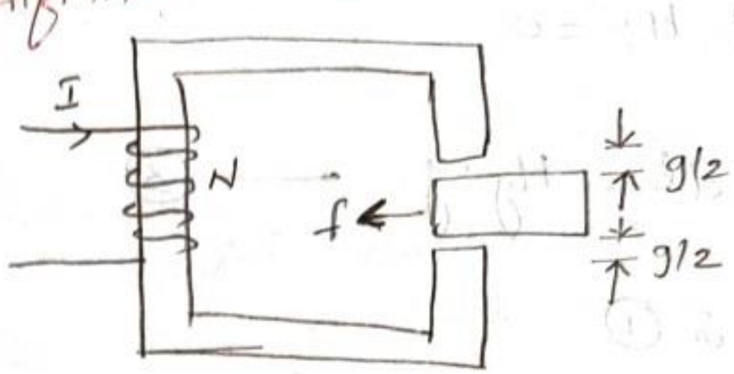
TORQUE EQUATION

Torque equation of stepper Motor.

Basic assumptions.

* Interms of magnetic energy & co-energy
* Considering ideal case of rotor & stator cores have infinite permeability.
* Proceed step by step to the case in which the cores are subject to magneti saturation.

Infinite permeable core



A current I, is flowing through the coil of N turns to yield the magnetic flux, force 'f' is acting on iron piece in the x-direction.

Let B_g - magnetic flux density in the airgaps.

Ampere's law.

$$\oint H \cdot dl = NI \quad \text{--- (1)}$$

$$\oint H \cdot dl = H_g (g/2) + H_g (g/2) + H_i (l)$$

$$= H_g (g) + H_i (l) \quad \text{--- (2)}$$

where

H_g = Magnetic field intensity in the gap.

H_i = Magnetic field intensity in the cores.

l - Total magnetic path in cores.

When permeability of cores is extremely large, & $H_i = 0$

$$\oint H \cdot dl = H_g \cdot g \quad \text{--- (3)}$$

Sub ③ in ①

$$H_g \cdot g = nI$$

$$H_g = \frac{nI}{g} \quad \text{——} \; (4)$$

The air gap flux density

$$B_g = \frac{\mu_0 n I}{g} \quad \text{——} \; (5)$$

μ_0 = Permeability in the air gap

Over lapped area $= x\omega$ —— (6)

where

x = length of iron piece

ω = Distance by which the rotor tooth & iron piece overlap.

Magnetic flux ϕ = area × B_g

$$\phi = x\omega \times \frac{\mu_0 n I}{g} \quad \text{——} \; (7)$$

Flux linkage $\psi = n\phi$

$$\psi = x\omega \frac{\mu_0 n^2 I}{g} \quad \text{——} \; (8)$$

Now, Let us assume that there is an incremental displacement Δx of the tooth during a time interval Δt.

$$\Delta \psi = \frac{\omega \mu_0 n^2 I}{g} \Delta x \quad (9)$$

The emf induced in the coils by the change in flux linkage is

$$e = -\frac{\Delta \psi}{\Delta t} = -\frac{\omega \mu_0 n^2 I}{g} \cdot \frac{\Delta x}{\Delta t} \quad (10)$$

Work done by the source is

$$\Delta P_i = I |e| \Delta t$$

$$= \frac{\omega \mu_0 n^2 I^2}{g} \cdot \Delta x \quad (11)$$

$$\Delta P_i = \frac{B_g^2}{\mu_0} g \omega \Delta x \quad (12)$$

The workdone by the source is converted partly to mechanical work & the rest spent ↑ the magnetic field energy in airgaps.

$$\Delta W_m = \frac{1}{2} \frac{B_g^2}{\mu_0} g w \Delta x \quad \text{—— (13)}$$

W.K.T

$$\Delta W_m = f \Delta x$$

$$f \Delta x = \frac{1}{2} \frac{B_g^2}{\mu_0} g w \Delta x$$

$$\boxed{f = \frac{1}{2} \frac{B_g^2}{\mu_0} g w} \quad \text{—— (14)}$$

Sub eq (8) in (14)

$$f = \frac{1}{2} \frac{w \mu_0 n^2 I^2}{g} \quad \text{—— (15)}$$

$$W_m = \frac{1}{2} \frac{B_g^2}{\mu_0} g w \quad \text{—— (16)}$$

from eq (14) & (16)

$$f = \left(\frac{dW_m}{dx}\right)_{I = \text{Constant}} \quad \text{—— (17)}$$