SNS COLLEGE OF ENGINEERING

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

19EE504 - SPECIAL ELECTRICAL MACHINES
UNIT – 3
STEPPER MOTOR
THEORY OF TORQUE PREDICTION

CONTENTS

- Mechanism of static torque production in a VR Motor
- The case of infinitely permeable cores
- The case of constant permeability’s

The case of constant permeability's

In the model with infinitely permeable cases, the magnetic field appears only in the gaps and its magnetic treatment is simple. When cores are of finite permeability, on the other hand, magnetic energy appears not only in the airgaps, but also in the cores and spaces other than the gaps. If the coil inductance is L in the model of figure the flux linkages ψ is given by

$$\psi = LI \qquad \text{----------(1)}$$

The case of constant permeability's

The magnetic energy w_m in the system is expressed as

$$w_m = \frac{1}{2}LI^2 \qquad \text{---------- (2)}$$

If the iron piece undergoes a displacement Δx during the time interval Δt, the inductance L will increase by ΔL. The emf induced in the coil is

$$e = -\frac{\Delta\psi}{\Delta t} = -\frac{\Delta(LI)}{\Delta t} \text{ - - - - - - - - (3)}$$

If the power supply is a current source and provides a current I during displacement (3) become

$$e = -I\frac{\Delta L}{\Delta t} \text{ - - - - - - - - - - (4)}$$

Since the voltage at the source is equal but opposite to the counter emf of equation (4), the work ΔP_i done by the source on the circuit is,

$$\Delta P_i = I|e|\Delta t = I^2\Delta L$$

$$= I\left|I.\frac{\Delta L}{\Delta t}\right|\Delta t = I^2\Delta L \text{ - - - - - - - - - (5)}$$

The case of constant permeability's

On the other hand, the increase in the magnetic energy

$$\Delta\omega_m = \frac{1}{2} I^2 \Delta L \text{ ---------(6)}$$

From comparison of equations (5) and (6) it is seen that half of the work done on the circuit by the source is converted into mechanical energy. Hence it is supposed that the other half is converted to mechanical work

$$\Delta P_o = f\Delta x = \frac{1}{2} I^2 \Delta L \text{ ---------(7)}$$

Then the force is

$$f = \frac{1}{2} I^2 \frac{\Delta L}{\Delta x} \text{ ---------(8)}$$

Assessment - 1

- In a stepper motor detent torque means
  - **Maximum of the static torque with phase winding unexcited**
  - Minimum of the static torque with phase winding unexcited
  - Minimum of the static torque with phase winding excited
  - Maximum of the static torque with phase winding excited

Assessment - 2

- Which of the following motors can have highest operating speed?
  - Stepper motor
  - Capacitor start motor
  - **Brushless DC Motor**
  - Universal motor


Thank you