SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

COIMBATORE-35

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

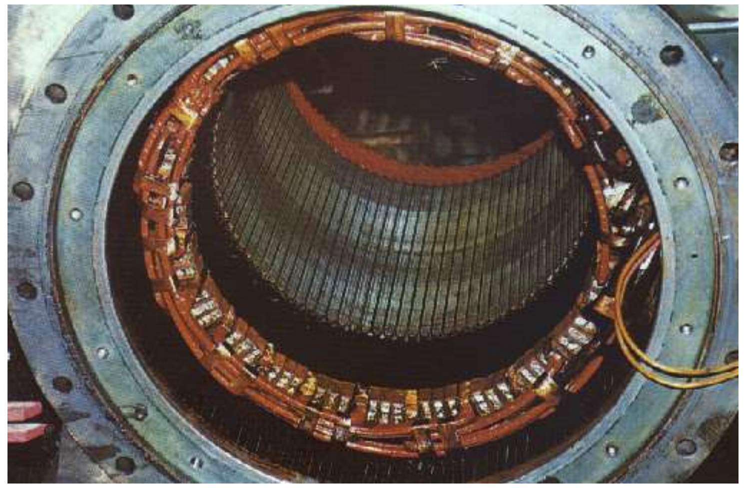
COURSE NAME: 23EET204/ ELECTICAL MACHINES II

II YEAR / IV SEMESTER

Unit 2 – SYNCHRONOUS MOTOR

Topic 5: Power input and power developed equations

GUESS THE TOPIC NAME…

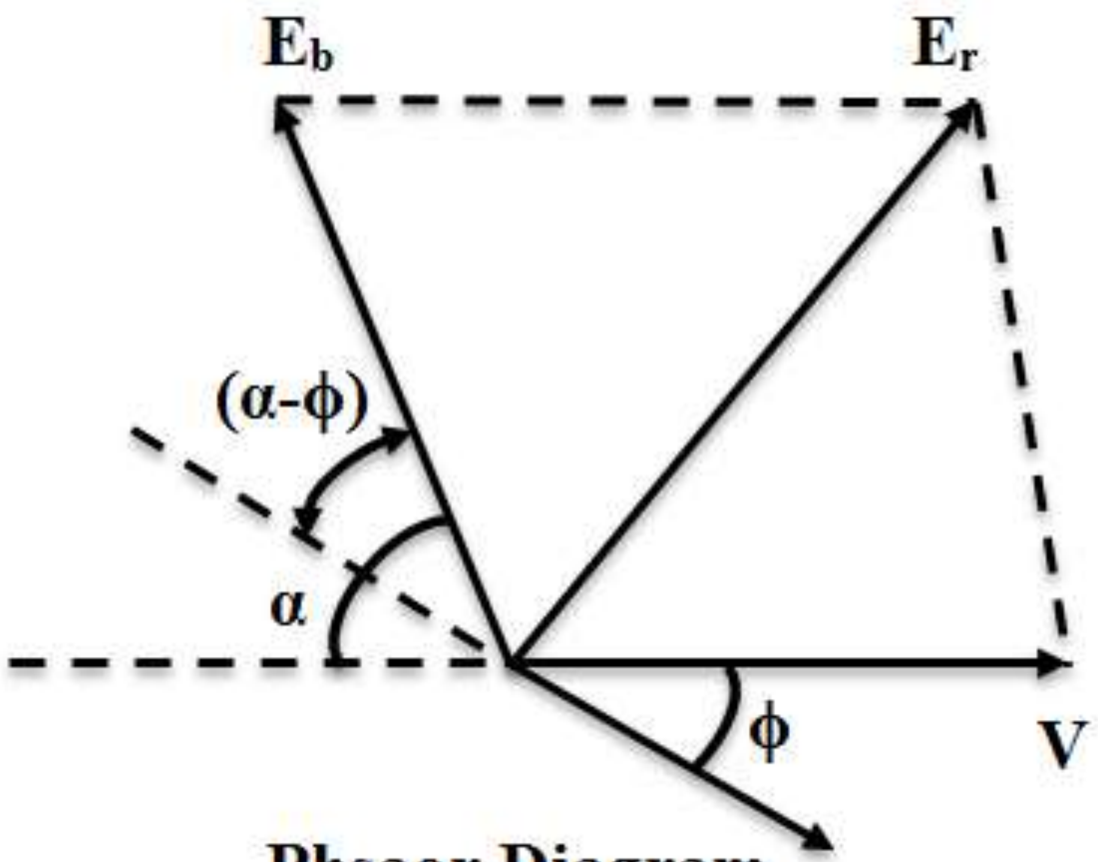


Synchronous Motor- phasor diagram

The phasor diagram of a synchronous motor is shown below. From the phasor diagram,

Let

- V = Supply voltage / phase
- I_a = Armature current / phase
- R_a = Armature resistance / phase
- α = Load angle
- ϕ = Power factor angle



Phsaor Diagram

Synchronous Motor-Power developed

Input Power to Motor :

Motor input power / phase = $V I_a \cos \phi$

Total input power for 3-ϕ star-connected motor,

$$P = \sqrt{3}\, V_L I_L \cos \phi$$
$$= 3 V_{ph} I_{ph} \cos \phi$$

Where

V_L and I_L are line values

V_{ph} and I_{ph} are phase values

Power Developed by Motor :

The mechanical power developed / phase,

P_m = Back emf * Armature current * Cosine of the angle between E_b and I_a

$$= E_b I_a \cos(\alpha - \phi) \quad \text{for lagging p.f}$$
$$= E_b I_a \cos(\alpha + \phi) \quad \text{for leading p.f}$$

Synchronous Motor-Power developed

The copper loss in a synchronous motor takes place in the armature windings.

Therefore,

Armature copper loss / phase $= I_a^2 R_a$

Total copper loss $= 3 I_a^2 R_a$

By subtracting the copper loss from the power input, we obtain the mechanical power developed by a synchronous motor as

$$P_m = P - P_{cu}$$

For three-phase,

$$P_m = \surd 3 I_L I_L \cos \phi - 3 I_a^2 R_a$$

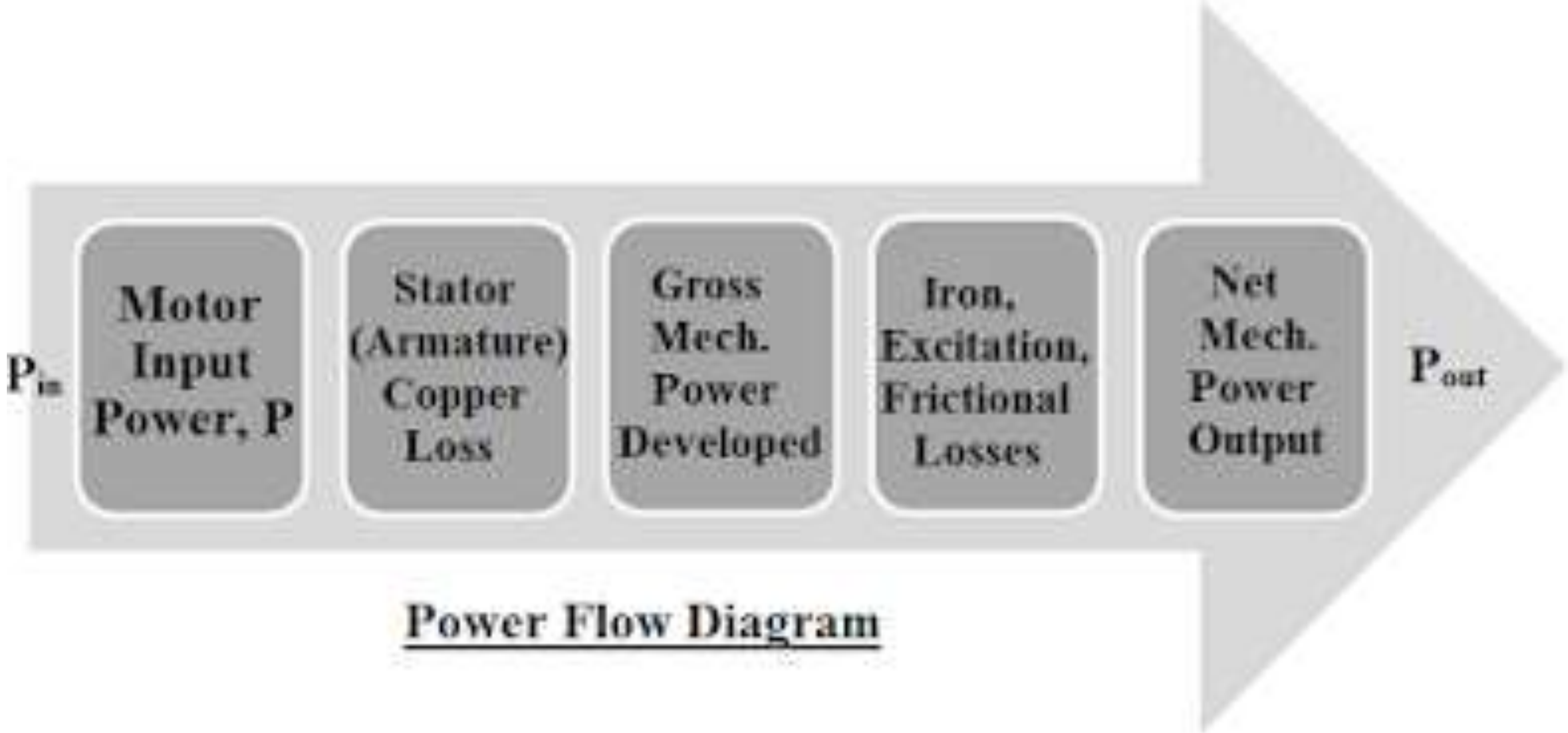
Power Output of the Motor :

To obtain the power output we subtract the iron, friction, and excitation losses from the power developed.

Therefore,

Net output power, $P_{out} = P_m$ - iron, friction, and excitation losses.

The above two stages can be shown diagrammatically called as Power Flow Diagram of a Synchronous Motor



Power Flow Diagram

The power developed in a synchronous motor as follows.

Motor Input Power, P

1. Stator (Armature) copper loss P_{cu}
2. Mechanical power developed, P_m
    a. Iron, friction, and excitation losses
    b. Output power, P_{out}

Net Power Developed by a Synchronous Motor :

The expression for power developed by the synchronous motor in terms of α, θ, V, E_b, and Z_s are as follows :

Let

V = Supply voltage

E_b = Back emf / phase

α = Load angle

θ = Internal or Impedance angle = $\tan^{-1}(X_r / Z_s)$

I_a = Armature current / phase = E_r / Z_s

Z_s = $R_a + J X_s$ = Synchronous impedance

Mechanical power developed / phase

$$P_m = \frac{E_b V}{Z_s}\cos(\theta - \alpha) - \frac{E_b^2}{Z_s}\cos\theta$$

Net Power Developed by a Synchronous Motor :

The armature resistance is neglected

If R_a is neglected, then $Z_s \approx X_s$ and $\theta = 90°$. substituting these values in the above equation

$$P_m = \frac{E_b V}{X_s} \cos(90 - \alpha) - \frac{E_b^2}{X_s} \cos 90^0$$

$$P_m = \frac{E_b V}{X_s} \sin \alpha$$

SUMMARY

Power input and power developed equations

KEEP LEARNING..

Thank u

SEE YOU IN NEXT CLASS