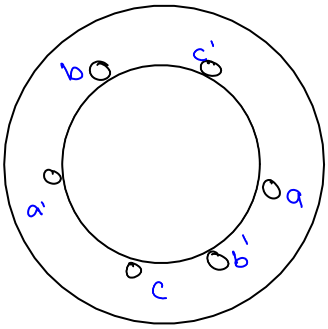
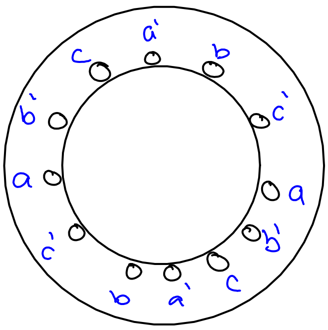
Lecture 10

Tuesday, 8 September 2009
4:36 PM



For one cycle of electricity we have found that the flux wave travels one complete circumference of the stator.

Now consider the following wiring arrangement:



An arrangement of wirings as shown constitutes a 4-pole machine. Notice how the travelling wave will move at half the velocity of the two pole machine.

So, for a two-pole machine there is one complete revolution per supply cycle and for a 4-pole machine there is half a revolution per cycle.

Generally:

$$\text{No of revolutions} = \frac{2}{p} \times \text{No of cycles of supply.}$$

where p = No of poles

$\frac{p}{2}$ = No of pole pairs

$$\text{rev/s} = \frac{2}{p} \times f_s$$

$$N_{mech} = 60 \times \frac{2 f_s}{p} \text{ rpm}$$

$$= \frac{120 f_s}{p} \text{ rpm}$$

$$\omega_{mech} = \frac{2\pi}{60} \times \frac{120 f_s}{p} \text{ r/s}$$

$$= \frac{4\pi f_s}{p} \text{ r/s}$$

$$= \frac{2}{p} 2\pi f_s \text{ r/s}$$

$$\therefore \omega_{mech} = \frac{2}{p} \omega_s$$

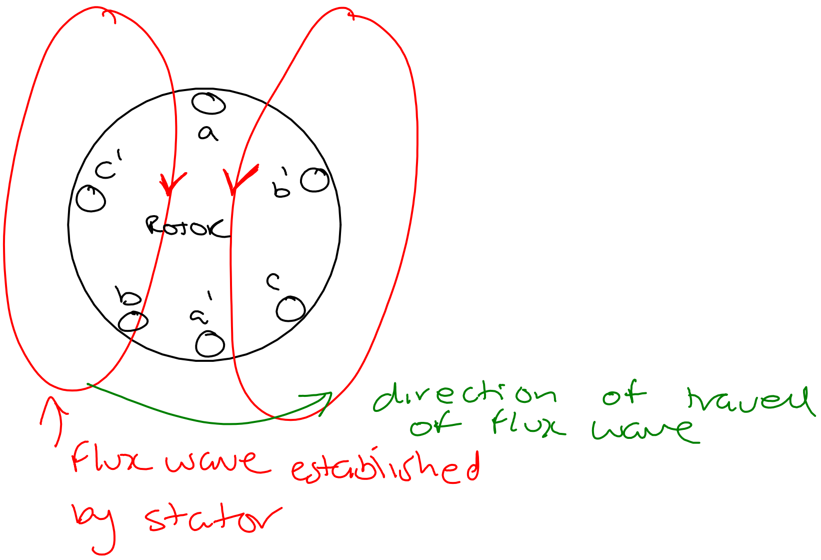
Note that almost all of the flux produced by the stator links with the rotor, but not all.

There is a small amount of leakage flux which gives the stator winding the property of leakage inductance.

For each stator winding, there is an applied voltage and a current flow which provides for magnetization and core losses.

There will also be a resistive voltage-drop and an induced emf.

Now consider the rotor:

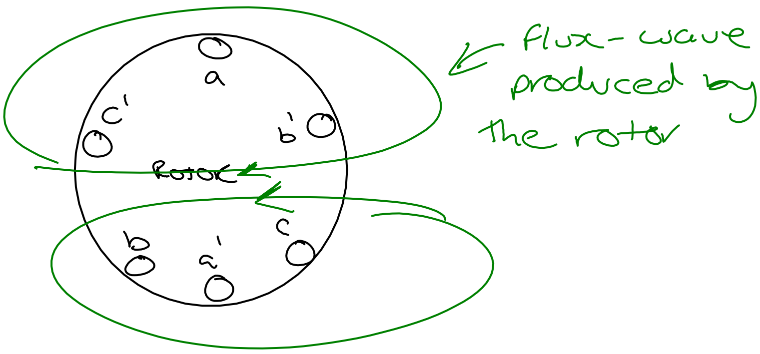


At the instant shown, the flux linking the phase a of the rotor is zero, but it is changing at its maximum rate.

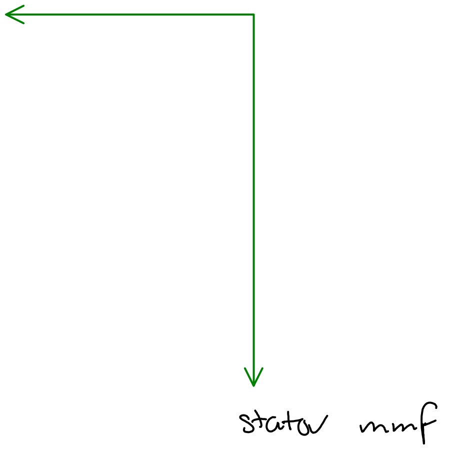
∴ the voltage in coil a is at a maximum.

If the rotor coil is purely resistive, the current in coil a of the rotor would be at a maximum also.

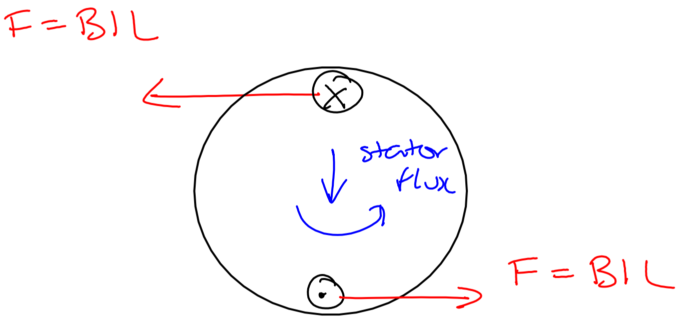
This would give rise to a flux wave which would be



Rotor mmf
(purely resistive coil)

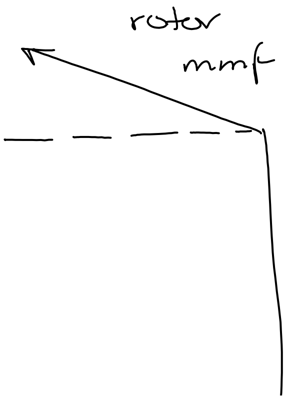


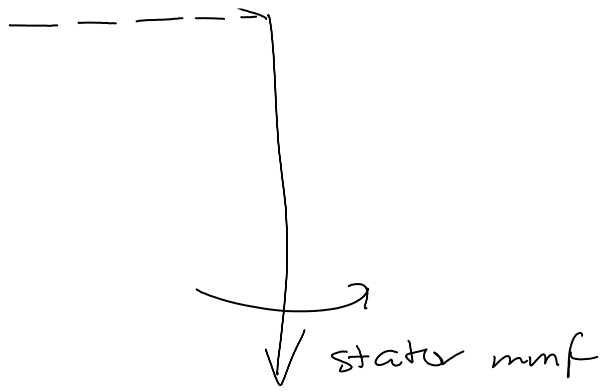
The tendency of these flux-wave patterns is to align ∴ a torque is exerted on the rotor in a direction of rotation of the stator flux.



If the forces on a ccc are considered as shown, then it is also clear that the forces will result in a torque on the motor in the direction of the stator flux rotation.

Note that because there will be a small amount of leakage flux attaching to the flow of current in the rotor, the rotor current will lag the rotor voltage





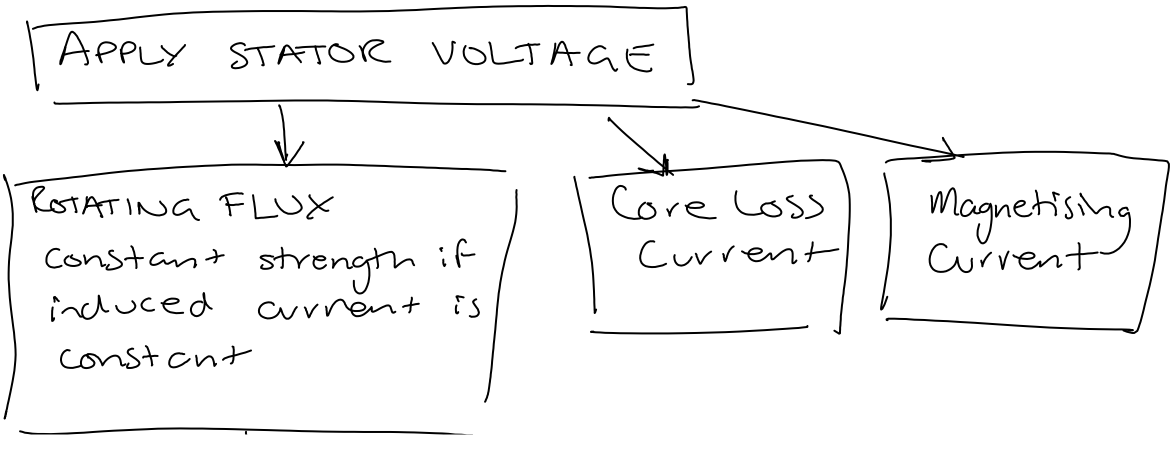
As the rotor gathers speed, the frequency of the induced emf in the rotor, falls as does their magnitude.

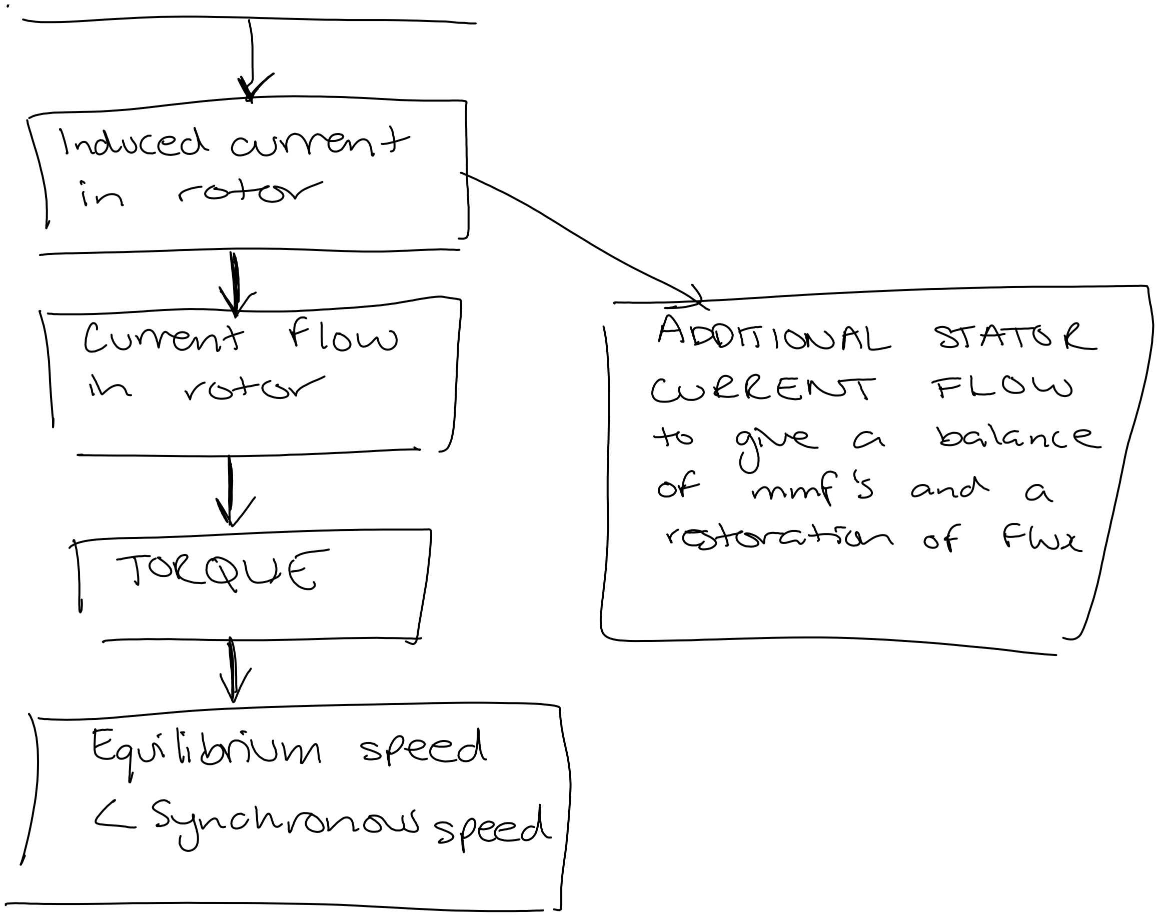
This means that $Z = j\omega L$ also falls and the rotor current comes more nearly into phase with the rotor emf's, but the magnitudes fall as well.

At steady state, there must be a constant amplitude of induced voltage in the stator and this implies a constant amplitude of flux wave. The presence of a rotor current mmf and flux - if present alone, would alter the resultant flux wave and hence, would give rise to an additional current flow in stator.

The similarity to a T/F is now apparent

$$(N_1 I_1 = N_2 I_2)$$





The frequency of the rotor emf is a function of the difference between the flux wave in the air gap and the actual speed of the rotor

for a 2-pole machine $\omega_m = \omega_s - \omega_r$

ω_r = rotor current frequency

ω_s = stator current frequency

ω_m = mechanical rotor speed

ω_{ms} = rotor synchronous speed.

for a p-pole machine

$$\omega_m = \frac{2}{p}\left(\omega_s - \omega_r\right)$$