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Homework #2
2102-464 Fundamentals of Electric Motor Drives

Due Date: 31 January 2023 (On-Line Submission)

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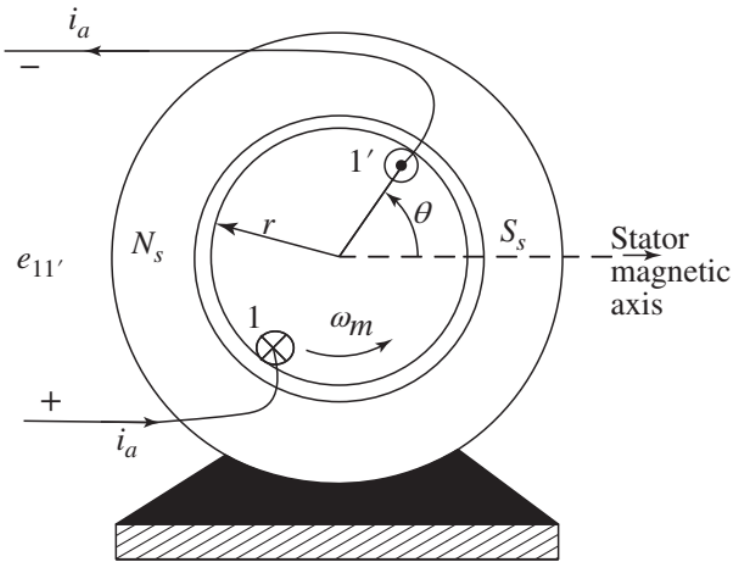
1. Assume the field distribution produced by the stator in the machine shown in figure to be radially uniform. The magnitude of the air-gap flux density is B_s, the rotor length is l, and the rotational speed of the motor is ω_m.

   (a) Plot the emf $e_{11'}$ induced in the coil as a function of θ for two values of i_a: 0 and 10 A.

   (b) In the position shown, the current i_a in the coil 11' equals I_a. Calculate the torque acting on the coil in this position for two values of instantaneous speed ω_m: 0 and 100 rad/s.



1) (a) Plot the emf $e_{11'}$ induced in the coil as a function of θ for two values of i_a : 0 and 10 A.

at $i_a = 0$ A, $e_r = 2 N_r B_s l \omega_m r$

$|e'_{11}| = 2 B_s l \omega_m r$

at $i_a = 10$ A, $e_r = 2 N_r B_s l \omega_m r$

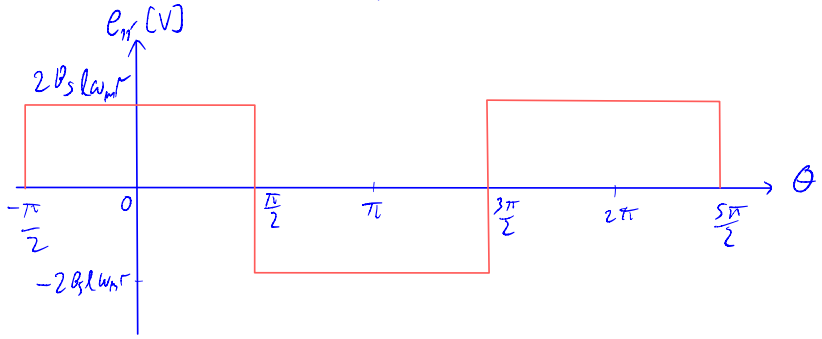
$|e'_{11}| = 2 B_s l \omega_m r$

i_a has no effect on $|e'_{11}|$

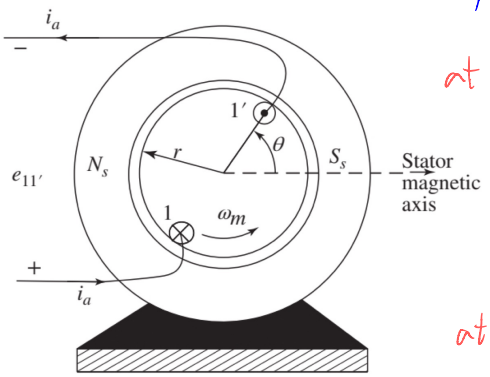
graph $e_{11} - \theta$

at $i_a = 0$ A

at $i_a = 10$ A



(b) In the position shown, the current i_a in the coil 11' equals I_a. Calculate the torque acting on the coil in this position for two values of instantaneous speed ω_m : 0 and 100 rad/s.



from $F_{em} = I \vec{l} \times \vec{B}$

at $\omega_m = 0$ rad/s ;

$\tau_{em} = 2 F_{em} r = 2 B_s (N_r I) l_r$

$\tau_{em} = 2 B_s I_a l_r$

at $\omega_m = 100$ rad/s

$\tau_{em} = 2 F_{em} r = 2 B_s I_a l_r$

ω_m has no effect on τ_{em}

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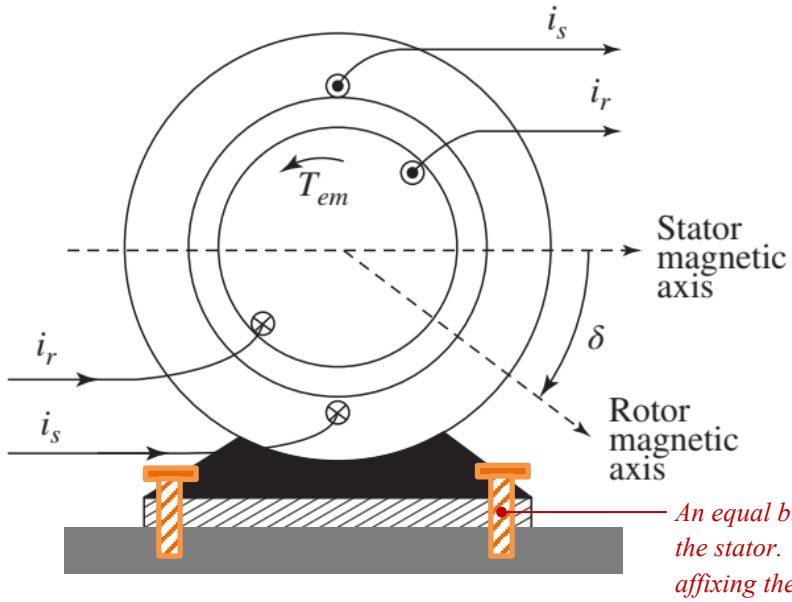
2. In the figure, the stator coil has N_s turns, and the rotor coil has N_r turns. Each coil produces in the air gap a uniform, radial flux density B_s, and B_r, respectively. In the position shown, calculate the torque experienced by both the rotor coil and the stator coil, due to the currents i_s and i_r flowing through these coils. Show that the torque on the stator is equal in magnitude, but opposite in direction, to that experienced by the rotor.

$\vec{T} = I\vec{\ell} \times \vec{B}$

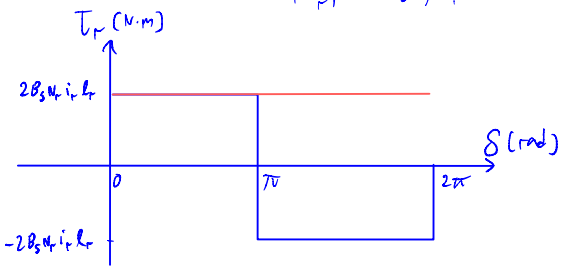


An equal but opposite torque is experienced by the stator. This is precisely the reason for affixing the stator to the foundation – to prevent the stator from turning !!

at Rotor; from $\tau_{em} = 2F_{em}r$

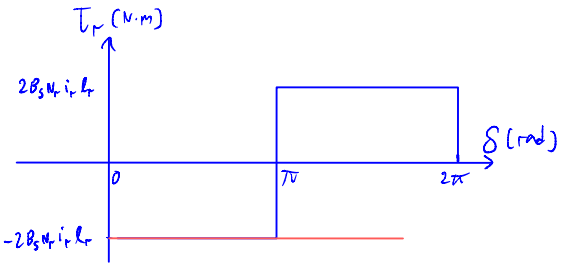
$= 2B_s(N_r I)\ell r$

$|\tau_r| = 2B_s N_r i_r \ell r$



at stator; $\tau_s = 2F_s r = 2B_r(N_s I_s)\ell r$

$|\tau_s| = 2B_r N_s i_s \ell r$



From $B_s = \dfrac{\mu_0 N_s i_s}{2\ell_g}$ and $B_r = \dfrac{\mu_0 N_r i_r}{2\ell_g}$ $\Rightarrow$ $|\tau_s| = 2B_r N_s i_s \ell r = 2\left(\dfrac{\mu_0 N_r i_r}{2\ell_g}\right) N_s i_s \ell r$

$= \mu_0 N_s N_r i_s i_r r \dfrac{\ell}{\ell_g}$

$|\tau_r| = 2B_s N_r i_r \ell r = 2\left(\dfrac{\mu_0 N_s i_s}{2\ell_g}\right) N_r i_r \ell r$

$= \mu_0 N_s N_r i_s i_r r \dfrac{\ell}{\ell_g}$

So that $|\tau|$ in stator is equal to $|\tau|$ in Rotor, but have opposite directions.