**Homework 6**

**EE 306: Electromechanical Devices - Semester 161**

**Ref: Principles of Electric Machines and Power Electronics, 3rd Edition**

Solve the following Exercise Problems from your text book (**Page 271**):

**Problem 5.3**

**Problem 5.6**

**Problem 5.7**

**Problem 5.9**

**Problem 5.12**

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## Solution Problem 5.3

(a) $0.03 = \frac{1200 - n}{1200}$, $n_s = \frac{120 \times 60}{6} = 1200$ rpm.

$n = 1164$ rpm → direction same as the rotating field.

(b) $f_2 = 0.03 \times 60 = 1.8$ Hz

(c) 1200 rpm

(d) 1200 rpm

(e) (i) $n_{st} = 0.03 \times 1200 = 36$ rpm → direction same as the rotor motion.

(ii) 1200 rpm

(iii) 0 rpm

## Solution Problem 5.6

(a)(i) $n_s = \frac{120 \times 60}{6} = 1200$ rpm

$s = \frac{1200 - 1140}{1200} = 0.05$

(ii) $E_{2s} = s E_2 = s \frac{E_1}{a}$

$a = \frac{1}{0.5} = 2.0$

$E_{2s} = 0.05 \times \frac{1}{2.0} \times \frac{208}{\sqrt{3}} = 3\ V$

$f_2 = 0.05 \times 60 = 3\ Hz$

(iii) - slip rpm $n_2 = s n_s = 0.05 \times 1200 = 60$ rpm
- with respect to stator → 1200 rpm.

(b) Inverted induction motor

(i) opposite

(ii) $E_{1s} = s E_1 = s\, a\, E_2 = 0$

$s = \frac{1200 - 1164}{1200} = 0.03$

$E_{1s} = 0.03 \times 2 \times \frac{208}{\sqrt{3}} = 7.2\ V$

$f_1 = 0.03 \times 60 = 1.8\ Hz$

## Solution Problem 5.7

(a) $P_{ag} = P_{in} - P_{core} - P_{cu,stator} = \sqrt{3} \times 460 \times 25 \times 0.9 - 900 - 1100$
$= 17926.2 - 900 - 1100 = 15926.2\ W$

(b) $P_{mech} = P_{ag} - P_{cu,rotor} = 15926.2 - 550 = 15376.2\ W$

(c) $P_{out} = 15376.2 - 300 = 15076.2\ W$

$HP = \frac{15076.2}{746} = 20.2$

(d) $Eff = \frac{15076.2}{17926.2} \times 100\% = 84.1\%$

## Solution Problem 5.9

(a) $n_s = \frac{120 \times 60}{2} = 3600 \text{ rpm}$

$s = \frac{3600 - 3546}{3600} = 0.015 \text{ or } 1.5\%$

(b) $T_{dev} = \frac{20 \times 10^3}{3546/60 \times 2\pi} = 53.86 \text{ N} \cdot \text{m}$

$n = 1800 \times (1 - 0.0345) = 1737.9 \text{ rpm}$

(c) If torque is doubled, slip is doubled,

$s = 0.03$

$n = 3600 \times (1 - 0.03) = 3492 \text{ rpm}$

(d) $T = 2 \times 53.86 = 107.72 \text{ N} \cdot \text{m}$

$\omega = 3492 \times 2\pi$

$P = T \cdot \omega = 107.72 \times \frac{3492}{60} \times 2\pi \times 10^{-3} \text{ kW} = 39.39 \text{ kW}$

## Solution Problem 5.12

$P_{out} = 2.5 \times 746 = 1865 \text{ W}$

$n_s = \frac{120 \times 60}{4} = 1800 \text{ rpm}$

$s = \frac{1800 - 1700}{1800} = 0.0555$

$P_{mech} = 1865 + 150 = 2015 \text{ W}$

$P_{ag} = \frac{2015}{1 - 0.0555} = \frac{2015}{0.9445} = 2133.4 \text{ W}$

$P_{cu2} = 0.0555 \times 2133.4 = 118.4 \text{ W}$

$3 \times I_2^2 R_2 = 118.4 \text{ W} \rightarrow I_2 = \sqrt{\frac{118.4}{3 \times 0.025}} = 39.73 \text{ A}$

~~End of homework problems~~