Module 13: Assignment 1

Motors and Speed Control Methods

Submitted by:

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Problem Statement:

As an engineer in the electric vehicle industry, your role involves analyzing various components' performance to ensure efficient operation. You're tasked with calculating critical parameters to evaluate the effectiveness of these components within the electric vehicle system

Tasks to be Performed:

1. Operating Speed of Rotor (No)

Given:
Synchronous speed of the rotor (N) = 1500 rpm
Slip speed (Ns) = 50 rpm

Calculate the operating speed of the rotor.

Solution:
Formula:
No = N – Ns
= 1500 – 50
=1450 rpm

Therefore, the operating speed of the rotor is **1450 rpm.**

2. Frequency of Rotor

Given:
Fractional slip = 0.03
Supply frequency = 50 Hz

Calculate the rotor's current frequency.

Solution:
Formula:
Rotor current frequency = Fractional slip x Supply frequency
= 0.03*50
= 1.5 Hz

Therefore, the rotor's current frequency is 1.5 Hz.

3. Hall Voltage (V_H) Generated Due to Hall Effect:

Given:
Drift velocity of the charges = 0.1 m/s
Magnetic field component perpendicular to the direction of current flow = 0.5 T

Calculate the hall voltage (V_H).

Solution:
Formula:
VH = -Vd*Bd
= -0.1*0.5
= -0.05 V

So, the hall voltage is **-0.05 V.**

4. Electromotive Force of DC Motor

Given:
Number of poles = 4
Magnetic flux = 0.02 Wb
The rotational speed of the motor's armature = 1500 rpm
Number of armature conductors = 100
Number of parallel paths in the armature winding = 2

Calculate the electromotive force (E_b).

Solution:
Formula:
Eb = PϕNZ / 60A
= 4*0.02*1500*100 / 60*2
= 12000 / 120
= 100 V

The electromotive force is **100 V.**

5. Torque of a 3-Phase Induction Motor

Given:
Flux per stator pole = 0.03 Wb
Rotor current at standstill = 10 A
The angle between rotor emf and rotor current = 30 degrees
Constant (k) = 0.5

Calculate the torque (T).

Solution:
Formula:
T = k * Φ * I2 * cos (Φ2)
= 0.5*0.03*10*cos (30)
= 0.12 Nm

Therefore, the torque produced by the three-phase induction motor is approximately **0.12 Nm.**

6. Switched Reluctance Motor Stroke Angle

Given:
Number of rotor poles = 8

Calculate the stroke angle (θ_st).

Solution:

Formula:

$\theta st = 2\pi / 3Nr$

$= 2* \pi / 3*8$

$= 2* \pi / 24$

$= \pi/12$

Angle to Degrees

$= \pi/12*180/ \pi$

$= 15$ degrees

So, the Switched reluctance motor stroke angle is **15 degrees.**

7. Rolling Resistance Force (Frr)

Given:

Coefficient of friction (μ) = 0.02

Mass of the vehicle (m) = 1200 kg

Acceleration due to gravity (g) = 9.8 m/s^2

Inclination angle (θ) = 4 degrees

Calculate the rolling resistance force (Frr).

Solution:

Formula:

$Frr = \mu * m * g * \cos(\theta)$

$= 0.02*1200*9.8*\cos(4)$

$= 234.62$ N

So, the rolling resistance force (Frr) is **234.62 N.**

8. Aerodynamic Drag Force (Fad)

Given:

Density of air = 1.2 kg/m3

Vehicle frontal area = 5 m2

Drag coefficient = 0.3

Vehicle speed = 30 m/s

Calculate the aerodynamic drag force (Fad).

Solution:

Formula:

$Fad = 1/2 * \rho * A f* Cd * v\text{^}2$

$= 0.5*1.2*5*0.3*30\text{^}2$

$= 0.9*900$

$= 810$ N

So, the aerodynamic drag force (Fad) is **810 N.**

9. Gradient Force (Fgr)

Given:
Mass of the vehicle = 2000 kg
Acceleration due to gravity = 9.81 m/s 2
Inclination angle = 5 degrees

Calculate the gradient force (Fgr)

Solution:
Formula:
$Fgr = m \times g \times \sin(\theta)$
= 2000*9.81*sin (8)
= 1709.99 N

So, the gradient force (Fgr) is approximately **1710 N.**

10. Total Tractive Force (Ftt)

Given:
Rolling resistance force = 200 N
Aerodynamic drag force = 120 N
Gradient force = 80 N

Calculate the gradient force (Ftt).

Solution:
Formula:
Ftt = Frr + Fad + Fgr
= 200+120+80
= 400 N

So, the gradient force (Ftt) is **400 N.**

11. Torque Exerted by Wheel

Given:
Total tractive effort = 500 N
Rolling radius = 0.3 meters
Gear ratio = 4

Calculate the torque exerted by wheel.

Solution:
Formula:
Tw = Total tractive effort*Rolling radius
= 500*0.3
= 150 Nm
Tm = Tw/Gear ratio
= 150/4
= 37.5 Nm

So, the torque exerted by wheel is **37.5 Nm.**