SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

COIMBATORE-35

Accredited by NBA-AICTE and Accredited by NAAC – UGC with A++ Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

COURSE NAME: 19EEO302 – INTRODUCTION TO HYBRID AND ELECTRIC VEHICLE

IV YEAR / VII SEMESTER

"Sizing and Performance Analysis of an ElectricMotor in an E-rickshaw" CASE STUDY

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What We'll Discuss

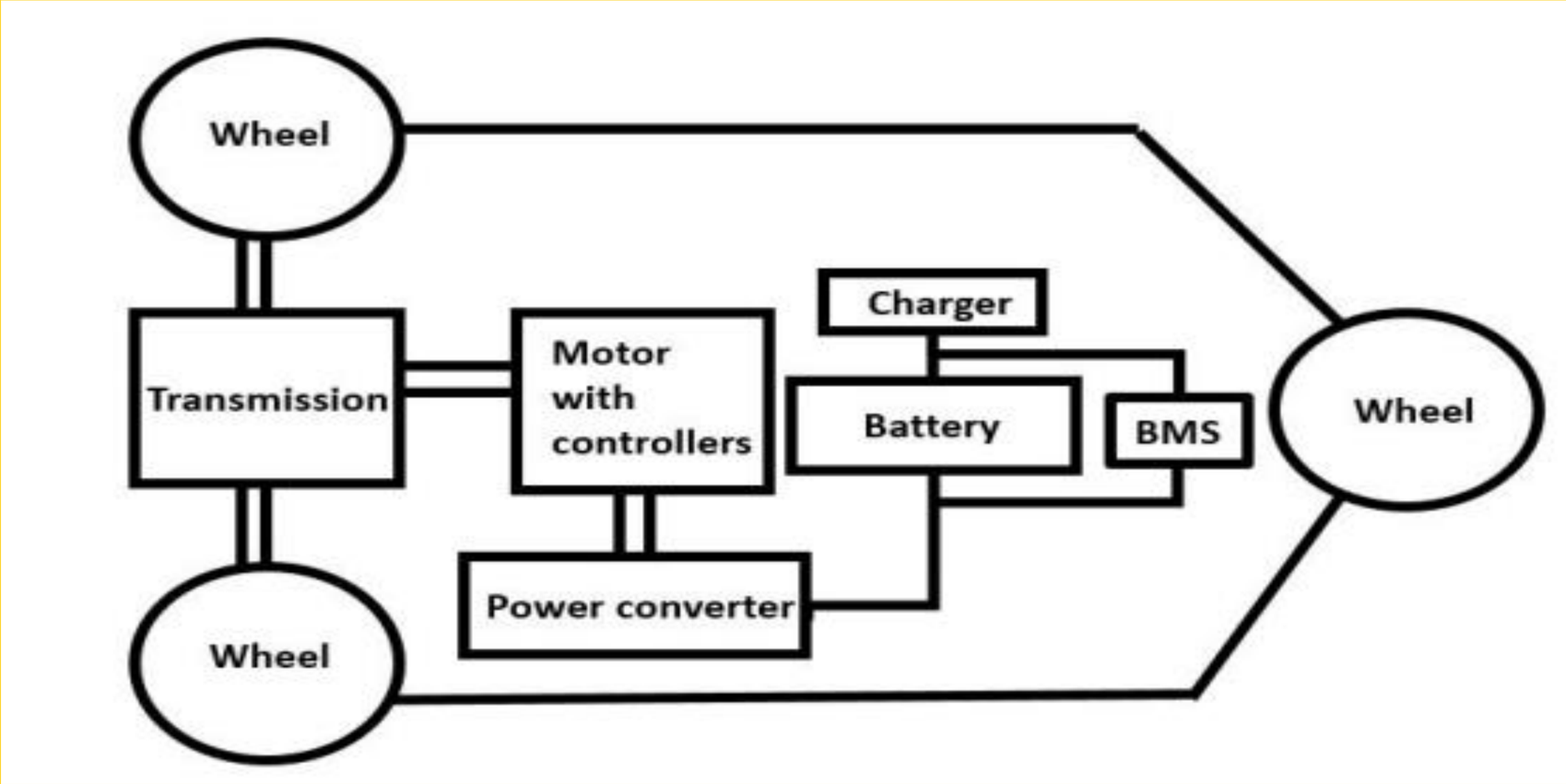
TOPIC OUTLINE

- Introduction
- Vehicle dynamics
- Rolling resistance
- Aerodynamic drag resistance
- Grading resistance
- Acceleration Resistance
- E-rickshaw parameters for dynamic calculations
- E-rickshaw dynamic calculation

INTRODUCTION

- Electric vehicles (EVs) have played an important role in the modern world with deficient petroleum products.
- The advantages of EVs are silent, pollution-free, effective re-generative braking, better road handling, and torque top-up capability.
- In a country like India, most of the people are depending upon three-wheelers for their day to day traveling.
- The joint government-industry is deploying billions of EV in 2020 for reducing atmospheric pollution.
- So the design and development of an efficient and cost-effective E-rickshaw can make a positive impact on society.
- The state government have already launched electric auto-rickshaw which is driven by BLDC motors

BLOCK DIAGRAM



VEHICLE DYNAMICS

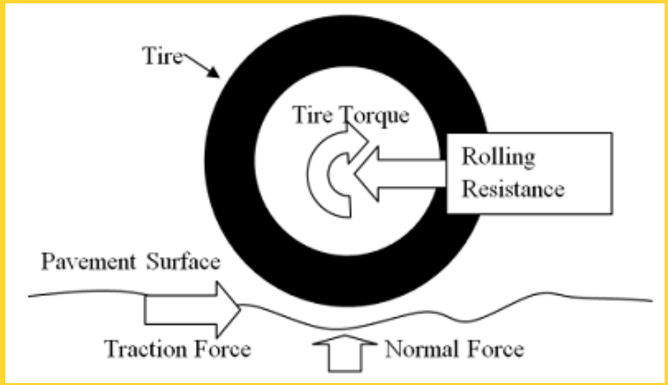
- The construction of PMSM for an E-rickshaw involves a lot of design specifications and calculations.
- Before the construction of PMSM, it is required to realize that the designed machine gives better performances for EV applications, otherwise different algorithms can be used for design optimizations.
- In order to verify the performance, virtual development and analysis can be used. This paper proposes the sizing, design, virtual development and performance analysis of PMSM using FEA method in the Ansys Maxwell platform.

ROLLING RESISTANCE

Rolling resistance is a force that opposes the motion of a rolling object on a surface. When a vehicle moves, the tires experience resistance from the surface it's rolling on. In the case of e-rickshaws or any vehicle, this resistance occurs between the tires and the road.

Factors affecting to rolling resistance include

- Tire Construction
- Road Surface
- Vehicle Load

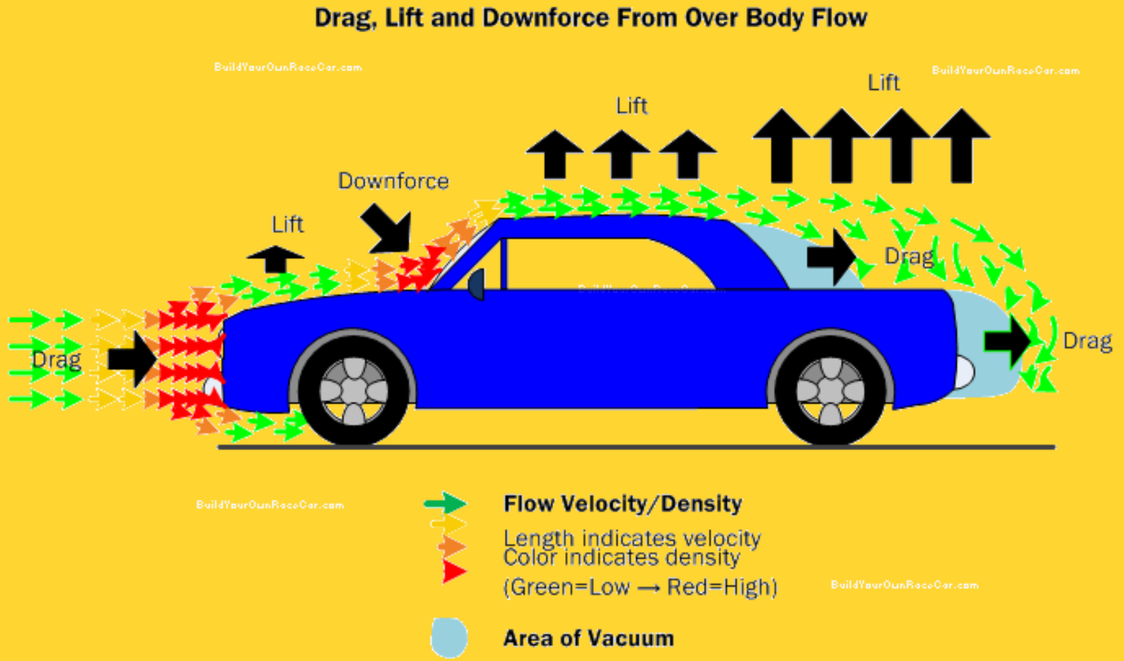


AERODYNAMIC DRAG RESISTANCE

- Aerodynamic drag resistance, often referred to simply as aerodynamic drag, is the force that opposes the motion of a vehicle as it moves through the air.
- It's a significant factor affecting the energy efficiency and overall performance of a vehicle, including e-rickshaws.
- Aerodynamic drag increases with the square of the vehicle's speed and can have a substantial impact on energy consumption, particularly at higher speeds.

$$F_{aero} = 0.5*\rho*A*Cd*V^2$$

F aero : is the aerodynamic drag force (in newtons)
ρ is the air density (in kilograms per cubic meter)
A is the frontal area of the vehicle (in square meters)
Cd is the drag coefficient
V is the velocity of the vehicle (in meters per second)

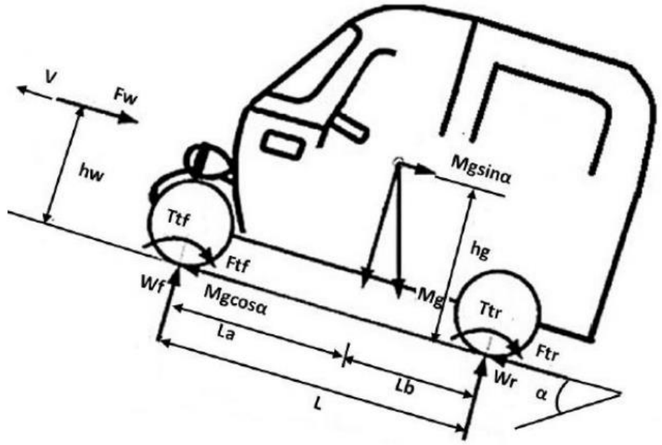


GRADING RESISTANCE

- Grade resistance, also known as gradient resistance or hill climbing resistance, is the force that opposes the motion of a vehicle when it travels on an incline or a hill. This resistance is primarily caused by the effects of gravity, which try to pull the vehicle back down the slope. Understanding and calculating grade resistance is important for designing efficient transportation systems and vehicles, including e-rickshaws.

$$F_{grade} = W \cdot \sin(\theta)$$

F grade is the grade resistance force (in newtons).
W is the weight of the vehicle (in newtons), which is equal to the mass of the vehicle (in kilograms) multiplied by the acceleration due to gravity (approximately 9.81 m/s^2).
θ is the slope or grade of the road, measured in radians.



Acceleration Resistance

In the entire journey of a vehicle, it has to vary the speed according to the situations, this change in speed at the time of acceleration or braking is dependent upon the total mass including the inertial mass of rotating parts.

The acceleration resistance is; $F_A = \lambda M \, dV \, dt$

The total resistance experienced by the vehicle.

$F_r = Mgf\cos\alpha + Mg\sin\alpha + 0.5\rho A f C_D V^2 + \lambda M \, dV \, dt$ (5)

E-rickshaw dynamics has been formulated with the desired specification

E-RICKSHAW PARAMETERS FOR DYNAMIC CALCULATIONS

Parameters	Values
Vehicle dimension	2.795*0.99*1.75 m
Passenger bay dimension	1*1.55*0.625 m
Gear ratio(i_g)on flat road	1:10
Gear ratio(i_g)on slope road	1:12
Mass of the vehicle (M)	400 Kg
Acceleration due to gravity (g)	9.8 m/s^2
Rolling resistance coefficient(f_r)	0.0279
Grade angle (α)	0.12217 radians
Air density (ρ)	1.225 kg/m^2
Drag coefficient (C_d)	0.5575
Velocity of vehicle (V)	6.944 m/s
Rotational inertia constant(λ)	1.04
Front area (A_f)	2.0825 m^2
Radius of the wheel (r)	0.254 m
Time for acceleration	10 s
Acceleration	0.6944 m/s^2
Efficiency of motor(η)	93%

E-RICKSHAW DYNAMIC CALCULATION

Parameters	Values
Rolling resistance	108.55 N
Aerodynamic resistance	11.31 N
Grading resistance	0 N
Acceleration resistance	165.89 N
Total resistance	285.75 N
Power required	1059.76 W
Tractive effort	445.26 N

E-RICKSHAW DYNAMIC CALCULATION ON FLAT ROAD

Parameters	Values
Rolling resistance	108.55 N
Aerodynamic resistance	7.85 N
Grading resistance	477.72 N
Acceleration resistance	0 N
Total resistance	594.12 N
Power required	1836.16 W
Tractive effort	727.05 N

E-RICKSHAW DYNAMIC CALCULATION ON SLOPE ROAD


THANK
YOU