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DESIGN AND ANALYSIS OF PMDC MOTOR FORELECTRIC VEHICLE

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Abstract

Growing of the country and rising in the cost of fuel, the universe is taking step towards the methods for transport. Most important is battery based electric vehicles and also cell based electric vehicles. In this work author will discussed About the basics about electric vehicle, vehicle fabrication condition, force calculation for the electric vehicle, selection of motor for the EV application, designing the motor to get the rating of the motor and also author will expressed this work in mat lab simulation software as well as hardware model values of both are compared and analyzed.

Keywords— Motion and dynamic equations for vehicle Vehicle design calculations, PMDC motor; electric vehicle, Mat lab simulation**.**

INTRODUCTION

By comparing the IC engine vehicles and electric vehicles the running cost of the electric vehicles are less and also more friendly for the environment. The EV will not produce any gas or dust partials to the environment while operating. These Electric vehicles are battery operated vehicles, Battery system is main source part to the electric vehicle. In the making processes of the electric vehicle selection of motor for EV application will plays the very important role. There are many motors are available in the market but nowadays special motors like permanent magnet direct current motors (PMDC) and brush less direct current motors (BLDC) will most used motors for the Electric vehicle application and also taken care with the economicconsideration,performance,control,orque characteristics.

Literature Review

[1].This paper deals with design of motor for high-speed operation with a small size EVs and also EV different design parameters are calculated.

[2].The technology of mounting electric direct drive motors into EV's has become one of the trends in the field of electric vehicle drive systems. The paper presents know age for answering the question. How should magnets be mounted on the External Rotor Permanent Magnet Machine (PMM), to ensure optimal operation of the electric machine in all climatic and weather conditions.

[3].This paper discussed about the use of hybrid motors for EV applications, and also explains about the operation and characterizes the motor parameters like speed, torque, and control of motor with the graphical presentation.

[4]. Electric vehicle (EV), as a bridge between the electricity market and EV owners, participates in the future and pool market to supply EVs' requirement. Because of the uncertain nature of pool prices and EVs' behavior, this paper proposed a two-stage scenario-based model to obtain optimal decision making of an EV aggregator.

[5].Implement of PMDC motors for electric vehicles and construction details of motor, characteristics of motor will be explained.

Battery Electric Vehicles (BEV)

Battery Electrics vehicles are the types of vehicles which operate with the battery system as a fuel these vehicles are known as BHV. These battery electric vehicles are compared with the IC engines 99% of less maintenance for the BHVs.

Advantages of a BEV:

- These electric vehicles will produces the less noise
- These are not depending on the spark plug, gear system
- It does not contains combustion chamber for fuel, instead of rechargeable batteries.

Motion and dynamic equations for vehicles

F_{rr} =Rolling resistance

F_{ad}= Aerodynamic drag force

F_{te}= Tractive force

F_{hc}= Hill climbing force

$P_{e=}$ Electrical Power

1. **Rolling resistance:**

$$F_{rr} = \mu_{rr} * W * g$$

2. **Aerodynamic drag force:**

$F_{ad} = W * \rho * A * C_d * v^2$

3. **Tractive force:**

$F_{te} = F_{rr} + F_{ad}$

4. **Hill climbing force:**

$F_{hc} = m * g * \sin\theta$

Permanent Magnet DC Motor (PMDC Motor)

Permanent magnet direct current motor (PMDC) is the one of the special motor which converts electrical energy to mechanical energy. It does not contains any field winding instead of field winding it contains

Rated power	350 or 0.47	Watts or Hp
Rated voltage	24V	Volts
Rated current	19 A	Amps
Rated speed	1500 rpm	RPM

Vehicle design calculations

F_{rr} =Rolling resistance

F_{ad}= Aerodynamic drag force

F_{te}= Tractive force

F_{hc}= Hill climbing force

$P_{e=}$ Electrical Power

1. **To calculate rolling resistance force of the electric vehicle:**

$F_{rr} = \mu_{rr} * W * g$

$F_{rr} = 0.05 * 105 * 9.8$

$F_{rr} = 51.450$ Watts.

2. **To calculate Aerodynamic drag force of the electric vehicle:**

$F_{ad} = W * \rho * A * C_d * v^2$

$F_{ad} = 0.5 * 1.250 * 0.500 * 1.200 * 5.556^2$

$F_{ad} = 11.574$ Watts.

Notation	Parameters		Vehicle	
			Value	Units
m	Weight	m	**105.000**	Kg
L	Length	L	**1.000**	m
W	Width	W	**0.500**	m
μ_{rr}	Rolling Resistance	μ_{rr}	0.050	
ρ	Air Density	ρ	1.250	kg/m2
Cd	Drag Coefficient	Cd	1.200	
g	gravitational Force	g	9.800	
	Speed in km		**20.000**	**kpmh**
A	Frontal Area	A	0.500	m2
v	Velocity	v	5.556	m/sec

Table .4.1.EV fabrication data

3. **To calculate tractive force of the electric vehicle:**

$F_{te} = F_{rr} + F_{ad}$

$F_{te} = 51.450 + 11.574$

$F_{te} = 63.024$ Watts.

To calculate the required electrical power for the electric vehicle motor

$P_{e=}F_{te} * v$

$P_{e=}63.024 * 5.556$

$P_{e=}350.134$ Watts .

If hill climbing force is required for the electric vehicle

$F_{hc} = m * g * \sin\theta$
$F_{hc} = 105 * 9.8 * \sin 45$
$F_{hc} = 51.40 * 9.8 * 0.707$
$F_{hc} = 727.612$ Watts.

To calculate tractive force of the electric vehicle

$F_{te} = F_{rr} + F_{ad} + F_{hc}$

$F_{te} = 51.450 + 11.574 + 727.612$

$F_{te} = 790.6$ Watts.

To calculate the total electrical power for the electric vehicle motor

$P_e = F_{te} * v$

$P_e = 790.6 * 5.556$

$P_e = 4392.778$ Watts or 4.3kW.

Design of Permanent Magnet DC Motor (PMDC) for Electric Vehicle

Sl. No.	Parameters	Value	Units
1	Rated power	350 or 0.47	Watts or Hp
2	Rated voltage	24V	Volts
3	Rated current	19 A	Amps
4	Rated speed	1500 rpm	RPM
5	Load torque (T_L)	2	Nm
6	Half load torque ($T_L/2$)	1	Nm

Table 5.1.PMDC motor specifications

The required electrical power for the EV motor is:

P_{out}=total output power

$P_{out} = 350$ Watts.

To converting the output power to watts to Hp (horse power) it becomes:

$Hp = \frac{350}{746} = 0.47$ (1Hp=746)

Cross verifying the output power we get:

$P_{out} = 0.47 * 746$

$P_{out} = 350.62$ Watts.

To calculate the rated voltage and rated current for the PMDC motor taking P_{out} as reference

Taking the 24V as a rated voltage (by observing the online resources)There for rated Voltage = 24V.

To calculate the required load current (I_L) for the PMDC motor:

$I = \frac{P_{out}}{V}$

$I = \frac{350 \text{ watts}}{24 \text{ volts}}$

I_L=14.5 A (to including the safety factor **I_L=19A**)

Different torques in the PMDC motor:

T_a= Motor torque

T_{lost}=Loss torque due to the friction and windage & iron loss

$T_{SH}=T_L$=Load torque

Gross mechanical torque ($Ta=T_{lost}+T_{SH}$)

For the calculation of load torque T_{SH} or T_L it required angular velocity ω:

$\omega = \frac{2*\pi*N}{60}$

$\omega = \frac{2*\pi*1500}{60}$

(N=1500 rpm)

ω=157.27 red/sec.

To find the load torque T_L:

$T_L = \frac{P_{out}}{\omega}$

T_L=2.2286 Nm.

The required full load torque of the PMDC motor is T_L=2 Nm

To calculate required the half load torque for the PMDC motor:

$\frac{T_L}{2} = \frac{2.2286}{2}$

$\frac{T_L}{2}$=1.1143 Nm.

To calculate required the 1/4th load torque for the PMDC motor:

$\frac{T_L}{} = \frac{2.2286}{}$

4 4

$\frac{T_L}{4}$ =0.55715 Nm.

4

PROPOSED WORK ON MAB-LAB SIMULATION AND HEARDWAREMODEL

MATLAB software is stand for the matrix laboratory. This software is simplest tool for programming, simulating, computing. MATLAB tools will play the very important role in making the projects also its having the high performance language for the computers. This MATLAB software is the one of the modern programming tool for the all the education institutes and also MATLAB has number of advantages as compeer to any other languages.

SYSTEM PARAMETERS USED FOR PMDC MOTOR MATLAB SIMULATION

- PMDC motor
- Bus selector
- Gain block
- Add block
- Constant block
- DC voltage source
- Displays
- Scopes
- Loads
- powergui block

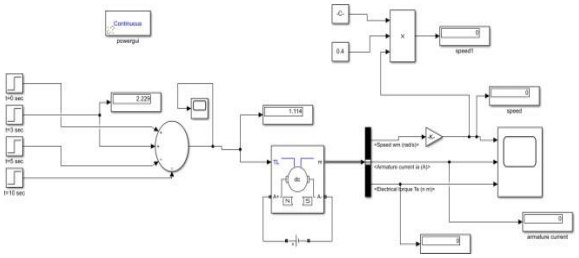

Figure 6.2.1. PMDC motor mat lab simulation

The above simulation model is proposed for analyzing the performance of the PMDC Motor . In this system the different value of loads are connected to the motor with respect to different time pried which are connected to the motor through the add block. The output of the motor is connected to the bus selector which collects the all the parameters of the motor. The output of the bus selector connected to the and also 24v dc supply is connected to the armature of the motor. In this model display and scope blocks are used as the output devices. The scope will gives the output in the forms of graph and display block will gives the numerical values as the output.

Simulation results:

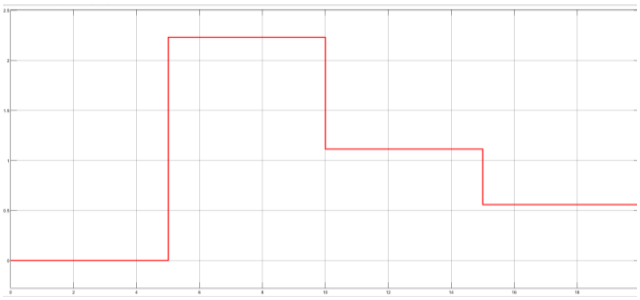

Fig.3.torque applied wrt time

The above graph will give the different values of loads are applying on the pmdc motor with respect to time. Initially no load is applied on the motor after the 5sec full load is applied, for 10 sec half load is applied then last one by fourth load is applied.

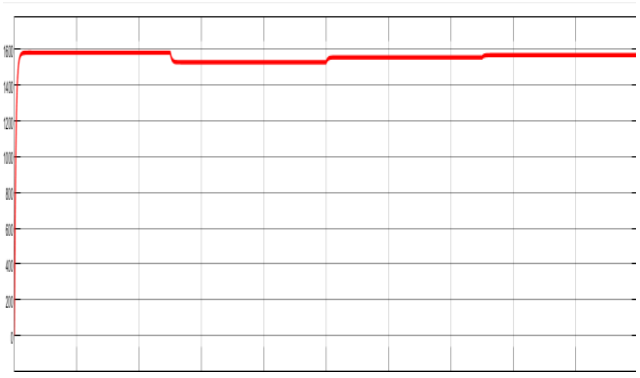

Fig.4.speed vs torque

The above graph will give the speed variation of the motor with the different load is applied with respect to time.

Initially under no load condition motor is running at rated speed after applying the full load speed of the motor will reduces vice versa.

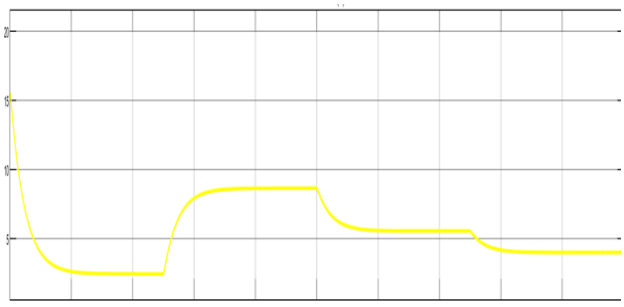

Fig.5.armature current vs torque

The above graph will gives the value of armature current vs. torque. When there is large value of torque is applied on that condition motor will draws the more current because torque is directly proportional to the current.

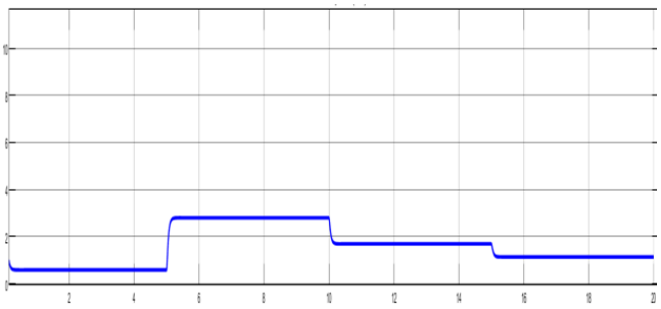

Fig.6.torque characteristics

The above graph will give the different values of torque are applying on the pmdc motor with respect to time. Initially no load is applied on the motor after the 5sec full load is applied in that time torque is maximum, for 10 sec half load is applied then last one by fourth load is applied in these conditions torque will be gradually increasing.

Conclusion

In this paper discussed about Electrical vehicle, EV fabrication, EV force calculation, Power calculation and also In this paper have done the design of PMDC motor for EV. The PMDC motor characteristics are verified by the help of mat lab simulator and also verified by practical hardware model. By observing the all characteristics we know about the performance of the PMDC motor of the Electric Vehicle.

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