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Cost Effective Improvement in the Design of E- Mobility

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Abstract - *In coming future, due to many advantages of electric vehicles over gasoline vehicles, the transport system is changing by increasing number of electric vehicles on the road. The advent of electric vehicles promises us to decrease in pollution levels and the pricing of vehicles. In this project, our focus is to increase the efficiency of electric vehicles and to make this possible we introduce a gearbox between electric motor and the wheels. The two step reduction gearbox influences positively on various parameters such as motor downsizing, providing high starting torque, starting acceleration, motor efficiency and battery downsizing.*

Key Words: **Electric vehicle, Battery downsizing, Gearbox, Starting torque.**

1. INTRODUCTION

Energy and environmental issues are major problems in today's world. It is believed that adoption of electric vehicles may reduce the impact of our concerns. Gasoline engines are creating high pollution levels and to reduce these levels in the cities, idea of replacement of conventional vehicles with electric vehicles is employed. There are advantages and disadvantages to everything. The biggest disadvantage to the gasoline engine is its efficiency. It is pronounced repeatedly that gasoline engine has efficiency around 30-40%. Analogous to engine in conventional vehicles, electric vehicles have motors. The efficiency of motors varies from 85-90%. The motor is specified by the maximum power and starting torque. Torque is force on which acceleration depends. To increase the acceleration, torque should be increased. However, to increase the torque, we want to select a motor, which gives higher torque value. The motor with high torque value is costly and it increases weight on the vehicle. The size of motor increases to provide high torque and with increasing the size of motor its efficiency decreases. This decrease in efficiency is due to higher losses that are discussed before. Better efficiency reflects battery downsizing or getting higher range with same battery.

1.1 Problem Statement

In India, there is lot of problems of environmental pollution people are facing. Global warming is also increasing day by day. To overcome these problems, there are electrical vehicles available. But these vehicles are too costly. To reduce this cost following methods are to be followed

-Downsizing of motor
- Increase motor efficiency
- Cost of motor is reduced

-Fast acceleration and
-Battery downsizing.

1.2 Objectives

As part of the initial stages of the project a number of goals were chosen to measure the project's success. They were divided into essential and extension goals, of which the essential goals are imperative to the project being considered a success.

These goals are:

-To improve the performance of vehicle by reducing the weight of the chassis.

-Drive train design (To increase the torque and thus gradablity.

-To make design of less cost.

2. LITERATURE REVIEW

An electric vehicle (EV), also referred to as an electric drive vehicle, is a vehicle which uses electric motors for propulsion. Depending on the type of vehicle, motion may be provided by wheels or propellers driven by rotary motors. An electric vehicle is an alternative fuel automobile that uses electric motors and motor controllers for propulsion, in place of more common propulsion methods such as the internal combustion engine (ICE).

2.1 Related Work

In paper[1], Martin Mruzek, Igor Gajdac, lubos kucera, dalibor presents a paper on Analysis of parameters Influencing electric vehicle range. Range is considered as a key parameter of electric vehicle for acceptance of electro mobility. This paper concerns with the parameters which affects the range such as aerodynamics drag, correct size of the motor.

In paper[2], D.Mohankumar,R.sabarish ,Dr.M.Prem jeya kumar presents a paper on Structural and Modal analysis

of scooter frame. This paper discusses the stress and deformation developed in the chassis during different load cases and identified the failure mode by the modal analysis. They have discussed about the material selection, properties of material. The analysis has done on ansys software.

In paper[3], Jakub Šmiraus1, Michal Richtář2 presents the Design of motorcycle chassis geometry. This paper presents defines the geometry of motorcycle angles and designing, effects of angles in dynamic conditions.

In paper[4], Abhijeet R. Raut1 Prof. Dr. A. D. Shirbhate2 presents the paper on Design and Analysis of Two Wheeler Composite Chassis Frame.This paper discuses about composite material which is light weight thus increases the efficiency of vehicle.

In paper[5], Maulik Lohia,Prof. Mohsin Bukhari , Prof.Dhaval P Patel, Amarishkumar J.Patel,Sunilkumar N.Chaudhari presented paper on Stress and Rigidity Analysis of Bike Chassis. This paper discuss about the frame which is an important part in a Two Wheeler and it carries the load acting on the vehicle.

3. METHODOLOGY

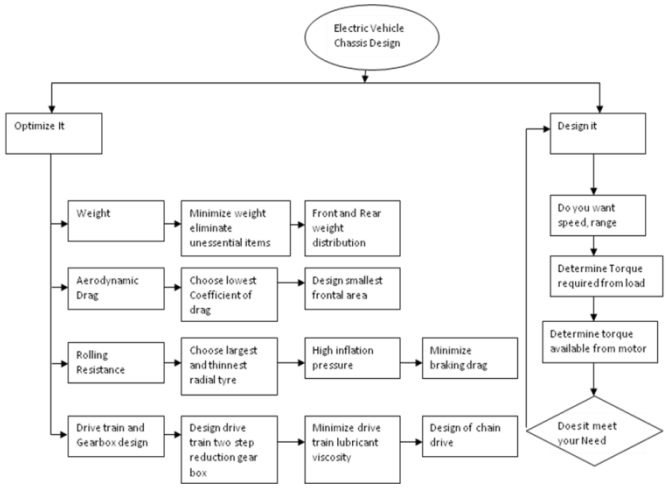

Figure no. 3.1 Flow chart

Step 1- Material selection for chassis with ultimate strength of 440 MPa.

Step 2- Chassis design on CATIA by considering all the parameters.

Step 3-Analysis of the chassis on ansys check the stresses on the chassis it should have FOS more than the ultimate strength.

Step 4- Gearbox design two step reduction to increase the torque and decrease the size of the battery and motor.

Step 5- Comparison parameters with and without gearbox on Gradability test.

Step 6-Final Result.

3.1 Downsizing of Motor

As it is seen from the previous study, the gearbox in electric vehicle is set to increase the torque characteristics. The torque is the reason for the acceleration of vehicle. Higher torque leads to higher acceleration.

Let the torque without gearbox be 'T'. Therefore, if we use a gear pair of reduction at least 6, then the output torque after the gearbox will be 6T, which is greater than without the gearbox. This shows, as we change the reduction of gear pair in vehicle, the starting torque increases.

In my project, I have used a motor of 750 watt, which gives a maximum torque of 15.91 Nm and speed (at maximum torque) equals 3000 rpm. When considering losses of motor, the motor power reduces to 675 W (efficiency 90%). Therefore, the maximum torque remains same, but speed at max torque reduces to 450 rpm.

Now, if we want to downsize a motor and we limit the maximum torque of motor to 15.91 Nm and speed of 450 rpm (as earlier). The required power of motor is 750 W. As the torque is reduced, the motor size is reduced. The graph of torque vs efficiency is shown in the figure. We can conclude that, we select a motor of particular torque and we let our motor work on this particular torque and so we can work under best efficiency.

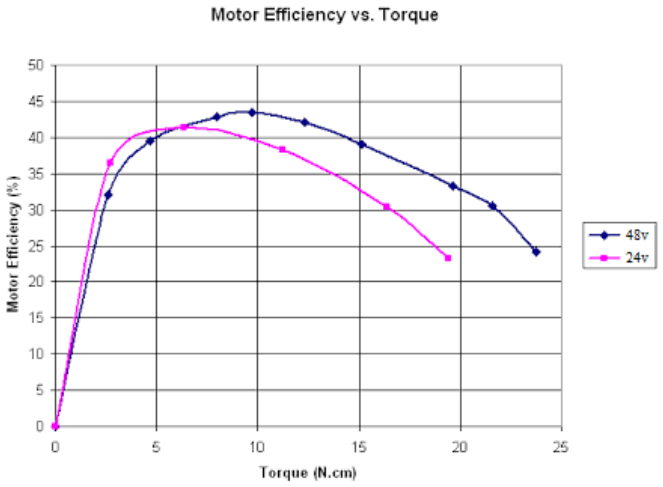

Figure 3.2 Efficiency Vs Torque

3. CALCULATIONS

Gear addition changes two properties of rotational motion-

a. Speed of rotation- i.e. RPM
b. Output Torque T.

This is shown by the following figure –

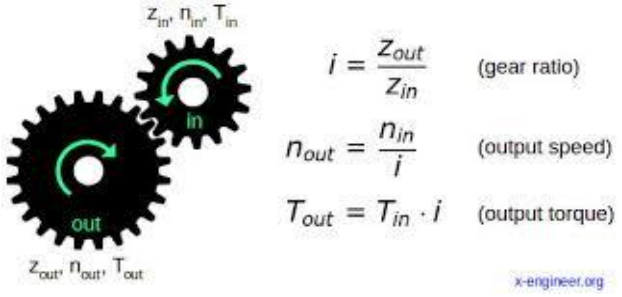

Figure 1.1: Gear ratio

What we will be doing is adding a reduction, calculating, and plotting the corresponding output.

The reduction ranges from gear ratio as 1 to 6 –

Now with addition of gearbox we have gear efficiency, which reduces the power output by a percent that ranges from 85-95% for spur gears used in vehicle transmission.

Here is the sample of how addition of gearbox affects the output –

Now the Pmax will reach earlier than before because when a reduction of ratio 6 is done the new torque is six times as the previous one I.e. T' = (2.38×6) Nm = 15.91Nm

Hence, max power is 750 W is reached for

$$Pmax*losses=\frac{2*pi*N*T'}{60}$$

Where Pmax = 750 W, T' = 15.91N-m

Hence we get N = 450 RPM

4. RESULTS

From the previous section, we understood how torque varies w.r.t speed, here power remains constant (due to losses there is a reduction in power).

In previous section, we calculated speed and torque for a gear pair with reduction of 6.

Similarly, by taking different values of reduction ratio we can plot a graph. The reduction ratios are from 1 to 6. As reduction ratio increases, the losses in gear pair increases.

As reduction increases, the Speed to which the Maximum Power is achieved reduces drastically with each reduction.

Table 4.1 Gear ratio vs speed

Gear ratio	1	2	3	4	5	6
N for Pmax	3000	1501	1000.27	750.73	633.80	450

The Torque increases with gear ratio increasing. The values are tabulated below,

Table 4.2 Gear ratio vs Torque

Gear Ratio	1	2	3	4	5	6
Torque (Nm)	2.38	4.77	7.16	9.54	11.3	15.91

5. CONCLUSIONS

The conclusions to our addition to the electric vehicle drive are as follows –

1. Downsizing of motor –
2. As discussed earlier downsizing can be done as the max torque for smaller motor is fixed and this additional torque can be accounted by using a gear of reduction equivalent to the required torque.
3. Battery capacity decreased –
4. Now owing to the reduction in motor size the requirements of motor in terms of voltage and current is decreased as a result the battery with same capacity will run for longer duration and thus the major problem of EV's which is charging is prolonged.
5. Greater acceleration –

   Owing to the increase in torque by addition of a gear reduction the as we know the inertia for whole drive train is constant and Torque = Inertia * acceleration. Increase in torque increases acceleration
6. Cost of the vehicle -

   Cost of the vehicle is reduced by downsizing the motor and efficiency increased with acceleration.

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