Sizing and Packaging of Electric Motor in electric Vehicle

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Abstract - Increased demands on rare earth fossil fuels and the global warming have led to development of alternative technology vehicles. Electrical vehicle (EV) is chosen as one of the alternative technologies to overcome these hindrances. In EVs the battery and the motor are the two most critical components used for generating the required power output. In this paper, work was done for selection Motor technology and relevant packaging for a small passenger car. The work done is described in Four stages: i) Motor selection based on Sizing, ii) Conventional car to be converted in EV iii) motor package design iv) Vehicle issues to be solved after Motor Packaging.

***Key Words*:** EV, Motor, Packaging, Selection

1.INTRODUCTION

EVs were popular as early as 1900s, but did not find widespread acceptance due to unreliability of the vehicle at that period compared to internal combustion engines (ICEs). EVs failure in 1900s were due to: i) range limitation, ii) abundant fossil fuel at the time (leading to cheaper prices) and easy refills, iii) low vehicle price resulting from mass production of ICEs, and iv) reliability of ICEs over EVs. In 1970s, with global energy crisis and from 1990s the climate change due to Green House Gas emissions, resulted re-consideration of the EV market, as they presented energy security solution and reduction in emissions.

There is an increasing acceptance of EVs today as alternative sustainable vehicles due to: i) environmental issues, ii) government policies, iii) commercial viability, and iv) new technological opportunities. EVs offer the advantage of zero tail-pipe emissions and have been recently recognized as a promising potential long-term solution to the key problem of sustainable personal mobility.

2. PROBLEM STATEMENT

An EV consists of two main subsystems: i) drivetrain system-electric motor, vehicle controller and transmission; ii) energy storage system batteries, battery management system and charging unit. During Conversion from Conventional Vehicle to EV, the power requirement was major issue because existing vehicle is powered with IC engine and same output expected from EV. It was requirement to develop same output motor with easily packageable and it can improve vehicle performance. This paper covers research work done on developing Motor for EVs and its packaging in vehicle

Key Objectives considered for the Motor selection are:

- less noise and less maintenance.
- Easily packageable,
- Simple and convenient speed control method
- Optimized thermal management,
- Low-cost implications

2.1 Design Requirements of Selection Of Motor

Transmissions should be able to

- ❖ Deliver high torque output.
- ❖ Should have minimum transmission losses
- ❖ Should overcome the effect of driving resistance caused by wheel resistance FR, air resistance FL, gradient resistance FST and acceleration resistance FA.
- ❖ Should have minimum wear.
- ❖ Should operate smoothly and should have a cooling and lubricating system.

2.2 Case Study

If a Single Speed transmission is to be designed for electric cars with an electric motor which has a power rating of 55 kW, output torque of 185 Nm and speed of 10000 RPM. So, a Single speed transmission should have a gear ratio of approx. 8 :1 and should be made of helical gears to reduce noise and backlash which is more prominent in spur gears.

2.3 Motor Torque Calculations for Electric Vehicle

Factors Affecting the Required Torque

When selecting drive motor for the electric vehicle, a number of factors must be taken into account to determine the maximum torque required. These factors are:

1. Rolling resistance 2. Grade resistance 3. Acceleration force

2.4 Vehicle Inputs for case study (Existing Conventional vehicle)

- ❖ 15 Inch Wheel Dia.
- ❖ Speed 80 kmph
- ❖ Battery weight 250 kgs
- ❖ Passenger + luggage = 300 kg's
- ❖ Kerb Weight = 1200 kg's
- ❖ Total Weight =1500 kg's

Vehicle Acceleration: 0-80 km/h in 18.84 Sec

Grade Resistance = GVW X Sin(ø)

= 1500 X 9.81 X Sin (0)

= 0 N

Aerodynamic Force = (0.5 X rho X Cd X A X v2)

= 0.5 X 1.225 X 0.22 X 2.5 (m2) X 22.22 (m/s)

= 171.5 N

Acceleration Force = (M (Mass of vehicle) X a)

= 1500 X (v-u/t)

= 1500 X 1.18 m/s2

= 1770 N

(Vehicle Acceleration: 0-80 km/h in 18.84 Sec)

2.5 Finding the Total Tractive Effort

The Total Tractive Effort is the total force required to move the vehicle with the desired characteristics and is the sum of the forces calculated in above three sections.

The Total Tractive Effort can be calculated as:

Tractive Force: (Net Force + Rolling Resistance + Grade Resistance + Aerodynamic Force)

Net Force = Acceleration Force

Tractive Force: 1770 N + 220.7 N + 0 + 171.5 N

: 2162 N

Wheel RPM: V: r x w

W: V/r

: 80 (5/18) X 0.381

: 58.32 Rad/Sec

N: 60 X W / 2π

: 557 rpm

Wheel Torque: F X r

: 2162 X 0.381

: 824 N/m

Motor Speed: (Wheel Speed X N)

: 557 X 8.14 (GR)

: 4534

Motor Torque / Wheel Torque = 1/ N

Motor Torque = 824 / 8.14 (GR)

= 103 N/m

Motor Power = 2 πN T / 60

= (2 X 3.14 X 4534 X 103) /60

= 48.9 KW

85% Motor Efficiency…

= 48.9/ 0.85

Motor Power = 55 KW… Required Motor

Motor Selection: PMSM Motor

Benchmarking - Motor Integration in vehicle, Benchmarks from Existing EV in markets

2.6 Motor Mounting Assembly

Currently most of the Indian OEM are using conventional type engine which is either Petrol or Diesel or CNG and a few high-end vehicles are using Hybrids. However, there is a recent trend on usage of electric vehicle as it is cost effective to the common user. There are two approaches which OEMs are following. First approach is to install a new electric motor in the engine compartment of existing internal combustion engine (ICE) vehicle, for this some components are required to be removed, while some functional parts are required to be retained. The demerits of motor mounts are limitation in design due to its original position (conventional engine).

Second approach is developed on a fresh platform where all motor mounts can be designed optimally based on requirements. Therefore, an investigation has to be done to identify the design parameters of EV engine mounting system The vibration isolation effectiveness of powertrain mount configurations is examined for electric vehicle application by considering the effect introduced by internal mount resonances. Unlike internal combustion engines where mounts are typically designed only for static support and low frequency 6-16 Hz dynamics, electric motors have higher excitation frequencies in a range of KHz where mount resonances often occur. The problem is first analytically formulated by considering a simple 3-dimensional powertrain system, and the vibration isolation effectiveness significantly deteriorates at the mount resonance.

Electric machine mounting is dominated by the need to react toque and isolation of gear meshing and motor order forcing. There are no idle nor torque roll axis considerations like conventional engine. The mounts are place to act as a couple with their elastic center on the center of gravity of the motor unit to provide good control under high toque transients

Fig -1: Chevrolet Bolt, Source: google

3. CONCLUSIONS

Above Design Guidelines & Lessons learned can be used for further Future Ev Vehicles, So It can save The Process Lead Time and same Design can be used for Other Platforms. Future is for Electrical Vehicles so scalable Motor Mounting assemblies can be used for Packaging Different Specification Motors, as per Product requirement.

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