Introduction

Basic Introduction talking about EV state.

From history as the technology progress in a country, it adopts more efficient and less polluting processes for specialized tasks. Electric vehicle is the future of mobility and big step towards net zero carbon goal. Internal Combustion Engines have very low efficiency about 20% to 30% and the combustion process produces polluting products such Carbon monoxides, Carbon dioxide, Sulphur dioxides, Nitrogen Oxides and other particulate matter. On the other hand, Electric Motors have high efficiency about 95% and they don’t produce any harmful by products.

However, the mass adoption of the electric vehicles is hindered by high initial cost of the cars, limited driving range and spread of charging stations. The problem of driving range can be solved using a bigger battery but then that again increases the cost of the car. The high initial cost of the cars can be majorly attributed to the battery cost, but the motor cost also plays a small role. Electric vehicles predominantly use Induction Motor and Brushless DC Motors for traction purposes. The limited availability of charging stations along with the fact that batteries take a longer time to charge leads to what is coined as “range anxiety” which can be described as the drivers concern of not reaching the destination with the current charge in the batteries [x1].

The range of the vehicle dependent on the driving conditions and the vehicle characteristic parameters. To solve the range anxiety issue more accurate range estimation algorithms are used. There are several studies on the range estimation of electric vehicles have been performed [x2]. Another method could be the influence of driving condition on range. Regenerative braking provides the energy which is usually wasted as heat during braking back to the energy storage system, increasing the range of the vehicle. During Regenerative braking, the motor rotates at a speed higher than the reference speed of controller. Because of this the motor now works as a generator and returns energy back to the batteries.

In urban cities, due to the nature of stop and go movement a large portion of the tractive energy is wasted to braking. In FTP75 urban drive cycle, the percentage of braking energy to total traction is about 43%. With Electric Vehicles this energy can be recovered, with regenerative braking increasing the total range of the vehicle [x3].

1.1) Previous Work

Electric vehicles predominantly use IM (Induction Motor) and BLDC (Brushless DC Motor) for traction purposes. Several studies have compared the motors in terms of their lifecycle and regenerative braking operation. BLDC motor is the most suitable one for performing regenerative braking operation [x4]. BLDC has its disadvantages too, first foremost being the use of permanent magnet which increases the cost of the motor. It also has short constant power range and is susceptible to demagnetization Faults.

A demand for variable speed operation machines led to the resurgence of interest in Switched Reluctance Motors. Due to the remarkable advances in Induction Machine Drives with good speed control accuracy, interest in SRM motors has dwindled. With increasing cost of permanent magnets, an overlooked motor Synchronous Reluctance motor came into picture. It uses the stator similar to Induction Motor, hence the developed assembly line of IM can be used. The advantages of SynRM include less power loss, high starting torque, increased speed ratio and better fault tolerance compared to Induction Motor[x5].

The paper by S.Sharifan compares the performance of the Induction motor and Brushless PM in HEV application. It concludes Brushless PM indicates superior performance in terms of traction capability and fuel efficiency[x6]. SynRM motor is left from most of the comparison papers due to its recent development.

The project focuses on the regenerative braking efficiency between the three motors. It also compares across other parameters such as cost per km and added range.

1.2) Significance and uniqueness of methodology

The project focuses on the regenerative braking efficiency of the three motors, namely IM , BLDC and SynRM motor. The analysis can be broken down into two major components. First, the effect of driving condition, weather condition onto the braking performance and vehicle characteristic parameteres. Second, optimizing the controlled as well the motor power efficiency. The project focuses more on the first aspect. The project doesn’t delve into the second aspect due to the fact that research on SynRM is very active and the remaining motors have exhaustive studies done on them.

The project focuses on the first aspect and considers a Tesla model S as the Electric Vehicle onto which the braking analysis is done. The parametric values are taken from the paper which investigates the induction motor of Tesla model S[x7]. The road is taken to be tarmac with no elevation. Further down the project variation in these parameters will be taken into consideration. Some of the vehicle characteristic parameters depend highly upon the weather conditions. These variations will also be considered. The end result will advise the best motor for Electric Vehicle application in terms of regenerative braking efficiency.

1.3) Work Schedule

References

[x1] Electric vehicle energy consumption modelling and prediction based on road information Jiquan Wang1 , Igo Besselink1 , Henk Nijmeijer1

[x2] Simplified Electric Vehicle Power Train Models and Range Estimation John G. Hayes, R. Pedro R. de Oliveira, Sean Vaughan, Michael G. Egan

[x3] Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, by [Mehrdad Ehsani](https://www.amazon.in/s/ref=dp_byline_sr_book_1?ie=UTF8&field-author=Mehrdad+Ehsani&search-alias=stripbooks) (Author), [Yimin Gao](https://www.amazon.in/s/ref=dp_byline_sr_book_2?ie=UTF8&field-author=Yimin+Gao&search-alias=stripbooks) (Author), [Ali Emadi](https://www.amazon.in/s/ref=dp_byline_sr_book_3?ie=UTF8&field-author=Ali+Emadi&search-alias=stripbooks) (Author)

[x4] A study on Regenerative braking system with matlab simulation. Debajit Kumar Sandilya. Bubumani Kalita

[x5] Induction and synchronous reluctance motors comparison Aldo Boglietti, Senior member IEEE, Michele Pastorelli

[x6] Performance Comparison Between Brushless PM and Induction Motors for Hybrid Electric Vehicle Applications Shahriar Sharifan, Seyyedmilad Ebrahimi, Ashknaz Oraee and Hashem Oraee

[x7] An Investigation into the Induction Motor of Tesla Model S Vehicle Grzegorz Sieklucki