Study and Development of Electric Vehicle with 200 kilometers Range and 350 Kilograms Gross Vehicle Weight

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Abstract - *Due to increase in effects of pollution to environment by ever increasing carbon deposits by vehicular emissions. Humans are constantly quest for alternative means of fuel for their transportation many people had proposed electric vehicle as alternative means but efficiency is not achieved by their proposals. In this project we will focus on study two wheeler present market condition, Identify vehicle usage and Environment exposure, Define the drive cycle for Urban usage, Sizing of motors and battery based on Gross Vehicle Weight (GVW), Development of the control system for the motor &battery communication, Integration of systems (Motors, Battery & control System).*

***Key Words*: Electric vehicle, Efficiency, Two wheeler, Market condition, Vehicle usage, Environment exposure, Drive cycle, Urban Usage, Sizing, Motors, Battery, GVW, Control System, Battery Communication, Integration, Systems, etc.**

1. INTRODUCTION

E-scooters have become popular in world, but because of regulations, their design has been limited to low-power (less than 500 watts [W]), light-weight (less than 60 kilograms [kg]), and low-speed models (less than 40 kilometers per hour [km/h]). These scooters do not provide the necessary performance to compete against gasoline scooters and motorcycles in other countries. Most E-bike producers do not have an incentive to develop larger models solely for the export market, given the strong domestic market for smaller models. Given this, existing e-scooters are generally unsuitable for the markets.

1.1 Market Study

India has emerged as the world's largest two-wheeler market, leaving behind China and Japan. In the financial year 2016-17, a total of 17.7 million two-wheelers were sold in India. According to the Society of Indian Automobile Manufacturers (SIAM), India sold 17.7 million two-wheelers in 2016 (over 48,000 units every day), against China's sales of 16.8 million two-wheelers. The two-wheeler sector contributes to around 7 per cent to our gross domestic product. It has the largest market share of automobile sector in India, holding 78 per cent of the market. The two-wheeler industry in India is basically divided into three segments – motorcycles, scooters, and mopeds. The bulk of India's two-wheeler sales come from commuter motorcycles and automatic scooters. The two-wheeler segment, in fact, has gained a head start with companies such as Hero Electric, Electrotherm selling electric scooters in India for several years now — the mainstream companies, though, are yet to launch their own electric two-wheelers. In the passenger vehicle segment, while Mahindra & Mahindra makes and sells electric cars, technology to commercially develop full-size electric vehicles is still at an early stage even globally.

Hero MotoCorp, Honda Motorcycle & Scooter India, TVS Motor, Mahindra Two Wheelers, Yamaha and Bajaj AutoBSE all have scheduled launches of electric two-wheelers from 2018.The government has a 2030 target to transition the country entirely to electric vehicles. Hero MotoCorp, the world's largest motorcycle maker by sales volume, is working on developing electric two-wheelers in-house at its Centre for Innovation & Technology in Jaipur. This is in addition to its strategic investment in electric two-wheeler startup Ather Energy.

1.2 Environment exposure of vehicle

- Working in a wide range of temperatures about -10^{0}C to 45^{0}C across the country.
- Potholes and irregular roads are nothing new and the problem has not been addressed for long.
- Our vehicle must be efficient enough to serve people during flood conditions.
- The vehicle designed must serve multiple Pinion riders & adding extra load on the Vehicle which greatly reduce the overall efficiency and affects the suspension and overall weight balancing.
- The vehicle must be repaired in local garages and can be serviced with local tools.
- Globally passenger safety is a priority loose clothing could get entangled in rotary wheels and demands additional packaging.

2. DRIVE CYCLE CONSIDERATIONS

Urban Conditions: The first step in developing a driving cycle is to measure and record real driving behaviors. The obtained data have to be analyzed in forming a representative cycle from real conditions. The obtained data are classified in different sections based on traffic conditions. The traffic condition varies with respect to different parts of the city. In classifying the traffic conditions, the parameters used are average speed and percentage of idle time for each of the trip. The four traffic conditions based on the above criteria are as follows:

- Congested urban conditions: An average speed of 8kmph to 10kmph with low to high idle time.
- Urban conditions: An average speed of 10kmph to25kmph with moderate to low idle time.
- Extra urban conditions: An average speed of 40kmph with low idle time.
- Highways: An average speed more than 40kmph with very low idle time.

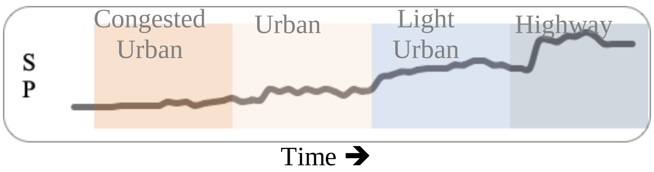

Chart -1: Speed vs time graph at various traffic condition.

Average-Speed:30Kmph; Top-Speed:50Kmph; Dist:4Kms

3. MOTOR DESIGN AND SELECTION

To calculate the motor power and torque rating the given parameters are considered.

- Gross Vehicle Weight (kgs) : 350.00

Range of the vehicle (kms) : 200.00

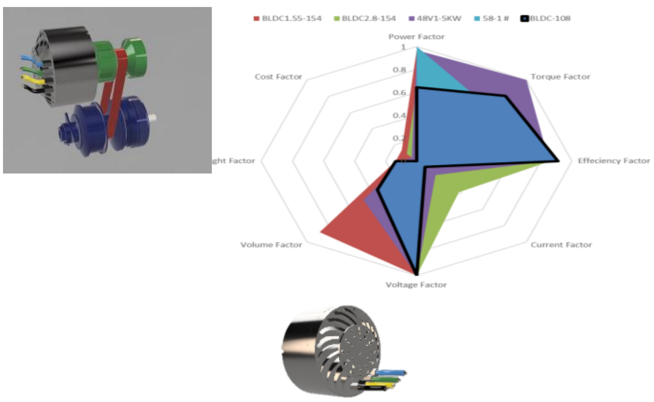

Fig -1: Motor & transmission system CAD design and design constraints.

The power required to move the vehicle from standstill (0 km/h) to (30 km/h) is calculated as follows :

The three contributing forces are computed

- Rolling Force = Co-efficient of rolling friction * vehicle mass (m) * acceleration due to gravity (g)= 0.022 * 350 * 10 = 77 N
- Gradient Force = m * g * gradient angle = 350 * 10 * sin (5) = 305 N
- Aerodynamic Force = 0.5 * Co-efficient of air friction * Cross sectional area * Air density * Square of air velocity= 0.5 * 0.34 * 0.1875 * 1.2 * 8.3 * 8.3 = 2.63 N

Ftotal = Frr + Fgrad + Faero

= 77 N + 305 N + 2.63 N

= 384.63 N

Total Power = (Ftotal * Average-speed)/3600

= (384.63 N * 30)/3600

= 3.20525 kW

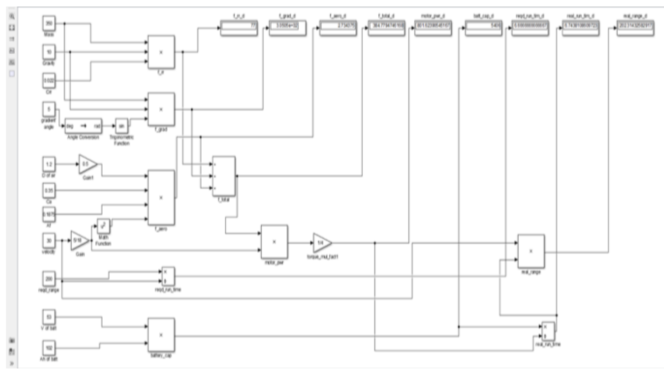

Fig -2: MATLAB Simulink model for design constraints.

The Continuous Variable Transmission is designed with the consideration that there must be a 4 times increase in torque output when and wherever the demand exists. Thus, this allows us to use a motor which is 4 times less powerful and achieve the same result. The motor technology being considered here is the BLDC motor when compared to Induction Motor or Brushed DC.

4. BATTERY SELECTION

The battery makes up a substantial cost of BEVs, which, unlike for fossil-fueled cars, profoundly manifests itself as a price of range. In the case of the MiEV 2012 model, the price tag and advertised range is close to proportional between two versions with a different battery, giving the (false) impression that the battery makes up close to 100% of the cost (95% for the higher-priced version). However, some of the price difference comes from extra features in the higher-priced version, plus an unknown price premium, making such a retail price comparison a very bad indicator of the actual cost of battery capacity, but nevertheless serves to quantify battery capacity as a premium feature. The few electric cars with over 500 km of range (including Tesla Model S with the 85 kWh battery), are firmly in the luxury segment, as of 2015.The cost of electric-vehicle batteries has been reduced by more than 35% from 2008 to 2014.

Table -1: Study of Various batteries & performance.

	NMC	LFP	Li-ion	Li-Polymer	LCO
Nominal V	3.60	3.20	3.7	3.7	3.6
Current Ah	9	8.8	8.5	9.5	8
Life cycle	1000 - 2000	1000 - 2000	500	500	500-1000
Weight (gm)	147	235	210	150	162
Thermal runway °c	50	60	270	240	150
Series parallel	14*15	14*13	17*14	15*14	15*16

Features of Lithium Nickel Manganese Cobalt Oxide ($LiNiMnCoO2$ or NMC).

- High capacity, high power.
- High specific energy allows to decrease weight and dimensions.
- Better Life cycle of upto 1000 – 2000 cycles.
- Typical Discharge rate of 25C allows us to power high current demand devices.

The secret of NMC lies in combining nickel and manganese. An analogy of this table salt in which the main ingredients, sodium and chloride, are toxic on their own but mixing them serves as seasoning salt and food preserver. Nickel is known for its high specific energy but poor stability; manganese has the benefit of forming a spinel structure to achieve low internal resistance but offers a low specific energy. Combining the metals enhances each other strengths.

NMC is the battery of choice for power tools, e-bikes and other electric powertrains. The cathode combination is typically one-third nickel, one-third manganese and one-third cobalt, also known as 1-1-1. This offers a unique blend that also lowers the raw material cost due to reduced cobalt content. Another successful combination is NCM with 5 parts nickel, 3 parts cobalt and 2 parts manganese (5-3-2). Other combinations using various amounts of cathode materials are possible.

Battery manufacturers move away from cobalt systems toward nickel cathodes because of the high cost of cobalt. Nickel-based systems have higher energy density, lower cost, and longer cycle life than the cobalt-based cells but they have a slightly lower voltage.

5.i-BMMC [Integrated Battery Management & Motor Control]

The battery monitoring system records the key operational parameters such as voltage, current and the internal temperature of the battery along with the ambient temperature during charging and discharging. The system provides inputs to the protective devices so that the monitoring circuits could generate alarms, and even disconnect the battery from the load or charger if any of the parameters exceed the values set by the safety zone.

The i-BMMC should include battery monitoring and protection systems, a system that can extend the life of the battery. The i-BMMC should include systems that control the charging regime and those that manage thermal issues.. In addition, it must interface with other on-board systems such as the motor controller, the climate controller, the communications bus, the safety system and the vehicle controller.

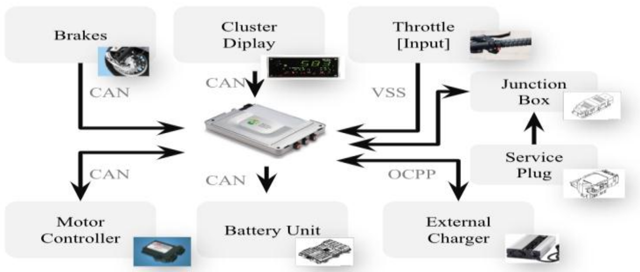

Fig -3: Architecture of i-BMMC controller unit.

The i-BMMC offers a cost effective solution.The module communicates with motor controller using CAN communication and directs the torque input required by the motor based upon the throttle input. Other important feature of the module is to diagnose the complete system for safety and checks the modules and sensors, each time the user switches on the Vehicle. The i-BMMC also communicates with the Junction box and controls each module separately. The modules check the service plug each time the vehicle goes for the charging and check the battery connections to avoid loose connections and system failure when in use.

The modules use OCPP 1.5 to communicate with External charger and monitors the electricity units consumed for charging. The i-BMMC has an Aluminium casing with heat sink and is IP67 protected to avoid water and dust entry keeping India Environmental considerations.

6. CHASSIS DESIGN AND SPECIFICATION

A chassis consists of an internal vehicle frame that supports an artificial object in its construction and can also provide protection for some internal parts. An example of a chassis design is the underpart of a motor vehicle consisting of frame (on which the body is mounted). If the running gear, such as wheels and transmission and sometime even driver's seat are included then the assembly is described as rolling chassis.

The EV designed is made up of re-inforced high strength steel body and composite material. The frame is made it steel body and the outer covering is made up of the composite material.

The specifications of the chassis model is as follows:

- Length: 1.78 meters
- Width: 0.69 meters
- Ground clearance: 150 mm
- Wheel base: 1.29 meters
- Wheel size: 0.254m or 10 inches
- Brakes: Drum brakes with ABS

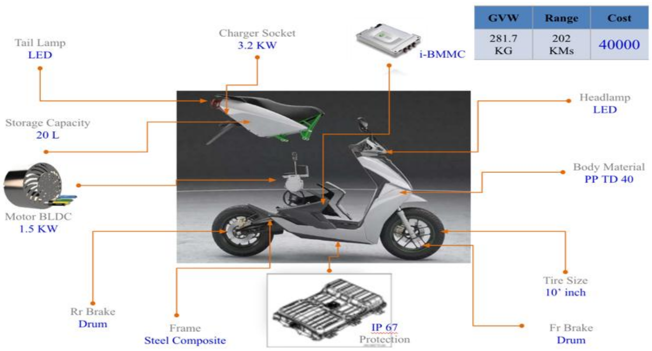

Fig -4: Final Architecture of Vehicle.

EV has two suspension modes, the rear is a mono suspension and the front is the Hydraulic and shock absorber. We are using a rear mono shock absorber in EV as:

- Better corning and highway stability
- Allows higher suspension and swing arm travel
- Eliminate torque to the swing arm
- Easy to tune and adjust
- Better handling and ride ability

Use of two hydraulic suspensions in the front wheel life three to five times longer:

- To minimize noise and vibration
- To prevent premature die ware
- To reduce mechanical failure

To calculate the weight of the vehicle built the following values are taken into consideration.

1. Chassis weight: 60 kg (density = 7860 kg/m 3)

2. Weight of ancillary components: 4 kg

3. Weight of brakes: 3.9 kg

4. Weight of suspension systems: 6.5 kg

5. Weigh of cooling systems: 14 kg

6. Weight of battery: 35 kg

7. Weight of Motor: 4.5 kg

8. Weight of CVT: 3.8 kg

Therefore, the total kerb weight is: 131.7 kg

The weight passengers of 75 kg x 2 = 150 kg

Therefore, gross vehicle weight = Kerb weight + Passenger weight = 131.7 + 150 = 281.7 kg

Hence GVW constraint of 350 kg is maintained.

7. CONCLUSIONS

Developed a Virtual Prototype of the Electric two wheelers with high usage in Urban Areas.The expected price for the two wheeler with 200 Kms/350 GVW : 40,000 (Excluding Battery). The Battery to power the E-Scooter is 6.78 kW with NMC Cells from GBS.

The Motor selected for the project is from Golden Motors make with rating 1.5KW.The Control System is developed i-BMMC as a Single Unit to monitor the Battery parameters and give input to motor based on throttle input thus reducing the wiring & additional cost of hardware. A digital cluster indicates the battery SOC , current speed and expected driving range ,an Eco mode Indicator.

The Battery cost is the major challenge for the project and with newer chemistries development over the coming years we have decided to offer the battery on lease.

The present model is commercially developed will appeal to the young generation to move to electric. The driving range of 200 Kms can be the USP and only needs single charging per week. High GVW achieved with the state of the art motor will allow the model to be modified for Commercial Use.

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