Increasing the Range of an Electric Vehicle

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***Abstract-* The automotive industries around the world are getting converted into the Electro-Automotive industries. There are several reasons for this some of them are Environment friendly, mobility, carbon-emission free vehicles and extinction of fossil fuels. By adapting this type of mobility there are several advantages and dis-advantages. The main dis-advantage faced by the Electric vehicle in the present generation is, the limitation of the distance covered by the electric vehicle per charge. At present the maximum distance an E-vehicle travels is around 300-400 km per charge and this also varies with the number of factors like type of vehicle, battery capacity, weight of the vehicle etc...**

The main intension of this paper is to increase the distance covered by an electric vehicle per charge, by calculating the time required for the battery to discharge and to increase the speed of the charging time, in time-saving method. Which is the main limitation for the present day Electric-vehicles.

***Indexed Terms-* Electro-automotive industry, Carbon free emission, Battery capacity, Time saving**

I. INTRODUCTION

When compared the electric vehicles with the conventional fossil fuel powered vehicles, the main drawback is the limitation of the distance travelled by an E-vehicle per charge. This limitation of distance travelled makes the vehicle less competitive between the conventional fossil fuel powered vehicles and battery powered vehicles. To reduce this limitation of an E-vehicle we need to come up with a solution in order to increase the distance travelled by a single charge. For this first we need to understand the energy consumed by an E-vehicle per kilometer. By knowing energy consumed by E-vehicle we can calculate the time required by an battery pack to get discharged fully by the E-vehicle. After knowing the time required to get discharged, we can come up with a solution to increase the distance travelling per kilometer per one charge.

For calculation of energy consumed by an E-vehicle, we need to know the types of E-vehicles depending on power to weight ratio.

Let PW be the power to weight ratio defined by :
PW=maximum power required by vehicle / total weight of the vehicle,
Then we classify as follows:
Type-1 : if $PW <= 22$,
Type-2 : if $22 <= PW <= 34$,
Type-3 : if $PW = 34$,

Where type-1 is a low powered vehicle and type-3 is a high powered vehicle.

For instance, we shall calculate the energy consumed by E-vehicle of type-3 i.e, high powered vehicle, this is same for all types of E-vehicles.

II. ENERGY CONSUMED BY E- VEHICLE

The total energy consumed by an E- vehicle is the sum of the energy required to power the power train starting from the battery to wheels and the energy required to power up the auxiliary devices such as head lamps, Air conditioners, Sensors etc.., in the vehicle. So this can be mathematically explained as follows

Etotal = E powertrain + E auxiliary

Firstly, we shall calculate the energy required by the power train. This can be calculated as follows

Ept = 0 Ppt dt
Ppt = Fpt * vehicle speed
Fpt = Fi + Frs + Ff + Fa

Where

Ept = Energy consumed by the power train
Ppt = Power required by the vehicle
Fpt = Total force required by the vehicle
Fi = Inertial force of vehicle
Frs = Road slope force
Ff = Frictional Force of the vehicle
Fa = Aerodynamic drag force

Mathematically each of the force can be explained as the following

1. inertial force:
The inertial force of the vehicle is given by the following formulae

Fi = Mv * Av

Where

Mv = Mass of the vehicle
Av = Acceleration of the vehicle

2. Road slope force:
The road slope force is given by the following formulae

Frs = Mv * g * sin (α)
Where

g = Gravitational force constant
α = Road slope angle

3. Frictional force:
The frictional force of the road is given by the following formulae
Ff = Mv * g * Rr * cos (α)

Where

Rr = Coefficient of the road rolling resistance
α = Road slope angle

4. Aerodynamic force:
The aerodynamic drag force of the vehicle is given by the following formulae
Fa = ½ * Da * C * Af* V^2

Where

Da = Air density
C = Air drag coefficient
Af = Frontal area of the vehicle
V = Vehicle speed

Hence the total force required by the vehicle is given by
Fpt = Fi + Frs + Ff + Fa
And the power for the power train is given by
Ppt = Fpt * vehicle speed

Thus the energy consumed by the power train of E-vehicle is given by
Ept = 0 Ppt dt

For Example:
The following values are taken to explain the calculation of the energy consumed by the electric vehicle

Let the gross mass of the E- vehicle be

Mv = 1780 kg
Let us assume the acceleration of the vehicle be
Av = ΔV / ΔT
= 1.66
Let us consider the slope angle of the road as zero such that the vehicle energy consumption can be easily calculated
α = 0 degrees
The rolling resistance can be calculated by the formulae
Rr = Crr * vehicle speed * load

For the instance let us assume the road rolling resistance as 0.00231
Rr = 0.00231
The air density at optimum temperature 30 degree is 1.164
Da = 1.164 kg\m^3
The air drag coefficient is given by the following formulae

C = Drag force / (velocity pressure*Af)

Let us assume the air drag coefficient as 0.14

C = 0.14

Let us assume the vehicle frontal area as 3.35

Af = 3.34 m^2

Let us assume the vehicle average speed as 30

V = 30 kmph

So let us calculate the energy consumed by the power train with the above mentioned formulae's

1. Inertial force:

Fi = Mv * Av
= 1780 * 1.66
= 2954.8 N

2. Road slope force:

Frs = Mv * g * sin (α)
= 1780 * 9.81 * sin (0)
= 0 N

3. Frictional force:

Ff = Mv * g * Rr * cos (α)
= 1780* 9.81*0.00231*cos (0)
= 40.36 N

4. Aerodynamic force:

Fa = ½ *Da * C * Af * V^2
= ½ * 0.164 * 0.014 * 3.35 *30^2
= 34.612 N

The total force Fpt is the some of all forces and is given by

Fpt = Fi + Frs + Ff + Fa
= 2954.8 + 0+ 40.336+ 34.612
= 3029.74 N

The power required by the E- vehicle is calculated as follows

Ppt = Fpt * vehicle speed
= 3029.74 * 30
= 90.89 KWh

Let us assume the total distance specified for the electric vehicle as 400 KM

90.89 KWh ⟹ 400 Km
? ⟹ 1 KM

So the energy consumed by one Km is calculated by

Energy consumed by power train in the electric vehicle per KM = 90.89 KWh / 400 Km
= 0.227 KWh / KM
= 227 Wh / KM

The energy consumed by the auxiliary devices varies depending upon the type vehicle. So let us assume the energy consumed by the auxiliary devices as 0.01% of the energy consumed by the power train

So the Energy consumed by auxiliary devices = 0.01% * 227 Wh /KM
= 2.27 Wh /KM

Therefore the total energy consumed by the electric vehicle is the sum of the energy consumed by power train and energy consumed by auxiliary devices in the vehicle. So it is given by

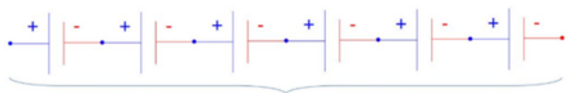
Etotal = Epowertrain + Eauxillary
= 227 Wh/Km + 2.27 Wh/Km
= 229.27 Wh/KM

III. DESIGHN OF A BATTERY PACK

The battery is the main source of energy in the E-vehicle. There are several types of batteries out of them the lithium ion(Li+) batteries are more reliable when compared with all the other types of batteries. A battery pack consists of number of battery cells connected in series and parallel to obtain the desired rated output. When the batteries are connected in series the current magnitude will be same but the voltage magnitude varies and when the cells are connected in parallel the voltage magnitude will be same but the current magnitude varies. Apart from battery pack there are also conventional single large unit batteries but when compared with the smaller cells connection they are less advantageous. In this paper let us design a battery pack whose rated output meets the above calculated energy requirement i.e 100KWh. Battery pack

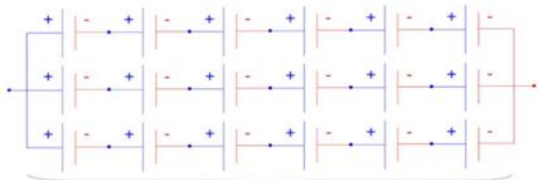
A typical small battery like a tesla battery has a voltage ranging from 3.7V to 12V

The battery cells can be connected in series and parallel depending upon the rated requirement



6 x 2 = 12 V

When the cells are connected in series the current magnitude remains same and the voltage magnitude varies with respect to the number of cells connected



12 V
3 times more capacity
3 times more current

When the cells are connected in parallel the voltage magnitude remains same but the current magnitude varies with respect to the number of cells connected in the pack.

In this way of series and parallel connection, the battery cells are connected into modules and the modules are connected into groups and groups are connected to form the battery pack. In this case, a 100 KWh battery pack is designed by using the same method.

For example:
The tesla battery pack of rating 85 KWh has the following configuration of battery cells

74 cells in parallel group
6 groups in series for a module
16 modules in series

For this battery pack let us calculate the power rating such that we can easily design the battery pack of 100KWh.

1. 74 cells in parallel
   74 * 1A = 74 amp , 12V
2. 6 groups in series for a module
   6 * 12V = 72V , 74amp
3. 16 modules in series
   16 * 72V = 1152V , 74 amp

So the power rating of a above battery pack can be calculated by

Power rating = 1152V * 74amp = 85.248 KWh

IV. TIME FOR CHARGING AND DISCHARGING

As discussed earlier, the main disadvantage of an E – vehicle is its limited range per a discharge of battery. We have to calculate the exact time for discharge of a battery such that the vehicle max range can be known. For this time calculation a mathematical expression is given as shown below

Time of charge or discharge (T) = 1 / Cr
Or T = Er / I
Where
I = Cr / Er
Cr = I * Er
T = time for charge or discharge
Er = Rated energy stored in Ah
Cr = C- rate of a battery
I = current of charge or discharge

The C-rate of a battery is used to scale the charging and discharging of a battery. The C-rate shows at what current a battery is charged to attain its maximum defined capacity

For example, if the C-rate is 1C

The battery of 1000Ah is charged at 1000A in one hour
If the C-rate is 0.5C

The battery of 1000Ah is charged at 500A in two hours
If the C-rate is 2C

The battery of 1000Ah is charged at 2000A so it actually takes only half an hour with which the battery gets damaged.

So by using the above formulae's we can calculate the time required for the charge and discharge hence by calculating the maximum range of E- vehicle depending upon the battery pack.

V. PROPOSED SYSTEM

In the present day generation everything is so quick and fast. The people around the world are habituated to the quick process rather than the things which consume lot of time. Coming to our topic, the extension of the range of an E-vehicle. According to us the more quick and fast methods to increase the range of an E-vehicle is to swap the battery pack with a fully charged one so that the time required for the battery charging is very less than the time required for the battery swapping. So that the E-vehicles can be more reliable when compared with the conventional fossil fuel vehicles. So, instead of setting up the charging stations by the famous car companies like TESLA, ABBS, etc. It is wise to set up the battery swapping stations so, that the E-vehicle user's when they find the battery level gets drained , They can easily come to the nearest battery swapping station of the car company and swap it with the fully charged one. With this the main dis-advantage of E-vehicle can be cleared. But in this method some dis-advantages will rise, which can be eliminated by taking care and with a little research into it. Mainly the battery health, the battery health of the swapping battery and vehicle battery health should be same such that, the battery of used vehicle should be replaced with the battery of the same battery health. More number of battery swapping stations should be made available to the consumers by taking care of these set-backs, the battery swapping would be an excellent replacement of battery charging, in this battery swapping stations the batteries are collected and charged fully and made available at the very instant time when required.

VI. EXISTING SYSTEM

The process followed at present daily life is to make E-vehicle a replacement to the conventional fossil fuel vehicles is to set-up the charging stations. In this system, the time required for the E-vehicle to reach it's full battery is high which makes E-vehicle not a better replacement of fossil fueled vehicles. At present the charging time of the E-vehicle for an average 100KWh battery pack is around (1-3)hours, depending on the type of the battery and type of chargers used, and if we tend to reduce the time of charge by adapting fast-charging options by increasing the charging rate (C-rate) of the charger. The battery health gets disturbed, It results in the complete wastage of the battery pack so, in our perception, the battery swapping is far more batter than the battery charging to make E-vehicles more compatible when compared with the conventional fossil fuel vehicles.

CONCLUSION

the proposed system makes the E-vehicle more better than the conventional fossil fuel vehicles, it is just similar to fossil fueled vehicles where we go to the nearest fossil fueled station to fill fuel or gas and continues our journey. But in the existing system, charging of electric vehicle in charging stations requires more time and it is un-convenient for consumers, which makes the E-vehicle not an option when compared with the conventional fossil-fuel vehicles.

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