All-Terrain Vehicle (Off Road Electric Vehicle) Distance Travelled 500Km

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Abstract

Due to Increase in the pollution by using gasoline engine the automobile industries started producing electrical vehicles. So, in future there will be no problem for transportation. This paper is going to explain about the off-road terrain electric vehicles which can reach a maximum possible distance. Manufacturing an off-road terrain electrical vehicles will ease the transportation in forests, hilly areas, deserts and mining areas.

Keywords: Terrain, Forests, Hilly Areas, Mining Areas

I. INTRODUCTION

As gasoline engines create more pollution in the environment which is harmful. So, to overcome these adverse effect on environment there is a scope for electrical vehicles. Gasoline engines mainly depends on Petroleum products, which will get exhausted in future. So, we need to look forward for electrical vehicles and show more interest on them. Selection of motor and battery parameters for design of electrical vehicles plays a vital role. Most of the designers fail to accomplish these parameters. So, in this report we try to explain about selection of motor with calculations and battery parameters. Design of off-road electrical vehicles is difficult than on-road electrical vehicles because of the simple reason that it requires more energy and more torque.

II. BLOCK DIAGRAM

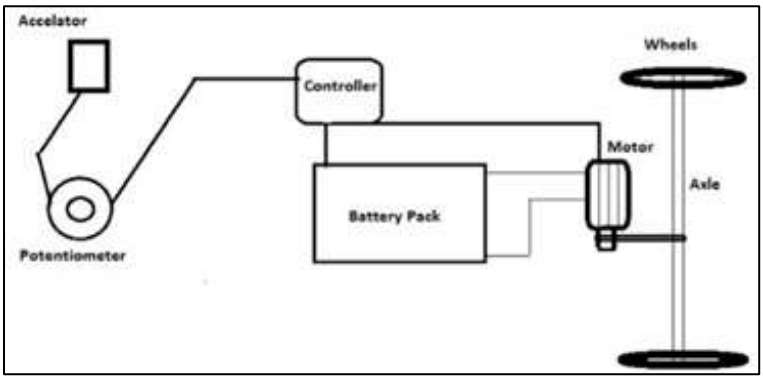

Fig. 1:

As referring to "Fig 1" the design of electric vehicle consists of the following main parts [2].

a) Potentiometer
b) Controller
c) Battery Pack
d) Motor

III. PARTS & THEIR FUNCTIONS

A. Potentiometer

Potentiometer serves as intermediate between the accelerator and the controller. As and when the accelerator is peddled the potentiometer signals the controller to deliver the required amount of power from battery to motor.

B. Controller

Controller is a device which transfer electric power from batteries to motor in pulses. It is the main component of electric vehicle. The controller is connected to battery pack and motor through heavy cables, which acts like switch to transfer electric power from batteries to motor in form of pulses. Function of controller is mainly depending on potentiometer where it checks equal signals from the potentiometer, if it fails, it doesn't allow electric power to pass from battery pack to motor.

C. Battery Pack

The energy source for the electric vehicle is battery pack. These battery pack are rechargeable.

D. Motor

Electric motor is a device which converts electric energy into mechanical energy. The motor receives power from the controller which is connected to axle and runs the transmission. (Motor, controller and Battery pack are the "Heart" of electric vehicles).

IV. ASSUMPTION

(All Units are in SI)

- Weight of the vehicle (w)= 400kg
- Coefficient of rolling resistance ($C_{rr)}$= 0.150 (soft sand)
- Grade or inclination angle (θ)= 10^0
- Acceleration due to gravity (g) = 9.81 m^2/sec.
- Required acceleration (v) = 10 km/hrs.
- Coefficient of aerodynamic drag ($C_{ad)}$= 1
- Overall length of the vehicle (L) = 2.108m.
- Overall width of the vehicle (b) = 1.219m.
- Overall height of the vehicle (h) = 1.1m.
- Radius of the wheel ($r_{wheel)}$ = 0.25m.
- Density of air (ρ) = 1.225kg/m^3.

V. POWER REQUIRED TO REACH THE DESIRED DISTANCE

Certain parameters of battery and motor required to reach the desired range. So, we need to calculate certain forces for selection of motor.

We need to consider certain factors affecting for selection of motor for electric vehicle. And to determine the torque required. The major thing we need to concentrate is off-road electric vehicles requires less rpm to get more torque. So, it can be calculated using equation 1 [1].

Torque (τ)= 9.54P/N (1)

Γ= Torque (N-m).

P= Power (KW).

N= Speed (rpm).

The factors are;

1) Rolling Resistance.
2) Aerodynamic Resistance.
3) Gradient Resistance.
4) Total tractive Power.

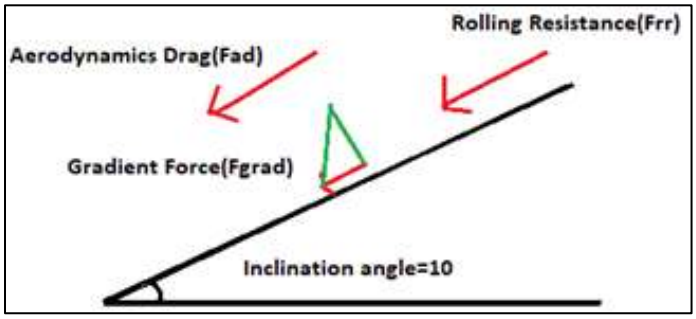

Fig. 2:

The "Fig.2" shows the various forces acting on the electric vehicle.

A. Rolling Resistance

Resistance offered by the surface to the wheels of the vehicle defines rolling resistance of the vehicle. The rolling resistance can be calculated by using equation 2 [1].

$$F_{rolling\ resistance} = C_{rr} * w * g \quad (2)$$
$$= 0.150 * 400 * 9.81$$
$$= 588.6\ N$$

Now, power required to overcome the rolling resistance

$$P_{rolling} = F_{rolling\ resistance} * V / 3600$$
$$= 588.2 * 10 / 3600$$
$$= 1.635 kw.$$

B. Aerodynamic Resistance

The force exerted by an air on the vehicle that is parallel and opposite to the direction of flow relative to the vehicle is said to be as Aerodynamic resistance. The aerodynamic resistance can be calculated by using equation 3 [1].

$$F_{aerodynamic\ resistance} = (1/2) * C_{ad} * A * \rho * v^2 \quad (3)$$
$$= (1/2) * 1 * 2.826 * 1.225 * (10)^2$$
$$= 173.0925N.$$

Now, power required to overcome aerodynamics resistance

$$P_{aerodynamic} = F_{aerodynamic\ resistance} * v / 3600$$
$$= 173.0925 * 10 / 3600$$
$$= 0.4808 kw.$$

But, due to certain change in density of air while moisture let us take the power required as 1 kw.

C. Gradient Resistance

The resistance offered when the vehicle is climbing up at a certain angle or climbing down at a certain angle. The angle at which vehicle climbs up or climbs down is given by angle ɵ, which is shown in "Fig.2". The gradient resistance is given by equation 4 [1].

$$F_{gradient\ resistance} = \pm W * g * \sin\theta \quad (4)$$
$$= 400 * 9.81 * \sin(10)$$
$$= 681.3954N.$$

("+" is used when the vehicle is climbing up. And "-"is used when the vehicle is climbing down).
The power required to overcome this Gradient resistance is given by,

$$P_{gradient} = F_{gradient\ resistance} * v / 3600$$
$$= 681.3954 * 10 / 3600$$
$$= 1.89 kw.$$

D. Total Tractive Power

The total tractive power is given by sum of all the power calculated above. Total tractive power is calculated by using equation 5 [1].

$$TTP = P_{rolling} + P_{aerodynamics} + P_{gradient} \quad (5)$$
$$= 1.635 + 1 + 1.89$$
$$= 4.525\ KW.$$

But, motor with 4.525KW has not to be selected. Because, we have to include certain parameters like gear ratio and transmission of power to wheels must be selected. So, mechanical tractive power required to drive the vehicle is given by equation 6 [3]

$$M_{\text{mechanical tractive}} = TTP / \eta \quad (6)$$
$$= 4.525 / 0.80$$
$$= 5.625 \text{ KW}.$$

So, the motor with 5KW has to be selected foe driving 400kg off-road electric vehicle.

VI. SELECTION OF BATTERY

After selecting the Motor, the next step is to select the battery for the vehicle. As, we know that there is huge research in developing the battery with maximum efficiency. Since, from olden days many vehicle runs with Lead acid battery. But the problem in choosing the Lead acid battery is it weigh more compare to present batteries like Li-ion batteries.

In future there will be huge demand for the Li-ion batteries because, they have more efficiency and light in weight. The self-discharge is more in other batteries compare to Li-ion battery. So, there is a huge demand in selection of Li-ion battery for designing our vehicle.

If a vehicle is to be used in a mountain area, larger ah batteries are required. Because of its C factor. When we select high ah battery more amount of heat will be generated. So, to overcome this problem we have to use some coolants. And the major step is to arrange the cells in series and parallel.

Let us select 48V 800Ah battery. After many calculations this Specified battery is used because, to reach the desired distance. The calculations are shown below.

Energy of the battery is calculated using equation 7 [4].

$$E = V*I \quad (7)$$
$$= 48*800$$
$$= 38.4 \text{ KWH}.$$

V= Battery voltage (volts).
I= Current (ampere).
E= Energy of the Battery (KWH).
If our wheel rpm is 1000rpm (assumed).

As we have 5kw motor it can be reached to 6000rpm. But, considering the torque we needed we build torque by reducing speed as on with 6:1 gear ratio or we can lower it to 2:4 or else.

So, the 5KW motor will be selected as 48V 100A.

$$\text{Motor} = 48*100$$
$$= 4800\text{W}$$
$$= 4.8\text{KW}.$$
$$\sim 5\text{KW}.$$

So, maximum hours the battery will discharge is calculated by,

$$38400 / 5000 = 7.68\text{Hours}.$$

The battery will run at 8hours without considering losses. Now we will consider 40% losses then vehicle will run up to 6hours.

VII. TORQUE REQUIRED ON DRIVE WHEEL

The torque required on drive wheel is given by equation 8.

$$\Gamma = R_f * TTP * r_{wheel} \quad (8)$$

The resistance factor results as the frictional losses wheels, motor and the drag on the motor bearing. Typical value range between 1.1 to 1.15.

The above calculations help us for the selection of the right battery pack and motor. So, by considering above all parameters we can meet the desired range of an off-road terrain electric vehicle. We need to consider the size and weight of the battery. Because, they constitute the major part in the selection. Lower the weight and lesser the size of the battery more efficient the vehicle travels.

VIII. RANGE CALCULATION BY USING BATTERY CAPACITY

Range is the distance covered by the electric vehicle in one charge. First we need to calculate the speed. If our vehicle wheel height is 0.5m. Then, circumference of the wheel is given by equation 9 [5].

$$\text{Circumference} = \text{wheel height} * \pi \quad (9)$$
$$= 0.5*\pi$$
$$= 1.570\text{m}.$$

Now, the motor is running at 1000 rpm then,

$$= 1000 * 1.570$$
$$= 1570.79\text{m/min}.$$

But we know that, 1km= 1000m
Then, 1570.79 / 1000 = 1.57079 km/min.
1.57079 * 60 = 94.2474 km / hrs.

So, the maximum distance the vehicle moves with these parameters is calculated by using equation 10.

$$\text{Range} = \text{Speed} * \text{time} \quad (10)$$
$$= 94.2474 * 6$$
$$= 565.4844 \text{ Km.}$$

But at initially we took speed as 10km/hr. and after choosing the certain parameter the speed is calculated and chosen as shown above to reach the desired distance. We have taken 10kw as loss, so that would be at maximum range at maximum air flow, road condition that would be 21hp of loss. We will get higher than this range and 20km/hr. speed may vary. So, by seeing the above calculation we can conclude that selection of battery is important to reach the desired distance.

IX. SCOPE OF OFF-ROAD ELECTRICAL VEHICLES

Now a day's electric vehicles are playing advantageous role on gasoline engines. So, the future scope is more in use of electric vehicles. As people are so crazy to travel in forests, deserts, muddy areas and hilly areas use of off-road vehicles are important. The future scope of off-road electrical vehicle is explained below in detail [6].

- The use of combustion engine for travelling on off-road creates more pollution and more consumption of petrol so, to overcome this problem the use of electric vehicle is a better solution.
- The solar energy is best source for generating electricity which will help to run the electric vehicles which is at a low cost compared to Petroleum products.

With less complex mechanisms, electric vehicles require significantly less maintenance over the course of their lifetime. Because, to travel on off-road the vehicle maintenance is more where it is too difficult in combustion engines rather than electric vehicles

X. CONCLUSION

India imports more than 80% of the petroleum products that it uses. The shift towards electric vehicles will have a positive impact on the economy as well as the environment. The above [7] mentioned all parameters are required to design the particular Off-road electric vehicles.

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