International Journal of Advance Research in Science and Engineering
Volume No. 11, Issue No. 12, December 2022
www.ijarse.com
IJARSE
ISSN 2319 - 8354

A study on electric vehicle performance of a selected 4-wheeler EV model on Indian roads

G.R.Deshpande[1] , J.M.Mulla[2] , B.H.Desai[3]

1(Senior Grade Lecturer in Department of Automobile Engineering Government Polytechnic, Belagavi, 590002 Karnataka ,India.)

2(HOD in Department of Automobile Engineering Government Polytechnic, Belagavi, 590002 Karnataka , India.)

3(Lecturer in Department of Electrical and Electronics Engineering Government polytechnic, Belagavi, 590002 Karnataka ,India.)

ABSTRACT:

Due to growing environmental awareness and concerns about traditional fossil fuel vehicles' greenhouse gas emissions, electric vehicles are becoming more and more popular. In India, the adoption of electric vehicles may take some time, but government encouragement and public demand are hastening the process.

Due to their remarkable efficiency, electric vehicles usually consume around one third less energy than gasoline-powered ones. Compared to internal combustion engines, which only convert less than 35-40 percentage of electric energy into mechanical power, electrical motors do so at a rate of over 80-85 percentage. In order to size the gear ratios, battery, and system capacity to reach desired performance, the calculations of electric vehicle performance is essential. Typically, a vehicle's maximum cruising speed, gradeability, and acceleration are used to define its performance. The link between tractive effort and vehicle speed is the foundation for predicting a vehicle's performance. For on-road vehicles, it is assumed that the maximum tractive effort is constrained by the power plant's maximum torque rather than the capacity to maintain road adhesion.

Key words: Electric vehicle, aerodynamic drag force, rolling resistance force, gradient resistance force, acceleration force and Tractive force.

I) INTRODUCTION:

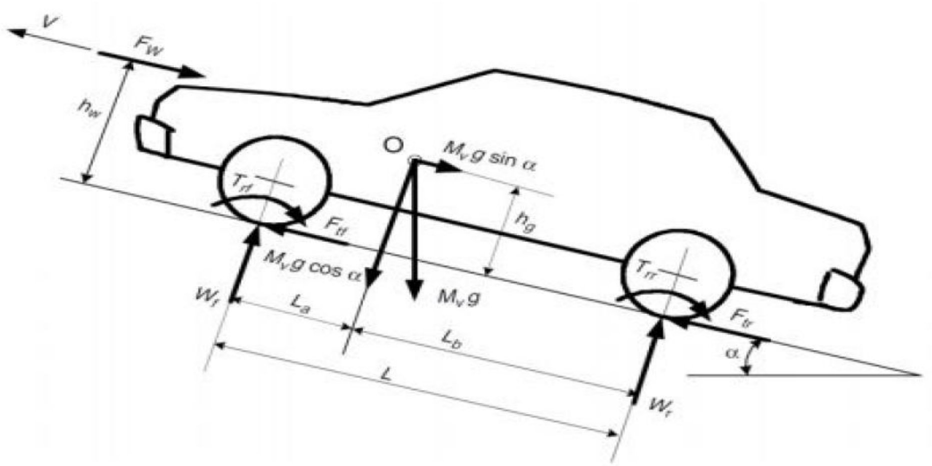
Electric vehicles reduce pollution, reduce fuel costs, and offer significant tax relief. Due to their slower speed and reduced tyre wear, they are significantly safer to ride in. All electric cars utilise direct current electric motors to drive the wheels, which is one feature they all have in common. Regardless of that these motors come in a variety of speeds, sizes, and modes of operation, the torque that the vehicle must produce to achieve the desired characteristics remains constant. The force that drives the wheels and propels the vehicle forward is made up in part by the torque. The turning power of the motor may be simply defined as its torque. It is very important to match the capacity of motor. battery and system capacity for required performance. Electric vehicle key performance parameters involve vehicle max speed, acceleration and power consumption and range.[1],[4]

IJARSE
ISSN 2319 - 8354

For the study purpose we have selected a model of electric vehicle made in India with standard specifications are used from company data for the study.

ELECTRIC VEHICLE PERFORMANCE:

General Description of Vehicle movement Figure 1.1 shows the forces acting on a vehicle moving up a grade. The tractive effort (F_t), in the contact area between tires of the driven wheels and the road surface propels the vehicle forward. It is produced by the power plant torque and is transferred through transmission and final drive to the drive wheels. While the vehicle is moving, there is resistance that tries to stop its movement. The resistance usually includes tire rolling resistance, aerodynamic drag, and uphill (gradient)resistance. [2],[4]



The factors that are affecting the vehicle performance are

- Aerodynamic drag force,
- Rolling resistance force,
- Gradient (Uphill)resistance force,
- Acceleration force.

1.AERODYNAMIC DRAG FORCE (AERODYNAMIC RESISTANCE):

A vehicle traveling at a particular speed in air encounters a force resisting its motion. This force is referred to as aerodynamic drag. It mainly results from two components: shape drag and skin friction.

Shape drag: The forward motion of the vehicle pushes the air in front of it. However, the air cannot instantaneously move out of the way and its pres- sure is thus increased, resulting in high air pressure. In addition, the air behind the vehicle cannot instantaneously fill the space left by the forward motion of the vehicle. This creates a zone of low air pressure. The motion has therefore created two zones of pressure that oppose the motion of a vehicle by pushing it forward (high pressure in front) and pulling it backward (low pressure in the back) as shown in Figure. The resulting force on the vehicle is the shape drag.[4]

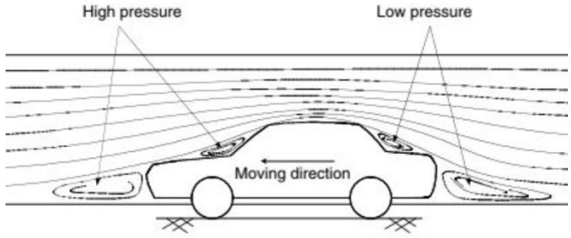


FIGURE : Shape drag

Skin friction: Air close to the skin of the vehicle moves almost at the speed of the vehicle while air far from the vehicle remains still. In between, air molecules move at a wide range of speeds. The difference in speed between two air molecules produces a friction that results in the second component of aerodynamic drag. Aerodynamic drag is a function of vehicle speed V, vehicle frontal area A, shape of the vehicle, and air density ρ. Aerodynamic drag is expressed as

$$F_{aero} = \frac{1}{2} \times \rho \times C_d \times A \times v^2$$

Where,

$\rho = Density\ of\ the\ Air\ @27°C = 1.2\left(\frac{Kg}{M^3}\right)$

V = Velocity (m/Sec)

A = Vehicle Frontal Area (or) Projected Area in Sq.m

Cd = Drag Coefficient

$$Aerodynamic\ Drag = \frac{1}{2}\ x\ \frac{Kg}{M^3}\ x\ Cd\ x\ M^2 x\left(\frac{M}{\sec}\right)^2$$

$$\frac{Kg.m}{Sec^2} = Newton = N$$

where Co is the aerodynamic drag coefficient that characterizes the shape of the vehicle and V is the component of wind speed on the vehicle's moving direction, which has a positive sign when this component is opposite to the vehicle speed and a negative sign when it is in the same direction as vehicle speed. The aerodynamic drag coefficients for a few types of vehicle body shapes are shown in Figure.

2.ROLLING RESISTANCE FORCE:

Tire rolling resistance is the energy that your vehicle needs to send to your tires to maintain movement at a consistent speed over a surface. In other words, it is the effort required to keep a tire rolling. The main contributor to rolling resistance is the process known as hysteresis. Hysteresis is essentially the energy loss that occurs as a tire rolls through its foot print.It is calculated by [4],[5].

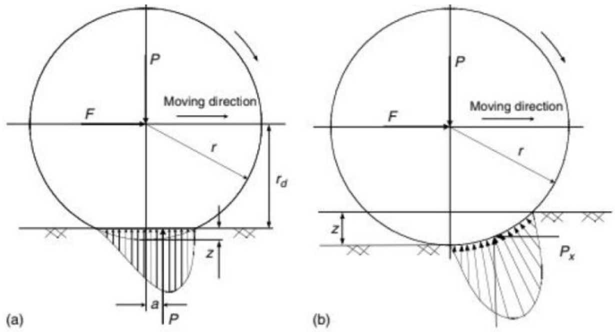


FIGURE
Tire deflection and rolling resistance on a (a) hard and (b) soft road surface

$$F_{rr} = m \times g \times cos\theta \times \mu$$

Rolling Resistance

$$Rolling\ Resistance = mg\ x\ \mu\ x\ cos\theta$$

Where,

m=Permissible Load in Kg

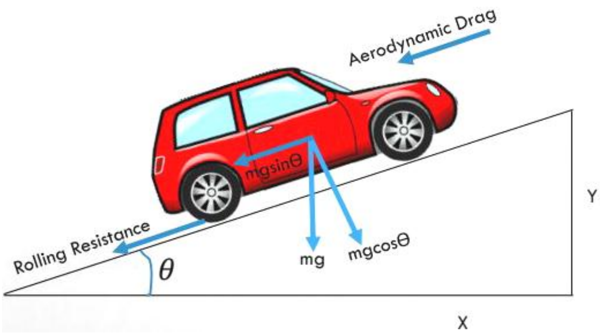
$g = gravity\ in \frac{m}{s^2}$

$\mu = Rolling\ Coefficient$

3.GRADIENT (UPHILL)RESISTANCE FORCE:

When a vehicle goes up or down a slope, its weight produces a component, which is always directed to the downward direction, as shown in Figure. This component either opposes the forward motion (grade climbing) or helps the forward motion (grade descending). In vehicle performance analysis, only uphill operation is considered. This grading force is usually called grading resistance. It is calculated by

$$F_{gr} = m \times g \times sin\theta$$



Where m= mass of vehicle in Kg

g= Acceleration due to gravity in m/sec^2

$\theta = gradient\ angle\ in\ radians$

4. ACCELERATION FORCE:

The acceleration force refers to the vehicle's resistance to speed variations. This force holds you back when you increase your speed and also moves you forward when you slow down. In other words, it means that you consume energy to accelerate up to a certain speed but can recover part of that energy when you decelerate, allowing you to drive a certain distance without consuming energy.

$$F_{acc} = m \times a$$

Where m= mass of vehicle in Kg

$$a = Acceleration\ of\ vehicle = \frac{v-u}{t}\ \ in\ \mathrm{m/sec2}$$

II) METHODOLOGY

For the following specifications of the 4-wheeler electric vehicle selected model.

Dimensions: Length x Width x Height (mm)	**3993 x 1811 x 1606**
Kerb Weight:	**1400 Kg**
Tyres:	**R16 215/60 LRR**
Acceleration:	**0-100 km/h in 9:9 seconds**

We will do calculations for 0-100 Km/hrs in 10 seconds

Assuming,

Air Density @27°C (ρ) =1.2 kg/m³

Coefficient of Drag (C_d) =0.24

Rolling Resistance Coefficient (μ) =0.01

Gradient Angle (θ) = 5°= $\frac{5\times\pi}{180} = 0.087\ radians$

Velocity (v) = 50 km/hrs= 13.9 m/s

Total Mass (m) = Vehicle Kerb Weight + Passenger Weight + Any Pay load (Luggage, etc)

Total Mass (m) = 1400 Kg +5×70 Kg + 50 Kg

Total Mass (m) = 1800 Kg

Results obtained as follows:

1. AERODYNAMIC DRAG FORCE (AERODYNAMIC RESISTANCE):

As frontal area (A)= 1811mm ×1606mm = $1.811\text{m} \times 1.606m = 2.90\ m^2$

Substituting in below equation

$$F_{aero} = \frac{1}{2} \times \rho \times C_d \times A \times v^2 = \frac{1}{2} \times 1.2 \times 0.24 \times 2.90 \times (13.9)^2$$

$$\therefore \boldsymbol{F_{aero} = 80.80N}$$

2.Rolling resistance force:

$$F_{rr} = m \times g \times cos\theta \times \mu$$

Total mass (m)=1800kg

Acceleration due to gravity g=9.81 m/sec^2

Rolling Resistance Coefficient (μ) =0.01

Gradient Angle (θ) = 5°= $\frac{5\times\pi}{180} = 0.087\ radians$

Velocity (v) = 50 km/hrs= 13.9 m/s

$\boldsymbol{F_{rr} = m \times g \times cos\theta \times \mu}$

$= 1800 \times 9.81 \times \cos 0.087 \times 0.01 \times (1 + \frac{13.9 + 3.6}{160}) = 195.14N$

$\therefore \boldsymbol{F_{rr} = 195.14N}$

3. Gradient (Uphill)resistance force:

$F_{gr} = m \times g \times sin\theta = 1800 \times 9.81 \times sin0.087 = 1539\ N$

$\therefore \boldsymbol{F_{gr} = 1539N}$

4. Acceleration force: $F_{acc} = m \times a = 1800 \times a$

Where from Newton's law of motion $v = u + at$

$\boldsymbol{but\ , a = \frac{v-u}{t}\ m/sec^2}$

Initial velocity u= 0 km/sec =0 m/sec

Final velocity v = 100km/hr = 27.7m/sec

Time taken to max velocity t= 10sec

$$\therefore F_{acc} = 1800 \times \frac{\mathbf{27.7 - 0}}{\mathbf{10}} = \mathbf{5000\ N}$$

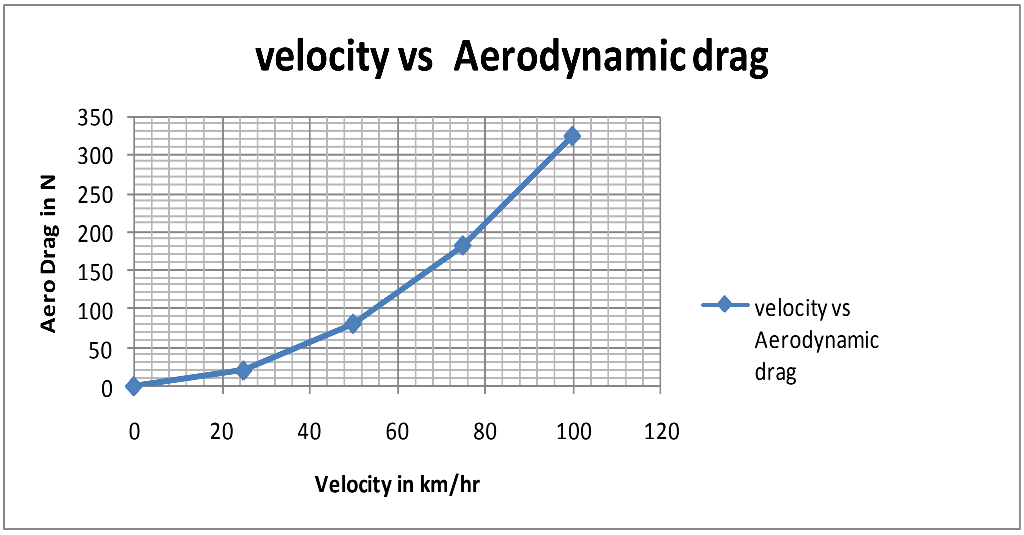
∴**Total Tractive Force (F_t)** is the sum of all resistive forces (road loads) acting on the vehicle.

$\therefore F_t = F_{aero} + \boldsymbol{F_{rr}} + F_{gr} + F_{acc}$

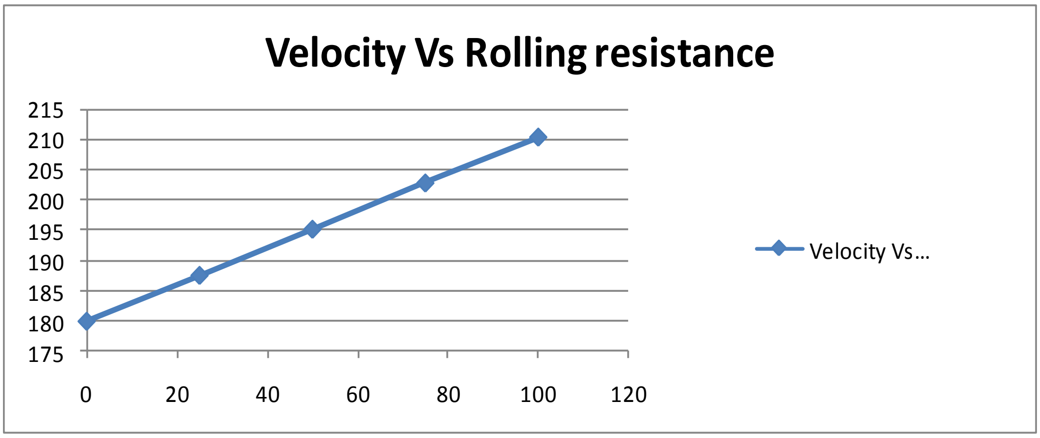
$$\therefore \boldsymbol{F_t = 80.8 + 195.14 + 1539 + 5000 = 6814.94\ N}$$

For different velocities evaluated following results						
Sl no	**Velocity in Km/hr**	**Aerodynamic drag force(Faero)**	**Rolling resistance force(Frr)**	**Gradient resistance force(Fgr)**	**Acceleration force(F acc)**	**Total Tractive Force (F_t)**
1	0	0	179.9	1539	5000	6718.9
2	25	20.2	187.5	1539	5000	6771.7
3	50	80.8	195.14	1539	5000	6864.94
4	75	181.8	202.8	1539	5000	6998.6
5	100	323.2	210.4	1539	5000	7172.6

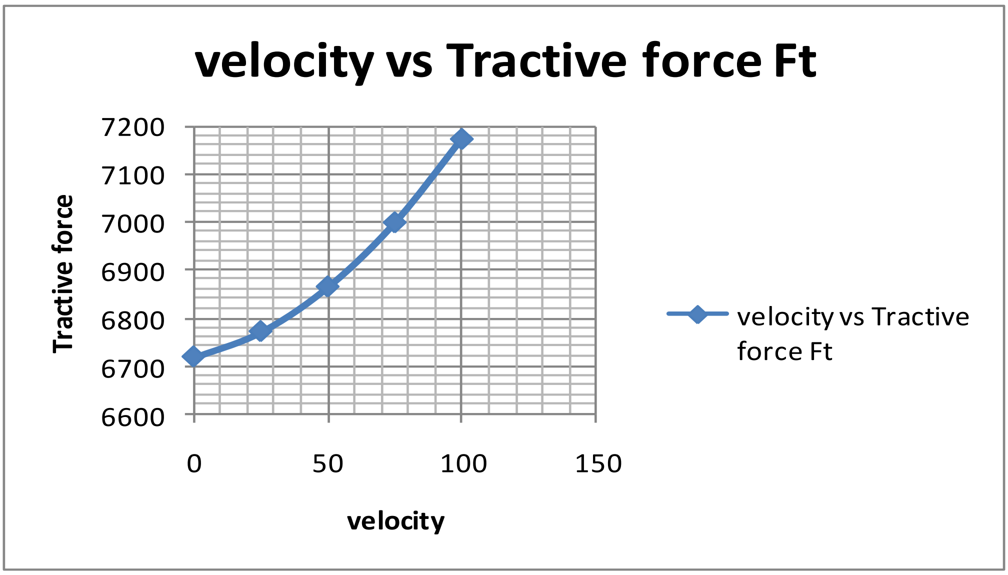
Plot between velocity v/s Aero dynamic drag



Plot between velocity v/s Rolling resistance



Plot between velocity v/s Tractive force



CONCLUSION:

The above results shows that variation in the velocity of electric vehicle variation of aerodynamic drag and rolling resistance but for gradiability and acceleration force is constant variation from the results.

REFERENCES

[1]Rony Argueta, "The Electric Vehicle," Technical Report, Santa Barbara College of Engineering. University of California, Mar. 2010.

[2] Dr NJS Gorst, Dr S J Williamson, Eur Ing P F Pallett and Professor LA Clark, "Friction In Temporary Works", Technical Report 071, School of Engineering, University of Birmingham, Birmingham, 2003.

[3] A. Dommenech, T. Domenech and J. Cerbiran, "Introduction To The Study Of Rolling Friction", American Association of Physics Teachers, Am. J. Phys. 55(3), March 1987.

[4] Modern Electric, Hybrid Electric and Fuel Cell Vehicles by Mehrdad Ehsani, Yimin Gao and Ali Emadi, CRC Press.

[5] Hybrid Electric Vehicles, Principles and Applications with practical perspective: Chris Mi, Wiley publications .