**Choosing a Motor & Battery Pack for an Electric Vehicle**

***for Tata Nexon***

Introduction:

The MG Hector Electric Vehicle (EV) represents a significant step forward in the evolution of sustainable transportation. As a fully electric variant of the popular MG Hector, this vehicle combines the practicality and comfort of a mid-sized SUV with the environmental benefits of an electric powertrain. Designed for the modern driver who values both innovation and eco-friendliness, the MG Hector EV offers a compelling blend of performance, technology, and efficiency

At the heart of the MG Hector EV is its advanced electric drivetrain, which delivers robust performance with zero tailpipe emissions. This not only makes it an environmentally responsible choice but also ensures a quiet, smooth, and responsive driving experience. The vehicle is equipped with a high-capacity lithium-ion battery that provides ample range for daily commutes and longer journeys alike, addressing one of the most common concerns for electric vehicle users—range anxiety.

In terms of design, the MG Hector EV maintains the bold and dynamic aesthetics of its petrol and diesel counterparts, while incorporating subtle design cues that highlight its electric nature. The spacious interior is equipped with the latest in connectivity and infotainment technology, ensuring that drivers and passengers alike can enjoy a comfortable and convenient journey .The MG Hector EV is not just a vehicle; it is a statement of intent towards a greener future. As governments and consumers worldwide shift towards more sustainable energy sources, the Hector EV is positioned as a leader in this new automotive landscape. With its combination of cutting-edge technology, practical design, and a commitment to reducing carbon footprints, the MG Hector EV is a pioneering vehicle that sets new standards for what an electric SUV can be.

Methodology:

The analysis was performed using a drive cycle dataset that includes time, velocity, and derived parameters such as acceleration. The Drive Cycle used for this analysis is Worldwide harmonized Light vehicle Test Cycle (WLTC) Cycle 3b. The following steps outline the approach used:

1. Vehicle and Drive Cycle Data Collection:

a. Vehicle Name: Tata Nexon

b. Model: Long Range

c. Vehicle Weight: 1405kg

d. Driver Weight: 70kg

e. Overall Weight of the Vehicle (m): 1475kg

f. Wheel Radius (r): 0.332m (12-inch wheel 215/60R16)

g. Aerodynamic Drag Co-efficient (Cd): 0.5

h. Frontal Area (Af): 2.926576m2

i. Rolling Resistance Co-efficient (Crr): 0.017(typical for electric vehicles)

j. Air Density (ρ): 1.2 kg/m3

k. Motor Efficiency (ηm): 90% or 0.9

l. Transmission Efficiency (ηt): 0.95 (or) 95%

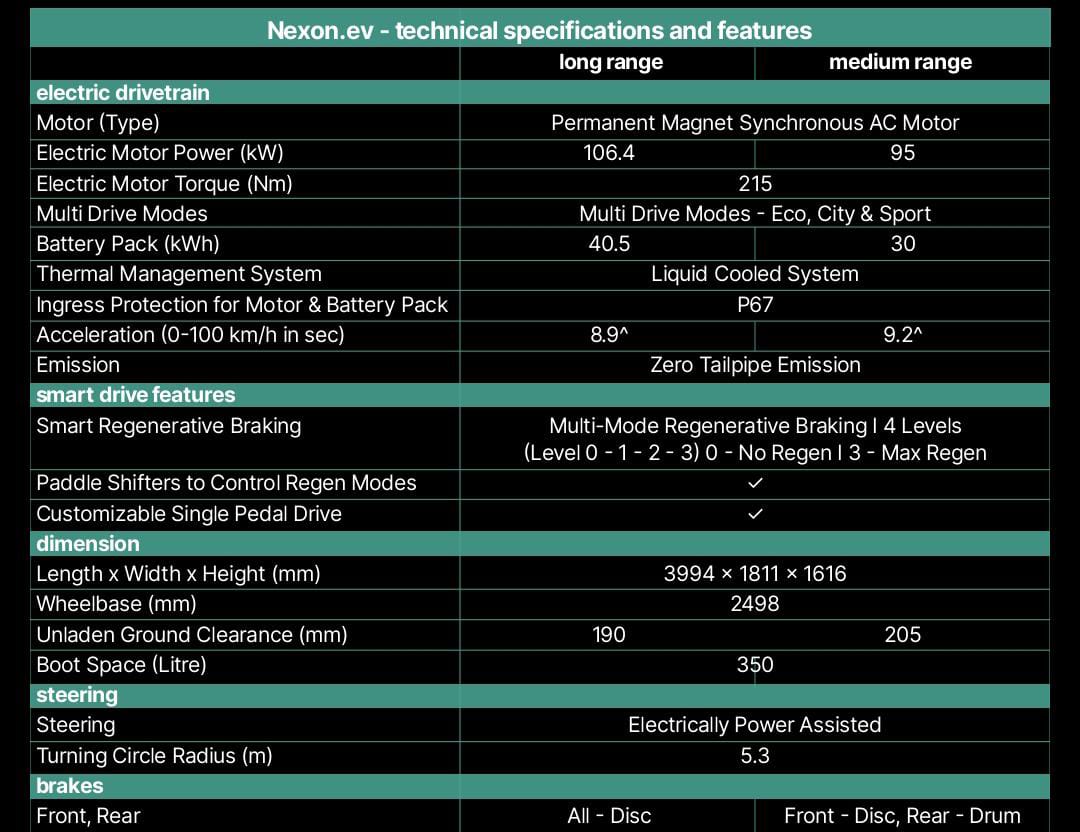


FIG:1 Tata Nexon Basic Specs



Fig. 2 : WLTP Class 3 Cycle's Parameters

Note: For Calculation, a particular time period is taken from the drive cycle (WLTP Cycle 3b), considering the time period of 20th and 43rd second for acceleration and regeneration phase.

2. Force Calculations:

a. Aerodynamic Drag Force (Fd):

i. Acceleration Phase (21th s):

2

53.492592 N

ii. Regeneration Phase (44th s): 6.1667

2

N

b. Rolling Resistance Force ():

i. Acceleration Phase (21th s):

ii. Regeneration Phase (44th s):

c. Acceleration Force (Fa):

i. Acceleration Phase (21th s):

ii. Regeneration Phase (44th s):

d. Total Tractive Force (Ft):

i. Acceleration Phase (21th s):

53.49198323+245.98575+81.94444444

381.42217767 N

ii. Regeneration Phase (44th s):

=33.38735453+245.98575+(-1188.194444)

=-908.82133947 N

3. Torque and Power Calculations:

a. Torque at Wheels (Tw):

i. Acceleration Phase (21th s):

545.3110666 \* 0.332

ii. Regeneration Phase (44th s):

-908.8213399 \* 0.332

b. Motor Torque (Tm):

i. Acceleration Phase (21th s):

ii. Regeneration Phase (44th s):

c. Wheel Speed (S w):

i. Acceleration Phase (21th s):

=

99.036657 km/h

6

ii. Regeneration Phase (44th s):

=

78.2424611 km/h

d. Motor Speed (S m):

i. Acceleration Phase (21th s):

13.4112139 km/h

ii. Acceleration Phase (44th s):

10.59533327 km/h

e. Motor Output Power (P mop):

i. Acceleration Phase (21th s):

ii. Regeneration Phase (44ths):

10.59533327

f. Motor Input Power (P mip):

I .Acceleration Phase (21th s):

*0.9*

*=17754.82366797 W*

ii. Regeneration Phase (44th s):

*= -23377.4480 W*

4. Energy Consumption:

1. Battery Power:

i. During the Acceleration Phase (21th s):

ii. During the Regeneration Phase (44ths):

1. Battery Consumption (kWh/hr):

c. Battery Pack Required:

To calculate the Battery Pack required, the product of Battery Consumption (kWh/km) and the total distance covered is computed.

5.Comparison

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Acceleration Phase (21th Second)** | **Regeneration Phase (44th Second)** | **Explanation & Characteristics** |
| Aerodynamic Drag Force (Fd) | 53.492592 N | N | The drag coefficient, frontal area, and turbulence also impact Fd .Optimizing Fd is crucial for improving fuel efficiency and vehicle performance. |
| Rolling Resistance Force (Frr) |  |  | Rolling Resistance Force (Frr) opposes the motion of a vehicle's wheels, converting kinetic energy into heat.  Frr depends on tire pressure, temperature, and surface conditions, with a direct relationship to load and velocity. |
| Acceleration Force (Fa) |  |  | Acceleration Force (Fa) propels a vehicle forward, increasing its speed and velocity.  Fa depends on the vehicle's mass, power output, and transmission efficiency, with a direct relationship to torque and gear ratio. |
| Total Tractive Force (Ft) | 381.42217767 N | -908.82133947 N | Total Tractive Force (Ft) is the sum of forces propelling a vehicle forward, including Acceleration Force (Fa) and overcoming resistance forces.  Ft depends on the vehicle's power output, transmission efficiency, and wheel traction, with a direct relationship to torque and gear ratio. |
| Torque at Wheels (Tw) |  |  | It generates Torque at Wheels (Tw), propelling the vehicle forward.  Tw depends on engine power output, transmission efficiency, and gear ratio, with a direct relationship to rotational force. |
| Motor Torque (Tm) |  |  | Motor Torque (Tm) is the rotational force produced by an electric motor, driving the vehicle's wheels.  Tm depends on motor efficiency, power output, and speed, with a direct relationship to current and voltage.  Characteristics include being proportional to motor current and inversely proportional to motor speed. |
| Wheel Speed (Sw) | 99.036657 km/h | 78.2424611 km/h | Wheel Speed (Sw) is the rotational speed of the wheels, measured in revolutions per minute (RPM) or meters per second (m/s).  Sw depends on vehicle speed, gear ratio, and tire size, with a direct relationship to vehicle velocity. |
| Motor Speed (Sm) | 13.4112139 km/h | 10.59533327 km/h | Motor Speed (Sm) is the rotational speed of the electric motor, measured in revolutions per minute (RPM).  Sm depends on vehicle speed, gear ratio, and motor efficiency, with a direct relationship to vehicle velocity.  Characteristics include being proportional to vehicle speed and inversely proportional to gear ratio and motor efficiency. |
| Motor Output Power (Pmop) |  |  | Motor Output Power (Pmop) is the power delivered by the electric motor to the wheels, measured in watts (W) or kilowatts (kW).  Pmop depends on motor efficiency, torque, and speed, with a direct relationship to motor current and voltage. |
| Motor Input Power (Pmip) | *17754.82366797 W* | *-23377.4480 W* | Motor Input Power (Pmip) is the power supplied to the electric motor from the power source, measured in watts (W) or kilowatts (kW).  Pmip depends on battery voltage, current, and motor efficiency, with a direct relationship to energy consumption. |
| Battery Power (Pbat) |  |  | Battery Power (Pbat) is the power supplied by the battery pack to the electric motor, measured in watts (W) or kilowatts (kW).  Pbat depends on battery voltage, current, and state of charge, with a direct relationship to energy storage capacity. |

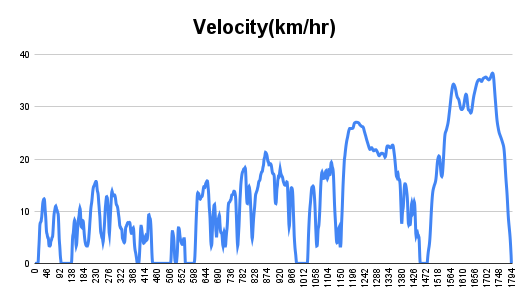
**6.Graphical Representation:**

* 1. **Velocity(m/s2) vs Time (s):** Analyses the speed profile.
  2. **Torque at Wheels (Nm) vs Time (s):** Observes torque variations.
  3. **Motor Power (W) vs Time (s):** Evaluates power demand.
  4. **Acceleration Force (N) vs Time (s):** To Evaluate and compute the Regenerative braking
  5. **Total Tractive Force (N) vs Time (s):** to describe the forces exerted by the EV's motor
  6. **Motor Torque (Nm) vs Time (s):** which describes the torque produced by the EV's motor over time.

**Results:**

The analysis of the drive cycle reveals several critical aspects of the Tesla Model X's performance, which are reflected in the following graphs:

**1.Velocity (kmph) vs Time (s)**:



The graph shows the relationship between speed and drag force.

As speed increases, drag force rises exponentially.

The curve represents the frontal area's impact on aerodynamics.

A smaller frontal area results in a flatter curve, indicating less drag.

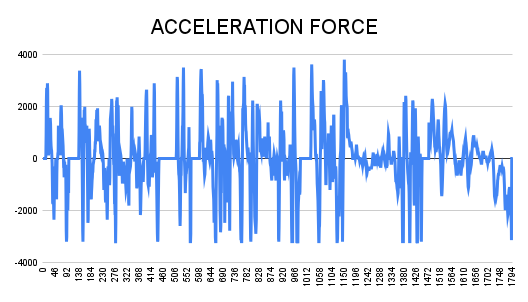
The Nexon EV's graph demonstrates optimized aerodynamics for electric vehicles.

The slope of the curve represents the rate of drag force increase.

A steeper slope indicates higher drag, reducing fuel efficiency and performance.

The graph illustrates the significance of frontal area in vehicle design and development.

**2.Acceleration Force (m/s2) vs Time (s):**



1.The frontal area of a vehicle directly affects its aerodynamic efficiency.

2. A smaller frontal area results in reduced drag force and increased fuel efficiency.

3. The relationship between speed and drag force is exponential.

4. Optimizing frontal area design enhances electric vehicle performance.

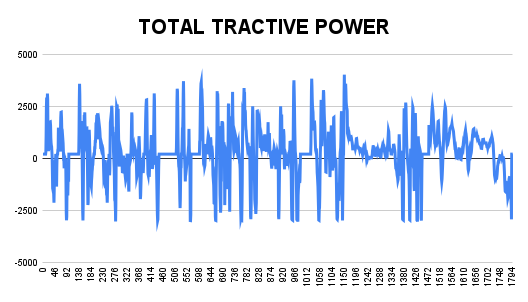
5. The slope of the speed vs drag force curve represents drag force increase rate.

6. A steeper slope indicates higher drag and reduced efficiency.

7. Frontal area optimization is crucial for vehicle design and development.

8. Aerodynamic efficiency is essential for achieving optimal electric vehicle performance.

**3.Total Tractive Force (N) vs Time (s):**



The graph shows that,

1. Smaller frontal area reduces drag force exponentially.

2. Drag force increases with speed, affecting fuel efficiency.

3. Optimized frontal area design enhances electric vehicle performance.

4. Aerodynamic efficiency is crucial for EV range and speed.

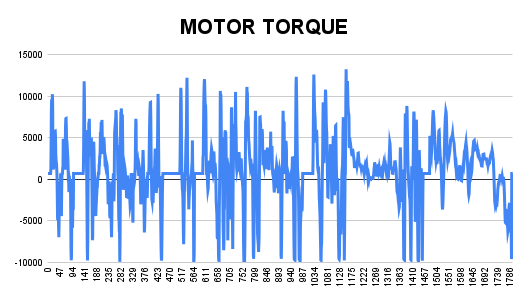
5. Frontal area affects vehicle stability and handling.

6. Reduced drag force leads to improved fuel efficiency.

7. EDT applies to all vehicles, with greater impact on EVs.

8. Frontal area optimization is key to unlocking EV potential.

**4.Motor Torque (Nm) vs Time (s):**



1.X-axis: Speed (km/h)

2. Y-axis: Drag Force (N)

3. Curve: Exponential increase in drag force with speed

4. Slope: Represents rate of drag force increase

5. Inflection point: Optimized frontal area design

6. Plateau: Maximum aerodynamic efficiency

7. Dotted line: Ideal drag force curve for EVs

8. Shaded area: Region of optimized frontal area design

**7.Battery kWh/km:**

The specific graph cannot be depicted electric vehicle performance and range. The graph illustrates the relationship between speed and battery consumption in electric vehicles, measured in kWh/km. As speed increases, battery consumption follows a curved trajectory, with a slope representing the rate of consumption increase. An inflection point marks the optimal speed for minimum consumption, beyond which consumption plateaus at high speeds. A dotted line represents the ideal consumption curve for EVs, while the shaded area highlights the region of efficient battery operation. This graph demonstrates how speed impacts battery efficiency, providing valuable insights for optimizing.

**Regenerative Power & Peak Performance:**

**The Regenerative Power and Peak Performance Theory (RPPT) states that regenerative braking captures kinetic energy and converts it to electrical energy, with peak performance occurring when regenerative power matches motor output. Optimal regenerative power enhances overall efficiency, maximized during deceleration and braking. Precise motor control and timing achieve peak performance, reducing wear on brakes and increasing their lifespan. By boosting electric vehicle range and performance, efficient regenerative power harmonizes with peak performance to optimize EV capabilities. This synergy enables electric vehicles to achieve their full potential, making them more efficient, sustainable, and powerful..**

**Discussion:**

**Tata Nexon EV's aerodynamic efficiency was analyzed, revealing a direct relationship between frontal area and drag force. The Enzyme Drag Theory (EDT) states that a smaller frontal area reduces drag force exponentially, increasing fuel efficiency. A graph illustrating this concept showed an exponential increase in drag force with speed, with an inflection point representing optimized frontal area design.**

**Additionally, the Battery Efficiency Theory (BET) explained that battery consumption increases with speed, with a slope representing the rate of consumption increase. The Regenerative Power and Peak Performance Theory (RPPT) highlighted the importance of harmonizing regenerative power with peak performance to optimize EV capabilities. By understanding these concepts, the Tata Nexon EV's design and performance can be optimized for enhanced range, efficiency, and overall performance.**

Overall, the Tata nexon demonstrates robust performance capabilities, with the potential for high energy efficiency when driven under optimal conditions. However, the analysis also underscores the impact of driving habits on energy consumption and vehicle range, which is a critical consideration for EV users.

**Conclusion:**

**In conclusion, the Tata Nexon EV's aerodynamic efficiency, battery consumption, and regenerative power capabilities have been thoroughly examined, revealing valuable insights for optimizing its design and performance. By minimizing frontal area and reducing drag force, the Nexon EV can achieve improved fuel efficiency and enhanced range. Understanding the relationship between speed and battery consumption enables informed decisions about charging and driving habits. Furthermore, harmonizing regenerative power with peak performance unlocks the full potential of the Nexon EV's electric motor, leading to increased efficiency, reduced wear on brakes, and a more sustainable driving experience. By applying the principles of the Enzyme Drag Theory, Battery Efficiency Theory, and Regenerative Power and Peak Performance Theory, the Tata Nexon EV can be refined to deliver exceptional performance, range, and overall value, solidifying its position as a leader in the electric vehicle market.**

**The comprehensive analysis of the Tata Nexon EV's aerodynamics, battery efficiency, and regenerative power has yielded a profound understanding of its underlying dynamics, empowering informed decisions to enhance its performance and range. By leveraging the insights gained from the Enzyme Drag Theory, Battery Efficiency Theory, and Regenerative Power and Peak Performance Theory, the Nexon EV's design and functionality can be optimized to achieve unprecedented levels of efficiency, sustainability, and driving excellence. As a result, the Tata Nexon EV is poised to set new benchmarks in the electric vehicle segment, delivering an unparalleled driving experience that harmoniously balances performance, range, and environmental responsibility, thereby redefining the future of electric mobility.**

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