PROJECT BASED LEARNING SYNOPSIS

On

CONVERT IC ENGINE TO ELECTRIC VEHICLE

DATE: ../11/2022

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Vehicle Name: Tata Nexon XZ+

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Chapter 1: Details of the Team members

S.no	Name	Engineering Field	Occupation	Role in Project
1	Anshul Kandari	Electrical engineering	Student	Made Whole Project Alone

1. Project Description

The transport sector is one of the biggest emitters of Carbon Dioxide, to reduce the overall carbon footprint, and a greener sustainable future. India has a huge challenge in shifting the transportation sector from ICE engines to EVs. This requires a lot of planning, research, and development. It is very important to create demand generation by making all government buses electric and offering tax exemptions for private EV owners. In this minor project, we converted a conventional IC engine vehicle of "NEXON XZ+" which comes under the one of most popular SUV segments to an electric vehicle. The ground clearance is 209 mm. It's powered by 1.2L 3cylinder petrol engine. The conversion requires removing the engine from the car, and putting motor, controller and on-board charger in this space. In this IC engine vehicle, source of energy is replaced by the battery.

The parameters of the existing ICE engine are:

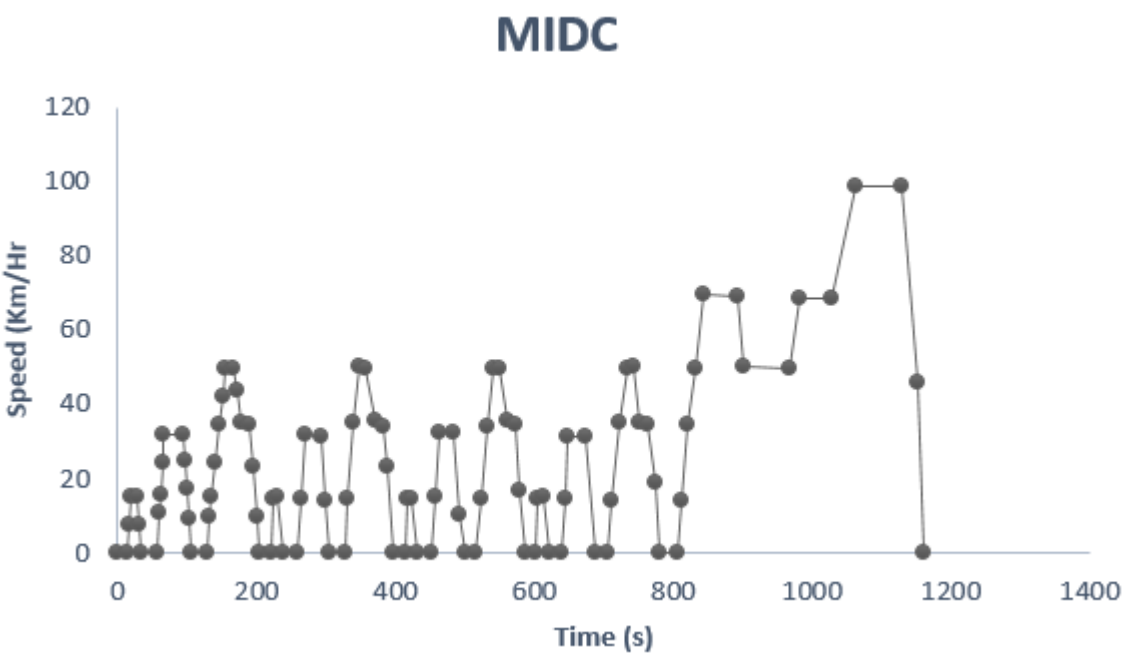
1. **Length:** 3993mm
2. **Height:** 1606 mm
3. **Width:** 1811 mm
4. **Wheelbase:** 2498 mm
5. **Kerb weight:** 1206 kgs
6. **Front tyre:** 195/60 R16
7. **Fuel type:** Petrol
8. **Mileage:** 16.3 kmpl
9. **Max Power:** 118bhp @ 5500 RPM
10. **Max Torque:** 170 NM @ 1750 RPM
11. **Drive train:** FWD

Converted Electric Vehicle Specifications

Tire Radius, R	0.32	m
Frontal Area (W*H), A	2.9084	m2
Mass [kerb_1785+driver_75+battery_450], m	1800	Kg
Velocity (150 Kmph), v	41.66	m/s
Acceleration (0-100 Kmph @ 9 sec), a	2.77	m/s2
Desired Range	300	Km
Drag coefficient, C_d	0.20	
Rolling resistance coefficient, C_r	0.015	
Grade, θ	0.52	Degree
Air density, ρ	1.2	kg/m3
G	9.8	m/s2

Table 2: Converted Electric Vehicle Specifications

MIDC CYCLE



2. Forces acting on Nexon XZ+

There are following standard forces that act on the vehicle:

- **Drag force (Fa_d)** = $0.5*\rho*C_d*A*v^2$

F_d= 0.5*1.2*0.20*2.9084* 41.6667^2 = 605.9176 N

- **Roll resistance force** (F_r) = m*g*cosα*μ*(1+(v+3.6)/160)

F_r= 1800*9.81*cos0.0872*0.01*(1+(41.6667+3.6)/160) = 225.6767 N

- **Grade force:** (F_g) = $m*g*sin\alpha$

F_g =1800*9.81*sin 0.0872 = 1538 N

- **Acceleration force** (F_{acc}) = $m*a$

F_{acc} = 1800*2.77= 5000.4N **Wheel torque (rated)** = $(Fa_d+F_r+F_g)*R$
= (605.9176 +225.6767 +1538) *0.32
= 758.2701 Nm

Wheel torque (peak) = $(Fa_d+F_r+F_g+F_{acc})$*R
= (605.9176 +225.6767 +1538+5000.4) *0.32
= 2358.3981 Nm

Wheel power (rated) = $(Fa_d+F_r+F_g)$*v/1000
= (605.9176 +225.6767 +1538) *41.6667/1000
=98.7331 KW

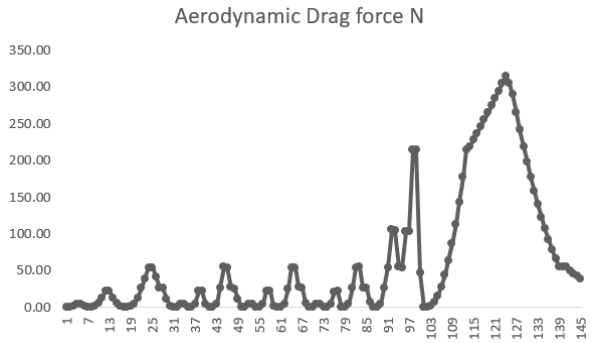
Wheel power (peak) = $(Fa_d+F_r+F_g+F_{acc})$*v/1000
= (605.9176 +225.6767 +1538+5000.4) *41.6667/1000
= 307.0883 KW

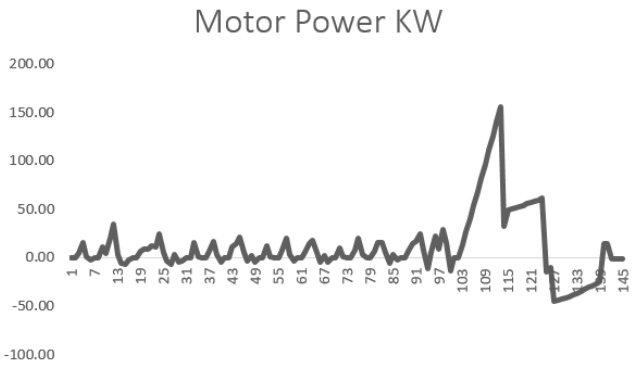
Wheel RPM (peak) = 60*v/(2*pi*R)
=60*44.44/ (2*3.14*0.32)
=1326.83
These are the theoretical values. When we selected a particular drive cycle like Modern Indian Drive Cycle (MIDC) and calculated wheel torque and wheel power at each instance, we get

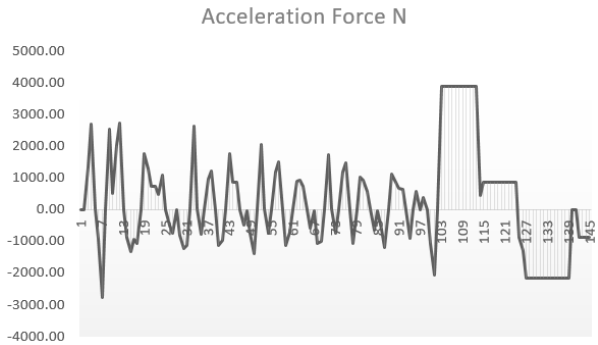
Wheel torque (peak)= 1514 Nm
Wheel power (peak)= 170 KW

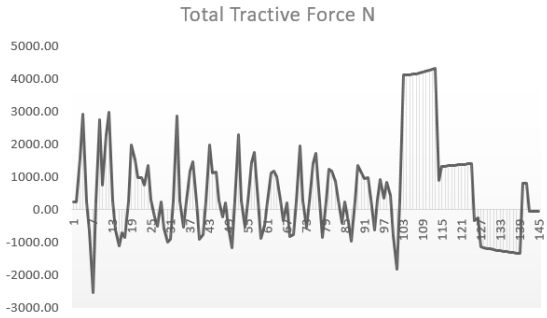
We also wanted to check that ‘is our vehicle is capable for starting gradability or not? So we also calculated wheel torque to start climbing at maximum gradient from standstill.

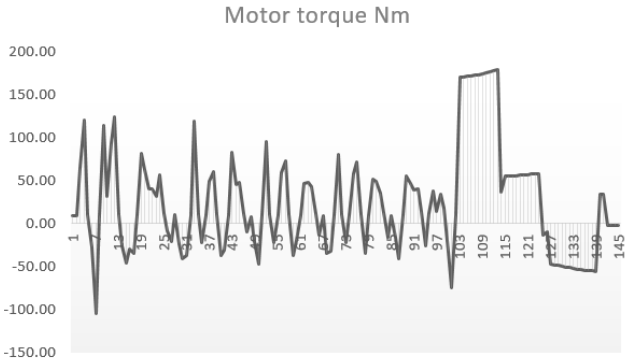
Force Plots


Aerodynamic Drag force N
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
1 7 13 19 25 31 37 43 49 55 61 67 73 79 85 91 97 103 109 115 121 127 133 139 145


Motor Power KW
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
1 7 13 19 25 31 37 43 49 55 61 67 73 79 85 91 97 103 109 115 121 127 133 139 145


Acceleration Force N
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
-1000.00
-2000.00
-3000.00
-4000.00
1 7 13 19 25 31 37 43 49 55 61 67 73 79 85 91 97 103 109 115 121 127 133 139 145


Total Tractive Force N
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
-1000.00
-2000.00
-3000.00
1 7 13 19 25 31 37 43 49 55 61 67 73 79 85 91 97 103 109 115 121 127 133 139 145


Motor torque Nm
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
1 7 13 19 25 31 37 43 49 55 61 67 73 79 85 91 97 103 109 115 121 127 133 139 145

Gradeability Test

For Our Electric XUV:

We consider Max Gradient 30° or 58%
Velocity= 5 m/s
Acceleration= 0.5 m/s2

Wheel power = $(F_d+F_r+F_g+F_{acc})$*v/1000
= 36.84 KW

Wheel torque = $(F_d+F_r+F_g+F_{acc})$*R
= 2980.3 Nm

Final torque on motor shaft = 2980.3 /10
= 298.03 Nm

Motor Specification

a. Type of Motor-3 phase PM-SynRM
b. Model-EM-PMI375-T500
c. Manufacturer -Danfoss
d. Motor Voltage - 500
e. Motor Rated Power (Kw) - 148
f. Motor Peak power (Kw) - 300
g. Motor Rated Torque (Nm) - 442
h. Motor Peak Torque (Nm) - 736
i. Motor Rated RPM - 3200
j. Motor Peak RPM - 4000
k. Efficiency- 96%

3. Battery Calculations

Energy Consumption (WH/Km)	162	Assuming DOD	0.85
Range (Km)	300	Voltage (V)	320

Table 3: Battery calculations

Length (m)	0.07015	Voltage	3.63
DIA (m)	0.0211	AH	3.2
Mass (Kg)	0.085	Volume(L)	0.02

Table 4: Panasonic cylindrical cell NCR-18650B Specifications

Energy of Battery Pack = Energy consumption*Range/(DOD*1000)
= 57.16 KWH

No. of modules in series = Battery Pack Voltage/Cell Voltage
=320/3.6
=88.88~ 89

No. of cells in module (Parallel) =57.16*1000/(89*3.63*3.2)
=55.43 ~ 56

No of cell in pack =88*56
=4928

Actual Pack Capacity = 55*3.2*89*3.63/1000
= 56.86 KWH

Battery Pack Design

Combination of cells = 56P88S

Each Pack Dimensions

Cell Holder Dimension = (22.5*22.5*20) mm

Length = 55*0.0225 =1.2375 m

Width = 89*0.0225 =2.0025 m

Height = 0.07015+0.04 = 0.11 m

Whole battery Pack volume = 1047 LTR
Whole battery Pack Mass = 4928*0.085
= 418 Kg

We are putting our Battery Pack on chassis. Max. space available.
We are removing OEMs Engine and putting Motor, controller and On board charger in that Space.

Battery Pack Thermal Management

Battery Peak Current = Peak Power/ Battery Voltage
= 325104/320
= 1015 A
Discharge Rate = Peak Current/ Battery Rated current
= 1015/176
= 5.76 C
Heat generation in cell = (Cell peak current) ^2 * cell Resistance
= (3.25) ^2 * 0.03
= 0.31 W
Heat generation in pack = 55*89*0.31
=1517.45 W
Convection Coefficient (h) = Total Heat generation/ (surface area * Temp Diff.)

Let Ambient Temp. =25 °C
Cell Max Temp. =55 °C

Convection Coefficient (h) = 1517/ ((1.2375 *2.0025) *30)
= 20.40

Typical values of the convective heat transfer	
Process	h $(W/m^2 \cdot K)$
Free convection	
Gases	2 - 20
Liquids	50 - 1000
Forced convection	
Gases	25 - 300
Liquids	100 - 40,000
Convection with phase change	
Boiling or condensation	2500 - 100,000

Figure 1: Typical values of the convective heat transfer

So we required Forced liquid Convection.

Battery Pack Specification

a. Battery Chemistry -Li-ion
b. Type of Cell -Cylindrical
c. Model - Panasonic NCR-18650B
d. Manufacturer - Panasonic
e. Voltage (V) -320
f. Capacity (AH) -176
g. Capacity (KWH) -56.86

4. On board Charger Specification

a. Model- OBC82
b. Manufacturer- Innolectric
c. Input Voltage- 380-480 VAC (3- AC)
120-240 VAC (1- AC)
d. Output Voltage (V)- 800 VDC
e. Power- 22 KW

5. Research Methodology

It involves various steps required during the conversion of Electric Vehicles like:

1. **Step 1:** Vehicle selection for retrofit, collecting OEM's technical specification of vehicle and specify converted electric vehicle performance like Range, Top speed and acceleration.
2. **Step 2:** Calculation of various forces acting on the vehicle.
3. **Step 3:** Calculation of Power and torque requirements by the vehicle to select the motor to fulfil required performance.
4. **Step 4:** Create model in Simulink to justify all calculations in MIDC and calculate energy consumption of vehicle.
5. **Step 5:** Battery pack calculation and design it to put in boot as per space available
6. **Step 6**: Battery pack thermal management requirement
7. **Step 7:** On-board charger selection

6. Tools used:

The calculations were done on Microsoft Excel, DIYGURU recorded lectures.

7.Bibliography

DIYguru Nanodegree programme in Electric Vehicles. (n.d.). Retrieved from DIYguru: https://diyguru.org
Mohmmad Saad Alam, R. K. (n.d.). *Infrastructure and Technologies for Electric Vehicles.* IGI Global.

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