

Battery Design Report

moto manipal e powertrain subsystem

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# Choice of Battery Chemistry (18650 Cell):

## Why Lithium Ion?

To decide the battery pack of an electric bike the first thing we need to decide is the type of battery we will be using. Nowadays lithium ion batteries are best suited for the application of electric vehicles. There several reasons why lithium ion batteries are chosen over other type of batteries such as lithium polymer batteries.

Lithium ion batteries have higher energy density and lower self-discharge than lithium polymer batteries.

Lithium ion batteries cost lesser as they have lower manufacture cost.

Lithium polymer batteries have shorter lifespan due to the electrolyte getting harder over time.

Lithium polymer batteries can suffer from gassing which leads to swelling of the battery.

For the application of an electric motorcycle the lithium ion battery would be a better option because of its higher energy density and lower self-discharge. This helps in packing more energy in a smaller case.

# Choice of Cell:

## Why NMC?

The choices are LMO, LFP, LNMCO(NMC), LCO, NCA, LTO:

We chose NMC because:

High charged voltage: can be charged till 4.2 V even with a safety factor we can charge them to 4V giving us some more reserve energy.

High specific energy/density: 18650 cells have 2500mAh to 3500mAh of charge capacity and hence can be considered energy dense. If packed efficiently the battery-level Specific density can be increased.

Lifespan: Considering that we are making a commercial bike we would hope for a longer battery span. The average cycle life is from 1000-2000. If used daily for 50 km usage we can have 16 years worth of average usage. LFP and LTO have better life span but fall short in specific energy.

Specific Power: It is average. Can only sustain 1C or lower rate for long periods. If C-rate is increased then lifespan is shortened. 4C to 5C rate can be sustained.

Cost: It is also average. 18650 cell of 3500mAh costs around 200 Rs.

Thermal runaway: At 210 Celsius, the thermal runaway is average. NCA has high specific energy but a very low thermal runaway at 150 Celsius.

Future application: The amount of interest in NMC and NCA is increasing in the aspect of EVs so it has the most growth potential as in the amount of research and development of these cells will increase leading to better and more efficient NMC cells.

# Deciding Capacity:

## Why 16P?

Considering the motor wattage as 2 Kw.

Considering the placement of all the heavy electrical components such as the battery, motor, motor controller e.t.c. and the position of the rider the overall weight on the rear wheel of the bike is taken to be about 55% of the total weight. Assume total weight of the bike and rider to be 190kgs.

Hence, total weight acting on the rear wheel will be = 0.55\*190 = 104.5kgs

Stall torque is the amount of torque required to move the bike from a standstill which is calculated using the radius of the wheel that is 320mm or 0.32m and coefficient of static friction. The coefficient of kinetic friction is mk = 0.015.

Stall torque = Ti = msmgr = 0.6\*104.5\*0.3200 = 196.6272Nm

Now the total force acting on the bike when it is moving at an inclination ‘q’ can be calculated using the following formula

Drag force is the force acting on the frontal area of the bike given by

V is the average velocity taken as 40kmph or 11.1111m/s

Drag force = ½\*r\*Cv\*A\*V­2 = ½\*1.1839\*0.55\*0.44\*11.11112 = 17.6853N

Density of air at 298K = r = 1.1839

Cv is the coefficient of drag = 0.55

A is the frontal area of the bike = 0.44m2

Feq = mkmgCos(q) + mgSin(q) + drag force = 110.5811N

Continuous torque of the bike is the torque that is subject to variation denoted by Tf =Feq\*r = 35.3859Nm

Power drawn by the motor is calculated by

Pav = 2pNwTf/60

Nw is the wheel rpm calculated using the motor rpm Nm and the gear ratio that is equal to 3.84

Nm = V\*60/(2pr) = 331.5724rpm

Nw= 331.5396/3.84 = 86.3469rpm

Pav = 319.9673W

Current drawn by the motor is given by

I = Pav/Voltage = 319.9673/48 = 6.6659A

Since only 70% of the capacity of the battery is used

Hence, the capacity required to keep the battery running for 5 hours at an average velocity of 40kmph is equal to 6.6659\*5/0.7 = **47.6141A-hr**

Hence keeping a safety factor of 20 percent we get **56Ah** i.e 16P = 16\*3500mAh

# Deciding Voltage:

Using the previous calculations by assuming a current of 41 A for driving 2kW motor we would need around 48 Volt battery to supply it. 48V\*41A = 2kW.

As the nominal voltage of each cell is around 3.7V it comes around to be 48 Volt when 13 of them are joined in series. For NMC, more than 1C rate of current consumption for prolonged periods is not advised and hence by keeping a factor of margin for voltage reduction after some charge has been drained.

The voltage supplied is directly proportion to the max speed of the bike. And the current supplied is directly proportional to the torque available.

Hence by keeping at 48 v we think we have found a balance of both. If voltage needs to be increased either range will be lost or more weight shall be added for the same range.

And the components of the electric powertrain have are made for most used voltages like- 24v,36v,48v,64v,72v etc.

Increasing the voltage means the cells would be run at very low Crates to compensate for motor wattage and that would result in a bike having a very low usable specific power.

# Modularizing using SCM/PCM approach:

## Reason:

## Approach:

## Number of Modules:

# BMS

# Battery Packing Structure and Cooling:

## inline packing or stagerred:

Inline packing means that the cells are placed perpendicular to each other in row and column arrangement. Staggered arrangement resembles honeycomb structure.

When using staggered arrangement :-

Volume: There is an average of 10-13 percent of reduction in volume.

Radiation: The amount of heat radiation is reduced by a small percentage. And hence temperature elevation is raised by 0.2%. [1]

Conduction: Conduction of heat is increased due to which the gradient of heat between the outer and inner cells is reduced by more than 20 percent.[1]

[[1]](#footnote-1)Tab placement: It becomes a bit more complex as now they are placed at a slant and clearances are smaller.

Area of covering materials: It is reduced by a small factor but still helps to decrease some weight if required.

Note: this sort of arrangement is better when used in conjunction with passive cooling as conduction and radiation will be the only pathway of heat conduction. When active cooling is used it is better to use inline arrangement so that straight channels of fluent are created easier flow.

# Safety and Insulation:

## Tabs:

## Wires:

## Casing:

## Fuse:

# References:

1. [Study on the thermal interaction and heat dissipation of cylindrical Lithium-Ion Battery cells](https://www.sciencedirect.com/science/article/pii/S1876610217360630)
2. [Encyclopedia on various types of battery technology](https://batteryuniversity.com/learn/article/types_of_lithium_ion)

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1. Check reference page for research and data. [↑](#footnote-ref-1)