Project-1

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1) Explain different architecture (PHEV, REV, BEV) in brief with current selling vehicles?

The PHEV is called Plug-in Hybrid EV, the basic concept of PHEV is it has both prime mover IC engine as well as electric motor.
PHEV have nearly the same arrangement of components like Battery EV and Hybrid EV. But, there is only difference, which is that PHEV can travel a greater distance on electric motor power alone.

There are few PHEV cars in market like Toyota Corolla, Volvo XC 40, BMW 3-Series. The Mitsubishi Outlander is PHEV, it has specifications as Battery- 12 kWh (300 V), Motor- 60 W, IC Engine capacity- 2.0 L.

The REV is called Extended Range EV, the basic concept of REV is it has also both IC engine and electric motor.
Here, the main prime mover is electric motor not IC engine, simply because IC engine is not directly connected to wheel shaft.. IC engine is used to provide the electrical current to motor (main prime mover). Here, IC engine is act as a generator only. The IC engine's rotational power output is converted into electrical energy with the help of generator. The assembly of IC engine + generator is called Range Extender. Chevrolet Volt is the example of REV. it has specifications as Battery- 18.5 kWh, Motor- 111 KW, Engine capacity- 1.5 L. One thi9ng to be noted here in Mitsubishi Volt is it has very higher battery pack capacity and motor power as it is the main prime mover than in the case of PHEV cars.

The BEV is called Battery EV. In BEV, the IC engine section is completely absent. Only battery + motor assembly is present. So, BEV is fully eco-friendly than REV and PHEV. It has nearly zero emission of green-house gases and BEV has 100% electrification. It has plug-in charging feature and BEV has simplest architecture unlike REV and PHEV. BEV has less moving part because of absence of IC engine. There are lot of BEV cars available in market like Tata Nexon EV, Tesla's all model cars. Tata Nexon EV has specifications as Battery- 30.2 kWh, Motor- 95 KW with single speed transmission.

2) What are the different Li-ion cell chemistry and how do they affect the performance?

The Li-ion cell has different elements like Anode, Cathode, Electrolyte, Separator, and Current Collector.
Different Anode Chemistry: Graphite, Lithium Carbide (LiC_6), Lithium Titanium Oxide (Li_4TiO_{12}).

Different Cathode Chemistry: Lithium Cobalt Oxide (LiCoO2), Lithium Manganese Oxide (LMO), Lithium Ferus Phosphate (LFP).
Separator Material: Single Layer Polypropylene, Multilayer Polyethylene.
Different Electrolyte Chemistry: Salt- Lithium, hexafluorophosphate ($LiPF_6$), Lithium perchlorate ($LiClO_4$). Solvents- EC/ PC/ DC/ EMC/ DEC. Additives- VC/ VA/ FEC. Ceramic Polymer Composite. Current Collector Material: Copper (Cu), Aluminium (Al). The cell chemistry of Li-ion battery affects the performance in many ways. The cell voltage is directly related to the oxidation and reduction reaction. The rechargeability of battery depends upon the electrochemistry. The cell chemistry also affects the cycle life of battery, as anode plating and chemical breakdown cause the drop into number of cycle. So, actual life will be depend upon the cell chemistry. The self discharge phase occurred in battery, this is because of cell chemistry. The unwanted chemical reaction occur when the cell or battery is in no-use. This unwanted chemical reaction cause the self discharge of battery. So, cell chemistry affects the different performance parameters.

3) What is C-rate? How does it affect the cell life, thermal aspects?

C-rate is basically the rate at which the battery charge or discharge, it is the division of current (A) and capacity (Ah) [current (A)/ capacity (Ah)]. For example, there is A battery with 100 Ah capacity and have 100 A discharge current so C-rate would be going to 1C (c-rate value). If B battery with the same capacity of 100 Ah have 50 A discharge current so C-rate would be 0.5C.

Basically, battery B has half the discharge capacity than battery A. battery A will fully discharged in 1 hour while battery B will fully discharged in 2 hours. The higher C-rate decreases internal resistance. Thus the internal resistance is directly proportional to the number of cycles. So lower internal resistance means lower cycle life. At high amount of current flow some of the energy can be lost and turned into heat, so C-rate also affects the thermal aspect.

4) What are the advantages of cylindrical cells and your opinion on selection parameters in Ather 450X?

Cylindrical cells has

Higher Specific Energy.
Good Mechanical Stability.
More safer than other cells because it has metal casing unlike plastic packing in pouch cells. So cylindrical cells are more durable.
Good Calendar life.
Low Cost.
Good Cycle life.

As per my opinion, at first the IP rating of battery is good as 67 which is used in Ather 450X.
The battery pack capacity selection of 2.9 kWh is optimum battery capacity for selection as it provides enough energy to run the motor at an adequate speed for Indian roads. The range of Ather 450X is also high as 116 Km. Nominal discharge is 1.25C which is actually not much higher, because at this C- rate the cell life won't be affected.
The weight of the battery pack is 23.16 kg. which is moderate and not high so that the total weight of vehicle wouldn't be going to higher.
The volume of battery pack is 0.008252 m^3 which is proper as it should be in order to occupy less space in vehicle body.
The Depth of Discharge (DOD) is 80%, which means to show the useable battery pack capacity as in actual scenario apart from the ideal 100% useable battery pack capacity. Well, 80% is not that much good DOD and it has to be more than 80%.

5) Add screenshot of simulation in excel or Simulink?

E-Bike Battery Pack Calculation

Samsung 40T 21700 4000 mAh Cell