Project : Mechanical design of battery pack

Aim: To develop a mechanical design of battery pack based on the required energy capacity Nanophosphate High Power Lithium Ion Cell ANR26650M1-B: A123's high-performance Nanophosphate lithium...

Nanophosphate High Power Lithium Ion Cell **ANR*26650*M1-B:**

A123's high-performance Nanophosphate lithium iron phosphate ($LiFePO_4$) battery technology delivers high power and energy density combined with excellent safety performance and extensive life cycling in a lighter weight, more compact package. Our cells have low capacity loss and impedance growth over time as well as high usable energy over a wide state of charge (SOC) range, allowing our systems to meet end-of-life power and energy requirements with minimal pack oversizing.

Applications:

Commercial Solutions:

Advanced lead acid replacement batteries for:

- Datacenter UPS

- Telecom backup
- IT backup
- Autonomously guided vehicle (AGV's)
- Industrial robotics and material handling equipment
- Medical devices

Government Solutions:

- Military vehicles
- Military power grids
- Soldier power
- Directed energy

Grid Solutions:

- Frequency regulation
- Renewables integration
- Reserve capacity
- Transmission and Distribution

Transportaion Solutions:

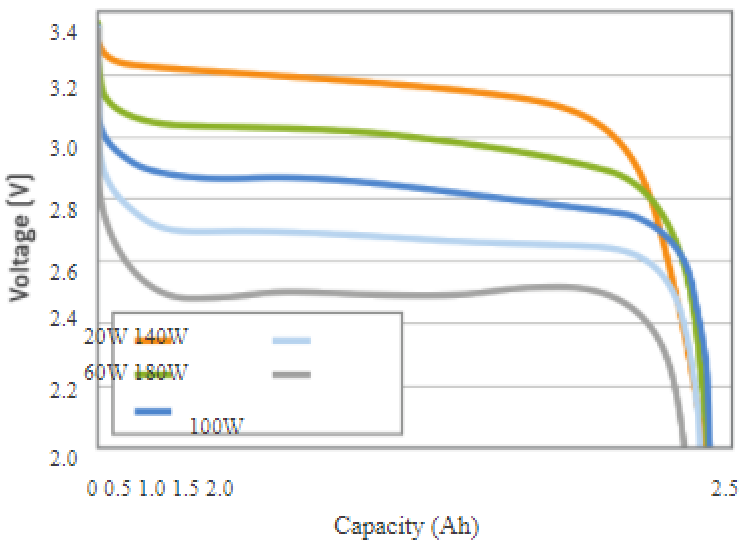
- Commercial vehicles
- Off-highway vehicles
- Passenger vehicles

ANR*26650*M1-B Technical data:

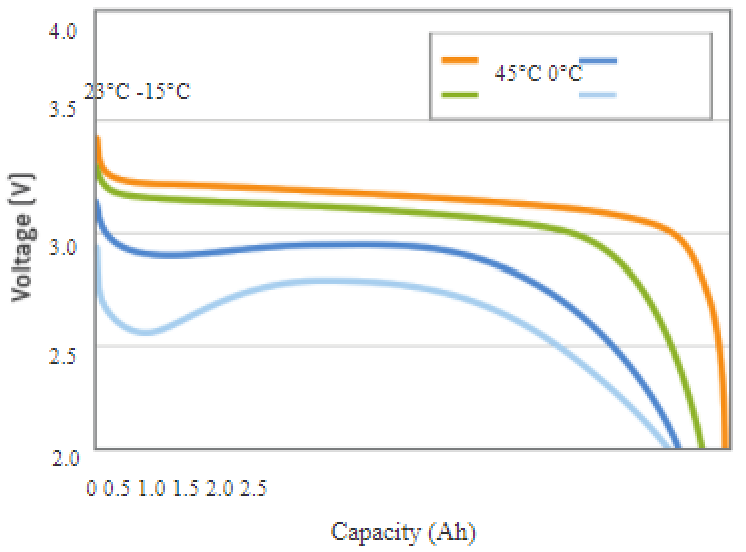
Cell Dimensions	26 x 65 mm
Cell Weight	76 g
Cell Capacity (nominal/minimum) (0.5C Rate)	2.5/2.4 Ah
Voltage (nominal)	3.3 V
Internal Impedance (1kHz AC typical)	6mΩ
Power	2600 W/kg
Recommended Standard Charge Method	2.5A to 3.6V CCCV, 60 min
Recommended Fast Charge Method to 80% SOC	10A to 3.6V CC, 12 min

Maximum Continuous Discharge	50 A
Maximum Pulse Discharge (10 seconds)	120 A
Cycle Life at 20A Discharge, 100% DOD	>1,000 cycles
Operating Temperature	-30°C to 55°C
Storage Temperature	-40°C to 60°C

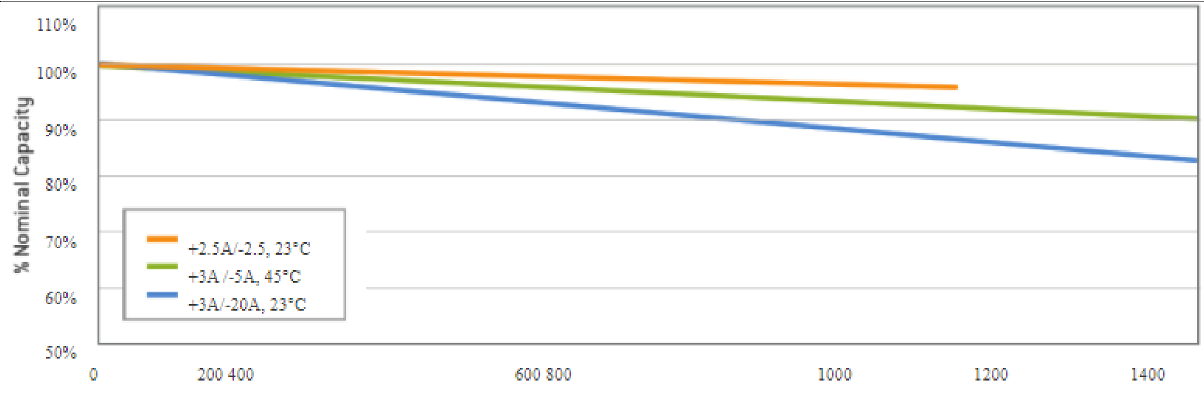
Constant Power Discharge Characteristics at 23°C :



2.5C Constant Current Discharge at Various Temperatures:



Cycle Life Performance, 100% DOD, Various Temperatures and Discharge Rates:



About cell:

The LithiumWerks ANR26650M1-B is the next generation of **A123** Systems' pioneering 26650 cylindrical cell, now with greater power and energy density and lower impedance. This versatile lithium ion cell is suitable for a wide variety of applications and system designs.

About module:

A battery management system (BMS) is any electronic system that manages a rechargeable battery (cell or battery pack), such as by protecting the battery from operating outside its safe operating area, monitoring its state, calculating secondary data, reporting that data, controlling its environment.

About Battery pack:

A battery pack is a set of any number of (preferably) identical batteries or individual battery cells. They may be configured in a series, parallel or a mixture of both to deliver the desired voltage, capacity, or power density.

Mechanical Design of battery pack:

The high voltage battery it is one of the most important component of a battery electric vehicle (BEV). The battery parameters have a significant influence on other components and attributes of the vehicle, like:

- maximum traction motor torque
- maximum regeneration brake torque
- vehicle range
- vehicle total weight
- vehicle price

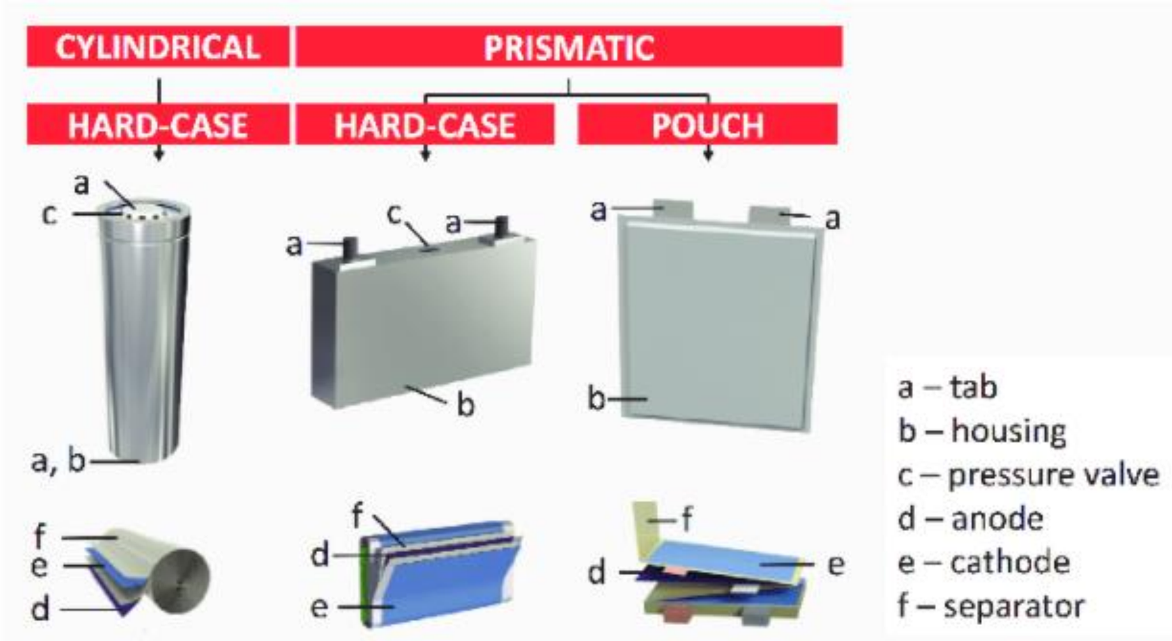
Pretty much all major aspects of a pure electric vehicle (EV) depend on the parameters of the high voltage battery.

For our electric vehicle battery design we are going to start from 4 core input parameters:

- chemistry
- voltage
- average energy consumption of the vehicle on a driving cycle
- vehicle range

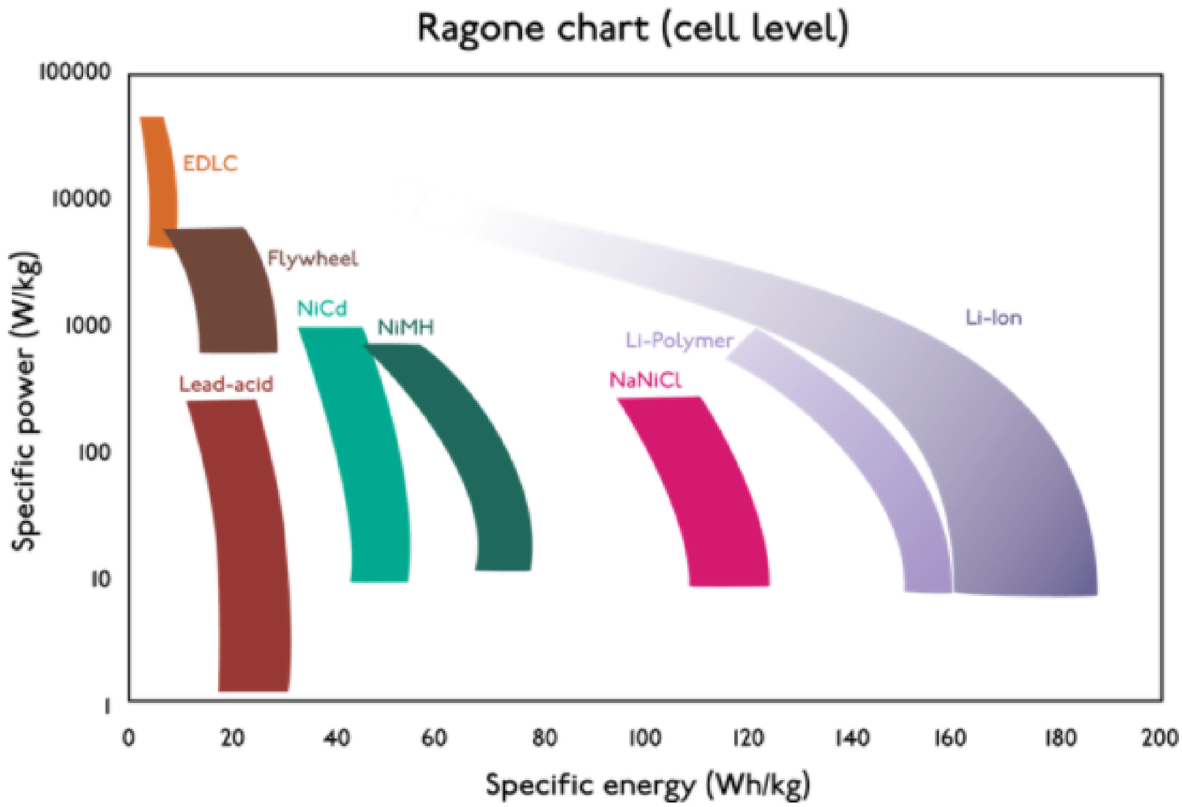
A battery consists of one or more electrochemical cells (battery cells) which are converting chemical energy into electrical energy (during discharging) and electrical energy into chemical energy (during charging). The type of elements contained within a battery and the chemical reactions during discharging-charging events define the chemistry of a battery.

A battery cell consists of five major components: electrodes – anode and cathode, separators, terminals, electrolyte and a case or enclosure. For automotive applications there are different types of cells used:



Individual battery cells are grouped together into a single mechanical and electrical unit called a battery module. The modules are electrically connected to form a battery pack.

There are several types of batteries (chemistry) used in hybrid and electric vehicle propulsion systems but we are going to consider only Lithium-ion cells. The main reason is that Li-ion batteries have higher specific energy [Wh/kg] and specific power [W/kg] compared with other types.



EV design - Battery calculation:

Assumptions:

Battery energy = 18 kwh

Voltage (to run the vehicle) = 400V

(i) Energy = 18 kWh

(ii) Number of cells (N) = energy / (nominal voltage*capacity)

N = 18000 / (3.3*2.5)

N = 2182

We need a minimum of 2182 cells to get 18 kWh energy, now based on that, we need to decide configuration – series and parallel.

In series configuration capacity remains the same and voltage will be the sum of individual cell voltage.

In a parallel configuration, the voltage remains the same and capacity accumulates.

And we assumed 400 Volts are need to run the vehicle.

The nominal voltage of one cell is 3.3 V

Number of series cells required to produce 400 V (Ns) = voltage required / nominal voltage of one cell

Ns = 400 / 3.3

Ns = 121.21 = 122

122 cells are connected in series will generate 400 voltage and the capacity of the whole module will be 2.5 Ah

Now we need to find the number of cells which will be connected in a parallel configuration

Np (cell in parallel) = total cell / Ns

Np = 2182 / 122

Np = 17.8 = 18

Hence we take 18 cells for each parallel row, although it is exceeding the required capacity, that is negligible.

Cell architecture = 122 Series and 18 Parallel = 122S18P

(iii) Battery capacity:

We know parallel configured cell multiplies individual cell capacity so,

Capacity = parallel cell row*individual cell capacity

Capacity = 18 * 2.5

Capacity = 45 Ah

(iv) Current supplied by the battery

We have already calculated battery capacity which is 45 Ah means it is going to supply 45 A current per hour. which can be considered as C-rate.

(v) Range:

Let's powertrain energy consumption = 100 Wh/km at 70% powertrain efficiency

Range = Capacity / energy consumed per kilometre

Range = 18000 / 100

Range = 180 km

So,our vehicle will be able to cover around 180 km with current parameters.

(vi) Internal Resistance of Battery:

The entire resistance encountered by a current as if it flows through a battery from the negative terminal to the positive terminal is known as internal resistance of battery.

(vii) Battery Dimensions:

ANR26650 cell has 26mm diameter and 65mm height. On the basis of that we need to decide battery size of battery casing.

Length of casing (L) = number of cells at series*(cell diameter (26) + margin at both side of cell (4)) + clearance at side (diameter of edged cell + margin)

L = 122*30 + 60

L = 3720 mm

Breadth of casing (B) = number of cells at parallel*(cell diameter (26) + margin at both side of cell (4) + clearance at side (diameter of edged cell + margin)

B = 18*30 + 60

B = 600 mm

Height of casing (H) = 65+35 (Height of cell + margin for wiring ,Cell holders and metal strips)

H = 100 mm

(viii) Weight of battery pack

Cell weight = 76g

Number of the cells = 2182

Battery pack weight (W) = cell weight*number of cells + weight of accessories

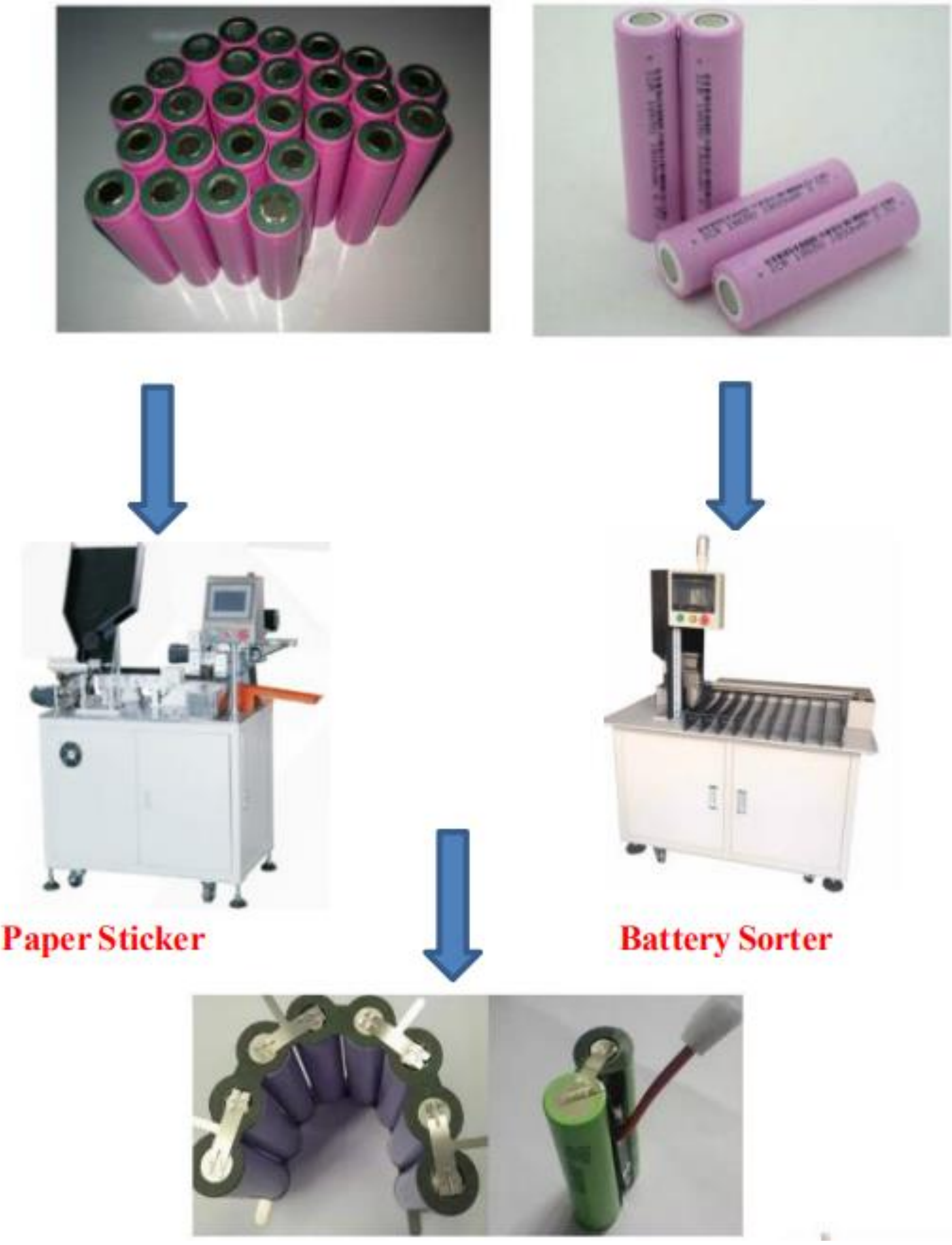
W = 76*2182 + 4.5 = 165.8 + 4.5 = 170.3 kg

Cylindrical battery pack assembly equipment:

Product Name	Description
Automatic Cylindrical Battery PVC Heat Shrink Wrapping Machine	Film speed:50~70PCS/MIN Film precision:±0.1MM
512 Channel Battery Tester	5V 2A/3A/5A/6A 512 Channel Battery Testser optional
Battery Labling Insulation Paper Sticking/Pasting Machine	Sticker Matrials:Barley paper or PVC Barley paper Maxium 350mm;Scroll Internal Diameter 72-75MM
Battery Sorting Machine	(5/6/9/11/13/22 Channel Battery Sorter optional) Data record funtion is selectable
Manual Spot Welding Machine	Pneumatic AC Spot Welding Machine (Single Welding Point or Doubel Welding Point)
Manual Spot Welding Machine	AC Pedal Manual Spot Welding Machine
Manual Spot Welding Machine	AC Pulse Pneumatic Spot Welding Machine
Manual Spot Welding Machine	DC Output Spot Welding Machine
Manual Spot Welding Machine	5000A/8000A Pneumatic Inverter DC Spot Welding Machine
Automatic Spot Welding Machine	Double Sides Spot Welding Machine
1-24 series or 1-32 series BMS Tester	Over-discharge Protection Current:0-120A Overcharge Protection Current:0-50A Overcharge/Overdischarge Voltage:0.5-5V
Battery Comprehensive Tester	100V 120A 18650 Battery Pack Comprehensive Tester
Aging Machine	30 V 10A Charging 20 A Discharging Aging Machine

Aging Machine	70 V 5A Charging 10 A Discharging Aging Machine
Aging Machine	100 V 10A Charging 20 A Discharging Aging Machine

Detailed images:



Conclusion:

Lithium Ion and Lithium Ion Polymer batteries are a great power source for some applications but they require preventive protection during discharging and charging.

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