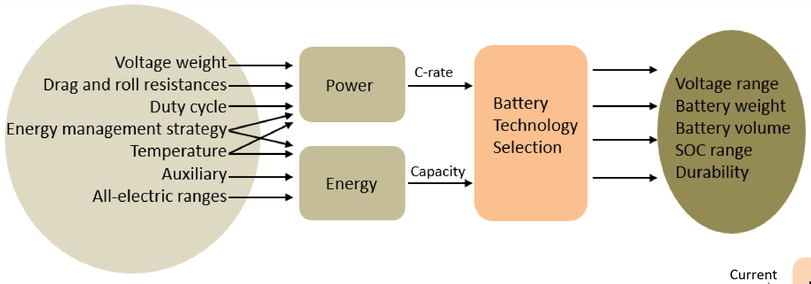
Battery Pack Design and Thermal Management

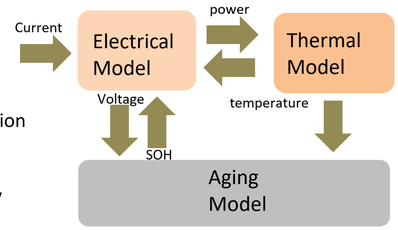
Centre for Mechatronics and Hybrid Technology*(CMHT)*
Mechanical Engineering McMaster University
Raven Chen

EECOMOBILITY (ORF) & HEVPD&D CREATE

Constrains and Objectives



- **General work procedure to select battery technology and battery design constrains**

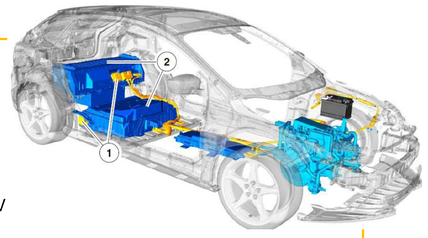


- **Design and dimension of battery pack based on suitable models**
  - evaluate suitable battery technologies to specify electric and thermal termination
  - battery management systems to predict state of charge, health, function
  - battery thermal management system to operate cooling and heating effectively

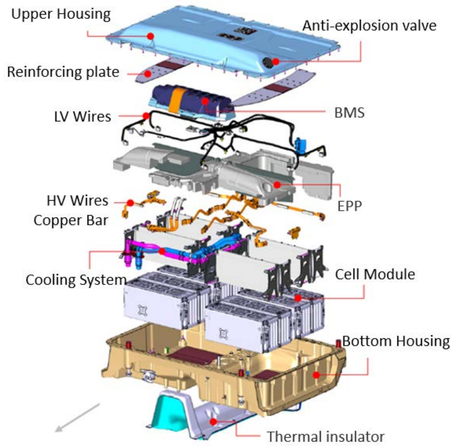
Main Battery Pack

Battery Parameters

Battery Manufacturer: LG Chem
Type: Lithium-Ion (LMO)
Cell Voltage Max/Min: 4.2/3.0 V
Pack Configuration.: 86S 5P
Number of Cells: 430
Nominal Cell Voltage: 3.7 V
Nominal System Voltage: 318.2 V
Rated Pack Capacity: 75 Ah
Rated Pack Energy: 23 kWh
Weight of Pack: 303 Kg
Cooling: Active – Liquid Cooling
Pack Location: Two Sections: (1) Behind Rear Seats (2) Under Rear Seats

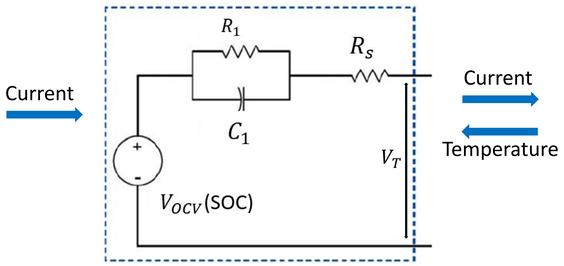


Explosive View of a VW Pack

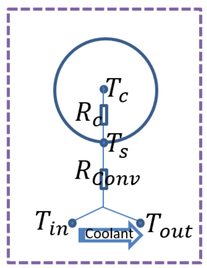


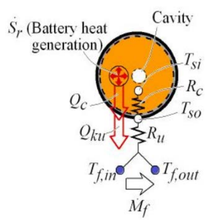
Electro-Thermal Model

Electrical Model



Thermal Model





Battery pack

$$V_T = V_{OCV} - V_1 - IR_s$$

$$\dot{V}_1 = -\frac{1}{R_1 C_1} V_1 + \frac{1}{C_1} I$$

Single cell

$$\frac{dT_c}{dt} = \frac{Q}{C_c} + \frac{T_s - T_c}{R_c \cdot C_c}$$

$$\frac{dT_s}{dt} = \frac{T_{in} - T_s}{C_{conv} R_{conv}} + \frac{T_s - T_c}{C_{conv} R_c}$$

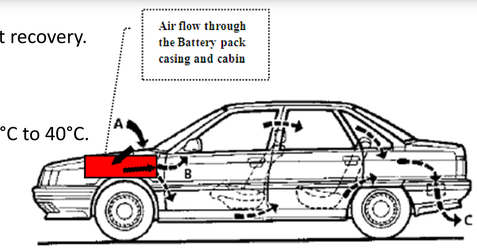
Conduction between cells

Where,
the second equation describes the dynamic voltage across the RC circuit
parameters $R\&C$ *are* function of SOC and T

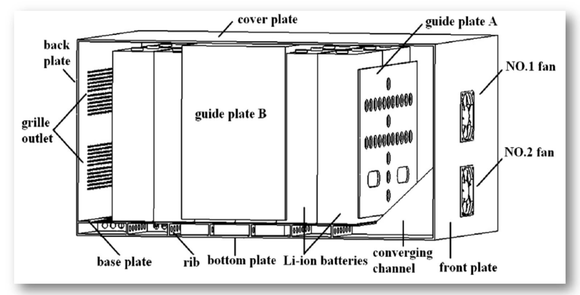
Where,
C is heat capacity (J/K)
R is heat transfer resistance (K/W)
Q is the rate of heat generated (W)

Secondary Battery Pack

- **Air cooling** of a battery creates a high potential for energy savings and heat recovery.
- Locate the pack **in the front of a vehicle** for improving heat transfer.
- The heat can be a source to warm up the cabin in cold weather conditions.
- The operation of most Li-ion cells should be limited to a temperature of 20°C to 40°C.
- Temperature differences between cells should maintain below 5°C.



› Battery designed with **ribs** can increase the heat transfer rate.



Cell provided by NRC
Type: Lithium-Silicon
Nominal Cell Voltage: 4.0V
Nominal Module Voltage: 48 V
Module Configuration.: 5 Parallel Strings of 12 Cells in Series
Pack Configuration: 7 Modules in Series
Number of Cells: 420
Nominal Pack Voltage: 336V
Rated Pack Capacity: 75 Ah
Rated Pack Energy: 25kWh
Weight of Pack: ?
Pack Location: In front of the vehicle ?
Cooling: Air Cooling

We acknowledge the support of the Ontario Research Fund: Research Excellence Program.

We acknowledge the support of the Natural Sciences and Engineering Council of Canada (NSERC), which invests annually over $1 billion in people, discovery and innovation.