Thermal Management of Battery Systems

APEC 2022 – PSMA – INDUSTRY SESSION

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Thank You……

To Peter Victor of Fedco Batteries, for the opportunity to present this session in conjunction with Fedco Batteries,
our manufacturing partner and an emerging leader
in large format battery systems.

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Why Thermal Management?

Correct thermal management provides a host of benefits:

Longer cell and therefor longer battery life (number of usable cycles)

Higher availability of the battery to the application

Extend operational temperature range

Increased available capacity

More consistent product performance

Better known safety

Better product capability

What do we mean by Battery Thermal Management?

Thermal management in battery systems is distinct from the thermal characteristics of individual battery cells, and is a super-set of cell

thermodynamics and that of associated electronics and

local environment

What a cell is capable of and what a battery unit is capable of thermally are two distinctly different things.

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Where is it prevalent?

Designed and deliberate thermal management is most often seen in:

High rate and Ultra High Rate Battery packs using high performance cells

Large scale battery systems (such as grid scale energy packs)

High density battery systems (such as electric vehicles)

Marine battery systems

Battery systems used in harsh environments – freezer farms

Contained systems (submarines)

- however many smaller systems also benefit.

Broad responsibility

Not only as designers are we responsible for “thermal management” but we are also responsible for “thermal safety”.

Yes, it says Fire right on the can…...

Types of Management

Often we opt for “no management”:

- For safety we rely on the cell manufacturer and the charger manufacture
- Efficiency and life concerns (capacity, number of cycles) are not dominant issues in design

When we get squeezed we may look at individual factors:

- For environments that are cold, we may provide enough heat to ensure charging starts
- For environments that may get hot, we use small fans or similar to nominally lower temperatures

When we execute full design:

- We may be in a regulated environment
- We may need maximal life and capacity
- We may be dealing with extreme environmental conditions

Thermal Management Design

"Full Design" requires an understanding of scope:

- Thermal capabilities and dynamics of the individual cells;
  - Charge and Discharge thermal energy rates vs charge and discharge currents;
  - Thermal resistance of the cell, and additional factors such as the cell jackets;
  - Maximum and minimum temperatures, correct measurement of temperatures and
  - Cell thermal thermal gradients under anticipated operating conditions
- Thermal environment of the battery pack and its associated infrastructure
  - Minimum and maximum temperature;
  - External mediums and their conductive capabilities;
  - Any aggravating or worse case scenarios – fan or pump failures, etc
- Additional thermal challenges
  - Control electronics contributions
  - Thermal impedance of the cell pack its self
- Calculations and effects related to catastrophic events
  - Short circuit heat management
  - Cell immolation heat diversion and dissipation

So where is this thermal challenge?

Intra Cell:

- Chemical conversion energy liberated as heat
- Electrical resistance and impedance of the cell and its components
- Thermal mechanics of cell materials and cell design

Inter Cell

- Thermal barrier of case coverings and coupling to exterior
- The challenge of your cell mate having the same issue next to you

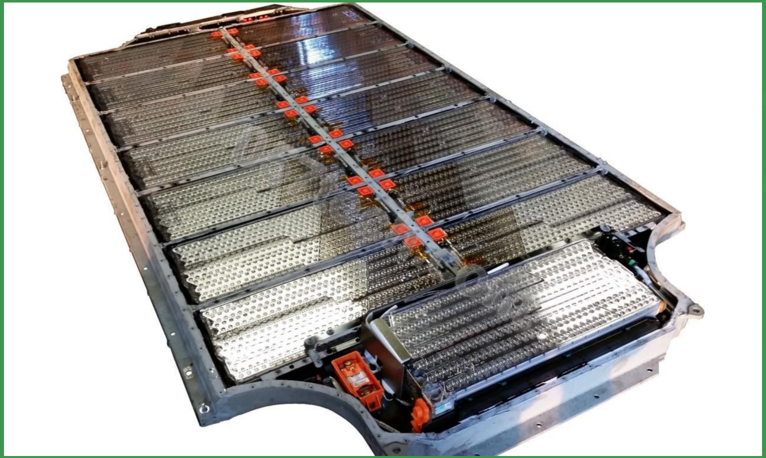
Intra Pack

- Electronic systems – such as the BMS
- Structural components – including the

External

High Rate Thermal Management

- There are many emerging high rate battery systems:



Tesla exemplifies this with continuous rate capabilities in the 3C to 6C range for production batteries – whist maintaining cycle life and extended temperature range operations – using expert thermal engineering.

High Rate Thermal Management

- And many companies working hard to progress the art:

  Liquid glycol heat exchange is used for heating and cooling of cells
    – a function integrated within the Tesla cell and battery management system

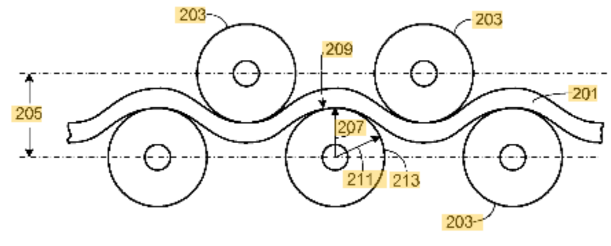


FIG. 2

Tesla Patent US8758924B2 (courtesy of the USPTO) describes the design and engineering concepts involved in this particular approach.

Low Temperature Challenges

Low rate, large capacity systems can become challenged in low temperatures:

- Slower chemical conversion
  - Non-preferred conversion paths
- Crystallization of electrolyte components
- Rapid capacity degradation
- Mechanical failure risks due to expansion and cracking

Low Temperature Techniques

There are standard approaches:

- Heater jackets
    - Externally powered (standby battery applications)
    - Self powered (the “eat yourself” approach)
- Static thermal blankets
    - Internal heat emission maintains warming

Cylindrical Heater Jacket (Courtesy of TGM Inc.)

But they can have drawbacks too:

- Non-dynamic systems have poor cooling capacity
- Dynamic systems may not be cost effective

Fully Enclosed Battery Packs

Come in a variety of forms:

- Encapsulated in resin;
- Sealed with a gas tight or fluid tight container;
- Appliance may seal the unit at a macro level.

Designing for submerged vehicles or craft:

- Particular care must be taken to exclude salt water
- Packs (principally cells in the pack) are very poor in relation to pressure
- PRV (Pressure Relief Valves) must be use in case of inadvertent outgassing

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Conciser the Thermal Safety Case

What happens when it all goes wrong…….

- Consequences of battery technology choices on final outcome
- Extent of design and testing resources
- Costs of testing

Major areas of consideration

- Venting and gas management
- Consequential events following major failure

Regulatory requirements and Physical testing

Summing it Up……

Thermal management can often be very straight forward, but should never be disregarded. Make sure as a minimum the boundary parameters of your use case and physical environment are considered in your design.

If you are getting close to thermal or use limits, do a proper study and involve mechanical, thermal and electrical designers in the analysis.

Do not forget to consider the safety case for the equipment, the battery pack, and the individual cells.

If in doubt, consult an expert.

Questions…

We welcome questions. Please feel free to contact us at any time…

For design related questions, contact Vercet at:

psma@vercet.com

For manufacturing related questions contact Fedco Batteries at:

sales@fedcobatteries.com

And check us out on the web any time at:

https://www.fedcobatteries.com

Thank you!!

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