Latent Heat Solutions

6 Factors to Consider with Thermal Runaway

A DIVISION OF CAVU GROUP

HOT PHONE SYNDROME

Everyone has been there. You're using your phone, when you start to feel some heat coming from the battery. Maybe it's been in the sun or maybe you're trying to run a lot of things on it at the same time.

Either way, too much heat can cause a battery to explode or damage your device. When heat inside a battery builds up, it can have a runaway effect. This is called thermal propagation and is especially problematic in larger battery systems

Keep reading to learn about what it is and 6 factors to consider when dealing with thermal propagation.

What Is Thermal Propagation?

Normally, a lithium-ion battery consists of an anode and a cathode which contain lithium ions. These positively charged ions are carried by electrolytes from one end to the other.

When the positive charges flow from one electrode to the other, this causes a flow of electrons otherwise known as current, that we use from the battery.

However, as a battery heats up, or if there is a short in the battery connection, or mechanical damage to the battery this process will start to enter a self-fed cycle of heating and degradation resulting in a **battery explosion or catastrophic release of this energy**.

This thermal runaway can propagate to adjacent cells in large multi-cell battery packs causing a thermal chain reaction and subsequent catastrophic events.

FACTORS TO CONSIDER

There are several factors to consider when designing a battery pack to deal with thermal propagation. From triggering a battery cell to see how it explodes to the components outside of the battery, here are 6 factors that affect thermal propagation.

1. Cell Ignition or Triggering Mechanism

With a cell ignition or triggering mechanism, you're trying to trigger thermal propagation in a battery. There are several ways to do this.

One is with a **large impact**. The impact from something like a nail being driven into a battery can cause an immediate thermal runaway. The nail will cause a short circuit in the battery, which will likely cause it to explode.

Another triggering mechanism is to **slowly heat up the battery** until it explodes. This method is called hot wire. It can tell you how a battery will react when it becomes overheated.

The third mechanism is manually **short-circuiting the battery**, causing it to explode. Each of these methods affects how the battery will explode and what damage it might cause under thermal runaway propagation.

2. Cell Type, Chemistry, SOC

Among the many factors that go into thermal propagation, the design is an important one. From the geometrical shape of the battery to its chemical composition, the design is significant.

The three different formats of batteries are cylindrical, pouch, and prismatic. Cylindrical batteries are one of the most popular formats and can be found in everything from batteries for power tools, medical devices, grid storage, robots, to aerial and ground based electric vehicles. Pouch and prismatic types are more commonly found in cell phones and other mobile electronics.

There are many different types of lithium-ion batteries that use different chemical compositions an to produce charge, such as lithium iron phosphate (LFP), Nickel, Manganese, Cobalt Oxide (NMC) and Lithium Nickel Cobalt Aluminum Oxide (NCA). These different compositions bring different energies and different risks of exploding.

SOC stands for state of charge and represents how much electrical energy is left in the battery. The higher the SOC, the more energy the battery has stored, which has a direct impact on how damaging thermal runaway can be. The lower the SOC, the lower the risk damaging effects.

3. Operating or Test Temperature

While most batteries are designed to operate within a range of temperatures, higher temperatures put batteries at a higher risk of thermal propagation being triggered.

When operating at higher temperatures, thermal instability within the battery can occur, causing internal components to decompose and pose a higher risk of energy being released in an uncontrolled way, such as an explosion.

4. Ejecta Control

Ejecta control refers to controlling the direction and energy of a battery venting or explosion event. The top or positive end of most cells or batteries contains a vent that ideally releases heat and gases during a thermal runaway event. However, depending on the cell design, **some cells within a battery will uncontrollably vent from the side or wall of the cell**.

This is especially important when you have other cells right next to each other. If one explodes through the side and hits an adjacent cell, it could cause that cell to fail, cascading to a much larger and damaging explosive event.

With most of the heat from a thermal runaway event being release via venting or ejecta, **the ability to control exactly where the energy goes when a battery fails is an important part of the design**.

5. Pack Components and Design

Another factor is the **design and components used in the pack**. This refers to things like cell holders, wiring, electrical boards, and the battery housing itself. Whether all these materials are flame-resistant is important to consider so they do not sustain a fire if the battery explodes.

Temperatures during thermal runaway can get up to 800°C, which can easily damage some of the pack components. Proper design, which includes availability of space for thermal protection materials are critical to protect not only cells but these components and prevent further propagation throughout the battery.

6. Structural and Electrical Connectivity

Cell holders are what keep the batteries in place in your device. Collector plates collect the charge from several batteries and transfer it to power a device or vehicle. Both are important factors to be aware of to minimize thermal runaway risk.

Both play important roles in the overall structural support of the battery. Failure of these components, particularly during a thermal runaway, can cause cells to come in direct thermal contact with each other, potentially contributing to a larger explosive event.

It is critical to consider whether cells or the batteries themselves are connect in series or parallel as different electrical configurations can impact thermal conditions within the battery itself. **Both localized temperature fluctuations and heat transfer through the electrical connections can influence how extensive thermal propagation can occur**.

Fusible connections, in which certain electrical connections will break under high currents, are another significant factor when mitigating thermal runaway in batteries. These are designed to electrically isolate surrounding cells from a failed cell or section, preventing damaging currents to lead to a larger catastrophic failure.

NEXT STEPS

There are many factors to consider when it comes to thermal runaway in batteries. Too much heat or external pressure can cause them to explode. Knowing how they will fail if they do and which factors impact this failure it is a crucial part of any safe battery design.

Now that you know what thermal propagation is and what factors to consider when designing or using a battery, feel free to contact us to learn how we can help with your next project. Whether you are looking to prevent thermal runaway or increase battery life, we can help.