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Thermal Spread Material (TSM) - Thermal Management of Batteries

-For design engineers of battery pack

We had heard enough news about battery's explosion and fire accident in the past few years. There are so many reasons lead to this unfortunate issue, and one of the reasons is that the temperature of battery goes too high during its charging and discharging process.

What will happen if the battery becomes too hot during charging and discharging process?

If the cells inside the battery pack get too hot, the potential problems could be:

a) It will reduce the battery cycle life;

b) The performance the battery will be decreased and;

c) The battery pack might explode or catch fire.

How does heat diffuse in the battery pack and what is the challenge?

To reduce the overheat during charging and discharging process, AA Portable Power Corp, a battery pack assembly manufacturer, installed a thermostat in the battery pack to control the temperature of battery for several years. However, there is still a challenge to find the perfect location for thermostat in the battery pack? Please see our test blow.

Test1: Examples of Battery Infrared Thermal Imaging during charging

1. Sample: 6-cell side by side in series configuration of NiMH battery pack.
2. A smart charger charges the battery pack from 6V to full.
    a. Picture 1: At beginning of charging, the battery temperature reaches 34.7°C
    b. Picture 2-5: Increment of temperature begin from the central cells, and then propagates to other cells on the side.
    c. Picture 6: The battery pack is fully charged and temperature reaches 55.5°C

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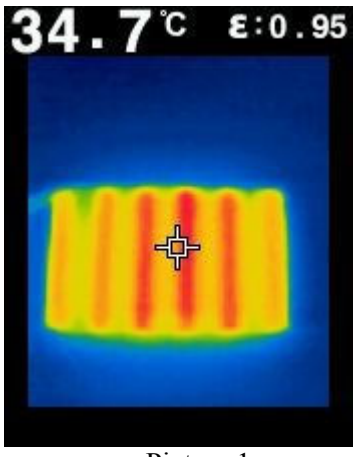
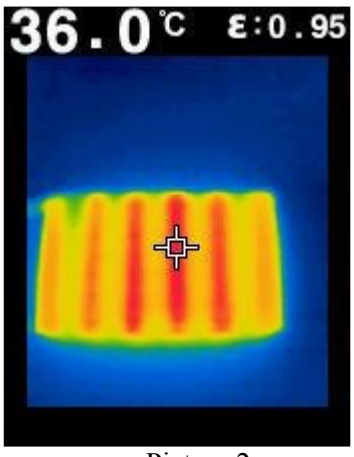
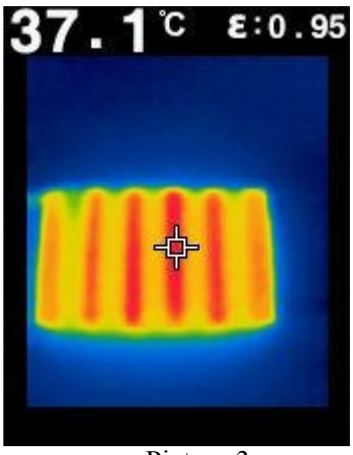


Picture 1



Picture 2



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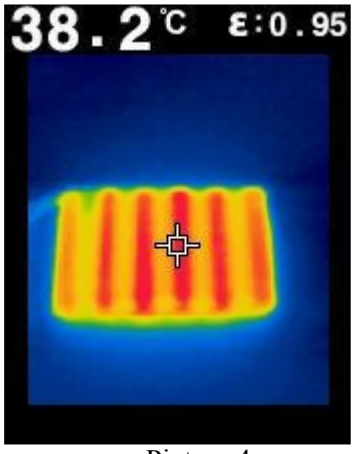

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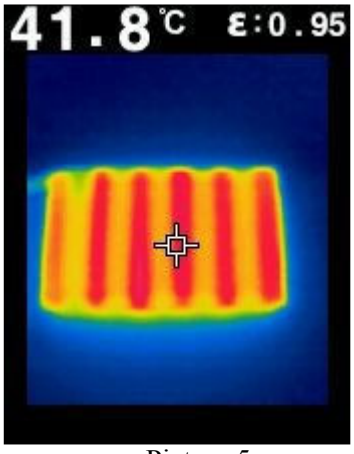

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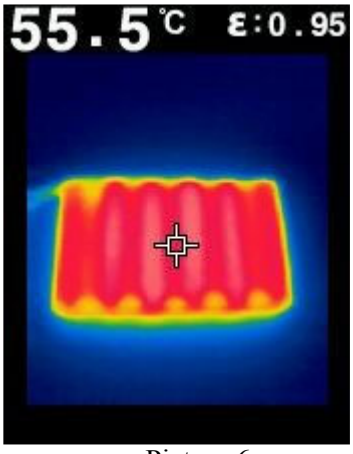

Picture 6

Nevertheless, For certain battery pack configurations, it is difficult to identify which cells will get highest temperature. If the thermostat is not located on the right location, the battery pack still could be overheated. For example:

Test 2: Examples of Battery Infrared Thermal Imaging during charging

1. Sample: 24V 10Ah (20-cell in series) NiMH Pack with 3 rows (7-6-7) configuration.
2. A smart charger charges battery pack from 20V to full.
    a. Picture 7 shows temperature difference between cells in the battery pack. The average temperature of the pack is 40.9°C
    b. Picture 8 shows temperature of the cell on the end of the middle row reaches 43.9°C

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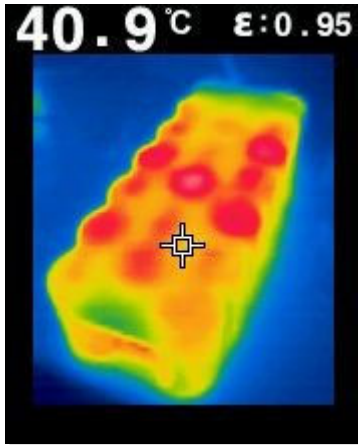
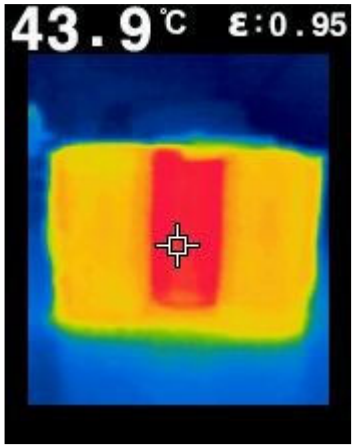
24V 10Ah NiMH Battery Pack

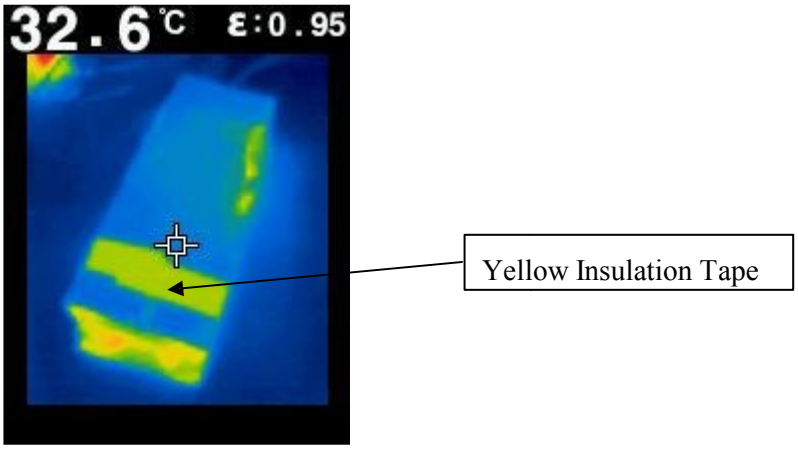


Picture 7



Picture 8 (Side view)

3. Picture 9: Finally, we apply our Thermal Spread Material (TSM) on the same battery pack and find out the surface temperature of the battery pack reduces to 32.6°C. Also, the temperature on the Thermal Spread Material becomes uniform distribution.



Picture 9

Advantages of TSM

(a) Exhaust heat from the hottest cell, and reduce the temperature of whole battery pack
(b) Make the temperature possibly even on each point of battery pack, and avoid misdetection of the thermostat for hottest point.
(c) Without TSM, the thermostat might kicks in when the middle cells reach corresponding temperature, the whole battery pack might not fully charged yet. With TSM, as long as the whole battery pack is under corresponding temperature, the battery can still get charged continuously, the smart charger will cut of charging process instead of thermostat, the battery pack will get fully charged.

What is the cost of applying TSM?

The estimation of overall cost with TSM will be around 20% more and size will be around 0.05" – 0.10" thicker per layer.

Conclusion

TSM is able to transfer the heat from the surface of each cell in the battery pack to TSM. When the thermostat attaches TSM, we have more confidence to detect the highest temperature in the battery pack. As a result, the thermostat will be able to efficiently cut off the circuitry in order to reinforce the safety of battery packs.

There are other factors which should be considered seriously before design the right battery:

1. The maximum continuous & surge discharge rate which the device needs
2. The maximum continuous & surge discharge rate which the battery can provide
3. The operating and storage temperature range of battery can stand and how to keep the cells in the desired temperature range during charge and discharge
4. For lithium batteries, you should use protection circuit board (PCB) to prevent over charge, over discharge, high current charge, and external short. Don't count on the PCB on the battery pack which should be used as a backup protection of whole system
5. Design a circuit in a smart charger to control charging current and cut off current/voltage when cells or battery pack is fully charged.