Phase-Change Induced Passive Cooling for Electric Vehicle Battery Systems

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Abstract

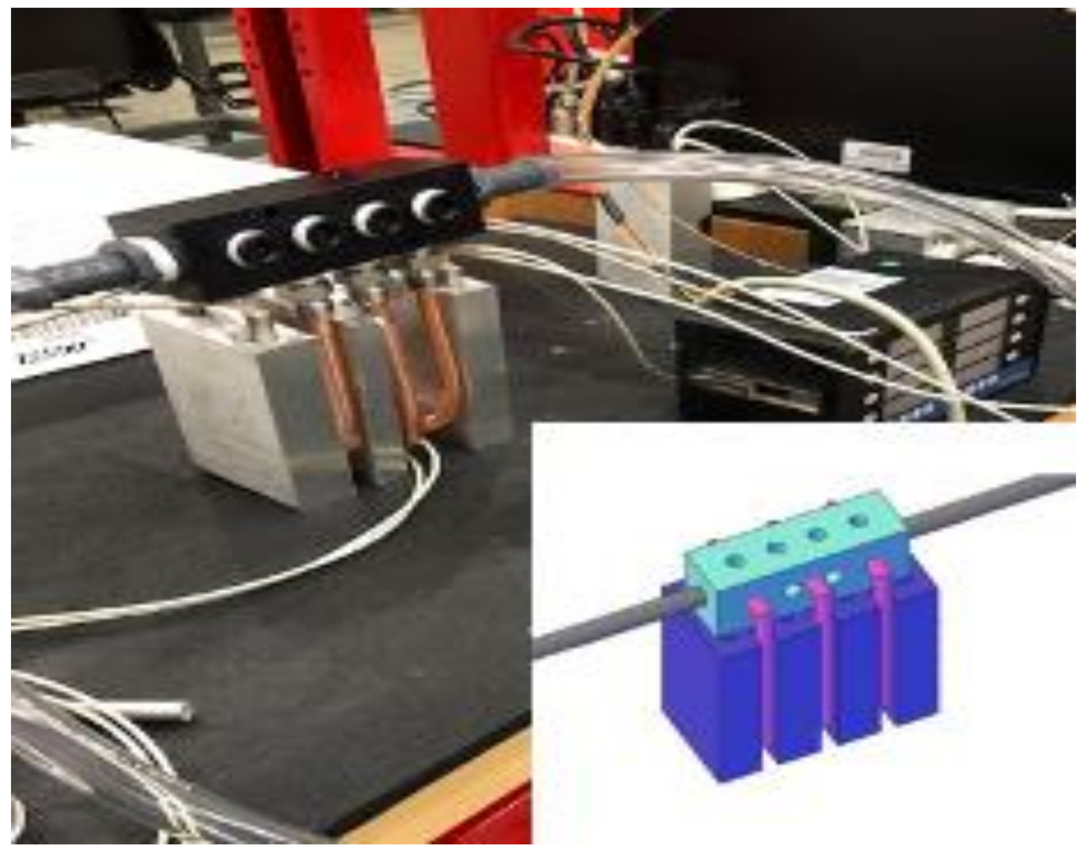
Efficient battery cooling systems are of the utmost importance in electric vehicle operation due to excessive heat generation. This will arise from rapid charging or discharging. Phase-Change Induced Passive Cooling (PCIPC) is a method that will increase cooling efficiency while reducing excessive heat generated. By introducing flat sintered heat pipes between cells, the refrigeration cycle will effectively release heat at a condenser. Using already available vehicle refrigerant to cool the condenser the heat transfer rate can increase both economically and efficiently.

Introduction

Battery systems found in Tesla and Boeing are connected in series increasing the likelihood of excessive heat generation causing fires. The need for having a compact, simple, and leak free system for cooling is the main issue in developing efficient systems. PCIPC uses sealed round sintered copper heat pipes that are flattened in between cells to maximize surface contact area. The pipes are then cooled by a manifold either above or below battery packs. The use of sintered heat pipes allows the luxury of choosing where the condenser and evaporator will be located.

Methods

Experimenting with battery systems can be a deadly task. The design had no actual batteries included because heater cartridges can achieve the same result. The cartridges were placed into aluminum blocks due to the fact Li-ion batteries share similar heat capacity values. Through the use of a temperature controller the cartridges began generating heat mimicking an authentic battery pack. J-type thermocouples were used to monitor temperatures through out the system due to their temperature range. Round copper heat pipes that would be flattened before insertion increase the total surface area being in contact with heat. More area translates to more heat that can possibly be removed. A large manifold located above the system utilizes compression fittings to create an important watertight seal. A simple coolant bath pumped water through the manifold effectively cooling the heat pipes and blocks.



Results

The optimum operating temperature is between 20 - 45º C and the temperature difference between batteries should not be more than 5º C. The table below illustrates a promising future.

Inner battery: Cell1					
Discharge Rate:		1C	2C	3C	4C
		Temperatures(°C):			
Time(min):	0	27.3	30.1	39.6	52.8
	5	27.8	29.5	39.0	52.8
	10	27.3	28.5	36.6	54.5
	15	27.0	27.6	35.7	55.3
	20	26.0	27.1	34.1	58.4
	25	25.5	26.7	34.0	58.9
	30	25.7	26.9	33.6	58.7
Heat transfer rate(BTU/hr):		10465.96	20931.93	39023.89	-37969.7

Conclusions

Managing excess heat generation in electric vehicles is the number one challenge to being able to have an efficient, reliable, and safe product. It is crucial to control the batteries as they are the heart of an electric vehicle. Managing this issue can completely change the way consumers and engineers view "green" transportation overall.

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