Automotive Battery Cooling Systems for Electrical Vehicles

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Abstract

The thermal management of automotive batteries is the key point to ensure the cells durability, vehicle autonomous and safety. Nowadays, the chemistries used in automotive field are mainly based on Lithium-Ion technology. These chemistries are sensitive to the temperature and need to be maintained in a temperature range that allows them to work at their optimum capacity without safety hazards, i.e. between 15°C to 40°C approximatively. Below 15°C, the cells cannot deliver their nominal power or accept high current level without any premature ageing. Such cold conditions need a pre-conditioning strategy to heat up the battery and a derating of the cell use until they are hot enough. During this time, charging power or acceleration/breaking regeneration of the vehicle are reduced. At the other side of the scale, above 40°C the cells are facing two main problems: capacity losses through thermal ageing and safety issues. That can lead to thermal events and in some extreme cases to thermal runaway: fire propagation inside the battery pack, and at the end vehicle fire. The energy amount involved in such thermal runaway events is so high that it cannot be controlled once started, and should absolutely avoided. In those hot conditions, a preconditioning strategy can occur before any intensive usage to bring the cells at a temperature cold enough to prevent any derating or safety issue. In addition to the external temperature, these kinds of cells release some heat when they are solicited. Their internal electrical resistance combined to the amount of current applied heat them up during intensive usage as fast charge and ultra-fast charge, strong and/or repeated accelerations. This heat should be removed thanks to a specific heat exchanger to avoid an over heat and to maintain the cell temperature below 40°C, ideally lower than 35°C. Another key parameter to extend the battery life and capacity is the temperature unbalance in the battery pack. The thermal exchanger of the battery should be designed so that all the cells of the battery pack are at the same temperature level along the vehicle life in any conditions. The cell aging being function of its temperature, the goal is to ensure that all the cells of a same battery pack age at the same rate. Typically, a temperature unbalance of 5K between all the cells is acceptable. The thermal exchanger should be consequently designed to reach that target. As top leader of Tier1 suppliers of battery thermal management systems, Valeo has developed along these last 10 years an unique expertise and competitive products that answer to battery thermal management problematics. We propose to review during that Keynote the different technologies that we are able to deliver to ensure the thermal comfort of the batteries, function of the thermal constraints, battery pack layouts, casing integrations and system architectures. From passive air systems to high heat transfer coefficient liquid exchangers through refrigerant cooling plates, we will thus present of the pro and cons of each solution, finally to conclude on the trends for the incoming years.

Keywords
Electrical Cars, Thermal management, Battery Pack, Fast Charge

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Biography
Jean-Damien Muller, Ph.D., Eng. is Valeo Battery Thermal Management Expert. He is graduated in Technological Diploma of Nantes University (France) in the Physicals Measurements field in 2002. He spends the next 3 years to study the materials properties to hold the title of Material Engineer of Polytech'Nantes in 2005. In parallel of the last engineering school year, he follows a Research Master course in Materials and Matter Physics at the Nantes' University. Passionate by the research, he prepares his Ph.D. thesis on Rotomolding Process within the INSA of Lyon (France), at the Polymer Materials Engineering (IMP) Laboratory. Graduated in 2008, he starts immediately in the

industry at Lyon in Influtherm, an engineering company working around the thermal measurements. During 5 years, he develops its skills in the development of measurements of the thermal properties of materials and thermal studies to become a recognized expert in his field. Valeo hires him in 2014 to work on new products called Battery Coolers in La Suze sur Sarthe near Le Mans (France). Its competencies as Research and Development Engineer allow him to become quickly Advanced Development Technical Leader, then Battery Thermal Management Expert since 2020. Additionally of supporting Valeos' engineers around the world, he is in charge of Valeos' internal training on Battery Thermal Management Systems and is internal standards writer and reviewer. He also contributes to the redaction of international norms thought AFNOR and ISO groups (ISO/TC22/SC37/WG3). He has filled 39 patents, whose 23 have been granted to date.