Innovative cable technology to enable faster charging of electric vehicle

ABSTRACT

Faster charging is mandatory for the adoption of electric vehicle technology. Thus, a simple solution considered is to develop a power cable capable of improving the heat dissipation of the overall charging path, while providing additional advantages such as reduction in weight and overall cost. A study was conducted in collaboration with the Research & Innovation department of a major OEM. A theoretical approach by numerical simulation followed by experimental evaluation made it possible to validate this innovation.

KEYWORDS

Inlet Charge, Faster charging, Heat Dissipation, Power Cable, XLPO insulation, Cost reduction, weight reduction

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CONTEXT

The evolution of the electric vehicle market has been punctuated by technological developments from lead-nickel-cadmium batteries to lithium-ion and lithium-polymer batteries. These new batteries allow more autonomy and power and offer new commercial prospects.

To support and accelerate the development of the electric vehicle market, it is necessary to reduce the charging time of these new electric vehicles range. The charging time depends on one hand on the capability of the charging station to provide the higher electric power necessary for a fast charge and on the other hand on the capability of the electric vehicle to accept and store this level of higher electrical power.

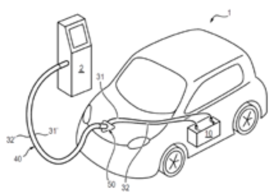

Fig. 1: Diagrams of electric vehicle charging solution (1) with charging terminal (2), OUTLET (40) and INLET (31,32) charging cable and battery (10)

Faster charging is mandatory for the adoption of the electric vehicle technology. However, fast charging implies to increase electrical currents going through cables and connectors that naturally leads, by Joule effect, to significant heating. Such heating is problematic because it accelerates components aging and can be detrimental to components integrity, hence affecting the vehicle safety. The reduction of the temperature increase is a task that can be tackled through several solutions (e.g. Use of calorific fluid …) that currently all tend to increase system cost and complexity. A simpler solution to limit this temperature increase is to develop a technological brick for power cable capable of improving the heat dissipation of the overall charging path, while also providing additional benefits such as weight and overall cost reduction.

A study on the state of the art of outlet charging systems shows the existence of deep technical knowledge as well as the presence of a strong innovative activity to respond to the problems of heating created at fast charging stations of electric vehicles. However, the various vehicle integration, safety and cost constraints make it impossible to transpose this current knowledge and solutions to our Inlet charging problem.

Indeed, the integration of electrical cables in the vehicles must meet implementation, scope and safety constraints. These constraints generally lead to cables having good flexibility to allow their handling and an integration in packaging and surroundings not optimal for this purpose. Most often, additional thermal, mechanical and electrical protections (braids and/or additional sheaths, etc.) are implemented around cables and connectors. All of the additional protections oppose the transfer of heat from cables and connectors to the environment. These protections therefore provide thermal insulation, which generates a rise in the temperature of the cables and connectors.

Therefore, we are facing a complex scientific problem: Improving the cooling of electrical cables and connectors, without increasing the section of the electrical conductor while meeting the constraints of integration into the vehicle.

In addition to the interest of increasing the electrical current in order to reduce the charging time of an electric vehicle, the improvement of the cooling of the electrical cables offers the car manufacturer the possibility of considering a cross section reduction of the electrical conductor to access further weight and cost savings.

DESCRIPTION OF THE APPROACH FOLLOWED AND THE WORK PERFORMED

Numerical studies carried out in permanent and transient regimes have enabled us to understand the thermal behavior of the current system. One of these numerical studies on innovative concepts helped us, by comparison, to assess the potential gains. By following this approach, we identified the characteristics and properties that could influence the cooling of the cable and the electrical connector.

The charging cable and the connectors at the cable ends are the heat source generated by the electrical current. This heat will be transmitted to the nearby environment according to different modes of heat transfer: conduction, convection and radiation. In permanent mode, we can consider that the quantity of heat transmitted is on one hand proportional to the difference in temperature between the transmitter and the receiver of heat and on the other