Master thesis on fast charger connector solution

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In todays industry there are a few examples of automated charging with high power. Though this area is quite unexplored. The range of power and size for the connectors in these examples are very limited.

I. Introduction

Volvo Construction Equipment are investigating new machine concept that involve fast charging with high power. This should be done automatically and independent on humans. The thesis set out to develop and design a complete system solution for this, including the connector and the automated system for connection.

Few of the examples are designed with a broader market in focus. Some can only be used for one or maybe two scenarios, for example two different buses, but if a vehicle of different size should be used a new system would be needed. This thesis work "Master thesis on fast charger connector solution" [1] develop a plug in connector for an automated system for any heavy vehicle between a local distribution truck to a dumper in a mine.

Fig. 1. Prototype connector

II. Results

A prototype plug-in connector is designed and produced, see figure 1, using the Ulrich and Eppinger methodology of product development. The connector is 50 percent smaller in volume compared to previously presented prototypes [5] at LTH. It can transfer 200A over all 4 phases with a working temperature of 100 degrees Celsius, see figure 2. The connector is designed with four phases, one protective ground, and two communication lines. Also there is a built in mechanical lock designed to withstand 50N of pulling force. Thus making sure that the male connector will not by accident be pulled/fall out of the female connector once inserted.

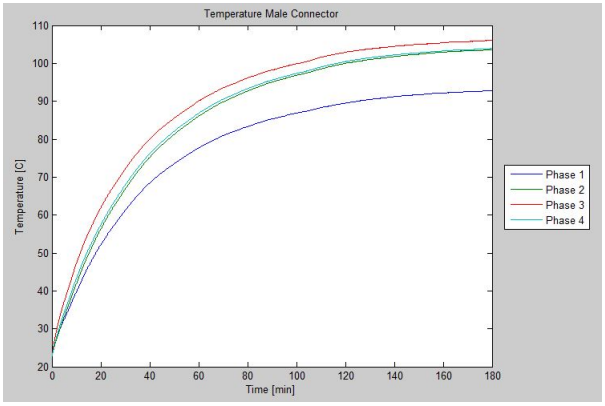

Fig. 2. Diagram on temperature over time when static current on 200 A

Since the connector has four phases it can be used for AC 3-phase charging with the power transfer 138 kW, with a voltage at 400 V. With DC 2-phase charging it is possible to transfer a power of 512 kW, with a voltage of 640 V. The high power transfer for DC charging is reached by using two phases on the connector in parallel as one phase for charging.

III. Thesis work

Many different concepts are taken into account. Also some very similar to concepts already introduced to the industry by, among others, Staubli [2] and Alstom [3]. This is both regarding the design of the conductive connector and of the automated system handling the connection.

The connector developed is rotationally symmetric to simplify the insertion of it. It is designed to be implementable to many various vehicles not only one type, this is due to the fact that the more vehicles that will use the connector the lower cost it will have. The size of the male connector is about 5 cm in diameter and 20 cm in lenght. It is made out of a shell/skeleton of a 3D printed plastic filled up by a thermally conductive and electrically insulating resin.

The phases are made of a copper beryllium alloy, that is much tougher than ordinary copper. This is important since the ware of inserting and withdrawing the connector hundreds of thousands of times would damage the phases very much.

The connection between the male and the female phases are done via a copper beryllium spring coil designed by BalSeal [4]. This technology makes it possible to in a very volume efficient way design a connector for high power transfer. It is already used in other connectors in the industry.

IV. Conclusion

The result of the thesis work is very promising for the future. Showing that it is possible to design a plug in connector for this magnitude of current, while keeping the size this small is important. The design also allows for serial production, of course with some minor changes. Though the way it is designed it is not only possible to make with 3D printing but it could actually be produces in larger quantities and gain on this regarding the cost. In the thesis it were not possible to include the development of an automated system for connection and disconnection. Due to time and resource limitations this development were only taken to concept level, even though it looked very promising. This is of course I something I would have liked to continue on. Overall I am very pleased with the work done and the results achieved. It has been very rewarding to work on this in collaboration with Volvo CE and the Division of Industrial Electrical Engineering and Automation at Lund University.

References

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