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Electrical Powertrain Oil Cooled for C-Crossover EV

Yukinori Tsukamoto [1)] **Hiroki Wada [1)]** **Takeshi Inoo [1)]** **Mikati Karim [1)]**

1) Powertrain and EV Electrical Technology Department
Powertrain and EV Engineering Division, Nissan motor Co., Ltd.
560-2, Okatsukoku, Atsugi, Kanagawa 243-0192, Japan

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A EESM (Externally Excited Synchronous Motor) consists of a rotor with winded copper wires. The copper wires will generate heat when the current is flowing which will require cooling to assure the optimal performance for the customer. This thermal challenge is the main differences with an IPM Motor, that has magnets in the rotor, and which little heat compared to an EESM. However, an EESM is larger than an equivalent IPM (Internal Permanent Magnet) for the same power class. Therefore, to design an EESM with the same size as an IPM, a new cooling structure had to be developed to compensate for the increase in power density. This new cooling structure consists of an internal oil projection directly at the rotor and indirectly at the stator.

Due to the rotor with winded copper wires, a certain surface of copper wires will be exposed inside the eMotor. This is called the Coil End (equivalent definition for the stator coil end). The Coil End is the perfect location for extracting the heat: The wires are exposed to the internal air of the eMotor, the wires allow the best heat transfer from the middle of the rotor/stator to the coil end (due to the high thermal conductivity of the copper) and the coil end will generate roughly 40% of the total joule losses.Due to the above facts, the oil structure was developed to directly cool the exposed coil end of the Rotor and Stator. And to optimize the size and cost of the EESM, only two oil projection points are designed, one on each side of the EESM and in front of the exposed Rotor Coil End.However, to carry the projected cooling oil from the rotor coil end to the stator coil end, a system of holes at the rotor crowns were designed. The concept consists of utilizing the centrifugal force of the rotor to project the oil via the rotor crown holes to the stator coil end. Therefore, with direct cooling on the rotor coil end, an indirect cooling on the stator coil end will be achieved via the rotor crown holes.

With this cooling structure, the continuous power will increase compared to other cooling system such as air cooling or water cooling. The main reason is the ability of oil to extract the heat directly from the heat sources and with a high thermal conductivity. Water cooling is unable to contact the copper wires directly due to insulation concern therefore there will always be a barrier between the water and the wire. While air cooling is able to contact directly the copper wires, the thermal conductivity of air is less performant than oil.

EESM Rotor requires that current/voltage to be sent from the Power Electronic Box. Due to this setup, measurement of the rotor current is achieved via current sensor. Each produced rotor will have a specific rotor resistance due to the copper wires. This resistance is measured on each rotor and recorded inside the Power Electronic Box. With the measurement current and the recorded initial resistance, it is possible to estimate the live rotor temperature during driving. This temperature estimation gives a direct indication of the margin with the max allowed temperature and allows to the constant monitoring of the EESM thermal conditions to optimize all the relevant parameters for cooling, performance, efficiency and safety. The temperature estimation is based on an equation that has been tuned and optimize to reach a high level of accuracy for all the possible customer driving condition.

As a result, the approach can solve both of rotor heating issue and size issue which is specific for EESM at same time. In addition, the EESM with this cooling system can make maximum output up with keeping motor housing size against conventional IPM.

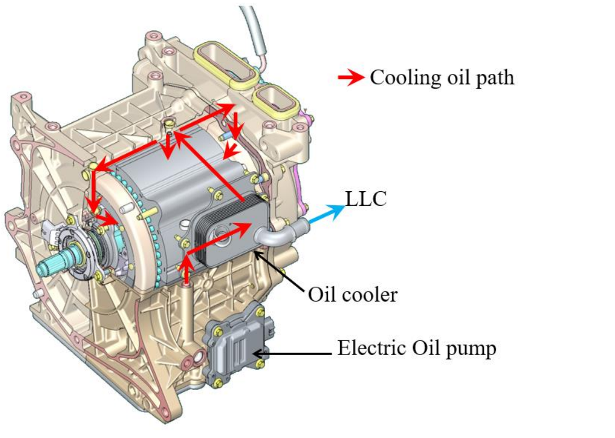

Fig.1 Oil Cooling System for EESM

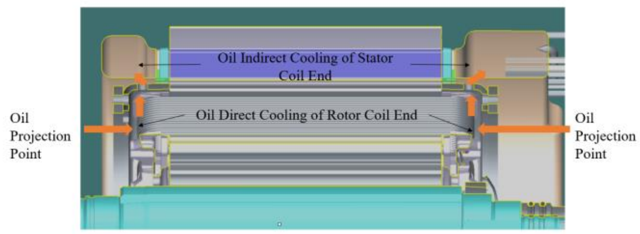

Fig.2 Oil indirect cooling of stator coil end

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