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Thermosets in Insulation Systems

Motivation

The increasing demand for electromobility and electrified vehicles calls for a further development of electric drive technology, as the requirements for the fabrication processes and the applications change. The insulation of the stator (Fig. 1) is an essential part of the fabrication process with shows high impact on the application properties. Due to limitations - for example, in terms of the suitable materials for the stator insulation - a new technology of integrated fabrication by injection molding of thermosets (Fig. 2) is required to meet the demands. The process of injection molding reduces defects like trapped air and the cycle time, which leads to more economic products with high repeat accuracy. Further, a wide range of material modification can be realized by filler systems, for example by increasing the thermal conductivity from 0.2 $\frac{W}{m \cdot K}$ to over 2.5 $\frac{W}{m \cdot K}$.

Application

Electric drives reveal a wide range of applications, such as pump and fan systems or gear motors, which require an insulation system. The insulation by injection molding and modified material systems improves the process conditions and adjusts the properties with respect to the application.

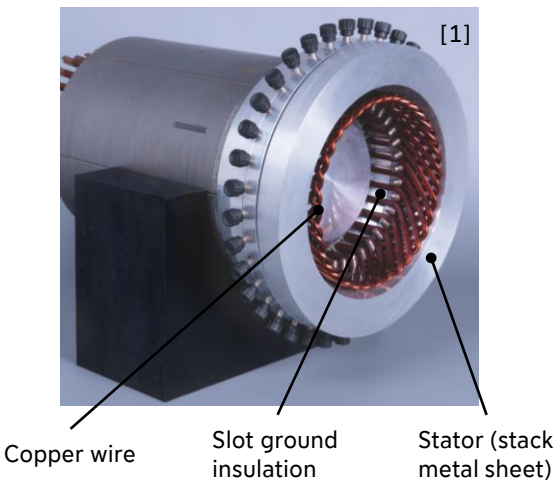

Fig. 1: Insulation system of a stator

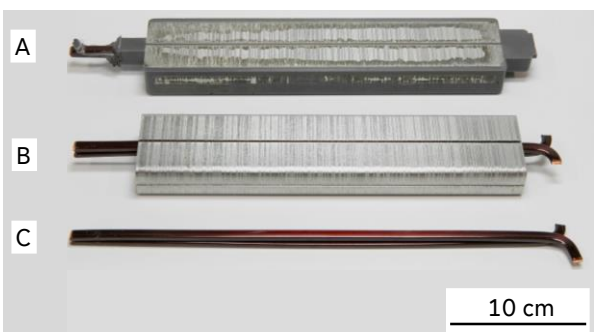

Fig. 2: Insulation system in stator segment by injection molding of thermosets:
A) insulation system by injection molding
B) copper wire inserted in stack metal sheet
C) copper wire

[1]: Aumann AG

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Research focus

To realize an insulation system by injection molding of thermosets, the general material behaviour has to be characterized and the process conditions defined. With respect to the application, the optimized viscosity within the process and the increasing of the insulation properties as well as the thermal conductivity have to be defined. Further, the filler system an d grade can be adopted to improve process and application conditions.

Main research results

Due to the fillers applied in the thermoset, the minimum of the viscosity of the material is increased and shifted to lower temperatures (Fig. 3). Further, the pot life is lowered by the fillers due to different thermal conductivity condicision during the curing. This leads to shorter cycle times and the requirement of highly defined process parameters. To ensure optimum insulation properties, the copper wire has to be completely and homogeneously impregnated by the thermoset system. By adjusting the process parameters properly and choosing, for example, a low holding pressure and injection velocity, the copper wires can be fully covered even with higher viscosity due to the fillers (Fig. 4). Standard process conditions reduce the distance between the wires, which leads to trapped air and reduced performance of the electric drives. The partial discharge voltage should reach a high value in terms of the application (Fig. 5). With respect to the material properties, the new insulation system by injection molding was realized and sufficient sample performance was reached.

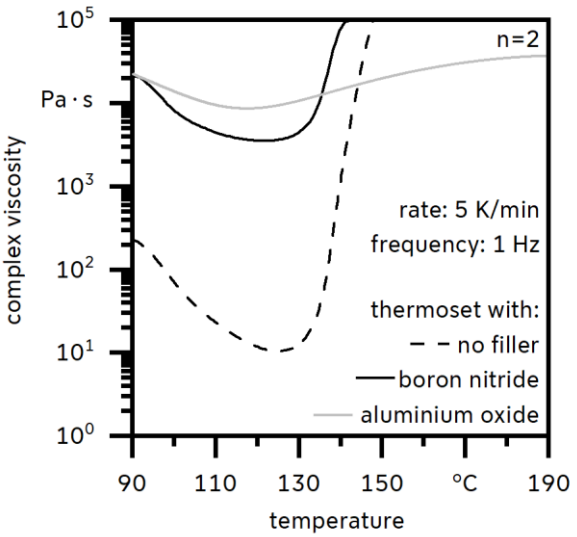

Fig. 3: Minimum of viscosity relative to material system

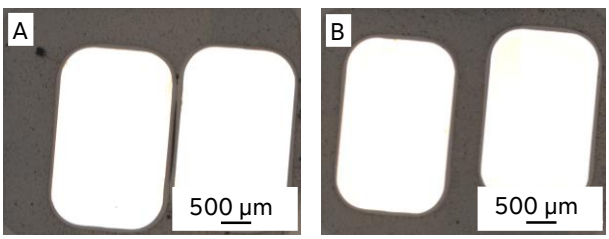

Fig. 4: Insulation system with:
A) standard process parameters
B) adjusted process parameters

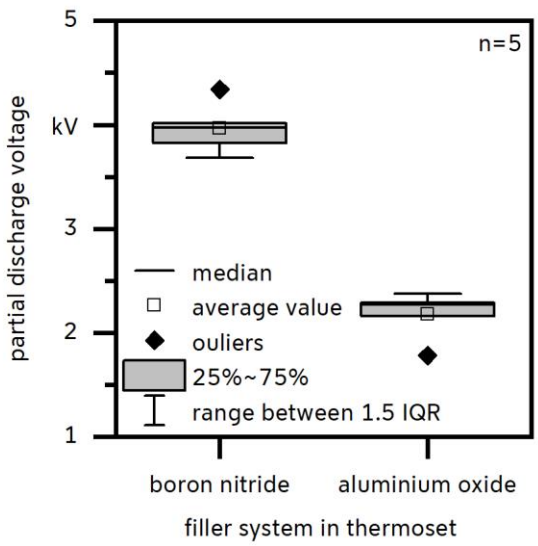

Fig. 5: Application performance relativ to material system

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