

Vibration Characteristics Assessment Technique for Motor-Generator Stator Structures with Laminated Cores and Resin Fixing Materials Using Simple Test Specimens

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Accurate prediction of stator resonance is important for reducing noise and vibration in electrified powertrains. Motor-generator stators with resin fixing materials have complex local stiffness around the teeth, and the equivalent shear stiffness required for CAE modeling is difficult to determine only from full-stator tests. This study therefore focuses on the local deformation mechanism around the tooth (Fig.1) and evaluates whether the stiffness change can be represented by a common equivalent shear modulus.

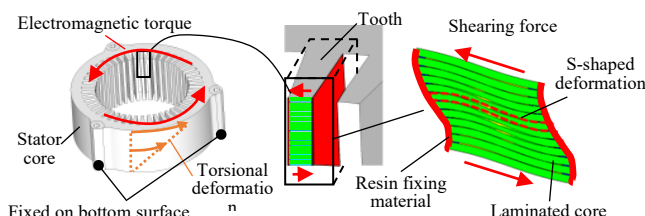


Fig.1 Deformation caused by shear force acting on the tooth section

Simple laminated-core specimens composed of laminated steel sheets and resin fixing material were prepared to represent the tooth section (Fig. 2). Specimen width and stacking thickness were varied to investigate the influence of geometry. In-plane vibration modes under shear excitation were measured using three-dimensional laser Doppler vibrometry. The comparison of transmission sensitivity showed an increase in the resonance frequency with resin fixing material, indicating an increase in tooth stiffness (Fig. 3). The measured mode shape confirmed S-shaped deformation of the laminated core, supporting the proposed mechanism for the stiffness increase around the tooth (Fig. 4).

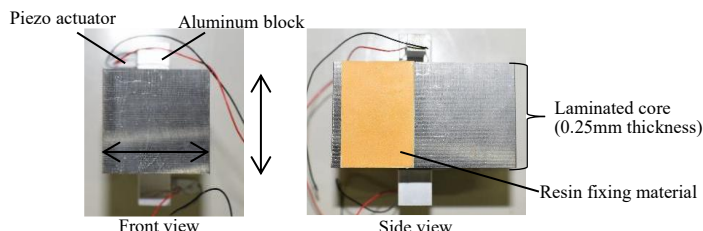


Fig.2 Simple test specimen

The test results showed that stacking thickness had little influence on the shear-mode frequency in the practical range. This tendency can be interpreted by considering that the mass increase and stiffness increase caused by greater stacking thickness are approximately balanced in the laminated and imperfectly bonded structure. In contrast, changing the specimen width altered the shear-mode frequency. The change was not interpreted as a direct width dependence of the equivalent shear modulus but as a transition of the dominant deformation mode between the fixing layer and the laminated core.

Based on these findings, the stiffness increase around the tooth was represented by a common equivalent shear modulus and applied to the stator CAE model. The updated model predicted the first torsional resonance frequencies of stators with different diameters and stacking thicknesses within 10% of the measured values. This result indicates that the simple laminated-core specimen approach provides a reusable modeling basis for early-stage prediction of motor-generator stator vibration characteristics.

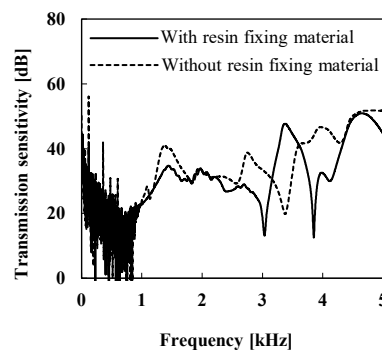


Fig.3 Comparison of transmission sensitivity with and without resin fixing material

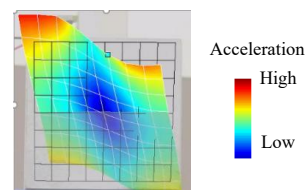


Fig.4 Measured mode shape with resin fixing material