BONDAL E IMPROVES THE ACOUSTICS OF ELECTRIC MOTORS

The three-layered composite material Bondal E in the stator of an electric motor reduces sound emissions by up to 10 dB(A). Bondal E's high structure-borne sound damping is the reason for this and is achieved thanks to a very thin intermediate layer of polymer material. The stacking factor therefore remains virtually unchanged and the electric motor's power-to-weight ratio is retained. Due to the electric motor's reduced sound emissions, secondary soundproofing measures can be dispensed. Therefore, package-, weight- and cost reductions must be anticipated in the overall system.

Bondal E is currently being developed specifically for use in electric motors and can significantly improve acoustics thanks to its very good damping characteristics. The composite material has a three-layer structure consisting of two cover sheets with a viscoelastic intermediate layer. Bondal E can be stamped using conventional stamping tools and then assembled.

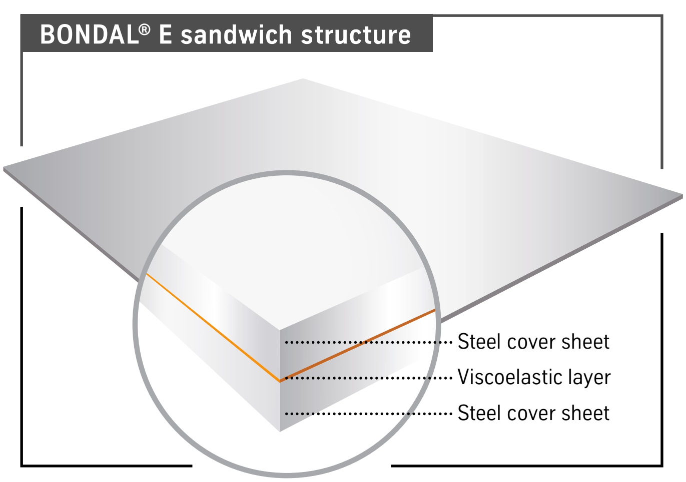
For use in the stator of an induction motor, the Bondal E cover sheets are manufactured from non-grain-oriented electrical steel of grade M 235-35 A with a C5 coating (Stabolit 20) and a sheet thickness of 0.35 mm, ❶. The viscoelastic intermediate layer is very thin as well as oil- and temperature-resistant. The stacking factor, which is very important to an electric motor's efficiency, is only reduced by around 0.7 % due to the selected combination.

Bondal E's structure-borne sound damping is responsible for the induction motor's reduced sound emission. A loss factor of η = 0.05-0.11 in the typical acoustic frequency and temperature range is measured for the composite material according to the EN ISO 6721 standard. Non-grain-oriented electrical steel without this layer only reveals a loss factor of $\eta < 0.001$.

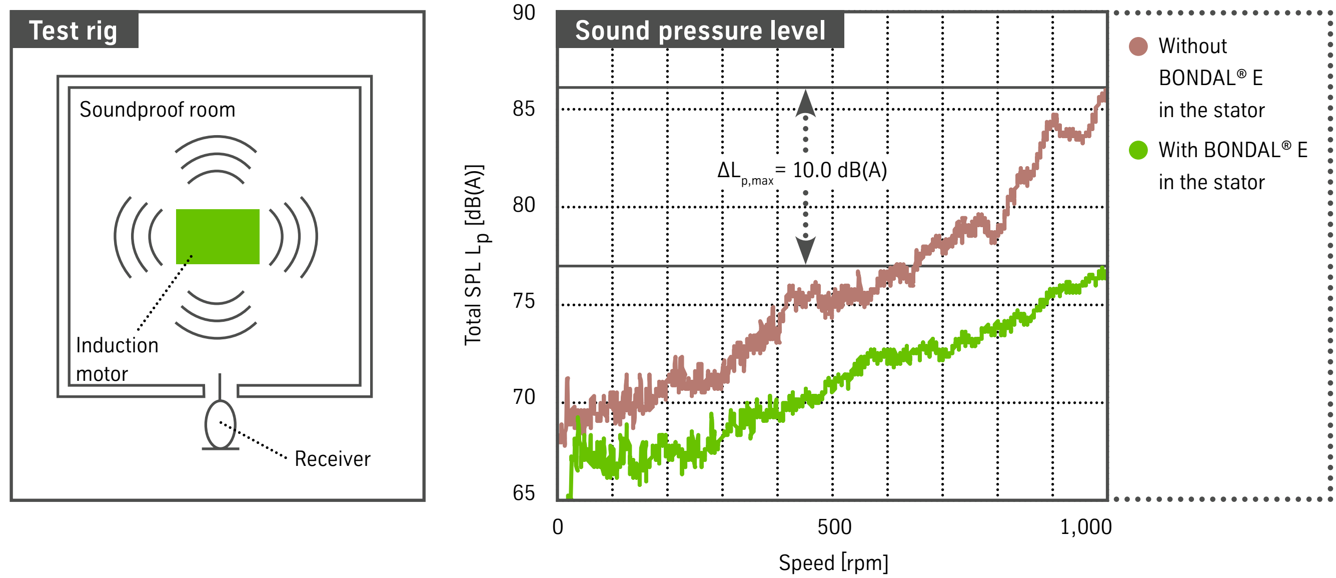
For a precise comparison, an electric motor is constructed with a Bondal E stator. As a reference, an identically designed electric motor has the same electrical steel grade M 235-35 A without viscoelastic intermediate layers. The two induction motors are installed in an acoustically defined environment and the sound pressure level is measured during machine rev-up, ❷. To do this, the rotational speed of both machines is increased from 0 to 1000 rpm within 45 s. The absolute sound pressure level measured in this process is reduced by up to 10 dB(A) due to the use of Bondal E.

However, noises cannot be described solely using the purely physical measurement variable of sound pressure. The tonality also determines whether noises sound more or less pleasant. This psychological perception is reflected in the Campbell diagram, ❸. Close and dominant frequency bands lead to a strong and unpleasant tonality. In the conventionally designed reference induction motor, two dominant frequency bands occur at around 500 and 950 Hz. When Bondal E is used in the stator, no dominant frequency bands can be measured; the noise has broader bands and is therefore perceived as more pleasant.

The good effectiveness of the new material is also proved by the representation of the vibration forms in the transfer path analyses. The amplitudes of the vibration forms in the dominant



❶ Structure of Bondal E: electrical steel as cover sheets with viscoelastic intermediate layer



❷ Schematic structure of the test rig and comparison of the total sound pressure level of the rev-up measurement

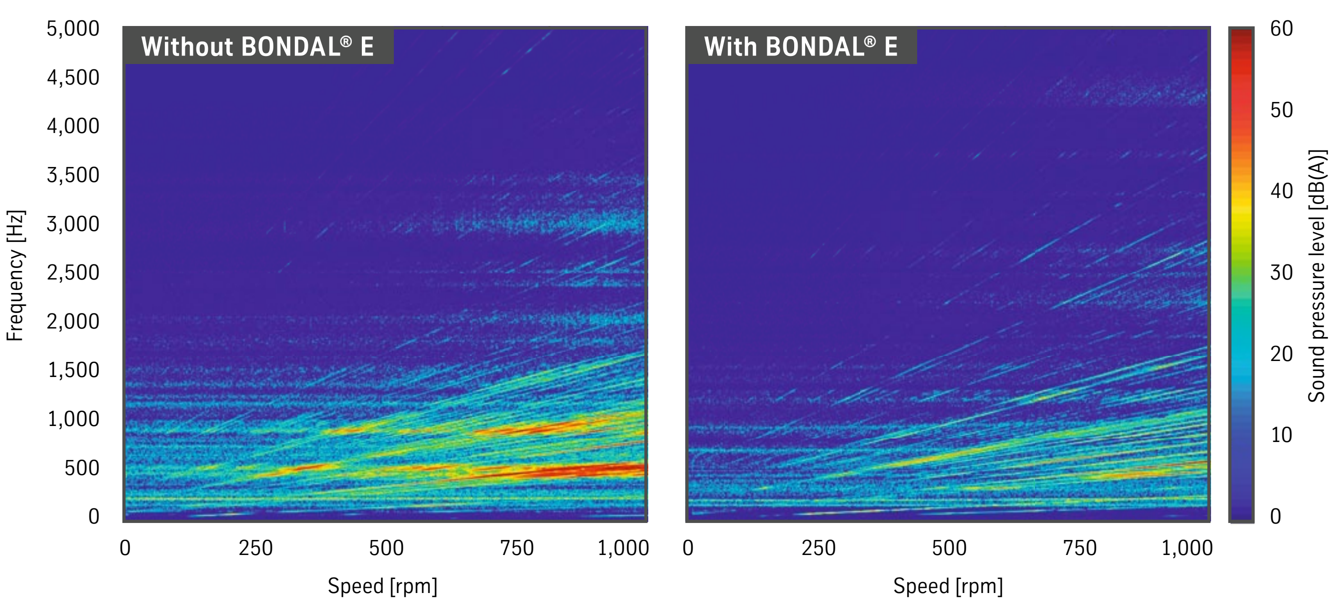
frequency bands are significantly reduced through the use of Bondal E.

The soft magnetic properties are characterized on the basis of a toroidal core sample. The specific magnetization energy and the permeability are determined. Comparison of these key values reveals no significant deterioration between the new Bondal E and the conventional, non-grain-oriented electrical steel.

OUTLOOK

Due to these very interesting results, further Bondal E studies are planned. Above all, work is focused on developing a large-scale production process and the technical boundaries for the sheet and intermediate layer thicknesses which can be processed.

The sheet thicknesses of the non-grain-oriented starting material for stators are currently being further reduced in order to increase the efficiency of electric motors, especially high-performance motors for passenger cars. However, thinner sheets mean increased processing effort in stator manufacturing. Bonding two thin sheets increases stiffness and facilitates processing. New insulating lacquer and intermediate layer combinations are being developed to further increase the stacking factor.



❸ Campbell diagram of the rev-up measurement; conventional induction motor with dominant frequency bands at 500 and 950 Hz (left), with new Bondal E in the stator (right)