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ADHESIVES FOR ELECTRIC MOTORS

- SCOPE: Adhesives have several uses in the construction of an electric motor but may need to cope with harsh environment operation.

Electric motors are becoming increasingly efficient in terms of size, weight and power, and one of the things making this possible is the use of adhesives in their construction. In this Inseto Knowledge Base article we explain where and how adhesives are being used.

When used in the construction of a motor, adhesives have several advantages over mechanical joining techniques. These include no disruption to the magnetic fields of the magnets, stresses being evenly distributed rather than being concentrated around a mechanical joint, and protection against vibration and noise reductions.

In addition, the use of adhesives is helping manufacturers achieve size, weight and power (SWaP) requirements that are, for example, being demanded in the automotive industry. Cost reductions are being sought there too and, again, the use of adhesives helps, not only as a material but also because the adhesive application process can be easily automated.

Adhesives can be used in the construction of an electric motor for many purposes, but one that is growing in popularity is to secure permanent magnets in place. Figure 1 gives examples.

Figure 1 – Left to right: permanent magnets bonded to a motor housing, the outside of rotor and buried with a rotor. In each case the adhesive is highlighted in purple. Image courtesy of DELO.

The mechanical power needed from the motor will govern which type of magnetic material is used. A DC motor for a fan (as found in a vehicle's ventilation system, for instance) will get by with two poles made from ferrite. An EV's drive train will use induction motors (for their high torque density), and they are typically rare earth neodymium iron boron magnets.

Temperature

As readers will recall form school physics lessons, temperature affects magnets, and there are two limits are of importance.

- The maximum operating temperature. As temperature increases, magnetic strength reduces. But provided the maximum operating temperature is not exceeded, the magnet's full strength will return as temperature reduces.
- The Curie temperature. This is named after French physicist Pierre Curie and, interestingly, the Curie temperature of a permanent magnet is determined by not only its material but also its size and shape. Between its maximum operating and Curie temperatures, a magnet will permanently lose some of its strength. Above the Curie temperature, the magnet is permanently demagnetised.

Ferrite magnets can be used at temperatures up to about 180°C (and it's worth noting they are not particularly effective at subzero temperatures). High-temperature neodymium magnets on the other hand can operate up to 200°C.

Understandably, the maximum temperature the motor will be operated at and how its magnets are to be bonded govern which type of adhesive will produce the best results.

For instance, three of Inseto's UK-based customers are electric motor OEMs. Of these, two are using adhesives to bond magnets.

- The first customer designs and manufactures motors for automotive and related applications. This company is using DELO-DUOPOX SJ8665, a thixotropic two-part epoxy mixed in a 2:1 ratio, to bond magnets in place. SJ8665 provides good resistance to chemicals, and DELO has conducted tests that expose the cured adhesive to ATF type III oil at 150°C for 1,000 hours. It lost little of its strength. SJ8665 also provides high temperature stability, up to 180°C, its cure time can be reduced to one hour at 80°C, it bonds well to nickel (which is notoriously difficult to bond to) and it has a shelf life of 12 months.
- The second customer is using DELO-ML DB140, an anaerobic-curing adhesive, to bond unmagnetised ferrous structures in place. Once bonded, the structures are then magnetised. For this company, production speed is of the essence. Under ambient conditions it take about three minutes for DB140 to achieve handling strength. However, the adhesive can be UV-light-fixed in a matter of seconds, enabling the customer to quicky move onto the next assembly stage. DB140 offers a high temperature stability of up to 180°C, and DELO has performed tests (1,000 hours) at this temperature to prove its bond strength remains good.

Adhesives can also be used to form segmented (or stacked) magnets. These are typically neodymium and are popular in the automotive sector because of their high efficiency as they reduce eddy current losses and, as a result, heat build-up.

Other Applications

Stator-to-housing (see Figure 2) and shaft bonding are other examples of where adhesives are used. Stators are typically made of thin (less than 0.5mm) electrical sheet steel (with a 2 to 3% silicon content) that are bonded into their housings (made from cast aluminium or magnesium), as an alternative to other joining methods such as pressing or shrinking.

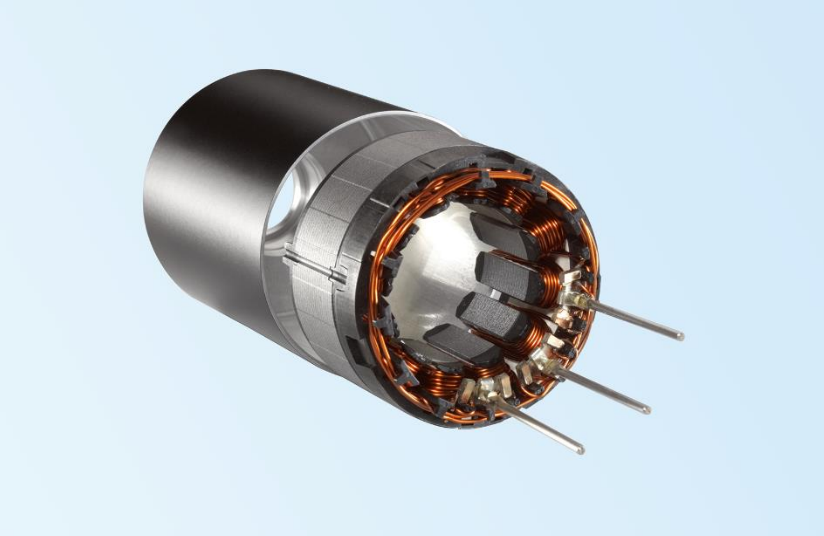
Figure 2 –On the left, a stator bonded to its housing.
Image ©, reproduced here courtesy of EBM Papst.

The use of adhesives is also supplanting pressing and shrinking methods for shaft bonding. Adhesives not only prevent play and slip but also protect against fretting or contact erosion. Anaerobic-curing, low-viscous adhesives tend to be used in this application as the joining gap can be quite small.

In addition, sensitive motor components must be protected against humidity, shock and vibration. Here, potting compounds with the following properties are used:

- Good thermal conductivity (to help with heat dissipation);
- Low thermal expansion (to minimise stress between the component and the compound);
- Low viscosity (to ensure a good flow when applying); and
- Fast light fixation and heat curing.

Another application is gasketing. As mentioned, a third customer is also an electric motor OEM. They are using SL4156, a highly thixotropic cure-in-place gasket (CIPG) adhesive that UV cures in just 8s, as an alternative to traditional gaskets to seal motor housings. This adhesive contains a fluorescing agent, so automatic optical inspection (AOI) systems can be used to verify that a complete bead has been formed before joining the lid to the housing.

The benefits of CIPGs include:

- No need to stock gaskets of different sizes/shapes;
- Complex/3D shapes can be formed (literally dispensed – see figure 3); and
- They allow for some flexibility where machining/moulding surfaces are concerned (particularly with regards to surface smoothness).

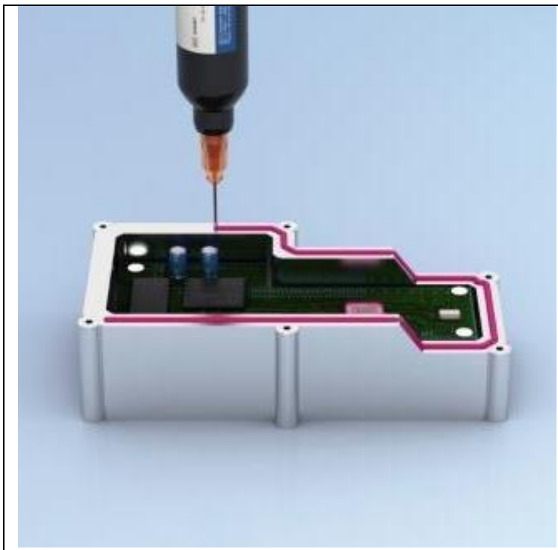

Figure 3 – One of the benefits of a CIPG is that complex-shaped gaskets can be easily created. *Image courtesy of DELO.*

One last application to discuss is additive balancing for motor fan wheels, in order to reduce vibration and extend the life of the motor. The conventional method of achieving balance is to remove material by machining or to use a balancing putty to add mass. However, applying a light-cured adhesive into dedicated slots in the fan (see figure 4) is a more precise process and it is quicker.

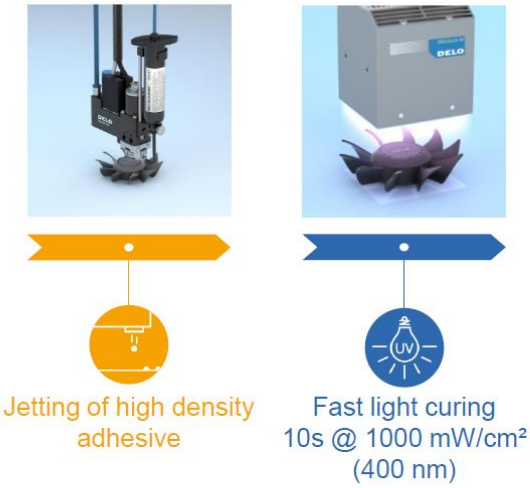

Figure 4 – A quantity of adhesive is applied to achieve balance and is then light cured. *Image courtesy of DELO.*

Conclusion

The drive for SWaP efficiency and cost reductions in most industry sectors is seeing different types of adhesives being used as practical alternatives to mechanical joining techniques. Electric motors are relatively harsh environments though, particularly with regards to heat, dust and contaminants.

Thankfully, today's adhesives are coping well with these harsh environment conditions, and their use means they can outperform mechanical joining techniques in terms of protecting against (and reducing) noise and vibration. Plus of course, cost is always an issue, and the use of adhesives is certainly paying off as a material and because of simplified manufacturing processes.