

- 1 *Aluminum tooth coil produced using investment casting.*
- 2 *Schematic view of the slot fill grades of various winding types for tooth coils.*
- 3 *Thermal image showing the clearly regular warming of the coil.*

CAST COILS OF ALUMINUM AND COPPER

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A multitude of demands are placed on the wound coils of electrical machines. On the one hand, the maximum performance of an electrical machine should be achieved through a high slot fill ratio and thus a good use of the available assembly space. On the other hand, a good cooling of the coil must be ensured and any additional losses through current deflection should be avoided. There is also an overarching need for cost-effective and automated manufacturing and mounting of the coils.

Fraunhofer IFAM has developed a process that enables a casting technological manufacture of coils for electrical machines. The coil geometries produced in this processes, with a flat conductor layout (Fig. 1), offer decisive advantages over conventionally produced coils.

Materials

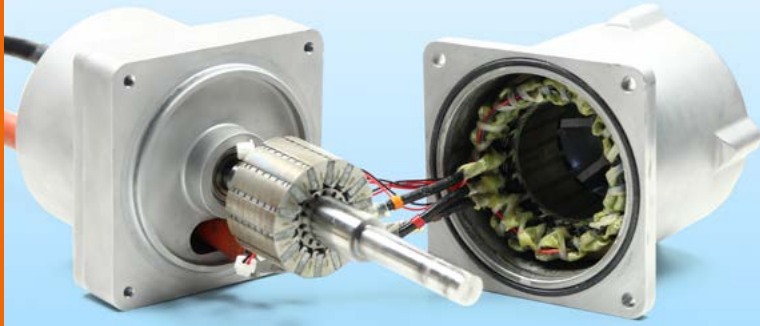
Various materials can be used for the casting technological manufacture of coils:

- Copper and copper alloys
- Aluminum and aluminum alloys

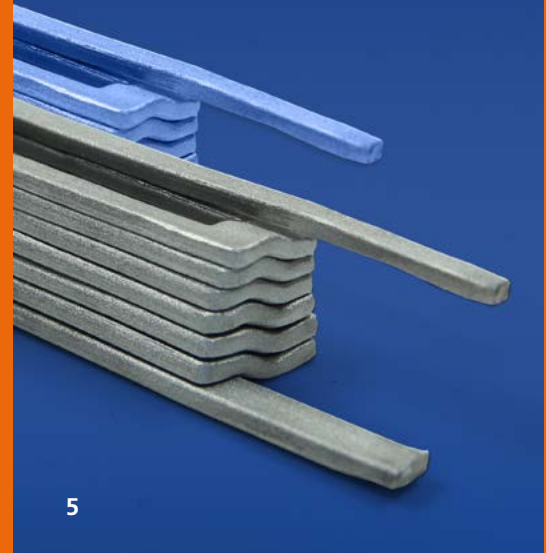
Thus it is possible, depending on the requirements, to focus on performance, weight, price or ease of manufacture.

Casting process

Cast coils can be produced with a number of casting processes. The best process can be selected according to the coil size, the material or the number to be produced.



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Fraunhofer IFAM offers the following casting processes for coils:

- High-pressure die casting
- Investment casting
- Lost Foam casting
- Low-pressure casting
- Metal Injection Moulding

Thus, it is possible to choose the appropriate manufacturing technology for the size, number, material, and use.

Insulating coatings

For the use in an electrical machine, the coil requires an insulating coating. Therefore, various coating processes are being developed and tested at Fraunhofer IFAM. Both conventional powder coatings and dip coating can be used, ensuring good dielectric strength as well as temperature resistance. Novel coatings offer the advantage of high temperature resistance with thinner layer thicknesses as well as the possibility of use in aggressive environments such as oils or refrigerants.

Advantages

Coils produced using casting technology offer many advantages over conventional wound coils. The greatest of these lies in a higher slot fill ratio due to the significantly better use of the available assembly space. Thus, coils with a slot fill ratio of up to

90% can be designed and manufactured. Essential advantages of cast coils are:

- Improved heat dissipation
- High current density
- High performance and torque density
- Ease of producing variants
- Substitution of copper with aluminum

Applications

Cast aluminum coils, especially in combination with novel coatings, enable the use of lighter electromotors for standard applications. High-performance machines with cast copper coils and very high slot fill ratios are also possible. Furthermore, specially coated aluminum coils enable the use in cooling systems with aggressive refrigerants to increase the effectivity of the plant and to counter the risk of corrosion to the electromotor.

Summary

The casting technological manufacture of coils enables completely new concepts for the design of electrical machines. From high-performance machines with copper coils to lightweight e-motors with aluminum coils, the fields of application are many.

Our services

- Electromagnetic simulation and constructive design of coil geometry
- Manufacture and coating of prototype series
- Fundamental process development for coils produced by casting technology
- Development, construction, and testing of electrical machines with cast coils
- Feasibility studies
- Consulting for setting up pilot series

- 4 *Demonstrator motor with a cast aluminum coil.*
- 5 *An aluminum coil produced using high-pressure die casting.*