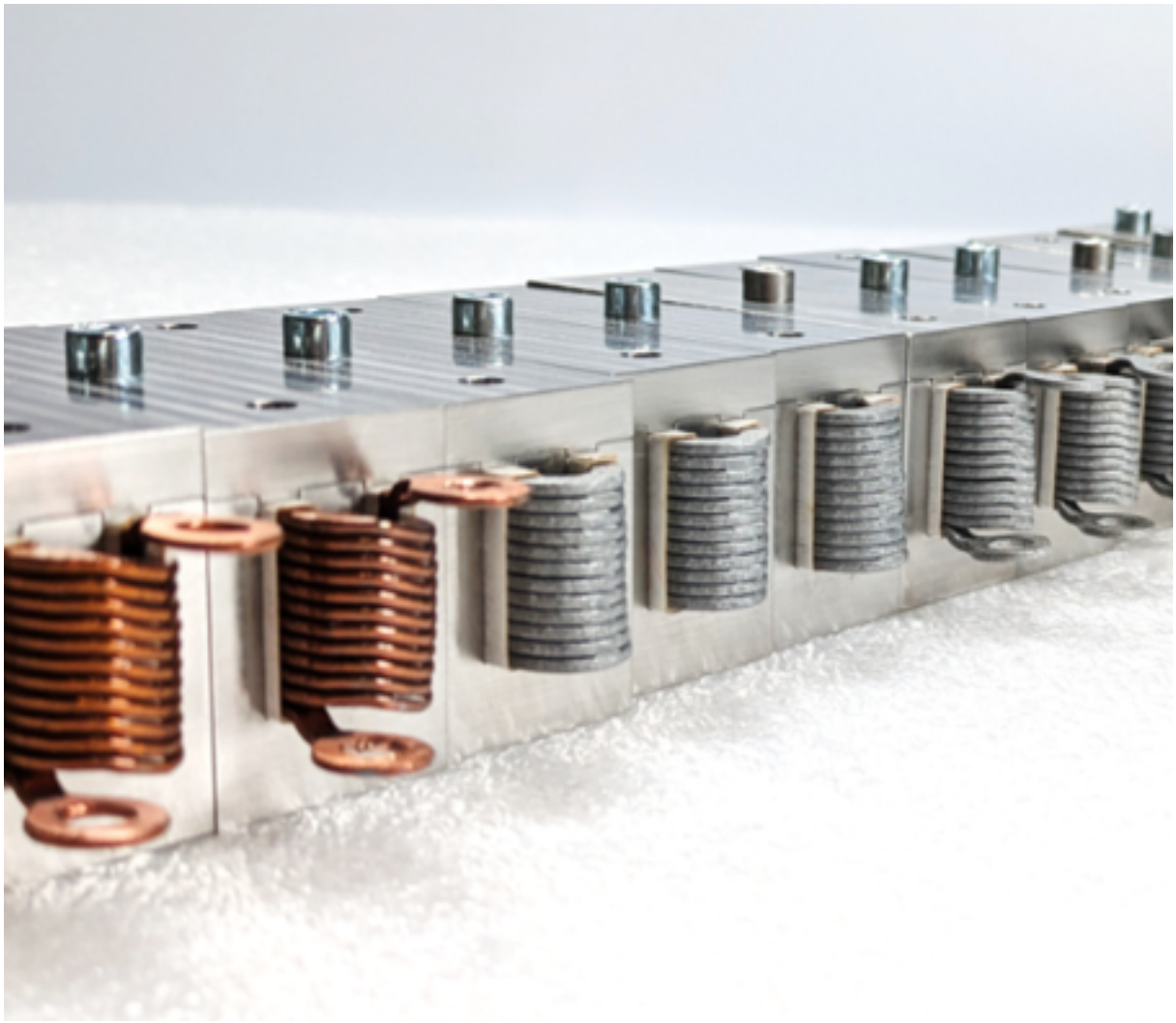
Ceramic-like conductor insulation made of aluminum oxide: dissipates heat from the winding

About this project



KLIMA

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Markets:

Material: Aluminium, Others (Copper)

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This project is funded by the Technology Transfer Programme Leichtbau (TTP LB) of the Federal Ministry of Economics and Energy.

Technology Transfer Program Leichtbau

Context

The energy transition is changing the requirements placed on electrical machines. Drives for vehicles, industrial plant and electric aviation are expected to deliver high power whilst losing less energy. For mobile applications, every kilogramme of weight counts. Power density – that is, the ratio of power to mass – is therefore crucial.

One technical limitation lies in the windings, where current flows through aluminium or copper conductors. As current or rotational speed increases, so does the heat generated in the windings. This heat must be dissipated. Today's insulation systems make this difficult. They consist of several layers: the insulation directly on the conductor, further insulating layers between components, and an impregnation that fills any voids. Polymer varnishes, films and resins are usually used. They provide reliable electrical insulation but are poor heat conductors. This results in temperature differences within the windings and particularly hot areas at the winding ends.

This build-up of heat limits the maximum current load, speed and continuous power for which the motor can be designed. For higher power densities, therefore, an insulation system is required that provides reliable electrical protection for the conductors and dissipates heat more effectively from the winding.

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Purpose

In the KLIMA research project, the project partners are developing a ceramic-like insulation made of aluminium oxide for aluminium and copper conductors. Aluminium oxide is an inorganic material that is temperature-stable and conducts heat more effectively than the varnish coatings used to date. The new conductor insulation thus meets two key requirements: it provides electrical protection for the conductors whilst simultaneously improving heat dissipation from the winding.

The project team is designing the coating to achieve high electrical breakdown strength. This value describes the voltage an insulation can withstand before it fails. At the same time, the researchers are aiming for a temperature stability of at least 300 degrees Celsius.

For preformed coil windings – that is, preformed coils in electrical machines – the aim is to increase power density by more than 30 per cent. This allows the mass of active components to be reduced. This includes the components that generate or conduct the electromagnetic field, such as conductors and electrical steel sheets. Less active material reduces resource consumption. Furthermore, the absence of organic components in the conductor insulation facilitates subsequent recycling.

Procedure

The project partners combine simulation, coating and testing. First, the team calculates the thermal and electrical behaviour of the new insulation. On this basis, the partners produce test samples made from aluminium and copper conductors, as well as samples for other active components of electrical machines.

The coating is applied electrochemically. For aluminium conductors, the researchers use anodisation. This involves the targeted oxidation of the surface to create an electrically insulating layer of aluminium oxide. For copper conductors, the partners employ an additional step. They first deposit aluminium onto the copper wire and then oxidise this intermediate layer. They are also investigating whether the process can be applied to laminated steel stacks and rotor bars in asynchronous machines.

The researchers are testing the coated samples in motorettes, i.e. sub-components of electric machines. There, they are investigating the behaviour of the winding insulation under artificial ageing as well as under thermal, electrical, environmental and mechanical stress. The measurement results are used to optimise the coating process. Finally, the team uses a demonstrator to assess how the new insulation system affects power density, material usage and resource efficiency.

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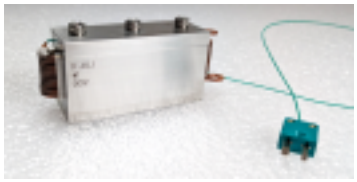

Funding duration:

Funding sign:	03LB3104	**Funding amount:**	EUR 1.9 million

Final report

Further websites

foerderportal.bund.de/foekat/jsp/SucheAction.do?actionMode=view&fkz=03LB3104A - KLIMA in the Federal Government's funding catalogue

www.htw-dresden.de/news/neues-isoliersystem-fuer-sparsamere-elektromotoren - HTW Dresden project website

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Project coordination

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English (EN){{ Projektpartner }}

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Lightweighting classification

	Realisation
Offer	
Products Parts and components	✓
Services & consulting Engineering	✓
Field of technology	
Design & layout Lightweight manufacturing, Lightweight material construction	✓
Functional integration Thermal activation	✓
Measuring and testing technology Component and part analysis, Materials analysis	✓
Modelling and simulation Materials	✓
Plant construction & automation	
Recycling technologies	

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Lightweighting classification

	Realisation
Manufacturing process	
Additive manufacturing 3D printing, Others (Electrochemical deposition, winding)	✓
Coating (surface engineering) Galvanising, Sputtering, Others (Anodising)	✓
Fibre composite technology	
Forming	
Joining	
Material property alteration Others (electrochemical)	✓
Primary forming	
Processing and separating	
Textile technology	
Material	
Biogenic materials	
Cellular materials (foam materials)	
Composites	
Fibres	
Functional materials	
Metals Aluminium, Others (Copper)	✓
Plastics	
Structural ceramics	
(Technical) textiles	