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Heatpipe cooling of a rotor of electrical

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HEATPIPE COOLING OF A ROTOR OF ELECTRICAL MACHINES

Technical task:
The object of the technical innovation is to increase the continuous power density of the electric machine by improving the cooling of the rotor.

Initial situation:
Currently, the cooling of the stator of electrical machines usually takes place via a water jacket on the housing. The removal of heat from the rotor, which is particularly important in rotor-critical machines (usually, asynchronous machines and power-driven synchronous machines) of great importance, takes place either by circulating air cooling or by a so-called internal rotor cooling (hollow shaft or lance cooling). The use of heatpipes (heat pipes) is already known. However, the technical innovations already existing in this context explicitly relate to the axial mounting position in the rotor.

The continuous power density (continuous power that a machine can provide at a given weight, or volume) is primarily thermally limited. In rotor-critical machines (asynchronous machines and power-driven synchronous machines), in particular the heat removal from the rotor is decisive for the continuous power density to be provided. The heat conduction path in a rotor internal cooling usually leads from the rotor cage through the rotor core into the fluid flow in the shaft. However, the radial thermal conductivity of the laminated core is significantly worse than about the thermal conductivity in the cage itself (factor 7 to 10). Thus, the heat conduction via the rotor lamination box forms the „bottleneck“ of this cooling concept.

In heat pipe concepts with axial arrangement in the rotor is such that the heat dissipation on the condensation side of the heat pipe usually in air, which results in a very low heat transfer coefficient.

With exclusively radially arranged heatpipes the thermal connection is coupled to the place of the loss origin. If this is very promising in an asynchronous machine due to the highly conductive material of the rotor cage, usually the axial path of the heat conduction within the rotor so long that in this case a very large thermal resistance can already arise. This is in particular due to the poor axial thermal conductivity of the laminated core, which is also due to the mutual isolation of the individual sheets.

Solution:
An improvement of the heat dissipation or heat dissipation can be achieved if the heat in a short-circuit cage or a rotor winding can be specified or transferred to a cooling fluid in a more direct way. This can be achieved by using so-called heatpipes (heat pipes) in an inverted U-shaped arrangement between the heat loss sources and the cooling fluid. Since the thermal conductivity of heat pipes is many times higher than the conventional metallic materials, even a few relatively small heat pipes mean a significant increase in the possible heat dissipated to the cooling fluid.

The inverted U-shaped arrangement is a very good thermal connection of the evaporator of the heat pipe to the place of loss. This also leads to an axially very uniform temperature, without the formation of individual hotspots. In particular, this concept is interesting for electric machines with rotor winding, but an application for other machine types is also conceivable in principle. Further advantages arise when the execution of the heat pipe in the paraxial portion is flat and round in the radial section. This is discussed in more detail in the Technical Implementation section.

Technical implementation:
Especially with an electric machine with windings in the rotor (separately excited synchronous machines) the design makes sense as follows, see also Fig. 2 and 3:

- The axis-parallel part of the heat pipe (the evaporator zone) is inserted into the groove base
  Particularly advantageous is a flat design of the heat pipe in the region of Nutgrundes, due to the better thermal connection, as well as a better utilization of the liquid distribution within the heat pipe as a result of the centrifugal acceleration (better wetting of a larger area)
- In the area of the bend and the transition of the heat pipe into the Rotor interior cooling is a round shape ideal for easy manufacture and Ensuring sealing of the shaft
- The heat pipe is thus introduced in the manufacturing process before the winding
- Then the winding is pulled in above the heatpipe
- The potting is carried out

Advantages:
- The effective thermal conductivity of a heat pipe is many times higher than the thermal conductivity of copper full material.
- Very good thermal connection of the evaporator zone to the place of heat generation in the active part of the rotor.
- At the same time very good thermal connection of the condenser zone to the place of heat dissipation in the rotor interior cooling.

Possible application:
- Electrical machines.

Technische Neuerung

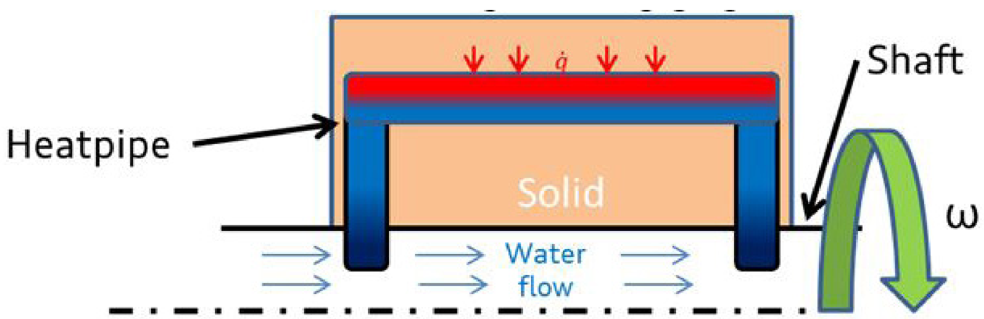

Abb. 1

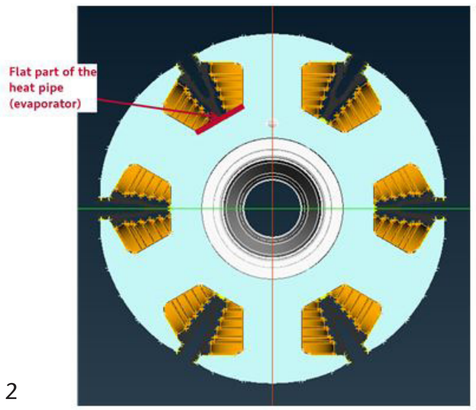

Abb. 2

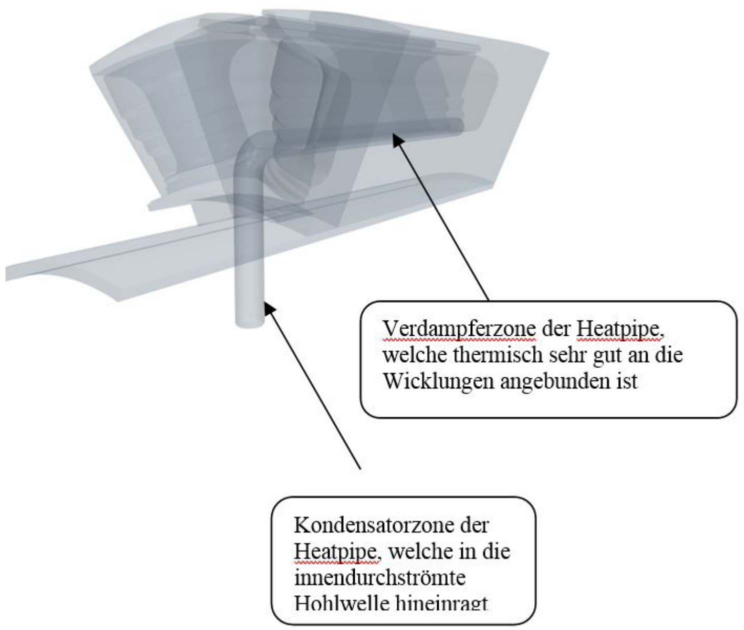

Abb. 3