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ELECTRIC MACHINE AS EXTERNAL ROTOR WITH DIRECT COOLING

Axel Unger
Bertrandt Ingenieurbüro GmbH

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Technical task:
Some electric machines are designed as external rotor machines. This means that the stator is on the inside and the rotor on the outside, see figure 1. This design is characterised by a high gravimetric and volumetric power and torque density.

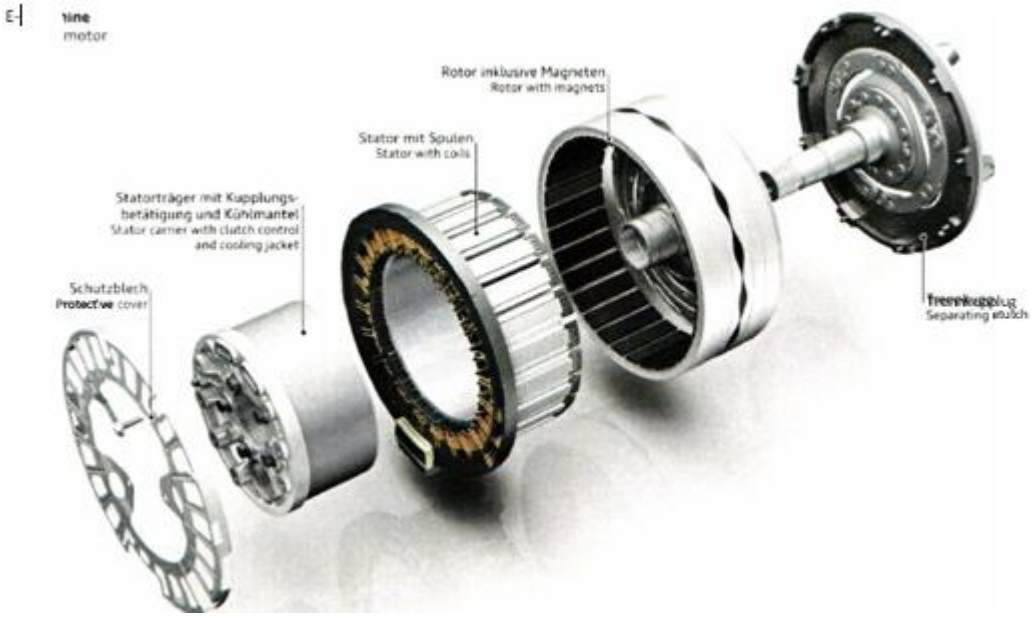

Figure 1: Exploded view of the external rotor e-machine of the Audi Q7 e-tron.

Many e-machines designed as internal rotors (rotor inside, stator outside) in passenger cars have direct cooling, also called wet cooling, whereby the rotor and stator are flowed through, wetted or spun by or with oil, see Figure 2. It is important that the rotor does not run in standing oil, as otherwise panting losses occur.

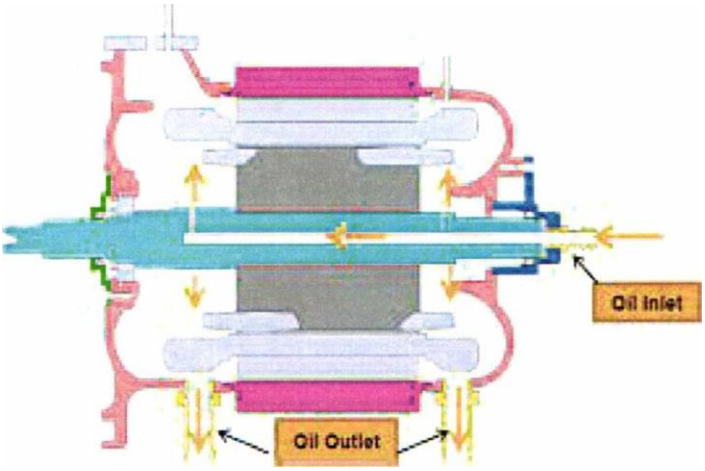

Figure 2: Sectional view of an internal rotor E-machine with direct cooling (source: https://ieeexplore.ieee.org/document/8507058)

Initial situation:

With an external rotor, cooling the stator by means of a water jacket is more complex and less effective than with an internal rotor due to the relatively small surface of the stator carrier.

Solution:

An e-machine as an external rotor is designed with direct cooling.

Advantages:

The high gravimetric and volumetric power and torque density of an external rotor are combined with the advantages of direct cooling. These include, for example, a significantly larger surface area that can be cooled, winding heads that can be cooled much better (usually the hottest part of the stator) or faster/better heating of the transmission oil (in the case of a common circuit), which usually leads to less power loss in the transmission and thus to more range/higher efficiency.

In general, better cooling of an e-machine primarily ensures higher continuous power and higher continuous torque.

Possible application:

The direct cooling of the external rotor is essentially made possible or favoured by three elements, see Figure 3:

(A) A web with a curved profile is provided on the inner side of the disc-shaped part of the rotor arm. This serves to throw oil onto the winding head facing the rotor, which is pressed outwards by the centrifugal force when the rotor arm rotates.
(B) Radial holes are distributed around the circumference of the cylindrical part of the rotor arm. These prevent larger quantities of oil from collecting in the rotor arm or entering the air gap.
(C) On the winding head facing away from the rotor, a collar-shaped web is fitted to prevent oil, which cools this winding head, from coming into direct contact with the rotor or entering the air gap.

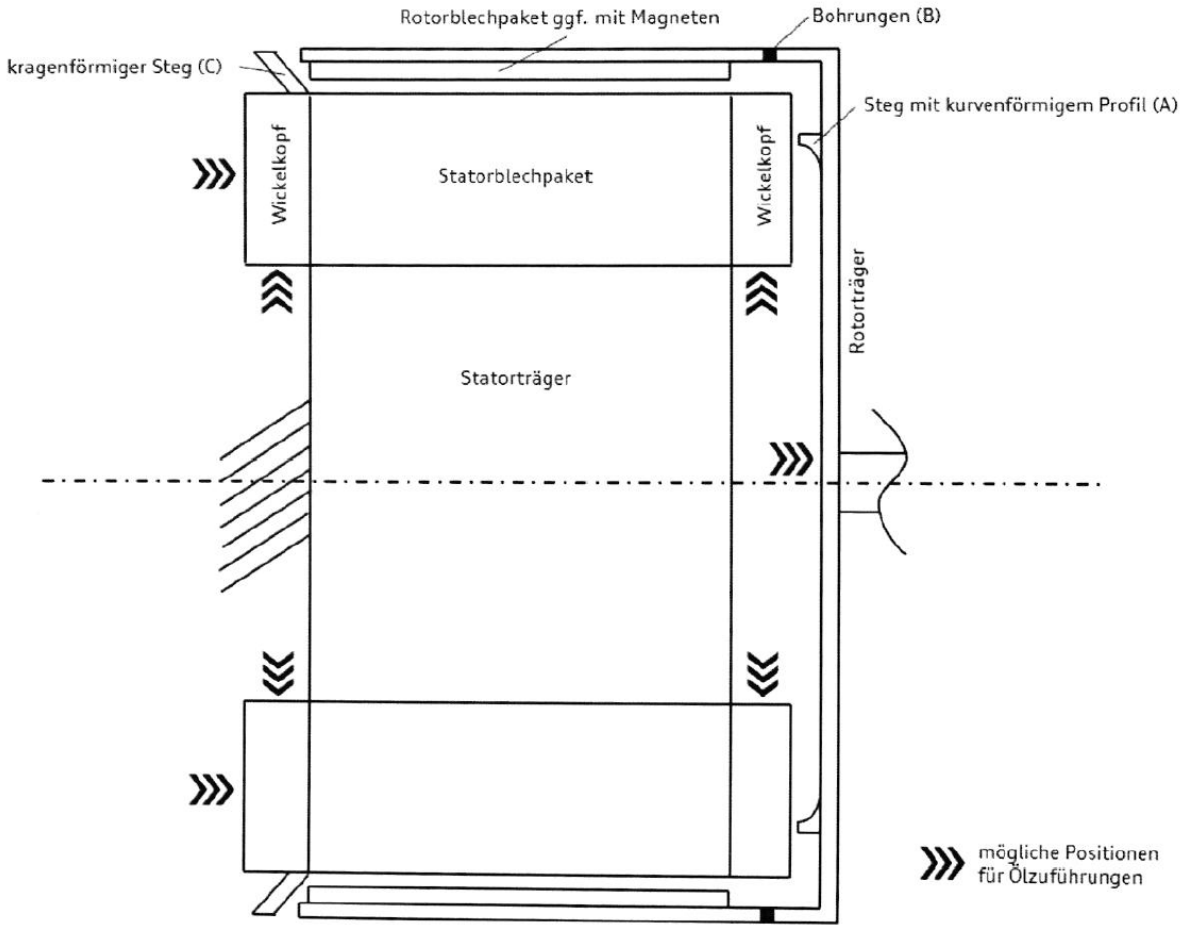

Figure 3: Sketch of a possible implementation as a sectional view.

Cooling of the stator via a cooling jacket in the stator carrier and/or cooling channels in the stator laminations (both state of the art) is also possible.