Institute of Automotive Technology
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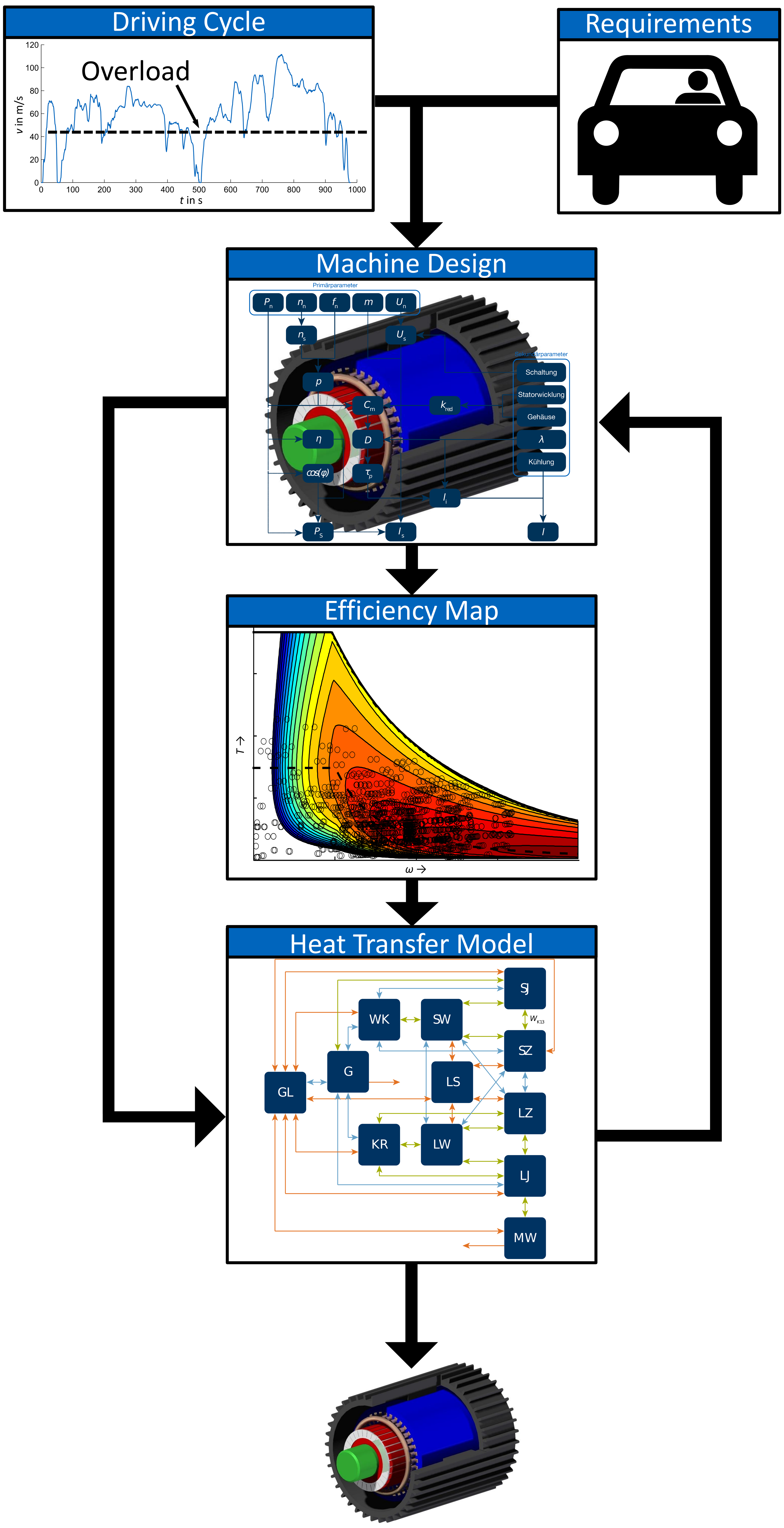
Design of Electrical Machines for Automotive Purposes Considering the Overload Potential



Unrealistic specifications like synthetic driving-cycles or interval acceleration tests determine the design of (electric) machines for automotive purposes.
The design-process is based on procedures and rules of thumb, which mostly are used in the same manner as for regular industrial applications.
However, electrical drives for automotive purposes are subject to entirely different requirements than industrial drives.
Hereby, many parameters are not of interest, especially the size that subsequently leads to great robustness of the machine because its failure would cost much more than a more restrictive and compact design. Also, the installation of an additional cooling is easy to realize.

The introduced method imposes a different procedure to design an electric drive with respect to the realistic load in passenger or utility vehicles. Hereby, it takes the electric machines ability to highly overload for a short period of time into account.
This makes it possible to cover many unsteady load points by the overload operation. Any other steady load points like maximum speed are not affected.

Every calculation is executed analytically because FE-based calculations are very time consuming and not suitable for the early stage of the design phase. When the machine's geometry is known to a higher degree, the FE-based calculations' advantages ultimately play off.

First of all, a realistic load-profile has to be derived out of a data-pool collected by the Institute of Automotive Engineering, to set the basis for the following calculations.
This profile takes into account 95 % of the recorded driving situations and leaves the unlikely situations unconsidered. Its goal is to represent as much real driving behavior as possible.

Subsequently, a machine is designed using established procedures. At that point a design is already chosen which for example takes into account the technical limits of the machine's utilization and the copper fill factor, as well as innovative manufacturing techniques or materials (e.g. compressed coils or special electrical steel).
Taking these abilities into consideration, the type of the machine can be chosen from permanent synchronous (PMSM) or induction machines (IM) or rather be automatically selected with respect to aspects like maximum efficiency or weight.

As soon as the preliminary dimensioning is done, an efficiency map is calculated using the before estimated magnetic key figures. For that purpose the machine's copper and iron losses are computed. Hereby, both machines benefit from innovative and more exact loss reducing control strategies.

The preliminary dimensioning also provides masses and measures of all the relevant machine components. With these it is possible to build a heat transfer model and in combination with the efficiency map it is then feasible to calculate the (unsteady) temperatures of the relevant machine parts.
Using this information it can be estimated if the machine is operated at its thermal limit. In case it is not, which means even at highest loads the machine's temperature does not reach its limit, the machine can be designed smaller with respect to measures and thus masses.

The following results are being expected:

- The machine's mass will be reduced.
- Accordingly by less use of material the machine becomes more economical.
- By the movement of the steady operational load points towards the nominal speed the machine becomes more efficient (mostly, in this area the high operational points with the highest efficiency are located).

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