Modelling of Convection in Motor-CAD.

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Motor-CAD is the world's only software package dedicated to the optimisation of motor cooling. Its solver is based on thermal lumped circuit analysis. This provides near instantaneous calculations speeds allowing "what-if" scenarios to be run in real time. A major feature of the software is its modern graphical user interface to simplify data entry. All the conduction, radiation and convection parameters are calculated automatically by the program. This article concentrates on the formulations used to predict the convection cooling within the machine.

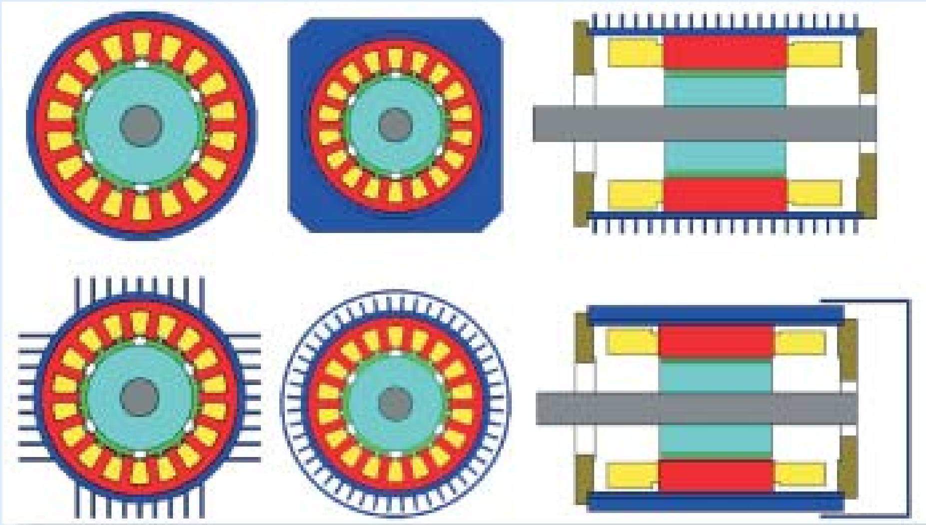

Figure 1: Examples of housing types suitable for TENV and TEFC cooling

Proven Convection Correlations based on Dimensional Analysis

Convection is the transfer process due to fluid motion. In natural convection, the fluid motion is due entirely to buoyancy forces arising from density variations in the fluid. In a forced convection system movement of fluid is by an external force (fan, blower, pump). If the fluid velocity is large then turbulence is induced. In such cases the mixing of hot and cold air is more efficient and there is an increase in heat transfer.

Motor-CAD automatically calculates the convection from all surfaces of the motor that are in contact with a fluid (air or liquid cooling). Proven empirical heat transfer correlations based on dimensional analysis are used [1] to predict the heat transfer coefficient, *h* [W/m2/C]. Many such correlations are built into Motor-CAD – the most appropriate formulation for a given surface and flow condition being chosen automatically. This means that the Motor-CAD user need not be an expert in heat transfer analysis to use the software effectively.

External Surface TEFC and TEFC Cooling

Motor-CAD includes many housing types suitable for external natural and forced convection (TENV and TEFC), a few of the types available being shown in figure1. The correlation chosen for a particular housing section depends on the cooling strategy, the motors orientation and the geometry of the given component. For instance, in open channel TEFC machines a special formulation based on the extensive testing carried out by Heiles [2] is used. He carried out a significant amount of testing of cooling from finned induction motor housings of various size and shape. Factors are incorporated into Motor-CAD to account for leakage from the semi-open channels and for channel blockage due to such practical features as terminal boxes and bolt lugs. Motor-CAD has the facilities to model both shaft mounted fans and constant speed blower units. The fan cover or cowling can also be included in the model as shown in figure 1.

Liquid Cooling

Motor-CAD includes a number of sophisticated liquid cooling methods, such as spiral grooves, direct liquid cooling of end-windings and spray cooling. Figure 2 shows examples for the liquid cooling types available. Correlations suitable for convection internal flow are used to calculate the heat transfer coefficient. The heating effect of the fluid is also taken into account in the formulation.

End-Space Cooling and Airgap Cooling

Convection for all surfaces within the internal sections of the machine are modeled, e.g. end-windings, airgap, etc. The cooling of the end sections of the machine can be quite complex. This is due to the fluid flow depends on many factors including the shape & length of the end winding, added fanning effects due to wafters (simple end-ring paddle fan), simple internal fans & the surface finish of the end sections of the rotor and turbulence. Several authors have studied such cooling and in general show much the same trends (figure 3).

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Any one of the correlations shown can be selected within Motor-CAD. The default correlation used is that of Schubert [EW] as its data is central to the given curves.

The correlation used for calculating the heat transfer across the airgap is based on published work on concentric rotating cylinders. It has been found that the heat transfer is by pure conduction when the flow is laminar but there is an increase in heat transfer when the airgap Reynolds number (velocity dependent) increases above a critical value - the flow taking on a regular vortex pattern. Above a higher critical Reynolds number the flow becomes turbulent and the heat transfer increases further.

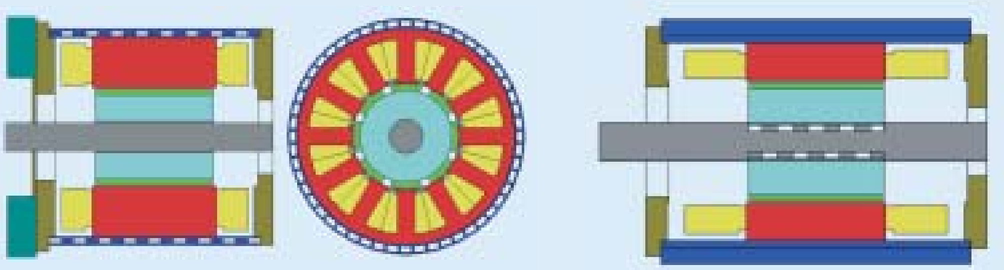

Figure 2: Examples of liquid cooling types

Conclusions

This article has briefly taken a look at the wide range of convection formulations used in Motor-CAD. All the formulations are automatically selected such that the user need not be an expert in thermal analysis to obtain reliable results.
A new through ventilation algorithm will be released in the spring and will form the subject an article in the next edition of the Flux Magazine.

References

[1] Incropera, F.P & DeWitt, D.P.: Introduction to Heat Transfer, Wiley, 1990.

[2] Heiles, F.: Design and Arrangement of Cooling Fins, Elecktrotecknik und Maschinenbay, Vol. 69, No. 14, July 1952.

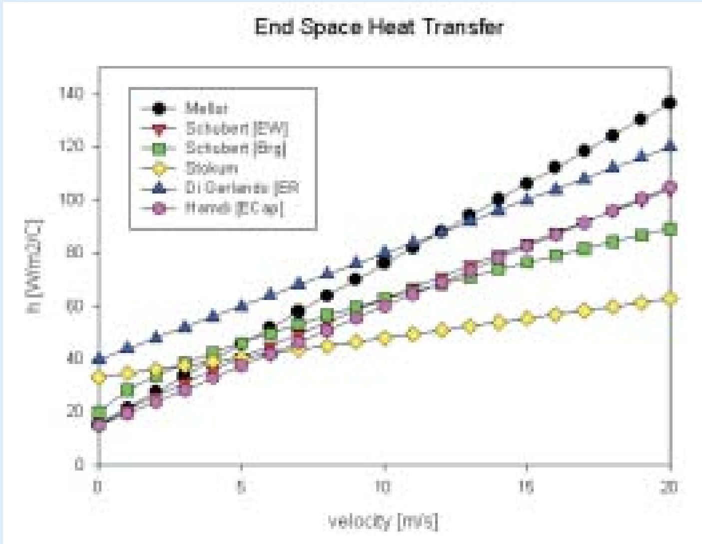

Figure 3: End-space convection correlations available in Motor-CAD

Kone corporation.

Dominique Roggo, COSPHI ONE.

KONE

Kone Corporation, Finland, announce the purchase of FLUX2D. Kone is one of the largest lift maker in the world in the term of market share. KONE was looking for a more accurate and efficient tool for the Finite Element Modelling of their new EcoDisc Synchronous Axial Flux Motors. The EcoDisc is a complete, AC gearless hoisting unit so compact it can be mounted onto the guide rail in a standard shaft. The controller is built into the door frame and no separate machine room for the elevator is needed.
Due to its original topology, the PM axial flux motor represent a special case in motor modelling. The use of FLUX2D «Rotating Motion» module will be of great help for this particular application. We wish that FLUX2D will help us to surprise you further with our new concepts.