Supplier of customised actuation systems

ROSNER-TDL

Thermal Analysis of Electric Motors

Necessity – Model – Conclusions

Overview:

The temperature rise of electric motors under load can cause a problem in many applications. For a safe estimation of the behaviour on overload (e.g. in cases of emergency), when no manufacturers data is available, we developed a method for the analysis of the thermal behaviour, which runs without additional temperature sensors. The method generates a physically plausible model, which can be linked directly with simulations. This report shows possible applications on a broad range of electric motors (motors with permanent magnets and masses between 15 g and 500 g, resp. 0.5 oz to 1 lb).

Necessity

For the operation of compact highly dynamic actuators it is important to select the motor not only on behalf of the performance data, but also based on the ability of the motor to cope with the associated temperature rise. To predict this behaviour sufficiently, it is necessary to analyse the thermal properties of the actuator.

Thermal behaviour

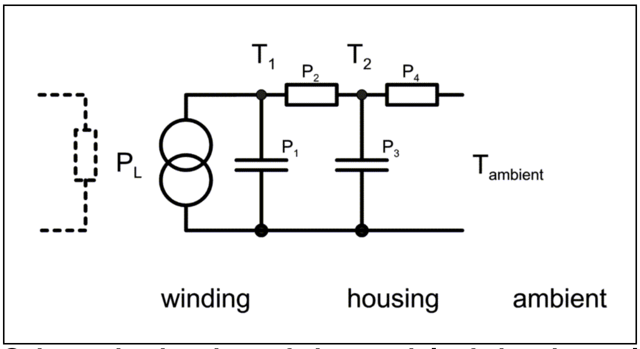
The reasons for the temperature rise of electric motors are manifold. The main reasons are the resistance of the winding, magnetic losses in the iron lamination or eddy currents. In most cases (especially in actuators) the first reason prevails significantly. On the other hand, the generated heat can dissipate on several ways: by conduction, by convection or by radiation. Here the first and the second way are dominant.

Model generation

The model is generated physically plausible:

- In the winding the current causes at the resistance a power loss.
- The winding conducts the power to a second outer mass, which encapsulates the first inner mass. This mass can be seen as the iron lamination armature and the housing.
- From this second mass the power is transferred or dissipated to the ambient.

The analytic model is based on the conservation of power, separately formulated for the inner mass (winding) and the outer mass (armature, housing).



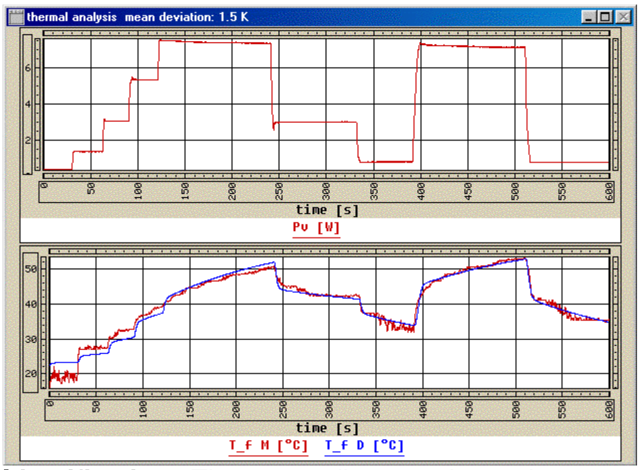
Schematic drawing of the model of the thermal behaviour: The power loss P_L in the winding flows through the housing to the ambient. The temperatures T_1 and T_2 represent the temperatures of winding and housing. The parameters P_1 to P_4 depend on the physical properties.

Parameter identification

The estimation of the four parameters based on geometric properties, masses and materials is insufficient. But we can conduct experiments in our laboratory, from which we can derive (through data analysis by parameter estimation) the four parameters. This method has been validated on a variety of motors and environmental conditions. We investigated brushless and brush servo motors from 15 g to 500 g (0.5 oz to 1 lb).

The main idea of parameter identification is to choose the four parameter of the model such, that the calculated behaviour matches the measured data best. So it makes sense to measure the temperature in the winding and to base the identification upon it. The straightest approach is to utilize the winding itself as the temperature sensor. For this the resistance of the winding is measured by a four-wire scheme and transformed into the average winding temperature.

The identification algorithm compares these derived data with the (inner) temperature T_1 of the model.



Identification: The upper diagram shows the power loss heating the motor The lower diagram shows the measured temperature (red) and the estimated temperature (blue), calculated with the identified set of parameters.

Conclusions

The model with four identified parameters enables us, to predict the thermal behaviour of the motor under almost any circumstances. So in an early stage of design or project potential shortcomings become clear, so they can be corrected, mostly before expensive construction or manufacturing costs occur. With the model you can derive potential additional motion strategies to extend the capabilities of the motor or actuator.

Offer

Based on our experiences we can analyse custom motors quickly and supply a tested model. Please send us some data about your application.

Rosner & Rosner GBR
Technical Design Laboratory

phone: +49 (0) 58 27 / 97 09 81
fax: +49 (0) 58 27 / 97 09 82

Neue Strasse 3
D-29 345 Unterluess
Germany

e-mail: rosner@rosner-tdl.de
internet: www.rosner-tdl.de