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Design method for application-specific linear direct drives with low power

Daniel Kreuzer

The existing design method for application-specific linear direct drives with low power is significantly improved by the content of this thesis, especially with regard to the required development time. Particular attention lies on the optimization of the structural synthesis, because previous methods are using the know-how of the developer to select the actuator. So there is always an uncertainty regarding on the choice of the best possible design. To reduce this uncertainty, the optimized dimensioning is developed. The process begins with the request list, like previous methods. This is followed by the structural optimization which uses optimum envelope curves. They describe for different linear drive concepts the realizable thrust force, actuation time or kinetic energy across the external surface. So that an estimation of the size and a rough favoring of some variants becomes possible.
Subsequently the automated dimensioning starts to get the most ideal geometrical parameters of the chosen designs for a final selection. Finally the most suitable drive can be constructed and built as a prototype.

In order to expand the optimized dimensioning with new variants, the present thesis explains the creation of further optimum envelope curves and their application. The underlying functions herefor were derived theoretical. In addition to that, four linear direct drives confirm the derivation and applicability with analytical calculation and simulation results.

Also the creation and application of the newly developed construction-specific automated dimensioning is shown. Here are two executions to be distinguished an analytical or simulation-based. The automated analytical dimensioning is constructed as a hybrid software from numerical and analytical calculation. It is based on the consideration of the different physical subsystems and their interactions. The objective of this is the optimal fulfillment of the requirements such as maximum thrust force or dynamics. In contrast, the automated simulation-based dimensioning is constructed as control software with finite element analysis. Therefore the control software itself contains the optimizer which executes the finite element analysis of different variants. In order to verify the developed software, both finite element analysis and eight prototypes are used. In addition, the optimizing algorithm has been tested by starting point variations with a result scatter less than 0.4%. For a holistic investigation of the dimensioning, it is not only necessary to increase the primary function parameters, such as thrust force or dynamics. In practice additional requirements like a defined supply voltage or a minimum permanent magnet volume are often necessary. Even these additional requirements can be integrated into the automated optimization software and verified with examples.

In summary the novel design methodology greatly improves the development process of linear direct drives. Due to the automated process an economical and well-founded maximum finding is possible. The most valuable aspect of this method forms the rapid structural synthesis with envelope curves. Because of this, the optimized dimensioning is a powerful tool to compare a lot of linear actuators for a required application. This helps the developer to choose the best suitable design and generates an enormous competition advantage. To improve the optimized dimensioning by expandation, further software and optimum envelope curves should be generated for additional drives.