

Statistics for electro-mechanical energy converter design

The project aims to catalyse significant advances in the design process of modern electro-magnetic energy converters as used in almost all renewable and sustainable energy systems by allowing consideration of manufacturing tolerances at the early stage of conceptual design at reasonable computational cost.

Project outline and objectives

Modern power-electronics based electro-magnetic energy converters find application both in industrial and consumer applications, and, most topical, are a core element of most renewable and sustainable energy systems. Research on the design of customised individually realised solutions has provided many new designs. However, transfer of these into mass production has been slow. One of the main reasons is the lack of tools to consider manufacturing tolerances at the early stage of conceptual design. If such tolerances are considered at a later design stage, time consuming lengthy computations are applied, where—often—thousands of computations are carried out to compute the distribution of the output parameters for given distributions of the input parameters.

This project will use a small manageable example design case and investigate the application of novel techniques (as seen under the Complexity Science umbrella) to deal with statistically distributed parameters and their interactions. These approaches will be compared to the traditional computationally heavy ones that are mostly scale-up of solutions for single-variable systems and do not consider the interaction of the variables within the system. The project thereby aims to catalyse significant advances in the design process of such converters, researching possibilities to include the statistical distribution of the parameters at an early stage and at reasonable computational cost. In addition, the field of electro-mechanical energy converters has always been rather conservative, and investigation of the applicability of techniques from Complexity Science in this context is by itself a highly novel—and interesting—field.

Methodology

The techniques studied in CO 905 will be of most relevance, where notably stochastic differential equations have a high potential to advance the existing techniques for conceptual design. The example case model that underlies the design will be implemented in a language of the student's choice, providing the base for the research itself. Then, different techniques to consider variations in the input variables will be identified and applied to the example case aim. Special emphasis will be placed on techniques developed for highly-interactive systems with multiple statistically distributed parameters. While doing so, the focus will be to develop generic statements on the computational effort and the extent of information available in the output parameters, where traditional techniques will be considered as a reference. Even if no computational advances were achieved, any statements on the efficiency and reliability of such techniques as applied to this field will already be results by themselves.

Required background

Apart from a good understanding of the above listed Complexity Science module the techniques required are analysis and simulation as well as basic programming skills. The example case model of manageable size is available and will be given to the student. It can be used as tool of the research without an understanding of the underlying electromagnetic and mechanical relationships.

Research outcome and outlook

The interest in the project stems from the application of the novel techniques of Complexity Science to an outside field, to research the feasibility and limits of doing so, and to thereby catalyse novel developments in this field (closer-to-market design). The deliverables will include generic statements on the computational effort and the gain of information of application of different techniques to consider with multiple statistically distributed parameters to the design of electro-mechanical energy converters, which are highly-interactive systems.

The prospects for this miniproject leading into a PhD project are high: There is a plethora of open questions concerning the consideration of uncertainty in the conceptual design of modern electric drive systems (which include electro-mechanical energy converters). The models and structures of the different components of such systems are numerous, providing a fast area of research, where Complexity Science at its intersection with electrical and mechanical engineering could make a major contribution towards closer-to-market design and thereby larger uptake of low-carbon and more sustainable systems.