Bearing failure data analysis

The proposed work addresses the bearing damage which occurs in machines of modern, highly energy-efficient variable-speed drive systems. It will serve the large community of users and designers of such drives, contributing towards significant reductions of costs for preventative measures.

Project outline and objectives

Modern power-electronics based variable speed electric drive systems have the potential to lead to significant energy savings in everyday's applications. Unfortunately, these systems are vulnerable to catastrophic bearing failures caused by high-frequency bearing-currents. Available statistics indicate that 51% of drive failures are related to bearing failures, with high-frequency currents playing a major role.

Previous research conducted by the applicant has shown that such failures cannot be satisfactorily explained with the conventional understanding of current-bearing interaction and that the failure mechanism is a highly complex system with many interlinked variables, some of them of statistical nature. Among others, this has been highlighted by a comprehensive series of tests resulting in 44 test bearings, where each can be described with a plethora of different parameters.

In this project, techniques from Complexity Science will be applied to this set of data to fully exploit the information contained, but still hidden, in these results. Since traditional approaches have not been able to provide satisfying answers, Complexity Science shall be used to exploit previously uncovered territory of understanding. In addition, since techniques of Complexity Science have hardly been applied in the context of electric drive systems—traditionally a rather conservative field—so far, the applications of these techniques in this context are by themselves highly novel and interesting.

Methodology

Different techniques studied in modules CO 901, 902, 903 and 905 shall be applied to analyse the dataset of the 44 different test bearings. These include notably computational methods for analysing data, as discussed in CO 902, but also treatment of stochastic variables and of parameters that change properties over time. After approximately a week of familiarisation and prior reading, the student will be free to choose the technique or techniques he will try over the dataset, with the aim to identify a model to explain the failure mechanism of the failures observed. While it cannot be guaranteed that such a model can be developed, in principle, and in the given time-frame, any findings as to the applicability of Complexity Science to the field of application will be methodological results by themselves.

Required background

Apart from a good understanding of the above listed Complexity Science modules the techniques required are analysis and simulation as well as basic programming skills. The dataset itself is available in a well organised way with all the different parameters directly accessible. It is not necessary to understand the engineering science behind the phenomena as well as the traditional answers to explain it. An understanding of the meaning of the different parameters of the dataset will be communicated by the advisor at the beginning of the project.

Research outcome and outlook

The interest in the project stems from the application of the novel techniques to an outside field, to research the feasibility and limits of doing so, and to thereby extract previously hidden information. The deliverables will include the results obtained from this approach, both concerning the analysis of the dataset itself, and to the methodology. This will benefit both the large modern electric drives community and the Complexity Science community, potentially opening a new field of application and research.

The prospects for this miniproject leading into a PhD project are high: Several isolated results on physical relationships between different parameters relating to the bearing failures have been identified. However, hardly anything is known on how they interlink to give the overall system, and traditional approaches have not been able to explain this. Here, Complexity Science at its intersection with electrical and mechanical engineering could make a major contribution by providing urgently needed answers.