MODULAR FLYWHEEL ENERGY STORAGE SYSTEM

Background

Fast, efficient and safe energy storage is indispensable for a sustainable future. The state of the art mechanical energy storage systems with flywheels have many advantages such as high specific power capacity (charge/discharge rates), thermal stability, decoupled energy and power capacity, and large number of life cycles. Therefore, these systems can be integrated in applications with intermittent energy sources (renewables) and in quick charge/discharge scenarios. However, on the downside, they lack safety and reliability due to the possibility of a sudden failure of the rotor and the release of the entire stored energy.

Mechanical batteries or flywheel energy storage systems (FESS), can be designed to circumvent the aforementioned disadvantages and operate with high efficiency at the expense of specific capacity by operating at reduced speeds. Figure 1 shows a typical FESS connected to a local grid. The current FESS consists of one flywheel rotor levitated with magnetic bearings, either active or passive, rotating at sub-critical speeds using either permanent magnet or synchronous reluctance motors. At such speeds the capacity of fiber reinforced composite (rotor) material is not fully utilized to its maximum achievable specific capacity. One possible solution is to design a compact and modular FESS system where, multiple small flywheel units operating synchronously at ultra-high speeds are connected in a desired pattern. Thereby, the reliability and safety are not compromised, but are improved multiple folds, while not losing the edge of this technology.

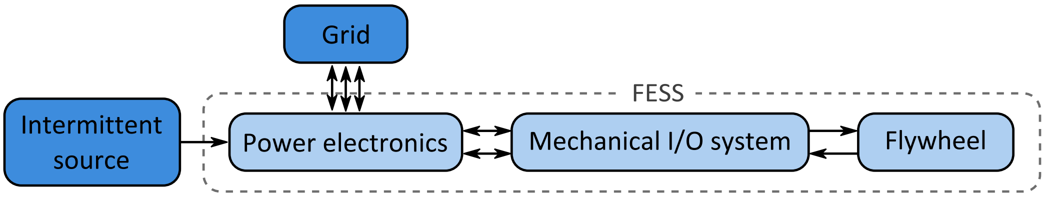

Figure 1: A typical scenario of a flywheel energy storage system connected to a local grid. I/O implies Input and Output.

Description

This assignment focusses on the <u>ultra-high speed electromechanical machine with integrated flywheel rotor</u>. The objective is to establish a design for a low-loss electrical machine (e.g. slotless, in-runner) with integrated rotor to be able to operate at 500 krpm at around 100-150 W capacity, and to design/choose a suitable inverter.

Approach

A preliminary approach in achieving the objective is as follows:

- Perform a literature survey to get familiar with the topics and establish the performance parameters of the machine with respect to the flywheel application, and in the context of reducing various losses (eddy losses in magnets, rotor, end-winding copper losses, etc.). Suggest ideas to improve the state-of-the art.
- Propose a concept design for the permanent magnet electrical machine and an inverter to control it.
- Perform fundamental calculations and/or simulations to evaluate the basic design parameters so as to arrive at the desired current loading, torque, radial forces and minimal magnetic viscous forces.
- Study parameter sensitivities on the performance, for example, with respect to composite-rotor material conductivity (shielding effect on magnets), rotor thickness and winding skew angle.
- Manufacture a prototype motor and an inverter (or buy of-the-shelf), and experimentally establish the performance parameters of the motor.
- Finalize the design and analysis of the machine with a thesis.

Administration and contact person

This assignment will be executed within the group of <u>Applied mechanics</u> and in collaboration with <u>Production technology</u> group. We need motivated masters student(s) to obtain valuable results in around 8 months' time and graduate with flying colors.

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