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Analysis of the effects of materials on the resistance of the flywheel

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Abstract

Wind generators are generators whose primary source of energy is wind. It is well known that this source has very fluctuating and unpredictable characteristics so it is impossible to predict its value for a given moment. This poses many problems for energy system managers in stabilizing electricity production, especially for sites not connected to the electricity grid.
The Flywheel energy storage system (FESS) is one of the technologies developed for the storage of wind energy. The flywheel accumulators associated with wind generators are electromechanical storage systems, enabling the storage of energy in kinetic form inside a flywheel, in particular when the wind speed increases. In addition, the accumulators allow the restoration of electrical energy to the grid during the reduction of the wind speed.
In this work, we chose a material with a low density and the highest breaking strength possible. We also chose a hollow cylinder as an appropriate geometric shape in order to increase the energy capacity of the FESS and its efficiency.
In order to model our structure, first we used the MATLAB software to obtain the expected results. Then we made a comparison between three flywheels of inertia technologies: flywheel of inertia in high-strength carbon fiber (R), in Kevlar and in high-performance glass (R) to check their deformation capacity.
Finally, we retained the least deformed and most efficient material to use for our storage machine.

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Keywords: FES; Inertia flywheels; Turbine generators; Power grid; Hollow cylinder; Energy capacity.

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1. Introduction

Renewable energy is nowadays an indispensable source of energy, mainly from the use of the natural environment. It retains an increasingly important position in industrial development strategies, especially in factories and large companies in the world and particularly in Morocco.

Wind energy is an efficient and sustainable renewable energy that is rapidly emerging in terms of its use and development. It is a clean and environmentally friendly form of energy, because it requires no fuel and does not create greenhouse gases. It represents a solution for the production of clean electricity. However, relocating wind power production to its use requires the combination of a storage system with the wind generator to smooth wind power fluctuations (short-term storage) and facilitate the integration of Wind turbines in the electricity grid (long-term storage).

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The design of this kind of system requires the study of several fields of mechanical engineering and electrical engineering. This work focuses on the development of a long term inertial energy storage system in the field of mechanical engineering.

This article is to make an analytical study on the effects of materials on the resistance of the Flywheel energy storage for choose the material we want to use for our storage machine to be more effective.

Nomenclature

ω	the rotation speed (rad/s)
J	the moment of inertia (kg/m²)
M	the mass (kg)
R_1	the internal radius of steering wheel (m)
R_2	the external radius of steering wheel (m)
r	the radius at point or analysis (m)
ρ	the density (kg/m²)
U_r	the radial displacement (m)
σ_{rr}	the radial stress (N/m²)
$\sigma_{\theta\theta}$	the tangential stress (N/m²)
ε_{rr}	the radial strain
$\varepsilon_{\theta\theta}$	the tangential strain
P_1	the internal pressure (Pa)
P_2	the external pressure (Pa)

2. The Flywheel Energy Storage System

By definition, the FESS consists of a large inertia flywheel, coupled to a generator motor that allows electric power to be transferred to the steering wheel (acceleration) and then recovered (braking), with magnetic bearings. In order to reduce the friction, the whole is installed in a vacuum enclosure (fast flywheel) to eliminate the friction of the air. The bearings must allow the rotation of the assembly with a minimum of losses.

The FESS can increase the value of electrical energy generated by wind power plants by providing energy during peak periods and accumulating electrical energy during periods when demand of energy is reduced. In addition, FESS facilitates the integration of wind energy sources. The FESS can be used to reduce peak loads in a power supply station. This can eliminate power plants operating only during peak periods and allow for better use of steady-state power plants. Also, FESSs are used to increase the quality of the electrical energy, by ensuring a better control of the frequency and the tension.