Universitatea
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HABILITATION THESIS

SUMMARY

Title: Dynamics of Planetary Speed Increasers with Multiple Inputs and Outputs for Counter-rotating Wind Systems

Domain: Mechanical Engineering

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This habilitation thesis, entitled "*Dynamics of planetary speed increasers with multiple inputs and outputs for counter-rotating wind systems*", aims to present relevant aspects regarding the dynamic behavior and performance in transient regimes of counter-rotating wind systems with multiple inputs and outputs, based on results obtained through analytical modeling, numerical simulation and comparative analysis of both adjustable wind systems with horizontal and vertical axis, respectively. These systems can include one or *two wind rotors*, as either a *monomobile* or *differential planetary speed increaser*, and a *conventional* or *counter-rotating electric generator*.

An improved rate of wind energy harvesting by wind turbines can be achieved by increasing the efficiency of converting wind energy into electrical energy. A novel affordable approach to this end is the use of two coaxial counter-rotating rotors and the integration of a counter-rotating electric generator, which requires a mechanical transmission with power branching at both the input and output. Such a solution can bring an additional power gain of approx. 40% compared to a traditional wind turbine (with a single wind rotor and a generator with fixed stator). For their operation in real-world applications, prior knowledge of dynamic behavior in transient regimes represents both a challenge for researchers and an advantage for designers in the process of wind system design and, particularly, in optimizing the control subsystem.
Consequently, this thesis addresses the dynamic modeling and numerical simulation of two adjustable counter-rotating wind systems, proposed for patenting (by the author and the collective), primarily aiming to develop a generalized dynamic algorithm that, through specific customizations, can be applied to all functional scenarios derived by appropriate adjustment of several couplings. Based on the obtained analytical dynamic models, the dynamic behavior of six functional variants of the adjustable horizontal-axis wind system is identified through numerical simulation using MATLAB-Simulink software, for both start-up and steady-state operation. Additionally, a starting strategy for differential counter-rotating wind systems is proposed, given the uncertainty of initiating operation from rest. The performances of the six variants are comparatively analyzed, and thus the similarities and functional differences in dynamic mode are identified depending on the number of wind rotors, the type of electric generator and the degree of mobility of the planetary speed increaser. Additionally, a starting strategy for differential counter-rotating wind systems is proposed, given the uncertainty of initiating operation from rest. These results allowed the identification of future priority research directions in the field of counter-rotating wind turbines aiming at optimizing their energy performances.

From a scientific and professional perspective (section B-I), this work, structured in six chapters, includes the main recent results obtained by the author (especially in the last 10 years, after completing the doctoral stage and obtaining the doctoral degree in 2001) in a priority research direction: planetary speed increasers for counter-rotating wind turbines. These planetary transmissions with multiple inputs and outputs have been investigated from the perspective of modeling and identifying their dynamic behavior in transient regime and

implicitly in steady-state. The analytical and numerical study of the two proposed adjustable structures of counter-rotating wind systems allowed the comparative identification of: a) the functional performances of the variants derived from the general systems, b) the uncertainties and implicitly the challenges related to the transient regime, such as in the case of starting from rest of bimobile turbines with two wind rotors.

The planetary transmissions were the subject of study of three research projects, in which I worked as a project team member. The results obtained in this field were capitalized by the development of 10 national patent proposals, for nine of which patents were granted, the publication of 10 articles in WoS indexed journals (with impact factor), 19 BDI indexed articles (ISI / SCOPUS), 28 articles published in the volumes of non-BDI indexed conferences. A significant part of the scientific research results was used in the development of 4 monographs, published by the Transilvania University Publishing House. I also contributed to the development of 7 university textbooks and 5 laboratory / project guides in the field of mechanisms in general and gear mechanisms in particular, intended for students in subjects such as: Mechanisms, Integrated Product Development, Conceptual Design. Noteworthy the monograph *Visa, I., Jaliu, C., Duta, A., Neagoe, M., Comsit, M., Moldovan, M., Ciobanu, D., Burduhos, B., Saulescu, R. The role of mechanisms in sustainable energy systems, Transilvania University Pub. House, 2015, ISBN 978-606-19-0571-3* received the Constantin Budeanu Award from the Romanian Academy in 2017.

In section B-II (*Career evolution and development plans*) the main stages of the evolution in the academic career are briefly specified, in correlation with the fields of *robotics* and *renewable energy systems* in which I have mainly focused my university activity, as well as the attended actions for my continuous professional development. The academic interests and the most important achievements obtained in the 33 years of teaching and research activity are also detailed, together with visibility highlights at local, national and international levels. Finally, the proposed directions for the academic career development plans are described, in terms of both the teaching and research areas, and as well as my involvement in the university community life. In this regard, the main initiatives aim to ensure textbooks for students and improve teaching methods for the coordinated subjects, involvement in educational projects and Erasmus+ mobility programs, participation in scientific / educational research project competitions and in solving the objectives of approved projects, attracting partners and strengthening university-industrial company cooperation, activation in research networks with national and European partners. Additionally, the activity of coordinating students for the development of the diploma/dissertation thesis and their involvement in student scientific research, and additionally the coordination of doctoral students for the development of the doctoral thesis in the field of mechanical engineering will be a constant concern in my future academic activity.