Universitatea Transilvania din Brașov

HABILITATION THESIS

SUMMARY

Title: The use of lightweight structures and optimization methods – a need for a more effective engineering

Domain: Mechanical Engineering

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This habilitation thesis describes the scientific and professional achievements reached by the author within 2012 and 2024 and it is organized in five chapters which are related to the fields of lightweight structures and optimization methods.

The first chapter presents the concept of hierarchical sandwich structures and the contribution of the author in this field. A second order hierarchical sandwich structure made of self-reinforced polymers by means of a continuous folding process was developed and analyzed in comparison with other existing solutions from a static strength and stiffness perspective, as well as from the impact energy absorption capacity perspective.

The second chapter describes the concept of hybrid structures. A practical approach is used here to prove the benefits of using carbon fiber reinforced PET when used to substitute steel in structural components. Another two investigated case studies in this chapter are related to the development of a hybrid ball screw drive with CFRP shaft and steel nut and the development of a hybrid wheel flange, both products being subjected to patent applications.

The third chapter discusses the topic of optimization of mechanical structures and systems, and it is split into four sub-chapters: the description of the topic, the parametric optimization, the non-parametric optimization and the multi-objective optimization.

A short description of what the optimization process means within the development of a mechanical product is given first, by showing what are the required steps for defining and solving an optimization problem.

Related to the parametric optimization subject, two study cases are addressed. The first one is related to the stiffness and strength graphical optimization of the second order hierarchical sandwich structure made of self-reinforced polymers based on an analytical model. The second study case is addressing the problem of mechanical system optimization, with the aim of proving the functionality of the concept and of increasing its efficiency.

The non-parametric optimization subject is covered by a study case related to the topology optimization of high-temperature pressure vessel of a 20KW ThermoLift Heat Pump. Apart

from the topology optimization, the other existing non-parametric optimization techniques are shortly addressed: shape optimization, topography optimization, size optimization and free-size optimization are shortly addressed.

The multi-objective optimization is first described from a theoretical point of view, indicating how the result of such optimization needs to be interpreted. Further on, the contribution of the author within the research project entitled *OptFRPBody* (Optimization of Body in FRP-Composite for small Electric Vehicle), at KTH – Royal Institute of Technology, Department of Aeronautical and Vehicle Engineering, is further on discussed. Another presented case study refers to the multi-objective optimization of thermally stressed steel-composite hybrid joints.

Eventually, the evolution and development plans for future career development of the author are detailed.