



Universitatea
Transilvania
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HABILITATION THESIS

SUMMARY

RESEARCH ON THE RELIABILITY, THE ACCELERATED TESTING AND THE ADDITIVE MANUFACTURING OF INDUSTRIAL PRODUCTS

Domain: Industrial Engineering

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The paper presents the author's scientific and professional results, published after obtaining his doctorate in the field of Industrial Engineering in 2010, with the doctorate thesis **Theoretical and experimental research regarding accelerated reliability testing** (scientific advisor: Prof. Dr. Eng. Ionel MARTINESCU).

The habilitation thesis, entitled **Research on the reliability, the accelerated testing and the additive manufacturing of industrial products**, represents a synthesis of the scientific results, published in two research directions: the study of reliability of industrial products and the fabrication of lightweight sandwich structures by additive manufacturing processes (selective laser melting and thermoplastic extrusion).

The current habilitation thesis, entitled **Research on the reliability, the accelerated testing and the additive manufacturing of industrial products**, comprises 3 sections. In the first section, the scientific and professional achievements were emphasized, which represent the main results obtained by the author of the habilitation thesis over the course of the past 10 years. In the second section, the growth and development plans for the teaching, scientific and professional career were presented. The habilitation thesis ends with the third section, which presents a list of the references used in this paper.

Section B1, entitled **SCIENTIFIC AND PROFESSIONAL ACHIEVEMENTS**, is structured in two subsections, as follows:

Subsection B1.1, Scientific achievements, is structured in 4 chapters, as follows:

Chapter 1, entitled **Theoretical aspects regarding experimental reliability**, presents briefly the current state of research regarding experimental reliability, applied on industrial products. In this chapter the calculation relations of the reliability indicators, that were frequently used in the experimental studies in this habilitation thesis, were presented. A couple of theoretical aspects regarding accelerated testing were also included here (advantages, classification, acceleration models).

In **Chapter 2**, entitled **Experimental research regarding the reliability and accelerated testing of industrial products**, two case studies regarding the accelerated testing of industrial products were presented.

The first case study (subchapter 2.1) refers to the testing and statistical processing of data resulted from accelerated tests. These tests were used to determine the life time and the main reliability indicators of the radial ball bearings.

The second study (subchapter 2.2) comprises an experimental research regarding the testing of pitch links using accelerated fatigue testing. The data obtained from the accelerated tests were statistically processed, pointing out a series of advantages provided by this testing technique.

Chapter 3, entitled Experimental research on the accelerated testing and the reliability of lightweight sandwich structures made from composite materials, presents four case studies regarding the accelerated testing of composite sandwich structures.

The first case study (subchapter 3.1) is dedicated to determining the mechanical performances and the reliability indicators of the sandwich structures with fiberglass skin and foam core, subjected to three-point bending tests, in static and dynamic regime.

The second case study (subchapter 3.2) describes the accelerated testing of the sandwich specimens with carbon fiber skin and balsa wood core. The results of the accelerated tests were statistically processed and the reliability indicators of the sandwich specimens for normal testing regime were determined. At the same time, the failure modes of the sandwich structures, subjected to three-point bending point tests in static and dynamic regime, were microscopically analyzed.

The third case study (subchapter 3.3) focuses on the testing and the processing of data obtained from the accelerated tests of the composite sandwich structures. The reliability indicators of the specimens with carbon fiber skin and Nomex honeycomb core were also determined.

The last case study of this chapter contains a research on the testing of sandwich specimens with fiberglass skin and Nomex honeycomb core, to which accelerated fatigue testing techniques were applied. The results of the accelerated fatigue testing were statistically processed, pointing out a number of advantages provided by this type of tests.

Chapter 4 of the habilitation thesis, entitled Experimental research on the manufacturing by additive processes of the lightweight sandwich structures, comprises three case studies regarding the fabrication of the sandwich structures by using additive manufacturing processes.

In the first case study (subchapter 4.1), cellular structures from stainless steel 316L, with honeycomb core, were manufactured through the process of selective laser melting. These cellular structures were tested under compression (plane and on edge), with the purpose of determining the mechanical performances. The cellular structures with honeycomb core were sectioned after a specific direction (perpendicular on the manufacturing direction) and the microhardness was measured. In this case study the accelerated corrosion tests of cellular specimens were also implemented, with the purpose of determining the mean life time under normal testing conditions.

In the second case study (subchapter 4.2) the feasibility of manufacturing through the process of selective laser melting of sandwich structures with honeycomb core, with two configurations (with perforated core and with perforated skin), was proven. The two configurations of sandwich structures, made from Inconel 718, were subjected to heat homogenization treatment. The sandwich structures were compression tested, with the purpose of determining the mechanical performances. The microscopic analysis of both heat and as fabricated specimens, after two directions (perpendicular, as well as parallel on the manufacturing direction) was used, obtaining the microstructures typical of the Inconel 718 material. The analysis of the specimens' microhardness showed an obvious change with the increase of the manufacturing height, both for the as fabricated specimens, as well as for the specimens subjected to the homogenization treatment. The failure modes of specimens subjected to compression testing were validated through finite element analysis.

The third case study approached the manufacturing of sandwich structures with three core configurations (honeycomb, diamond and corrugated) through the process of thermoplastic extrusion from the PLA-PHA material. The three specimen configurations were subjected to three types of tests: compression, three-point bending and tensile. The failure modes were investigated using macroscopic analysis. Similarly, the tested specimens were analyzed from the standpoint of the strength-to-mass ratio. Also, the experimental tests at three-point bending were validated using the finite element method. The three core types (honeycomb, diamond and corrugated) were used for the manufacturing through thermoplastic extrusion and the impact testing of some leading edge wing specimens.

Subsection B1.2, Professional achievements, encompasses the accomplishments of the author of the habilitation thesis in the following three directions: studies and professional experience, teaching activity and scientific research.

Section B2 of the habilitation thesis, entitled **Career growth and development plans**, is dedicated to presenting the growth and development plans in the following three directions: teaching career, scientific career and professional career.

Section B3, entitled **References**, contains a list of the references used in this habilitation thesis.

The scientific results presented in this habilitation thesis are based on 9 papers (8 of them published in ISI journals), published by the author of the habilitation thesis after obtaining his doctorate. The results obtained during the research projects, where he activated as a director or as a member, constituted the basis for publishing these important studies in ISI indexed journals.