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Designing thermosets composites for automotive engineering applications

Domain: Aerospace, Automotive and Transport Engineering

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Summary

'The better you understand the materials that you use, the better the design of the car and, ultimately, the better the car you build.'

Tim Foecke, Director, NCAL

The overall aim of the work is to provide comprehensive means on manufacturing and material properties evaluation for various self-developed hybrid thermoset based composite architectures that can simultaneously yield results of practical utility. This is accomplished by comparing, whenever possible, the theoretical predictions for the effective properties to available experimental data.

The present work is divided into two parts. Part I deals with the author's scientific achievements that enabled to characterize quantitatively the main effective properties of self-developed hybrid thermoset based composite architectures and statistical/theoretical methods used for comparison. Part II identifies future directions for scientific and research evolution and development.

The introductory chapter in Part I was reserved to the state-of-the-art in the subject intended to be covered with the main body of the habilitation thesis. This was done on purpose to illustrate the importance of developed subject that is under continuous evolution and that expanded after herein contributions. It is noteworthy that significant advances have been made recently in the quantitative characterization of hybrid composite materials of any type both theoretically and experimentally.

The general objectives were underlined and concise delivered to give the reader a preview of the concepts that will be discussed specifically in the subsequent chapters. Indirectly, they point toward one of the main aims of this work, namely to provide a direction for systematically analysis of hybrid thermoset based composite materials.

Chapter 2 provides several theoretical models used deploying a multi-step homogenization scheme to apply for individual combinations and effective property under consideration. These theoretical models were selected due to their ability to describe the 'details of the microstructures' (i.e. constitutive volume fractions, orientations etc.) and ability to encompass particular information that can be ascertained in practice.

Chapter 3 was dedicated to the brief presentation of individual materials' selection, manufacturing issues, details on hybrid microstructures and finally, some practical information on experimental devices and settings considered. Practically, reproducibility issue of the experimental data processing can be potentially addressed through sharing these particular information results.

In the light of above, particular concerns were given to those structure/property relations that can be easily understood by apprentices, unaccustomed researchers on engineering field and finally, to materials' designers bounded by cost and time to perform measures on their engineering applications.

Chapter 4 extensively approaches the effective mechanical, dynamical, thermal stability and conductivity, fire retardant and electrical conductivity of particular hybrid thermoset based composites developed. These effective material properties were retrieved by subjecting the various hybrid composite specimens to various loading conditions in order to address the sustainability issue and some practical implementation considerations.

Over the entire sections of this chapter was followed the same formalism, including: applied standards used to run the exploratory tests, particular and representative experimental curves, details on the retrieved values, predicted over recovered data comparison relevant for the effective property vs. micro-structural dependence description and analysis.

Structural design and applications emerging from this cannot be sough strictly to comply or use solely the mechanical properties. In the mechanical engineering field, especially in automotive design, the applications are driven by a multitude of influencing factors whose cross-dependencies can be regarded to the seemingly different effective properties considered here.

Moreover, the experimental data can be effectively translated to practice and have important implications for the optimal design of composites. Space limitations and overcome the settled objectives do not enable us to treat, in any detail, the cost and error minimization topics identified as the major issues that benefit from the herein retrieved information.

General conclusions presented in Chapter 5 provide the merits of the theoretical predictions, the main reasons behind the effective property's behavior during the conditions imposed within the experimental runs and a unified framework to study a variety of different hybrid composite architectures with their tailored effective properties.

Additionally, these can be regarded as an ex-ante foundation and conditionality for further hybrid thermoset based composited architectures with constitutive closely following life-cycle design principles. In the light of previous mentioned and with respect to the effective properties of hybrid thermoset based composites, further directions for scientific research were identified and briefly described at the beginning of Part II of the work.

Specific citation to the literature used, both co-authored contributions and other sources have been kindly provided at the end of Part II as references. These were used in correlation to the section's subject and can be easily identified and suitable checked. It is noteworthy that few sections contain unpublished work of undersigned used to clarify some aspects related to the effective property under discussion and provided to enable readers to comprehend the ongoing discussions and related conclusions.