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Preface

Laminated composite materials have been used since the 1960s for structural applications. This first generation of materials penetrated the majority of highly structural sectors because of the materials' high stiffness and strength at low-density, high-specific energy absorption behaviour and excellent fatigue performance.

High cost and the impossibility of having fibres in the laminate thickness direction, which greatly reduces damage tolerance and impact resistance, are two main limitations of these materials. However, the manufacturing costs are considerably reduced when using 3-D textile reinforced composite materials, the second generation of materials, which are obtained by applying highly productive textile technologies in the manufacture of fibre preforms. On the other hand, the damage tolerance and the impact resistance are increased since the trend to delamination is drastically diminished because of the existence of reinforcements in the thickness direction.

However, methods for predicting mechanical properties of 3-D textile reinforced composite materials tend to be more complex than those for laminated composites because the yarns are not straight. Also, the existence of undulations or crimps in the yarns may reduce some mechanical properties such as tension or compression strengths.

Even though this second generation of composite materials is clearly more advantageous than laminated composite materials in terms of cost, damage tolerance and impact resistance, some disadvantages have been identified. These demand research and development work in the following areas:

- Textile preforms
- Micro- and macromechanical modelling
- Manufacturing processes
- Characterization

If researchers are able to go deeper into these four areas and overcome the problems related to the existence of crimps in the yarns, the 3-D textile reinforced composite material will emerge as a highly competitive family of materials for all those applications where the structural behaviour and weight are critical.

The aims of this book are to describe the manufacturing processes, to highlight the advantages, to identify the main applications, to analyse the methods for prediction of mechanical properties and, finally, to focus on the key technical aspects of these promising candidates in order to know better how to exploit their main features and overcome their disadvantages in relation to the laminated composite materials.

The present book focuses on the textile technologies, which use 3-D textile reinforcements for composite materials. Manufacturing techniques, design methodologies, key application fields and specific issues are studied.

The first chapter is devoted to the general description of the 3-D fabrics for composite materials. The typologies available will be described and the manufacturing techniques are also explained.

The needs of the transportation industry provide the most powerful reasons for the development of new materials since weight, stiffness, fatigue strength and energy absorption constitute the key design factors. The second chapter analyses the 3-D textile reinforcements for the transportation industry.

The analysis of the 3-D textile reinforcements is more complex than that for unidirectional and 2-D fabrics composite materials. In our case, both micro- and macromechanical analyses must be developed. The micromechanical study is essential to determine the behaviour of the material in a fibre scale. The stiffness and strength properties must be determined as a function of type of fibre and matrix, fibre fraction, interface and fibre configuration. Chapters 3 and 4 are devoted to micro- and macromechanical analyses, respectively.

The composite grid structure constitutes an amazingly efficient system to combine high stiffness and strength with lightness for high load-bearing composite applications. In the present system, the 3-D reinforcement is obtained by the inclusion of a system of ribs in the core of the material and the implementation of two outer skins. Both in-plane and out-of-plane stresses can be controlled by a proper sizing of the skins and an adequate design of the ribs. Chapter 5 discusses this type of reinforcement.

Chapter 6 analyses knitted fabric composites. The knitting system is one of the most interesting manufacturing techniques for reinforcing the composite material in the thickness direction. By an appropriate design of the knitted fibres, both interlaminar normal and shear stresses can be easily controlled.

The braiding technique is a very efficient method for reinforcing a large number of composite structures. Plates, beams, profiles and 3D structures can be braided nowadays, the result being a robust structure in terms of stiffness, strength, energy absorption and impact loading. Hybrid schemes can be used and fibres of different materials can be oriented in the critical directions to optimize the desired criterion. This technology is discussed in Chapter 7.

Chapter 8 studies the 3-D forming of continuous fibre reinforcements for composite materials.

Finally, resin impregnation and *xyz* prediction of fabric properties are analysed in Chapter 9.

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