

Composite materials are available in many forms and are produced using a variety of manufacturing methods. A range of fibre types is used – primarily carbon and glass – and these can be combined with a variety of polymer matrices. This book concentrates on ‘long’ fibre composites, including fibres from a few centimetres in length (i.e. excluding injection moulding compounds). So the processing methods of interest include compression moulding of thermoplastic or thermoset moulding compounds; resin transfer moulding based on dry fibre preforms; forming and consolidation of thermoset prepreg and thermoplastic sheets; and forming of new material forms including composite/metal laminates and polymer/polymer (self-reinforced) composites.

Whatever the material form or manufacturing process, there is one common step: forming of initially planar material into a three dimensional shape. This is the focus of ‘Composite Forming Technologies’. The book includes descriptions of industrial forming processes, case studies and applications, and methods used to simulate composite forming. This description is intended for manufacturers of polymer composite components, end-users and designers, researchers in the fields of structural materials and manufacturing, and materials suppliers. Whilst the bulk of the text is devoted to modelling tools, the intention is to provide useful guidance and to inform the reader of the current status and limitations of both research and commercial tools. It is hoped that this will form essential reading for the users of such modelling tools, whilst encouraging others to ‘take the plunge’ and adopt a simulation approach to manufacturing process design.

This text may be considered broadly in two halves, with Chapters 1–7 covering the fundamental aspects of modelling and simulation, and Chapters 8–13 describing practical aspects including manufacturing technologies and modern practices in composites design. The first chapter provides a comprehensive introduction to the range of deformation mechanisms that can occur during forming for a range of materials, along with appropriate test methods and representative data. Chapter 2 describes fundamental constitutive models as required for composite forming, including the bases for commercial kinematic (draping) and mechanical (forming) simulations. The latter topic is

continued in Chapter 3, including a detailed description of finite element simulation techniques for forming of dry fabric preforms. The methodology here can be considered similar to that used for sheet metal forming, albeit with a more complex material model. Chapter 4 continues the modelling theme, with a description of 'virtual testing', whereby materials input data for forming simulation are predicted from the material structure. This topic is of particular interest, as it may offer the opportunity to select materials that are fit-for-forming, or even to design new materials with a specific component in mind. Chapter 5 details the use of modern simulation techniques for composite forming within an optimisation scheme, with the aim of selecting materials and process parameters to eliminate such defects as wrinkling or undesirable fibre orientations. Chapter 6 describes the methodology and current status of simulation tools for compression moulding, including applications to sheet moulding compound (SMC) and glass mat thermoplastic (GMT). The following chapter completes the initial treatment of simulation and modelling, with a description of composite distortion – notably the common phenomenon of 'spring-in' – caused by manufacturing induced stresses.

The second half of the book begins with four chapters describing forming technologies for a range of materials. This begins with a relatively new family of materials – composite/metal hybrids – which have recently found applications in the aerospace sector (notably as fuselage panels for the Airbus A380). Another new family is covered next, referred to as 'self-reinforced polymers'. These materials include fibre and matrix from the same polymer material, addressing one of the current concerns for polymer composites – recycling. The next two chapters cover more conventional materials – thermoset prepreg and thermoplastic composite sheet. Prepreg forming technologies are described in detail, from the traditional hand lay-up and autoclave cure approach to current developments in automated tape placement and diaphragm forming. The thermoplastics chapter includes a detailed description of the range of material forms, along with their appropriate forming and consolidation techniques. Chapter 12 describes the current state-of-the-art in simulation software for composite forming within an industrial context, detailing the use of modern software tools to design the material lay-up, and describing how these tools can be integrated within the manufacturing environment. Finally Chapter 13 covers the issue of benchmarking of composite forming. This topic is particularly timely, drawing on current worldwide efforts to compare both formability characterisation tests and forming simulation tools for benchmark materials. It is hoped that this will lead to standardisation of formability testing – a key requirement for more widespread use of analysis tools – and guidelines on the accuracy of the range of simulation approaches that are currently available.