Chapter 14
Out-of-Autoclave (OOA) Manufacturing Technologies for Composite Sandwich Structures

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ABSTRACT

This chapter gives an overview of cost effective processing techniques, employed for manufacturing of sandwich structures, primarily for high performance applications. The scope of this chapter is to review the processes which may produce the autoclave cured quality parts, without the use of autoclave. The chapter starts with an overview of autoclave processing, highlighting the different features, which depicts the capacity of technique to produce highly repeatable parts. Studies related to manufacturing of sandwich structures in autoclave, with and without adhesive film, are reviewed and discussed. Process briefs and recent developments of different out of autoclave (OOA) techniques for manufacturing of sandwich structures are then discussed which includes, OOA prepregs systems, Quickstep processing, Vacuum Infusion Process, compression molding, double belt press and filament winding. A brief overview of manufacturing processes for thermoplastic based sandwich structures is also provided at the end.

1. INTRODUCTION

A sandwich consists of three major components i.e. two rigid, strong and relatively thin faces which are separated by weaker, light and thick core materials. The American Society for Testing and Materials (ASTM) defines a sandwich structure as follows:

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A special sandwich is a special form of a laminated composites comprising of a combination of different materials that are bonded to each other so as to utilize the properties of each separate component to the structural advantage of the whole assembly.

Sandwich structures are used in almost every industrial sector ranging from building to aerospace applications. High performance sandwich structures, especially for aerospace applications, are usually manufactured using prepregs, followed by cure in autoclave. This requires high manufacturing temperature, pressure, heavy tooling and a cycle time of several hours. As the aerospace timescale requirements are shortening, an increase in production rates is required and this is difficult to achieve with traditional autoclave manufacturing. Also, high capital expenditure, infrastructure requirements and time to commission has made autoclave processing, increasingly undesirable.

There are several techniques, which have been established as out of autoclave (OOA) approaches for construction of sandwich structures, however, minor modifications in each technique may be required, because of different types of face-sheets and core materials used in sandwich construction. These core materials may be wood, foam or honeycomb. Several configurations are available in each category of core materials. Face-sheets are usually constructed using glass, carbon and Kevlar fiber, depending upon the application areas and are usually provided in prepregs form for high performance applications. These face-sheets materials, however, also being used in dry form in different OOA approaches.

Voids are among the most common manufacturing induced defects in the composites. The voids can be formed in the composite structures due to many reasons; some of them are (1) due to dissolved volatiles within premix resins, (2) bubbles evolved from mixing process itself, (3) air pockets trapped during lay-up (Boey, 1990), (4) due to moisture absorbed during storage, (5) due to resin rich areas in the cured part (Costa, Almeida, & Rezende, 2001), (6) due to volatile by-products during the cure reaction of the polymeric matrix, (7) due to use of high viscosity resin combined with closely packed fiber that are not completely wetted by resin, (8) due to fabrication mishaps such as leaking vacuum bag or a poor vacuum source (Costa, Almeida, & Rezende, 2005; Guo, Liu, Zhang, & Du, 2009). Air pockets trapped during lay-up of sandwich structure is reported as the major source of porosity (Kratz & Hubert, 2013), which not only weakened the skin performance but also affects skin to core adhesion properties.

Extensive research has been conducted on the development of new resin systems to match the existing processing techniques; however, the development of new processes for manufacturing of high performance sandwich structures are limited. This chapter will discuss the recent developments in materials and manufacturing techniques of composites sandwich structures, their approaches to reduce the porosity and enhanced skin-core bonding strength and modification (if any) required for different core materials. The chapter started with brief overview of topic and comments on chapter structure. Section 2 covered the autoclave processing, advantages and limitations of autoclaves with adequate number of references for further study. Section 3 listed down the OOA prepregs systems, which have gained popularity over the recent years in high performance applications. Brief comments are also provided on the issues associated with fabrication of sandwich structures with OOA prepregs systems. Section 4 explained the Quickstep processing, one of the emerging OOA approach for leading applications ranging from aerospace to sports goods. Few success stories are provided, depicting the suitability of the approach for different applications. Section 5, overviewed the liquid molding techniques like vacuum assisted resin infusion (VARI) for sandwich construction. Section 6 highlighted the commercial aspect of compression molding technique for fabrication of sandwich structures while section 7 briefly described different techniques like wet lay-up, double belt press and filament winding for construction of sandwich structures. Sec-