Chapter 5
Processing, Properties, and Uses of Lightweight Glass Fiber/Aluminum Hybrid Structures

Noureddine Ramdani
Ecole Militaire Polytechnique, Chahid Abderrahmane Taleb, Algiers, Algeria

Mohammed Seddik Razali
Ecole Militaire Polytechnique, Chahid Abderrahmane Taleb, Algiers, Algeria

ABSTRACT

The replacement of heavy metallic structures by high-performance lightweight composite materials is a prominent solution to fulfill the continuous demand in different industrial sectors. Lightweight structures based on aluminum-glass fiber reinforced plastics (GFRP) sandwich panels have been increasingly utilized in the shipbuilding, automotive, and aerospace industries for their striking mechanical and physical properties. These advantageous properties have resulted from the combination of the high tensile and flexural strengths, increased hardness, and the improved wear-resistance of aluminum laminate with the unique properties of lightweight stiffness and high strength weight ratio of glass fiber-reinforced. In this chapter, the various processing approaches, properties, and applications of these sandwich structures are summarized from a wide range of literature.

INTRODUCTION

During the last few decades, a strong need in the aircraft industry for high-performance, lightweight materials has motivated an increasing trend towards the progress of improved types for fiber-metal laminates (FMLs). These materials are exhibiting several advantageous structural, physical, and mechanical characteristics as given in Table 1. These FMLs are hybrid composite materials constituted

DOI: 10.4018/978-1-7998-7864-3.ch005

from interweaving thin metallic layers and fiber-reinforced thermoplastic or thermoset-based polymer composites (FRPC) adhesives.

Table 1. Advantageous features of FML.

Aspect	Characteristics
Material behaviour	• High strength • High fracture toughness • High fatigue and impact resistance • High energy absorbing capacity
Physical properties	Low density
Durability	• Excellent moisture resistance • Good corrosion resistance • Lower material degradation
Safety	Fire resistance

Due to their outstanding mechanical and physical properties, engineering fibers such as carbon, glass, and Kevlar are widely used to reinforce metallic laminates like aluminum and titanium to produce high-performance lightweight hybrid structures. Table 2 compares the advantages and shortcoming characteristics of these fibers. The market of these sandwich composite contains several commercially-models of FMLs such as the CARALL (Carbon Reinforced Aluminium Laminate), based on carbon fibres, the ARALL (Aramid Reinforced Aluminium Laminate), containing aramid fibres, and the GLARE (Glass Reinforced Aluminium Laminate), containing stronger glass fibres. By combining the striking properties of the hybrid feature from their two main components: metals (usually aluminium) and fiber-reinforced polymer laminate, these materials demonstrated many outstanding performances including lightweight, superior mechanical tensile and bending properties, a good damage tolerance to fatigue crack development, and impact damage, especially for aeronautic part productions (Sinmazçelik et al., 2011).

Aluminium metal matrix composites were extensively produced and developed in the last few years to fit the requirement of high engineering industries such as aerospace, military, marine, and automotive. Aluminum matrix layers and fiber-reinforced polymer laminate can be assembled using various traditional processes, like mechanically and adhesively. Adhesively joined fiber aluminum laminates have been revealed to be exhibit much-improved fatigue-resistance than those mechanically joined hybrid structures (Baburaja, Venkata Subbaiah, and Kalluri, 2016). Due to the fact that machining aluminum hybrid composites to a preferred geometrical form via some optimum machine process parameters affords increased material removal rates, a small surface roughness, and the best tool wear (Garg et al., 2019.) Thus, the selection of the optimal production methods could be of great importance. Some simulation works using finite elemental analysis and various software could be critical before producing such hybrid composites to ensure the desired performances (Ananda Rao, Reddy, and Seshaiah, 2014; Kumar, Dirgantara, and Krishna, 2020). Recently, the design of automotive lightweight aluminum/FRPC hybrid structures along with their mechanical behaviour and most relevant production techniques were presented (Kumar, Dirgantara, and Krishna, 2020). For example, the GLARE hybrid composites are now extensively applied and more progress has been achieved for providing high strength, lightweight, strong stiffness, and the recommended mechanical performances. These hybrids are developed in six main grades by using the various arrangement of glass fiber prepreg, types of aluminum matrix