Chapter 7
Modern Joining Methods: Case Studies in Aerospace, Automotive, and Sustainability

Amit Kumar Jain
https://orcid.org/0009-0008-6942-9987
Poornima University, India

Pooja Vijay
https://orcid.org/0009-0005-9641-7883
Poornima University, India

Neeraj Jain
https://orcid.org/0009-0009-2843-543X
Poornima College of Engineering, India

ABSTRACT

In recent years, incorporation of high technology welding processes to fabricate lightweight materials and structures for aerospace vehicles has posed more challenges in engineering design. This chapter also aims at elucidating the various approaches to bonding such materials, challenges that are faced when bonding lightweight materials like aluminum alloys, titanium, and composites, which are critical to the aviation industry's search for higher performance, efficiency, and durability. Besides, the chapter presents an outlook in this field and further research with regards to material selection, joint design and control of the process, since aerospace structures are currently crucial for reliability and efficiency. This chapter has captured the current advancements in the state of the art joining technologies in aerospace materials and consequently presents engineers, researchers, and industry practitioners with a consolidated source of information for the further development of lightweight material welding technologies.

DOI: 10.4018/979-8-3373-1797-7.ch007

1. INTRODUCTION

The aerospace industry is ever changing to improve fuel efficiency, structural integrity and sustainability. The use of lightweight materials including aluminum alloys, titanium and composites is the most important advancement of modern aerospace engineering as the reduce aircraft weight, improve aerodynamics and lessen fuel consumption. Yet, the integration of these materials is faced with its own challenges because they differ in terms of thermal properties, mechanical strengths and corrosion resistance. In order to meet these challenges, Friction Stir Welding (FSW), Laser Welding, Adhesive Bonding, and even Hybrid Joining have been developed to create durable and high-performance aerospace structures.

In this chapter the various techniques and processes involved in joining lightweight materials in aerospace applications are presented in a comprehensive way. This includes lightweight materials importance, joining them challenges and the most recent developments on welding and bonding technologies. Furthermore, it covers five real world case studies which show how these technologies have been applied in the aerospace industry.

1.1 Key Points Covered in This Chapter

Importance of lightweight materials: Goes on to discuss their role in fuel efficiency, structural strength and environmental sustainability.
Challenges in Joining Lightweight Materials: Thermal expansion mismatches, weld cracking and joint durability.
Advanced Joining Techniques: Friction Stir Welding, Laser Welding, Adhesive Bonding and Hybrid Joining Methods.
Case Studies: Real applications investigated in fuselage panels, jet engine components, composite structures and spacecraft assembly.

2. OBJECTIVE OF THIS CHAPTER

The aim of this chapter is to give a fundamental comprehension of methods for joining lightweight materials used in aerospace applications. The continuous evolution of the aerospace industry with the need for stronger, lighter and more fuel-efficient aircraft has spurred universal adoption of aluminum alloys, titanium and composite materials. Despite these advantages, these materials can be joined exclusively by the use of hydride bonding, which presents the following consequences: (1) Although these materials may be composed of metals differing in thermal expansion, their mechanical properties enjoy very close agreement, and their bonding compatibility is

Abrasive Jet Machining of Aluminum and Aluminum Alloys

Laureniu Sltineanu, Irina Besliu-Bancescu, Oana Dodun, Gheorghe Nagîand Adelina Hriuc (2026). *Engineering Advanced Materials for Manufacturing, Energy, and Smart Systems (pp. 125-164).*

www.irma-international.org/chapter/abrasive-jet-machining-of-aluminum-and-aluminum-alloys/402173