COMPOSITE FABRICATION ON AGE-HARDENED ALLOY USING FRICTION STIR PROCESSING

Namrata Gangil
Arshad Noor Siddiquee
Sachin Maheshwari

CRC Press
Taylor & Francis Group

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CRC Press
Taylor & Francis Group
Boca Raton London New York

CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business

CRC Press
Boca Raton and London

First edition published 2021
by CRC Press
6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742

and by CRC Press
2 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

ISBN: [978-0-367-43417-5] (hbk)
ISBN: [978-1-003-00303-8] (ebk)

Typeset in Palatino LT Std
by KnowledgeWorks Global Ltd.

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Preface

The sustainability concerns have put a lot of stress on taking out most of what we produce and use. The quest for an ever-increasing specific strength, inter alia, is one such implacable issue that should be perpetually deplored. The materials for aircraft, space, and aerospace, in particular, are very sensitive to specific strength as this very factor forms the fulcrum of safety, weight saving, payload capacity building, and in-flight energy consumption. All these design, manufacturing, and operational objectives are met by using materials that qualify on these parameter. Due to this reason, 7xxx and 2xxx series aluminum alloys occupy the majority of normal temperature metallic materials application in this key industrial sector.

The discovery of DURALUMIN generated a EUREKA in the age-hardened aluminum alloys and a great many Al-alloys other than any other systems are being developed. But the development of new materials is time, capital, knowledge, and infrastructure intensive and yet incomprehensible too. Ways to strengthen existing alloys beyond their known strength can be very useful.

The present treatise takes a comprehensive panorama on behavior of age-hardened aluminum alloys during processing. This book presents strategies to employ a recent and the most popular materials processing route to enhance the strength of existing alloys via composite fabrication. The recent friction stir processing is presented in a comprehensive way and strategies are presented to deploy this recent process to enhance the strength in a simple and cost-effective way. A detailed view on the process characteristics and material's behavior is given and the facts are presented in the light of recent literature and experimental investigations.

Author Biographies

Dr. Namrata Gangil is working as an Assistant Professor in the Department of Mechanical Engineering, Ajay Kumar Garg Engineering College, Ghaziabad, India. She has earned her Master's from SGSITS, Indore, India, and PhD from Netaji Subhas Institute of Technology, New Delhi, India. She has over ten years of teaching experience at undergraduate and post-graduate levels and is a dedicated and committed researcher. She has published several high impact SCI research articles in esteemed journals. Her research areas include welding, friction stir welding/processing, and material-structure-property correlation.

Dr. Arshad Noor Siddiquee is a Professor in the Department of Mechanical Engineering at Jamia Millia Islamia (A Central University), New Delhi, India. He earned both PhD and M.Tech from IIT Delhi, India. He has supervised several M.Tech dissertations, SIX PhDs, and currently he is supervising more than ten doctoral theses. His major research interest includes frictions stir welding, friction stir processing, material technology, welding engineering, and machining. He has published more than 145 articles in reputed journals. He has also co-authored five books/monographs and he has patents to his credit.

Dr. Sachin Maheshwari is a Professor in the Division of Manufacturing Processes and Automation Engineering at Netaji Subhas University of Technology, New Delhi, India. He has done his M.Tech from IIT Roorki, India and earned his PhD from IIT Delhi, India. He has supervised several M.Tech dissertations, more than ten PhDs, and currently he is supervising several doctoral theses as well. His major research interest includes welding fluxes, frictions stir welding, friction stir processing, materials-structure-property correlation, and welding engineering. He has a number of research articles on promising areas in reputed journals and several patents many of which have been commercialized too. He is known as an able and inspiring academic leader.

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Introduction

1.1 Aircraft Manufacturing Outlook

Boeing's current market outlook projects that the aircraft industry may deliver as many as 42,000 aircraft in the next 20 years. This translates into a very robust growth rate in the manufacture of the aircraft [1]. This growth rate is forecasted based on the increase in the passenger traffic expecting to shoot up to 16 billion by 2050 (as against 3 billion in 2012) [2]. During this course of time span, the industry product-line is expected to witness a huge transformation with the great adaptation in every single batch of manufactured aircraft. Innovations in designs, materials, and processes shall drive enhancements in efficiency. The "Cleaner, Greener, and Quieter" have emerged as the criteria for efficiency of aviation, space, and aerospace vehicles. The 12% (by weight) of the total transportation sector generated CO_2 emission is contributed by the aviation sector. Evidently, emission from this source is growing faster than other modes of transport. This alarming affluent release requires urgent efforts to reduce its detrimental effect. An urgent need to improve the fuel efficiency and eventually become Carbon neutral by the year 2020 has been proposed as a strategy to tackle this serious issue. Simultaneous improvement in fuel efficiency at an annual rate of 1.5% has also been recommended [3]. The affluent emission restrictions put considerable stress on the weight reduction. Importantly, weight reduction and structural safety are mutually contradicting and don't go hand in hand. Further, the safety and airworthiness propel the structural safety; which, in turn, puts stringent challenges on its design, material, and processing.

Above all, airworthiness and safety of such vehicles are of prime importance. An aircraft (typically, civil aircraft) comprises of various systems and structures. Systems are essential for the efficient and safe operation and control of the aircraft. The design, shape, and size of the vehicle are all based on airframe structure; and, more importantly, structural members, which also provide bearing and support, and relative positions of the aircraft systems in place. The systems that are classified based on functions they perform or based on the medium of control occupy various locations on several

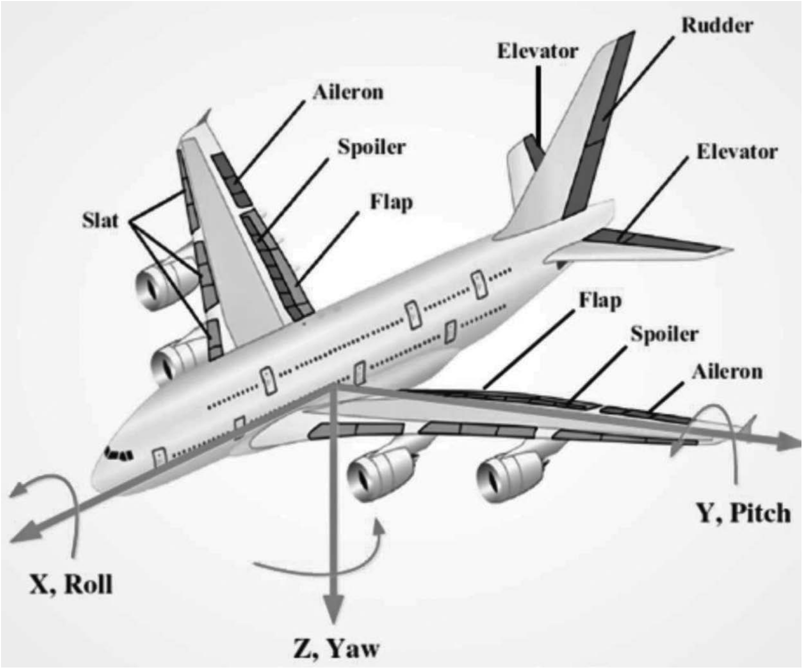

FIGURE 1.1
Primary flight controls of commercial aircraft [5].

parts of the aircraft. The typical systems include (and not limited to) flap operating system, flight control linkage system, hydraulic actuation systems, electrical control systems (elevator, aileron, spoiler, slats, flaps, speed brakes/lift dumpers, tailplane trim), mechanical (rudder, tailplane trim), and pneumatic control system (refer Figure 1.1) [4–8].

1.2 Aircraft Structure

The basic structure of any aircraft consists of fuselage frame, wings, and tail assembly. The fuselage frame comprises a number of parts known as structural members as shown in Figure 1.2 (these members include components such as bulkhead, longerons, stringers, ribs, formers, and skin). Primary loads of the entire structure are supported by longerons. A longeron, in turn, is supported by other longitudinal members, called stringers. Stringers are numerous in number, smaller than longeron, and act as stiffeners. The frame, bulkhead, and formers are the vertical structural members of an airframe structure [4].