

CHAPTER – 3

ALUMINIUM – LITHIUM ALLOYS

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ABSTRACT

This chapter summarises the development and limitations of the 1st and 2nd generation Al-Li alloys, and then discusses the recent developments leading to the 3rd generation alloys. Emphasis is placed on the physical metallurgy of Al-Li alloys, progressive development of the three generations of these alloys, and finally the strategies for obtaining improved property combinations via various microstructural modifications closely linked to multi-stage processing. The way forward for Indian Development of Al-Li alloys is also briefly discussed.

3.1. History of Alloy Development

Interest in aluminium - lithium (Al-Li) alloys arises from the important consideration that as the lightest metal, lithium additions to Al reduce its density (~3% decrease per every wt%) and increase the elastic modulus (~6% increase per every wt%). The increase in specific strength (strength/density) and specific stiffness (E/density) combine with good fatigue and cryogenic properties to offer possibilities for the use of Al-Li alloys in aerospace structural applications, including fuel tanks in launch vehicles, like the external tank of the US space shuttle [1-3].

Developmental activities started from the 1920s, but the first commercial alloy AA2020 (Al-1.1Li-4.5Cu-0.5Mn-0.2Cd) was introduced only in 1958. This alloy was successfully used for the wing skins and tails of the Northrop RA-5C Vigilante aircraft, but concerns about its fracture toughness led to its withdrawal in the 1960s. In the same time period, research work in the former Soviet Union led to the development of VAD-23 with the nominal composition Al-1.1Li-5.3Cu-0.6Mn-0.17Cd and 1420 (Al-2.0Li-5.3Mg-0.5Mn). All three alloys are customarily referred to as 1st generation alloys.

In the 1970s, the potential threat of replacement of aluminium alloys by carbon fibre composites resulted in extensive research work on a new, 2nd generation of Al-Li alloys. Development of these alloys has been largely unsuccessful owing to unacceptable degrees of property anisotropy, low short-transverse properties and thermal instability. Work began in the late 1980s and early 1990s on a 3rd generation of Al-Li alloys, and developments are ongoing. These newer alloys are candidates for widespread replacement of conventional aluminum alloys in aerospace structures. Table 3.1 lists typical compositions of some Al-Li alloys from all three generations [1].

3.2. Aircraft Structural Property Requirements

Figure 3.1 illustrates the engineering property requirements for several of the main structural areas in a transport aircraft, namely (i) Fuselage and Pressure Cabins, (ii) Wings and (iii) Empennage. The engineering properties required for these aircraft structures are strength (TS, CYS), stiffness (E), damage tolerance (DT: fatigue, fatigue crack growth, fracture toughness), and corrosion (general and stress corrosion). Also very important is the material density (ρ), reflected in weight savings *per se* and the specific strength and stiffness.

Figure 3.2 summarises calculations of aircraft structural weight savings due to property improvements [2], showing that a lower density is the most effective way of reducing the overall weight of an aircraft structure. Next are enhancements in strength and stiffness, which combine with reduced density to give improvements in specific strength and stiffness. Finally, improvements in damage tolerance (DT) properties have the least potential for saving weight, though even small amounts of weight savings can be important.

Aluminum Lithium Alloys Design Development And Application Update

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Table of Contents Aluminum Lithium Alloys Design Development And Application Update

1. Understanding the eBook Aluminum Lithium Alloys Design Development And Application Update
 - The Rise of Digital Reading Aluminum Lithium Alloys Design Development And Application Update
 - Advantages of eBooks Over Traditional Books
2. Identifying Aluminum Lithium Alloys Design Development And Application Update
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Aluminum Lithium Alloys Design Development And Application Update
 - User-Friendly Interface
4. Exploring eBook Recommendations from Aluminum Lithium Alloys Design Development And Application Update
 - Personalized Recommendations
 - Aluminum Lithium Alloys Design Development And Application Update User Reviews and Ratings
 - Aluminum Lithium Alloys Design Development And Application Update and Bestseller Lists
5. Accessing Aluminum Lithium Alloys Design Development And Application Update Free and Paid eBooks
 - Aluminum Lithium Alloys Design Development And Application Update Public Domain eBooks
 - Aluminum Lithium Alloys Design Development And Application Update eBook Subscription Services
 - Aluminum Lithium Alloys Design Development And Application Update Budget-Friendly Options

6. Navigating Aluminum Lithium Alloys Design Development And Application Update eBook Formats
 - ePub, PDF, MOBI, and More
 - Aluminum Lithium Alloys Design Development And Application Update Compatibility with Devices
 - Aluminum Lithium Alloys Design Development And Application Update Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Aluminum Lithium Alloys Design Development And Application Update
 - Highlighting and Note-Taking Aluminum Lithium Alloys Design Development And Application Update
 - Interactive Elements Aluminum Lithium Alloys Design Development And Application Update
8. Staying Engaged with Aluminum Lithium Alloys Design Development And Application Update
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Aluminum Lithium Alloys Design Development And Application Update
9. Balancing eBooks and Physical Books Aluminum Lithium Alloys Design Development And Application Update
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Aluminum Lithium Alloys Design Development And Application Update
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Aluminum Lithium Alloys Design Development And Application Update
 - Setting Reading Goals Aluminum Lithium Alloys Design Development And Application Update
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Aluminum Lithium Alloys Design Development And Application Update
 - Fact-Checking eBook Content of Aluminum Lithium Alloys Design Development And Application Update
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements

- Interactive and Gamified eBooks

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