

## *Aluminum lithium alloys*



*Al - Li*

*Al Li alloys not only have low density, high strength and high stiffness, but also have good fatigue properties, superplasticity, corrosion resistance and so on.*



# Aluminum Lithium Alloys

**Biliyar N. Bhat, Thomas T. Bales, E. J.  
Vesely**

## **Aluminum Lithium Alloys:**

**Aluminum-Lithium Alloys** R.J.H. Wanhill, 2013-09-20 The material and manufacturing property requirements for selection and application of 3rd generation aluminium lithium Al Li alloys in aircraft and spacecraft are discussed Modern structural concepts using Laser Beam Welding LBW Friction Stir Welding FSW SuperPlastic Forming SPF and selective reinforcement by Fibre Metal Laminates FMLs are also considered Al Li alloys have to compete with conventional aluminium alloys Carbon Fibre Reinforced Plastics CFRPs and GLASS REinforced FMLs GLARE particularly for transport aircraft structures Thus all these materials are compared before discussing their selection for aircraft This is followed by a review of the aluminium alloy selection process for spacecraft Actual and potential applications of 3rd generation Al Li alloys are presented For aircraft it is concluded that the competition between different material classes aluminium alloys CFRPs and FMLs has reached a development stage where hybrid structures using different types of materials may become the rule rather than the exception However aluminium alloys are still the main contenders for spacecraft liquid propellant launchers

**Aluminum-Lithium Alloys** N Eswara Prasad, Amol Gokhale, R.J.H Wanhill, 2013-09-20 Because lithium is the least dense elemental metal materials scientists and engineers have been working for decades to develop a commercially viable aluminum lithium Al Li alloy that would be even lighter and stiffer than other aluminum alloys The first two generations of Al Li alloys tended to suffer from several problems including poor ductility and fracture toughness unreliable properties fatigue and fracture resistance and unreliable corrosion resistance Now new third generation Al Li alloys with significantly reduced lithium content and other improvements are promising a revival for Al Li applications in modern aircraft and aerospace vehicles Over the last few years these newer Al Li alloys have attracted increasing global interest for widespread applications in the aerospace industry largely because of soaring fuel costs and the development of a new generation of civil and military aircraft This contributed book featuring many of the top researchers in the field is the first up to date international reference for Al Li material research alloy development structural design and aerospace systems engineering Provides a complete treatment of the new generation of low density AL Li alloys including microstructure mechanical behaviour processing and applications Covers the history of earlier generation AL Li alloys their basic problems why they were never widely used and why the new third generation Al Li alloys could eventually replace not only traditional aluminum alloys but more expensive composite materials Contains two full chapters devoted to applications in the aircraft and aerospace fields where the lighter stronger Al Li alloys mean better performing more fuel efficient aircraft

**Aluminum-Lithium Alloys** G. Jagan Reddy, R.J.H. Wanhill, Amol A. Gokhale, 2013-09-20 Mechanical working of Al Li alloys is primarily concerned with aerospace alloy rolled products sheet and plate extrusions and to a lesser extent forgings These products are fabricated by hot working with intermittent and final heat treatments This thermomechanical processing TMP can be rather complex for the modern 3rd generation Al Li alloys but is necessary to obtain optimum combinations of properties This Chapter is in two parts Part 1

discusses the workability of metals and alloys and the hot deformation characteristics of Al Li alloys leading to the concept of Process Maps A comprehensive Process Map for a binary Al Li alloy illustrates the usefulness of these Maps for defining temperature strain rate regions for safe and unsafe hot working recrystallization and recovery and superplastic behaviour Part 2 provides some general considerations about processing Al Li alloy products followed by a review and discussion of the currently available information for 3rd generation alloys It is concluded that their complex TMP schedules may make it difficult to obtain optimum combinations of properties for thicker products *Aluminium-Lithium Alloys III* Colin Baker,1986

**Aluminum-Lithium Alloys** Olga Grushko,Boris Ovsyannikov,Viktor Ovchinnokov,2016-11-18 Aluminum Lithium Alloys Process Metallurgy Physical Metallurgy and Welding provides theoretical foundations of the technological processes for melting casting forming heat treatment and welding of Al Li alloys It contains a critical survey of the research in the field and presents data on commercial Al Li alloys their phase composition microstructure and heat treatment of the ingots sheets forgings and welds of Al Li alloys It details oxidation kinetics protective alloying hydrogen in Al Li alloys and crack susceptibility It also discusses grain structure and solidification as well as structural and mechanical properties The book is illustrated with examples of Al Li alloy applications in aircraft structures Based on the vast experience of the coauthors the book presents recommendations on solving practical problems involved with melting and casting ingots welding of Al Li alloys and producing massive stampings for welded products Provides comprehensive coverage of Al Li alloys not available in any single source Presents research that is at the basis of the production technology for of ingots and products made of Al Li alloys Combines basic science with applied research including upscaling and industrial implementation Covers welding of Al Li alloys in detail Discusses gas and alkali earth impurities in Al Li alloys Describes technological recommendations on casting and deformation of Al Li alloys *Aluminum-Lithium Alloys* Edgar A. Starke,2013-09-20 This chapter provides a brief overview and history of the development of aluminium lithium alloys from the earlier days of the discovery of age hardening by Alfred Wilm to its current status It examines the progress of alloy development from simple binary alloys to the complex alloys that are currently used in aerospace systems The driving force for this development has been the advantages gained by weight reduction of aerospace systems by replacing conventional aluminium alloys with the lower density higher modulus aluminium lithium alloys The problems associated with the development of these alloys and the scientific solutions to solving these problems are described **Aluminum-Lithium Alloys** K.V. Jata,A.K. Singh,2013-09-20 This chapter describes the development of crystallographic texture and its effects on mechanical properties in aluminum lithium alloys Crystallographic texture evolves during the forming of wrought products from cast ingots of Al Li alloys and consequently affects the mechanical properties Practical approaches to control the texture have been developed and have been successfully used in the products obtained from industrial scale ingots This texture tailoring has significantly reduced the yield strength anisotropy In addition theoretical approaches have been used to

model the yield strength anisotropy of aluminum alloys in the presence of complex precipitates **Aluminum-Lithium Alloys** R.J.H. Wanhill, G.H. Bray, 2013-09-20 The structural and engineering property requirements for widespread deployment of aluminium lithium Al Li alloys in aircraft are discussed particularly with respect to commercial transport aircraft The development of Al Li alloys has been driven mainly by the fact that additions of lithium to aluminium alloys lowers the density and increases the elastic modulus thereby offering the potential of significant weight savings with respect to conventional non lithium containing alloys The first use of Al Li alloys in aircraft goes back to the late 1950s alloy AA 2020 and mid 1960s alloys 1420 and 1421 These materials are referred to as the 1st generation Al Li alloys Subsequently there have been two major development programmes resulting in the 2nd and 3rd generation alloys Development of the 2nd generation alloys began in the 1970s and continued through the 1980s Attempts were made to develop families of Al Li alloys for widespread replacement of conventional alloys Ultimately this was unsuccessful except for niche applications The failure to find widespread application was associated largely with the too high lithium contents of the alloys typically more than 2 wt% This resulted in serious disadvantages including mechanical property anisotropy low short transverse ductility and fracture toughness and thermal instability Development of the 3rd generation Al Li alloys began in the late 1980s and is ongoing These alloys have significantly reduced lithium contents 0.75-1.8 wt% and there are other important compositional changes Silver and zinc have been added for strength and zinc improves the corrosion resistance and manganese is added besides zirconium which was already present in 2nd generation alloys to control recrystallization and texture These differences and improved knowledge about thermomechanical processing and heat treatment have resulted in a family of alloys with significant property advantages covering all major structural areas and applications for transport aircraft

Aluminum-Lithium Alloys for Aerospace Applications Workshop Biliyar N. Bhat, Thomas T. Bales, E. J. Vesely, 1994

Aluminum-lithium Alloys Ramesh J. Kar, Suphal P. Agrawal, William E. Quist, 1988 *Aluminum-Lithium Alloys* T.S.

Srivatsan, Enrique J. Lavernia, N. Eswara Prasad, V.V. Kutumbarao, 2013-09-20 The emergence of Al Li alloys as potential light metal for safe use in a spectrum of aircraft structures and related aerospace applications has in recent years engendered an unprecedented widespread interest aimed at studying understanding and improving their mechanical properties In this chapter we present and discuss some of the key aspects relevant to aluminum lithium alloys spanning the specific domain of precipitation kinetics as influenced by composition and heat treatment intrinsic microstructural features and their effects the fundamental mechanisms contributing to strength ductility fracture toughness and overall anisotropy in mechanical properties of these alloys The tensile behavior of representative first generation second generation and third generation aluminum lithium alloys is also presented and briefly discussed Microstructural influences on mechanical properties are examined with specific reference to matrix microstructural features dislocation microstructural feature interaction and matrix slip characteristics **Aluminum-lithium Alloys** T. H. Sanders, 1989 **Aluminum-lithium Alloys** Ramesh J.

Kar, Suphal P. Agrawal, William E. Quist, 1988      **Aluminum-Lithium Alloys** K. Satya Prasad, N. Eswara Prasad, Amol A. Gokhale, 2013-09-20 This chapter reviews the precipitation and precipitate phases that occur during heat treatments in multi component Al Li based alloys It describes aspects related to nucleation growth morphology and orientation relationships of the strengthening precipitates and T1 the toughening precipitate S and the recrystallisation inhibiting precipitate Equilibrium precipitate phases such as T2 which are deleterious to the mechanical and corrosion properties of the alloys are also described It is shown that careful alloy chemistry control two step homogenization and controlled stretching prior to ageing can be employed to improve the volume fraction and distribution of the precipitate phases All these processing aspects are necessary to achieve optimum combinations of properties for the alloys      Aluminum-Lithium Alloys S.P. Lynch, R.J.H. Wanhill, R.T. Byrnes, G.H. Bray, 2013-09-20 Aluminium Lithium Al Li alloys have been of interest since the 1950s when they were first used on a military aircraft Having lithium as the main alloying element in Al alloys is attractive since i each 1 wt% Li reduces the density by 3% and increases modulus by 5% and ii high strengths can be achieved by precipitation hardening During the 1980s extensive research and development was carried out on alloys with high lithium contents 2 wt% 8 at% such as AA 8090 Al 2 4 Li 1 2 Cu 0 7 Mg 0 12 Zr wt% The mechanical properties of these second generation Al Li alloys however did not match those of conventional Al Zn Mg Cu alloys and the lower fracture toughness of these alloys for equivalent strengths was a particular problem Thus 2nd generation Al Li alloys did not see widespread use The experience with 2nd generation Al Li alloys led to the development of 3rd generation alloys with lower Li contents 0 75 1 7 wt% and some of these alloys have a better overall balance of properties including fracture toughness than the best available conventional Al alloys These 3rd generation Al Li alloys should therefore see extensive use in future civil and military aircraft This chapter on fracture toughness and fracture modes of aerospace Al Li alloys outlines why fracture toughness is important for aerospace structures and components and summarises testing procedures and terminologies in regard to plane strain and plane stress fracture toughness The relationships between fracture toughness fracture modes and microstructural features such as grain morphology constituent particles impurity phases matrix precipitates grain boundary precipitates and grain boundary segregation are then discussed Proposed explanations for the low fracture toughness of 2nd generation Al Li alloys associated with low energy intergranular and transgranular shear fractures are discussed in some depth followed by a summary of the alloy design principles behind the development of 3rd generation Al Li alloys with a much improved resistance to low energy fracture modes Quantitative data for fracture toughness of 2nd and 3rd generation Al Li alloys in comparison with conventional Al alloys are provided showing that 3rd generation Al Li alloys have outstanding combinations of toughness and strength combined with reduced densities The superior toughness of 3rd generation Al Li alloys compared with 2nd generation alloys is reflected in the differences in fracture surface topography and fracture path The chapter concludes with a summary of the current and proposed uses of 3rd generation Al Li alloys in aircraft structures and

components      **Aluminum-Lithium Alloys** N. Eswara Prasad, T.R. Ramachandran, 2013-09-20 The formation of metastable and equilibrium phases in binary Al Li ternary Al Li Mg and Al Li Cu and quaternary Al Cu Li Mg alloys has been studied by using a variety of experimental techniques including differential scanning calorimetry electrical resistivity X ray diffraction conventional and high resolution electron microscopy and 3D atom probe measurements Al<sub>3</sub>Li is the strengthening phase in binary Al Li and ternary Al Li Mg alloys Mg reduces the solubility of Li in Al and also substitutes for Li in The characteristics of  $\theta$  and  $\theta'$  phases in Al Li Cu alloys and the composition limits where these phases are formed are well understood For low Li contents 1 4 1 5% Formation of  $\theta'$  is promoted by small additions of Ag and Mg and by cold work prior to artificial aging Zr forms the metastable Al<sub>3</sub>Zr phase which has an appreciable effect on retarding recrystallization besides providing nucleation sites for composite particles Sc and Yb additions behave in a similar way the added advantage is improved creep strength The available information from phase equilibria studies of Al Li Cu Mg alloys is somewhat limited but sufficient to give an indication of the desirable solution treatment and aging temperatures and the phases formed at these temperatures 3D atom probe studies suggest the involvement of Mg atoms in the formation of clusters which lead to the formation of the  $\theta'$  phase during artificial ageing of aging of quenched Al Cu Mg Ag alloys All these aspects are covered in detail with specific reference to different commercial and semi commercial Al Li alloys wherever possible      *Aluminum-Lithium Alloys* Vijaya Singh, Amol A. Gokhale, 2013-09-20 Information on the technology of melting and casting aluminium lithium alloys is rarely published Therefore this chapter presents important findings from many research investigations on various aspects of melting casting and cast structure development of Al Li alloys Presence of reactive element such as Li in the molten alloy requires special melt protection techniques containment materials alloying practices and casting equipment Problem of grain refinement linked to the presence of Zr in most commercial compositions has also been discussed Finally it is surmised that the lower Li contents present in the third generation alloys compared to their older counterparts is expected to ease difficulties in their melting and casting      *Aluminium-lithium Alloys* , 1986      Aluminum and Aluminum Alloys Joseph R. Davis, 1993-01-01 This one stop reference is a tremendous value and time saver for engineers designers and researchers Emerging technologies including aluminum metal matrix composites are combined with all the essential aluminum information from the ASM Handbook series with updated statistical information      **Aluminum-Lithium Alloys** N.J.H. Holroyd, G.M. Scamans, R.C. Newman, A.K. Vasudevan, 2013-09-20 Industrial interest in wrought heat treatable aluminium lithium Al Li based alloys dates back to around 1919 in Germany However the exploitation of these alloys has historically been limited by their mechanical property anisotropy and concerns over their localized corrosion resistance and temperature stability Recently in the last ten years alloy and process development has resulted in alloy compositions and thermomechanical treatments that potentially can overcome these issues To put these developments in perspective we have reviewed the corrosion characteristics of first second and third generation alloys with an emphasis on localized corrosion

intergranular and exfoliation and stress corrosion cracking SCC Intergranular corrosion susceptibility of Al Li Cu and Al Li Cu Mg alloys increases with copper content and the depth of attack increases with ageing i e UAPA 30 mm further analysis of corrosion test results is required



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