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(54) **Aluminum-lithium alloy (3).**

(57) An aluminium-lithium alloy exhibiting good fracture toughness and relatively high strength having a composition of 2,0 to 2,4% Li, 2,3 to 2,7% Cu, up to 0,9% Mg, up to 0,15% Zr, up to 0,15% Fe, up to 0,12% Si, balance Al.

A preferred composition has 2,2% Li, 2,5% Cu, 0,7% Mg, 0,12% Zt, balance Al.

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ALUMINUM-LITHIUM ALLOY (3)

Background of the Invention

The present invention relates to aluminum-lithium alloys and more particularly to an aluminum-lithium alloy composition with good fracture toughness and high strength.

It has been estimated that current large commercial transport aircraft may be able to save from 15 to 20 gallons of fuel per year for every pound of weight that can be saved when building the aircraft. Over the projected 20 year life of an airplane, this savings amounts to 300 to 400 gallons of fuel. At current fuel costs, a significant investment to reduce the structure weight of the aircraft can be made to improve overall economic efficiency of the aircraft.

The need for improved performance in aircraft of various types can be satisfied by the use of improved engines, improved airframe design, and improved or new structural materials in the aircraft. Improvements in engines and aircraft design have pushed the limits of these technologies. However, the development of new and improved structural materials is now receiving increased attention, and is expected to yield further gains in performance .

Materials have always played an important role in dictating aircraft structural concepts. In the early part of this century, aircraft structure was composed of wood, primarily spruce, and fabric. Because shortages of spruce developed in the early part of the century, lightweight metal alloys began to be used as aircraft structural materials. At about the same time, improvements in design brought about the development of the all metal cantilevered wing. It was not until the 1930's, however, that the metal skin wing design became standard, and firmly established metals, primarily aluminum alloys, as the major airframe structural material. Since that time, aircraft structural materials have remained remarkably consistent with aluminum structural materials being used primarily in the wing, body and empennage, and with steel comprising the material for the landing gear and certain other speciality applications requiring very high strength materials.

Several new materials are currently being developed for incorporation into aircraft structure. These include new metallic materials, metal matrix composites and resin matrix composites. It is believed that improved aluminum alloys and carbon fiber composites will dominate aircraft structural materials in the coming decades. While composites will be used in increased percentages as aircraft structural materials, new lightweight aluminum alloys, and especially aluminum-lithium alloys show great promise for extending the usefulness of aluminum alloys.

Heretofore, aluminum-lithium alloys have been used only sparsely in aircraft structure. The relatively low use has been caused by casting difficulties associated with aluminum-lithium alloys and by their relatively low fracture toughness compared to other more conventional aluminum alloys. Aluminum-lithium alloys, however, provide a substantial lowering of the density of aluminum alloys (as well as a relatively high strength to weight ratio), which has been found to be very important in decreasing the overall weight of structural materials used in an aircraft. While substantial strides have been made in improving the aluminum-lithium processing technology, a major challenge still outstanding is an ability to obtain a good blend of fracture toughness and high strength in an aluminum-lithium alloy.

Summary of the Invention

The present invention provides a novel aluminum alloy composition that can be worked and heat treated so as to provide an aluminum-lithium alloy with high strength, good fracture toughness, and relatively low density compared to conventional aluminum alloys that it is intended to replace. An alloy prepared in accordance with the present invention has a nominal composition on the order of 2.2 weight percent lithium, 0.7 percent magnesium, 2.5 percent copper and 0.12 percent zirconium. By underaging the alloy at a low temperature, an excellent combination of fracture toughness and high strength results.

Detailed Description of the Invention

An aluminum-lithium alloy formulated in accordance with the present invention can contain from about 2.0 to about 2.4 percent lithium, 0 to 0.9 percent magnesium, 2.3 to 2.7 percent copper and a maximum of 0.15 percent zirconium as a grain refiner. Preferably from 0.10 to 0.15 percent zirconium is incorporated. All percentages herein are by weight percent based on the total weight of the alloy unless otherwise indicated. While no magnesium need be employed in the alloy, it is preferred that magnesium be included to increase strength without increasing density. Magnesium also provides solid solution strengthening. Preferred amounts of magnesium range from 0.5 to 0.9 percent, with 0.7 percent being more preferred. The copper adds strength to the alloy.

Iron and silicon can each be present in maximums up to a total of 0.3 percent. It is preferred that these elements be present only in trace amounts, limiting the iron to a maximum of 0.15 percent and the silicon to a maximum of 0.12 percent, and preferably maximums of 0.10 and 0.10 percent respectively. Certain trace elements such as zinc, may be present in the amounts up to, but not to exceed, 0.25 percent of the total. Other elements such as chromium and manganese must be held to levels of 0.05 percent or below. If these maximums are exceeded, the desired properties of the aluminum-lithium alloy will tend to deteriorate.The trace elements sodium and hydrogen are also thought to be harmful to the properties (fracture toughness in particular) of aluminum-lithium alloys and should be held to the lowest levels practically attainable, for example on the order of 15 to 30 ppm (0.0015-0.0030 wt. %) for the sodium and less than 15 ppm (0.0015 wt. %) and preferably less than 1.0 ppm (0.0001 wt. %) for the hydrogen. The balance of the alloy, of course, comprises aluminum.

An aluminum-lithium alloy formulated in the proportions set forth in the foregoing paragraph is processed into an article utilizing known techniques. The alloy is formulated in molten form and cast into an ingot. The ingot is then homogenized at temperatures ranging from 925°F to 1000°F. Thereafter, the alloy is converted into a usable article by conventional mechanical formation techniques such as rolling, extrusion or the like. Once an article is formed, the alloy is normally subjected to a solution treatment at temperatures ranging from 950°F to 1000°F, quenched in a quenching medium such as water that is maintained at a temperature on the order of 70°F to 150°F. If the alloy has been rolled or extruded, it is generally stretched on the order of 1 to 3 percent of its original length to relieve internal stresses.

The alumium alloy can then be further worked and formed into the various shapes for its final application. Additional heat treatments such as solution heat treatment can be employed if desired. For example, an extruded product after being cut to desired length are generally solution heat treated at temperatures on the order of 975° F for 1 to 4 hours. The product is then quenched in a quenching medium held at temperatures ranging from about 70° F to 150° F.

Thereafter, in accordance with the present invention, the article is preferably subjected to an aging treatment at relatively low temperatures on the order of from 200 to 300° F. Since this alloy is intended to replace conventional 7XXX series type alloys, it is preferred that the alloy be aged for a period of time that will allow it to achieve at least about 95 percent of its peak strength. It is preferred that the alloy be aged for a period of time allowing it to achieve 95 to 97 percent of its peak strength. Preferred aging temperatures range from 250 to 275° F. Within these temperature ranges, 95 to 97 percent peak age can be achieved by aging from about 4 to 120 hours.

Example

The following example is presented to illustrate the superior characteristics of an aluminum-lithium alloy aged in accordance with the present invention and to assist one of ordinary skill in making and using the present invention. Moreover, it is intended to illustrate the signifcantly improved and unexpected characteristics of an aluminum-lithium alloy formulated and manufactured in accordance with the paramters of the present invention. The following example is not intended in any way to otherwise limit the scope of this disclosure or the protection granted by Letters Patent hereon.

An aluminum alloy containing 2.2 lithium, 0.5 percent magnesium, 2.5 percent copper, 0.1 percent zirconium with the balance being aluminum was formulated. The trace elements present in the formulation constituted less than 0.25 percent of the total. The iron and silicon present in the formulation constituted less than 0.07 percent of the formulation. The alloy was cast and homogenized at about 975° F. Thereafter, the alloy was hot rolled to a thickness of 0.2 inches. The resulting sheet was then solution treated at about 975° F for about 1 hour. It was then quenched in water maintained at about 70° F. Thereafter, the sheet was subjected to a stretch of 1 1/2 percent of its initial length. The material was then cut into specimens. The specimens were cut to a size of 0.5 inch by 2 1/2 inch by 0.2 inch for the precrack Charpy impact tests, which measure fracture toughness. The specimens prepared for the tensile strength tests were 1 inch by 4 inches by 0.2 inches. A plurality of specimens were then aged for 120 hours at 275° F. Each of the specimens aged at each of the temperatures and times were then subjected to the tensile strength and precrack Charpy impact tests in accordance with standard ASTM testing procedures.

The specimens underaged at 275°F exhibit an ultimate strength ranging from about 865 ksi to about 95 ksi with a toughness on the order of 220 to 280 in-lbs/in^2.

The present invention has been described in relation to various embodiments, including the preferred formulation and processing parameters. One of ordinary skill after reading the foregoing specification will be able to effect various changes, substitutions, other equivalents and other alterations without departing from the broad concepts departed herein. It is therefore intended that the scope of the Letters Patent granter hereon will be limited only by the definition contained in the appended claims and equivalents thereof.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

CLAIMS

1. An aluminum-lithium alloy exhibiting good fracture toughness consisting essentially of

Element	Amount (wt. %)
Li	2.0 to 2.4
Mg	0 to 0.9
Cu	2.3 to 2.7
Zr	0.15 max
Fe	0.15 max
Si	0.12 max
Other trace elements	0.25 max
Al	Balance.

2. The alloy of Claim 1 wherein said zirconium is present in amounts up to about 0.12 percent.

3. The alloy of Claim 1 having a nominal composition of 2.2 percent lithium, 0.5 percent magnesium, 2.5 percent copper, and 0.12 percent zirconium.

4. The alloy of Claim 1 wherein said alloy has been aged at a relatively low temperature to near peak strength.

5. The alloy of Claim 1 wherein said alloy has been aged at a temperature in the range of from 200° F to 300° F.

6. The alloy of Claim 5 wherein said alloy has been aged for a period of at least 4 hours.

7. The alloy of Claim 1 wherein magnesium is present in an amount ranging from 0.5 to 0.9 percent.

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EUROPEAN SEARCH REPORT

0156995

Application number

EP 84 11 5928

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	CHEMICAL ABSTRACTS, vol. 77, no. 26, 1972, page 199, no. 167699m, Columbus, Ohio, US; B.NOBLE et al.: "T1(Al2CuLi) precipitation in aluminum-copper-lithium alloys" & METAL SCI. J.1972, 6(SEPT.), 167-74 * Abstract * ---	1	C 22 C 21/00 C 22 C 21/12
A	GB-A- 787 665 (J.STONE & CY. LTD.) * Claims 1,3,5 * & FR - A - 1 148 719 & DE - B - 1 126 625 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			C 22 C 21

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18-06-1985	LIPPENS M.H.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document