A wrought aluminium AA7000-series alloy product, including (in wt %): Zn 7.5 to 14.0, Mg 1.0 to 5.0, Cu<0.28, Fe<0.30, Si<0.25, and one or more members selected from the group of: Zr<0.30, Ti<0.30, Hf<0.30, Mn<0.80, Cr<0.40, V<0.40, and Sc<0.70, remainder: incidental elements and impurities, each <0.05, total <0.15, and balance aluminium. The product having reduced hot crack sensitivity, and improved strength and toughness properties, and when in artificially aged condition having a hardness of more than 180 HB.
WROUGHT ALUMINIUM AA7000-SERIES ALLOY PRODUCT AND METHOD OF PRODUCING SAID PRODUCT

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This claims the benefit of U.S. provisional patent application No. 60/702,303, filed Jul. 26, 2005, and European patent application No. 05076673.2, filed Jul. 21, 2005, both incorporated herein by reference in their entirety.

FIELD OF THE INVENTION

[0002] This invention pertains to a weldable wrought aluminium AA7000-series alloy in the form of a rolled, extruded or forged product and to a method of producing said product. The invention further relates to a welded component comprising such a product.

BACKGROUND TO THE INVENTION

[0003] As will be appreciated herein below, except as otherwise indicated, alloy designations and temper designations refer to the Aluminium Association designations in Aluminum Standards and Data and the Registration Records, as published by the Aluminium Association.

[0004] For any description of alloy compositions or preferred alloy compositions, all references to percentages are by weight percent unless otherwise indicated.

[0005] Aluminium alloys of the Aluminium Association ("AA") 7000-series are known for their high strength which renders them suitable for applications such as structural components for aircraft or for tooling plate. Alloys AA7075 and AA7055 are examples of this type of alloy and have achieved widespread use in aerospace applications because of their high strength and other desirable properties. Alloy AA7055 comprises 7.6-8.4% of Zn, 1.8 to 2.3% of Mg, 2.0 to 2.6% of Cu, 0.08-0.25% of Zr, below 0.15% Si and below 0.15% Fe, the balance being aluminium together with incidental elements and impurities. Alloy AA7075 comprises 5.1 to 6.1% of Zn, 2.1 to 2.9% of Mg, 1.2 to 2.0% of Cu, 0.18 to 0.28% Cr, below 0.40% Si, below 0.50% Fe and below 0.50% Mn, the balance being aluminium together with incidental elements and impurities. When artificially aged to its highest strength, which ageing treatment usually involves a period of 20 hours or more at a relatively low ageing temperature of between 100 and 150°C, the alloy is obtained in a condition which is commonly referred to as a T6 temper condition. In this condition, alloys AA7075 and similar alloys are susceptible to stress corrosion cracking ("SCC"), exfoliation corrosion ("EXCO") and intergranular corrosion ("IGC"). This susceptibility can be reduced by a so called T7x heat treatment, but only at the cost of a considerable strength loss. It is known that higher strengths can be obtained by higher levels of alloying additions (in particular Zn, Mg and Cu) but this increase in strength leads to lower toughness values. In addition thereto, the high copper content of the aforementioned alloys makes them susceptible to hot cracking after welding. For tooling plate, in addition to good weldability in view of possible repairs, it is also very important that the material provides high hardness values.

SUMMARY OF THE INVENTION

[0006] It is an object of this invention to provide a wrought alloy product, ideally for aerospace application or tooling plate, of the AA7000-series having a combination of improved strength and toughness properties and reduced hot crack sensitivity during welding, relative to at least one alloy selected from the group consisting of AA7050 or AA7075 and, when in an artificially aged condition, having a hardness of more than 180 HB.

[0007] It is another object of this invention to provide a wrought alloy product of the AA7000-series having a combination of improved IC-G resistance, improved strength properties, reduced hot crack sensitivity during welding and, when in an artificially aged condition, having a hardness of more than 180 HB.

[0008] It is yet another object of this invention to provide a wrought alloy product of the AA7000-series having a combination of good weldability, improved strength properties and, when in an artificially aged condition, having a hardness of more than 180 HB.

[0009] It is also an object of this invention to provide a method for producing a wrought alloy product of the AA7000-series having a combination of improved strength and toughness properties, reduced hot crack sensitivity during welding and, when in an artificially aged condition, having a hardness of more than 180 HB or a wrought alloy product of the AA7000-series having a combination of improved IC-G resistance, improved strength properties, reduced hot crack sensitivity during welding and, when in an artificially aged condition, having a hardness of more than 180 HB which can be executed more economically than currently known and practiced industrial scale methods.

[0010] One or more of these objects and further advantages are met or exceeded by the present invention concerning a wrought aluminium AA7000-series alloy product, comprising (in wt %):

[0011] Zn 7.5 to 14.0
[0012] Mg 1.0 to 3.0
[0013] Cu ≤ 0.28
[0014] Fe < 0.30
[0015] Si < 0.25
[0016] and one or more of selected from the group consisting of: Ti < 0.30, Hf < 0.30, Mn < 0.80, Cr < 0.40, V < 0.40, and Sc < 0.70,

[0017] remainder: incidental elements and impurities, each <0.05, total <0.15,

[0018] and balance aluminium, the product having reduced hot crack sensitivity, also having improved strength and toughness properties, and when in artificially aged condition having a hardness of more than 180 HB.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] The present invention provides a wrought aluminium AA7000-series alloy product, consisting essentially of, in wt %:

[0020] Zn 7.5 to 14.0,
[0021] Mg 1.0 to 3.0, preferably 2.0 to 4.5,
[0022] Cu ≤ 0.28
Fe <0.30, preferably <0.14, more preferably <0.08
Si <0.25, preferably <0.12, more preferably <0.07,
and one or more of:
Zr <0.30, preferably 0.04 to 0.15, more preferably 0.04 to 0.13
Ti <0.30, preferably <0.20, more preferably <0.10
Hf <0.30
Mn <0.80, preferably <0.40
Cr <0.40
V <0.40, preferably <0.30
Sc <0.70, preferably <0.50.

remainder: incidental elements and impurities, each <0.05, total <0.15, and balance aluminium, the product having reduced hot crack sensitivity, also having improved strength and toughness properties, relative to at least one alloy selected from the group consisting of AA7050 or AA7075, and when in artificially aged condition having a hardness of more than 180 HB. Preferably the hardness is more than 185 HB, and more preferably more than 190 HB. And in the best examples a hardness of more than 210 HB has been obtained in the age hardened condition. For this description when measurements of the hardness are reported or mentioned, it will be appreciated by the skilled person that these have been measured at mid-section thickness as this represents to most quench sensitive location of a wrought product. By the product having reduced hot crack sensitivity and also having improved strength and toughness properties relative to at least one alloy selected from the group consisting of AA7050 or AA7075, the comparison is typically to at least one alloy selected from the group consisting of AA7050 or AA7075 in a T6 or T7 temper, for example a T651, T7751 or T7761 temper. For example, the comparison may be between an alloy of the present invention in T6 temper and at least one AA7050 or M7075 alloy in T6 temper, or between an alloy of the present invention in T7 temper and at least one AA7050 in T7 temper, or between alloys in the same temper, e.g., an alloy of the present invention in T651 temper and at least one AA7050 or M7075 alloy in T651 temper.

By reducing the hot crack sensitivity, the weldability of the material is significantly improved. The iron and silicon contents should preferably be kept low, for example not exceeding about 0.08% Fe and/or about 0.07% Si or less. In any event, it is conceivable that still slightly higher levels of both impurities, up to about 0.14% Fe and/or up to about 0.12% Si may be tolerated, though on a less preferred basis. In particular for the mould plate embodiments or tooling plate embodi-ments, even higher levels of up to 0.3% Fe and up to 0.25% Si or less, are tolerable.

By increasing the Zn-content of the alloy along with the Mg-content, while keeping the Cu-content low, it is possible to obtain very high strengths, while maintaining toughness levels equal or higher than a AA7055 reference material, and with good weldability which is believed to a large extent to be the resultant of the low copper content of the alloy. The alloy also provides a high hardness when in artificially aged condition such as a T6 or T7-type temper, but with improved weldability compared to an AA7075 reference material in T6 condition, which is believed to be because of the low copper content of the alloy. The artificial aged material may for example be a T6, T74, T76, T751, T7451, T7651, T77 or T79 temper.

Each of the dispersoid forming elements Zr, Sc, Hf, V, Cr and Mn can be added to control the grain structure and the quench sensitivity. The optimum levels of dispersoid formers depend on the processing, but when one single chemistry of main elements (Zn, Cu and Mg) is chosen within the preferred window and that chemistry will be used for all relevant products forms, then Zr levels are preferably less than 0.13%.

A preferred maximum for the Zr level is 0.15%. A suitable range of the Zr level is 0.04 to 0.15%. A more preferred upper-limit for the Zr addition is 0.13%. Zr is a preferred alloying element in the alloy product according to this invention.

The addition of Sc is preferably less than or equal to 0.50% or more preferably less than or equal to 0.3%, and even more preferably not more than 0.18%. When combined with Sc, the sum of Sc+Zr should be less than 0.5%, preferably less than 0.2%, and more preferably at a maximum of 0.17%, in particular where the ratio of Zr and Sc is between 0.7 and 1.4%.

Another dispersoid former that can be added, alone or with other dispersoid formers is Cr. Cr levels should preferably be below 0.3%, and more preferably at a maximum of 0.20%, and even more preferably 0.15%. A preferred lower limit for the Cr would be 0.04%. Although Cr alone may not be as effective as solely Zr, at least for use in tooling plate of the alloy wrought product, similar hardness results may be obtained. When combined with Zr, the sum of Zr+Cr should not be above 0.20%, and preferably not more than 0.17%.

The preferred sum of Sc+Zr+Cr should not be above 0.4%, and more preferably not more than 0.27%.

Mn can be added as a single dispersoid former or in combination with one of the other dispersoid formers. A maximum for the Mn addition is 0.80%. A suitable range for the Mn addition is in the range of 0.05 to 0.40%, and preferably in the range of 0.05 to 0.30%, and even more preferably 0.12 to 0.30%. A preferred lower limit for the Mn addition is 0.12%, and more preferably 0.15%. When combined with Zr, the sum of Mn plus Zr should be less than 0.4%, preferably less than 0.32%, and a suitable minimum is 0.12%.

In another embodiment of the aluminium alloy wrought product according to the invention the alloy is free of Mn, in practical terms this would mean that the Mn-content is <0.02%, and preferably <0.01%, and more preferably the alloy is essentially free or substantially free from Mn. With “substantially free” and “essentially free” we mean that no purposeful addition of this alloying element was made to the composition, but that due to impurities and/or leaching from contact with manufacturing equipment, trace quantities of this element may, nevertheless, find their way into the final alloy product.
In a preferred embodiment of the aluminium alloy wrought product according to this invention the alloy has no deliberate addition of V such that it is only present, if present, at regular impurity levels of less than 0.05%.

The copper content has a considerable influence on the hot crack sensitivity of the alloy and consequently also on the weldability of the alloy.

It was found that weldability was further improved at copper content of 0.28% or below 0.25%. A very good weldability was obtained at copper contents of lower than 0.25% or even lower than 0.20%. A preferred minimum addition for the Cu-content is 0.03% and more preferably 0.08%. When the alloy product according to this invention is used as tooling plate the weldability properties come in particular at play during repair operations of the tooling plate.

In an embodiment of the invention the Zn content is in the range of 7.5 to 14.0%, preferably the amount of Zn is in a range having a lower limit of 8.5%, 9.0% or 9.5% and an upper limit of 12.0%, 11.0% or 10.0%, for example Zn is preferably in the range of 8.5 to 11%, and more preferably Zn is in the range of 8.5 to 10.0%, in particular for use in aerospace applications. Whereas for tooling plate application the upper limit for the Zn-content is 14.0%, preferably 12.0% and more preferably 11.0%.

By limiting the Zn content to a maximum of 12.0%, 11.0% or even 10.0%, the corrosion resistance and particularly the EXCO is maintained at a high level, which is of particular relevance for aerospace applications of the alloy product according to this invention.

In an embodiment of the invention the Mg content is in the range of 1.0 to 5.0% or 2.5 to 5.0%. A preferred upper limit is 4.5%. Where alloy product according to this invention is used as tooling plate a more preferred upper limit for the Mg content is 4.0%.

The addition of Mg markedly increases the strength of the alloy. A maximum content of 5.0% is used to avoid formation of unfavourable Mg-precipitates such as Mg2Al3 or Mg2Al4, which may produce an undesirable susceptibility to IGIC and SSC.

In an embodiment of the invention the amount of Mg in the alloy is at least the value provided by the relation 6.6–(0.45×Zn), and preferably wherein Mg≥10–(0.79×Zn).

Mg and Zn form Mg2Zn12 precipitates, which have a profound effect on the final hardness and strength properties after quenching and ageing. If the Mg content lies above the values given by the relations above, the excess Mg will contribute to the strengthening of the alloy.

The present invention is directed to an alloy composition which, when processed to a variety of products, such as, but not limited to, sheet, plate, thick plate, etc., will meet or exceed the desired material properties. The property balance of the product will out-perform the property balance of the product made from nowadays commercially used alloys.

Preferably the alloy product according to this invention is processed to thicker gauges of more than 1 inch (25.4 mm) up to about 11 inch (279.4 mm) or more and will provide improved properties for structural aircraft components such as integral parts machined from plate, or to form an integral spar for use in an aircraft wing structure, or in the form of a rib for use in an aircraft wing structure or as upper wing plate. The thicker gauge products can be used also as tooling plate or mould plate, e.g., moulds for manufacturing formed plastic products via die-casting, injection moulding or comparable methods. When thickness ranges are given hereinabove, it will be immediately apparent to the skilled person that this is the thickness of the thickest cross sectional point in the alloy product made from such a thin plate or thick plate. The alloy products according to the invention can also be provided in the form of a stepped extrusion or extruded spar for use in an aircraft structure, or for example in the form of a forged spar for use in an aircraft wing structure.

In the embodiment where the alloy product has been extruded, preferably the alloy products have been extruded into profiles having at their thickest cross sectional point a thickness in the range of up to 10 mm, and preferably in the range of 1 to 7 mm. However, in extruded form the alloy product can also replace thick plate material which is conventionally machined via high-speed machining or milling techniques into a shaped structural component. In this embodiment the extruded alloy product has preferably at its thickest cross sectional point a thickness in a range of 2 inches (50.8 mm) to 6 inches (152.4 mm).

In an embodiment of the invention the product is a high strength and toughness aerospace plate, such as an upper wing plate, the Mg-content of the product preferably depending on the Zn-content according to Mg=6.6–(0.45×Zn).

It was found that a particularly advantageous combination of mechanical properties, toughness properties and corrosion resistance was obtained if the Mg content is at least equal to or exceeds the value given by the aforementioned relation between Mg and Zn, a combination of properties which is particularly attractive for high strength and toughness aerospace plate or extrusions.

In an embodiment of the invention the product is a high strength tooling plate, preferably having a hardness after artificial ageing of more than 185 HB, preferably of more than 190 HB, the Mg-content of the product preferably depending on the Zn-content according to Mg=6.6–(0.45×Zn), and more preferably according to Mg=10–(0.79×Zn). It is noted that all hardness values in this description and the claims are Brinell hardness values, measured according to ASTM E10, version 2002, and whereby the hardness is being measured at mid-section thickness.

It was found that a particularly advantageous combination of mechanical properties, hardness, weldability and corrosion resistance was obtained if the Mg content is at least equal to or exceeds the value given by the aforementioned relations between Mg and Zn, a combination of properties which is particularly attractive for high strength tooling plate.

In a preferred embodiment the wrought alloy product consists of a tooling plate in a T6 or T7 temper and having a composition consisting essentially of:

Zn 7.5 to 14.0, preferably 7.5 to 12.0, more preferably 8.5 to 11.0, or 9.5 to 12.0
[0061] Mg 1.0 to 5.0, preferably 2.0 to 4.5 or 2.5 to 4.5, and more preferably 2.5 to 3.5, and preferably wherein the Mg-content depends on the Zn-content according to Mg\(\geq 6.6-(0.45\times \text{Zn})\), and more preferably Mg\(\geq 10-(0.79\times \text{Zn})\)

[0062] Cu 0.03 to 0.25, preferably 0.03 to 0.20

[0063] Zr 0.04 to 0.15, and optionally also with Cr at most 0.20

[0064] Ti<0.10

[0065] Fe<0.30, preferably<0.14

[0066] Si<0.25, preferably<0.12

[0067] remainder incidental elements and impurities, each<0.05, total<0.15, and balance aluminium.

[0068] In another embodiment the tooling plate further consists of 0.05 to 0.40% Mn.

[0069] In a preferred embodiment the wrought alloy product consists of a tooling plate in a T6 or T7 temper and having a composition consisting essentially of:

[0070] Zn 7.5 to 14.0, preferably 7.5 to 12.0, more preferably 8.5 to 11.0 or 9.5 to 12.0

[0071] Mg 1.0 to 5.0, preferably 2.0 to 4.5 or 2.5 to 4.5, and more preferably 2.5 to 3.5, and preferably wherein the Mg-content depends on the Zn-content according to Mg\(\geq 6.6-(0.45\times \text{Zn})\), and more preferably Mg\(\geq 10-(0.79\times \text{Zn})\)

[0072] Cu 0.03 to 0.25, preferably 0.03 to 0.20

[0073] Cr 0.04 to 0.20

[0074] Zr up to 0.15

[0075] Ti<0.10

[0076] Fe<0.30, preferably<0.14

[0077] Si<0.25, preferably<0.12

[0078] remainder incidental elements and impurities, each<0.05, total<0.15, and balance aluminium.

[0079] In another preferred embodiment the wrought alloy product according to this invention, consists of an aerospace product selected from the group consisting of a sheet, plate, extrusion, or a structural aircraft component made from such a sheet, plate or extrusion, and being in a T6 or T7 temper and having a composition consisting essentially of:

[0080] Zn 7.5 to 11.0

[0081] Mg 1.0 to 5.0, and wherein the Mg-content depends on the Zn-content according to Mg\(\geq 6.6-(0.45\times \text{Zn})\), and preferably Mg\(\geq 10-(0.79\times \text{Zn})\)

[0082] Cu 0.03 to 0.25

[0083] Zr 0.04 to 0.15

[0084] Ti<0.10

[0085] Fe<0.14, preferably<0.08

[0086] Si<0.12, preferably<0.07

[0087] remainder incidental elements and impurities, each<0.05, total<0.15, the balance aluminium.

[0088] In a more preferred embodiment of the aerospace product it has a Mg content of 2.0 to 4.5% and wherein further the Mg content depends on the Zn content according to Mg\(\geq 10-(0.79\times \text{Zn})\). In a further embodiment of the aerospace product it has a Zn content in a range of 7.5 to 11.0%, and preferably 8.5 to 10.0%.

[0089] In yet another embodiment of the aerospace product it further consists of Mn in a range of 0.05 to 0.40%, and preferably 0.05 to 0.30%.

[0090] The invention is also embodied in a welded component comprising at least a first component part being a product according to the invention and at least a second component part, the component parts being welded together to form the welded component, preferably wherein the welded component is a welded structural aircraft component. More preferably the first and second component parts comprise a product according to the invention. Even more preferably substantially all or even all component parts forming the welded component or the welded structural aircraft component comprise a product according to the invention. The good weldability and other favorable properties are used to provide a welded component or welded structural aircraft component with excellent strength, corrosion properties and weld quality.

[0091] In another aspect of the invention there is provided a method of forming a wrought aluminium AA7000-series alloy product as described above and set forth in the examples, comprising the processing steps of:

[0092] a) casting an ingot having a composition as set out in the present description;

[0093] b) homogenising and/or pre-heating the ingot after casting;

[0094] c) hot working the ingot into a pre-worked product by one or more methods selected from the group consisting of: rolling, extruding and forging;

[0095] d) optionally reheating the pre-worked product and either,

[0096] e) hot working and/or cold working the pre-worked product to a desired workpiece shape;

[0097] f) solution heat treating (SHT) the formed workpiece at a temperature and time sufficient to place into solid solution substantially all soluble constituents in the alloy;

[0098] g) quenching the solution heat treated workpiece, preferably by one of spray quenching or immersion quenching in water or oil or other quenching media;

[0099] h) optionally stretching or compressing of the quenched work piece or otherwise cold worked to relieve stresses, for example levelling of sheet products;

[0100] i) artificially ageing the quenched and optionally stretched or compressed workpiece to achieve a desired temper, in particular to a T6 or T7-type temper, such as the tempers selected from the group comprising: T6, T74, T76, T751, T7451, T7651, T77 and T79, and

[0101] wherein the homogenising treatment comprises a first homogenisation stage and optionally a second homoge-
homogenisation stage wherein the duration and the temperature during the first homogenisation stage for an ingot or a slab is chosen such that a cold spot, the cold spot being defined as the coldest spot in the ingot or slab, in the ingot or slab is at a dissolving temperature for at least a dissolving time necessary to dissolve substantially all of the m-phase precipitates.

Optionally the homogenising treatment also comprises at least a second homogenisation stage consecutive to the first homogenisation stage. It should be noted that the dissolving temperature is reached at an earlier time at the perimeter of the ingot or cast, and that the temperature in the cold spot slowly increases to the dissolving temperature. In practice, the dissolving temperature is usually called the homogenisation temperature.

The alloy products of the present invention are conventionally prepared by melting and may be direct chill ("D.C.") cast into ingots or other suitable casting techniques. Hot working the alloy product can be done by one or more methods selected from the group consisting of rolling, extruding and forging. For the present alloy hot rolling is preferred. Solution heat treatment is typically carried out in the same temperature range as used for homogenisation, although the soaking times can be chosen somewhat shorter.

In an embodiment a method is provided wherein the duration of the first homogenisation stage for an ingot or a slab is chosen such that the cold spot is at a dissolving temperature for at least a dissolving time necessary to dissolve the m-phase precipitates, wherein preferably the dissolving time is at most 2 hours, preferably 1 hour, more preferably as short as possible, such as 30 minutes or 20 minutes, or even shorter. Preferably the dissolving temperature is about 470°C.

In an embodiment a method is provided wherein the duration of the first homogenisation stage for an ingot or a slab is at most 24 hours, preferably at most 12 hours, preferably wherein the homogenisation temperature is 470°C.

In an embodiment a method is provided wherein for an ingot or a slab having Cu≤0.28%, even more preferably having Cu≤0.20% the first homogenisation stage is at most 12 hours at 470°C and wherein there is no second homogenisation stage.

In an embodiment a method is provided wherein for an ingot or a slab having Cu>0.20%, preferably having Cu>0.25%, more preferably having Cu of max. 0.28% the homogenising step comprises a first homogenisation stage and a second homogenisation stage, the first homogenisation stage is at most 24 hours, preferably at most 12 hours at 470°C and wherein the second homogenisation stage is at most 24 hours, preferably at most 12 hours at 475°C.

With the process according to the invention, a product having reduced hot crack sensitivity, also having improved strength and toughness properties, and when in artificially aged condition having a hardness of more than 180 HB is obtained. For Cu of preferably Cu≤0.25% or even Cu≤0.20% a homogenisation treatment of at most 24 hours preferably at most 12 hours at 470°C is adequate to dissolve all m-phase precipitates and yield a product having the desired properties after SHT, quenching, optionally stretching, and ageing. By choosing the shortest possible homogenisation stage and the lowest possible homogenisation temperature, depending on the copper-content, the process can be performed very economically while maintaining excellent properties and achieving excellent weldability. The process can be performed even more economically if the ageing treatment is a single step ageing treatment. This way a product having reduced hot crack sensitivity, also having improved strength, and when in T6 temper condition having a hardness of more than 180 HB is obtained, excellent for high strength tooling plate applications. In a two-stage ageing treatment, a product having an advantageous combination of improved mechanical properties, hardness in artificially aged condition, toughness properties and corrosion resistance is obtained, excellent for high strength and high toughness weldable aerospace plate. Either after a single-stage or after a 2-stage ageing treatment, the corrosion resistance, particularly IGC and EXCO were found to be improved.

It was found that the m-phase precipitates dissolve rapidly for alloys according to the invention having Cu≤0.28%, and more rapidly at lower copper contents ≤0.25% or ≤0.20% respectively, so that the process can be made more economical by choosing the duration of the first homogenisation stage time chosen such that a cold spot, said cold spot being defined as the coldest spot in the ingot or slab, usually the centre of the ingot or slab, in the ingot or slab is at the homogenisation temperature, for instance of 470°C, for at least a dissolving time necessary to dissolve the m-phase precipitates, wherein preferably the dissolving time is at most 2 hours, preferably 1 hour, more preferably as short as possible. Ideally, the homogenisation treatment is ended when all m-phase precipitates have been dissolved after which the slab or ingot can be transferred to the hot rolling mill to be hot-rolled once the slab has reached the rolling temperature, optionally after having undergone a reheating treatment to bring the slab or ingot to or down to the rolling temperature.

In an embodiment control means, such as a mathematically or physically based computer model calculating the temperature development of the ingot or cast during the homogenisation treatment, are used for controlling the homogenisation treatment to determine the optimum residence time of the slab or ingot at the homogenisation temperature such that the cold spot of the ingot or slab is at the dissolving temperature of e.g. about 470°C for at least a dissolving time necessary to dissolve the m-phase precipitates. It will be clear to the skilled person that annealing times and temperatures are exchangeable to a certain extent by the concept of equivalent time, as defined in EP-087514 B1 (paragraph [0028]) and incorporated herein by reference, although of course the minimum annealing temperature should be sufficiently high to enable dissolution of the precipitates. It may also be important to avoid dissolution of certain other precipitates, so that the liberty of choosing the annealing temperature is limited by a maximum and a minimum homogenisation temperature.

In an embodiment of the method according to the invention the artificial ageing step i.) comprises a first ageing step at a temperature in a range of 105°C to 135°C preferably for 2 to 20 hours, and a second ageing step at a temperature in a range of 135°C to 210°C preferably for 4 to 20 hours. In a further embodiment a third ageing step
may be applied at a temperature in a range of 105°C to 135°C, and preferably for 20 to 30 hours.

[0112] In the following, the invention will be explained by the following, non-limitative examples.

EXAMPLES

Example 1

[0113] Lab ingots of chemistries A.1 to A.7 indicated in Table 1 have been cast and processed according to the following route (v=heating rate, @=at):

[0114] Homogenisation: v<=30°C/h and 12 h at 470°C C.,

[0115] Pre-heat: v=35°C/h and 6 h at 420°C C.,

[0116] Hot rolling: from 80 mm gauge to 30 mm,

[0117] SHT: v was as fast as possible, 2 h at 470°C C. followed by water quench,

[0118] Stretching: 1.5%.

[0119] Ageing: T76, v=30°C C./h and 5 h @ 120°C C./h plus v=15°C C./h and 12 h @ 145°C C./h.

TABLE 1

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Zn</th>
<th>Mg</th>
<th>Cu</th>
<th>R_p (MPa)</th>
<th>R_m (MPa)</th>
<th>K_c (MPa/m)</th>
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</thead>
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<tr>
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<td>2.8</td>
<td>0.15</td>
<td>531</td>
<td>549</td>
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<td>614</td>
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<td>1.9</td>
<td>0.16</td>
<td>584</td>
<td>558</td>
<td>62.1</td>
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<td>0.15</td>
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<td>595</td>
<td>41.3</td>
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<td>2.8</td>
<td>0.15</td>
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<td>636</td>
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<td>0.17</td>
<td>647</td>
<td>666</td>
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</tr>
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<td>11.0</td>
<td>2.8</td>
<td>0.18</td>
<td>659</td>
<td>669</td>
<td>24.2</td>
</tr>
</tbody>
</table>

*K_c* is fracture toughness

[0120] As is apparent from Table 1, it is possible to obtain very high strengths, while maintaining toughness levels equal or higher than the reference materials, by increasing Zn and Mg but keeping the Cu level low. It also appears from Table 1 that to reach desired strength level of at least 580 MPa, the Mg level depends on the Zn level according to Mg\geq6.6\times(0.45\times Zn).

Example 2

[0121] Lab ingots of chemistries B.1 to B.4 as indicated in Table 2 have been cast and processed according to the route described above except that the final hot rolling thickness was 3 mm and that the alloy B.3 has been homogenised for a longer time (12 h @470°C C. followed by 24 h @475°C C. C.) wherein the homogenisation step comprises a first and a second stage.

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Zn</th>
<th>Cu</th>
<th>R_p (MPa)</th>
<th>EXCO</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.1</td>
<td>9.3</td>
<td>2.3</td>
<td>0.16</td>
<td>565</td>
</tr>
<tr>
<td>B.2</td>
<td>9.4</td>
<td>2.3</td>
<td>0.80</td>
<td>564</td>
</tr>
<tr>
<td>B.3</td>
<td>9.3</td>
<td>2.8</td>
<td>0.15</td>
<td>598</td>
</tr>
<tr>
<td>B.4</td>
<td>10.7</td>
<td>2.8</td>
<td>0.15</td>
<td>626</td>
</tr>
</tbody>
</table>

[0122] The mechanical (L-direction) and corrosion (EXCO, measured according to the standard ASTM G34-97) properties of the alloys are also shown in Table 2. An 0.8% Cu level (see alloy B.2) does not improve the mechanical properties, but has an adverse influence on the corrosion behaviour of the alloy. On the other hand, Mg and Zn additions (see alloys B.3 and B.4) lead to better corrosion properties and to a considerable strength increase.

Example 3

[0123] Seven alloys with compositions as given in Table 3 were investigated. Most alloys (C.1-C.5) have low Cu levels and some contain more Cu (alloy C.6, C.7). They were all processed to 3.5 mm gauge plate according to the following route:

[0124] Casting of ingots, machining rolling blocks of 80x80x100 mm³ out of the ingots.

[0125] Homogenisation: v=30°C C./hr+470°C C. @ 12 hrs for Cu\leq0.2%, v=30°C C./hr+470°C C. @ 12 hrs, v=15°C C./hr+475°C C. @ 24 hrs for Cu\geq0.2%.

[0126] Hot rolling: preheat @ 430°C C., rolled from 80 mm to 3.5 mm thickness,

[0127] SHT: 1 hr @ 470°C C., followed by quenching in water or oil,

[0128] stretching: 1.5%.

[0129] After SHT, all the alloys in this example were aged into T6 temper.

[0130] Before artificial ageing the alloys were quenched in both water and oil, to investigate the quench sensitivity of the alloys. The oil quench is comparable to the quench rate in the core of a about 70 mm thick plate, where the plate core cannot be quenched as fast as the surface. After ageing, the Brinell hardness was measured according to ASTM E10, version 2002. The achieved hardness values are given in Table 3. Table 3 shows that the water quenched values are typically higher or similar to the oil quenched values. Alloys with the highest overall alloying content are most quench sensitive. Alloys C.2, C.3, C.5, C.7, which are all \geq9.3% in Zn, obtain hardness values of at least 190 HB. In alloy C.6, the Cu addition significantly increases the hardness over omitting this addition (alloy C.1), however in high Zn alloy C.7 the addition of Cu hardly results in any extra hardness in the oil quenched condition. Contrary to the metallurgical expectation that combinations of Mg and Cu lead to higher strength than an equivalent amount of Mg only, surprisingly, at higher Zn contents, Cu is no more effective in increasing the hardness than extra Mg.
TABLE 3

Compositions of series C in wt. % with balance aluminium, including Brinell hardness values (HB) for different quench media (WQ = Water-Quenched; OQ = Oil-Quenched).

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Zn</th>
<th>Mg</th>
<th>Cu</th>
<th>Ti</th>
<th>Zr</th>
<th>Fe</th>
<th>Si</th>
<th>HB WQ</th>
<th>HB OQ</th>
<th>ΔHB (WQ - OQ)</th>
<th>IGC type, OQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.1</td>
<td>7.4</td>
<td>1.92</td>
<td>0.17</td>
<td>0.04</td>
<td>0.10</td>
<td>0.04</td>
<td>0.02</td>
<td>164</td>
<td>164</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>C.2</td>
<td>9.3</td>
<td>2.8</td>
<td>0.16</td>
<td>0.04</td>
<td>0.11</td>
<td>0.03</td>
<td>0.02</td>
<td>192</td>
<td>190</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>C.3</td>
<td>9.5</td>
<td>3.3</td>
<td>0.16</td>
<td>0.04</td>
<td>0.098</td>
<td>0.03</td>
<td>0.02</td>
<td>209</td>
<td>197</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>C.4</td>
<td>7.4</td>
<td>4.2</td>
<td>0.17</td>
<td>0.04</td>
<td>0.098</td>
<td>0.04</td>
<td>0.02</td>
<td>189</td>
<td>189</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>C.5</td>
<td>10.7</td>
<td>2.8</td>
<td>0.16</td>
<td>0.04</td>
<td>0.097</td>
<td>0.03</td>
<td>0.02</td>
<td>210</td>
<td>197</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>C.6</td>
<td>7.4</td>
<td>1.86</td>
<td>1.65</td>
<td>0.05</td>
<td>0.10</td>
<td>0.03</td>
<td>0.02</td>
<td>179</td>
<td>179</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>C.7</td>
<td>9.4</td>
<td>2.3</td>
<td>1.66</td>
<td>0.04</td>
<td>0.099</td>
<td>0.03</td>
<td>0.02</td>
<td>204</td>
<td>191</td>
<td>13</td>
<td>2</td>
</tr>
</tbody>
</table>

[0131] Furthermore, the low Cu alloys, even if quenched in oil, show an excellent resistance to intergranular corrosion (IGC, test performed according to the standard ASTM G110-92), while the high Cu containing alloys present a slight degree of IGC. The alloy is thus less quenched sensitive, which has various advantages in processing the alloy as is has a larger tolerance for fluctuations in the process.

Example 4

[0132] Five alloys with compositions as in Table 4 were investigated. The alloys have low Cu levels. They were processed to 3 mm gauge plate according to the following route:

[0133] Casting of ingots, machining rolling blocks of 80x80x100 mm³ out of the ingots.

[0134] Homogenisation: v=30° C./hr+470° C. @ 12 hrs,

[0135] Hot rolling: pre-heat @ 430° C., rolled from 80 mm to 3 mm thickness,

[0136] SHT 1 hr @ 470° C., followed by water quench,

[0137] Stretching: 1.5%,


[0139] In Table 4 the resulting average hardness values after 1- and 2-step ageing are given. The results in Table 4 indicate that for a HB of 190 or higher, given a Zn content of 9.47%, there is a minimum level of Mg, which lies in between 1.92% and 2.85%. Table 3 provides a value of 2.8. Furthermore, comparable hardness levels are obtained for 1-step and 2-step artificial ageing. This increases the applicability of this alloy for multiple product ranges, were 2-step ageing is needed (aerospace material requirements) or 1-step is preferred (cost saving).

[0140] Table 4 shows that the ageing time for the 145° C-step of artificial ageing is allowed to lie in a wide range for reaching hardness levels of 190 HB or higher.

[0141] A compositional relationship between the Mg and the Zn content, above which a high hardness can be expected with proper processing of the alloy can be derived from Table 3 and 4. The relation between Mg and Zn content can be approximated by Mg=10-0.79° Zn in wt %. For a Mg content higher than that given by this relationship in dependency with the Zn content will provide a hardness of at least 185 HB, even of at least 190 HB, particularly for the alloys where the Zn-content is above 7.4%.

Example 5

[0142] Three alloys according to the invention (E.1 to E.3) and which are particularly suitable for tooling plate application have been processed according to the process of this invention and subsequently peak-aged at 130° C. for 24 hours. The tensile properties (yield strength and tensile strength) has been determined in the L-direction and the hardness has been measured at mid-section thickness. The alloys have been compared against regular AA7050 and M7075 alloys in the T651 temper.

[0143] The alloy compositions and the properties are listed in Table 5. From these results it can be seen that the alloy according to this invention is capable of achieving very high hardness values rendering is very much suitable for use as tooling plate.
### TABLE 5
Composition of alloys according to this invention in wt. % (0.12% Zr, 0.05% Fe, 0.03% Si, 0.15% Cu, balance aluminium) and the tensile properties and hardness.

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Zn (wt. %)</th>
<th>Mg (wt. %)</th>
<th>Temper</th>
<th>Rp (MPa)</th>
<th>Rm (MPa)</th>
<th>Hardness (HB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA7050</td>
<td>6.2</td>
<td>2.3</td>
<td>T651</td>
<td>532</td>
<td>575</td>
<td>180</td>
</tr>
<tr>
<td>AA7075</td>
<td>5.6</td>
<td>2.5</td>
<td>T651</td>
<td>533</td>
<td>462</td>
<td>150</td>
</tr>
<tr>
<td>E.1</td>
<td>9.4</td>
<td>3.5</td>
<td>Peak-aged</td>
<td>695</td>
<td>708</td>
<td>236</td>
</tr>
<tr>
<td>E.2</td>
<td>11.5</td>
<td>3.1</td>
<td>Peak-aged</td>
<td>734</td>
<td>736</td>
<td>246</td>
</tr>
<tr>
<td>E.3</td>
<td>11.4</td>
<td>3.0</td>
<td>Peak-aged</td>
<td>680</td>
<td>689</td>
<td>245</td>
</tr>
</tbody>
</table>

### TABLE 6-continued
Composition of alloys according to this invention in wt. % (0.12% Zr, 0.05% Fe, 0.03% Si, 0.15% Cu, balance aluminium) and the results of the Houldcraft welding test.

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Zn</th>
<th>Mg</th>
<th>Zn + Mg</th>
<th>% Cracking</th>
</tr>
</thead>
<tbody>
<tr>
<td>F.1</td>
<td>9.3</td>
<td>2.8</td>
<td>12.1</td>
<td>31</td>
</tr>
<tr>
<td>F.2</td>
<td>9.5</td>
<td>3.3</td>
<td>12.8</td>
<td>28</td>
</tr>
<tr>
<td>F.3</td>
<td>10.7</td>
<td>2.8</td>
<td>13.5</td>
<td>31</td>
</tr>
</tbody>
</table>

Example 6

The weldability of three alloys processed according to the invention (F.1 to F.3) has been assessed using a well defined procedure used to assess the hot crack sensitivity of an aluminium alloy, and which procedure is also known as the Houldcroft test described in the paper "A simple Cracking Test for use With Argon-Arc Welding", by P.T. Houldcroft, British Welding Journal, October 1955, pp. 471-475, incorporated herein by reference. The procedure uses either a fish bone sample geometry or a tapered specimen geometry, and for laser welding the tapered specimen geometry is preferred and used for this example and having a thickness of 2 mm. The laser is used to create a full penetration bead-on-plate weld. The weld starts at the narrow end of the sample and runs the entire length of the sample. A hot crack is formed during solidification of the weld pool, and at a certain point the crack stops. The crack length is a measure of the hot crack sensitivity, such that the longer the crack, the higher the hot crack sensitivity. The samples were not constrained during the test and all of the welds were produced without a filler wire addition. In the tests a Nd:YAG laser was used with a spot size of 0.45 mm (150 mm focus lens) and with the focus position on the top surface of the plate. The laser processing parameters were kept constant at 4500 W laser power and 4 m/min welding speed.

The alloys selected for investigation are given in Table 6 and also the results of the welding tests. The crack sensitivity is represented by % cracking being the crack length divided by the specimen length; thus a lower % cracking represents a lower hot crack sensitivity. It can clearly be seen that as the total Zn and Mg solute content is increased, so the crack sensitivity decreases leading to higher weldability. For comparison, the aluminium AA7017 was also tested and this is accepted by the aluminium industry as a weldable alloy. It can clearly be seen that all of the alloys according to this invention were better weldable than AA7017.

It is of course to be understood that the present invention is not limited to the described embodiments and examples described above, but encompasses any and all embodiments within the scope of the description and the following claims.

1. A wrought aluminium AA7000-series alloy product, consisting essentially of (in wt. %):
   
   Zn 7.5-14.0
   Mg 1.0-5.0
   Cu ≤ 0.28
   Fe ≤ 0.30
   Si ≤ 0.25
   and one or more of:
   
   Zr ≤ 0.30,
   Ti ≤ 0.30,
   Hf ≤ 0.30
   Mn ≤ 0.80,
   Cr ≤ 0.40
   V ≤ 0.40,
   Sc ≤ 0.70,

   remainder: incidental elements and impurities, each ≤ 0.05, total < 0.15, the balance aluminium,

   the product having reduced hot crack sensitivity, and
   improved strength and toughness properties relative to
   at least one alloy selected from the group consisting of
   AA7050 or AA7075, and when in artificially aged condition having a hardness of more than 180 HB.

2. A product according to claim 1, wherein Cu is ≤ 0.25%.
3. A product according to claim 1, wherein Cu is ≤ 0.20%.
4. A product according to claim 1, wherein the Cu content has a lower limit of 0.03%.
5. A product according to claim 1, wherein the Cu content has a lower limit of 0.08%.
6. A product according to any claim 1, wherein the Zr content is in a range of 0.04 to 0.15%.
7. A product according to any claim 1, wherein the Zr content is in a range of 0.04 to 0.13%.
8. A product according to claim 1, wherein the Zn content has a lower limit of 8.5%.
9. A product according to claim 1, wherein the Zn content has a lower limit of 9.0%.
10. A product according to claim 1, wherein the Zn content has a lower limit of 9.5%.
11. A product according to claim 1, wherein Zn content has an upper limit of 12.0%.
12. A product according to claim 1, wherein Zn content has an upper limit of 11.0%.
13. A product according to claim 1, wherein Zn content has an upper limit of 10.0%.
14. A product according to claim 1, wherein the Mg content has a lower limit of 2.5%.
15. A product according to claim 1, wherein the Mg content has an upper limit of 4.5%.
16. A product according to claim 1, wherein the Mg content has an upper limit of 4.0%.
17. A product according to claim 1, wherein the Fe content is at most 0.14%.
18. A product according to claim 1, wherein the Fe content is at most 0.08%.
19. A product according to claim 1, wherein the Si content is at most 0.12%.
20. A product according to claim 1, wherein the Si content is at most 0.07%.
21. A product according to claim 1, wherein the Mn content is in a range of 0.05 to 0.40%.
22. A product according to claim 1, wherein the Mn content is <0.02%.
23. A product according to claim 1, wherein Mg is 6.6 - (0.45×Zn).
24. A product according to claim 1, wherein Mg is 10 - (0.79×Zn).
25. A product according to claim 1, wherein the product is in the form of a sheet, plate, or extrusion.
26. A product according to claim 1, wherein the product is in the form of a plate.
27. A product according to claim 1, wherein the product is in a T6-type or T7-type condition.
28. A product according to claim 1, wherein the product has reduced hot crack sensitivity, and improved strength and toughness properties relative to at least one alloy selected from the group consisting of AA7050 or AA7075 in T6 or T7-type temper.
29. A product according to claim 1, wherein the product has reduced hot crack sensitivity, and improved strength and toughness properties relative to at least one alloy selected from the group consisting of AA7050 or AA7075 in the T651 temper.
30. A welded component comprising:
   at least a first component part being a product according to claim 1, and
   at least a second component part,
   the component parts being welded together to form the welded component,
   the at least one first and the at least one second component part being products according to claim 1, and
   wherein the welded component is a welded structural aircraft component.
31. A wrought product according to claim 1, wherein the wrought product is a weldable aerospace sheet or plate product in a T6-type or T7-type condition, and wherein said product consists essentially of, in wt. %:
   Zn 7.5 to 11.0
   Mg 1.0 to 5.0, and wherein the Mg-content depends on the Zn-content according to Mg is 6.6 - (0.45×Zn),
   Cu 0.03 to 0.25
   Zr 0.04 to 0.15
   Ti<0.10
   Fe<0.08
   Si<0.07,
   remainder incidental elements and impurities, each <0.05, total <0.15, the balance aluminum.
32. A wrought product according to claim 1, wherein the wrought product is a weldable aerospace sheet or plate product in a T6-type or T7-type condition, and wherein said product consists essentially of, in wt. %:
   Zn 7.5 to 11.0
   Mg 2.0 to 4.5, and wherein the Mg-content depends on the Zn-content according to Mg is 10 - (0.79×Zn),
   Cu 0.03 to 0.25
   Zr 0.04 to 0.15
   Ti<0.10
   Fe<0.08
   Si<0.07,
   remainder incidental elements and impurities, each <0.05, total <0.15, the balance aluminum.
33. A wrought product according to claim 1, wherein the wrought product is a weldable aerospace sheet or plate product in a T6-type or T7-type condition, and wherein said product consists essentially of, in wt. %:
   Zn 8.5 to 10.0
   Mg 2.0 to 4.5, and wherein the Mg-content depends on the Zn-content according to Mg is 10 - (0.79×Zn),
   Cu 0.03 to 0.25
   Zr 0.04 to 0.15
   Ti<0.10
   Fe<0.08
   Si<0.07,
   remainder incidental elements and impurities, each <0.05, total <0.15, the balance aluminum.
34. A wrought product according to claim 1, wherein the wrought product is a weldable aerospace sheet or plate product in a T6-type or T7-type condition, and wherein said product consists essentially of, in wt. %:
   Zn 8.5 to 10.0
   Mg 2.5 to 4.5, and wherein the Mg-content depends on the Zn-content according to Mg is 10 - (0.79×Zn),
   Cu 0.03 to 0.25
   Zr 0.04 to 0.15
   Ti<0.10
   Fe<0.08
   Si<0.07,
   remainder incidental elements and impurities, each <0.05, total <0.15, the balance aluminum.
35. A wrought product according to claim 1, wherein the wrought product is a weldable aerospace extrusion in a T6-type or T7-type condition, and wherein said product consists essentially of, in wt. %:
   Zn 7.5 to 11.0
   Mg 1.0 to 5.0, and wherein the Mg-content depends on the Zn-content according to Mg≥6.6−0.45×Zn,
   Cu 0.03 to 0.25
   Zr 0.04 to 0.15
   Ti≤0.10
   Fe≤0.14
   Si≤0.12,
   remainder incidental elements and impurities, each <0.05, total <0.15, the balance aluminium.

36. A wrought product according to claim 1, wherein the wrought product is a weldable aerospace sheet or plate product in a T6-type or T7-type condition, and wherein said product consists essentially of, in wt. %:
   Zn 8.5 to 10.0
   Mg 2.5 to 4.5, and wherein the Mg-content depends on the Zn-content according to Mg≥10−0.79×Zn,
   Cu 0.03 to 0.25
   Cr 0.04 to 0.20
   Zr up to 0.15
   Ti≤0.10
   Fe≤0.08
   Si≤0.07,
   remainder incidental elements and impurities, each <0.05, total <0.15, the balance aluminium.

37. A wrought product according to claim 1, wherein the wrought product is a weldable tooling plate product in a T6-type or T7-type condition, and wherein said plate product consists essentially of, in wt. %:
   Zn 7.5 to 14.0
   Mg 1.0 to 5.0, and wherein the Mg-content depends on the Zn-content according to Mg≥6.6−0.45×Zn,
   Cu 0.03-0.25
   Zr 0.04-0.15
   Ti≤0.10
   Fe≤0.30
   Si≤0.25,
   remainder incidental elements and impurities, each <0.05, total <0.15, and balance aluminium.

38. A wrought product according to claim 1, wherein the wrought product is a weldable tooling plate product in a T6-type or T7-type condition, and wherein said plate product consists essentially of, in wt. %:
   Zn 7.5 to 14.0
   Mg 2.0 to 4.0, and wherein the Mg-content depends on the Zn-content according to Mg≥10−0.79×Zn,
   Cu 0.03-0.25
   Zr 0.04-0.15
   Ti≤0.10
   Fe≤0.30
   Si≤0.25,
   remainder incidental elements and impurities, each <0.05, total <0.15, and balance aluminium.

39. A wrought product according to claim 1, wherein the wrought product is a weldable tooling plate product in a T6-type or T7-type condition, and wherein said plate product consists essentially of, in wt. %:
   Zn 7.5 to 12.0
   Mg 2.0 to 4.0, and wherein the Mg-content depends on the Zn-content according to M≥10−0.79×Zn,
   Cu 0.03-0.25
   Zr 0.04-0.15
   Ti≤0.10
   Fe≤0.30
   Si≤0.25,
   remainder incidental elements and impurities, each <0.05, total <0.15, and balance aluminium.

40. A wrought product according to claim 1, wherein the wrought product is a weldable tooling plate product in a T6-type or T7-type condition, and wherein said plate product consists essentially of, in wt. %:
   Zn 9.5 to 12.0
   Mg 2.5 to 4.5, and wherein the Mg-content depends on the Zn-content according to Mg≥10−0.79×Zn,
   Cu 0.03-0.25
   Zr 0.04-0.15
   Ti≤0.10
   Fe≤0.30
   Si≤0.25,
   remainder incidental elements and impurities, each <0.05, total <0.15, and balance aluminium.

41. A wrought product according to claim 1, wherein the wrought product is a weldable tooling plate product in a T6-type or T7-type condition, and wherein said plate product consists essentially of, in wt. %:
   Zn 8.5 to 11.0
   Mg 2.5 to 4.5, and wherein the Mg-content depends on the Zn-content according to Mg≥10−0.79×Zn,
   Cu 0.03-0.25
   Zr 0.04-0.15
   Ti≤0.10
   Fe≤0.30
   Si≤0.25,
   remainder incidental elements and impurities, each <0.05, total <0.15, and balance aluminium.
42. A wrought product according to claim 1, wherein the wrought product is a weldable tooling plate product in a T6-type or T7-type condition, and wherein said plate product consists essentially of, in wt. %:

- Zn 9.5 to 12.0
- Mg 2.5 to 3.5
- Cu 0.03-0.25
- Zr 0.04-0.15
- Ti<0.10
- Fe<0.30
- Si<0.25,

remainder incidental elements and impurities, each <0.05, total <0.15, and balance aluminium, and having a hardness of more than 190 HB.

43. Method of producing a wrought aluminium AA7000-series alloy product according to claim 1 comprising the steps of:

a) casting an ingot having a composition according to claim 1
b) homogenising and/or pre-heating the ingot after casting
c) hot working the ingot into a pre-worked product by one or more methods selected from the group consisting of: rolling, extruding and forging
d) optionally reheating the pre-worked product and either e) hot working and/or cold working the pre-worked product to a desired workpiece shape
f) solution heat treating (SHT) the formed workpiece at a temperature and time sufficient to place into solid solution essentially all soluble constituents in the alloy
g) quenching the solution heat treated workpiece, preferably by one of spray quenching or immersion quenching in water or other quenching media
h) optionally stretching or compressing of the quenched work piece or otherwise cold worked to relieve stresses, for example levelling of sheet products
i) artificially ageing the quenched and optionally stretched or compressed workpiece to achieve a desired temper, and

wherein the homogenising treatment comprises a first homogenisation stage and optionally a second homogenisation stage wherein the duration and the temperature during said first homogenisation stage for an ingot or a slab is chosen such that a cold spot, said cold spot being defined as the coldest spot in the ingot or slab, in the ingot or slab is at a dissolving temperature for at least a dissolving time necessary to dissolve the m-phase precipitates.

44. Process according to claim 41, wherein during process step i) the product is artificially aged to a T6-type or T7-type temper.

* * * *