

July 3, 1973

E. DI RUSSO ET AL
THERMOMECHANICAL PROCESS FOR IMPROVING THE TOUGHNESS
OF THE HIGH STRENGTH ALUMINUM ALLOYS

3,743,549

Filed June 7, 1971

3 Sheets-Sheet 1

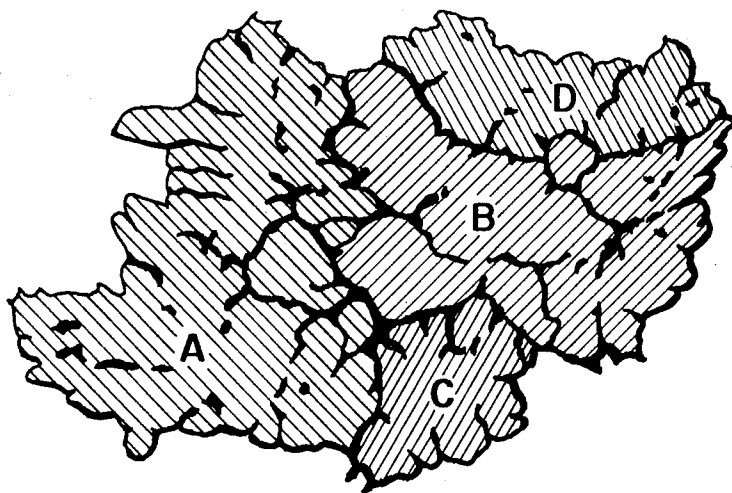


FIG. 1

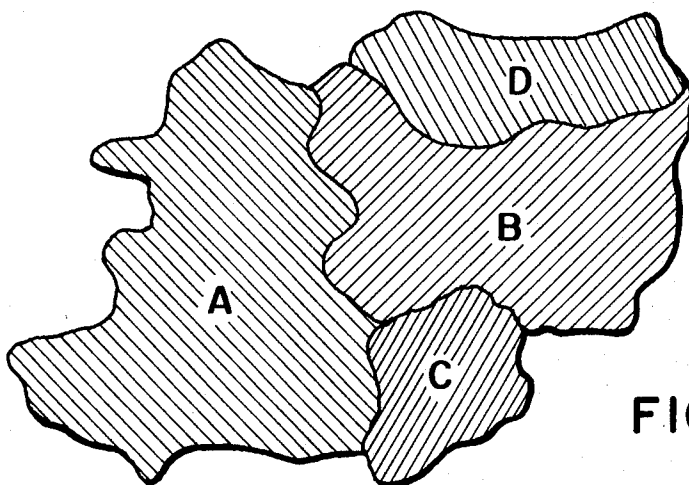


FIG. 1a



FIG. 1b

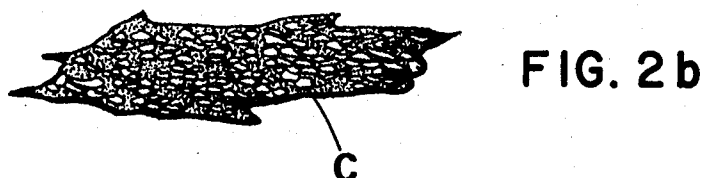
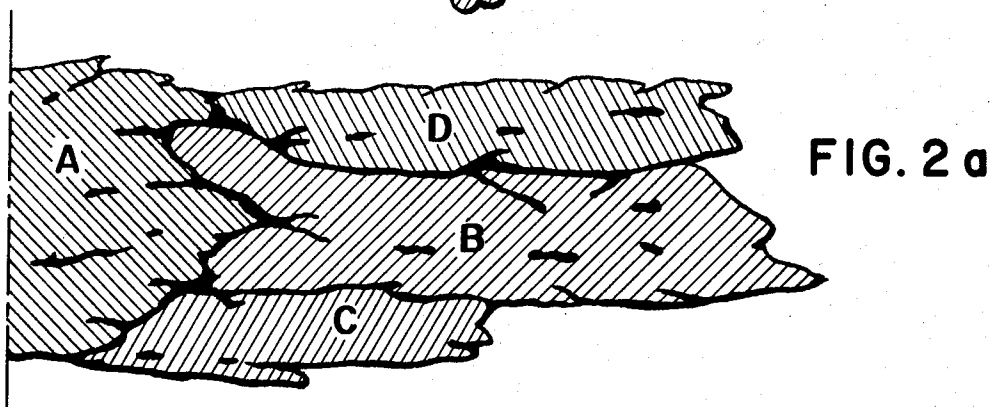
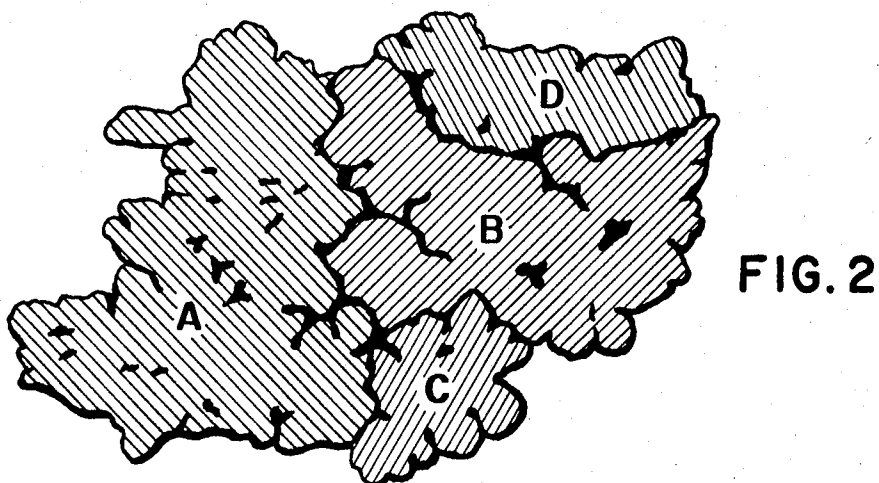
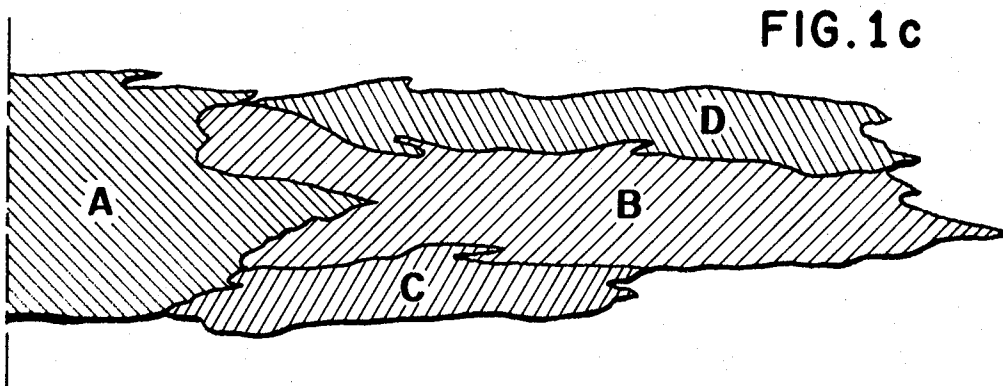
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FIG. 2c

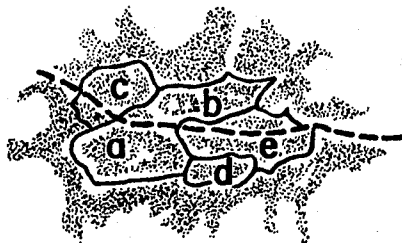
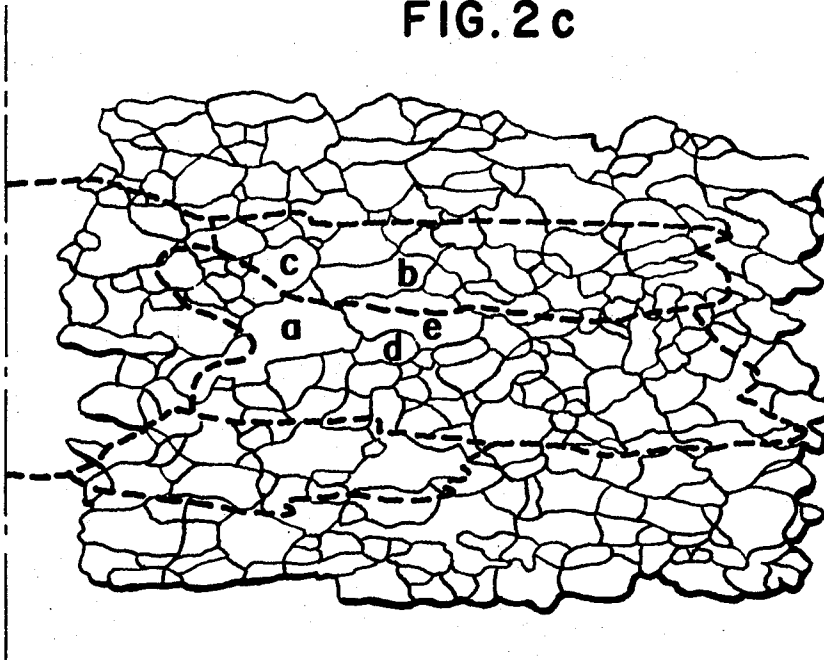


FIG. 2d

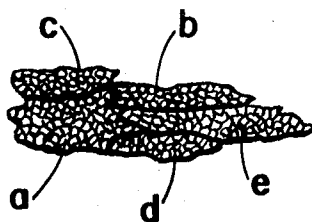


FIG. 2e

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THERMOMECHANICAL PROCESS FOR IMPROVING THE TOUGHNESS OF THE HIGH STRENGTH ALUMINUM ALLOYS

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Int. Cl. C22f 1/04

U.S. Cl. 148—12.7

12 Claims

ABSTRACT OF THE DISCLOSURE

A thermomechanical process is disclosed for improving some secondary properties, such as ductility and toughness, of high strength heat-treatable aluminum alloys, containing one or more anti-recrystallizing elements, and in particular the alloys of the system Al-Zn-Mg-(Cu), without degrading their peculiar strength, the process comprising submitting the aluminum alloy, in the form of slab or billet and in its as-cast state, to a partial homogenization at a temperature between 300° and 430° C., for a soaking time of about 2 to 15 hours, followed by a first plastic deformation at a temperature ranging from 150° to 250° C., and by a rapid heating up to a temperature from ten to 20 centigrade degrees below the low melting point, the material being kept at this temperature for a time of about 10 to about 30 hours and afterwards being cooled in calm air and in then submitting the material to a second plastic deformation according to conventional cycles of rolling, extrusion or forging to the final product dimensions, said product being finally submitted to a solution heat treatment, quenching and ageing in one or more stages.

The present invention relates to a thermomechanical process particularly suitable for obtaining a significant improvement in some secondary properties of the wrought products of aluminum alloys belonging to the Al-Zn-Mg and Al-Zn-Mg-Cu systems (hereinafter for brevity indicated as Al-Zn-Mg(Cu)), without reducing the high strength values which can be obtained with the above mentioned alloys when said alloys are produced according to the traditional work cycles.

Specifically, the present invention contemplates the realization of suitably combined thermal and mechanical treatments—at an intermediate stage of the technological cycle for obtaining wrought products such as hot rolled plates, extrusions and forgings—by which it is possible to obtain materials having a strength equal to or higher than the strength of similar materials produced in a traditional way, but with markedly improved characteristics of ductility as well as notch and fracture toughness, mainly in the transverse and in particular in the short transverse direction.

The expression "short transverse direction" used in connection with wrought products means a direction normal to that of working or of prevalent metal deformation and parallel to the shorter side of a transverse section normal to the deformation direction.

It is known that in the field of aluminum base alloys, the alloys which contain zinc, magnesium and copper in suitable proportions show a high strength at ambient temperature after having been submitted to hot plastic working followed by a thermal cycle consisting of a solutionizing treatment, a quenching to a remarkably reduced temperature—generally the ambient temperature—and finally a precipitation hardening (ageing) induced by heating at relatively low temperatures and for controlled times.

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The values of the elongation at rupture and the reduction in area (which define the "ductility" of the materials) are always, in the conventional thermal state, more or less remarkably reduced in the transverse direction, especially in the short transverse direction of the industrially fabricated wrought products with oriented structures.

Above all, the striction to which other important physical parameters—like notch toughness—are linked attains inadequate values. The problem of a low transverse ductility appears still more serious for the wrought products obtained from some Al-Zn-Mg-(Cu) alloys having exceptionally high mechanical strength.

Another property, linked to the ductility, is the resistance to "tearing," namely the resistance a material opposes against the propagation of a crack in consequence of an imposed static stress. The fundamental datum determined by the tear test (carried out according to suitable principles on a particular kind of specimen which bears a machined notch) is the unit propagation energy of the crack. This value gives a measure of that combination of mechanical strength and ductility which allows a material to withstand the crack propagation under stresses within the elastic-plastic field.

Many experiments carried out on wrought products of alloys belonging to the Al-Zn-Mg-Cu system have evidenced that said materials produced and thermally treated according to the traditional schemes present a tear resistance insufficient to assure a behaviour satisfying various applications; also in this case the lower values of the unit crack propagation energy are recorded in the short transverse direction.

A new physical parameter recently revealed itself to be of fundamental importance for the design of highly stressed structures made of high strength alloys of the above mentioned system. Said parameter is the "fracture toughness"; namely, the resistance a low ductility material opposes against the unstable propagation of a crack under stresses in the elastic field. The experiment is in this case carried out on special test specimens having a notch obtained by machining and then pre-cracked by fatigue, and leads to the determination of data (for example, the factor K_{Ic}) which are indicative of the capacity a brittle material (as the concerned alloys can be considered in their traditional state) has for bearing a load in the presence of cracks (or discontinuities) of determined length (or size).

Also in this case the fracture toughness offered by the strongest alloys of the Al-Zn-Mg-Cu group revealed itself as excessively low. A certain, but still non-determinant, improvement has been reached by using high purity aluminum (>99.9% Al).

Finally, as to the behaviour of the concerned alloys under repeated cyclic stresses, this is linked to a large extent to the direction of the load application with respect to the direction of the prevalent deformation.

In particular, a more or less large decrease in the fatigue resistance at low loads is always noted when the applied stress goes from the longitudinal direction to the short transverse direction.

Such a decrease can be excessive when the fatigue test is carried out on specimens with a pre-notch involving high local stress concentrations.

An increase in the tear resistance and in the fracture toughness was obtained in recent past years by submitting the Al-Zn-Mg-(Cu) alloys to the so-called step-ageing cycles (for example, T 73 for alloy 7075, according to the U.S.A. specifications), namely cycles carried out in two successive stages at two different temperatures.

However, the obtained advantages are always limited. Moreover, it is to be noted that the introduction of said step ageing cycles involves a strength decrease of 15–

20% when compared to the strength that the same material has in its traditional thermal state (isothermal ageing=T6). Finally, said cycles either exert no influence or, when they do; this influence is negative on the fatigue behaviour of the alloy being tested. Particularly, it has been noted that the rotating bending fatigue resistance, measured in the short transverse direction, is lower in respect to that of the T6 state (already by itself somewhat low) after two-step ageing cycles (for example, of the hereinabove type T 73).

The conventional cycles for obtaining wrought products (plate, extrusion, forging) of Al-Zn-Mg-(Cu) alloys are essentially carried out in three successive stages: the first stage consists of a so-called "homogenization" treatment of the slab (rolling ingot) or billet (ingot for extrusion of forging), that is in submitting the slab or billet to a heating at more or less high temperatures (410°-460° C.), for highly variable times (10 to 24 hours); the second stage consists in a plastic deformation of the homogenized slab or billet, in a single step at temperatures from 380° to 420° C. or more, by which the wrought product is obtained; finally the third stage consists in submitting the wrought material to the previously described thermal treatments of solutionizing (at 460°-470° C.), quenching (for example, in water at room temperature) and ageing (for example, at 120°-135° C., for 16-24 hours.)

The most common defects that can be found in a wrought product with an anisotropic structure (extrusion, plate forging) and that exalt the transverse effect, consist in stringers of oxide inclusions and in segregations of intermetallic compounds. However, a peculiar characteristic structure could result determinantly in regard to the transverse effect, independent of the presence of the above specified defects: This is represented by the original cast grain boundaries of the ingot, oriented in the working direction.

Obviously, the oxide inclusions and the segregations can be avoided with a careful control of the composition and of the melting, casting and solidification conditions of the alloy, while the other structure details are typical of the conventional plastic (hot) working cycles. In fact, a normal homogenization cycle at 440°-460° C. for 15-24 hours, carried out on an ingot—for example of a composition having a base of aluminum with 5.6% Zn, 2.5% Mg, 1.6% Cu and 0.22% Cr—causes, besides the more or less complete elimination of the eutectic net-work, a general precipitation of phases, which develops strong anti-recrystallizing action, containing the ancillary element (Cr) kept in solution during solidification. Such a precipitation strongly limits any migration of the original boundaries of the dendritic grains both during the homogenization cycle and during the following stages of the hot plastic working as well as in the course of the final thermal treatment, in such a way that said boundaries persist, well distinct and essentially parallel to the prevalent deformation direction (oriented structure), in the final wrought product. It has been observed that the fracture path preferentially follows said boundaries when the material is stressed transversally to the working direction, and particularly in the short transverse direction.

FIGS. 1, 1a, 1b, 1c and 1d of the accompanying drawing schematically show the evolution of the structure of an alloy of the composition specified above, from the starting ingot to the wrought product, through a conventional hot rolling cycle. More particularly, FIG. 1 shows the structure of an as-cast ingot, obtained by direct chill casting, consisting of grains A-B-C-D. FIG. 1a shows the new ingot structure after full homogenization at high temperature, for long heating times. FIG. 1b shows—for zone A of FIG. 1a—the distribution of the precipitates of chromium-bearing compounds. FIG. 1c shows the structure modification the ingot received after a conventional hot-rolling cycle, final quenching treatment and

ageing (T6), the original grain boundaries being referenced 1, 2, 3. Finally, FIG. 1d shows the sub-grain structure that characterizes each grain A-B-C-D illustrated in FIG. 1c.

The object of this invention is the realization of a thermomechanical process particularly suited to remarkably improve some secondary properties—such as ductility, notch and fracture toughness—of the wrought heat-treatable aluminum alloys, and particularly the alloys belonging to the Al-Zn-Mg-(Cu) system, without decreasing the high strength values these alloys have when produced according to the traditional working cycles.

The thermomechanical process for obtaining the wrought product according to this invention differs substantially from the conventional cycles in consequence of a particular combination of intermediate stages of heating and plastic transformation by which it is possible to obtain intermediate and final structural states quite different from the states characterizing a wrought product obtained through traditional processes. In particular, the thermomechanical process according to this invention aims to completely destroy the cast structure by means of an intermediate recrystallization of the ingot, partially worked.

It has been observed that the dendritic structure of an as-cast ingot of an Al alloy containing ancillary elements (Cr, Mn, etc.), as for example an Al-Zn-Mg-(Cu) alloy, cannot be replaced with a recrystallized grain structure by means of a simple thermal treatment, even if temperatures near to the melting point and very high purity materials are employed.

A thermal and mechanical treatment process, which is the basis of the present invention, has therefore been developed for obtaining wrought products—plates, extrusions or forgings—independently of the cast structure and the degree of purity of the alloys, said process being such as to cause an intermediate recrystallization of the partially plastically worked billet (or slab).

More particularly, the process according to this invention consists in submitting the Al alloy—in its form of an as-cast slab or billet—to a partial homogenization at temperatures ranging from 300° up to 430° C. for 2-15 hours; in giving the so-treated alloy a first plastic deformation at lower temperatures ranging between 150° and 350° C.; in rapidly heating the alloy up to temperatures from ten to twenty centigrade degrees below the lower melting point, then keeping the material at such temperatures for durations of about 10 to about 30 hours, with the aim of fully recrystallizing and homogenizing it; in successively cooling the material in calm air and then submitting it to a further plastic deformation, in order to achieve the final product size; in finally carrying out a traditional solution heat treatment, quenching and ageing in one or several steps, or a thermomechanical treatment consisting of a solution heat treatment and quenching (T) followed by a first ageing (A₁), a plastic deformation (H) and afterwards a further ageing (A₂), as well as, if desired, a repetition of the step H+A, according to the general scheme TA₁HA₂HA₃ . . . as described in copending patent application Ser. No. 28,514 filed Apr. 4, 1970, and now U.S. Patent No. 3,706,606.

According to an alternative procedure also coming within the scope of the present invention, the material, which underwent said first plastic deformation, is heated through two following steps, the first of which involves a rapid increase to a temperature from sixty to a hundred centigrade degrees lower than the 460°-500° C. temperature of the following step, the latter reached not necessarily in a rapid way, the heating from the temperature of the first step to the temperature of the second step being carried out either after cooling of the material from the temperature of the first step down to ambient temperature or directly, i.e. without said intermediate cooling down to ambient temperature.

The process to which this invention relates has proved to be particularly suitable for wrought products obtained through hot plastic transformation of the aluminum alloys belonging to the Al-Zn-Mg-(Cu) system, preferably having compositions included within the following limits: Al 99.0%–99.999%; Zn 4.5%–10%; Mg 1.5%–3.5%; Cu 0%–3% and at least one element selected from the class consisting of chromium 0.005%–0.35%, manganese 0.15%–0.65%, zirconium 0.05%–0.30%, and titanium 0.05%–0.20%.

Remarkable increases in the elongation to rupture, and above all, in the reduction in area as well as in all the mechanical properties linked to the ductility of said alloys, were achieved after final thermal cycle of solutionizing, quenching and ageing, without any decrease in the typical strength values.

The thermomechanical treatment according to this invention substantially consists of cycles carried out at an intermediate stage of the conventional processes for producing wrought aluminum alloys having high strength and containing antirecrystallizing elements: these cycles are in fact based on a deformation, obtained by rolling or forging the slabs or billets at suitably reduced temperatures (from 150° to 350° C.), in structural states such that an important fraction of the ancillary elements is still in solid solution at the moment of deformation, namely in a state partially ineffective for preventing recrystallization phenomena. This state is achieved through a partial homogenization cycle at 300°–430° C. for a soaking time of 2–5 hours. The ingot (or slab) is deformed up to values of percent reduction in cross section or thickness not less than 50%, heated with very rapid heating rate at temperatures from ten to twenty centigrade degrees below the lower melting point—which for each composition is a function of the ingot homogenization state (e.g. 480°–500° C. for an aluminum alloy containing 5.6% Zn, 2.5% Mg, 1.6%, Cu(Cr, Fe, Si))—and then kept at said temperatures for a time of not less than about 10 to 30 hours, sufficient to fully recrystallize the material, to produce an accentuated precipitation of the anti-recrystallizing phases containing the ancillary elements and to complete the solution of the alloying elements. As previously indicated, the recrystallization-homogenization treatment can be also performed in two subsequent steps, the first (recrystallization) step taking place at temperatures lower (for example 400° C., for the above specified alloy) or equal to the temperatures of the second (homogenization) step (for example 480° C., for the above specified alloy), with or without intermediate cooling down to ambient temperature between the two steps.

A high heating rate is necessary to attain a recrystallization state as advanced as possible and contemporaneously a recrystallized structure with equiaxial grains having very reduced dimensions. Such a structure must therefore be "locked" by the following precipitation of the anti-recrystallizing phases; thus in the subsequent plastic working carried out according to conventional methods, every single recrystallized grain is transformed into stable aggregate of sub-grains on which a traditional thermal treatment of solutionizing, quenching and ageing, or a thermomechanical treatment of the previously specified kind (TA₁HA₂HA₃ . . .) can be carried out.

The accompanying figures, from FIGS. 2 to 2e, schematically show the evolution of the structure of the alloy through the thermomechanical cycle which is the subject of this invention. In particular, FIG. 2 shows the structure of a partially homogenized ingot (with negligible precipitation of chromium-containing compounds). FIGS. 2a and 2b show the ingot structure after the first plastic deformation (FIG. 2b, in particular, shows the sub-grain structure characterizing each grain A–B . . . etc. appearing in FIG. 2a); FIG. 2c shows the structure after the recrystallization-homogenization treatment at high temperature attained in few minutes; FIG. 2d evidences the chromium precipitation features in a group of grains

(a–b–c . . . etc.), while finally FIG. 2e shows the final (sub-grain) structure of the wrought product after traditional hot-rolling and full heat treatment (T6).

By a direct comparison with the scheme of the traditional cycle represented in FIGS. 1a to 1d, the substantial differences induced by the two cycles in the evolution of the structure of the alloy, are clearly evidenced.

In order to better stress the results reached through the process of this invention, some detailed working examples of treatments of extremely pure

Al–Zn–Mg–Cu

alloys follow hereinafter. These are given merely for illustrative purposes and without any limitation of the scope of the invention. These examples, together with the tables that follow, include also already known treatments, besides the process according to this invention, for the purpose of still better evidencing the remarkable improvements obtained in the final product properties. In these examples:

R_m is the ultimate tensile strength (UTS) in kg./mm.²

$R_{p(0.2)}$ is the yield strength, in kg./mm.²

A percent is the elongation to rupture, in percent

Z percent is the reduction in area, i.e. the percent reduction between the initial cross section area of the test specimen and the minimum cross section area after fracture

K_{IC} is the plain strain fracture toughness factor, in kg./mm.^{3/2} $\sqrt{mm}$

EXAMPLE 1

Three slabs of 35 mm. thickness obtained by semicontinuous D.C. casting of an aluminum alloy with the balance consisting of 5.78% Zn; 2.64% Mg; 1.64% Cu; 0.22% Cr; 0.0013% Fe; 0.0041% Si and 0.0024% Ti, were submitted to the following cycles of thermal treatments and plastic deformations:

Slab A (process according to the known technology)

Homogenization performed in two steps at 450° C. for 8 hours plus 480° C. for 24 hours, followed by cooling in calm air, reheating of the slab at 430° C. for 1 hour, followed by rolling—at a temperature included between the 430° C. initial and the 390° C. final temperatures—down to a thickness of 9.2 mm. Solution treatment of the rolled plate at 468° C. for 1 hour, quenching in water at ambient temperature, natural ageing for about 4 days, and artificial ageing at 120° C. for 24 hours.

Slab B (process with the thermomechanical treatment according to the present invention)

Partial homogenization at 400° C. for 10 hours followed by cooling in calm air; reheating of the slab at 330° C. for 1 hour, followed by rolling at the above specified temperature down to a thickness of about 15 mm., without any intermediate heating; heating of the rolled plate at 482° C. using a very rapid heating rate (the temperature is reached in a time of the order of 3 minutes) and holding at the temperature above specified for 24 hours; subsequent cooling in calm air; preheating at 430° C. for 1 hour and then rolling—at a temperature included between the 430° C. initial and the 390° C. final temperatures—down to a thickness of 9.2 mm. Solution treatment of the rolled specimen at 468° C. for 1 hour, quenching in water at ambient temperature, natural ageing for about 4 days, and artificial ageing at 120° C. for 24 hours.

Slab C (process with the thermomechanical treatment according to the present invention)

The modes of working adopted for this slab were completely analogous to those described above for slab B with the exception of the partial homogenization cycle which in this case was carried out at 400° C. for 24 hours.

Specimens were made from the three rolled plates, produced as specified above, to test the tensile properties in the long transverse direction and the fracture toughness in the short transverse direction. The results obtained are reported below in Table I.

From the data therein it can be seen that the thermomechanical cycles which are the subject of this invention evidence a clear improvement in the reduction in area and in the fracture toughness, with an appreciable increase in the elongation to rupture. The strength remains at levels analogous to or even slightly higher than those relative to the rolled plate produced by traditional cycles.

EXAMPLE 2

Three 77 mm. thick slabs, obtained by semicontinuous D.C. casting an aluminum alloy with the balance consisting of 5.61% Zn; 2.52% Mg; 1.63% Cu; 0.22 Cr; 0.0012% Fe; 0.0037% Si and 0.0025% Ti, were submitted to the following cycles of thermal treatments and plastic deformations.

Slab D (traditional process)

Full homogenization carried out in two steps at 450° C. for 8 hours plus 480° C. for 24 hours followed by cooling in calm air; reheating of the slab at about 425° C. for 1 hour, followed by rolling—at a temperature included between the 425° C. initial and the 385° C. final temperatures—down to a thickness of 9.5 mm. Solution treatment of the rolled plate at 467° C. for 1 hour, quenching in water at ambient temperature, natural ageing for about 4 days, and artificial ageing at 120° C. for 24 hours.

Slab E (process according to the thermomechanical treatment of this invention)

Partial homogenization at 400° C. for 10 hours followed by cooling in calm air; reheating of the plate at about 325° C. for 1 hour and then forging at the above specified temperature down to a thickness of about 22 mm., without carrying out intermediate heatings; heating up to 483° C. with a very high heating rate (in a time not longer than three minutes) and holding at the above mentioned temperature for about 24 hours followed by cooling in calm air; reheating at 430° C. for 1 hour, followed by rolling at a temperature included in a range between the 430° C. initial and the 390° C. final temperatures, down to a thickness of 9.5 mm. Solution heat treatment of the rolled sample at 467° C. for 1 hour, quenching in water at ambient temperature, natural ageing for 4 days, and artificial ageing at 120° C. for 24 hours.

Slab F (process according to the thermomechanical treatment of this invention)

The method for producing the rolled plate was the same as that used for slab E with the exception of the partial homogenization treatment, which in this case was carried at 350° C. for 5 hours, and of the forging cycle, performed after preheating at 200° C. for 1 hour.

Specimens were prepared from the three rolled plates, produced as described above, to test the tensile properties in the long transverse direction, and the fracture toughness in the short transverse direction. The results obtained are reported below in Table II.

Examination of these results shows that the cycles which are the subject of this invention enables one to obtain, in particular, a significant increase in the reduction in area and in the fracture toughness, in contrast to the corresponding values obtained through the traditional cycle.

The above examples clearly evidence that the intermediate thermomechanical treatment of this invention, and based on an intermediate recrystallization to fine equiaxial grains of the cast material, in a stage preceding the final plastic transformation carried out according to the conventional procedures adopted for the hot rolling, invariably leads to an appreciable increase in the ductil-

ity and in the fracture toughness, while leaving unchanged or actually improving the strength values typical of the traditional material.

These improvements are obtained also for final transformation cycles specifically different from that shown in the examples (hot rolling), namely by forging and extrusion. In fact, although the final deformation process is different in the various cases considered (rolling, forging, extrusion), the main factor conditioning the structure and the properties of the wrought piece, is the state of complete recrystallization preceding the final plastic working, said recrystallization being realizable by the thermomechanical process of this invention. It is to be moreover observed that these improvements are independent of the alloy purity degree, that is, the purity of the aluminum used in the alloy production.

It is to be finally pointed out that this invention can be extended to all heat-treatable aluminum alloys, even those belonging to systems different from the system considered in the examples given, and containing anti-recrystallizing elements, said alloys showing, after hot plastic working and final thermal treatment, an oriented structure characterized by transverse effect.

It is obvious that many modifications and alternatives of equivalent character can be in practice (mainly for specific types of alloys and wrought products) employed in conjunction with the above specified thermomechanical process, without departing from the invention as hereinabove described and hereinafter claimed.

TABLE I

Material	Mechanical properties				
	Kg./mm. ²		Percent		K _{IC} , kg./mm. ^{3/2}
	Rm	Rp(0.02)	A	Z	
Rolled plate obtained from slab A (conventional hot rolling cycle).....	62.0	55.0	8.0	16	90
Rolled plate obtained from slab B (thermomechanical cycle as per this invention).....	61.5	56.5	11.0	35	120
Rolled plate obtained from slab C (thermomechanical cycle as per this invention).....	62.0	57.0	10.5	34	125

NOTE.—The values of Rm, Rp (0.20), A% and Z% are relative to the long transverse direction; the values of K_{IC} refer to the short transverse direction;

TABLE II

Material	Mechanical properties				
	Kg./mm. ²		Percent		K _{IC} , kg./mm. ^{3/2}
	Rm	Rp(0.2)	A	Z	
Rolled plate obtained from slab D (conventional rolling cycle).....	62.3	55.1	7.5	15	93
Rolled plate obtained from slab E (thermomechanical cycle as per this invention)....	62.3	56.7	11.1	38	120
Rolled plate obtained from slab F (thermomechanical cycle as per this invention)....	62.8	56.8	12.2	39	125

NOTE.—The values of Rm, Rp(0.2), A% and Z% are relative to the long transverse direction; the values of K_{IC} refer to the short transverse direction.

What is claimed is:

1. A thermomechanical process for improving certain secondary properties, such as ductility and toughness, of high strength heat-treatable aluminum alloys, containing one or more anti-recrystallizing elements, without degrading their peculiar strength, the process consisting essentially in submitting the aluminum alloy, in the form of slab or billet and in its as-cast state, to a partial homogenization at a temperature between 300° and 430° C., for a soaking time of about 2 to 15 hours, followed by a first plastic deformation at a temperature ranging from 150° to 250° C. and by a rapid heating up to a temperature from ten to twenty centigrade degrees below the lower melting point, the material being kept at this temperature for a time of about 10 to about 30 hours and afterwards being cooled in calm air and in then submitting the material to a second plastic deformation according to con-

ventional cycles of rolling, extrusion or forging to the final product dimensions, said product being finally submitted to a solution heat treatment, quenching and ageing in one or more stages.

2. A process according to claim 1, wherein the heat-treatable aluminum alloy is one of the system Al-Zn-Mg-(Cu).

3. A process according to claim 2, wherein the aluminum alloy after said second plastic deformation undergoes a thermomechanical treatment including solution, quenching (T), ageing (A₁) deformation (H) and ageing (A₂) in the sequence TA₁HA₂, with possible repetition of the H-A step, in the sequence TA₁HA₂HA₃. . .

4. A process according to claim 2, wherein the partial homogenization is carried out at a temperature included between 300° and 430° C., for a soaking time from 1 to 15 hours, and is followed by cooling in calm air down to ambient temperature.

5. A process according to claim 4, wherein the partial homogenization, carried out at a temperature ranging from 300° to 430° C. for soaking times included between 2 and 15 hours, is followed by a cooling down to a temperature ranging from 350° to 150° C. for the subsequent plastic deformation.

6. A process according to claim 2, wherein the first plastic deformation, carried out by rolling or forging, is brought about in such a way as to impart a reduction in thickness or cross section of at least 50%.

7. A process according to claim 2 wherein after said first plastic deformation the material is heated up to a temperature included between 460° and 500° C. using very high heating rates of the order of a few minutes, then kept at this temperature for a duration of time varying from 10 to 30 hours, followed by cooling in air down to ambient temperature.

8. A process according to claim 7, wherein the heating which follows the first plastic deformation is carried out in two steps, the first of which at temperatures, reached with very high heating rates, which are from 60 to 100 centigrade degrees lower than the temperatures of the following step ranging between 460° and 500° C., and wherein the rise to the soaking temperature of the second step is not necessarily a rapid one.

9. A process according to claim 8, wherein when the heating is carried out in two following steps, the passing from the first to the second step takes place directly.

10. A process according to claim 8, wherein when the heating is carried out in two following steps, the passing from the first to the second step is realized through intermediate cooling down to ambient temperature.

11. A process according to claim 10, wherein the material, after treatment at 460° to 500° C., is cooled down to a predetermined temperature for the following final plastic transformation.

12. A process according to claim 2, wherein a casting of Al-Zn-Mg-(Cu) alloy produced with high solidification rate is employed in the process.

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