Abstract:

World NL-2624

Applicant

Inventors/Inventors: NL-2624

Priority

Publication

International

Classification:

Language:

Date:

08167899.7

Data:

NL-2071

Duffel

Delft

26, 2009

October

2008

28.10.2009

October

30.10.2008

English

English

Subject to

Subject to

2010/049445

A1

Shangping Wise, Alexander Stockelaar, Theo Dreven

B-9830

21/10

C22C

C22F 1/053

NL-2624


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(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, UZ, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published: with international search report (Art. 21(3))

(54) Title: STRUCTURAL AUTOMOTIVE COMPONENT OF AN ALUMINIUM ALLOY SHEET PRODUCT

(57) Abstract: This invention relates to a structural automotive component of an aluminium alloy sheet product having a gauge in a range of about 0.5 to 4 mm, and having a composition consisting of: Zn 5.0 to 7.0, Mg 1.5 to 2.3, Cu max. 0.20, Zr 0.05 to 0.25, optionally one or two elements selected from Mn and Cr, Ti max. 0.15, Fe max. 0.4, Si max. 0.3, and balance is made by impurities and aluminium.
Structural automotive component of an aluminium alloy sheet product

FIELD OF THE INVENTION

The present invention relates to a structural automotive component made of an aluminium alloy sheet product of the Al-Zn-Mg type, and to a method of manufacturing such aluminium alloy sheet product into a formed structural automotive member.

BACKGROUND TO THE INVENTION

In the production of vehicles in particular aluminium alloys of the AA6xxx- and AA5xxx-series aluminium alloys, like 5051, 5182, 5454, 5754, 6009, 6016, 6022, and 6111, have been used to produce body panels, whereas the lead-bearing structural parts such as door beams and pillar reinforcements are commonly made from steel due to its higher strength. For example the B-pillar reinforcement, which plays an important role in protecting the occupants of a vehicle in a side impact incident, is currently produced from ultra-high steel, for example boron steel. Such a B-pillar is manufactured from a rolled steel sheet in a hot stamp forming operation.

European patent document EP-0952067-A2 discloses a bodywork B-column or B-pillar for an automobile made from an aluminium alloy in a die-casting operation.

Patent document GB-1,392,722 discloses an aluminium alloy for use as armour plate for armoured fighting vehicles, the alloy having the following composition, in wt.\%:
5.0-6.0% Zn, 1.7-2.1% Mg, 0.05-0.2% Zr, up to 0.15% Cu, preferably 0.10-0.15% Cu, up to 0.1% Ti, up to 0.5% Fe, up to 0.3% Si, and balance impurities and aluminium.

Patent document JP-2007-100157-A discloses an aluminium alloy plate product having a composition, in wt.\%, of 5-8% Zn, 1-2% Mg, 0.25-0.6% Cu, 0.001-0.05\% Ti, 0.15-0.35\% Fe, one or more of 0.05-0.5% Mn, 0.05-0.15% Cr and 0.05-0.25% Zr, balance aluminium with impurities.

Patent document JP-07-070688-A discloses an extruded aluminium alloy product having a composition of, in wt.\%, 5.0-7.0% Zn, 1.0-1.5% Mg, 0.1-0.3% Cu, 0.05-0.2% Zr, 0.001-0.05\% Ti, and 0.03 to 0.2% Cr, optional maximum 0.3% Mn, and the balance aluminium and impurities.

Patent document US-3,945,861 discloses an aluminium alloy bumper which has been shaped or bent and then solution heat treated, quenched and artificially aged. The aluminium alloy contains, in wt.\%, 5.5-9% Zn, 0.8-2\% Mg, 0.1-0.25\% Cu and 0.05-0.2\% Zr, with optional additions of 0.05-0.35% Mn or 0.05-0.3% Cr, balance aluminium and impurities.

There is a demand for structural automotive components made of formable and high-strength aluminium alloy sheet products.
DESCRIPTION OF THE INVENTION

It is an object of the invention to provide a structural automotive component of a formable aluminium sheet product and having a high strength after being subjected to a paint-bake cycle.

It is another object of the invention to provide a method of manufacturing aluminium sheet products into formed structural automotive parts.

These and other objects and further advantages are met or exceeded by the present invention concerning a structural automotive component made of an aluminium alloy sheet product having a gauge in a range of 0.5 to 4 mm, preferably of 0.5 to about 3 mm, and having a composition consisting of, in wt. %:

- Zn 5.0 to 7.0,
- Mg 1.5 to 2.3,
- Cu max. 0.20,
- Zr 0.05 to 0.25,
- optionally one or two elements selected from the group consisting of:
  - (Mn 0.20 to 0.50 and Cr 0.10 to 0.35),
  - Ti max. 0.15,
- Fe max. 0.4,
- Si max. 0.3,
- and optionally at most: (about 0.05% Ca, about 0.05% Sr, about 0.004% Be), normal and/or inevitable incidental elements and impurities, and balance is made by aluminium. Typically such elements or impurities are present at each maximum 0.05%, and total maximum 0.2%.

As will be appreciated herein below, except as otherwise indicated, all aluminium alloy designations refer to the Aluminum Association designations in Aluminium Standards and Data and the Registration Records, as published by the Aluminium Association in 2008.

For this invention "sheet product" refers to a rolled product form over 0.5 mm through 4 mm in thickness.

For this invention "automotive body sheet" or "ABS" refers to aluminium alloy sheet for automotive body applications, in particular interior panels and structural parts.

For any description of alloy compositions or preferred alloy compositions, all references to percentages are by weight percent unless otherwise indicated.
In accordance with the invention there is provided a structural automotive component made from an aluminium alloy sheet having a good formability and high strength prior to forming into a structural vehicle member and furthermore having a high strength, in particular a high yield strength, after being subjected to a paint-bake cycle.

To provide sufficient strength levels in the aluminium sheet product the Zn content should be in a range of 5.0% to 7.0%. A preferred lower-limit for the Zn-content is 5.2%, and a preferred upper-limit for the Zn-content is 6.5%, and more preferably of 6.4%, and most preferably of 6.1%, to provide a balance in formability and strength after the paint-bake cycle.

The Mg content in the aluminium sheet product should be in the range of 1.5% to 2.3%, and preferably in a range of 1.65% to 2.3%, and more preferably in a range of 1.85% to 2.3%. A more preferred upper-limit for the Mg content is 2.15% to provide together with the Zn content an improved balance in formability and strength after the paint-bake cycle.

Cu can be present in the aluminium sheet product only up to 0.20%, and is preferably less than 0.10%. More preferably the Cu content is not more than 0.05%, in particular to control the corrosion performance of the sheet product. A too high Cu content has an adverse effect on the yield strength of the sheet product.

The aluminium alloy sheet has a Zr-content in the range of 0.05% to 0.25%, and preferably of 0.08% to 0.2%, and may optionally contain one or two elements selected from the group consisting of Mn of 0.20% to 0.50% and Cr of 0.10% to 0.35%. Preferably each of Mn and Cr are at a level of maximum 0.05%, and preferably each is present at an impurity level, which in practical terms would mean that the Mn and Cr content is at regular impurity levels of <0.05%, and preferably <0.02%, and more preferably the alloy is essentially free or substantially free from Cr and Mn. With "substantially free" or "essentially free" we mean that no purposeful addition of these elements was made to the composition, but that due to impurities and/or leaching from contact with manufacturing equipment, trace quantities of these elements may, nevertheless, find their way into the final alloy product.

Aluminium alloys of the 7xxx-series are well known for their use in aerospace application where there is a very strict control of the upper-limits for the Fe- and the Si-contents to maintain high levels of damage tolerance properties, such as toughness. However, it has been found that according to this invention the Fe and Si levels are less critical and the upper-limits can be raised to 0.4% and 0.3% respectively. A preferred lower limit for the Si content is 0.08% as Si increases the n-value of the sheet product which is a product property relevant in forming operations.

Ti can be added to the alloy product amongst others for grain refiner purposes during casting of the alloy stock, e.g. ingots or billets. The addition of Ti should not exceed about 0.15%, and preferably it should not exceed about 0.1%. A preferred lower limit for the Ti
addition is about 0.01%. Ti can be added as a sole element or with either boron or carbon serving as a casting aid for grain size control.

Traditionally, beryllium additions have served as a deoxidizer and/or ingot cracking deterrent and may be used in the alloy product according to this invention. Though for environmental, health and safety reasons, more preferred embodiments of this invention are substantially Be-free. Minor amounts of Ca and Sr alone or in combination can be added to the alloy product for the same purposes as Be. Preferred addition of Ca is in a range of about 10 to 100 ppm.

The balance in the aluminium alloy product is made by aluminium and normal and/or inevitable incidental elements and impurities. Typically such elements or impurities are present at a level of 0.05% maximum, and a total of 0.2% maximum.

The aluminium alloy sheet product has a front face and a back face. In an embodiment the aluminium alloy sheet product is clad on at least one of said faces with an aluminium alloy from the AA5xxx-series having less than 3.6% of Mg, amongst others to obtain a good intergranular corrosion resistance. Particularly suitable alloys are chosen from the AA5005, AA5754, AA5051A, AA5052, AA5252, AA5352, or AA5018-series aluminium alloys.

In another embodiment the aluminium alloy sheet product is clad on at least one of said faces with a low alloyed AA6000-series aluminium alloy having less than 0.25% Cu, preferably less than 0.2% Cu, and preferably an AA6000-series alloy having a substantially balanced Mg<sub>2</sub>Si composition to improve the bendability, the hemming performance and the crash performance of the clad sheet product according to this invention. A preferred aluminium alloy has a chemical composition consisting of, in wt. %:

- Si: 0.4 to 0.9
- Mg: 0.4 to 0.8,
- Fe: < 0.35
- Cu: < 0.25, preferably < 0.2, and more preferably < 0.1,
- Mn: < 0.50
- Cr: < 0.30
- Zr: < 0.30
- Zn: < 0.3, preferably < 0.1,
- Ti: < 0.1

impurities each < 0.05, total 0.15, balance aluminium.

A more preferred choice is the AA6005 alloy, and more in particular the AA6005A-series alloy, for both alloys with the proviso that the Cu-content is <0.25%, and preferably <0.2%.

For the AA6005A alloy the sum of Mn+Cr is preferably less than 0.50%, and more preferably in a range of 0.1% to 0.50% for optimum hemming performance.
The sheet product in accordance with the present invention may comprise only one clad sheet applied to only one of the faces. In another embodiment a clad sheet is applied to both faces of the sheet product. As a result, a composite material is obtained which exhibits excellent balanced properties, viz. strength and formability versus corrosion performance, dent resistance and hemming performance.

Such a composite material can be manufactured via various techniques known in the art, and which includes roll bonding and casting techniques such as disclosed in European patent document EP-A-1638715.

Although the dimensions of the aluminium composite material can be varied in many ways for use as automotive body sheet it is made from the aluminium alloy sheet product according to this invention and having a thickness in the range of 0.5 to 4 mm, preferably 0.5 to 3 mm, and more preferably of about 0.7 to 1.5 mm. The clad layer or clad layers are usually much thinner than the core sheet, and each clad layer constituting about 1% to 25% of the total composite sheet thickness. A clad layer more typically constitutes around about 1% to 12% of the total composite sheet thickness.

In a further aspect of the invention it relates to a method of manufacturing a formed structural automotive component incorporating the aluminium alloy sheet product as described herein.

The method comprises of casting, preheating and/or homogenisation, hot rolling, cold rolling, solution heat-treating ("SHT"), and rapid cooling or quenching after SHT to provide the sheet product, optionally having a cladding on one or both of its faces.

In a further embodiment of manufacturing the product according to this invention the cast rolling ingot material has been at least homogenised at a temperature of at least 500°C, and more preferably at a temperature of at least 520°C. It has been found that using such relatively high homogenisation temperature leads to coarsening of the precipitates in the rolling ingots in the presence of at least Zr. These coarse precipitates facilitate the formation of the preferred fully recrystallised isotropic grain structure in the sheet product in the underaged T6 temper resulting in the favourable combination of strength and formability.

In an embodiment of the method according to this invention, the aluminium alloy sheet during the solution heat treatment has been heated to the solution heat treatment temperature in a range of about 400°C to 500°C using an average heat-up rate of more than 30°C/sec, and preferably of more than 50°C/sec. It has been found that a very fast heat-up rate facilitates the formation of a recrystallised and very fine isotropic grain structure in the solution heat-treated and quenched aluminium alloy sheet leading amongst others to increased n-values. The aluminium alloy sheet can be, for example, rapidly heated-up in a
continuous annealing furnace by means of inductive heating. In an alternative embodiment the rapid heat-up rate is obtained by other means such as infra-red heating.

After SHT and rapid cooling or quenching, the aluminium alloy sheet product is aged. Preferably the cooled aluminium alloy sheet product is first naturally aged, for example for several minutes up to about four weeks, and preferably for up to about two weeks, to obtain a T4 temper and then artificially aged to an underaged T6 temper, e.g. T61, T64 or T65 according to EN515, by a heat-treatment comprising of 1 to 10 hours at 100°C to 140°C. In this underaged T6 temper the sheet product has a near peak yield strength ensuring no significant strength loss during possible further heat treatment, in particular no significant strength loss following a subsequent paint bake cycle after forming. With no significant loss in yield strength is meant that less than 10%, and in the best examples less than 5%, of the yield strength is lost following a paint bake cycle after the forming operation. In the underaged temper the sheet product has typically a yield strength or proof strength of at least 390 MPa, preferably of at least 405 MPa, and more preferably of the least 415 MPa. Furthermore in this underaged temper the sheet product has typically an elongation A50 of at least 12%. At this stage the alloy sheet product has preferably also a fully recrystallised isotropic grain structure. In this context "fully recrystallised" means that at least 80%, and preferably at least 90%, of the grains in this underaged T6 temper are recrystallised. The alloy composition combined with the specific underaged T6 temper provides for a grain structure allowing a high degree of forming, e.g. by means of deep-drawing or stamping to a formed automotive structural component, while maintaining a high strength. In accordance with this invention it has been found that the formability at this temper is better in various forming modes than the formability of the sheet product in a T4 temper. Before forming, the sheet product may be coated with a lubricant, oil or dry lubricant, suitable for the forming operation, the assembly and the surface treatment of the structural part to be produced. The sheet product may also be treated to apply a surface passivation layer to enhance adhesive bonding performance.

Following the forming operation the formed automotive structural component is then optionally provided with a lacquer or paint layer, and is made part of an assembly of other metal components as is regular in the art for manufacturing vehicle components, and subjected to a paint bake operation to cure any paint or lacquer layer applied. The paint bake operation or cycle comprises one or more sequential short heat treatment in the range of 150°C to 210°C for a period of 10 to less than 40 minutes, and typically of less than 30 minutes. A typical paint bake cycle would comprise a first heat treatment of 180°C@20 minutes, cooling to ambient temperature, then 160°C@20 minutes and cooling to ambient temperature. In dependence of the OEM such a paint bake cycle may comprise of 2 to 5 sequential steps and includes drying steps, but either way the cumulated time at elevated

6
temperature (100°C to 190°C) of the aluminium alloy product is less than 120 minutes. After
being subjected to a paint-bake cycle the formed automotive structural component made
according to this invention maintains a high strength level, typically having a yield strength of
380 MPa or more, and preferably of 395 MPa or more, after the paint-bake cycle.

Thus it has been found that the rolled aluminium alloy sheet product used in the method
according to this invention has a high yield strength after the paint bake cycle. Such high
yield strength levels after the paint bake allow for the design for thinner parts compared to
similar part made from the known AA5000- and AA6000-series alloys commonly used in
structural automotive application. Alternatively or in addition thereto, the subject 7000-series
alloy when processed in accordance with the invention may replace structural parts currently
made from high strength steels leading to considerable weight saving opportunities in the
motor vehicle.

In a further aspect of the invention the automotive structural part is one selected from
the group consisting of: a door beam, roof beam, side beam, instrumental panel support
beam, pillar reinforcement, tunnel, B-pillar reinforcement, body-in-white part.

In another aspect of the invention it relates to other structural application parts made
from the aluminium alloy sheet, such as a part of a drive train.

In another aspect of the invention is relates to the use and to a method of use of the
aluminium alloy sheet product as set out in this description and defined in accordance with
the claims in a method of manufacturing a forming automotive part whereby the sheet
product has been aged to near-peak strength levels, then formed and the formed sheet
product has been subjected to a paint-bake cycle to achieve a yield strength of at least 380
MPa, and preferably of 395 MPa or more, after the paint-bake cycle.

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

Example 1.

On a laboratory scale 2.7 mm sheet has been produced from 5 different aluminium
alloys as listed in Table 1, wherein alloy no. 4 is the alloy according to this invention. The
aluminium alloys have been homogenised, hot rolled to 22 mm, re-heated at 460°C, hot
rolled to 5.5 mm, cold rolled to a final gauge of 2.7 mm, SHT for 30 min@475°C, quenched,
and aged for 8 hours@150°C to near peak strength properties.

For some alloys two different homogenisation practices have been investigated, namely
homogenised at 24 hours@470°C or alternatively for 2 hours@460°C hours followed by 20
hours@530°C.
Table 1. Alloy compositions (in wt.%) of the alloys tested, all alloys had 0.03% Ti, 0.1% Si and 0.15% Fe. Balance is made by aluminium and inevitable impurities.

<table>
<thead>
<tr>
<th>Alloy no.</th>
<th>Zn</th>
<th>Mg</th>
<th>Cu</th>
<th>Zr</th>
<th>Mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.3</td>
<td>1.45</td>
<td>0.09</td>
<td>0.15</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>5.3</td>
<td>1.45</td>
<td>0.6</td>
<td>0.15</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>6.1</td>
<td>1.2</td>
<td>0.09</td>
<td>0.1</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>6.0</td>
<td>1.8</td>
<td>0.09</td>
<td>0.1</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>6.0</td>
<td>1.7</td>
<td>0.09</td>
<td>-</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Alloy 1 represents a regular 7021 alloy and which is commonly homogenised at about 470°C. This has been compared against alloy no. 4 both homogenised at 470°C and at 530°C. The mechanical properties in the L-direction of the sheets in the near peak strength condition are listed in Table 2.

Table 2. Mechanical properties of alloys No. 1 and 4 in the near peak strength condition.

<table>
<thead>
<tr>
<th>Alloy no.</th>
<th>HomopRACTice</th>
<th>Mechanical Property</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rp [ MPa ]</td>
</tr>
<tr>
<td>1</td>
<td>24hrs@470°C</td>
<td>377</td>
</tr>
<tr>
<td>4</td>
<td>24hrs@470°C</td>
<td>427</td>
</tr>
<tr>
<td>4</td>
<td>2hrs@460°C+20hrs@530°C</td>
<td>420</td>
</tr>
</tbody>
</table>

From the results of Table 2 it can be seen that the alloy according to this invention offers increased strength levels while maintaining favourable formability characteristics (at least when assessed on the basis of the elongation) in comparison with the regular 7021 alloy sheet product. Furthermore, it can be seen that a homogenisation practice at elevated temperature, thus above 500°C, results in an increased elongation.

It has been found also that material homogenised at 475°C has a fully unrecrystallised grain structure, whereas material homogenised at above 500°C, e.g. at 530°C, provides a more favourable fully recrystallised grain structure.
The alloys 2, 3, 4, and 5 have all been processed in a similar manner using a homogenisation practice incorporating the step at 530°C. The mechanical properties in the L-direction of the sheets in the near peak strength condition are listed in Table 3.

Table 3. Mechanical properties of the alloys in the near peak strength condition when homogenised for 2hrs@460°C+20hrs@530°C.

<table>
<thead>
<tr>
<th>Alloy no.</th>
<th>Mechanical Property</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rp [MPa]</td>
</tr>
<tr>
<td>2</td>
<td>373</td>
</tr>
<tr>
<td>3</td>
<td>371</td>
</tr>
<tr>
<td>4</td>
<td>420</td>
</tr>
<tr>
<td>5</td>
<td>424</td>
</tr>
</tbody>
</table>

From the results of Table 3 it can be seen a too high Cu content (alloy no. 2) results in unfavourable low yield strength (Rp). Also a low Mg content (alloy no. 3) results in unfavourable low yield strength (Rp). The Mn-containing alloy (alloy no. 5) appears to have favourable mechanical properties, however, in subsequent bending tests (180° around a r/t = 1.5 former) the sheet product failed. Whereas, alloy no. 4 in accordance with the invention combines high mechanical properties, including elongation, with a good bendability.

All tensile properties had been measured at ambient temperature in accordance with norm EN10002-1.

Example 2.

The sheet material of alloy no. 4 had also been subject to a simulated 3-step paint bake cycle consisting of a first treatment of 20 min@180°C, air cooled to room temperature, followed by a second treatment of 20 min@160°C, air cooled to room temperature, and then followed by a third treatment of 20 min@140°C followed by air cooling to room temperature.

The sheet material had an initial Rp of 420 MPa (see also Table 2 above) and had after the simulated 3-step paint bake cycle an Rp of 410 MPa, illustrating that when the sheet material prior to forming is at near peak strength it does not loose much of its original yield strength following a paint bake cycle (in this example about 2%), but instead the yield strength levels are maintained at a desirable high levels.

Whereas sheet material of alloy no. 1 of Example 1 had been subjected to the same 3-step paint bake cycle and showed a loss of about 8% in yield strength value.
Having now fully described the invention, it will be apparent to one of ordinary skill in the art that many changes and modifications can be made without departing from the spirit or scope of the invention as herein described.
CLAIMS

1. Structural automotive component of an aluminium alloy sheet product having a gauge in a range of 0.5 to 4 mm and having a composition consisting of, in wt. %:
   
<table>
<thead>
<tr>
<th>Element</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zn</td>
<td>5.0 to 7.0</td>
</tr>
<tr>
<td>Mg</td>
<td>1.5 to 2.3</td>
</tr>
<tr>
<td>Cu</td>
<td>max. 0.20</td>
</tr>
<tr>
<td>Zr</td>
<td>0.05 to 0.25</td>
</tr>
</tbody>
</table>

   optionally one or two elements selected from the group consisting of:
   
<table>
<thead>
<tr>
<th>Element</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn</td>
<td>0.20 to 0.50</td>
</tr>
<tr>
<td>Cr</td>
<td>0.10 to 0.35</td>
</tr>
<tr>
<td>Ti</td>
<td>max. 0.15</td>
</tr>
<tr>
<td>Fe</td>
<td>max. 0.4</td>
</tr>
</tbody>
</table>
   | Si      | max. 0.3, unavoidable impurities and balance aluminium.

2. Structural automotive component according to claim 1, wherein the aluminium alloy sheet product has a Zn-content in a range of 5.2 to 6.5%, and preferably of 5.2 to 6.4%.

3. Structural automotive component according to claim 1 or 2, wherein the aluminium alloy sheet product has Mg-content is in a range of 1.65 to 2.3%, and preferably of 1.85 to 2.3%.

4. Structural automotive component according to any one of claims 1 to 3, wherein the aluminium alloy sheet product has a Mn level and Cr level each of 0.05% maximum.

5. Structural automotive component according to any one of claims 1 to 3, wherein the aluminium alloy sheet product has a Mn level and Cr level each at impurity level.

6. Structural automotive component according to any one of claims 1 to 5, wherein the aluminium alloy sheet product has a Cu content of less than 0.10%.

7. Structural automotive component according to any one of claims 1 to 6, wherein the aluminium alloy sheet product has a front face and a back face and wherein the aluminium alloy sheet product is clad with a metal layer on at least one of said faces with an aluminium alloy from the AA5xxx-series having less than 3.6% of Mg or with a AA6000-series aluminium alloy having less than 0.25% Cu.
8. Structural automotive component according to any one of claims 1 to 7, wherein the aluminium alloy sheet product has a front face and a back face and wherein the aluminium alloy sheet product is clad on at least one of said faces with a metal layer selected from the AA5005, AA5754, AA5051A, AA5052, AA5252, AA5352, or AA5018-series aluminium alloys.

9. Structural automotive component according to any one of claims 1 to 8, wherein the aluminium alloy sheet product has a front face and a back face and wherein the aluminium alloy sheet product is clad on at least one of said faces with a metal layer selected from the AA6005 or AA6005A-series aluminium alloys and having less than 0.25% of Cu.

10. Structural automotive component according to any one of claims 1 to 9, wherein the structural automotive component is one selected from the group consisting of: a door beam, roof beam, side beam, instrumental panel support beam, pillar reinforcement, tunnel, B-pillar reinforcement, and body-in-white part.

11. Method of manufacturing a formed structural automotive component, the method comprising the sequential steps of:

   a. providing a rolled aluminium sheet product having a gauge in a range of 0.5 to 4 mm and being subjected to a solution heat treatment (SHT) and having been rapidly cooled following said SHT, and wherein the SHT and cooled aluminium sheet product has a chemical composition or structure according to any of claims 1 to 9,

   b. ageing of the cooled aluminium sheet product to a yield strength of 390 MPa or more,

   c. forming the aluminium alloy sheet to obtain a formed structural automotive component,

   d. assembling the formed structural automotive component with one or more other metal parts to form an assembly forming a motor vehicle component, and

   e. subjecting said motor vehicle component to a paint-bake cycle.

12. Method according to claim 10, wherein the solution heat-treated and cooled sheet product is transferred by a heat-treatment of 1 to 10 hours at a temperature in a range of 100°C to 140°C to an underaged condition and then forming into formed structural automotive component in step (c).
13. Method according to claim 10 or 11, wherein the SHT, cooled and aged aluminium alloy sheet is provided with a fully recrystallised isotropic microstructure prior to forming into formed structural automotive component in step (c).
A. CLASSIFICATION OF SUBJECT MATTER

INV. C22C21/10 C22F1/053

According to International Patent Classification (IPC) or to both national classification and IPC.

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C22C C22F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US 3 945 861 A (ANDERSON WILLIAM A ET AL)</td>
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Further documents are listed in the continuation of Box C

See patent family annex

Date of the actual completion of the international search
2 February 2010

Date of mailing of the international search report
11/02/2010

Name and mailing address of the ISA/
European Patent Office, P B 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel (+31-70) 340-2040.
Fax (+31-70) 340-3016

Authorized officer
Patton, Guy
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<td>Y</td>
<td>&quot;Internati onal alloy desi gnati ons and chemical compositi on l imi ts for wrought al uminium and wrought al umini um al loys&quot; REGISTRATION RECORD SERIES, ALUMINUM ASSOCIATION, WASHINGTON, DC, US, 1 January 2004 (2004-01-01 ), pages 1-26, XP020030949 page 10 - page 11; exampl es 7005, 7014, 7015, 7017-7019, 7021, 7025, 7030, 70 35; tables 7046, 7046A</td>
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<td>US 4 559 089 A (DROMSKY JOHN A [US] ET AL) 17 December 1985 (1985-12-17) col umn 1, line 7 - line 33 col umn 2, line 62 - col umn 3, line 56 col umn 3; examples AA7021, AA7046, AA7146; tab l e 1 figures c laims</td>
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<td>GB 1 392 722 A (ALCAN RES &amp; DEV) 30 April 1975 (1975-04-30) cited in the appl icati on page 2, line 30 - page 4, line 18; exampl e 1 page 4, line 20 - page 5, line 23; example 2 c laims</td>
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<td>JP 07 070688 A (KOBE STEEL LTD) 14 March 1995 (1995-03-14 ) cited in the appl icati on abstract page 4; exampl e 3; table 1 paragraph [0001 ] paragraph [0021 ] figures</td>
<td>1-10</td>
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<tr>
<td>A</td>
<td>FR 2 341 661 A (VMW RANSHOFEN BERNDORF AG [AT] ) 16 September 1977 (1977-09-16) page 2, line 21 - line 34 page 3, line 9 - line 17</td>
<td>1,6</td>
</tr>
<tr>
<td>A</td>
<td>JP 2007 100157 A (MITSUBISHI ALUMINIUM) 19 April 2007 (2007-04-19) cited in the appl icati on page 8; examples 4,8-11 ; table 1</td>
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<tr>
<td>A</td>
<td>EP 1 081 242 A (KOBE STEEL LTD [JP] ) 7 March 2001 (2001-03-07 ) page 5; examples 7,11 ; table 1</td>
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<tr>
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<td>US 4559089</td>
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<td>NONE</td>
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<td>GB 1392722</td>
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<td>BE 785856 A1</td>
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<td>DE 2233028 A1</td>
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