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(54) HIGHLY FORMABLE AND INTERCRYSTALLINE CORROSION-RESISTANT AIMG STRIP

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(57) **ABSTRACT**

The invention relates to a cold-rolled aluminium alloy strip made of an AlMg aluminium alloy as well as a method for producing the same. Furthermore, corresponding components made from said aluminium alloy strips are also proposed. The problem for the invention of providing a single-layer aluminium alloy strip that is sufficiently resistant to intercrystalline corrosion and is nevertheless very formable so that even large-area deep-drawn parts, e.g. interior parts of motor vehicle doors, can be made with sufficient strength, is solved by an aluminium alloy strip made of an AlMg aluminium alloy as described herein.

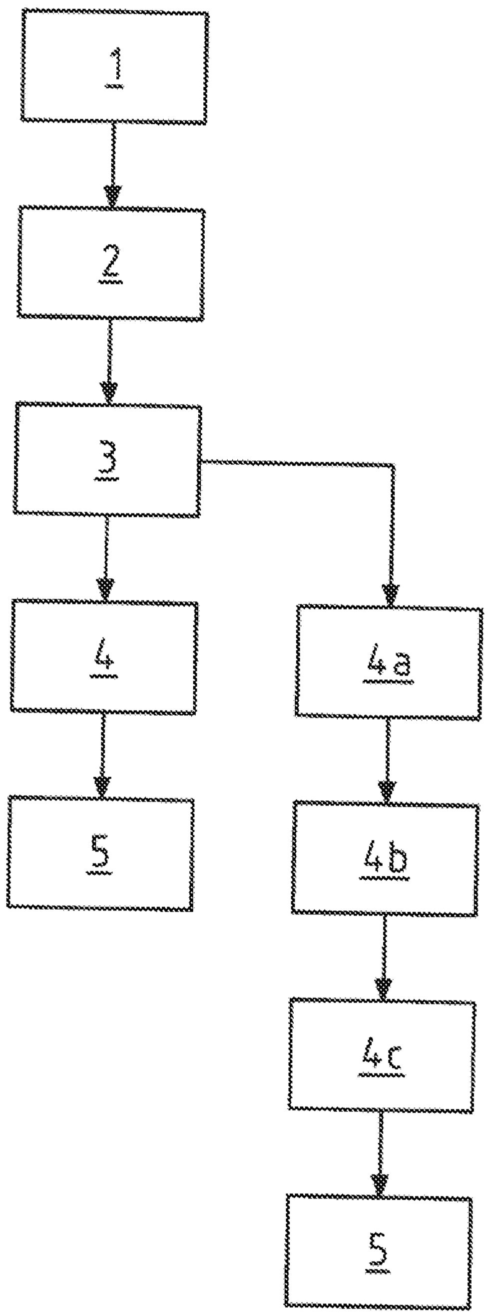

Fig.1

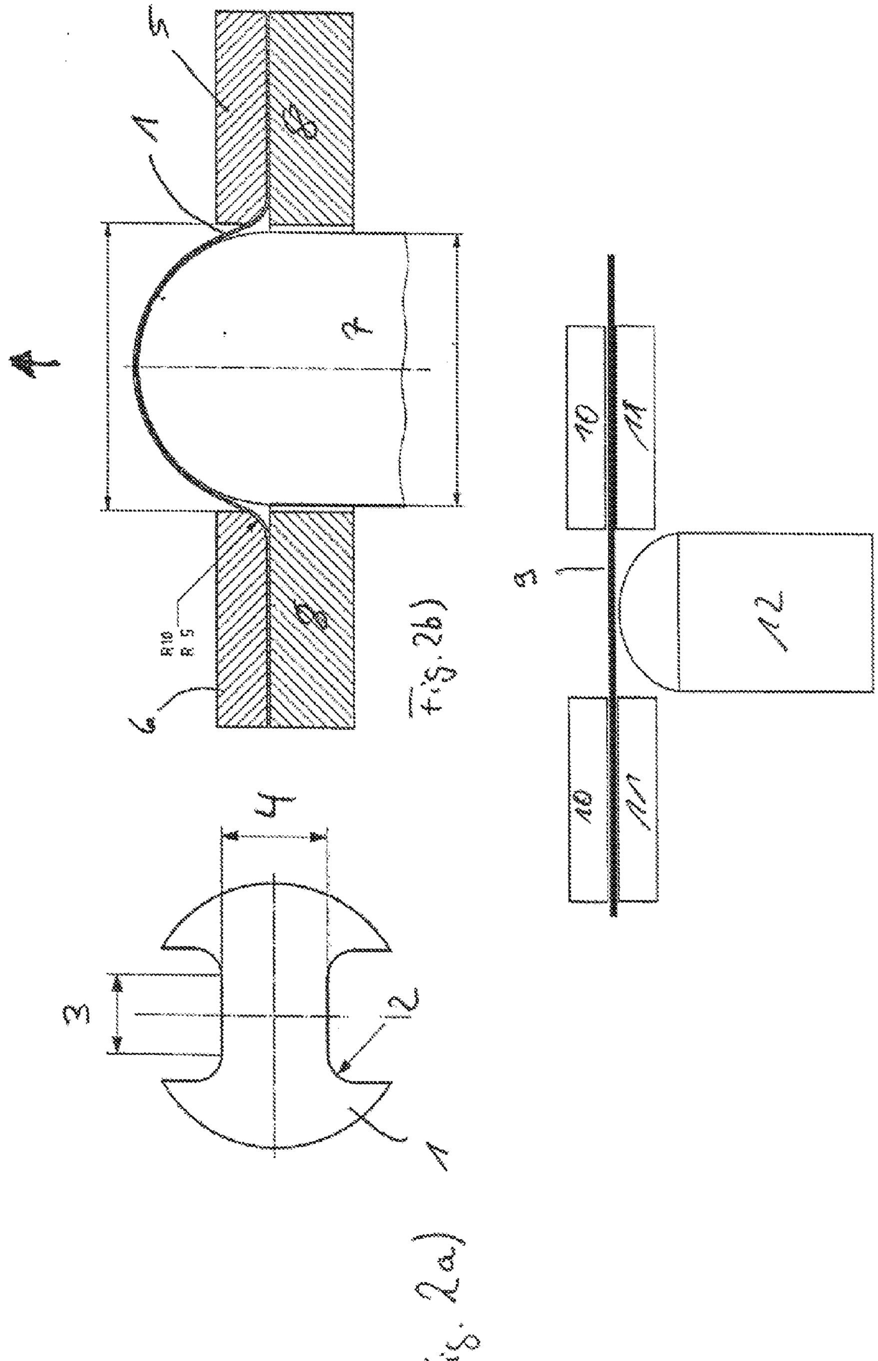
Fig. 2a)
Fig. 2b)
Fig. 3)
1
2
3
4
5
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11
12
R18
R5

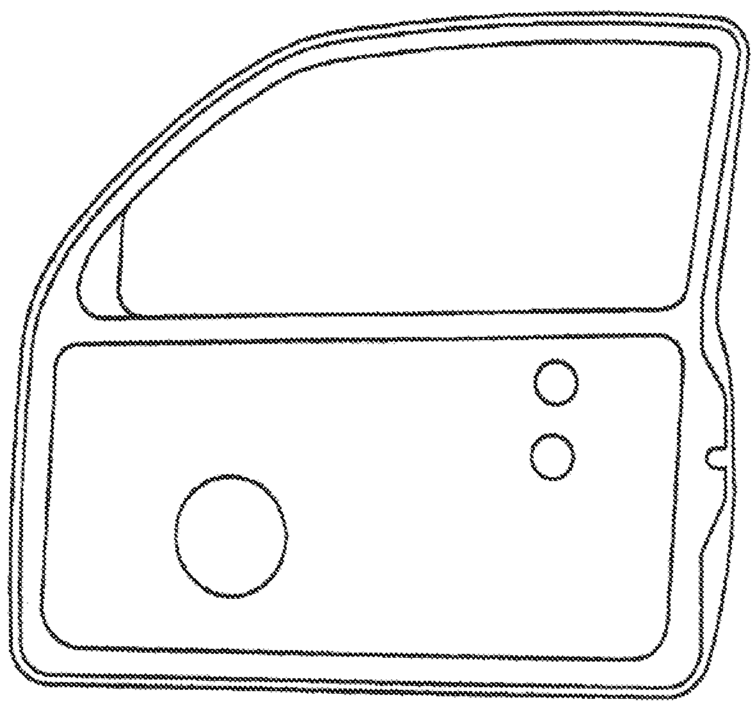

Fig. 4

HIGHLY FORMABLE AND INTERCRYSTALLINE CORROSION-RESISTANT AIMG STRIP

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

[0001] This patent application is a continuation of PCT/EP2013/067487, filed Aug. 22, 2013, which claims priority to European Application No. 12 181 356.2, filed Aug. 22, 2012, and PCT/EP2013/064736, filed Jul. 11, 2013, the entire teachings and disclosures of which are incorporated herein by reference thereto.

FIELD OF THE INVENTION

[0002] The invention relates to a cold-rolled aluminium alloy strip composed of an AlMg aluminium alloy and a method for the production thereof. Furthermore, corresponding components produced from the aluminium alloy strips will be proposed.

BACKGROUND OF THE INVENTION

[0003] Aluminium-magnesium-(AlMg-)-alloys of the AA 5xxx type are used in the form of sheets or plates or strips for the construction of welded or joined structures in ship, automotive and aircraft construction. They are characterised by high strength which increases as the magnesium content rises. AlMg-alloys of the AA 5xxx type with Mg contents of more than 3%, in particular more than 4%, have an increasing tendency towards intercrystalline corrosion, when exposed to high temperatures. At temperatures of 70-200° C., β-$AlsMg_3$ phases precipitate along the grain boundaries, which are referred to as β-particles and in the presence of a corrosive medium can be selectively dissolved. The result of this is that the AA 5182-type aluminium alloy (Al 4.5% Mg 0.4% Mn) having very good strength properties and very good formability in particular cannot be used in heat-stressed areas, where the presence of a corrosive medium such as water in the form of moisture must be contended with. This concerns in particular the components of a motor vehicle which normally undergo cathode dip painting (CDP) and are then dried in a stoving process, as already due to this stoving process, normal aluminium alloy strips can become susceptible to intercrystalline corrosion. Furthermore, for use in the automotive sector, forming during the manufacture of a component and subsequent operational stressing of the component must be taken into consideration.

[0004] The susceptibility to intercrystalline corrosion is normally checked in a standard test (NAMLT test) according to ASTM G67, during which the specimens are exposed to nitric acid and the mass loss due to the intercrystalline corrosion is measured. According to ASTM G67, the mass loss of materials which are not resistant to intercrystalline corrosion, is more than 15 mg/cm^2.

[0005] Sheet metal for the automotive industry, e.g. for internal door parts, must have very good formability. Here, the requirements are essentially determined by the stiffness of the component concerned, with the strength of the material playing only a subordinate role. The components often undergo multi-stage forming processes, such as for example doors with integrated window frame areas.

[0006] So, apart from the corrosion properties, the formability of the AlMg aluminium alloy also has a major influence on the usage possibilities for this material. For example, the materials known so far have meant that it is not possible for the side walls of a motor vehicle to be deep-drawn from a single sheet, making not only reconstruction of the side wall but also additional process steps for providing the side wall of a motor vehicle necessary.

[0007] The forming behaviour can, for example, be measured in a stretch drawing trial by an Erichsen cupping test (DIN EN ISO 20482), in which a test piece is pushed against the sheet, resulting in cold forming. During the cold forming, the force and the force displacement of the test piece are measured, until a load drop occurs, caused by the formation of a crack. The SZ32 stretch drawing measurements quoted in the application were performed with a punch head diameter of 32 mm and a die diameter of 35.4 mm with the help of a Teflon deep-drawing film to reduce friction. Further measurements of the deep drawability were performed using the so-called plane-strain-cupping test using a Nakajima geometry according to DIN EN ISO 12004 with a punch diameter of 100 mm. For this, specimens with a specific geometry underwent drawing tests until a crack appeared, with the depth until cracking being used as a measure of the formability of the material.

[0008] From JP 2011-052290 A, an aluminium alloy strip for can lids is known, which is preferably load-resistant despite its small thickness. Here, the strip has a recrystallized microstructure.

[0009] Further, from EP 2 302 087 A1, a chassis part is known made from an aluminium composite material, which has aluminium alloy layers as outer layers. Due to the alloying constituents, the Al composite material is characterized by excellent strength values with a high corrosion resistance at low weight.

[0010] Composite material solutions composed of AA5xxx aluminium alloys with a high Mg content and outer aluminium alloy layers to protect against corrosion, however, have the disadvantages that manufacture is complex and additionally at joining points where the aluminium composite material joins to other parts, for example at cutting edges, drill-holes and breakouts, there is furthermore an increased danger of corrosion.

SUMMARY OF THE INVENTION

[0011] The present invention is therefore concerned with single-layer aluminium materials. On this basis, the object of the invention is to provide a single-layer aluminium alloy strip, having sufficient resistance to intercrystalline corrosion but nevertheless having good formability, so that large-area, deep-drawn parts, such as interior parts of motor vehicles doors, with sufficient strength can be provided. Furthermore, a method will be indicated with which single-layer aluminium alloy strips can be produced. Finally, components produced from the aluminium alloy strips according to the invention will be indicated.

[0012] According to a first teaching of the present invention, the object indicated is achieved by a cold-rolled aluminium alloy strip composed of an AlMg aluminium alloy, wherein the aluminium alloy has the following alloying elements:

[0013] Si≤0.2 wt. %.

[0014] Fe≤0.35 wt. %,

[0015] Cu≤0.15 wt. %,

0.2 wt. %≤Mn≤0.35 wt. %,

4.1 wt. %≤Mg≤4.5 wt. %,

[0016] Cr≤0.1 wt. %,
[0017] Zn≤0.25 wt. %,
[0018] Ti≤0.1 wt. %,
the remainder being Al and inevitable impurities, amounting to a maximum of 0.05 wt. % individually and a maximum of 0.15 wt. % in total, wherein the aluminium alloy strip has a recrystallized microstructure, the average grain size of the structure ranges from 15 μm to 30 μm, preferably from 15 μm to 25 μm and the final soft annealing of the aluminium alloy strip is carried out in a continuous furnace.

[0019] It has been found that within the specification of the AA5182-type aluminium alloy, there is a specific, narrow, alloying range which offers sufficient resistance to intercrystalline corrosion and at the same time, by taking into account certain constraints, such as for example the average grain size and the type of final soft annealing, results in an exceptional forming behaviour. In particular, the combination of the average grain size with the claimed alloying elements of the aluminium alloy of the aluminium alloy strip means that degrees of formability can be achieved allowing the production of large-area design, deep-drawn sheet aluminium products with sufficient strength. In particular it has been found that the use of a continuous furnace rather than the normal coil annealing performed in a chamber furnace provides a further significant increase in formability.

[0020] According to a first configuration of the aluminium alloy strip, the aluminium alloy also has one or more of the following restrictions to the contents of alloying elements:

0.03 wt. % Si≤0.10 wt. %,

[0021] Cu≤0.1% preferably 0.04%≤Cu≤0.08%,
[0022] Cr≤0.05 wt. %,
[0023] Zn≤0.05 wt. %,

0.01 wt. %≤Ti≤0.05 wt. %

[0024] Restricting the alloying content for copper to a maximum of 0.1 wt. % leads to an improvement in the corrosion resistance of the aluminium alloy strip. A Cu content of 0.04 wt. % to 0.08 wt. % ensures that the copper contributes to an increase in strength, but that nevertheless the corrosion resistance is not reduced too sharply. Silicon, chromium, zinc and titanium contents higher than the values indicated lead to a worsening of the formability of the aluminium alloy. The amount of silicon present in the alloy of 0.03 to 0.1 wt. %, in combination with the iron and manganese components in the stated quantities, in particular leads to relatively evenly distributed, compact particles of the quaternary α-Al(Fe,Mn)Si-phase, increasing the strength of the aluminium alloy, without negatively influencing other properties such as the formability or corrosion behaviour.

[0025] Titanium is normally added during continuous casting of the aluminium alloy as a grain refiner, for example in the form of titanium boride wire or rods. Therefore in a further embodiment the aluminium alloy has a Ti content of at least 0.01 wt. %.

[0026] A further improvement in the corrosion behaviour and the formability of the aluminium alloy strip can be achieved by the aluminium alloy also having one or more of the following restrictions to the contents of alloying elements:
[0027] Cr≤0.02 wt. %,
[0028] Zn≤0.02 wt. %

[0029] It has been found that chromium in contents below the contamination threshold of 0.05 wt. % significantly influences the formability of the aluminium alloy strip and therefore should be contained in the smallest possible proportions in the aluminium alloy of the aluminium alloy strip according to the invention. The zinc content is set at below the contamination threshold of 0.05 wt. %, in order not to impair the general corrosion behaviour of the aluminium alloy strip.

[0030] It has furthermore been found that iron within the values permitted according to the AA5182-type aluminium alloy in conjunction with silicon and manganese contents as described above has an effect on the formability. In combination with silicon and manganese, iron contributes to the thermal stability of the aluminium alloy strip, so that preferably the Fe-content of the aluminium alloy strip according to a next configuration is 0.1 wt. % to 0.25 wt. % or 0.10 wt. % to 0.20 wt. %.

[0031] The same also applies to the Mn content of a further configuration of the aluminium alloy strip, which should preferably be limited to 0.20 wt. % to 0.30 wt. %, in order to achieve optimum formability of the aluminium alloy strip.

[0032] An especially good compromise between the provision of high strength properties, good corrosion resistance to intercrystalline corrosion and improved forming properties can be achieved according to a further configuration of the aluminium alloy strip with an Mg content of 4.2 wt. % to 4.4 wt. %.

[0033] In order to provide the strength properties necessary for the areas of application, the aluminium alloy strip according to a next embodiment has a thickness of 0.5 mm to 4 mm. The thickness is preferably 1 mm to 2.5 mm, since most of the areas of application of the aluminium alloy strip fall within this range.

[0034] Finally, in the automotive sector the aluminium alloy strip according to the invention allows areas of application wherein the aluminium alloy strip in the soft state has a yield point $R_{p0.2}$ of at least 110 MPa and a tensile strength R_m of at least 255 MPa. It has been found that aluminium alloy strips with such yield points and tensile strengths especially are particularly well-suited for use in the automotive sector.

[0035] According to a second teaching of the present invention the object shown above is achieved by a method for producing an aluminium alloy strip according to the embodiments described above, wherein the method comprises the following process steps:

[0036] casting a rolling ingot preferably in the DC continuous casting process;

[0037] homogenisation of the rolling ingot at 480° C. to 550° C. for at least 0.5 hours;

[0038] hot rolling of the rolling ingot at a temperature of 280° C. to 500° C.;

[0039] cold rolling of the aluminium alloy strip to the final thickness with a degree of rolling of 40% to 70% or 50% to 60%; and

[0040] soft annealing of the finished rolled aluminium alloy strip at 300° C. to 500° C. in a continuous furnace.

[0041] It has been found that with the indicated parameters in conjunction with the stated aluminium alloying components an aluminium alloy strip with average grain sizes of 15 μm-30 μm can be produced, having sufficient resistance to intercrystalline corrosion, providing sufficient strength properties and also having very good forming properties, so that large-area, deep-drawn sheet metal parts can be produced.

Homogenisation of the rolling ingot ensures a homogenous structure and a homogenous distribution of the alloying elements in the hot rolling ingots to be rolled. The hot rolling at temperatures of 280° C.-500° C. allows recrystallization throughout during hot rolling, wherein the hot rolling typically is performed up to a thickness of 2.8 mm-8 mm. The final cold-rolling step is restricted to a degree of rolling of 40% to 70% or 50% to 60%, in both cases in order to ensure recrystallization throughout the aluminium alloy strip during soft annealing. The higher the degree of rolling of the aluminium alloy strip, the lower the average grain sizes become, wherein it has been found that above a 70% degree of rolling in the final soft annealing an average grain size can result that is too low. At a degree of rolling below 40% during soft annealing the average grain sizes are on the other hand too large, so that despite the resistance to intercrystalline corrosion increasing, the formability is nevertheless reduced. Soft annealing of the finish-rolled aluminium alloy strip takes place in a continuous furnace, which will normally have a heat-up rate of 1-10° C./second and so unlike a chamber furnace, in which an entire coil is heated, because of the rapid heating will have a marked effect on the later properties of the structure of the aluminium alloy strip. In particular, it has been possible to establish that during soft annealing in the continuous furnace an improved formability of the strip compared to variants annealed in the chamber furnace is achieved.

[0042] Alternatively, according to a further embodiment of the method, the aluminium alloy strip can also be produced with an intermediate annealing. According to this alternative variant after hot rolling alternatively the following process steps are performed:

- **[0043]** cold rolling of the hot-rolled aluminium alloy strip to an intermediate thickness which is determined in such a way that the final degree of cold rolling to the final thickness is 40% to 70% or 50% to 60%;
- **[0044]** intermediate annealing of the aluminium alloy strip at 300° C. to 500° C.;
- **[0045]** cold rolling of the aluminium alloy strip to the final thickness with a degree of rolling of 40% to 70% or 50% to 60%;
- **[0046]** soft annealing of the finish-rolled aluminium alloy strip at 300° C. to 500° C. in a continuous furnace.

[0047] The intermediate annealing of the aluminium alloy strip can take place both in the chamber furnace and in the continuous furnace. An effect on formability could not be determined. The decisive factors here are the degree of rolling achieved in cold rolling to the final thickness and if the soft annealing of the strip takes place in the continuous furnace. This determines the formability and corrosion resistance in conjunction with the alloying composition, irrespective of the type of intermediate annealing.

[0048] In order to prevent a further change in the microstructural state in the coiled condition following soft annealing, the aluminium alloy strip according to a further configuration of the method is cooled after soft annealing to a maximum temperature of 100° C., preferably a maximum of 70° C. and then coiled.

[0049] As already stated above, the intermediate annealing can be carried out in a further configuration of the method in a batch furnace or in a continuous furnace.

[0050] If the aluminium alloy strip is cold-rolled to a final thickness of 0.5 mm-4 mm, preferably to a final thickness of 1 mm-2.5 mm, this provides the typical areas of application, in particular automotive construction, with sheet metal with very good formability, and which can be deep-drawn with large surface areas and at the same time provide high strength properties together with sufficient corrosion resistance to intercrystalline corrosion.

[0051] The soft annealing is preferably performed in the continuous furnace at a metal temperature of 350° C.-550° C., preferably at 400° C.-450° C. for 10 seconds to 5 minutes, preferably 20 seconds to 1 minute. This allows the cold rolled strip to recrystallize sufficiently thoroughly and the corresponding properties with regard to the very good formability and the average grain size to be achieved reliably and economically.

[0052] Finally, the object indicated above is achieved by a component for a motor vehicle, composed of the aluminium alloy strip according to the invention. The components are characterised in that, as already stated, they can be deep-drawn with a large surface area and therefore for example large-area components for automotive construction can be provided. Furthermore, because of the strength properties provided these also have the necessary stiffness and the corrosion resistance required for use in automotive construction.

[0053] It is conceivable, for example, for the component according to a further configuration to be a motor vehicle body part or body accessory, which apart from being subject to high strength requirements is also heat-stressed. Preferably, the body-in-white parts such as an internal door part or an internal tailgate part, are made from the aluminium alloy strip according to the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0054] The invention is explained in more detail below with the help of the drawing. The drawing shows as follows:

[0055] FIG. **1** shows a schematic flow diagram of an embodiment of the production method of the aluminium alloy strip.

[0056] FIG. **2***a* shows a top view of the specimen geometry for the plane-strain cupping test according to DIN EN ISO 12004.

[0057] FIG. **2***b* shows a side-view of the schematic test set-up for the plane-strain cupping test according to DIN EN ISO 12004.

[0058] FIG. **3** shows a sectional view of the test setup for the SZ32 stretch drawing measurements in the Erichsen cupping test according to DIN EN ISO 20482.

[0059] FIG. **4** shows a typical embodiment of a large-area, deep-drawn sheet metal part according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0060] FIG. **1** shows the sequence of embodiments for the production of aluminium strips.

[0061] The flow diagram of FIG. **1** is a schematic representation of the various process steps of the production process of the aluminium alloy strip according to the invention.

[0062] In step **1**, a rolling ingot of an AlMg aluminium alloy with the following alloying elements is cast, for example in DC continuous casting:

- **[0063]** Si≤0.2 wt. %.
- **[0064]** Fe≤0.35 wt. %,
- **[0065]** Cu≤0.15 wt. %,

0.2 wt. %≤Mn≤0.35 wt. %,

4.1 wt. %≤Mg≤4.5 wt. %,

[0066] Cr≤0.1 wt. %,
[0067] Zn≤0.25 wt. %,
[0068] Ti≤0.1 wt. %,
the remainder being Al and inevitable impurities, amounting to a maximum of 0.05 wt. % individually and a maximum of 0.15 wt. % in total.

[0069] Then the rolling ingot in process step **2** undergoes homogenisation, which can be performed in one or more stages. During homogenisation, temperatures of the rolling ingot of 480 to 550° C. are reached for at least 0.5 hours. In process step **3** the rolling ingot is then hot rolled, wherein typically temperatures of 280° C. to 500° C. are reached. The final thicknesses of the hot-rolled strip are for example 2.8 to 8 mm. The hot-rolled strip thickness can be selected such that after hot rolling only a single cold rolling step **4** takes place, in which the hot-rolled strip, with a degree of rolling of 40% to 70%, preferably 50% to 60%, has its thickness reduced to the final thickness.

[0070] Then the aluminium alloy strip that has been cold-rolled to its final thickness undergoes soft annealing. According to the invention the soft annealing is performed in a continuous furnace. In the embodiments shown in Table 1, the second route was applied with an intermediate annealing. For this, the hot-rolled strip after hot rolling according to process step **3** is passed for cold rolling **4***a*, in which the aluminium alloy strip is cold rolled to an intermediate thickness, which is determined in such a way that the final degree of cold rolling to the final thickness is 40% to 70% or 50% to 60%. In a subsequent intermediate annealing the aluminium alloy strip preferably recrystallizes throughout. The intermediate annealing was carried out in the embodiments either in the continuous furnace at 400° C. to 450° C. or in the chamber furnace at 330° C. to 380° C.

[0071] The intermediate annealing is shown in FIG. **1** by process step **4***b*. In process step **4***c* according to FIG. **1** the intermediately-annealed aluminium alloy strip is finally passed for cold rolling to the final thickness, wherein the degree of rolling in process step **4***c* is between 40% and 70%, preferably between 50% and 60%. Then the aluminium alloy strip is again converted to the soft state by soft annealing, wherein according to the invention the soft annealing is carried out in the continuous furnace at 400° C. to 450° C. The annealings of the comparative examples in table 4 were carried out in the chamber furnace (KO) at 330° C. to 380° C. During the various trials, apart from the different aluminium alloys various degrees of rolling after the intermediate annealing were set. The values for the degree of rolling after the intermediate annealing are likewise shown in Tables 1 and 4. The average grain size of the soft-annealed aluminium alloy strip was also measured. To this end, longitudinal sections were anodised according to the Barker method and then measured under the microscope according to ASTM E1382 and the average grain size determined from the average grain diameter.

[0072] The aluminium alloy strips manufactured in this way had their mechanical characteristics determined, in particular the yield point $R_{p0.2}$, the tensile strength R_m, the uniform elongation Ag and the elongation at rupture A_{80mm}, Tables 2, 5. Apart from the mechanical characteristics of the aluminium alloy strips measured according to EN 10002-1 or ISO 6892 in addition the average grain sizes according to ASTM E1382 in μm are given. Furthermore, the corrosion resistance to intercrystalline corrosion in accordance with ASTM G67 was measured, and in fact without additional heat treatment in the initial state (at 0 h). In order to simulate use in a motor vehicle, the aluminium alloy strips, prior to the corrosion test, furthermore underwent various heat treatments. A first heat treatment consisted of storage of the aluminium strips for 20 minutes at 185° C., in order to model the CDP cycle.

[0073] In a further series of measurements the aluminium alloy strips were also stored for 200 hours or 500 hours at 80° C. and then underwent the corrosion test. Since the forming of aluminium alloy strips or sheets can also affect the corrosion resistance, the aluminium alloy strips were stretched in a further trial by approximately 15%, and underwent heat treatment or storage at raised temperature and then a test for intercrystalline corrosion according to ASTM G67, during which the mass loss was measured.

[0074] Table 1 gives the alloying contents of a total of four different aluminium alloys, which fall within the specification of the AA5182-type aluminium alloy. The reference alloy is constituted by the material used to date and is shown in comparison to variants 1, 2 and 3. Table 1 also contains details of the type of final annealing, the final degree of rolling and the measured average grain size (grain size diameter) in μm. Variants 1 and 2 differ here merely in terms of final degree of rolling, which leads to the formation of a different grain size. Thus variant 2 differs from variant 1 irrespective of the almost identical alloying elements essentially in terms of the final degree of rolling of 57% at identical continuous furnace conditions. The result was that variant 2 had an average grain size of 18 μm compared to 33 μm for variant 1. The strips in Table 1 were heated in the continuous furnace for 20 seconds to 1 minute to a temperature of 400° C. to 450° C., then cooled and coiled at less than 100° C. The specimens taken were then, as indicated in Table 2, measured according to the corresponding DIN EN ISO standards.

[0075] It is clear from Table 2 that variant 1 in terms of the yield point does not reliably reach the value of 110 MPa and in the diagonal measurement, identified by the D symbol, has a value of less than 110 MPa. The measurement in the direction of rolling L and transversally to the direction of rolling Q showed, however, that variant 1 actually reached a yield point $R_{p0.2}$ of 110 MPa. The reference and variants 2 and 3 were significantly above this lower limit for the yield point. The embodiment according to the invention in variant 2 reliably achieved the yield point value of 110 M Pa in all tensile directions. It is clear to see that variant 3 with the highest Mg content of 4.95 wt. % achieves the highest yield point and tensile strength figures. It can also be seen that the different degree of rolling between variants 1 and 2 not only markedly influences the grain size, but in particular raises the yield point to a value of significantly higher than 110 MPa.

[0076] In particular the alloy according to the invention in variant 2 has a lower anisotropy compared to the reference, reflected in lower values of the planar anisotropy Ar. Here, the planar anisotropy Δr is defined as $\frac{1}{2}*(r_L+r_Q-2\,r_D)$, wherein r_L, r_Q and r_D correspond to the r-values in the longitudinal, traversal and/or diagonal direction. Here, the average r-value F, calculated from $\frac{1}{4}*(r_L+r_Q+2r_D)$, does not differ significantly from that of the reference material.

[0077] Table 3 gives the measured values recorded in relation to the resistance to intercrystalline corrosion. It can be seen that variant 2 according to the invention in terms of the measured values of the reference, in particular in respect of the long-time stressing, has comparable values both in the stretched state and in the unstretched state. Here variant 2 and the reference are almost identical. Variant 3, which despite the having the highest yield point values and tensile strength values, nevertheless in the corrosion test demonstrated that an excessive Mg content results in an excessive mass loss, in particular in the long-time tests, which apart from a short temperature cycle of 20 minutes at 185° C. also include long-time stressing of 200 hours at 80° C.

[0078] With regard to the measured values in Table 3 regarding the formability it can be seen that in particular variant 2 was superior in terms of the stretch forming properties in the SZ32 cupping test and in the plane-strain cupping test to the reference alloy. The clear improvement in forming behaviour of the aluminium alloy strip according to variant 2 compared to the reference aluminium alloy strip shows that even with a reduced Mg content comparable yield point values and tensile strength vales could be achieved with the reference alloy, without major losses in resistance to intercrystalline corrosion. This was demonstrated in particular by the mass loss measurement performed according to ASTM G67 in the NAML test. Significantly, with variant 2 an improvement in the deep drawing behaviour in the Erichsen cupping test by 7% and in the plane-strain cupping tests by approximately 10% was found, demonstrating the additional forming potential of the aluminium alloy strip according to the invention. This additional forming potential can be used to produce deep-drawn, large-area sheet metal parts, for example internal door parts of a motor car.

[0079] A brief explanation of the test setup for the "SZ32 cupping" test according to DIN EN ISO 20482 and the plane-strain cupping test with Nakajima geometry according to DIN EN ISO 12004 is provided below.

[0080] FIG. **2***a* shows the geometry of test piece **1**. From a circular sheet metal cut-out the tapered test piece **1** is cut such that the web **4** has a width of 100 mm and the radii **2** at the waisted parts are 20 mm. Dimension **3**, which is 100 mm, represents the diameter of the punch. FIG. **2***b* shows the test piece **1** clamped between two holders **5**, **6**. The test piece **1**, which was placed on a mount **8** and via the holders **5**, **6** pushed against the support, is pulled with a punch **7**, having a semi-circular tip with a radius of 100 mm, in the direction of the arrow. The holders also have entry radii of 5 or 10 mm on their side facing the mount **8**. The force with which the cupping test is performed is measured during the forming and a sudden drop in load, signalling the formation of a crack, leads to the measurement of the corresponding punching depth.

[0081] The "SZ32 cupping" test according to Erichsen has a similar setup, but no wasted test pieces are used, however. Here, a test piece **9** is simply held between a holder **10** and a support **11** and drawn with a punch **12** until likewise a drop is measured in the load of the drawing force. Then, again, the corresponding position of the punch is measured. The opening of the dies in FIG. **3** was 35.4 mm and the punch diameter 32 mm, meaning that the punch radius was 16 mm. A Teflon deep-drawing film was also used to reduce friction in the SZ32 deep-drawing test.

[0082] In Tables 4 and 5, further embodiments and comparative examples were created and measured according to their mechanical characteristics and their resistance to intercrystalline corrosion. It can be seen that the combination of using the continuous furnace and a specifically selected grain size of 15 μm-30 μm, preferably of 15 μm-25 μm results in a good compromise between corrosion resistance and mechanical measured values. Thus, for example, the embodiments according to the invention Nos. 3, 4, 7 and 11 have a satisfactory resistance to intercrystalline corrosion and also exhibit the mechanical measured values $R_{p0.2}$ and R_m necessary for use in the automotive sector, so that these are ideal for the provision of large-area, deep-drawn components.

[0083] FIG. **4** shows as an example a corresponding body-in-white part in the form of an interior part of a door, which by using the aluminium alloy strip of the present invention can be produced from a single deep-drawn sheet. Here, the sheet thickness is preferably 1.0-2.5 mm. Furthermore, other parts of a motor vehicle are conceivable in sheet metal shell construction, such as the interior parts of tailgates, bonnets, and components in the vehicle structure, which are subject to stringent requirements in terms of formability and intercrystalline corrosion.

TABLE 1

	Material [wt. %]									Final	Final degree of rolling (cold	Grain
	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Impurities	annealing	rolling)	size [μm]
min.				0.20	4.0				Individually max.			
AA 5182	0.20	0.35	0.15	0.50	5.0	0.10	0.25	0.10	0.05 in total max.			
max.									0.15			
Reference	0.07	0.24	0.036	0.3	4.57	0.005	0.007	0.016	0.05 0.15	BDLO	46	15
Var. 1	0.06	0.16	0.004	0.27	4.37	0.008	0.002	0.013	0.05 0.15	BDLO	21	33
Var. 2	0.06	0.16	0.004	0.27	4.38	0.008	0.003	0.013	0.05 0.15	BDLO	57	18
Var. 3	0.05	0.17	0.023	0.26	4.95	0.008	0.003	0.026	0.05 0.15	BDLO	57	17

TABLE 2

Test piece	Pos.	$R_{p0.2}$ N/mm^2	Rm N/mm^2	Ag %	Ag (elong) %	$A_{80\,mm}$ %	$A_{80\,mm}$ (Hand) %	Z-value %	n-value	r-value	Δr	$\bar{r}$
Ref.	L	137	284	21.3	20.7	24.5	25.2	69	0.316	0.827	0.197	0.754
	T	133	276	22.2	21.4	25.2	25.8	72	0.306	0.704		
	D	133	277	21.9	21.6	25.5	26.3	71	0.305	0.779		

TABLE 2-continued

Test piece	Pos.	$R_{p0.2}$ N/mm^2	Rm N/mm^2	Ag %	Ag (elong) %	$A_{80\,mm}$ %	$A_{80\,mm}$ (Hand) %	Z-value %	n-value	r-value	Δr	$\bar{r}$
Var. 1	L	110	262	21.2	21.9	25.9	26.4	71	0.335	0.668	−0.363	0.779
	T	107	256	24.7	23.0	27.7	28.7	72	0.338	0.870		
	D	111	259	22.0	21.2	24.6	25.7	65	0.332	0.708		
Var. 2	L	128	266	23.2	22.7	26.8	27.7	67	0.332	0.724	0.035	0.693
	T	127	261	23.1	22.2	26.2	27.0	67	0.332	0.685		
	D	128	262	23.9	22.5	26.5	27.6	66	0.333	0.681		
Var. 3	L	141	290	24.1	23.5	28.4	29.1	70	0.335	0.697	−0.12	0.710
	T	140	286	22.6	23.4	27.0	27.8	68	0.336	0.740		
	D	141	286	22.6	23.3	27.1	27.7	65	0.335	0.663		
				DIN EN ISO 6892-1:2009					DIN EN ISO 10275:2009	DIN EN ISO 10113:2009		

TABLE 3

	IK-mass losses						Formability	
Variant	Not thermally treated	20 min. 185° C.	20 min 185° C. plus 200 h 80° C.	17 h 130° C.	15% stretched 20 min. 185° C.	15% stretched 20 min. 185° C. plus 200 h 80° C.	SZ32 cupping [mm]	Plane-strain cupping [mm]
Limit	2.0	4.0	35.0	50.0	15.0	45.0		
Reference	1.2	2.1	29.8	48.8	10.4	42.1	14.2	27.9
Var. 1 (comp.)	1.2	1.7	10.4	21.3	4.4	12.9	14.5	30.3
Var. 2 (inv.)	1.2	2.4	33.7	42.2	13.5	40.1	14.6	30.7
Var. 3 (comp.)	1.3	5.3	41.7	55.0	30.4	53.5	14.6	31.6

TABLE 4

No	Alloy	Degree of rolling [%]	Final annealing	Grain size [μm]	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti
1	III	46	KO	16	0.07	0.24	0.040	0.30	4.50	0.005	0.007	0.016
3	II	57	BOLO	18	0.06	0.16	0.004	0.27	4.35	0.008	0.002	0.013
4	I	45	BOLO	18	0.03	0.13	0.002	0.25	4.15	0.001	0.004	0.021
6	I	45	KO	21	0.03	0.13	0.002	0.25	4.15	0.001	0.004	0.021
7	III	30	BOLO	22	0.07	0.24	0.040	0.30	4.50	0.005	0.007	0.016
11	III	25	BOLO	27	0.07	0.24	0.040	0.30	4.50	0.005	0.007	0.016
13	I	32	BOLO	29	0.03	0.13	0.002	0.25	4.15	0.001	0.004	0.021
15	III	30	KO	30	0.07	0.24	0.040	0.30	4.50	0.005	0.007	0.016
16	I	25	BOLO	31	0.03	0.13	0.002	0.25	4.15	0.001	0.004	0.021
18	II	21	BOLO	33	0.06	0.16	0.004	0.27	4.35	0.008	0.002	0.013
20	I	20	BOLO	34	0.03	0.13	0.002	0.25	4.15	0.001	0.004	0.021

TABLE 5

		IK-mass loss, unstretched**				IK-mass loss, 15% stretched**		Mechanical characteristics, soft state				
No		Start (O h)	20 min. 185° C.	20 Min. 185° C. + 200 h 80° C.	20 Min. 185° C. + 500 h/80° C.	20 Min. 185° C.	20 Min. 185° C. + 200 h 80° C.	$R_{p0.2}$	Rm	Ag	$A_{80\,mm}$	Result
1	III	15.4	16.6	25.7	26.9	18.8	33.6	135	279	20.7	25.2	Comparison
3	II	1.2	2.4	33.7	36.7	13.5	40.1	128	262	23.9	26.5	Invention
4	I	1.3	1.9	17.8	22.2	1.6	20.1	117	258	22.8	25.3	Invention
6	I	8.2	10.8	18.6	22.1	9.6	20.7	106	250	23.8	26.7	Comparison
7	III	1.1	1.7	18.0	24.5	3.3	25.1	119	276	20.3	24.9	Invention
11	III	1.1	1.6	14.3	17.7	2.8	19.8	116	275	20.2	24.4	Invention
13	I	1.1	1.2	13.3	16.7	2.1	17.4	104	251	22.2	24.8	Comparison
15	III	2.8	3.0	7.9	10.9	6.4	18.0	125	281	19.5	23.6	Comparison
16	I	1.1	1.3	10.8	13.1	1.9	14.2	103	252	21.6	26.1	Comparison
18	II	1.2	1.7	10.4	12.5	4.4	12.9	109	259	22.0	24.6	Comparison
20	I	1.1	1.2	8.3	11.1	1.7	12.4	101	251	20.8	25.1	Comparison

1. Cold-rolled aluminium alloy strip composed of an AlMg aluminium alloy, wherein the aluminium alloy comprises the following alloying elements:

Si≤0.2 wt. %,

Fe≤0.35 wt. %,

Cu≤0.15 wt. %,

0.2 wt. %≤Mn≤0.35 wt. %,

4.1 wt. %≤Mg≤4.5 wt. %,

Cr≤0.1 wt. %,

Zn≤0.25 wt. %,

Ti≤0.1 wt. %,

the remainder being Al and inevitable impurities, amounting to a maximum of 0.05 wt. % individually and to a maximum of 0.15 wt. % in total, wherein the aluminium alloy strip has a recrystallized microstructure, the grain size of the microstructure ranges from 15 μm to 25 μm and the final soft annealing of the aluminium alloy strip is performed in a continuous furnace.

2. The Aluminium alloy strip according to claim **1**, wherein the aluminium alloy also has one or more of the following restrictions to the contents of alloying elements:

0.03 wt. % Si≤0.10 wt. %,

Cu≤0.1,

Cr≤0.05 wt. %,

Zn≤0.05 wt. %,

0.01 wt. %≤Ti≤0.05 wt. %.

3. The Aluminium alloy strip according to claim **1**, wherein the aluminium alloy also has one or more of the following restrictions to the contents of alloying elements:

Cr≤0.02 wt. %,

Zn≤0.02 wt. %.

4. The Aluminium alloy strip according to claim **1**, wherein the Fe content is 0.10 wt. % to 0.25 wt. % or 0.10 wt. % to 0.2 wt. %.

5. The Aluminium alloy strip according to claim **1**, wherein the Mn content is 0.20 wt. % to 0.30 wt. %.

6. The Aluminium alloy strip according to claim **1**, wherein the Mg content is 4.2 wt. % to 4.4 wt. %.

7. The Aluminium alloy strip according to claim **1**, wherein the aluminium alloy strip has a thickness of 0.5 mm to 4 mm.

8. The Aluminium alloy strip according to claim **1**, wherein the aluminium alloy strip in the soft state has a yield point $R_{p0.2}$ of at least 110 MPa and a tensile strength R_m of at least 255 MPa.

9. A Method for producing an aluminium alloy strip according to claim **1** comprising the following process steps:

casting a rolling ingot;

homogenisation of the rolling ingot at 480° C. to 550° C. for at least 0.5 hours;

hot rolling of the rolling ingot at a temperature of 280° C. to 500° C.;

cold rolling of the aluminium alloy strip to the final thickness with a degree of rolling of 40% to 70% or 50% to 60%; and

soft annealing of the finished-rolled aluminium alloy strip at 300° C. to 500° C. in a continuous furnace.

10. The Method according to claim **9**, wherein after hot rolling alternatively the following process steps are performed:

cold rolling of the hot-rolled aluminium alloy strip to an intermediate thickness which is determined in such a way that the final degree of cold rolling to the final thickness is 40% to 70% or 50% to 60%;

intermediate annealing of the aluminium alloy strip at 300° C. to 500° C.;

cold rolling of the aluminium alloy strip to the final thickness with a degree of rolling of 40% to 70% or 50% to 60%;

soft annealing of the finish-rolled aluminium alloy strip at 300° C.-500° C. in a continuous furnace.

11. The Method according to claim **9**, wherein aluminium alloy strip after soft annealing is cooled to a maximum temperature of 100° C. and then coiled.

12. The Method according to claim **10**, wherein the intermediate annealing is performed in a batch furnace or in a continuous furnace.

13. The Method according to claim **9**, wherein the aluminium alloy strip is cold rolled to a final thickness of 0.5 mm to 4 mm.

14. Method according to claim **9**, wherein the soft annealing is performed in the continuous furnace at a metal temperature of 350° C. to 550° C. for 10 seconds to 5 minutes.

15. A Component for a motor vehicle, composed of an aluminium alloy strip according to claim **1**.

16. The Component according to claim **15**, wherein the component is a body part or a body accessory of a motor vehicle.

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