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(54) Title of the Invention: **A method for forming a part from aluminium alloy**
Abstract Title: **A method of forming a part from aluminium alloy sheet**

(57) A method of forming a part from aluminium alloy by rolling the alloy to form a sheet at a first manufacturing plant and cutting or stamping a blank from the sheet, solution heat treating the blank and placing the blank between dies where it is cooled shaped at a second manufacturing plant. The alloy can be a 6xxx series alloy such as 6082 which is heated to a solution heat treatment temperature in the range 520-575 °C in 30 seconds or less, a 7xxx series alloy such as 7075 with solution heat treatment at a temperature in the range 460-520 °C, a 2xxx series alloy or a 5xxx series alloy.

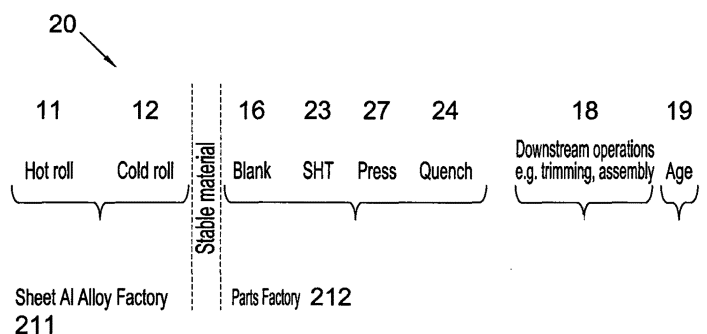


Fig. 2

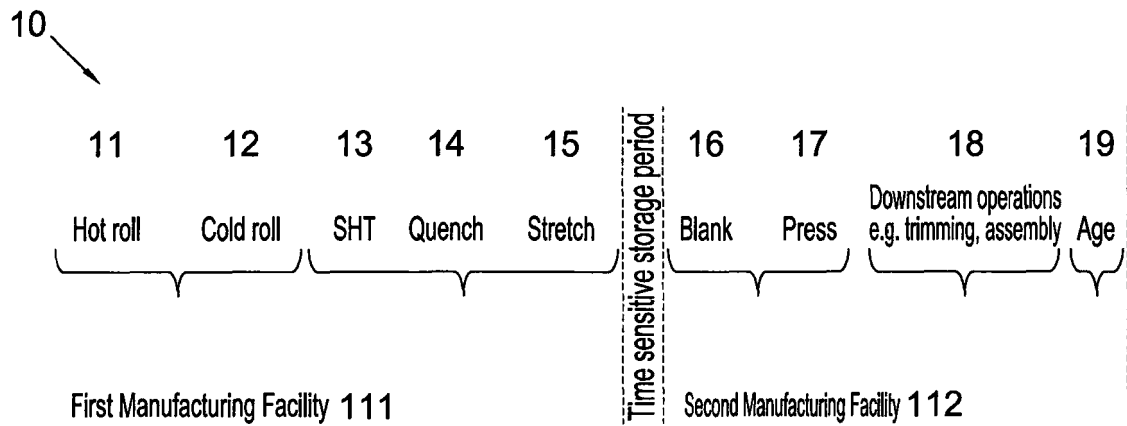


Fig. 1

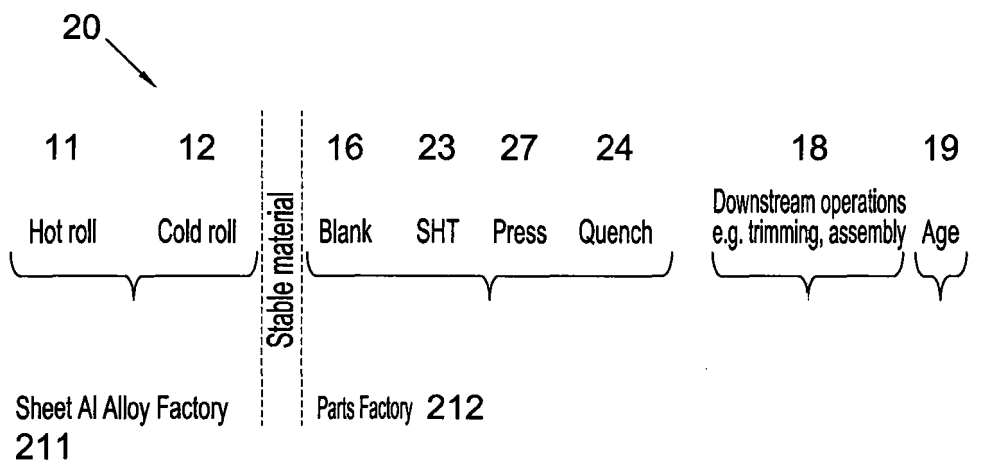


Fig. 2

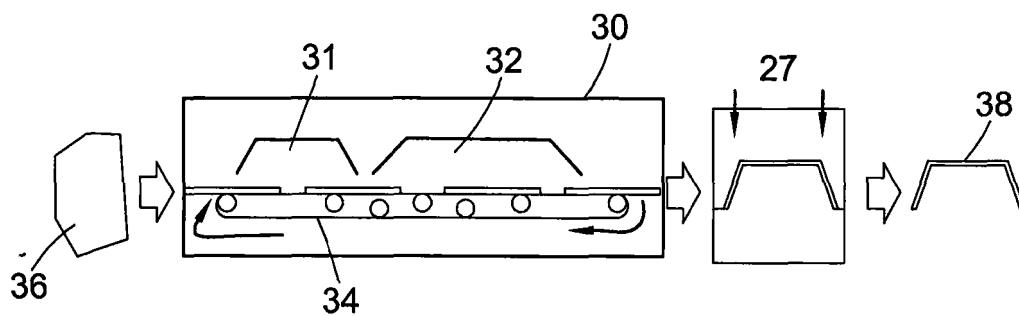


Fig. 3

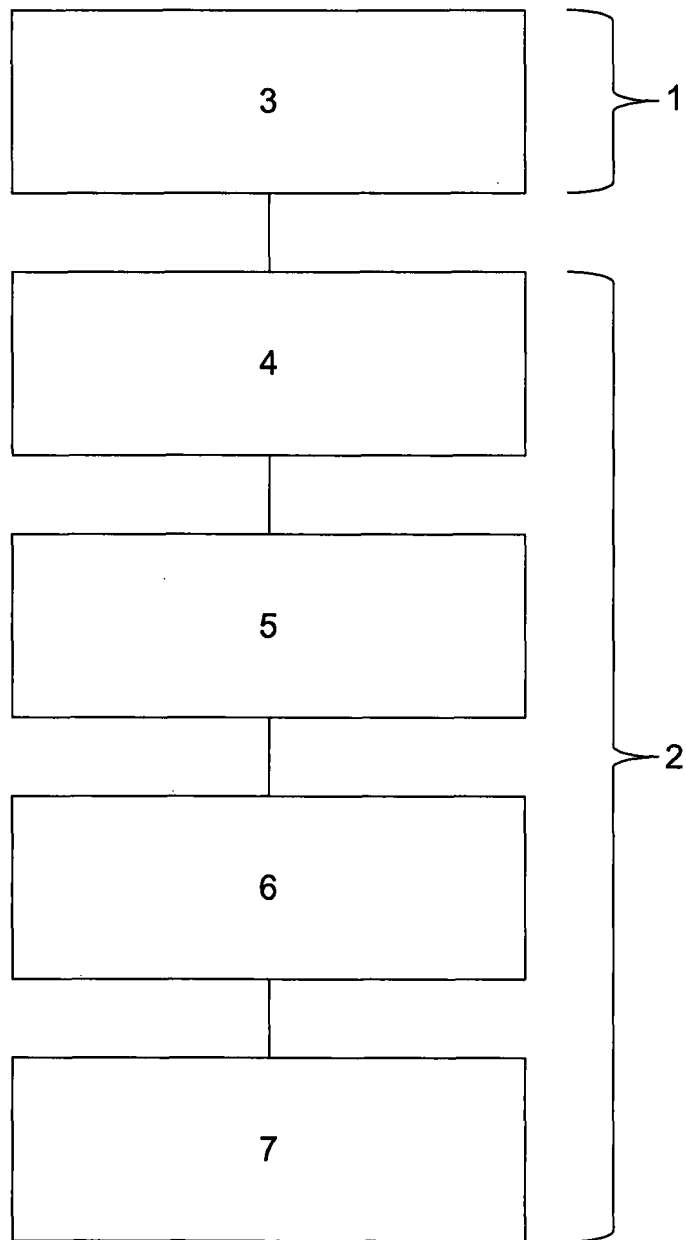


Fig. 4

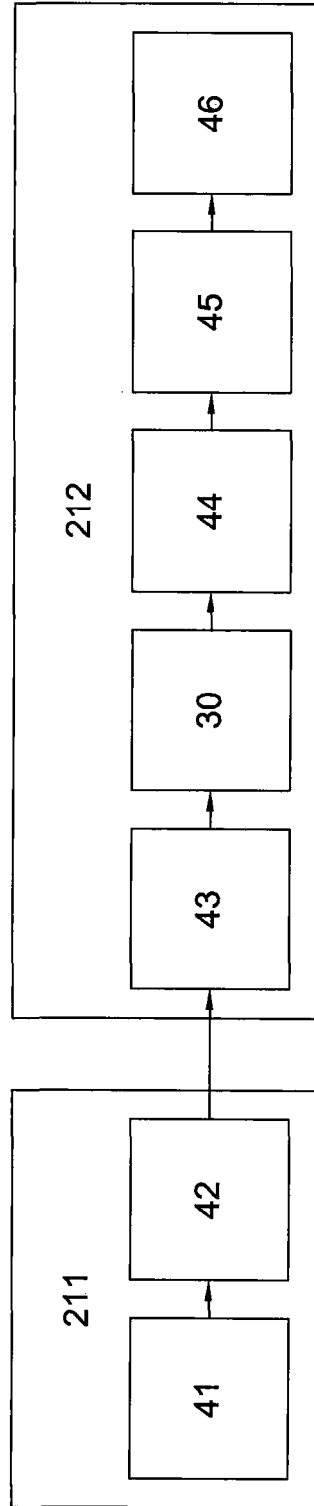


Fig. 5

A METHOD OF FORMING A PART FROM ALUMINIUM ALLOY

FIELD

5 The invention relates to a method of forming a part from aluminium alloy.

BACKGROUND

10 Heat-treatable aluminium alloy can be used to make light-weight parts, for example for automotive and aerospace applications. Such light-weight parts, in these applications, contribute to reducing the weight of an automobile or aircraft and thus can help to reduce its fuel use.

15 In existing methods, heat-treatable aluminium alloy is both rolled and heat-treated (heat treating is also known as “tempering”) at a sheet aluminium manufacturing facility. Tempering involves heating the rolled stock to (or above) its Solution Heat Treatment (SHT) temperature, quenching it quickly to form a supersaturated solid solution, and stretching to remove any distortion introduced during the thermal treatment. This requires a finishing line at the first manufacturing facility. The installation of such a finishing line is a significant expense. The expense of installing such a finishing line acts as a barrier to the more widespread use of heat-treatable aluminium sheet, despite the
20 above advantages associated with this material.

In addition, once the aluminium alloy has been tempered, unless it is also artificially aged, it is not stable at room temperature. It must therefore be used within a certain time after rolling and tempering. Any material not used within this time must be scrapped, or tempered again. Existing
25 methods therefore require either an additional step of artificial aging at the sheet aluminium manufacturing facility, or that the rolled and heat-treated alloy be used within a limited period of time.

30 It is generally desirable to address these problems.

SUMMARY

According to a first aspect of the invention, there is provided a method of forming a part from aluminium alloy, the method comprising the steps of:

- 35
- (a) at a first manufacturing facility, rolling aluminium alloy so as to form sheet aluminium alloy;
 - (b) at a second manufacturing facility, substantially remote from the first manufacturing facility, receiving the sheet aluminium alloy;
 - 40 (c) at the second manufacturing facility, cutting a blank from the sheet aluminium alloy;
 - (d) at the second manufacturing facility, heating the blank to a temperature at which solution heat treatment of the alloy occurs and so as to achieve solution heat treatment; and
- 45

- (e) at the second manufacturing facility, placing the blank between dies so as to cool it and form it into or towards the part.

Steps (a), (b), (c), (d) and (e) may occur in that order.

5

[Effects]

As mentioned above, in existing methods, heat-treatable aluminium alloy is both rolled and tempered at a sheet aluminium manufacturing facility. Tempering requires a finishing line at the sheet aluminium manufacturing facility, the installation of which, as also mentioned above, is a significant expense. Since in the method of the first aspect, SHT is performed at a second manufacturing facility, remote from the first manufacturing facility, the first manufacturing facility need only have equipment to roll the aluminium alloy. This is less expensive than equipment to both roll and temper the alloy, meaning that heat-treatable aluminium alloy sheet in a form usable by manufacturers of complex parts can be made more widely available. Since equipment to heat and form the sheet aluminium alloy is in any case required at the second manufacturing facility, the present method does not result in greater expense at the second facility.

If the alloy is not artificially aged after tempering, it is in the T4 temper. In certain heat-treated conditions, including the T4 temper, sheet alloy is not stable at room temperature and thus must be used within a certain time after rolling and tempering. Any material not used within this time must be scrapped, or tempered again. In the method of the first aspect, rolling the aluminium alloy at the first manufacturing facility, and not tempering it, means that the sheet is stable at room temperature, allowing more time for transfer to the second manufacturing facility, thereby reducing either wastage (by preventing scrapping) or energy use (by preventing re-tempering).

[Alloy]

The aluminium alloy may be of an age-hardening grade. The aluminium alloy may be of a precipitation hardening grade. The aluminium alloy may be a 2xxx, 6xxx or 7xxx series alloy. The aluminium alloy may be 6082. The aluminium alloy may be 7075.

[Blank]

The blank may be an element of substantially the same area as the part to be formed. Solution heat treating only the blank which is to be formed into or towards a complex part, and not the whole sheet from which the blank is cut, saves energy, since a lower mass of material needs to be heated. Furthermore, the tooling costs for the method are greatly reduced since the apparatus required to solution heat treat a blank is smaller and less expensive than the apparatus required to solution heat treat the whole sheet from which the blank is cut.

[Manufacturing facility]

The first manufacturing facility may be a facility at which aluminium alloy is rolled so as to form sheets of aluminium alloy. The second manufacturing facility may be a facility at which parts are

produced from sheets of aluminium alloy. The first manufacturing facility may be a factory arranged to produce sheets of aluminium alloy. The second manufacturing facility may be a factory arranged to produce parts from sheets of aluminium alloy.

- 5 In contrast to existing batch manufacturing methods, where sheets of aluminium are heat treated at a first manufacturing facility, as described above, the present method is an in-line method since a blank is cut, solution heat treated and formed into or towards a part, all at the second manufacturing facility. As discussed above in relation to the blank, the present, in-line, manufacturing method, is significantly more cost-effective than existing manufacturing methods
10 since energy and tooling costs are decreased.

[Substantially remote]

- The distance between the first manufacturing facility and the second manufacturing facility may be
15 such that if step (d) were to take place at the first manufacturing facility, the blank would have cooled to a temperature at which it could no longer be formed between dies by the time it was received at the second manufacturing facility. The distance between the first manufacturing facility and the second manufacturing facility may be at least 500m. The distance between the first manufacturing facility and the second manufacturing facility may be at least 1km. The distance
20 between the first manufacturing facility and the second manufacturing facility may be at least 1.5km. The distance between the first manufacturing facility and the second manufacturing facility may be at least 2km. The distance between the first manufacturing facility and the second manufacturing facility may be at least 10km. The distance between the first manufacturing facility and the second manufacturing facility may be at least 20km. The distance between the first
25 manufacturing facility and the second manufacturing facility may be at least 50km. The distance between the first manufacturing facility and the second manufacturing facility may be at least 100km. The distance between the first manufacturing facility and the second manufacturing facility may be at least 500km. The distance between the first manufacturing facility and the second manufacturing facility may be at least 1000km.

30

[Step (a)]

- Step (a) may comprise hot-rolling and cold-rolling. The sheet aluminium alloy formed by step (a) may be untempered sheet aluminium alloy. The sheet aluminium alloy formed by step (a) may be
35 partially annealed sheet aluminium alloy. The sheet aluminium alloy formed by step (a) may be annealed sheet aluminium alloy.

The sheet aluminium alloy may not have been tempered at the first facility.

- The sheet aluminium alloy may have been partially annealed at the first facility. The sheet
40 aluminium alloy may have been annealed at the first facility. The sheet aluminium alloy may not have been heated at the first facility to a temperature at which SHT of the alloy occurs. The sheet aluminium alloy may not have been stretched at the first facility.

[Step (c)]

45

Step (c) may comprise stamping the blank from the sheet aluminium alloy.

[Step (d)]

- 5 By solution heat treating the blank before it is formed, higher ductilities can be attained than in a process without the SHT step.

[Step (d): target temperature]

- 10 The temperature to which the sheet is heated in step (d) will depend on the alloy and on the application of the finished part. There is a range of temperatures at which SHT can be achieved. The lower end of that range may be the solvus temperature for the alloy. The solvus temperature may be defined as the temperature at which alloying elements in the blank which will precipitate go into solution or start to go into solution. The upper end of that range may be the solidus temperature for the alloy. The solidus temperature may be defined as the temperature at which alloying elements in the blank precipitate. Step (d) may comprise heating the blank to a temperature between the solvus temperature and the solidus temperature for the alloy. Step (d) may comprise heating the blank to at least the temperature at which precipitates in the alloy are dissolved. When the blank is of aluminium alloy 6082, step (d) may comprise heating the sheet to between 520°C and 575°C (575°C is the solidus temperature of aluminium alloy 6082). When the blank is of aluminium alloy 6082, step (d) may comprise heating the sheet to between 520°C and 565°C. When the blank is of aluminium alloy 6082, step (d) may comprise heating the blank to between 560°C and 570 °C. When the blank is of aluminium alloy 6082, step (d) may comprise heating the blank to between 520°C and 540°C. When the blank is of an aluminium 5xxx series alloy, step (d) may comprise heating the sheet to between 480°C and 540°C. When the blank is of an aluminium 7xxx alloy, step (d) may comprise heating the sheet to between 460°C and 520°C. Step (d) may comprise heating the blank to a target temperature.

[Step (d): soaking]

- 30 Step (d) may comprise heating the sheet to a temperature within a range of temperatures at which SHT of the alloy occurs. Step (d) may comprise maintaining the sheet within the range of temperatures for at least 15 seconds. Step (d) may comprise maintaining the sheet within the temperature range for at least 30 seconds. Step (d) may comprise maintaining the sheet within the temperature range for at least 1 minute. Step (d) may comprise maintaining the sheet within the temperature range for at least two minutes. Step (d) may comprise maintaining the sheet within the temperature range for at least three minutes. Step (d) may comprise maintaining the sheet within the temperature range for at least four minutes. Step (d) may comprise maintaining the sheet within the temperature range for at least five minutes. Maintaining the sheet within its SHT temperature range dissolves alloying elements into the metal matrix.

[Step (d): rate of heating]

Step (d) may comprise controlling a rate of heating of the blank to reduce the time taken to achieve SHT of the blank. Reducing the time taken to achieve SHT means that the blank can be processed more quickly and this make production of complex parts more efficient.

- 5 When the aluminium alloy is 6xxx, step (d) may comprise heating the blank in an environment that is at substantially a first temperature that is higher than the target temperature. This increases the rate of heating of the blank towards the temperature at which SHT occurs for the alloy, and thereby increases the efficiency of the method. It may also reduce the time required for solution heat treatment of the alloy to occur. When the aluminium alloy is 6082, the first temperature may be
- 10 between 540°C and 580°C. When the aluminium alloy is 6082, the first temperature may be between 540°C and 560°C. Step (d) may comprise ceasing to heat the blank in an environment that is at substantially the first temperature when the blank reaches a temperature of about 500°C to about 550°C.
- 15 When the aluminium alloy is 6082, the blank may be heated in an environment that is at the first temperature for about 5 minutes. When the aluminium alloy is 6082, the blank may be heated in an environment that is at the first temperature for about 2 minutes or less. When the aluminium alloy is 6082, the blank may be heated in an environment that is at substantially the first temperature for about 30 seconds. When the aluminium alloy is 6082, the blank may be heated in an environment
- 20 that is at substantially the first temperature for less than 30 seconds.

Although SHT of aluminium alloy 6082 can be achieved at 525°C, heating the blank to a temperature higher than this temperature increases the speed at which SHT of the blank is achieved, increasing the efficiency of the method.

- 25 6xxx aluminium alloys are relatively insensitive to the heating rate towards and above the temperature at which SHT occurs, and so heating a blank of 6xxx aluminium alloy in an environment that is at substantially a first temperature greater than the temperature at which SHT occurs provides enough control over the heating rate and the temperature to which the blank is heated to
- 30 avoid alloy elements precipitating at grain boundaries.

- When the aluminium alloy is 7xxx, step (d) may comprise heating the blank in an environment that is at substantially a first temperature that is lower than the temperature at which SHT occurs for the alloy. 7xxx aluminium alloys are more sensitive to the heating rate than 6xxx aluminium alloys. For
- 35 blanks of a 7xxx aluminium alloy, heating the blank in an environment that is at substantially a first temperature that is lower than the temperature at which SHT occurs for the alloy provides ensures that the temperature rise to the SHT temperature for the alloy is gradual, so as to reduce precipitation of the alloy elements. When the aluminium alloy is 7075, the first temperature may be about 470°C

- 40 When the aluminium alloy is 7075, the blank may be heated in an environment that is at substantially the first temperature for less than 10 minutes. When the aluminium alloy is 7075, the blank may be heated in an environment that is at substantially the first temperature for less than 2 minutes.

45

Step (d) may comprise heating the blank in an environment that is at substantially the first temperature and then heating the blank in an environment that is at substantially a second temperature. When the aluminium alloy is 6xxx, the second temperature may be lower than the first temperature. When the aluminium alloy is 7xxx, the second temperature may be higher than the first temperature. The second temperature may be greater than or substantially equal to the temperature at which SHT of the alloy occurs. When the blank is of a 7xxx alloy, the second temperature may be 490°C. When the blank is of a 6xxx alloy, the second temperature may be 535°C.

- 10 The temperature of the blank can be raised towards the SHT temperature relatively rapidly by the heating towards the first temperature. Heating towards the second temperature can then be used to control more precisely the rate of heating of the blank to the SHT temperature.

[Step (d): manner of heating]

- 15 The environment that is at substantially the first temperature may be a first environment and the environment that is at substantially the second temperature may be a second environment. Step (d) may comprise using heating apparatus to heat the blank. The heating apparatus may be an oven. The heating apparatus may be a furnace. The oven may comprise a first region at substantially the first temperature. The first environment may be the first region. Step (d) may comprise heating the blank in the first region of the heating apparatus.

- 20 The heating apparatus may comprise a second region at substantially the second temperature. The second environment may be the second region. Step (d) may comprise transferring the blank from the first region of the heating apparatus to the second region of the oven and heating the blank in the second region of the heating apparatus.

[Step (e)]

- 30 The dies may be at substantially a lower temperature than the blank. The dies may be unheated. The dies may be cooled. The maximum suitable temperature depends on the alloy being formed. The dies may be at a temperature of 100°C or at a temperature below 100°C. Placing the blank between the dies may be so as to quench the blank.

- 35 [Step (e): effects]

- 40 By forming the sheet in that are at substantially a lower temperature than the blank, the problems of warm forming of low cost-effectiveness (due to heating of the sheet and the die set), and of the possibility of destruction of the microstructure of the workpiece (degrading post-form strength), are avoided.

[Further Step]

- 45 The method may comprise an additional step between step (d) and step (e) of cooling the sheet. The additional step may comprise applying a cooling medium to the sheet. Step (b) may comprise

directing a cooling medium at the heated sheet. When an oven is used to heat the blank, the additional step may comprise removing the blank from the oven. The method may comprise an additional step (f), after step (e), of any of trimming, hemming or joining the blank.

- 5 When the alloy is an age-hardening grade, including when the alloy is aluminium alloy 2xxx, 6xxx or 7xxx, the method may comprise an additional step (g), after step (e) or step (f), of artificial ageing of the part. Step (g), of artificial aging of the part, may comprise heating the part and maintaining it at this temperature so as to achieve precipitation heat treatment. Step (g) may comprise heating the part and maintaining it at this temperature so that alloying elements are precipitated. Step (g) may
10 comprise heating the blank and maintaining it at this temperature so as to form T6 or T7 tempered microstructure in the blank.

[Part]

- 15 The method may be a method of forming a complex part. The method may be a method of forming parts for automotive applications. The method may be a method of forming parts for aerospace applications. The method may be a method of forming panel parts for aerospace applications. The method may be a method of forming interior structural sheet components, load-bearing parts, or parts adapted to bear load in static or moving structures.

- 20 The method may be a method of forming conceivably any part that might beneficially be formed from high-strength, heat-treatable aluminium alloy sheet. As discussed above, the expense involved in installing traditional tempering equipment at a first manufacturing facility is currently a barrier to the widespread use of these grades of aluminium alloy. Use of the present method would at least
25 lower this barrier.

[Other Aspects]

- According to a second aspect of the invention, there is provided a method of forming a part from
30 sheet aluminium alloy, the method comprising the steps of:

- (a) cutting a blank from the sheet aluminium alloy;
- (b) heating the blank to a temperature at which solution heat treatment of the alloy occurs so as to
35 achieve solution heat treatment; and
- (c) placing the blank between dies so as to cool it and form it into or towards the part.

- According to a third aspect of the invention, there is provided a method of solution heat treating
40 6xxx series aluminium alloy, the method comprising the steps of:

- (a) heating the aluminium alloy in an environment that is at substantially a first temperature that is higher than a temperature at which SHT occurs for the alloy; and then

(b) heating the aluminium alloy in an environment that is at substantially a second temperature that is lower than the first temperature.

According to a fourth aspect of the invention, there is provided a method of solution heat treating 7xxx series aluminium alloy, the method comprising the steps of:

(a) heating the aluminium alloy in an environment that is at substantially a first temperature that is lower than a temperature at which SHT occurs for the alloy; and then

(b) heating the aluminium alloy in an environment that is at substantially a second temperature that is substantially equal to or greater than a temperature at which SHT occurs for the alloy.

Optional features of any aspect may also be optional features of any other aspect.

BRIEF DESCRIPTION OF THE DRAWINGS

Specific embodiments of the invention are described below by way of example only and with reference to the accompanying drawings, in which:

Figure 1 shows an existing method of manufacturing a part from sheet aluminium alloy;

Figure 2 shows an embodiment of the method of the first aspect of manufacturing a part from sheet aluminium alloy;

Figure 3 shows a heating apparatus, in the form of an oven, for use with the method;

Figure 4 shows, in a flow diagram, the method of the first aspect of manufacturing a part from sheet aluminium; and

Figure 5 shows, schematically, an apparatus for use with the method.

SPECIFIC DESCRIPTION OF CERTAIN EXAMPLE EMBODIMENTS

[Figure 1: Existing Process]

An existing method of manufacturing a part from sheet aluminium alloy is shown in Figure 1.

Initially, sheet aluminium alloy is manufactured at a first manufacturing facility 111. This process is shown at the left of Figure 1. The sheet is made from aluminium alloy by first hot-rolling 11 the aluminium alloy and then cold-rolling 12 the sheet thus produced. At this stage, if existing forming methods are to be used, the sheet must be heat-treated to enable a part with satisfactory mechanical properties to be formed from the sheet. This heat treatment, also known as

“tempering” includes the following steps: heating the sheet to at least its SHT temperature 13, and then quenching 14 it so that the structure of the sheet is in super saturated solid solution. The final

step that takes place at the first manufacturing facility is stretching 15 the sheet. This is necessary to remove any distortion which heating and quenching the sheet has introduced. The aluminium alloy sheet is then ready for sale to producers of parts of sheets of aluminium alloy.

As noted above, however, it is expensive to install a finishing line to perform the steps of SHT 13, quenching 14 and stretching 15 that are currently required by producers of parts from sheet aluminium alloy. Thus, despite the advantages associated with parts formed of aluminium alloy – in particular that such parts are lighter-weight than parts formed from many other metals - this expense means that sheets of aluminium alloy required in order to make aluminium alloy parts are not as widely available as would be desirable. Furthermore, the sheets of aluminium alloy thus produced reduce in ductility over time. Thus, any manufacturer of parts from sheet aluminium alloy must obtain and use the sheet aluminium alloy produced at the first manufacturing facility within a limited period of time, while the ductility of the sheet is still great enough for a part to be formed. This can be within as little as three months from production at the first manufacturing facility.

At a secondary manufacturing facility, which is a factory that produces parts from sheets of aluminium alloy, a blank is cut or stamped 16 from sheet aluminium alloy produced at the manufacturing facility. A blank is a portion of sheet aluminium alloy that has approximately the same area as a part to be formed from sheet aluminium alloy. If the blank, once pressed, is to be trimmed in order to complete the part, the blank will be a portion of the sheet aluminium alloy with a greater area than the part eventually to be formed. In general, the dimensions of the blank cut from the aluminium sheet are selected to provide adequate sheet for the forming of a part, without wasting the material by using more than is required. Once a blank has been cut from the aluminium alloy sheet supplied by the first manufacturing facility, the blank is pressed 17 to form a part. Finishing of the part can involve trimming it, or assembling it with other parts 18. Finally, the part is aged 19.

[Figure 4: overview of the method]

Figure 4 shows, in a flow diagram, the method of the first aspect of manufacturing a part from sheet aluminium. The method comprises the following steps:

(a) at a first manufacturing facility 1, rolling 3 aluminium alloy so as to form sheet aluminium alloy;

(b) at a second manufacturing facility 2, substantially remote from the first manufacturing facility, receiving 4 the sheet aluminium alloy;

(c) at the second manufacturing facility 2, cutting 5 a blank from the sheet aluminium alloy;

(d) at the second manufacturing facility 2, heating 6 the blank to a temperature at which solution heat treatment of the alloy occurs and so as to achieve solution heat treatment; and

(e) at the second manufacturing facility 2, placing 7 the blank between dies so as to cool it and form it into or towards the part.

[Figure 2: steps of the method]

Figure 2 shows an embodiment 20 of the method of manufacturing a part from sheet aluminium alloy. In this embodiment, the aluminium alloy is 6082. The method 20 takes place at a first manufacturing facility and a second manufacturing facility. The first manufacturing facility is a sheet aluminium alloy factory 211. The second manufacturing facility is a parts factory 212. In this embodiment 20, the method includes the followings steps:

- A. at the sheet aluminium alloy factory 211, aluminium alloy is hot-rolled 11 and then cold-rolled 12 to form sheet aluminium alloy;
- B. the sheet aluminium alloy is transferred to the parts factory 212 and received there;
- 10 C. at the parts factory 212, a blank 36 (shown in Figure 3) is cut 16 from the sheet aluminium alloy;
- D. at the parts factory 212, SHT is performed 23 on the blank 36;
- E. at the parts factory 212, the blank 36 is pressed 27 to form a part 38 (shown in Figure 3) and simultaneously quenched 24;
- 15 F. also at the parts factory 212, the part 38 is trimmed 18; and
- G. finally, still at the parts factory 21, the part 38 is artificially aged 19.

These steps are described in more detail below. It should be noted that the present method is not simply an alternative division of the steps of producing a part from sheet aluminium alloy between two manufacturing facilities. Rather, the present method makes use of the process of hybrid forming and quenching (HFQ (RTM)) as disclosed in EP2324137, to rearrange and divide these steps with advantages that will be discussed below.

At step A, in the present method 20, aluminium alloy is hot-rolled 11 and cold-rolled 12 as described above in relation to the existing method 10. Existing hot-rolling apparatus 41 and cold-rolling apparatus 42 (both shown schematically in Figure 5) is used for this.

25 In this embodiment 20, substantially no further steps are carried out at the sheet aluminium alloy factory 211. Once a sheet has been produced by hot-rolling 11 and cold-rolling 12, the sheet is stable. There is thus no limit on the time in which it must be received at the parts factory 212, and also no limit on the time within which the sheet aluminium alloy must be used to form a part 38. In addition, by contrast to the existing method described above, the step (A) to be performed at the sheet aluminium alloy factory 211 is simpler. No finishing line for solution heat treating, quenching and stretching the sheet is required at the sheet aluminium alloy factory 211. Tooling costs and energy costs for the sheet aluminium alloy factory 211 are therefore low compared to those of the first manufacturing facility using the existing method.

At step B, the sheet is transferred to the parts factory 212 and received there.

At step C, at the parts factory 212, a blank 36 is cut 16 from the sheet aluminium alloy. This step is carried out using existing cutting apparatus 43 (shown in Figure 5) in substantially the same manner as in the existing method 10.

Next, at step D, the blank 36 is solution heat treated 23 in an oven 30 (shown in Figures 3 and 5).

- 5 The SHT 23 of the blank 36 in this embodiment will be described further below with reference to Figure 3. Solution heat treating only the blank 36 cut from the aluminium alloy sheet, and not solution heat treating the whole of the aluminium alloy sheet (as is done in an existing method) saves energy, since the smaller area or volume of material is required to be solution heat treated.

- 10 Next, the sheet is transferred to a press 44 (shown schematically in Figure 5). At step E, the blank 36 is pressed and held between cooled dies 27 of the press 44 which rapidly reduce its temperature 24. This thus forms 27 the part 38 at the same time as quenching it 24, creating a quenched, tempered micro structure.

At step F, the pressed part 38 is trimmed 18 (as discussed above with reference to Figure 1).

Finally, at step G, the part 38 is artificially aged 19.

- 15 Trimming 18 and aging 19 of the part 38 are both carried out in known fashion using known trimming apparatus 45 and artificial aging apparatus 46 respectively (both apparatuses are shown schematically in Figure 5).

[Figure 3: Step D in more detail]

- 20 Figure 3 illustrates steps C, D, and E of the method and thus shows, schematically, the apparatus used for step D. In this embodiment, the apparatus used to perform SHT 23 on the blank 36 (that is, to perform step D) is an oven 30. In this embodiment, the oven has two zones each at a different temperature. The temperature in the first oven zone 1 is higher than that in the second oven zone 32. In this embodiment, the temperature in the first zone 1 of the oven is 580°C.
- 25 To perform step D, the blank 36 is conveyed into the oven 30 and into the first oven zone 31 by a conveyor 34. The speed at which the blank 36 passes through the oven is controlled. In this embodiment it is controlled so that the blank 36 remains in the first zone 31 of the oven 30 for long enough to rise in temperature to between about 520°C and 540°C. The exact time taken to reach this temperature, and thus the rate at which the blank 36 is conveyed through the oven 30, depends
- 30 on the size and thickness of the blank 36. A time for the blank 36 to reach a temperature between 520°C and 540°C is calculated based on its size and thickness. The blank remains in the first zone 31 of the oven 30 for this time. Once the blank 36 has been heated for this time and is thus within this temperature range, the blank 36 is conveyed to the second zone 32 of the oven 30. The temperature in the second zone 32 of the oven 30 is 535°C. This is the SHT temperature for the
- 35 alloy. The rate at which the conveyor 34 conveys the blank 36 is through this second zone 32 of the oven 30 is such as to hold the blank 36 at the temperature of the second zone 32 of the oven 30 until SHT is achieved; that is, until precipitates in the alloy are dissolved. The conveyor 34 then conveys the blank 36 out of the oven 34 so that step E can take place.

[Alternative embodiment: aluminium alloy is 7075]

In an alternative embodiment of the method, the aluminium alloy is 7075. As described above in relation to aluminium alloy 6082, in this alternative method, at the sheet aluminium alloy factory 211, aluminium alloy is hot-rolled 11 and then cold-rolled 12 to form sheet aluminium alloy (step A); the sheet aluminium alloy is transferred to the parts factory 212 and received there (step B); and at the parts factory 212, a blank 36 is cut 16 from the sheet aluminium alloy (step C). The alternative embodiment of the method differs, however, from the method performed on aluminium alloy 6082 in step D: performing SHT 23 on the blank 36 in the parts factory 212. The remaining steps (E, F and G) of the method of the alternative embodiment are as described above in relation to aluminium alloy 6082.

7xxx aluminium alloys are more sensitive to the heating rate than 6xxx aluminium alloys. Thus, in step D of the alternative embodiment, the blank 36 is heated more slowly than in the embodiment in which the blank is of aluminium alloy 6082 so as to reduce precipitation of the alloy elements. The manner of achieving this slower heating of the blank 36 will be described further below. The apparatus used for step D in this embodiment is structurally the same as the apparatus used for step D in the embodiment in which the blank is of aluminium alloy 6082. It is an oven 30, as shown in Figure 3. The temperatures in the two zones of the oven 30 in this alternative embodiment differ from the temperatures in the oven 30 of the embodiment in which the blank is of aluminium alloy 6082. The temperature in the first zone 31 of the oven is lower than that in the second zone 32 of the oven. In this embodiment, the temperature in the first zone 31 of the oven 30 is 470°C. The temperature in the second zone 32 of the oven is 490°C: a temperature at which SHT of aluminium alloy 7025 occurs. The temperature in the first zone 31 of the oven 30 in this embodiment is therefore lower than the temperature in the first zone 31 of the oven 30 in the embodiment in which the blank is of aluminium alloy 6082, which was 580°C.

In step D, the blank 36 is placed on a conveyor 34 which carries the blank 36 into the first oven zone 31. The speed of the conveyor 34 is set to ensure that the blank 36 spends enough time in the first oven zone 31 to rise in temperature to about 470°C. As mentioned above, this is the temperature of the first zone 31 of the oven. Since the temperature of the first oven zone 31 in this embodiment is lower than in the embodiment in which the blank is of aluminium alloy 6082, the blank 36 in this embodiment is heated more slowly than in the embodiment in which the blank is of aluminium alloy 6082. The exact time that the blank 36 will take to reach the temperature of the first zone 31 of the oven 30 depends on the size and thickness of the blank 36. The speed of the conveyor 34 is calculated accordingly. From the first zone 31 of the oven 30, the blank is conveyed to the second zone 32 of the oven 30. As mentioned above, the temperature in the second zone 32 of the oven 30 is 490°C. The second zone 32 of the oven 30 is longer than the first zone 31, such that for a given speed of the conveyor 34, the blank 36 remains in the second zone 32 for longer than in the first zone 31. The blank 36 remains in the second zone 32 of the oven for long enough to reach the temperature of the second zone 32 of the oven and to remain at that temperature until SHT is achieved; that is, until precipitates in the alloy are dissolved. The conveyor 34 then conveys the blank 36 out of the oven 30, and step D is complete. Steps E, F and G are then performed on the blank 36 in the manner described above with reference to Figure 2.

CLAIMS

1. A method of forming a part from aluminium alloy, the method comprising the steps of:
 - (a) at a first manufacturing facility, rolling aluminium alloy so as to form sheet aluminium alloy;
 - (b) at a second manufacturing facility, substantially remote from the first manufacturing facility, receiving the sheet aluminium alloy;
 - (c) at the second manufacturing facility, cutting a blank from the sheet aluminium alloy;
 - (d) at the second manufacturing facility, heating the blank to a temperature at which solution heat treatment of the alloy occurs and so as to achieve solution heat treatment; and
 - (e) at the second manufacturing facility, placing the blank between dies so as to cool it and form it into or towards the part.
2. The method of claim 1, in which steps (a), (b), (c), (d) and (e) occur in that order.
3. The method of claim 1 or claim 2, in which the blank is an element of substantially the same area as the part to be formed.
4. The method of any preceding claim, wherein in step (b), the sheet aluminium alloy has not been tempered at the first facility.
5. The method of any preceding claim, wherein step (d) comprises controlling a rate of heating of the blank so as to reduce the time taken to achieve solution heat treatment of the blank.
6. The method of claim 5, wherein step (d) comprises heating the blank in an environment that is at substantially a first temperature which is higher than the temperature at which SHT occurs for the alloy.
7. The method of claim 6, wherein step (d) comprises heating the blank in an environment that is at substantially the first temperature and then heating the blank in an environment that is at substantially a second temperature that is lower than the first temperature.
8. The method of claim 7, wherein the second temperature is greater than or substantially equal to the temperature at which SHT of the alloy occurs.
9. The method of any of claims 5 to 8, wherein the aluminium alloy is a 6xxx series alloy.
10. The method of claim 9, wherein the aluminium alloy is 6082.

11. The method of claim 10, wherein the first temperature is between 540°C and 560°C.

12. The method of claim 10 or of claim 11, wherein step (d) comprises heating the blank towards the first temperature for 30 seconds or less than 30 seconds.

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13. The method of any of claims 1 to 4, wherein step (d) comprises controlling a rate of heating of the blank so as to reduce precipitation of the alloy elements.

14. The method of claim 14, wherein step (d) comprises heating the blank towards a first temperature which is lower than the temperature at which SHT of the alloy occurs and then heating the blank towards a second temperature that is substantially equal to the temperature at which SHT of the alloy occurs.

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15. The method of claim 13 or of claim 14, wherein the aluminium alloy is a 7xxx series alloy.

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16. The method of claim 15, wherein the aluminium alloy is 7075 and wherein the first temperature is about 470°C.



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Claims searched: 1-16

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Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-6,9-16	US 2012/0073347 A1 (LUCKEY) - the whole document, especially paragraphs [0029]-[0044] and figure 3.
X	1-6,9-16	WO 2014/068493 A1 (AISIN) - the whole document, especially paragraphs [0015], [0019] & [0028]-[0033] and figure 1.
X	1-6,9-16	US 2012/0152416 A1 (FOSTER) - the whole document, especially paragraphs [0010]-[0015], [0025]-[0026] & [0035] and figure 1
X	1-6,9-16	WO 2008/059242 A2 (UNIVERSITY) - the whole document, especially page 3 lines 10-20.
X	1 at least	WO 2009/130175 A1 (ALERIS) - the whole document, especially page 2 lines 1-15 and page 3 lines 6-26.
X	1 at least	JP 2010159489 A (SUMITOMO) - the EPODOC abstract.
X	1 at least	JP 2010159488 A (SUMITOMO) - the EPODOC abstract.

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