(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 896 188 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
20.10.2021 Bulletin 2021/42

(51) Int Cl.:
C22F 1/04 *(2006.01)* ***C22F 1/00*** *(2006.01)*
C21D 1/673 *(2006.01)*

(21) Application number: **20169730.7**

(22) Date of filing: **15.04.2020**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicants:
- **Politechnika Wroclawska**
  50-370 Wrocklaw (PL)
- **Kirchhoff Polska**
  39-300 Mielec (PL)

(72) Inventors:
- **Kaczynski, Pawel**
  53-617 Wroclaw (PL)
- **Jaskiewicz, Karol**
  50-305 Wroclaw (PL)
- **Gronostajski, Zbigniew**
  53-336 Wroclaw (PL)
- **Polak, Slawomir**
  56-500 Syców (PL)
- **Krawczyk, Jakub**
  58-260 Bielawa (PL)
- **Skwarski, Mateusz**
  67-120 Kozuchów (PL)
- **Chorzepa, Wladyslaw**
  39-300 Mielec (PL)
- **Sliz, Krzysztof**
  39-331 Chorzelów (PL)
- **Uzar, Slawomir**
  39-331 Chorzelów (PL)

(54) A METHOD OF MANUFACTURING OF ENERGY-ABSORBING ELEMENTS MADE OF AGE-HARDENABLE ALUMINUM ALLOY SHEETS THAT FACILITATE FURTHER JOINING

(57) The purpose of the invention was to develop a new method of manufacturing of energy-absorbing elements made of aluminum alloy sheets that facilitate further joining. A method of manufacturing of energy-absorbing elements made of aluminum alloy sheets that facilitates further joining is disclosed. The method comprises steps of: cutting out the blank from sheet metal, heating an Al-alloy blank to its solution heat treatment temperature (T_{SHT}) and holding it until solution heat treatment (SHT) is complete, immediate transferring of hot blank to a forming station, preforming of hot blank, i.e. simultaneous stamping and cooling the blank, in order to produce a solutionized preform having shape intermediate between the blank and a final product, finishing stamping of the cold preform to obtain the final shape of the drawpiece, trimming, in order to remove the excess of the material and subjecting components to artificial ageing in order to increase the strength of the material.

EP 3 896 188 A1

Description

[0001] Various methods of producing energy-absorbing elements made of age-hardenable aluminum alloy sheets are commonly known. Most of them involve solution heat treatment (SHT) and artificial ageing steps. The application of these methods in the automotive industry is usually limited by the time in which all the operation (i.e. forming, joining with other components and artificial ageing) following after solutionizing must be done. Another well-known approach is to use an age-hardenable aluminum alloy in T6 temper and heat it up only below SHT temperature. This increases the plastic properties of the material by some amount and allows to stamp complicated shapes. The main limitation is the decrease of the strength of the final product which cannot be reversed without heat treatment.

[0002] A method of forming a metal alloy sheet component taking advantage of SHT is presented in WO2008059242A2 international patent (Process for forming metal alloy sheet components). The method comprises of heating a metal alloy sheet blank to its SHT temperature and maintaining that temperature until SHT is complete, rapid transferring the sheet blank to a set of cold dies, immediate closing the cold dies to form the sheet blank into a shaped component, and holding the formed component in the closed dies during cooling of the formed component. An additional artificial ageing step at the end of the process is added which allows precipitation hardening to occur.

[0003] The main disadvantage of the described method is that the part is formed in one step. Therefore there is large risk of thinning and cracking in case of forming of part of a complex geometry (i.e. deep drawing operation combined with small radius of the final part). The second disadvantage is that the part after forming must be artificially aged in just a few hours to prevent uncontrolled artificial ageing. Additionally, the joining of the final product follows after artificial ageing, which hardens the final product and increases its strength. This makes the joining process more difficult and increases the wear of joining tools.

[0004] Another approach is presented in the US10029624 patent (Sheet metal molding for motor vehicles and process for producing a sheet metal molding for motor vehicles). The process involves the production of parts by hot forming from a metal sheet composed of an aluminum alloy which cannot be precipitation hardened, which contains at least magnesium and optionally manganese in addition to aluminum as an alloy component. The metal sheet is heated at least locally to a temperature in the range from 200°C to 400°C for a period of time equal to 1-60 seconds. The heated metal sheet is subsequently placed in a forming tool of a forming press and formed to produce the final part.

[0005] The limitation of this solution is that local heating of the formed sheet leads to its partial softening. As a result, the unfavorable gradient of the strength is obtained.

[0006] The another solution is presented in US20120186706A1 patent (Stamping of age-hardenable aluminum alloy sheets). It consists of preparing an overaged aluminum alloy by heating it up to SHT temperature, rapid cooling and aging the alloy to peak strength and continuing to age the alloy until its strength is less than 90% of its peak aged strength. In the next step, a cold forming by stamping is done, but only to a certain degree. As a result a preformed sheet with a shape intermediate between that of the workpiece and the component is produced. Next, heating up the preform, holding it and rapid cooling it is repeated to retain the dissolved alloying elements in the aluminum matrix. Further, the preform is stamped again to fully form the component and exposed to a suitable temperature and for a suitable time to age and strengthen the component.

[0007] The main disadvantage is the complexity of the process. It involves two full cycles of heating, holding and rapid cooling and additional age-hardening of the final product after the last stamping phase. It makes the use of this method in the automotive industry unprofitable and practically impossible.

[0008] Another technology for forming a 6xxx or 7xxx series Al alloy blank is presented in EP3467138 patent (Method and system for forming aluminum alloy blank). The method comprises the steps of heating the blank to an SHT temperature, holding it until SHT is complete, cooling the blank at a cooling station to an intermediate temperature at which the kinetic movement of atoms in the blank stops and at a cooling rate that is high enough to stop the re-crystallization in the alloy. Next, the warm blank is formed and quenched to room temperature. After stamping artificial ageing is performed in an ageing station.

[0009] The disadvantage of this technology is the lower strength of the final product which is caused by structural changes occurring during stamping in elevated temperature. Additionally, the mentioned technology requires more time to perform two-stage cooling.

[0010] Another approach is presented in US8613820B2 patent (Structural automotive part made from an Al-Zn-Mg-Cu alloy product and method of its manufacture). The method comprises of solution heat treatment (SHT) and subsequent quenching of a rolled aluminum sheet having a gauge in a range from 0.5 to 4 mm. Then the sheet metal is stored for maximum 10 hours prior to the forming operation. Before forming material is once again soaked for a period of 3 seconds to 10 minutes at a temperature in a range from 400 °C to 490 °C and then rapidly cooled or quenched. The last step is subjecting motor vehicle component to a paint bake cycle that comprises of holding the component at a temperature in a range from 140 °C to 190 °C for a period of 10-40 minutes.

[0011] The limitation of this solution is the use of an additional annealing operation to eliminate the strengthening effect resulting from natural aging.

[0012] The other method is presented in EP3117019A2 patent (A method of forming parts from sheet metal alloy). The method concerns forming parts from sheet metal alloy and comprise the steps of: heating the sheet to a temperature at which SHT of the alloy occurs and so as to achieve SHT, applying at least the critical cooling rate and then placing the sheet between dies to form it into or towards the complex part.

[0013] The disadvantage of this solution is that cooling the blank in a separate operation results in its bending. The situation occurs independetly of cooling method (by immersion in water, between cooled plates), which is depicted in fig. 5.

[0014] The purpose of the invention was to develop a new method of manufacturing of energy-absorbing elements made of aluminum alloy sheets that facilitate further joining. The developed method enables simultaneous production of the drawpieces and solutionizing of the material, which ensures outstanding plastic properties. Additionally, the final product may be cooled down, which allows the so-called "freezing the structure" and prevents natural aging. This results in holding high plastic properties of the drawpiece for a longer period of time. The advantage of this solution is the possibility of using joining methods taking advantage of high plastic properties of the material (such as clinching or riveting) after finishing stamping. At the end of the process, the artificial ageing is performed which restores high strength of the final product. It is also possible to perform artificial ageing during the paint bake cycle of paint layers applied beforehand.

[0015] The essence of the method is the manufacturing of energy-absorbing elements made of aluminum alloy sheets (specifically 2xxx, 6xxx or 7xxx). **It consists of 7 main steps** (as depicted in fig. 1). In the **first** of them, the blank is cut out from the rolled sheets of metal. This step is usually done in the punching process by means of the stamp and the die. In the **second** step, the blank is heated up to solution heat treatment temperature (T_{SHT}), so that the strengthening phases dissolve in the solid matrix solution. This is preferably done in the type of furnace taking advantage of convection heating, which allows minimizing the time needed to reach SHT temperature. This step is being continued for a period of time that allows to fully dissolve hardening phases into an aluminum-rich solid solution. Immediately after this, the **third** step is performed. It consists of transferring the blank to the stamping station. The transfer time should be minimized in order to prevent an excessive reduction in the temperature of the blank. Next, the blank is formed in two stages (**fourth** and **fifth** step). First, it is preformed, i.e deformed into an intermediate shape between the flat blank and the final geometry of the part. The main goal of this step is to dissipate the blank's heat to the forming tools, which allows the material to be solutionized. Therefore, the deformation level reached in this step is significantly lower than during the second stamping step. In the next forming step, the beforehand solutionized preform is subjected to finishing stamping, which allows obtaining the desired final shape of the drawpiece. Following this, the drawpiece is subjected to the **sixth** step during which the part is being trimmed, in order to remove the excess of the material. This step is usually done in the punching process. In the last, **seventh** stage of the presented method, the standalone drawpiece or the assembly of the drawpiece with other parts is artificially aged. This is obtained by holding the drawpiece at elevated temperature for a specific amount of time. The artificial ageing may be done during the paint bake cycle or any other process focused on the restoration of high strength properties close to the properties of T6 temper. Additionally, the drawpieces undergoing artificial ageing may be overaged for improvement of the strength stability over time.

[0016] The main advantage of two-stage stamping is that after the first stamping stage material is solutionized which makes it more susceptible to further stamping operations. In the first stage the larger radius and small strain should be obtained, whereas in the second operation the lager strain and small radius could be performed. This approach is not mentioned in other patents. The large strain and complex shape of the final product may be obtained due to the proper cooling conditions applied in the preforming, i.e. cooling rate larger than 20 °C/s to temperature below 200°C (Fig. 6). The optimal cooling rate equals to 40 °C/s.

[0017] This behavior results from the character of the stress-strain curve of solutionized material, which is depicted in fig. 4. The solutionized material is characterized by about 3 times lower yield stress and the ultimate tensile strength lower by about 40% in comparison to as delivered, T6 temper material. This results in a decidedly lower stamping force. The additional advantage is significantly larger strain hardening exponent. This prevents the localization of strain and increases the chance of manufacturing complex shapes drawpieces free from cracks and excessive thinning of drawpieces. Additionally, the material after solutionization is characterized by a larger strain level at the instant of failure. Therefore, the deeper drawing of drawpieces may be involved during the second stage of the stamping. The drawpieces after finishing stamping are in the so-called "soft state".

[0018] Optionally the part after **sixth** step (the trimming operation) may be cooled and stored at a sub-zero temperature, which allows maintaining high plastic properties of the material for a decidedly longer period of time. Without freezing the parts material starts immediately to age naturally. Just after 3 h the material's hardness increases by 22% (fig. 3). The parts cooled to sub-zero temperatures gain only 5% of the strength after 7 days (fig. 2). Therefore, the cooling to sub-zero temperatures allows maintaining the drawpiece in the so-called "soft" state. Thanks to phenomenon the joining process can be postponed and almost no age hardening occurs. Thanks to this, the joining forces can be minimized, and the drawpiece can be assembled easily with other parts.

[0019] Preferably the aluminum alloy sheet of a thickness range from 0.5 mm to 4 mm is used.

[0020] Preferably the cutting out the blank from sheet metal in the first step is done in the process of punching by means of the punch and the die or by laser cutting.

[0021] Preferably the temperature of solution heat treatment (T_{SHT}) to which the blank is heated up in the second step is in the range of (450 to 550) °C.

[0022] Preferably the T_{SHT} of the blank in second step is maintained for 10 to 60 minutes which allows to fully dissolve hardening phases into an aluminum-rich solid solution.

[0023] Preferably the transfer of the hot blank from a heating station to the preforming station in the third step is done within 30 seconds.

[0024] Preferably the initial temperature of the hot blank at the instant when preforming (fourth step) is started is not lower than (T_{SHT} - 150) °C.

[0025] Preferably the deformation level in preforming step (fourth step) is significantly lower than deformation level in finishing forming step (fifth step).

[0026] Preferably simultaneous preforming and cooling in the fourth step is done by means of tools being cooled by fluid, preferably by water.

[0027] Preferably each radius of the blank after preforming operation (fourth step) is larger than 15 mm.

[0028] Preferably the blank during preforming operation (fourth step) is cooled to a temperature below 200 °C and the cooling rate equals to at least 20 °C/s.

[0029] Preferably the trimming in the sixth step is done in the process of punching by means of the punch and the die.

[0030] Preferably the artificial ageing of the final product which is performed in the seventh step is done in one of four ways: 1) during paint bake cycle (PBC) of the components; 2) in the temperature of 120 °C for 8h; 3) in the following conditions: 4 days of natural ageing → 170 °C for 25 min. → 165 °C for 25 min → 130 °C for 20 min → final cooling to room temperature; 4) in any other conditions accounting for a significant increase of the material's strength to the value of at least 80% of T6 temper strength.

[0031] Preferably the optional cooling of the drawpiece to sub-zero temperature is done not later than 3 h after trimming performed in the sixth step. The authors have tested that after this period of time material starts to age naturally itself which results in drastic hardness increase. The results are presented in details in fig. 3.

[0032] Preferably the temperature range to which the drawpiece is optionally cooled after trimming is in the range of (-60 to -20) °C which successfully prevents natural ageing and precipitation hardening of the final part.

[0033] Preferably the optional holding of the drawpiece in sub-zero temperatures is continued for a period of time equal to 0-7 days. The authors have tested that this period of holding time successfully prevents the material from hardening. This is clearly depicted in fig. 2.

[0034] Preferably the optional assembling is done by means of a method taking advantage of low strength and high ductility of joined material, for example mechanical clinching or riveting.

Fig. 1 depicts the material temperature during the production process (steps a-g, solid line) and optional freezing+joining process (steps i-iii, dotted line) along with formation operations marked by zigzag line.

Fig. 2 depicts the change over time in the hardness of 7075 aluminum alloy sheet cooled to -24 °C immediately after solutionizing in water.

Fig. 3 depicts the change over time in the hardness of the 7075 aluminum alloy sheet that has not undergone cooling after solutionizing in water.

Fig. 4 depicts the outcome of the tensile tests of the material in as delivered T6 temper and after solutionizing.

Fig. 5 depicts the influence of the cooling rate of the blank pre-heated to 480 °C to room temperature on the hardness of the drawpiece after artificial ageing in 120 °C for 8h

Example 1:

[0035] A method of manufacturing of energy-absorbing elements made of aluminum alloy sheets that facilitates further joining, wherein the method comprising the steps of:

a) installing 1000 m coil of 3 mm thick T6 temper 7075 aluminum alloy sheet metal in an unwinding machine which feeds the punching station for cutting out the desired shape of the blanks,

b) transferring the blanks to the multi-chamber furnace (also known as pizza oven) whose temperature is set to 480 °C. The blanks are held in the furnace for 35 min after reaching the temperature of the furnace. The mentioned setting allows to fully dissolve hardening phases into aluminum-rich solid solution,

c) removing the hot blanks from the furnace and immediately transferring them by industrial robot to the first set of tools of 500-ton transfer press, which takes about 5 seconds,

d) using thermal camera in order to check if the temperature of the hot blank is in the range from 460 to 490 °C and preforming of the hot blank in case the mentioned condition is met. The operation is done by means of water-cooled tools in order to simultaneously deform and cool down the blank. As a result, the solutionized preform having shape intermediate between the blank and a final product is made. The manufactured shape minimum radius equals to 15 mm, which helps to avoid the cracking of the material.

After preforming the tools are stopped in position for 5 seconds in order to cool down the preform below 200 °C and fully solutionize the preformed sheet. The tools are made of HTCS steels (high thermal conduction steel) in order to provide the cooling rate larger than 30 °C/s,

e) transferring the cold preform to the finishing set of tools of transfer press and finishing stamping of the cold preform to obtain the final shape of the drawpiece.

f) transferring the finished product to the punching set of tools and trimming the excess of the material in order to provide the desired outer shape of the part.

g) Subjecting the final product to artificial ageing in order to increase the strength of the material. This step is done during the paint bake cycle (PBC) of the lacquer applied beforehand.

Example 2:

[0036] The method of manufacturing of energy-absorbing elements made of aluminum alloy sheets that facilitates further joining as in Example 1, differing in that three additional steps are added after trimming in step f) and before artificial ageing in step h):

i) accumulation of the drawpieces and transferring them after gathering every 20 pieces (which takes maximum 5 minutes) into the industrial freezer having a temperature of -40 °C. This prevents natural ageing and precipitation hardening of the final part.

ii) storing the drawpieces in sub-zero condition for 5 days. This prevents hardening of the material and allows to transport it to the assembly site.

iii) Due to the fact that material is still in the so-called "soft" state the deterioration of the plastic properties is stopped, which makes the joining process easier. The drawpieces are joined with other 3 mm thick 7075 aluminum alloy parts by means of cold clinching using 8 mm joints. Due to the fact that it doesn't matter if the drawpiece is heated up to room temperature, the joining takes place immediately after removing it from the industrial freezer.

Example 3:

[0037] The method of manufacturing of energy-absorbing elements made of aluminum alloy sheets that facilitates further joining as in Example 1, differing in that preforming in step d) and finishing forming in step e) is done using only one set of water-cooled tools. The preforming in step d) is done by using only 50% of the total stroke of the press. After using 50% of the stroke the press is stopped and the blank is stretched over the punch, which provides cooling of the material and results in its solutionizing. After 5s the obtained, solutionized preform is being further stamped using the rest of the stroke until the tools are fully closed. After this, the drawpiece has desired final shape and the further operations (trimming, artificial ageing) are performed as in Example 1.

Claims

1. A method of manufacturing of energy-absorbing elements made of aluminum alloy sheets that facilitates further joining, wherein the method comprising the steps of:

a) cutting out the blank from sheet metal,

b) heating an Al-alloy blank to its solution heat treatment temperature (T_{SHT}) and holding it until solution heat treatment (SHT) is complete,

c) immediate transferring of hot blank to a forming station,

d) preforming of hot blank, i.e. simultaneous stamping and cooling the blank, in order to produce a solutionized preform having shape intermediate between the blank and a final product,

e) finishing stamping of the cold preform to obtain the final shape of the drawpiece,

f) trimming, in order to remove the excess of the material,

g) subjecting components to artificial ageing in order to increase the strength of the material.

2. Method according to claim 1, wherein the T_{SHT} of step b) is in the range of (450 to 550) °C and is maintained for a period of time allowing to fully dissolve hardening phases into an aluminum-rich solid solution, preferable for 10-60 minutes.

3. Method according to any of preceding claims, wherein the hot blank of a temperature not lower than (T_{SHT} - 150) °C is simultaneously preformed and cooled in step d) by means of water-cooled tools, to a temperature below 200 °C and the cooling rate equals at least 20 °C/s.

4. Method according to any of preceding claims, wherein each radius of the preform manufactured in step d) is larger than 15 mm and the deformation level obtained in step d) is significantly lower than deformation level obtained in step e), which helps to avoid the cracking of the material.

5. Method according to any of preceding claims, wherein trimming in step f) is done by means of punching or laser trimming.

6. Method according to any of preceding claims, wherein artificial ageing in step g) is done in one of following ways:

i) during the paint bake cycle (PBC) of the components.

ii) in the temperature of 120 °C for 8h.
iii) in the following conditions: 4 days of natural ageing → 170 °C for 25 min → 165 °C for 25 min → 130 °C for 20 min → final cooling to room temperature.
iv) in any other conditions accounting for a significant increase in the material's strength to the value of at least 80% of T6 temper strength.

7. Method according to any of preceding claims, in which three additional steps are added after step f) and before step g):

i) the cooling of the drawpiece to sub-zero temperature,
ii) holding the drawpiece in sub-zero temperature,
iii) assembling the formed drawpiece with other parts.

8. Method according to claim 7, wherein the cooling performed in step i) is done not later than 3h after trimming performed in step f).

9. Method according to claim 7 wherein the temperature range to which the drawpiece is cooled in step i) is in the range of -60 to -20 °C, which prevents natural ageing and precipitation hardening of the final part.

10. Method according to claim 7, wherein the holding time in step ii) is in the range from 0 to 7 days.

11. Method according to any of claims 1-6, in which after step f) and before step g) one additional steps is added:
iii) assembling the formed drawpiece with other parts.

12. Method according to any of claims 7 - 11, in which step iii) is performed either with or without prior restoring the room temperature of the drawpiece.

13. Method according to any of claims 7 - 11, wherein the assembly process in step iii) is done by means of method taking advantage of low strength and high ductility of joined material, for example mechanical clinching or riveting.

14. Method according any of preceding claims, including additional overageing step at the end of the process.

15. Method according to any of the claims, wherein the sheet is made of 2xxx, 6xxx or 7xxx aluminum alloy of a thickness from 0.5 mm to 5 mm.

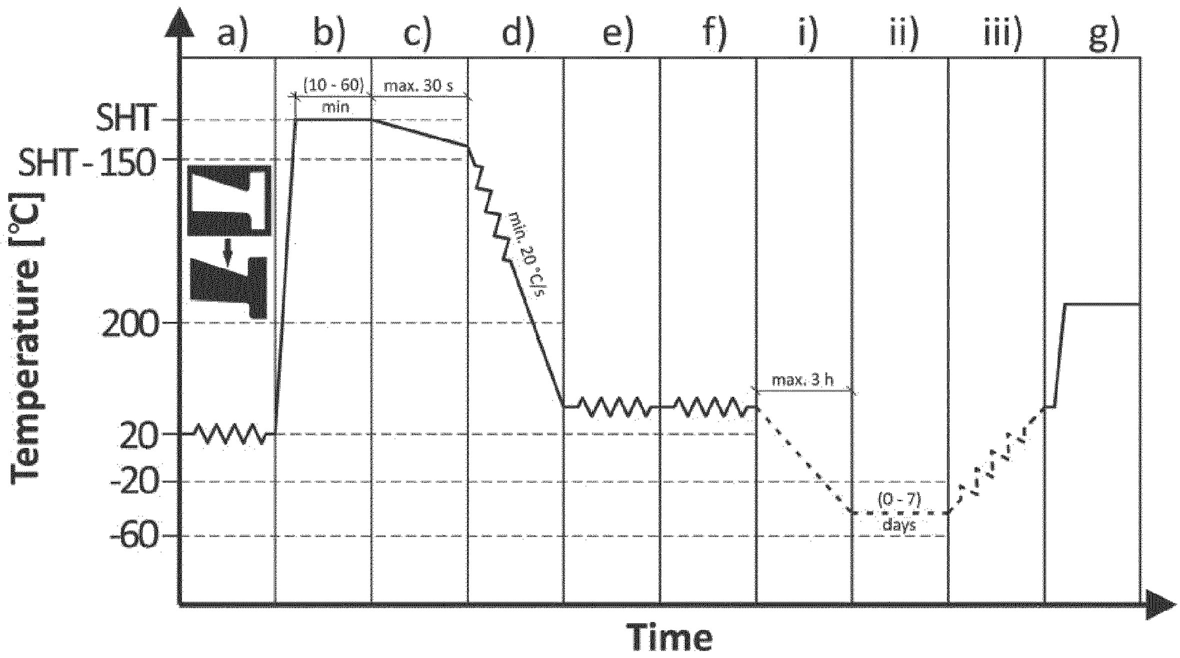
a)
b)
c)
d)
e)
f)
i)
ii)
iii)
g)
(10 - 60) min
max. 30 s
SHT
SHT - 150
min. 20 °C/s
200
20
-20
-60
max. 3 h
(0 - 7) days
Temperature [°C]
Time

Fig. 1.

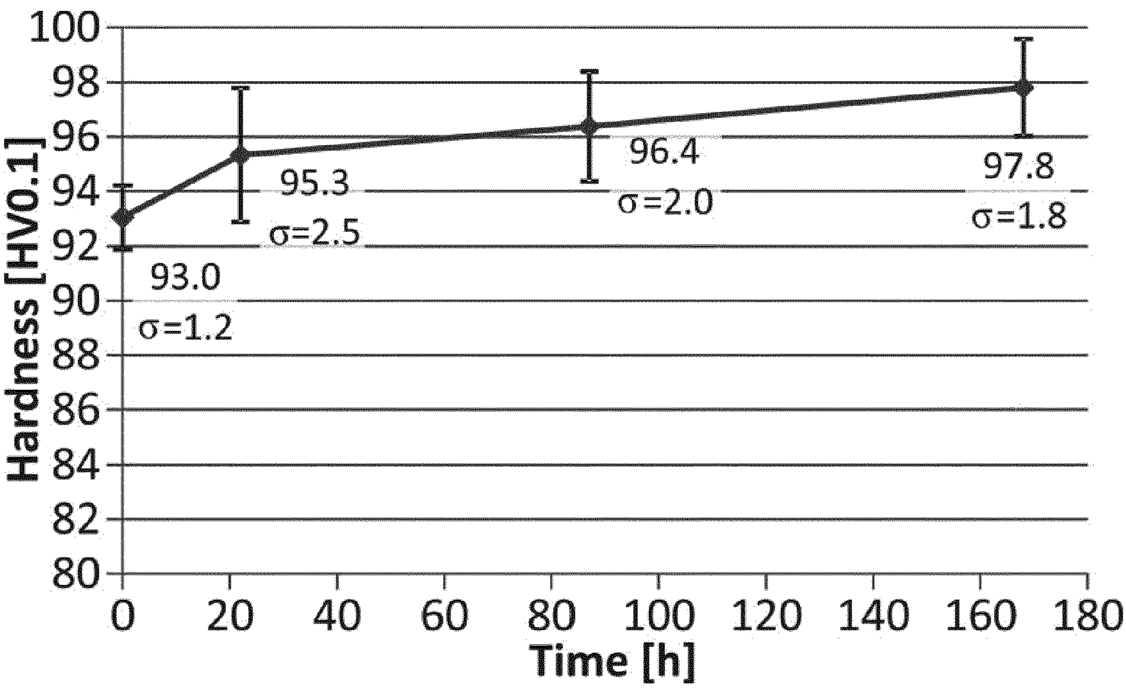
Hardness [HV0.1]
100
98
96
94
92
90
88
86
84
82
80
93.0
σ=1.2
95.3
σ=2.5
96.4
σ=2.0
97.8
σ=1.8
0
20
40
60
80
100
120
140
160
180
Time [h]

Fig. 2.

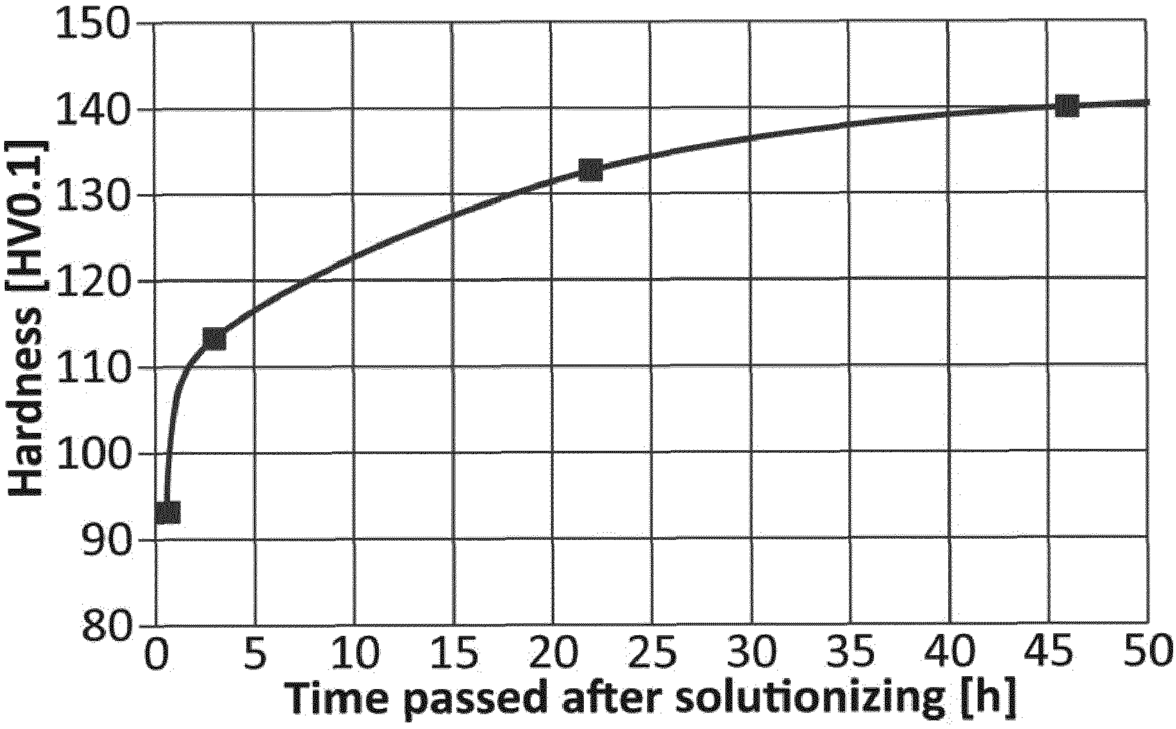
150
140
130
120
110
100
90
80
Hardness [HV0.1]
0 5 10 15 20 25 30 35 40 45 50
Time passed after solutionizing [h]

Fig. 3.

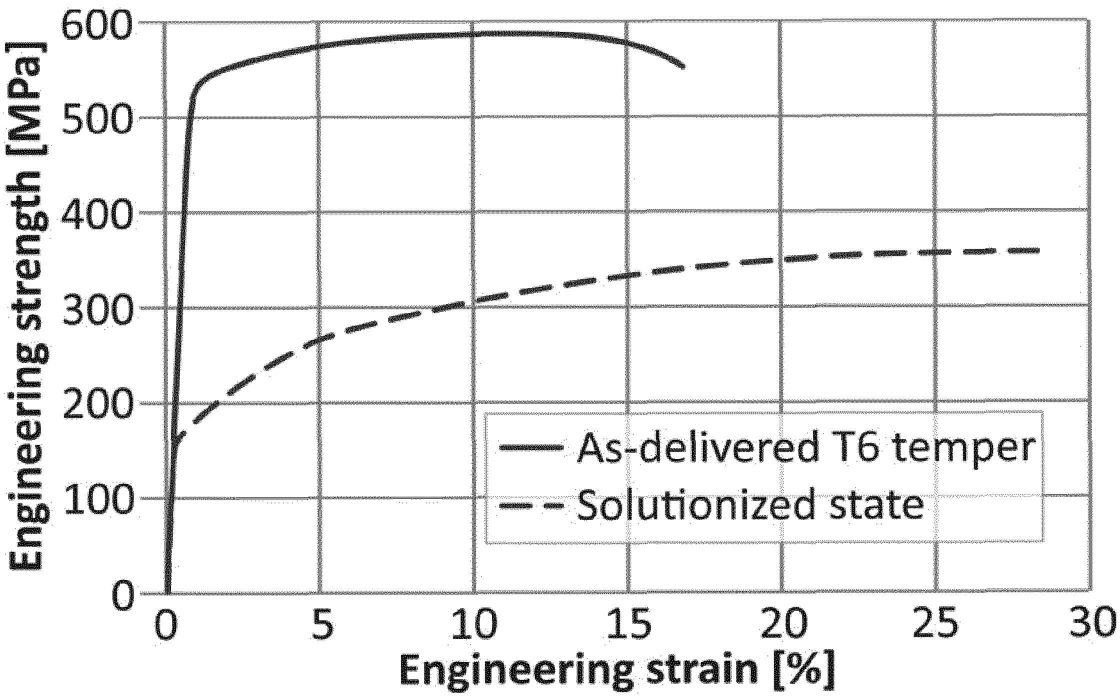
600
500
400
300
200
100
0
Engineering strength [MPa]
0 5 10 15 20 25 30
Engineering strain [%]
As-delivered T6 temper
Solutionized state

Fig. 4.

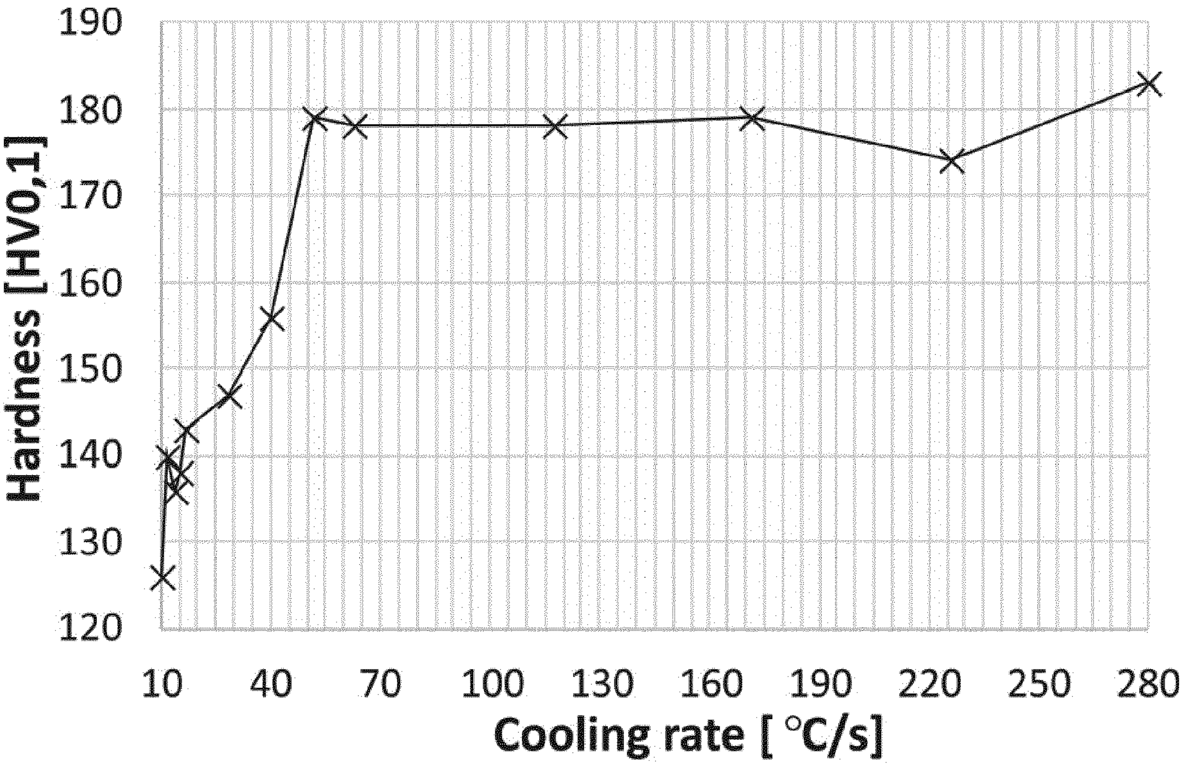
190
180
170
160
150
140
130
120
Hardness [HV0,1]
10
40
70
100
130
160
190
220
250
280
Cooling rate [°C/s]

Fig. 5

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 20 16 9730

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2019/070652 A1 (PFRANG JAN ANDREAS [DE]) 7 March 2019 (2019-03-07) * paragraphs [0009] - [0014], [0022], [0025]; claim 1; figures 1-5 * -----	1-15	INV. C22F1/04 C22F1/00 ADD. C21D1/673
X	JAE-YEOL JEON ET AL: "Two-Step Die Motion for Die Quenching of AA2024 Aluminum Alloy Billet on Servo Press", MATERIALS TRANSACTIONS, THE JAPANESE INSTITUTE OF METALS AND MATERIALS, JP, vol. 55, no. 5, 11 April 2014 (2014-04-11), pages 818-826, XP002745093, ISSN: 1345-9678, DOI: 10.2320/MATERTRANS.L-M2014806 * Section 1. Introduction, Section 3. Experimental procedure; figure 1 * -----	1-15	
A	CN 107 740 014 A (UNIV CENTRAL SOUTH) 27 February 2018 (2018-02-27) * paragraph [0026]; claim 1 * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

C22F
B21D
C21D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	5 August 2020	Martinavicius, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 16 9730

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

05-08-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2019070652 A1	07-03-2019	CN 108602104 A	28-09-2018
		DE 102016208014 A1	16-11-2017
		EP 3455006 A1	20-03-2019
		US 2019070652 A1	07-03-2019
		WO 2017194313 A1	16-11-2017
CN 107740014 A	27-02-2018	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2008059242 A2 **[0002]**
- US 10029624 B **[0004]**
- US 20120186706 A1 **[0006]**
- EP 3467138 A **[0008]**
- US 8613820 B2 **[0010]**
- EP 3117019 A2 **[0012]**