Abstract

A process for producing a shaped part of a pre-form of hardenable and heat formable steel sheet, by means of heat treatment with cold deforming tools, in which by the heat forming a hardened component is produced, which exhibits a martensitic and/or bainitic microstructure, wherein the hardened component is tempered subsequent to heat forming so that a shaped part is formed which exhibits, at least in areas, a higher yield strength and a pronounced break limit compared to the hardened component.
PROCESS FOR PRODUCING SHAPED STEEL PARTS

BACKGROUND OF THE INVENTION

1. Field of Invention

The invention concerns a process for producing a shaped component from a pre-form or semi-manufactured part of hardenable and hot formable steel sheet metal, by means of hot working with cold deforming tools, wherein as a result of the hot forming a hardened component is produced, which exhibits a martensitic and/or bainitic microstructure. The invention in particular concerns a process for press-hardening of steel sheets for production of automobile parts with high toughness.

2. Related Art of the Invention

For weight reduction in body construction and in body components the current trend is to reduce sheet metal thickness. For this, it is necessary that the conventional steels are replaced with hard and hardly hardened steel materials. The savings in materials must be compensated for by an increased toughness of the materials. With respect to the requirements of tensile strength, steel 22MnB5 is suited for example, which belongs to the class of the ultra highly hardened steels with a stiffness of 2000 MPa and more.

Press hardening is a particularly economical process for the series production of shaped components. This applies in particular for sheet-like pre-forms or semi-manufactured parts, since here, due to the low thickness, a through-hardening of the entire sheet is made possible. Press hardening is known for example from DE 198 15 022 A1, in which the pre-form is first cold formed by a drawing process, thereafter heated and then press hardened in a hot forming tool.

From DE 197 43 802 C1 a process for press hardening of sheet blanks is known. Therein a metallic shaped part for vehicle body components, which has areas exhibiting a higher ductility, is produced from a boron-manganese steel alloy. The composition of the steel, expressed it in weight percent, is: carbon (C) 0.18% to 0.3%, silicon (Si) 0.1% to 0.7%, manganese (Mn) 1.0% to 2.5%, phosphorus (P) maximum 0.025%, chrome (Cr) 0.1% to 0.8%, molybdenum (Mo) 0.1% to 0.5%, sulfur (S) maximum 0.1%, titanium (Ti) 0.02% to 0.05%, boron (B) 0.02% to 0.05%, aluminum (Al) 0.01% to 0.6%. The sheet blanks are heated to temperatures of about 900°C and formed in a cold pressed tool wherein aging occurs. Subsequently individual areas of the shaped component are subjected to a partial thermal treatment at temperatures of between 600°C and 900°C.

Press hardened components are in general very brittle, so that the possibility of their employment in motor vehicle bodies, in particular in crash structures, is very limited as long as they are in this condition. A material characteristic with a pronounced yield strength and high elastic limit behavior Re/Rm would be needed to come close to the requirements of car body manufacturing. Likewise, for the component design for a passenger cell, besides the construction geometry, the component-material-yield strength is also determinative, and not the maximal component-material-tensile strength.

It is thus the task of the invention to provide an economical manufacturing process for high strength steel shaped components, in which the material exhibits both a high strength as well as a high ductility.

SUMMARY OF THE INVENTION

The task is inventively solved by a process for production of a shaped component of a blank or pre-form of hardenable and hot deformable steel sheet metal, by means of hot forming with cold deforming tools, wherein by the hot forming a hardened component is produced, which exhibits a martensitic and/or bainitic microstructure, when the hardened component is tempered after the hot forming, so that a shaped component is produced which, in comparison to the hardened component condition, exhibits in areas a higher yield strength.

In a further embodiment, the invention is solved by a process for production of a shaped component of a blank or pre-form of hardenable and hot formable steel sheet metal, including the steps:

a) heating the semi-finished part to an austenitising temperature and;

b) press hardening in a cold tool, wherein by quenching at least partially a martensitic and/or bainitic microstructure is produced; and

c) annealing the deformed semi-finished product at temperatures below 400°C with formation of a shaped part with increased yield strength and/or tensile strength compared to the hardened component.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be described in greater detail with reference to the figures which show in:

FIG. 1. a tension/elongation diagram for component A according to the invention, and

FIG. 2. a tension/elongation diagram for comparative Component B.

DETAILED DESCRIPTION OF THE INVENTION

In accordance with the invention it is proposed that a hot formed and hardened component is tempered in a cold tool, so that a shaped part is produced, which in comparison to the hardened condition exhibits at least in areas a higher and a pronounced yield strength. By tempering the component and improvement of the mechanical characteristics takes place. Therein it is important that the yield strength is increased and a pronounced yield strength is achieved. Thereby the component is not only highly hard, but also sufficiently ductile for use in vehicle body construction.

A pronounced yield strength is achieved when the tension-elongation curve reflecting a draw test clearly deviates following a linear area (Hookish area) and exhibits a more or less pronounced short almost level progression. The yield strength (elastic limit) (Rm) is defined by the location of the deviation point. In materials without pronounced elastic limit, frequently the Rp0.2-limit is used for the constructive determination or interpretation.
It is further envisioned in accordance with the invention that the press hardened component is subject to a thermal treatment below 400° C., which leads to a shaped component with higher yield strength and/or break elongation in comparison to the hardened component. This thermal treatment is to be understood as annealing at low temperatures. The temperatures selected in accordance with the invention lay significantly below the temperature level conventional for annealing high and high strength steels. By the inventive thermal treatment a component with high strength at simultaneously high ductility is produced, which meets the requirements of vehicle body construction and in particular also is satisfactory in crash structures in automobiles.

Preferably the temperature and the duration of the tempering or annealing is so selected that the yield strength is increased by at least 20%. Therein the breaking elongation of the shaped part can also be increased or, at worst, be only insubstantially reduced.

In the crash structures in the case of deformation it is desired that the components have high energy absorption during deformation. This is achieved by the combination of strength and ductility achievable with the inventive process.

In a preferred embodiment of the invention the semi-manufactured part is formed of a chrome-molybdenum steel. The content of Cr and Mo preferably lies, for Cr, at 0.8 to 1.3% and, for Mo, at 0.13 to 0.4%, in which the content of carbon lies at 0.2 to 0.5%.

Suitable examples of these steels include 25CrMo4, 34CrMo4 or 42CrMo4, as well as 25CrMo84, 34CrMo84 and 42CrMo84. For these steels, the manufacturers recommend hardening temperatures in the range of 840 to 880° C, and annealing temperatures at 540 to 680° C. The indicated annealing temperatures may lead to an improvement in ductility, however at the same time they also lead to an unacceptable reduction in strength or, as the case may be, yield strength. For the inventive temperatures of annealing below 400° C. no cause is observed for embrittlement, but rather an increase in lateral contraction, yield strength and break elongation. Tempering is preferably carried out in the temperature range of 250° C. to 400° C. For these steels the annealing temperature particularly preferably lies in the range of 250 to 350° C.

In a preferred further development of the invention the similar manufactured component is formed of a boron alloyed case-hardened steel or heat-treated (quenched and tempered) steel. Suitable representatives of these steels are, for example, 17MnB3, 22MnB5, or 27MnCr5-2. Particularly preferably the annealing temperature for these steels lies in the range of 300 to 330° C.

The time required for annealing depends in particular upon the material thickness of the component. For example, for material thickness of about 1 mm, 2 to 10 minutes are suitable. If the holding temperature is too long then depending upon the steel alloy negative influences can be exercised on the component or, as the case may be, on the material characteristics.

For the inventive manufacturing process sheet-like semi-manufactured parts are particularly preferably suited. Preferably the semi-manufactured component is comprised of a flat plate of an already cold deformed steel blank or of a cut component semi-manufactured part. The material thickness typically lies in the range of 0.8 to 3 mm.

By the inventive deformation process, in particular profile members or beams or hollow beams for automobile body and undercarriage are produced.

It is useful that the hardened pre-form or semi-manufactured component is cut to the end contour or shape only directly prior to or after the annealing or, as the case may be, tempering. For this, the surface of the hardened shaped part is preferably cleaned prior to annealing. A contamination of this surface during annealing is to be avoided if possible, so that the follow up treatment of the surface following annealing can be minimized. A preferred cleaning process is particle blasting and dry cleaned by means of blasting.

In a further preferred embodiment of the invention a surface treatment or formation of a defined corrosion protection and/or wear protection for the shaped part is carried out during annealing (in step c), preferably simultaneously also during tempering. Therein the temperature of the annealing, which can be for example 250 to 400° C, can be taken advantage of or used for burning in of a coating, in particular corrosion protection coating.

Particularly preferred is when during annealing or, as the case may be, tempering, a galvanizing or thin layer zinking is carried out as the surface treatment. Herein the semi-finished product is preferably comprised of multiple heat treatable steel sheets, of which at least one is a hardenable steel.

The process is preferably used for manufacture of a form part for a hollow beam integrated in a passenger cell of a motor vehicle body or for a hollow beam or support member integrated in the undercarriage of a vehicle. Particularly preferred is when the hollow beam is provided in the crash structure or the deformation structure of automobiles.

**EXAMPLE**

For comparative purposes a number of pre-forms of a 22MnB5-steel were subjected to an inventive heat formation or, as the case may be, press hardening, thereafter annealing (Component A) and on the other hand only hot forming or as the case may be press hardening (Component B). The material thickness of the sheet metal plates lies at approximately 1.0 mm.

For annealing (Component A) a temperature of 320° C. and a duration of approximately 4 to 6 minutes was selected.

For the Component A the following average values resulted:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield Strength</td>
<td>1226</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>1335</td>
</tr>
<tr>
<td>Tear Strength</td>
<td>1000</td>
</tr>
<tr>
<td>Stretch Load Limit</td>
<td>2.4%</td>
</tr>
<tr>
<td>Elongation Breakage</td>
<td>4.1%</td>
</tr>
<tr>
<td>Contraction at Fracture</td>
<td>29.8%</td>
</tr>
</tbody>
</table>
For component B the following average values resulted:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield Strength</td>
<td>923 MPa</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>1659 MPa</td>
</tr>
<tr>
<td>Tear Strength</td>
<td>1351 MPa</td>
</tr>
<tr>
<td>Stretch Load Limit</td>
<td>3.2%</td>
</tr>
<tr>
<td>Elongation Breakage</td>
<td>5.0%</td>
</tr>
<tr>
<td>Contraction at Fracture</td>
<td>18.3%</td>
</tr>
</tbody>
</table>

It has been shown that by the inventive process a substantial increase in yield strength can be achieved. For user as auto body components the measured reduction in tensile strength is insignificant, since this plays only a subordinate role in the design of the construct. The break elongation decreases only insubstantially from 5 to 4.1% as a result of the inventive process. In contrast, the reduction in tear sensitivity increases in comparison to the contraction at fracture. Here also the condition with subsequent annealing or tempering shows, with 29.8 instead of 18.3%, a significant improvement in performance compared to only heat treated and hardened condition.

The course of tensioning of the tensile samples of Components A or B is reproduced in the form of tension/elongation diagrams in FIG. 1 for Component A and in FIG. 2 for Component B.

For the Component A significant yield points or elastic limits are recognizable. The curves clearly deviate following the linear (Hookish) area, in a short almost horizontal progression. The subsequent long area of the plastic deformation is likewise comparatively level.

In contrast to this, the curves in FIG. 2 for Component B show no deflection and no recognizable elastic limit.

1. A process for producing a shaped part from a pre-form of hardenable and heat deformable steel sheet metal, by means of heat forming with cold deforming tools, in which by hot forming a hardened component is produced, exhibiting martensitic and/or bainite microstructure, wherein the hardened component is tempered subsequent to hot forming, so that a shaped component is produced, which in comparison to the hardened component condition, exhibits at least in areas a higher yield strength and/or pronounced yield strength.

2. The process according to claim 1, wherein temperature and duration of tempering are so selected, that the yield strength is increased by at least 20%.

3. A process for producing a shaped part from a pre-form of hardenable and heat deformable steel sheet metal, including the steps:

a) heating the pre-form to an austenitising temperature;

b) press hardening in a cold tool as a result of which, by quenching, at least partially a martensitic and/or bainitic microstructure is produced,

c) wherein an annealing of the shaped pre-form at temperatures below 400° C., with formation of a shaped part with increased yield strength and/or break elongation occurs in comparison to the hardened component.

4. The process according to claim 1, wherein the pre-form is a chrome-molybdenum steel.

5. The process according to claim 3, wherein the chrome-molybdenum steel is 25CrMo4, 34CrMo4 or 42CrMo4.

6. The process according to claim 1, wherein the pre-form is a boron alloyed case hardened and heat treated steel.

7. The process according to claim 7, wherein the boron alloyed case hardened and heat treated steel is 17MnB3, 22MnB5 or 27MnCr5-2.

8. The process according to claim 1, wherein the pre-form is a flat plate, a cold deformed steel pre-form or cut or trend pre-form.

9. The process according to claim 1, wherein the annealing occurs at a temperature in the range of 250 to 400° C.

10. The process according to claim 1, wherein the annealing occurs at a temperature of from 300 to 330° C.

11. The process according to claim 1, wherein the hardened pre-form is cut to its final contour prior to or subsequent to step e).

12. The process according to claim 1, wherein the surface of the hardened shaped part is cleansed prior to annealing, in particular, by a powder blasting process.

13. The process according to claim 1, wherein during annealing in step c), at the same time also a surface treatment for formation of a defined corrosion protection and/or friction resistance for the shaped part occurs.

14. The process according to claim 13, wherein the surface treatment is galvanizing or thin layer zinking.

15. The process according to claim 1, wherein the pre-form is a collection of multiple heat deformable steel sheets, of which at least one is comprised of a hardenable steel.

16. The process according to claim 1, wherein the shaped part is used to produce shell parts for the hollow beams or carriers integrated in the passenger cell of a vehicle undercarriage.

17. The process according to claim 1, wherein from the shaped part shell parts are produced for a hollow beam integrated in the undercarriage of a vehicle.

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