TAILORED PROPERTIES BY POST HOT FORMING PROCESSING

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ABSTRACT

A method of forming a shaped product from an initial blank comprises subjecting the initial blank to a hot forming and press hardening operation to form the shaped product with substantially a uniform first tensile strength. Subsequently, the shaped product is at least partially immersed in a fluidized bed that is maintained within a known range of operating temperatures. While the shaped product is immersed into the fluidized bed, a first region of the shaped product is heated selectively to above a known temperature. The first region is then cooled, such that the first region attains a second tensile strength that is substantially less than the first tensile strength.
FIG. 5c
hot forming and press hardening an initial blank to form a shaped product

immersing the shaped product into a fluidized bed for heating a first region, and cooling the first region to produce a region of reduced hardness

FIG. 6

heat an initial blank to an austenitizing temperature

hot-shape the initial blank to form the shaped product

cool at a rate that is sufficiently rapid to form martensite

at least partially immerse the shaped product into a fluidized bed, to selectively heat a first portion of the shaped product

cool the shaped product such that tempered martensite is formed within the first portion while the second portion remains substantially free of tempered martensite

FIG. 7
provide an initial blank

heat the initial blank to the austenite state

hot form the initial blank to form a shaped product

hardening the entire shaped product

transfer the shaped product to a fluidized bed

at least partially immerse the shaped and hardened product into the fluidized bed to heat a first portion

remove the product from the fluidized bed

cool the shaped product such that tempered martensite is formed within the first portion while the second portion remains substantially free of tempered martensite

FIG. 8
provide a B column blank

heat the B column blank to the austenite state

hot form the B column blank to form a B column

hardening the entire B column

at least partially immerse the hardened B column into the fluidized bed to heat a first portion thereof

cool the B column such that tempered martensite is formed within the first portion while the second portion remains substantially free of tempered martensite

FIG. 9
TAILORED PROPERTIES BY POST HOT FORMING PROCESSING

FIELD OF THE INVENTION

[0001] The instant invention relates generally to shaped metallic products having tailored properties, and more particularly to a method of producing regions of reduced hardness and reduced strength in shaped products via post hot forming processing.

BACKGROUND OF THE INVENTION

[0002] In the field of vehicle construction, more and more vehicle parts made of high-strength and ultra-high-strength steel are being employed in order to satisfy criteria for lightweight construction. This applies to car body construction where, in order to meet weight goals and safety requirements, for instance structural and/or safety elements such as door intrusion beams, A and B columns, bumpers, side rails and cross rails are increasingly being produced from UHSS (Ultra High Strength Steel), thermo-shaped and press-hardened steel having tensile strengths greater than 1000 MPa.

[0003] In different applications of motor vehicle engineering, shaped parts are to have high strength in certain regions while in other regions they are to have higher ductility relative thereto. “Tailoring” the properties of shaped parts in this way facilitates subsequent forming operations, such as for instance trimming or perforating the part, and results in regions that can convert crash energy into deformation by crumpling.

[0004] It is known to treat a part using heat treatments such that local regions have higher strength or higher ductility. Lundstrom discloses one such approach in U.S. Pat. No. 5,916,389, wherein a sheet of hardenable steel is heated to an austenitization temperature and then pressed between cooled die halves in order to form a shaped part having a desired profile. Sections of the die halves adjacent to portions of the part that are to have higher ductility in the finished product are adapted to prevent rapid cooling, such that hardening does not occur within these portions to the same extent that occurs within other portions of the finished product. Unfortunately, the die halves must be specially made for each part, which is both laborious and costly. In addition, special effort is required in order to minimize the extent of formation of transition regions between the different portions, since typically these transition regions exhibit properties that are less well defined than the properties of the rest of the finished product.

[0005] In another approach a shaped product having substantially uniform hardness is produced using conventional hot forming and press hardening techniques, followed by separate additional heat treatment of the product to form regions of lower tensile strength therein. For instance, in United States Patent Application Publication 2010/0086803, Patberg discloses a method of forming mild zones along a bend edge of a hot formed and press hardened component. In particular, a laser beam is used to heat a narrow region of the component along the bend edge. Additionally, Patberg suggests that the heat that is produced by welding may result in the formation of mild zones adjacent to a weld joint. Unfortunately, the use of highly specialized laser equipment adds to the cost and complexity of the component. In addition, this approach is not well suited either to batch processing or to applications requiring the formation of substantial regions having reduced tensile strength within the component.

[0006] It would be advantageous to provide a method that overcomes at least some of the above-mentioned limitations of the prior art.

SUMMARY OF EMBODIMENTS OF THE INVENTION

[0007] According to at least one embodiment of the instant invention a method of forming a shaped product from an initial blank is provided, in which the initial blank is subjected firstly to a hot forming and press hardening operation so as to form the shaped product with substantially a uniform first tensile strength. In particular, the initial blank is heated to a temperature above its transition temperature Ac3, which is defined as the temperature at which transformation of ferrite into austenite is completed upon heating. By way of a specific and non-limiting example, the initial blank is heated to approximately 950°C. The heated initial blank is inserted into a cooled press having a pair of die halves, which is used for both hot forming and hardening the shaped product. The press is subsequently closed, thereby deforming the initial blank such that it conforms to contours that are defined along facing surfaces of the die halves. Deformation and concomitant rapid cooling of the initial blank within the die halves produces the desired shaped product, in which the austenite structure has been transformed into martensite structure. The tensile strength and hardness of the shaped product is substantially uniform throughout. Optionally, the die halves are not cooled provided that a suitably rapid cooling rate of the shaped product can be achieved.

[0008] Subsequently, in a second thermal treatment, a first region of the shaped product is heated in a selective fashion to a known temperature that is lower than the transition temperature Ac3. By way of a specific and non-limiting example, the first region of the shaped product is heated to a temperature between approximately 730°C and 800°C. Optionally, the first region of the shaped product is heated to a temperature within the range of temperatures between about 500°C and 750°C. According to an embodiment, the shaped product is at least partially immersed into a fluidized bed that is maintained within a known range of operating temperatures. For instance, the fluidized bed comprises a solid particulate such as sand, which is heated by a flow of hot air passing through the bed. Of course, the temperature of the flow of hot air is selected to attain the known range of operating temperatures. The second region is then cooled in such a way that the first region attains a second tensile strength that is substantially less than the first tensile strength. The second thermal treatment at a temperature between approximately 370°C and 800°C results in a tempered martensite composition within the first region. Optionally, a particulate other than sand is used and/or a fluid other than hot air is used to form the fluidized bed.

[0009] According to at least one embodiment of the instant invention, the first region of the shaped product is gas-cooled. Optionally, the first region of the shaped product is cooled using another suitable cooling technique, such as for instance one of blasted fluidized bed cooling, die cooling, water/mist cooling, and cooling with the use of cooling fans/jets.

[0010] According to at least one embodiment of the instant invention, the shaped product is only partially immersed into the fluidized bed. In particular, a portion of the shaped product corresponding to the first region is immersed into the
fluidized bed and is heated to the known temperature. Other portions of the shaped product, which are not immersed into the fluidized bed, are cooled or insulated from being heated to the known temperature as a result of being placed in close proximity to the fluidized bed. For instance, the shaped product is gripped using a cooled collar that surrounds a second region of the shaped product adjacent to the first region. Optionally, the cooled collar is immersed at least partially into the fluidized bed. Optionally, the second region of the shaped product is protected from being heated by using a curtain of a cooled gas such as for instance air, or by spraying or misting with a suitable cooling liquid.

[0011] According to at least one embodiment of the instant invention, the shaped product is immersed fully into the fluidized bed. In that case, a collar surrounds a second region of the shaped product that is adjacent to the first region. The collar may provide cooling functionality (e.g., a gas-cooled collar (such as air-cooled) or a liquid-cooled collar (such as water-cooled)) or the collar may be insulating, such that the second region of the shaped product is protected from being heated to the known temperature. Optionally, the collar both cools and insulates the second region of the shaped product. Optionally, a plurality of collars is used to protect a plurality of non-contiguous second regions from being heated to the known temperature. Optionally, a single collar surrounds and protects a plurality of second regions from being heated to the known temperature, whilst allowing at least one first region of the shaped product to be heated to the known temperature.

[0012] Optionally, intermediate processing such as for instance forming and/or cutting and/or perforating, etc. is performed subsequent to the hot stamping and press hardening steps but prior to the post hot forming processing in the fluidized bed. Optionally, forming and/or cutting and/or perforating, etc. is performed subsequent to the post hot forming processing in the fluidized bed.

[0013] According to another embodiment of the instant invention, the hot forming and press hardening steps are omitted. By way of a specific and non-limiting example, the product is roll formed from a coil of Ultra High Strength Steel and subjected subsequently to post-forming thermal treatment in a fluidized bed as described supra. In particular, products may be formed having a geometry that is not sufficiently complex so as to require the use of hot forming and press hardening techniques.

[0014] Optionally, the initial blank is formed from a coated material or an uncoated material.

[0015] In accordance with an aspect of an embodiment of the invention there is provided a method of forming a shaped product from an initial blank, comprising: subjecting the initial blank to a hot forming and press hardening operation to form the shaped product with substantially a uniform first tensile strength; and subsequently, at least partially immersing the shaped product into a fluidized bed that is maintained within a known range of operating temperatures so as to selectively heat a first region of the shaped product to above a known temperature, while simultaneously maintaining below the known temperature a second region of the shaped product that is adjacent to the first region, and then cooling the first region such that the first region attains a second tensile strength that is substantially less than the first tensile strength.

[0016] In accordance with an aspect of an embodiment of the invention there is provided a method of forming a shaped product from an initial blank, comprising: heating the initial blank to an austenitizing temperature; hot-shaping the initial blank in a cooled pair of dies to form the shaped product; cooling the shaped product during a first period of time, using a rate of cooling that is sufficiently rapid to support formation of a martensitic structure within substantially the entire shaped product; at least partially immersing the shaped product into a fluidized bed that is maintained within a known range of operating temperatures, so as to selectively heat a first portion of the shaped product to a known temperature that is less than the austenitizing temperature, while simultaneously maintaining below the known temperature a second portion of the shaped product that is adjacent to the first portion; and, cooling the shaped product such that tempered martensite is formed within the first portion of the shaped product while at the same time the second portion of the shaped product remains substantially free of tempered martensite.

[0017] In accordance with an aspect of an embodiment of the invention there is provided a method of forming a shaped product from an initial blank, comprising: providing the initial blank; heating the initial blank to the austenite state; hot-shaping the initial blank in a cooled pair of dies to form the shaped product; hardening the entire shaped product while it is still inside the pair of dies by cooling the product using a rate of cooling that is sufficiently fast to form a martensitic structure; transferring the shaped and hardened product from the pair of dies to a fluidized bed that is maintained within a known range of operating temperatures; at least partially immersing the shaped and hardened product into the fluidized bed, so as to heat a first portion of the product to at least a predetermined first temperature, while at the same time maintaining a second portion of the product below a predetermined second temperature that is lower than the first temperature; removing the product from the fluidized bed; and, cooling the shaped product such that tempered martensite is formed within the first portion of the shaped product while at the same time the second portion of the shaped product remains substantially free of tempered martensite, wherein subsequent to cooling a tensile strength of the first portion of the shaped product is less than a tensile strength of the second portion of the shaped product.

[0018] In accordance with an aspect of an embodiment of the invention there is provided a method of making a B column for an automobile, comprising: providing a B column blank; heating the B column blank to the austenite state; hot-shaping the B column blank in a cooled pair of dies to form the B column; hardening the B column while it is still inside the pair of dies, by cooling the B column during a first period of time using a rate of cooling that is sufficiently rapid to support formation of a martensitic structure within substantially the entire B column; at least partially immersing the B column into a fluidized bed that is maintained within a known range of operating temperatures, so as to selectively heat a first portion of the B column above a known temperature that is less than the austenitizing temperature, while simultaneously maintaining below the known temperature a second portion of the B column that is adjacent to the first portion; and, cooling the B column such that tempered martensite is formed within the first portion of the B column while at the same time the second portion of the B column remains substantially free of tempered martensite, wherein subsequent to cooling, a tensile strength of the first portion of the B column is less than a tensile strength of the second portion of the B column.
A method of forming a shaped product from an initial blank, comprises: providing an initial blank fabricated from an Ultra High Strength Steel; forming the shaped product from the initial blank; and, at least partially immersing the shaped product into a fluidized bed that is maintained within a known range of operating temperatures so as to selectively heat a first region of the shaped product to above a known temperature, while simultaneously maintaining below the known temperature a second region of the shaped product that is adjacent to the first region and then cooling the first region such that the first region attains a second tensile strength that is substantially less than the first tensile strength.

Exemplary embodiments of the invention will now be described in conjunction with the following drawings, in which:

FIG. 1 is a schematic diagram of a thermoforming line for a steel component, according to an embodiment of the instant invention;

FIG. 2 shows a B column of substantially uniform tensile strength, as formed by a conventional hot forming process;

FIG. 3 shows a collar box attached to the B column of FIG. 2;

FIG. 4 shows a B column having substantially two regions of different tensile strength after post hot-forming processing in a fluidized bed;

FIG. 5a shows locations of tensile strength samples taken from a representative B column formed using a method according to an embodiment of the instant invention;

FIG. 5b is a plot showing tensile strength values (MPa) and elongation (%) values for the locations that are indicated in FIG. 5a;

FIG. 5c is a plot showing Vickers Hardness values as a function of distance within the transition zone between the first region and the second region;

FIG. 6 is a simplified flow diagram of a method according to an embodiment of the instant invention;

FIG. 7 is a simplified flow diagram of another method according to an embodiment of the instant invention;

FIG. 8 is a simplified flow diagram of yet another method according to an embodiment of the instant invention; and,

FIG. 9 is a simplified flow diagram of still another method according to an embodiment of the instant invention.

The following description is presented to enable a person skilled in the art to make and use the invention, and is provided in the context of a particular application and its requirements. Various modifications to the disclosed embodiments will be readily apparent to those skilled in the art, and the general principles defined herein may be applied to other embodiments and applications without departing from the scope of the invention. Thus, the present invention is not intended to be limited to the embodiments disclosed, but is to be accorded the widest scope consistent with the principles and features disclosed herein.

Referring to FIG. 1, shown is a schematic illustration of a thermoforming line for a steel component, according to an embodiment of the instant invention. By way of a specific and non-limiting example, the component that is produced in FIG. 1 is a B column for an automobile. Of course, other types of components may be produced in a similar fashion.

An initial blank 100 is provided. For instance, the initial blank 100 is stamped from a sheet of hardenable steel, such as usibor® 1500, another suitable boron steel or any suitable hot stamp press hardened material. Optionally, the initial blank 100 is pre-shaped specifically for producing a B column, such as for instance by an additional cutting step or an additional cold forming step (not shown in FIG. 1). The entire initial blank 100 is then heated in an oven 102 to a temperature above the Ac3 temperature. By way of a specific and non-limiting example, the oven 102 is a roller-hearth or a batch style oven. Once the initial blank 100 is in the austenite state it is transferred rapidly to a die set shown generally at 104, the die set 104 having an upper die half 106 and a lower die half 108. The die set 104 optionally is cooled in order to ensure that a sufficiently rapid cooling rate of the initial blank 100 is achieved, such that martensite is formed. By way of a specific and non-limiting example, channels are defined through the upper die half 106 and the lower die half 108 for flowing a cooling fluid, such as for instance water, through the die halves to achieve the rapid cooling rate of the product that is being formed from the initial blank 100. For instance, a typical cooling rate is in the range of about 30°C/second to about 100°C/second. The product is held inside the die set during cooling, so as to maintain the desired shape of the product while it is being cooled and hardened. After being removed from the die set 104, the product (shown at 110) is further cooled to about room temperature, or at least to a temperature between about 20°C and about 250°C. At this stage, the product 110 has substantially a uniform martensite structure.

After the product 110 has cooled to the desired temperature, a collar box 112 is placed around a portion of the product 110 that is to have high tensile strength in the finished product (i.e., the “hard zone”). The collar box 112 may be one of gas-cooled (e.g., air-cooled) and liquid-cooled (e.g., water-cooled). Optionally, the collar box 112 merely insulates the portion of the product 110 from the fluid bed heated portion.

Referring still to FIG. 1, the product 110 is at least partially immersed in a fluidized bed, shown generally at 114. The fluidized bed 114 comprises a solid particulate 116 (e.g., sand) that is heated by a fluid 118 (e.g., hot compressed air) flowing through the solids particulate 116. By way of a specific and non-limiting example, the fluidized bed 114 is set to a desired temperature between about 370°C and about 800°C. In particular, a desired temperature in the range of between about 500°C and about 750°C may. Only a first region 120 of the product 110 is immersed in the fluidized bed and heated to approximately the desired temperature. Further, the collar box 112 acts as a barrier and prevents substantial heating of a portion of the product 110 that is adjacent to the first region 120. In the example that is shown in FIG. 1, the product 110 and the collar box 112 are lowered into the fluidized bed 114 to a point up to the collar box 112. Optionally, a small gap is left between the collar box 112 and the fluidized bed 114, or the collar box 112 is lowered slightly into the fluidized bed 114. Optionally, in at least one embodiment, the collar box 112 is omitted and the portion of the product 110 that is to have high tensile strength in the finished product is protected from being heated using a curtain of cooled gas (such as for
instance cooled air) or by spraying or misting with a cooling liquid (such as for instance water).

[0037] The product 110 and the collar box 112 are left immersed in the fluidized bed 114 until the first region 120 reaches a desired temperature in the range of between about 370° C. to about 800° C. and may or may not be soaked at that temperature for a period of time. The product 110 and the collar box 112 are then removed from the fluidized bed 114, and the product 110 is cooled to room temperature. According to one embodiment of the instant invention, the first region 120 is gas-cooled. Optionally, a fixture is used to maintain the dimensions of the product 110 during the cooling process. Further optionally, the first region 120 is cooled using another suitable cooling technique, such as for instance one of gas-blasting, fluidized bed cooling, die cooling, water/mist cooling, and cooling with the use of cooling fans/jets, etc. Optionally, additional not illustrated post processing is performed subsequent to cooling, such as for instance trimming or perforating, etc. Optionally, the additional not illustrated post processing is performed subsequent to the hot forming and press hardening steps, but prior to the post hot forming treatment in the fluidized bed.

[0038] Tempered martensite is formed within the first region 120 of the product 110 by the steps of reheating to between about 370° C. and about 800° C. and then cooling. On the other hand, the collar box 112 protects a second region 122 of the product 110 from being reheated to between about 370° C. and about 800° C., such that tempered martensite is not formed within the second region 122. Instead, the original martensite structure that is formed during the hot forming and press hardening operation is retained within the second region 122 in the finished product. Of course, a transition zone (not illustrated) of finite width exists along the “boundary” between the first region 120 and the second region 122. The tensile strength of the product 110 within the transition zone is intermediate the tensile strength within the first region 120 and the tensile strength within the second region 122.

[0039] Optionally, additional cycles of heating the product 110 in the fluidized bed followed by cooling the product 110 are performed, in order to form additional “soft regions.” Alternatively, the collar box 112 is designed to leave two or more non-contiguous regions of the product 110 unprocted from being heated, such that when the product is reheated by immersion in the fluidized bed 114 and is subsequently cooled, two or more “soft regions” are formed in a single pass. Of course, a plurality of products 110 and/or products of other types may be immersed in the fluidized bed simultaneously, so as to batch-process a plurality of products 110 and/or products of other types in a single pass.

[0040] Referring now to FIG. 2, shown is the product 110 that is obtained at point “A” of the thermoforming line of FIG. 1. The product 110 at point “A” is substantially uniform of martensite structure. Referring now to FIG. 3, shown is the product 110 corresponding to point “B” of the thermoforming line of FIG. 1. The structure of the product 110 at point “B” is also substantially uniform of martensite structure, but the product 110 has been mounted in collar box 112 so as to define an unprocted first region 120 and a protected second region 122. FIG. 4 illustrates that two regions of substantially different tensile strength are obtained at point “C” of the thermoforming line of FIG. 1, following post hot-forming processing of the product 110. More particularly, subsequent to being reheated in the fluidized bed 114 and then cooled to room temperature, the protected second region 122 retains the original martensite structure, whereas tempered martensite has been formed within the first region 120. As discussed supra a transition zone (not illustrated) of finite width exists along the “boundary” between the first region 120 and the second region 122. As is discussed in greater detail with reference to FIGS. 5a and 5b, the tensile strength of the product 110 within the transition zone is intermediate the tensile strength within the first region 120 and the tensile strength within the second region 122.

[0041] Referring now to FIG. 5a, shown are the locations of a plurality of tensile strength samples taken from a representative B column that was formed using the thermoforming line of FIG. 1. A sample is taken from the transition zone along the “boundary” between the first region 120 and the second region 122, one sample is taken on each side of the “boundary” and at a distance of 20 mm from the line, and additional samples are taken proximate each end of the B column, within the first and second regions 120 and 122, respectively. As is shown graphically in FIG. 5b, tensile strength values of the samples that are taken from the first region 120 are approximately uniform and lower than the tensile strength values of the samples that are taken from the second region 122. The sample that is taken from the transition zone between the first and second regions 120 and 122, respectively, has a tensile strength value that is intermediate the high and low tensile strength values. Accordingly, the product 110 is characterized by a first region 120 of low tensile strength and a second region 122 of high tensile strength, separated by a relatively transition zone of intermediate tensile strength.

[0042] FIG. 5c is a plot showing experimentally measured Vickers Hardness values as a function of distance proximate the transition zone between the first region and the second region of the B column of FIG. 5a. As is shown in FIG. 5c, the hardness is substantially uniform within the first region between about 0 mm and about 60 mm, and within the second region between about 80 mm and about 140 mm. Within the transition zone between about 60 mm and 80 mm, the hardness changes rapidly with distance, indicating a narrow and well defined transition zone between the first region and the second region.

[0043] Referring now to FIG. 6, shown is a simplified flow diagram of a method according to an embodiment of the instant invention. At 600 an initial blank is subjected to a hot forming and press hardening operation to form a shaped product with substantially a uniform first tensile strength. At 602 the shaped product subsequently is immersed, at least partially, into a fluidized bed that is maintained within a known range of operating temperatures. While the shaped product is at least partially immersed into the fluidized bed, a first region of the shaped product is heated selectively to above a known temperature, while at the same time a second region of the shaped product that is adjacent to the first region is maintained below the known temperature. The first region is then cooled, such that the first region attains a second tensile strength that is substantially less than the first tensile strength.

[0044] Referring now to FIG. 7, shown is a simplified flow diagram of a method according to an embodiment of the instant invention. At 700 the initial blank is heated to an austenitizing temperature. At 704 the initial blank is hot-shaped in a cooled pair of dies to form the shaped product. At 706 the shaped product is cooled during a first period of time, using a rate of cooling that is sufficiently rapid to support
formation of a martensitic structure within substantially the entire shaped product. At 706 the shaped product is at least partially immersed into a fluidized bed that is maintained within a known range of operating temperatures. While the shaped product is at least partially immersed into the fluidized bed, a first portion of the shaped product is heated selectively to a known temperature that is less than the austenitizing temperature. During this time a second portion of the shaped product, which is adjacent to the first portion, is maintained below the known temperature. At 708 the shaped product is cooled such that tempered martensite is formed within the first portion of the shaped product while at the same time the second portion of the shaped product remains substantially free of tempered martensite.

[0045] Referring now to FIG. 8, shown is a simplified flow diagram of a method according to an embodiment of the instant invention. The initial blank is provided at 800. At 802 the initial blank is heated to the austenite state. At 804 the initial blank is hot-shaped in a cooled pair of dies so as to form the shaped product. At 806 the entire shaped product is hardened, while it is still inside the pair of dies, by cooling the product using a rate of cooling that is sufficiently fast to form a martensitic structure. At 808 the shaped and hardened product is transferred from the pair of dies to a fluidized bed that is maintained within a known range of operating temperatures. At 810 the shaped and hardened product is at least partially immersed into the fluidized bed, so as to heat a first portion of the product to at least a predetermined first temperature, while at the same time maintaining a second portion of the product below a predetermined second temperature that is lower than the first temperature. At 812 the product is removed from the fluidized bed. At 814 the shaped product is cooled such that tempered martensite is formed within the first portion of the shaped product while at the same time the second portion of the shaped product remains substantially free of tempered martensite. In a product that is formed according to the method that is described with reference to FIG. 8, a tensile strength of the first portion of the shaped product is less than a tensile strength of the second portion of the shaped product.

[0046] Referring now to FIG. 9, shown is a simplified flow diagram of a method according to an embodiment of the instant invention. At 900 a B column blank is provided. At 902 the B column blank is heated to the austenite state. At 904 the B column blank is hot-shaped in a cooled pair of dies, thereby forming the B column profile. At 906 the B column is hardened while it is still inside the pair of dies, by cooling the B column during a first period of time using a rate of cooling that is sufficiently rapid to support formation of a martensitic structure within substantially the entire B column. At 908 the B column is at least partially immersed into a fluidized bed that is maintained within a known range of operating temperatures, so as to selectively heat a first portion of the B column above a known temperature that is less than the austenitizing temperature, while simultaneously maintaining below the known temperature a second portion of the B column that is adjacent to the first portion. At 910 the B column is cooled such that tempered martensite is formed within the first portion of the B column while at the same time the second portion of the B column remains substantially free of tempered martensite. In a B column that is formed according to the method that is described with reference to FIG. 9, a tensile strength of the first portion of the B column is less than a tensile strength of the second portion of the B column.

[0047] Numerous other embodiments may be envisaged without departing from the scope of the instant invention.

1. A method of forming a shaped product from an initial blank, comprising:

(a) subjecting the initial blank to a hot forming and press hardening operation to form the shaped product with substantially a uniform first tensile strength; and subsequently,

(b) at least partially immersing the shaped product into a fluidized bed that is maintained within a known range of operating temperatures so as to selectively heat a first region of the shaped product to above a known temperature, while simultaneously maintaining below the known temperature a second region of the shaped product that is adjacent to the first region, and then cooling the first region such that the first region attains a second tensile strength that is substantially less than the first tensile strength.

2. A method according to claim 1, wherein the initial blank is heated to an austenitizing temperature during the hot forming and press hardening operation, and wherein the known temperature is substantially lower than the austenitization temperature.

3. A method according to claim 1, wherein the first region is immersed into the fluidized bed, while the second region of the shaped product that is adjacent to the first region is not immersed into the fluidized bed.

4. A method according to claim 3, further comprising protecting the second region from being heated to substantially the known temperature.

5. A method according to claim 4, wherein protecting the second region comprises directing a flow of a cooling fluid toward the second region.

6. A method according to claim 1, wherein the entire shaped product is immersed into the fluidized bed.

7. A method according to claim 1, wherein a collar is provided about the second region of the shaped product, the collar for protecting the second region of the shaped product from being heated substantially.

8. A method according to claim 7, wherein the collar gas-cools or liquid-cools the second region of the shaped product.

9. A method according to claim 7, wherein a central portion of the collared second region is prevented from heating above a predetermined temperature, the predetermined temperature being substantially lower than the known temperature.

10. A method according to claim 1, comprising at least partially immersing the shaped product into the fluidized bed a second time, so as to selectively heat a third region of the shaped product to above the known temperature, and then cooling the third region such that the third region attains a third tensile strength that is substantially less than the first tensile strength.

11. A method according to claim 7, wherein the collar has a predetermined shape and is provided about the shaped product so as to define the second region and a plurality of non-contiguous first regions.

12. A method according to claim 7, wherein the collar comprises a plurality of collars defining a plurality of second regions and a plurality of first regions.

13. A method according to claim 1, wherein prior to at least partially immersing the shaped product into the fluidized bed, substantially the entire shaped product has a martensitic structure.
14. A method according to claim 1, wherein the known temperature is between approximately 370° C. and approximately 800° C.

15. A method according to claim 1, wherein the known temperature is between approximately 500° C. and approximately 750° C.

16. A method according to claim 1, wherein the initial blank is fabricated from a press hardenable steel alloy material.

17. A method according to claim 1, comprising performing an intermediate processing step subsequent to subjecting the initial blank to the hot forming and press hardening operation and prior to at least partially immersing the shaped product into the fluidized bed.

18. A method of forming a shaped product from an initial blank, comprising:
   - heating the initial blank to an austenitizing temperature;
   - hot-shaping the initial blank in a cooled pair of dies to form the shaped product;
   - cooling the shaped product during a first period of time, using a rate of cooling that is sufficiently rapid to support formation of a martensitic structure within substantially the entire shaped product;
   - at least partially immersing the shaped product into a fluidized bed that is maintained within a known range of operating temperatures, so as to selectively heat a first portion of the shaped product to a known temperature that is less than the austenitizing temperature, while simultaneously maintaining below the known temperature a second portion of the shaped product that is adjacent to the first portion; and,
   - cooling the shaped product such that martensite within the first portion of the shaped product is tempered while at the same time martensite within the second portion of the shaped product is other than tempered.

19. (canceled)
20. (canceled)
21. (canceled)
22. (canceled)
23. (canceled)
24. (canceled)
25. (canceled)
26. (canceled)
27. (canceled)
28. (canceled)

29. A method of forming a shaped product from an initial blank, comprising:
   - providing the initial blank;
   - heating the initial blank to the austenite state;
   - hot-shaping the initial blank in a cooled pair of dies to form the shaped product;
   - hardening substantially the entire shaped product while it is still inside the pair of dies by cooling the product using a rate of cooling that is sufficiently fast to form a martensitic structure;
   - transferring the shaped and hardened product from the pair of dies to a fluidized bed that is maintained within a known range of operating temperatures;
   - at least partially immersing the shaped and hardened product into the fluidized bed, so as to heat a first portion of the product to at least a predetermined first temperature, while at the same time maintaining a second portion of the product below a predetermined second temperature that is lower than the first temperature;
   - removing the product from the fluidized bed; and, cooling the shaped product such that martensite within the first portion of the shaped product is tempered while at the same time martensite within the second portion of the shaped product is other than tempered,
   - wherein subsequent to cooling, a tensile strength of the first portion of the shaped product is less than a tensile strength of the second portion of the shaped product.

30. (canceled)
31. (canceled)
32. (canceled)
33. (canceled)
34. (canceled)
35. (canceled)
36. (canceled)

37. A method of making a B column for an automobile, comprising:
   - providing a B column blank;
   - heating the B column blank to the austenite state;
   - hot-shaping the B column blank in a cooled pair of dies to form the B column;
   - hardening the B column while it is still inside the pair of dies, by cooling the B column during a first period of time using a rate of cooling that is sufficiently rapid to support formation of a martensitic structure within substantially the entire B column;
   - at least partially immersing the B column into a fluidized bed that is maintained within a known range of operating temperatures, so as to selectively heat a first portion of the B column above a known temperature that is less than the austenitizing temperature, while simultaneously maintaining below the known temperature a second portion of the B column that is adjacent to the first portion; and,
   - cooling the B column such that martensite within the first portion of the B column is tempered while at the same time martensite within the second portion of the B column is other than tempered,
   - wherein subsequent to cooling, a tensile strength of the first portion of the B column is less than a tensile strength of the second portion of the B column.

38. (canceled)
39. (canceled)
40. (canceled)
41. (canceled)
42. (canceled)
43. (canceled)
44. (canceled)
45. (canceled)
46. (canceled)
47. (canceled)

48. A method of forming a shaped product from an initial blank, comprising:
   - providing an initial blank fabricated from an Ultra High Strength Steel;
   - forming the shaped product from the initial blank; and,
   - at least partially immersing the shaped product into a fluidized bed that is maintained within a known range of operating temperatures such as to selectively heat a first region of the shaped product to above a known temperature, while simultaneously maintaining below the known temperature a second region of the shaped product that is adjacent to the first region, and then cooling
the first region such that the first region attains a second tensile strength that is substantially less than the first tensile strength.

49. (canceled)
50. (canceled)
51. (canceled)
52. (canceled)
53. (canceled)
54. (canceled)
55. (canceled)
56. (canceled)
57. A press-hardened sheet-metal product for use as a motor vehicle structural element, comprising:
   a plurality of non-contiguous first regions, each first region containing martensite that has been tempered;
   a second region that is substantially free of martensite that has been tempered; and
   a transition zone disposed between the second region and each first region of the plurality of first regions,
   wherein each first region of the plurality of non-contiguous first regions has a first tensile strength, the second region has a second tensile strength greater than the first tensile strength, and wherein for each transition zone the tensile strength varies between the first tensile strength and the second tensile strength along a direction between a respective first region and the second region.

58. The press-hardened sheet-metal product according to claim 57, wherein the second region has substantially a uniform martensite structure.
59. (canceled)

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