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(54) **HOT STAMPING COMPONENT AND MANUFACTURING METHOD THEREFOR**

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(57) **ABSTRACT**

A hot stamping component includes: a base material; a decarburization layer located on the base material; and an inner oxide layer located on the decarburization layer, wherein the hot stamping component has a tensile strength (TS) of 1350 MPa to 1680 MPa, and a hardness of the hot stamping component within a depth of 50 μm from a surface of the hot stamping component in a plate thickness direction of the hot stamping component and an average hardness of the hot stamping component satisfy Relational Expression 1.

$$(A/B) \leq 0.7 \quad \text{< Relational Expression 1 >}$$

(In Relational Expression 1, A denotes the hardness (Hv(≤50 μm)) within the depth of 50 μm in the plate thickness direction of the hot stamping component, and B denotes the average hardness (Hv(avg.)) of the hot stamping component.)

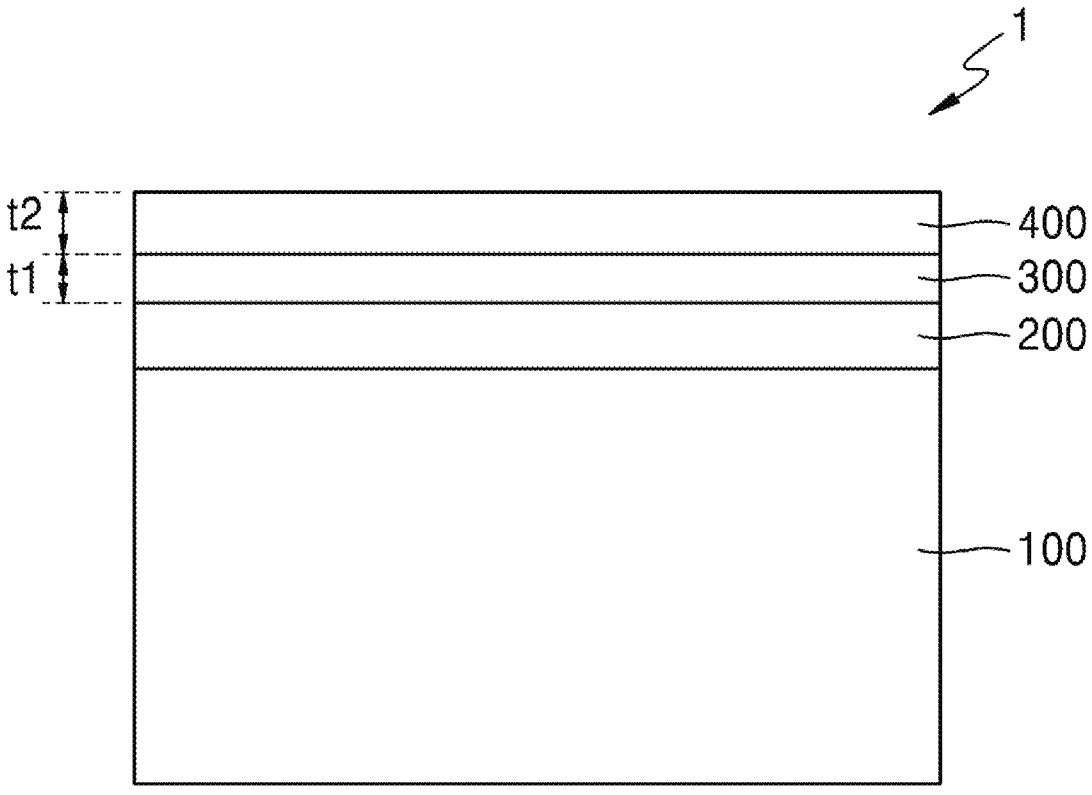


FIG. 1

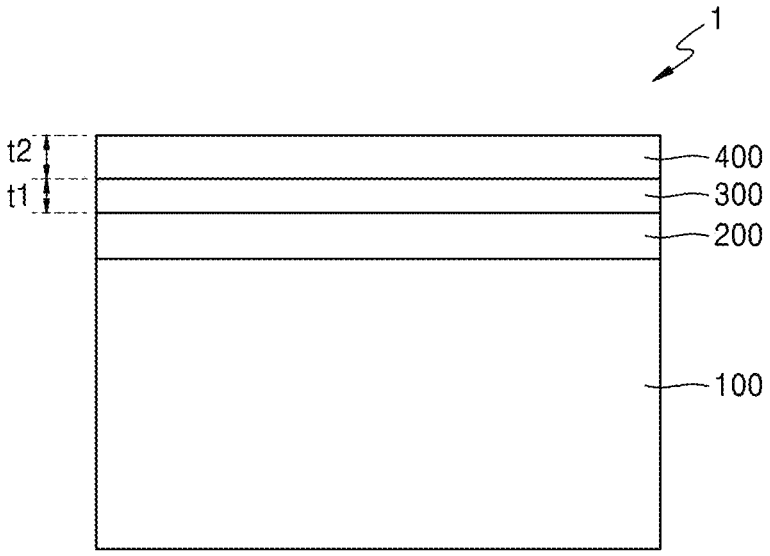


FIG. 2

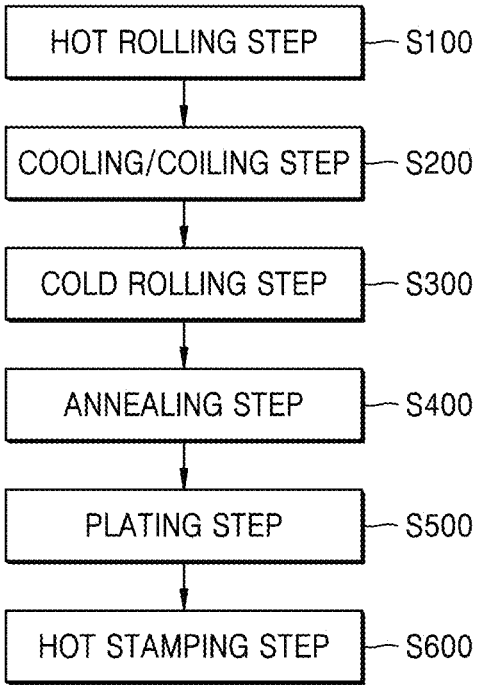

HOT ROLLING STEP
S100
COOLING/COILING STEP
S200
COLD ROLLING STEP
S300
ANNEALING STEP
S400
PLATING STEP
S500
HOT STAMPING STEP
S600

FIG. 3

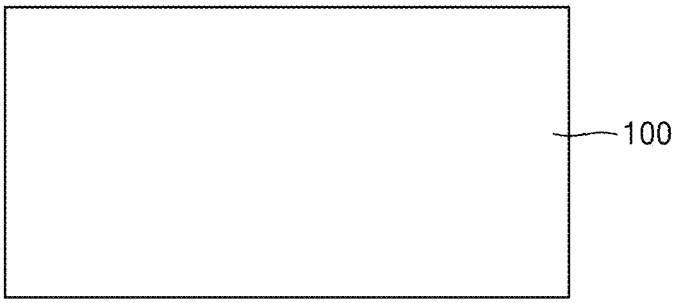


FIG. 4

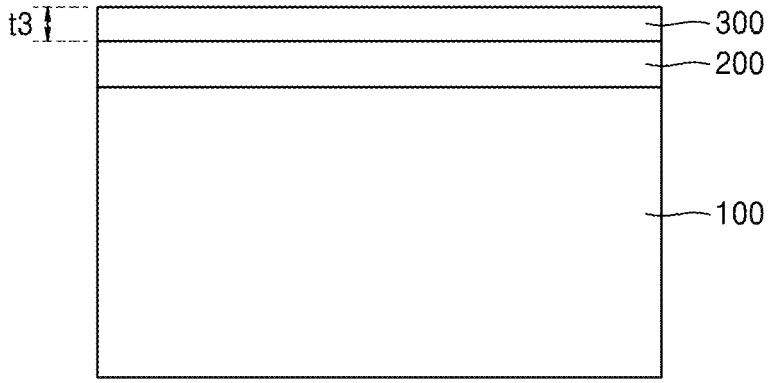


FIG. 5

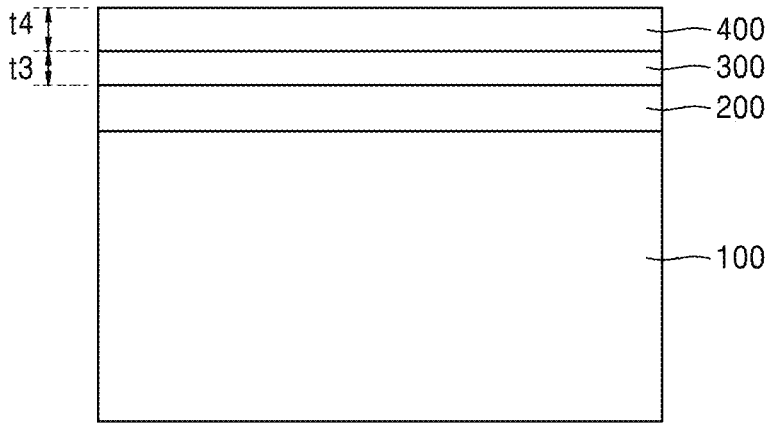


FIG. 6

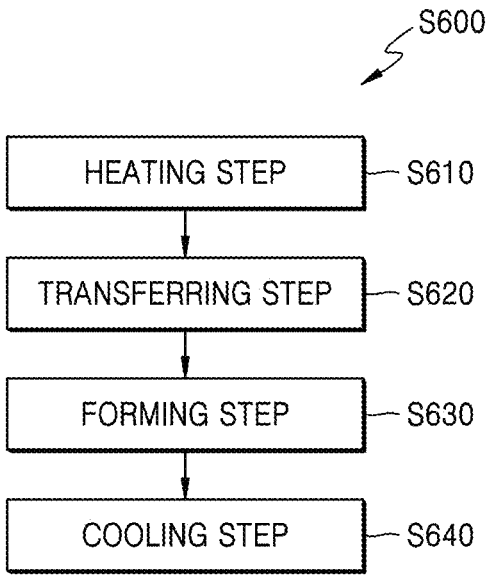

S600
HEATING STEP
S610
TRANSFERRING STEP
S620
FORMING STEP
S630
COOLING STEP
S640

FIG. 7

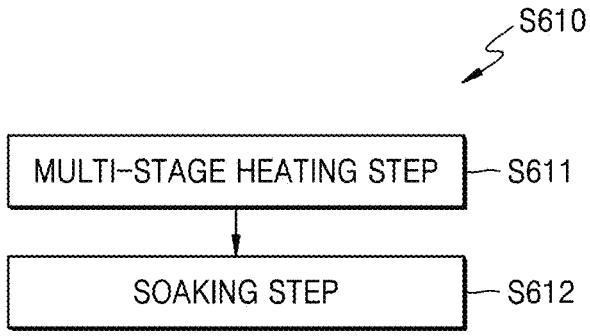
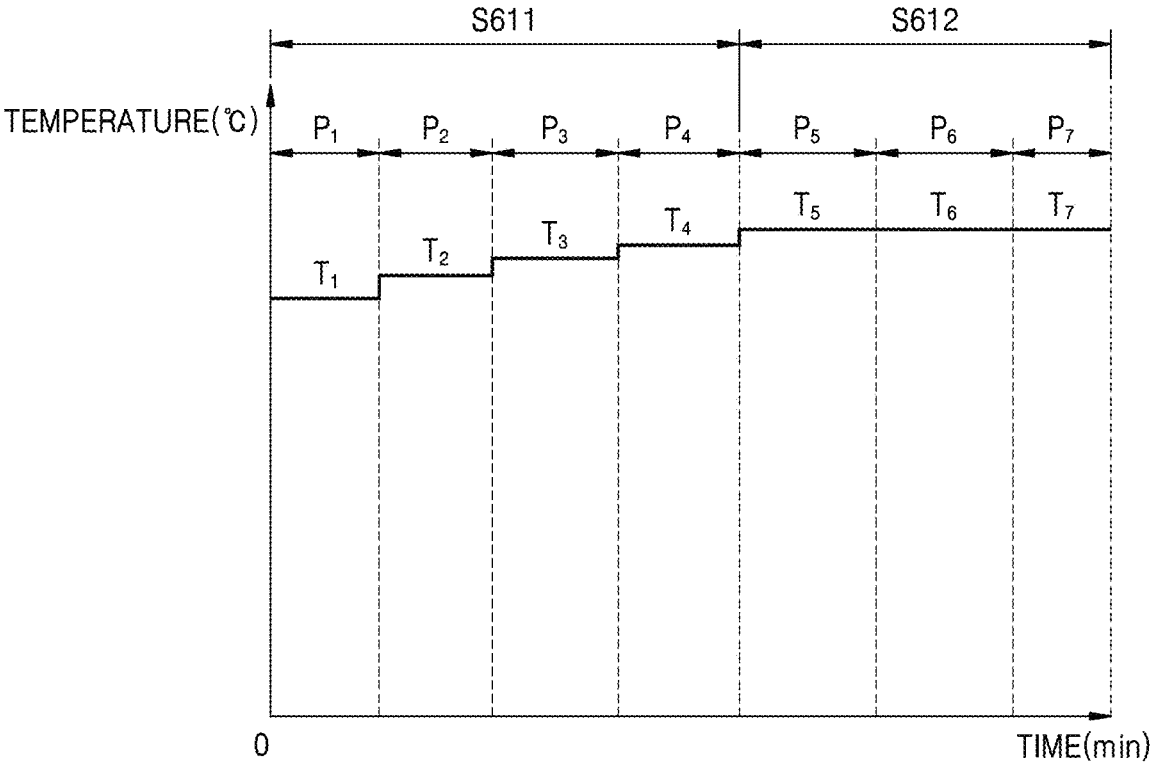


FIG. 8


S611
S612
TEMPERATURE(℃)
P1
P2
P3
P4
P5
P6
P7
T1
T2
T3
T4
T5
T6
T7
0
TIME(min)

HOT STAMPING COMPONENT AND MANUFACTURING METHOD THEREFOR

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application is a continuation of International Patent Application No. PCT/KR2022/020564, filed on Dec. 16, 2022, which claims priority to Korean Patent Application No. KR 10-2022-0067234, filed on May 31, 2022. The disclosures of both applications are incorporated herein by reference in their entirety.

BACKGROUND

Technical Field

[0002] The present disclosure relates to a hot stamping component and a manufacturing method therefor.

Background

[0003] As environmental regulations and fuel economy-related regulations are strengthened worldwide, the need for lighter materials for vehicles is increasing. Accordingly, research on and development of ultra-high-strength steel and hot stamping steel have been actively conducted.

[0004] A hot stamping process generally includes heating/forming/cooling/trimming and may use phase transformation of materials and a change in microstructures during the process. In order to improve the toughness of hot stamping steel, research has been actively conducted on a method of improving the toughness of a base material by using alloy components.

[0005] However, when alloy components are changed or increased, the cost may increase, and economical feasibility may decrease.

[0006] Related technologies include Korean Patent Publication No. 10-2021-0129902 (entitled "hot stamping product and method of manufacturing the same").

SUMMARY OF DISCLOSURE

[0007] Embodiments of the present disclosure may improve the toughness of a manufactured hot stamping component by appropriately forming a decarburization layer and an inner oxide layer on a surface of a base material, and at the same time, may prevent cracks from occurring during hot stamping forming.

[0008] An embodiment of the present disclosure provides a hot stamping component including: a base material; a decarburization layer located on a surface of the base material; and an inner oxide layer located on a surface of the decarburization layer, wherein the hot stamping component has a tensile strength (TS) of 1350 MPa to 1680 MPa, and a hardness of the hot stamping component within a depth of 50 μm from a surface of the hot stamping component in a plate thickness direction of the hot stamping component and an average hardness of the hot stamping component satisfy Relational Expression 1.

$$(A/B) \leq 0.7 \qquad \text{< Relational Expression 1 >}$$

[0009] (In Relational Expression 1, A denotes the hardness (Hv(≤50 μm)) within the depth of 50 μm in the plate thickness direction of the hot stamping component, and B denotes the average hardness (Hv(avg.)) of the hot stamping component.)

[0010] In the present embodiment, a depth of the inner oxide layer may satisfy Relational Expression 2.

$$C \leq 5\ \mu m \qquad \text{< Relational Expression 2 >}$$

[0011] (In Relational Expression 2, C denotes the depth of the inner oxide layer in the plate thickness direction of the hot stamping component.)

[0012] In the present embodiment, the hot stamping component may have a VDA bending angle of 60° or more.

[0013] In the present embodiment, the hot stamping component may have a yield strength (YP) of 900 MPa to 1300 MPa and an elongation (EL) of 4% to 10%.

[0014] In the present embodiment, the hot stamping component may have a microstructure with a martensite fraction of 90% or more.

[0015] In the present embodiment, the hot stamping component may further include a plating layer located on a surface of the inner oxide layer.

[0016] In the present embodiment, a thickness of the plating layer may be 10 μm to 30 μm.

[0017] Another embodiment of the present disclosure provides a method of manufacturing a hot stamping component, including: forming a blank by cutting a plated steel sheet having a plating layer formed on at least one surface of a base material; and heating the blank in a heating furnace having a plurality of sections with different temperature ranges, wherein the heating of the blank includes: a multi-stage heating step of heating the blank stepwise; and a soaking step of heating the stepwise heated blank to a temperature of Ac1 to 910° C., wherein a hardness of the hot stamping component within a depth of 50 μm from a surface of the hot stamping component in a plate thickness direction of the hot stamping component and an average hardness of the hot stamping component satisfy Relational Expression 3.

$$(A/B) \leq 0.7 \qquad \text{< Relational Expression 3 >}$$

[0018] (In Relational Expression 3, A denotes the hardness (Hv(≤50 μm)) within the depth of 50 μm in the plate thickness direction of the hot stamping component, and B denotes the average hardness (Hv(avg.)) of the hot stamping component.)

[0019] In the present embodiment, a dew point of an annealing furnace of the base material may be −15° C. to +15° C.

[0020] In the present embodiment, an annealing temperature of the base material may be 750° C. to 900° C.

[0021] In the present embodiment, the method of manufacturing a hot stamping component may further include: after the heating of the blank, transferring the heated blank; forming a molded body by pressing the transferred blank with a mold; and cooling the formed molded body.

[0022] In the present embodiment, the hot stamping component may further include: a decarburization layer formed on a surface of the base material; and an inner oxide layer formed on a surface of the decarburization layer.

[0023] In the present embodiment, a depth of the inner oxide layer may satisfy Relational Expression 4.

$$C \leq 5\ \mu m \qquad \text{< Relational Expression 4 >}$$

[0024] (In Relational Expression 4, C denotes the depth of the inner oxide layer in the plate thickness direction of the hot stamping component.)

[0025] In some embodiments, a hot stamping component may comprise a base material including carbon (C), silicon (Si), manganese (Mn), chromium (Cr), boron (B), and other elements, wherein the base material has a microstructure with a martensite fraction of about 90% or more. The component may include a decarburization layer located on the base material, an inner oxide layer located on the decarburization layer, and a plating layer located on the inner oxide layer. The hot stamping component may satisfy the following conditions: a tensile strength (TS) of about 1350 MPa to 1680 MPa, a VDA bending angle of about 60° or more, a relational expression (A/B)≤0.7, and a relational expression C≤5 μm, where A denotes the hardness (Hv(≤50 μm)) within the depth of 50 μm in the plate thickness direction of the hot stamping component, B denotes the average hardness (Hv(avg.)) of the hot stamping component, and C denotes the depth of the inner oxide layer in the plate thickness direction of the hot stamping component.

[0026] The decarburization layer may be softer than the base material and may have an average hardness of 70% or less compared to the average hardness at an about ¼ plate thickness of the hot stamping component. The plating layer may be a zinc (Zn)-based or aluminum (Al)-based layer with a thickness of about 10 μm to 30 μm, providing corrosion resistance and preventing toughness reduction. The depth of the decarburization layer may be controlled to improve the toughness of the component without increasing the risk of liquid metal embrittlement (LME) during high-temperature forming.

[0027] The hardness ratio (A/B) may ensure that the hot stamping component maintains high toughness and high-temperature formability, reducing surface cracks during forming. The component may have a yield strength (YP) of about 900 MPa to 1300 MPa and an elongation (EL) of about 4% to 10%. The plating layer, decarburization layer, and inner oxide layer may provide a layered structure, enhancing both corrosion resistance and bendability under VDA standards.

[0028] Other aspects, features, and advantages of the present disclosure will become more apparent from the detailed description, the claims, and the drawings for implementing the present disclosure.

[0029] According to an embodiment of the present disclosure as described above, because a decarburization layer is formed on a surface of a base material, the toughness of a manufactured hot stamping component may be improved.

[0030] Also, according to an embodiment of the present disclosure, because an inner oxide layer formed on a surface of the decarburization layer is provided below a preset depth, cracks may be prevented from occurring during a hot stamping process.

[0031] As discussed, the method and system suitably include use of a controller or processer.

[0032] In another embodiment, vehicles are provided that comprise an apparatus as disclosed herein.

[0033] As referred to herein, the term Ac1 indicates a temperature at which, during the heating, austenite's transformation begins (approximately from 700° C. to 750° C.).

[0034] As referred to herein, yield strength (YP), tensile stress and elongation can be measured according to the ISO standard ISO 6892-1, published in October 2009.

BRIEF DESCRIPTION OF DRAWINGS

[0035] FIG. **1** is a cross-sectional view schematically illustrating a hot stamping component, according to an embodiment of the present disclosure.

[0036] FIG. **2** is a flowchart schematically illustrating a method of manufacturing a hot stamping component, according to an embodiment of the present disclosure.

[0037] FIGS. **3** to **5** are cross-sectional views schematically illustrating a method of manufacturing a hot stamping component, according to an embodiment of the present disclosure.

[0038] FIG. **6** is a flowchart schematically illustrating a hot stamping step, according to an embodiment of the present disclosure.

[0039] FIG. **7** is a flowchart schematically illustrating a heating step, according to an embodiment of the present disclosure.

[0040] FIG. **8** is a diagram for describing a heating furnace having a plurality of sections, in a heating step of a method of manufacturing a hot stamping component, according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

[0041] As the present disclosure allows for various changes and numerous embodiments, certain embodiments will be illustrated in the drawings and described in the detailed description. Effects and features of the present disclosure, and methods for achieving them will be clarified with reference to embodiments described below in detail with reference to the drawings. However, the present disclosure is not limited to the following embodiments and may be embodied in various forms.

[0042] Although the terms "first," "second," etc. may be used to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another.

[0043] As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0044] It will be further understood that the terms "comprises" or "comprising" used herein specify the presence of stated features or components, but do not preclude the presence or addition of one or more other features or components.

[0045] It will be further understood that, when a layer, region, or component is referred to as being "on" another layer, region, or component, it may be directly on the other layer, region, or component, or may be indirectly on the other layer, region, or component with intervening layers, regions, or components therebetween.

[0046] Sizes of components in the drawings may be exaggerated or reduced for convenience of explanation. For example, because sizes and thicknesses of elements in the

drawings are arbitrarily illustrated for convenience of explanation, the present disclosure is not limited thereto.

[0047] "A and/or B" is used herein to select only A, select only B, or select both A and B. Also, "at least one of A and B" is used herein to select only A, select only B, or select both A and B.

[0048] In the following embodiments, "a plan view of an object" refers to "a view of an object seen from above, and "a cross-sectional view of an object" refers to "a view of an object vertically cut and seen from the side. In the following embodiments, when elements "overlap," it may mean that the elements overlap in a "plan view" and a "cross-sectional view".

[0049] It is understood that the term "vehicle" or "vehicular" or other similar term as used herein is inclusive of motor vehicles in general such as passenger automobiles including sports utility vehicles (SUV), buses, trucks, various commercial vehicles, watercraft including a variety of boats and ships, aircraft, and the like, and includes hybrid vehicles, electric vehicles, plug-in hybrid electric vehicles, hydrogen-powered vehicles and other alternative fuel vehicles (e.g. fuels derived from resources other than petroleum). As referred to herein, a hybrid vehicle is a vehicle that has two or more sources of power, for example both gasoline-powered and electric-powered vehicles.

[0050] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the disclosure. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. These terms are merely intended to distinguish one component from another component, and the terms do not limit the nature, sequence or order of the constituent components. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. In addition, the terms "unit", "-er", "-or", and "module" described in the specification mean units for processing at least one function and operation, and can be implemented by hardware components or software components and combinations thereof.

[0051] Although exemplary embodiment is described as using a plurality of units to perform the exemplary process, it is understood that the exemplary processes may also be performed by one or plurality of modules. Additionally, it is understood that the term controller/control unit refers to a hardware device that includes a memory and a processor and is specifically programmed to execute the processes described herein. The memory is configured to store the modules and the processor is specifically configured to execute said modules to perform one or more processes which are described further below.

[0052] Further, the control logic of the present disclosure may be embodied as non-transitory computer readable media on a computer readable medium containing executable program instructions executed by a processor, controller or the like. Examples of computer readable media include, but are not limited to, ROM, RAM, compact disc (CD)-ROMs, magnetic tapes, floppy disks, flash drives, smart cards and optical data storage devices. The computer readable medium can also be distributed in network coupled computer systems so that the computer readable media is stored and executed in a distributed fashion, e.g., by a telematics server or a Controller Area Network (CAN).

[0053] Unless specifically stated or obvious from context, as used herein, the term "about" is understood as within a range of normal tolerance in the art, for example within 2 standard deviations of the mean. "About" can be understood as within 10%, 9%, 8%, 7%, 6%, 5%, 4%, 3%, 2%, 1%, 0.5%, 0.1%, 0.05%, or 0.01% of the stated value. Unless otherwise clear from the context, all numerical values provided herein are modified by the term "about".

[0054] Hereinafter, embodiments of the present disclosure will be described in detail with reference to the accompanying drawings, wherein the same or corresponding elements are denoted by the same reference numerals throughout.

[0055] FIG. **1** is a cross-sectional view schematically illustrating a hot stamping component, according to an embodiment of the present disclosure.

[0056] Referring to FIG. **1**, a hot stamping component **1** according to an embodiment may include a base material **100**, a decarburization layer **200**, an inner oxide layer **300**, and a plating layer **400**. The base material **100**, the decarburization layer **200**, the inner oxide layer **300**, and the plating layer **400** may be sequentially stacked in a plate thickness direction of the hot stamping component **1**.

[0057] In an embodiment, the base material **100** may include carbon (C), silicon (Si), manganese (Mn), phosphorus (P), sulfur(S), chromium (Cr), boron (B), remaining iron (Fe), and other unavoidable impurities. For example, the base material **100** may include about 0.15 wt % to about 0.3 wt % of carbon (C), about 0.05 wt % to about 0.8 wt % of silicon (Si), about 0.8 wt % to about 3.0 wt % of manganese (Mn), more than 0 wt % but not more than about 0.1 wt % of phosphorus (P), more than 0 wt % but not more than about 0.1 wt % of sulfur(S), about 0.1 wt % to about 0.9 wt % of chromium (Cr), about 0.001 wt % to about 0.005 wt % of boron (B), remaining iron (Fe), and other unavoidable impurities.

[0058] Also, the base material **100** may further include at least one component from among titanium (Ti), niobium (Nb), and vanadium (V). Also, the base material **100** may further include calcium (Ca). For example, the base material **100** may further include at least one component from among about 0.01 wt % to about 0.1 wt % of titanium (Ti), about 0.01 wt % to about 0.1 wt % of niobium (Nb), about 0.01 wt % to about 0.1 wt % of vanadium (V), and about 0.0001 wt % to about 0.01 wt % of calcium (Ca).

[0059] Carbon (C) is a major element that determines the strength and hardness of steel and may be added to ensure a tensile strength of a steel material after a hot stamping (or hot pressing) process. Also, carbon (C) may be added to ensure hardenability characteristics of the steel material. In an embodiment, carbon (C) may be included in an amount of about 0.15 wt % to about 0.3 wt % based on a total weight of the base material **100**. When carbon (C) is included in an amount less than about 0.15 wt % based on the total weight of the base material **100**, it may be difficult to achieve a desired mechanical strength. On the other hand, when carbon (C) is included in an amount more than about 0.3 wt % based on the total weight of the base material **100**, the toughness of the steel material may be reduced or a problem of controlling brittleness of steel may occur.

[0060] Silicon (Si) may function as a ferrite stabilizing element in the base material **100**. Silicon (Si) may improve ductility by purifying ferrite and may improve a carbon concentration in austenite by suppressing formation of low-

temperature carbide. Furthermore, silicon (Si) may be a key element for hot-rolled, cold-rolled, and hot-stamped structure homogenization (perlite and manganese segregation control) and ferrite microdispersion. In an embodiment, silicon (Si) may be included in an amount of about 0.05 wt % to about 0.8 wt % based on the total weight of the base material **100**. When silicon (Si) is included in an amount less than about 0.05 wt % based on the total weight of the base material **100**, the above-described effects may not be sufficiently obtained. On the other hand, when silicon (Si) is included in an amount greater than about 0.8 wt % based on the total weight of the base material **100**, hot rolling and cold rolling loads may increase, hot rolling red scale may be excessive, and adhesion may deteriorate.

[0061] Manganese (Mn) may be added to increase hardenability and strength during heat treatment. In an embodiment, manganese (Mn) may be included in an amount of about 0.8 wt % to about 3.0 wt % based on the total weight of the base material **100**. When manganese (Mn) is included in an amount less than about 0.8 wt % based on the total weight of the base material **100**, there may be a high possibility that a material after hot stamping is insufficient (e.g., insufficient hard phase fraction) due to insufficient hardenability. On the other hand, when manganese (Mn) is included in an amount greater than about 3.0 wt % based on the total weight of the base material **100**, ductility and toughness may be reduced due to manganese (Mn) segregation or perlite bands, bending performance may be reduced, and a inhomogeneous microstructure may be generated.

[0062] Phosphorus (P) may be an element that easily segregates and reduces the toughness of steel. In an embodiment, phosphorus (P) may be included in an amount more than 0 wt % and less than or equal to about 0.1 wt % based on the total weight of the base material **100**. When phosphorus (P) is included in the above range based on the total weight of the base material **100**, a decrease in the toughness of steel may be prevented. On the other hand, when phosphorus (P) is included in an amount greater than about 0.1 wt % based on the total weight of the base material **100**, cracks may occur during the process, and an iron phosphide compound may be formed, thereby reducing the toughness of steel.

[0063] Sulfur(S) may be an element that reduces workability and physical properties. In an embodiment, sulfur(S) may be included in an amount more than 0 wt % and less than or equal to about 0.1 wt % based on the total weight of the base material **100**. When sulfur(S) is included in an amount greater than about 0.1 wt % based on the total weight of the base material **100**, hot workability may be reduced, and surface defects such as cracks may occur due to formation of large inclusions.

[0064] Chromium (Cr) may be added to improve the hardenability and strength of steel. In an embodiment, chromium (Cr) may be included in an amount of about 0.1 wt % to about 0.9 wt % based on the total weight of the base material **100**. When chromium (Cr) is included in the above range based on the total weight of the base material **100**, the hardenability and strength of steel may be improved, an increase in production cost may be prevented, and a decrease in the toughness of the steel material may be prevented.

[0065] Boron (B) is added to ensure the hardenability and strength of steel by securing a martensite structure and may have a grain refinement effect by increasing an austenite grain growth temperature. In an embodiment, boron (B) may be included in an amount of about 0.001 wt % to about 0.005 wt % based on the total weight of the base material **100**. When boron (B) is included in above range based on the total weight of the base material **100**, hard grain boundary brittleness may be prevented, and high toughness and bendability may be ensured.

[0066] Titanium (Ti) may be added to strengthen hardenability and improve a material by forming precipitates after hot stamping heat treatment. Also, titanium (Ti) may effectively contribute to refinement of austenite grains by forming a precipitated phase such as Ti (C,N) at a high temperature. In an embodiment, titanium (Ti) may be included in an amount of about 0.01 wt % to about 0.1 wt % based on the total weight of the base material **100**. When titanium (Ti) is included in the above range based on the total weight of the base material **100**, continuous casting defects may be prevented, coarsening of precipitates may be prevented, physical properties of the steel material may be easily ensured, and cracks on a surface of the steel material may be prevented or minimized.

[0067] Niobium (Nb) may be added to increase strength and toughness according to a decrease in a martensite packet size. In an embodiment, niobium (Nb) may be included in an amount of about 0.01 wt % to about 0.1 wt % based on the total weight of the base material **100**. When niobium (Nb) is included in the above range based on the total weight of the base material **100**, the grain refinement effect of the steel material may be high in hot rolling and cold rolling processes, cracks in a slob and brittle fracture of a product during steelmaking/casting may be prevented, and formation of coarse precipitates in steelmaking may be minimized.

[0068] Vanadium (V) may be added to increase the strength of steel through a precipitation strengthening effect by forming precipitates. In an embodiment, vanadium (V) may be included in an amount of about 0.01 wt % to about 0.1 wt % based on the total weight of the base material **100**. When vanadium (V) is included in the above range based on the total weight of the base material **100**, the strength of the steel material may be improved.

[0069] Calcium (Ca) may be added to form CaS to reduce the content of sulfur in steel, and to prevent formation of MnS inclusions that are drawn during hot rolling and induce defects such as hook cracks during electrical resistance welding.

[0070] In an embodiment, the base material **100** may have a microstructure with a martensite fraction of 90% or more. In detail, the base material **100** may have a microstructure including 90% or more of martensite, and less than 10% of remaining other unavoidable structures and other precipitates.

[0071] In an embodiment, the decarburization layer **200** may be located on the base material **100**. In detail, the decarburization layer **200** may be located on a surface of the base material **100**. When the decarburization layer **200** is located on the base material **100**, because the decarburization layer **200** is softer than the base material **100**, the toughness of the hot stamping component **1** may be improved.

[0072] A layer having a hardness of about 70% or less compared to an average hardness at about ¼ point in the plate thickness direction of the hot stamping component **1** from the surface of the base material **100** may be defined as the decarburization layer **200**. Alternatively, a layer having

a hardness of about 70% or less compared to the average hardness at about ¼ point in the plate thickness direction of the hot stamping component **1** from a surface of the hot stamping component **1** may be defined as the decarburization layer **200**. That is, an average hardness of the decarburization layer **200** may be about 70% or less of the average hardness at about ¼ point in the plate thickness direction of the hot stamping component **1** from the surface of the base material **100** or from the surface of the hot stamping component **1**. In other words, the average hardness of the decarburization layer **200** may be about 70% or less of the average hardness at about ¼ point in the plate thickness direction of the hot stamping component **1** from the surface of the base material **100** or from the surface of the hot stamping component **1**.

[0073] In an embodiment, the inner oxide layer **300** may be located on the decarburization layer **200**. In detail, the inner oxide layer **300** may be located on a surface of the decarburization layer **200**. The inner oxide layer **300** may include silicon (Si), manganese (Mn), chromium (Cr), etc.

[0074] In an embodiment, a depth (or thickness t**1**) of the inner oxide layer **300** may be about 5 μm in the plate thickness direction of the hot stamping component **1**, which will be described below in more detail.

[0075] In an embodiment, the plating layer **400** may be located on the inner oxide layer **300**. In detail, the plating layer **400** may be located on a surface of the inner oxide layer **300**. The plating layer **400** may be a zinc (Zn)-based plating layer or an aluminum (Al)-based plating layer. For example, the plating layer **400** may include zinc (Zn) and/or aluminum (Al).

[0076] In an embodiment, when the plating layer **400** is a zinc (Zn)-based plating layer, the plating layer **400** may include iron (Fe), aluminum (Al), manganese (Mn), silicon (Si), remaining zinc (Zn), and other unavoidable impurities. For example, the plating layer **400** may include about 10 wt % to about 70 wt % of iron (Fe), more than 0 wt % but not more than about 5 wt % of aluminum (Al), more than 0 wt % but not more than about 1 wt % of manganese (Mn), more than 0 wt % but not more than about 1 wt % of silicon (Si), remaining zinc (Zn), and other unavoidable impurities.

[0077] The plating layer **400** may have a depth (or thickness t**2**) of about 10 μm to about 30 μm in the plate thickness direction of the hot stamping component **1**. When the thickness t**2** of the plating layer **400** is less than about 10 μm the sacrificial effect of zinc may be reduced, and when the thickness t**2** of the plating layer **400** is greater than about 30 μm, the thickness t**2** of the plating layer **400** is too large, and thus, the toughness of the hot stamping component **1** including the plating layer **400** may be reduced. Accordingly, when the plating layer **400** has the thickness t**2** of about 10 μm to about 30 μm, the surface of the base material (or steel material) may be protected, and at the same time, a decrease in the toughness of the hot stamping component **1** may be prevented or minimized.

[0078] The decarburization layer **200** is softer than the base material **100**, and when the hot stamping component **1** includes the decarburization layer **200**, the toughness of the hot stamping component **1** including the decarburization layer **200** may be improved.

[0079] However, as described above, when the depth (or thickness t**1**) of the inner oxide layer **300** is too large, liquid zinc may more easily penetrate into the base material **100** by the inner oxide layer **300**, the risk of cracks during hot stamping forming may increase, and thus, the bendability of the manufactured hot stamping component **1** may be reduced. In detail, when the depth (or the thickness t**1**) of the inner oxide layer **300** is greater than about 5 μm, liquid zinc may more easily penetrate into the base material **100** due to the inner oxide layer **300**, the risk of cracks during hot stamping forming may increase, and thus, the bendability of the manufactured hot stamping component **1** may be reduced.

[0080] As described below in a method of manufacturing a hot stamping component, the decarburization layer **200** may be formed on the base material **100** in an annealing step. In this case, the inner oxide layer **300** may be simultaneously formed on the decarburization layer **200**. In detail, in the annealing step, the decarburization layer **200** may be formed on the surface of the base material **100**, and at the same time, the inner oxide layer **300** may be formed on the surface of the decarburization layer **200**.

[0081] When a dew point of an annealing furnace where the annealing step is performed increases, a depth (or thickness) of the decarburization layer **200** may increase. However, when the depth (or thickness) of the decarburization layer **200** increases, the depth (or thickness) of the inner oxide layer **300** may also increase. That is, in order to increase the toughness of the hot stamping component **1**, the depth (or thickness) of the decarburization layer **200** should increase. However, when the depth (or thickness) of the decarburization layer **200** increases, the depth (or thickness) of the inner oxide layer **300** may also increase, thereby increasing the risk of cracks during hot stamping forming and reducing the bendability of the manufactured hot stamping component **1**. Accordingly, it is necessary to appropriately adjust the depth (or thickness) of the decarburization layer **200** and the depth (or thickness) of the inner oxide layer **300**.

[0082] Accordingly, the inventors of the present disclosure have derived Relational Expressions 1 and 2 through excessively repeated experiments to enable the hot stamping component **1** to have a VDA bending angle of about 60° or more. In an embodiment, the hot stamping component **1** may satisfy Relational Expressions 1 and 2. In detail, a hardness within a depth of about 50 μm in the plate thickness direction of the hot stamping component **1** from the surface of the hot stamping component **1** and an average hardness of the hot stamping component **1** may satisfy Relational Expression 1, and the depth (or thickness) of the inner oxide layer **300** may satisfy Relational Expression 2. For example, the hot stamping component **1** may satisfy both Relational Expression 1 and Relational Expression 2.

$$(A/B) \leq 0.7 \qquad \text{< Relational Expression 1 >}$$

[0083] In Relational Expression 1, A denotes the hardness (Hv(≤50 μm)) within the depth (or thickness) of about 50 μm in the plate thickness direction of the hot stamping component **1**, and B denotes the average hardness (Hv(avg.)) of the hot stamping component **1**.

[0084] In this case, the hardness within the depth of about 50 μm in the plate thickness direction of the hot stamping component **1** from the surface of the hot stamping component **1** may be a hardness value measured with a Vickers hardness tester at a depth of about 50 μm or less in the plate

thickness direction of the hot stamping component **1** from the surface of the hot stamping component **1**, and the average hardness (Hv(avg.)) of the hot stamping component **1** may be a hardness value measured with the Vickers hardness tester at about ¼ point in the plate thickness direction of the hot stamping component **1**.

$$C \leq 5\ \mu m \qquad \text{< Relational Expression 2 >}$$

[0085] In Relational Expression 2, C denotes the depth (or thickness) of the inner oxide layer **300** in the plate thickness direction of the hot stamping component **1**.

[0086] Because the decarburization layer **200** is located on the surface of the base material **100**, the decarburization layer **200** may be located on a portion adjacent to the surface of the hot stamping component **1**. Because the decarburization layer **200** is softer than the base material **100**, a hardness of a portion of the hot stamping component **1** adjacent to the surface of the hot stamping component **1** may be lower than the average hardness of the hot stamping component **1**. In this case, when the depth (or thickness) of the decarburization layer **200** increases, a difference between the hardness of the portion of the hot stamping component **1** adjacent to the surface of the hot stamping component **1** and the average hardness of the hot stamping component **1** may increase. On the other hand, when the depth (or thickness) of the decarburization layer **200** decreases, a difference between the hardness of the portion of the hot stamping component **1** adjacent to the surface of the hot stamping component **1** and the average hardness of the hot stamping component **1** may decrease.

[0087] When a ratio between the hardness (Hv(≤50 μm)) within the depth (or thickness) of about 50 μm in the plate thickness direction of the hot stamping component **1** and the average hardness (Hv(avg.)) of the hot stamping component **1** is greater than 0.7, the decarburization layer **200** is not formed (or provided) to a sufficient depth (or thickness), and thus, the toughness of the hot stamping component **1** including the decarburization layer **200** may be low. In particular, a VDA bending angle of the hot stamping component **1** may be less than about 60°.

[0088] When the ratio between the hardness (Hv(≤50 μm)) within the depth (or thickness) of about 50 μm in the plate thickness direction of the hot stamping component **1** and the average hardness (Hv(avg.)) of the hot stamping component **1** is equal to or less than 0.7, it may mean that the decarburization layer **200** is formed (or provided) to a sufficient depth (or thickness). Accordingly, when the ratio between the hardness (Hv(≤50 μm)) within the depth (or thickness) of about 50 μm in the plate thickness direction of the hot stamping component **1** and the average hardness (Hv(avg.)) of the hot stamping component **1** satisfies about 0.7 or less, the decarburization layer **200** is formed (or provided) to a sufficient depth (or thickness), and thus, the toughness of the hot stamping component **1** including the decarburization layer **200** may be improved. In particular, the hot stamping component **1** may have a VDA bending angle of about 60° or more.

[0089] Also, as described above, the depth (or thickness) of the inner oxide layer **300** included in the hot stamping component **1** may be about 5 μm or less.

[0090] When the plating layer **400** is a zinc (Zn)-based plating layer, liquid metal embrittlement (LME) may occur due to a low melting point of zinc, which may cause cracks to occur inside and may reduce the bendability of the hot stamping component **1**. In this case, when the depth (or thickness) of the inner oxide layer **300** is large, liquid zinc may more easily penetrate into the inside due to the inner oxide layer **300**, the risk of cracks during hot stamping forming may increase, and thus, the bendability of the manufactured hot stamping component **1** may be reduced.

[0091] When the depth (or thickness) of the inner oxide layer **300** is greater than about 5 μm, liquid zinc may more easily penetrate into the inside due to the inner oxide layer **300**, the risk of cracks during hot stamping forming may increase, and thus, the bendability of the manufactured hot stamping component **1** may be reduced.

[0092] Accordingly, when the depth (or thickness) of the inner oxide layer **300** is about 5 μm or less in the plate thickness direction of the hot stamping component **1**, cracks may be prevented from occurring during hot stamping, and thus, the high-temperature formability of the hot stamping component (or blank) may be improved.

[0093] In an embodiment, the hot stamping component **1** may satisfy Relational Expression 1 and Relational Expression 2 at the same time. When the hot stamping component **1** satisfies Relational Expression 1 and Relational Expression 2 at the same time, the hot stamping component **1** may have high toughness and the high-temperature formability of the hot stamping component **1** may be excellent. In detail, when the hardness within the depth of 50 μm in the plate thickness direction of the hot stamping component **1** from the surface of the hot stamping component **1** and the average hardness of the hot stamping component **1** satisfy Relational Expression 1, and the depth (or thickness) of the inner oxide layer **300** satisfies Relational Expression 2, the hot stamping component **1** may have high toughness and the high-temperature formability of the hot stamping component **1** may be excellent.

[0094] In an embodiment, when the hot stamping component **1** satisfies both Relational Expression 1 and Relational Expression 2, the hot stamping component **1** may have a tensile strength (TS) of about 1350 MPa to about 1680 MPa, a yield strength (YP) of about 900 MPa to about 1300 MPa, and an elongation (EL) of about 4% to about 10%. Also, the hot stamping component **1** may have a VDA bending angle of about 60° or more. In this case, the VDA bending angle may be measured in accordance with the VDA standard (VDA238-100).

[0095] FIG. **2** is a flowchart schematically illustrating a method of manufacturing a hot stamping component, according to an embodiment of the present disclosure. FIGS. **3** to **5** are cross-sectional views schematically illustrating a method of manufacturing a hot stamping component, according to an embodiment of the present disclosure.

[0096] Referring to FIGS. **2** to **5**, a method of manufacturing the hot stamping component **1** (see FIG. **1**) according to an embodiment may include a hot rolling step **S100**, a cooling/coiling step **S200**, a cold rolling step **S300**, an annealing step **S400**, a plating step **S500**, and a hot stamping step **S600**.

[0097] First, a reheating step of the base material **100** (e.g., steel slab) prepared with the composition described with reference to FIG. **1** may be performed. In the steel slab reheating step, the steel slab obtained through a continuous

casting process may be reheated to a certain temperature so that components segregated during casting are resolved. In an embodiment, a slab reheating temperature (SRT) may be about 1,200° C. to about 1,400° C. When the slab reheating temperature (SRT) is lower than about 1,200° C., the components segregated during the casting may not be sufficiently resolved, and thus, it may be difficult to have the homogenization effect of alloy elements significantly and it may be difficult to have the solution effect of titanium (Ti) significantly. When the slab reheating temperature (SRT) is high, the slab reheating temperature (SRT) is favorable for homogenization. However, when the slab reheating temperature (SRT) is higher than about 1,400° C., an austenite crystal grain size may increase, and thus, it may be difficult to ensure strength, and the manufacturing cost of a steel sheet may increase due to an excessive heating process.

[0098] In the hot rolling step S**100**, the reheated base material **100** may be hot-rolled at a certain finishing rolling temperature. A hot-rolled steel sheet may be manufactured through the hot rolling step S**100**. In an embodiment, a finishing delivery temperature (FDT) may be about 880° C. to about 950° C. In this case, when the finishing delivery temperature (FDT) is lower than about 880° C., the workability of the steel sheet may not be ensured due to the occurrence of a mixed grain structure caused by abnormal area rolling, workability may be reduced due to microstructure unevenness, and a passing ability problem may occur during hot rolling due to a rapid phase change. When the finishing delivery temperature (FDT) is higher than about 950° C., austenite grains may be coarsened, TiC precipitates may be coarsened, and thus, the performance of the hot stamping component may deteriorate.

[0099] In the cooling/coiling step S**200**, the hot-rolled base material **100** may be cooled and coiled to a certain coiling temperature (CT). In an embodiment, the coiling temperature (CT) of the cooling/coiling step S**300** may be about 550° C. to about 800° C. The coiling temperature (CT) may affect the redistribution of carbon (C), and when the coiling temperature (CT) is lower than about 550° C., a low-temperature phase fraction may increase due to subcooling, strength may increase, a rolling load may increase during cold rolling, and ductility may rapidly decrease. In contrast, when the coiling temperature (CT) is higher than about 800° C., abnormal crystal grain growth or excessive crystal grain growth may cause deterioration in formability and strength.

[0100] In the cold rolling step S**300**, the coiled base material **100** may be uncoiled, pickled, and then cold rolled. In this case, the pickling may be performed to remove scale from the coiled steel sheet (or base material), that is, a hot-rolled coil manufactured through the hot rolling process described above. A cold-rolled steel sheet may be manufactured through the cold rolling step S**300**.

[0101] In the annealing step S**400**, the cold-rolled base material **100** may be annealed at a temperature of about 700° C. or more. For example, the annealing step S**400** may include heating the cold-rolled base material **100** and cooling the heated base material **100** at a certain cooling rate.

[0102] In an embodiment, the base material may be annealed in the annealing step S**400**. The annealing step S**400** may be performed in an annealing furnace.

[0103] The annealing of the base material **100** may be performed in a gas atmosphere including about 0.5 vol % to about 25 vol % of hydrogen and remaining nitrogen. In this case, water may be sprayed into the annealing furnace together with hydrogen gas and nitrogen gas. When water is sprayed into the annealing furnace, a dew point of the annealing furnace may increase. Accordingly, the dew point of the annealing furnace may be controlled by controlling the amount of water sprayed into the annealing furnace.

[0104] In an embodiment, when the dew point of the annealing furnace increases, the decarburization layer **200** may be formed on the base material **100**. For example, carbon may be lost from a surface of the base material **100** to form the decarburization layer **200**. Also, at the same time, the inner oxide layer **300** may be formed on the decarburization layer **200**. That is, the decarburization layer **200** may be formed on the surface of the base material **100**, and the inner oxide layer **300** may be formed on a surface of the decarburization layer **200**. In this case, the decarburization layer **200** and the inner oxide layer **300** may be layers obtained by changing a portion of the base material **100**.

[0105] In this case, a layer having a hardness of about 80% or less compared to an average hardness at about ¼ point from the surface of the base material **100** may be defined as the decarburization layer **200**. That is, an average hardness of the decarburization layer **200** may be about 80% or less of the average hardness at about ¼ point from the surface of the base material **100**.

[0106] In an embodiment, the dew point of the annealing furnace where the annealing of the base material **100** is performed may be about −15° C. to about +15° C. The decarburization layer **200** is formed on the base material **100** in order to improve the toughness of the manufactured hot stamping component **1**. However, when the dew point of the annealing furnace is about −15° C. or lower, a depth (or thickness) of the decarburization layer **200** may be too small, and thus, the effect of improving the toughness of the manufactured hot stamping component may be insignificant. On the other hand, when the dew point of the annealing furnace is about +15° C. or higher, a depth (or thickness t**3**) of the inner oxide layer **300** may be too large, and thus LME cracks may occur, and operability may be reduced due to equipment oxidation. For example, a large amount of water should be supplied to the annealing furnace in order to increase the dew point of the annealing furnace. When a large amount of water is supplied to the annealing furnace, equipment of the annealing furnace may be oxidized, and it may take a long time to clean the equipment, thereby reducing operability. Also, when the dew point of the annealing furnace is high, the depth (or thickness) of the decarburization layer **200** and the depth (or thickness t**3**) of the inner oxide layer **300** may increase, and thus, cracks may occur inside during high-temperature forming due to the inner oxide layer **300**. Accordingly, when the dew point of the annealing furnace where the annealing of the base material **100** is performed satisfies about −15° C. to about +15° C., the toughness of the manufactured hot stamping component **1** may be improved and the efficiency of a manufacturing process may be improved.

[0107] In an embodiment, a line speed of the annealing furnace where the annealing of the base material **100** is performed may be about 30 meters per minute (mpm) to about 200 mpm. When the line speed of the annealing furnace is about 30 mpm or less, a moving speed of the base material **100** may be too slow, which may lead to a sharp decrease in productivity. When the line speed of the annealing furnace is about 200 mpm or more, a staying time of the

base material **100** in the annealing furnace may be too short, the depth (or thickness) of the decarburization layer **200** may decrease, and thus, the effect of improving the toughness of the manufactured hot stamping component may be insignificant. Accordingly, when the line speed of the annealing furnace where the annealing of the base material **100** is performed satisfies about 30 mpm to about 200 mpm, the productivity of the hot stamping component may be improved, and at the same time, the toughness of the manufactured hot stamping component may be improved.

[0108] In an embodiment, an annealing temperature of the base material **100** may be about 750° C. to about 900° C. When the annealing temperature of the base material **100** is lower than about 750° C., a desired structure may not be obtained, and recrystallization may not be sufficiently completed. On the other hand, when the annealing temperature of the base material **100** is higher than about 900° C., the annealing temperature may be too high, and thus, the efficiency of the manufacturing process may be reduced. Accordingly, when the annealing temperature of the base material **100** satisfies about 750° C. to about 900° C., a desired structure may be obtained, recrystallization may be sufficiently completed, and the efficiency of the manufacturing process may be improved.

[0109] The plating step S**500** may be a step of forming the plating layer **400** on the annealed base material **100**. In an embodiment, the plating layer **400** may be formed on the annealed base material **100** through the plating step S**500**. In detail, the plating layer **400** may be formed on a surface of the inner oxide layer **300** through the plating step S**500**. In this case, the plating layer **400** may include a zinc (Z)-based plating layer or an aluminum (Al)-based plating layer.

[0110] In detail, in the plating step S**500**, the annealed base material **100** may be immersed in a plating bath. In this case, the plating bath may be maintained at a temperature of about 400° C. to about 700° C. The adhesion amount of the plating layer may be about 40 g/m^2 to about 200 g/m^2 on both surfaces of the base material **100** (or the inner oxide layer **300**).

[0111] In an embodiment, a depth (or thickness t**4**) of the plating layer **400** formed on the base material **100** or the decarburization layer **200** may be about 5 μm to about 20 μm in the plate thickness direction of the base material **100**. When the depth (or thickness) of the plating layer **400** is about 5 μm or less, the sacrificial method of the plating layer **400** may be insufficient. When the depth (or thickness) of the plating layer **400** is about 20 μm or more, the cost of forming the plating layer **400** may increase, thereby reducing economic feasibility. Accordingly, when the depth (or thickness t**4**) of the plating layer **400** satisfies about 5 μm to about 20 μm, corrosion of the base material **100** of the hot stamping component **1** may be prevented or minimized.

[0112] In an embodiment, the annealing step S**400** and the plating step S**500** may be performed on the same line. Accordingly, a line speed at which the plating step S**500** is performed may be about 30 mpm to about 200 mpm. When the line speed is about 30 mpm or less, the line speed may be too slow, and thus, productivity may be reduced. A plating amount is controlled by using an air knife. When the line speed is about 200 mpm or more, the line speed may be too fast, and thus, it may be difficult to control the plating amount by using the air knife. Accordingly, when the line speed at which the plating step S**500** is performed satisfies about 30 mpm to about 200 mpm, productivity may be improved, and at the same time, the plating amount may be easily controlled.

[0113] In an embodiment, a plated steel sheet having the plating layer **400** formed on at least one surface of the base material **100** may be manufactured through the plating step S**500**. In this case, the plated steel sheet may include the base material **100**, the decarburization layer **200** formed on the base material **100**, the inner oxide layer **300** formed on the decarburization layer **200**, and the plating layer **400** formed on the inner oxide layer **300**. In detail, the plated steel sheet may include the base material **100**, the decarburization layer **200** formed on the surface of the base material **100**, the inner oxide layer **300** formed on the surface of the decarburization layer **200**, and the plating layer **400** formed on the surface of the inner oxide layer **300**.

[0114] FIG. **6** is a flowchart schematically illustrating a hot stamping step, according to an embodiment of the present disclosure. FIG. **7** is a flowchart schematically illustrating a heating step, according to an embodiment of the present disclosure.

[0115] Referring to FIGS. **6** and **7**, the hot stamping step S**600** may be performed after the plating step S**500** (see FIG. **2**). The hot stamping step S**600** may include a heating step S**610**, a transferring step S**620**, a forming step S**630**, and a cooling step S**640**.

[0116] First, a blank may be formed by cutting the plated steel sheet having the plating layer **400** (see FIG. **5**) formed on at least one surface of the base material **100** (see FIG. **5**). In this case, the decarburization layer **200** (see FIG. **5**) and the inner oxide layer **300** (see FIG. **5**) may be located between the base material **100** and the plating layer **400**.

[0117] In the heating step S**610**, the blank may be heated in a heating furnace having a plurality of sections with different temperature ranges. As shown in FIG. **7**, the heating step S**610** may include a multi-stage heating step S**611** and a soaking step S**612**. The multi-stage heating step S**611** and the soaking step S**612** may be steps in which the blank is heated while passing through the plurality of sections provided in the heating furnace.

[0118] In an embodiment, an overall temperature of the heating furnace may be about 680° C. to about 910° C. In detail, the overall temperature of the heating furnace where the multi-stage heating step S**611** and the soaking step S**612** are performed may be about 680° C. to about 910° C. In this case, a temperature of the heating furnace where the multi-stage heating step S**611** is performed may be about 680° C. to about Ac1, and a temperature of the heating furnace where the soaking step S**612** is performed may be about Ac1 to about 910° C.

[0119] In the multi-stage heating step S**611**, the blank may be heated stepwise while passing through the plurality of sections provided in the heating furnace. From among the plurality of sections provided in the heating furnace, there may be a plurality of sections in which the multi-stage heating step S**611** is performed, and a temperature may be set for each section so as to increase in a direction from an inlet of the heating furnace into which the blank is inserted to an outlet of the heating furnace from which the blank is taken out, and thus, a temperature of the blank may be raised in stages.

[0120] The soaking step S**612** may be performed after the multi-stage heating step S**611**. In the soaking step S**612**, the stepwise heated blank may be heated (or soaked) while

passing through a section of the heating furnace set to a temperature of about Ac1 to about 910° C. From among the plurality of sections provided in the heating furnace, there may be at least one section in which the soaking step **S612** is performed.

[0121] FIG. **8** is a diagram for describing a heating furnace having a plurality of sections, in a heating step of a method of manufacturing a hot stamping component, according to an embodiment of the present disclosure.

[0122] Referring to FIG. **8**, a heating furnace according to an embodiment may include a plurality of sections with different temperature ranges. In detail, the heating furnace may include a first section P_1 with a first temperature range T_1, a second section P_2 with a second temperature range T_2, a third section P_3 with a third temperature range T_3, a fourth section P_4 with a fourth temperature range T_4, a fifth section P_5 with a fifth temperature range T_5, a sixth section P_6 with a sixth temperature range T_6, and a seventh section P_7 with a seventh temperature range T_7.

[0123] In an embodiment, in the multi-stage heating step **S611**, a blank may be heated stepwise while passing through the first section P_1 to the fourth section P_4 defined in the heating furnace. Also, in the soaking step **S612**, the blank stepwise heated in the first section P_1 to the fourth section P_4 may be soaked while passing through the fifth section P_5 to the seventh section P_7.

[0124] The first section P_1 to the seventh section P_7 may be sequentially arranged in the heating furnace. The first section P_1 with the first temperature range T_1 may be adjacent to an inlet of the heating furnace into which the blank is inserted, and the seventh section P_7 with the seventh temperature range T_7 may be adjacent to an outlet of the heating furnace from which the blank is taken out. Accordingly, the first section P_1 with the first temperature range T_1 may be a first section of the heating furnace, and the seventh section P_7 with the seventh temperature range T_7 may be a last section of the heating furnace.

[0125] Temperatures of the plurality of sections provided in the heating furnace, for example, temperatures of the first section P_1 to the seventh section P_7, may increase in a direction from the inlet of the heating furnace into which the blank is inserted to the outlet of the heating furnace from which the blank is taken out. However, temperatures of the fifth section P_5, the sixth section P_6, and the seventh section P_7 may be the same. Also, a temperature difference between two adjacent sections from among the plurality of sections provided in the heating furnace may be greater than about 0° C. and less than or equal to about 100° C. For example, a temperature difference between the first section P_1 and the second section P_2 may be greater than about 0° C. and less than or equal to about 100° C.

[0126] A heating furnace temperature of the soaking step **S612** may be about Ac1 to about 910° C. When the heating furnace temperature of the soaking step **S612** is about Ac1 or lower, the manufactured hot stamping component may not have a desired material. On the other hand, when the heating furnace temperature of the soaking step **S612** is about 910° C. or higher, zinc (Zn) included in the plating layer **400** may be vaporized, resulting in loss of the plating layer **400**. Accordingly, when the heating furnace temperature of the soaking step **S612** satisfies about Ac1 to about 910° C., the manufactured hot stamping component may be formed of a desired material, and loss of the plating layer **400** may be prevented.

[0127] Although the heating furnace according to an embodiment includes seven sections with different temperature ranges in FIG. **8**, the present disclosure is not limited thereto. The heating furnace may include five, sixth, or eight sections with different temperature ranges.

[0128] In an embodiment, because the heating step **S610** includes the multi-stage heating step **S611** and the soaking step **S612**, a temperature of the heating furnace may be set in stages, and thus, the energy efficiency of the heating furnace may be improved.

[0129] In an embodiment, the heating furnace may have a length of about 20 m to about 40 m along a transfer path of the blank. The heating furnace may include the plurality of sections with different temperature ranges, and a ratio between a length of a section where the blank is stepwise heated and a length of a section where the blank is soaked from among the plurality of sections may satisfy about 1:1 to about 4:1. When the length of the section where the blank is soaked in the heating furnace increases and the ratio between the length of the section where the blank is stepwise heated and the length of the section where the blank is soaked is greater than about 1:1, the amount of hydrogen penetrating into the blank in the soaking section may increase, thereby increasing delayed fracture. On the other hand, when the length of the section where the blank is soaked decreases and the ratio between the length of the section where the blank is stepwise heated and the length of the section where the blank is soaked is less than about 4:1, the soaking section (or time) is not sufficiently secured, and thus, the strength of the hot stamping component manufactured by the process of manufacturing a hot stamping component may be uneven. For example, the length of the soaking section from among the plurality of sections provided in the heating furnace may be about 20% to about 50% of a total length of the heating furnace.

[0130] In an embodiment, a total heating time during which the heating step **S610** is performed may be about 2 min to about 20 min. That is, a total time during which the blank stays in the heating furnace may be about 2 min to about 20 min. When the total heating time during which the heating step **S610** is performed is about 2 min or less, a heating time may be insufficient and thus, the manufactured hot stamping component **1** may not have a desired material. On the other hand, when the total heating time during which the heating step **S610** is performed is about 20 min or more, a heating time may be too long and thus, a production speed may decrease, and economic feasibility may decrease. Accordingly, when the total heating time during which the heating step **S610** is performed satisfies about 2 min to about 20 min, the manufactured hot stamping component **1** may have a desired material, and at the same time, a decrease in the economic feasibility of the manufacturing process may be prevented or minimized.

[0131] After the heating step **S610**, the transferring step **S620**, the forming step **S630**, and the cooling step **S640** may be further performed.

[0132] In an embodiment, the transferring step **S620** may be a step of transferring the heated blank from the heating furnace to a mold. In this case, in the transferring step **S620**, the heated blank may be cooled to an atmospheric temperature (or room temperature). That is, the heated blank may be air-cooled during transfer. When the heated blank is not air-cooled, a mold entry temperature (e.g., forming start temperature) may increase, and thus, wrinkles (or bends)

may occur on a surface of the manufactured hot stamping component **1**. Also, because the use of a refrigerant may affect a post-process (hot stamping), it may be preferable that the heated blank is air-cooled during transfer.

[0133] In an embodiment, the forming step **S630** may be a step of hot stamping the transferred blank to form a molded body. In detail, in the forming step **S630**, the blank may be pressed with the mold to form a molded body.

[0134] In an embodiment, the forming start temperature may be about 500° C. to about 700° C. When the forming start temperature is lower than about 500° C., the forming start temperature may be too low, and thus, the formability of the blank may decrease, and the manufactured hot stamping component **1** may not have a desired structure and properties. On the other hand, when the forming start temperature is higher than about 700° C., wrinkles (or bends) may occur on the surface of the manufactured hot stamping component **1**. Also, the plating layer **400** may stick to the mold. Accordingly, when the forming start signal is about 500° C. to about 700° C., the formability of the blank may be improved, the manufactured hot stamping component **1** may have a desired structure and properties, and the occurrence of wrinkles (or bends) on the surface of the manufactured hot stamping component **1** may be prevented or minimized.

[0135] In an embodiment, the cooling step **S640** may be a step of cooling the molded body. The cooling step **S640** may be performed in the mold in which the blank is pressed.

[0136] In detail, a final product may be formed by cooling the molded body at the same time as forming the molded body into a final component shape. A cooling channel through which a refrigerant circulates may be provided in the mold. The molded body may be rapidly cooled by circulation of the refrigerant supplied through the cooling channel provided in the mold. In this case, in order to prevent a spring back phenomenon of a plate material and maintain a desired shape, the blank may be pressed and rapidly cooled while the mold is closed. When the molded body is formed and cooled, the molded body may be cooled at an average cooling rate of at least about 10° C./s to a martensite end temperature.

[0137] In an embodiment, a cooling end temperature at which the cooling step **S640** ends may be about room temperature to about 200° C. When the cooling end temperature is lower than room temperature, the productivity of the manufacturing process may decrease. On the other hand, when the cooling end temperature is higher than about 200° C., the manufactured hot stamping component **1** is air-cooled at room temperature, and in this case, distortion may occur in the hot stamping component **1**, and it may be difficult to secure a target material. Accordingly, when the cooling end temperature at which the cooling step **S640** ends satisfies room temperature to about 200° C., the productivity of the manufacturing process may be improved, and distortion of the manufactured hot stamping component **1** may be prevented or minimized.

[0138] Accordingly, the inventors of the present disclosure have derived Relational Expressions 3 and 4 through excessively repeated experiments to enable the manufactured hot stamping component **1** to have a VDA bending angle of about 60° or more. In an embodiment, the manufactured hot stamping component **1** may satisfy Relational Expressions 3 and 4. In detail, a hardness within a depth of 50 μm in the plate thickness direction of the hot stamping component **1** from the surface of the hot stamping component **1** and an average hardness of the hot stamping component **1** may satisfy Relational Expression 3, and a depth (or thickness) of the inner oxide layer **300** may satisfy Relational Expression 4. For example, the hot stamping component **1** may satisfy both Relational Expression 3 and Relational Expression 4.

$$(A/B) \leq 0.7 \qquad \text{< Relational Expression 3 >}$$

[0139] In Relational Expression 3, A denotes the hardness (Hv(≤50 μm)) within the depth (or thickness) of about 50 μm in the plate thickness direction of the hot stamping component **1**, and B denotes the average hardness (Hv(avg.)) of the hot stamping component **1**.

[0140] In this case, the hardness within the depth of about 50 μm in the plate thickness direction of the hot stamping component **1** from the surface of the hot stamping component **1** may be a hardness value measured with a Vickers hardness tester at a depth of about 50 μm or less in the plate thickness direction of the hot stamping component **1** from the surface of the hot stamping component **1**, and the average hardness (Hv(avg.)) of the hot stamping component **1** may be a hardness value measured with the Vickers hardness tester at about ¼ point in the plate thickness direction of the hot stamping component **1**.

$$C \leq 5\ \mu m \qquad \text{< Relational Expression 4 >}$$

[0141] In Relational Expression 4, C denotes the depth (or thickness) of the inner oxide layer **300** in the plate thickness direction of the hot stamping component **1**.

[0142] In an embodiment, when the manufactured hot stamping component **1** satisfies both Relational Expression 3 and Relational Expression 4, the toughness of the hot stamping component **1** manufactured through the method of manufacturing a hot stamping component may be improved. For example, the hot stamping component **1** manufactured through the method of manufacturing a hot stamping component may have a VDA bending angle of about 60° or more. Also, the hot stamping component **1** manufactured through the method of manufacturing a hot stamping component may have a tensile strength (TS) of about 1350 MPa to about 1680 MPa, a yield strength (YP) of about 900 MPa to about 1300 MPa, and an elongation (EL) of about 4% to about 10%.

Experimental Examples

[0143] Hereinafter, the present disclosure will be described through experimental examples. However, the following experimental examples are intended to explain the present disclosure in more detail, and the scope of the present disclosure is not limited by the following experimental examples. The following experimental examples may be appropriately modified and changed by one of ordinary skill in the art within the scope of the present disclosure.

TABLE 1

Components (wt %)							
C	Si	Mn	P	S	Cr	B	Ti
0.22	0.3	1.5	0.02 or less	0.015 or less	0.25	0.0025	0.05

TABLE 2

	SRT (° C.)	FDT (° C.)	CT (° C.)	Annealing temperature (° C.)	Annealing furnace Dew point (° C.)	Heating temperature (° C.)	Heating time (min)
Embodiment 1	1215	900	713	820	0	870	5
Embodiment 2	1215	900	713	820	14	870	5
Comparative Example 1	1215	900	713	820	20	870	5
Comparative Example 2	1215	900	713	820	−30	870	5

[0144] Embodiment 1, Embodiment 2, Comparative Example 1, and Comparative Example 2 are hot stamping components (samples) manufactured using a slab having a composition shown in Table 1 under process conditions shown in Table 2.

TABLE 3

	A/B	C (μm)	VDA bending angle (°)	Crack depth (μm)
Embodiment 1	0.70	1.3	72.19	2.8
Embodiment 2	0.39	5	75.44	4.1
Comparative Example 1	0.33	7.1	58.96	15.2
Comparative Example 2	0.72	0.1	54.77	1.0

[0145] In Table 3, A denotes the hardness (Hv(≤50 μm)) within the depth (or thickness) of about 50 μm in the plate thickness direction of the hot stamping component, B denotes the average hardness (Hv(avg.)) of the hot stamping component, and C denotes the depth (or thickness) of the inner oxide layer **300** in the plate thickness direction of the hot stamping component. In this case, the hardness within the depth of about 50 μm in the plate thickness direction of the hot stamping component **1** from the surface of the hot stamping component **1** may be a hardness value measured with a Vickers hardness tester at a depth of about 50 μm or less in the plate thickness direction of the hot stamping component **1** from the surface of the hot stamping component **1**, and the average hardness (Hv(avg.)) of the hot stamping component **1** may be a hardness value measured with the Vickers hardness tester at about ¼ point in the plate thickness direction of the hot stamping component **1**.

[0146] In Table 3, the VDA bending angle was evaluated by using the VDA standard (VDA238-100), and the crack depth was measured by using a scanning electron microscope. In this case, the crack depth corresponds to a deepest crack depth measured through the scanning electron microscope.

[0147] The VDA bending angle of the hot stamping component required by the present disclosure is 60° or more. Also, when the crack depth in the hot stamping component is large, the VDA bending angle of the hot stamping component may decrease, and the toughness of the hot stamping component may decrease. Accordingly, the crack depth in the hot stamping component required by the present disclosure is 10 μm or less. When the crack depth is out of the range, it corresponds to a case where the required conditions are not satisfied.

[0148] Embodiments 1 and 2 correspond to a case where both Relational Expression 1 ((A/B)≤0.7) and Relational Expression 2 (C≤5) are satisfied, Comparative Example 1 corresponds to a case where Relational Expression 2 (C≤5) is not satisfied, and Comparative Example 2 corresponds to a case where Relational Expression 1 ((A/B)≤0.7) is not satisfied. Embodiment 1, Embodiment 2, Comparative Example 1, and Comparative Example 2 correspond to samples manufactured using the base material **100** (or steel sheet) satisfying the composition of FIG. **1** according to the method of manufacturing a hot stamping component. However, Comparative Example 1 and Comparative Example 2 are samples that do not satisfy Relational Expression 1 ((A/B)≤0.7) and/or Relational Expression 2 (C≤5) due to a difference in process control conditions.

[0149] When both Relational Expression 1 ((A/B)≤0.7) and Relational Expression 2 (C≤5) are satisfied, it may be found that the VDA bending angle, and the crack depth satisfy the required conditions. In detail, when both Relational Expression 1 ((A/B)≤0.7) and Relational Expression 2 (C≤5) are satisfied, it may be found that the VDA bending angle is 60° or more and the crack depth is 10 μm or less.

[0150] However, when Relational Expression 2 (C≤5) is not satisfied, it may be found that the VDA bending angle, and the crack depth do not satisfy the required conditions. In detail, when Relational Expression 2 (C≤5) is not satisfied, it may be found that the VDA bending angle is less than 60° and the crack depth is greater than 10 μm.

[0151] Also, when Relational Expression 1 ((A/B)≤0.7) is not satisfied, it may be found that the VDA bending angle does not satisfy the required condition. In detail, when Relational Expression 1 ((A/B)≤0.7) is not satisfied, it may be found that the VDA bending angle is less than 60°.

[0152] Accordingly, when the hot stamping component **1** satisfies both Relational Expression 1 ((A/B)≤0.7) and Relational Expression 2 (C≤5), the hot stamping component **1** may have the required VDA bending angle, and the crack depth in the hot stamping component **1** may be formed below a preset value. That is, when the hot stamping component **1** satisfies both Relational Expression 1 ((A/B)≤0.7) and Relational Expression 2 (C≤5), the hot stamping component **1** may have excellent toughness and high-temperature formability.

[0153] While the present disclosure has been particularly shown and described with reference to embodiments thereof, they are provided for the purposes of illustration, and it will be understood by one of ordinary skill in the art that various modifications and equivalent other embodiments made be made from the present disclosure. Accordingly, the true technical scope of the present disclosure is defined by the technical spirit of the appended claims.

What is claimed is:

1. A hot stamping component comprising:

a base material;

a decarburization layer located on the base material; and

an inner oxide layer located on the decarburization layer,

wherein the hot stamping component has a tensile strength (TS) of about 1350 MPa to 1680 MPa, and

wherein a hardness of the hot stamping component within a depth of about 50 μm from a surface of the hot stamping component in a plate thickness direction of the hot stamping component and an average hardness of the hot stamping component satisfy Relational Expression 1.

$$(A/B) \leq 0.7 \quad \text{< Relational Expression 1 >}$$

(In Relational Expression 1, A denotes the hardness (Hv(≤50 μm)) within the depth of 50 μm in the plate thickness direction of the hot stamping component, and B denotes the average hardness (Hv(avg.)) of the hot stamping component.)

2. The hot stamping component of claim **1**, wherein a depth of the inner oxide layer satisfies Relational Expression 2.

$$C \leq 5\ \mu m \quad \text{< Relational Expression 2 >}$$

(In Relational Expression 2, C denotes the depth of the inner oxide layer in the plate thickness direction of the hot stamping component.)

3. The hot stamping component of claim **1**, wherein the hot stamping component has a VDA bending angle of about 60° or more.

4. The hot stamping component of claim **1**, wherein the hot stamping component has a yield strength (YP) of about 900 MPa to 1300 MPa and an elongation (EL) of 4% to 10%.

5. The hot stamping part of claim **1**, wherein the hot stamping component has a microstructure with a martensite fraction of about 90% or more.

6. The hot stamping component of claim **1**, further comprising a plating layer located on the inner oxide layer.

7. The hot stamping component of claim **6**, wherein a thickness of the plating layer is about 10 μm to 30 μm.

8. A method of manufacturing a hot stamping component, comprising:

forming a blank by cutting a plated steel sheet having a plating layer formed on at least one surface of a base material; and

heating the blank in a heating furnace having a plurality of sections with different temperature ranges,

wherein the heating of the blank comprises:

a multi-stage heating step of heating the blank stepwise; and

a soaking step of heating the stepwise heated blank to a temperature of Ac1 to about 910° C.,

wherein a hardness of the hot stamping component within a depth of about 50 μm from a surface of the hot stamping component in a plate thickness direction of the hot stamping component and an average hardness of the hot stamping component satisfy Relational Expression 3.

$$(A/B) \leq 0.7 \quad \text{< Relational Expression 3 >}$$

(In Relational Expression 3, A denotes the hardness (Hv(≤50 μm)) within the depth of 50 μm in the plate thickness direction of the hot stamping component, and B denotes the average hardness (Hv(avg.)) of the hot stamping component.)

9. The method of manufacturing a hot stamping component of claim **8**, wherein a dew point of an annealing furnace of the base material is about −15° C. to +15° C.

10. The method of manufacturing a hot stamping component of claim **8**, wherein an annealing temperature of the base material is about 750° C. to 900° C.

11. The method of manufacturing a hot stamping component of claim **8**, further comprising:

after the heating of the blank,

transferring the heated blank;

forming a molded body by pressing the transferred blank with a mold; and

cooling the formed molded body.

12. The method of manufacturing a hot stamping component of claim **11**, wherein the hot stamping component further comprises:

a decarburization layer formed on the base material; and

an inner oxide layer formed on the decarburization layer.

13. The method of manufacturing a hot stamping component of claim **12**, wherein a depth of the inner oxide layer satisfies Relational Expression 4.

$$C \leq 5\ \mu m \quad \text{< Relational Expression 4 >}$$

(In Relational Expression 4, C denotes the depth of the inner oxide layer in the plate thickness direction of the hot stamping component.)

14. A hot stamping component, comprising:

a base material including carbon (C), silicon (Si), manganese (Mn), chromium (Cr), boron (B), and other elements, wherein the base material has a microstructure with a martensite fraction of about 90% or more;

a decarburization layer located on the base material;

an inner oxide layer located on the decarburization layer; and

a plating layer located on the inner oxide layer,

wherein the hot stamping component satisfies the following conditions:

a tensile strength (TS) of about 1350 MPa to 1680 MPa;

a VDA bending angle of about 60° or more;

Relational Expression 3 : $(A/B) \leq 0.7$,

and Relational Expression 4 : $C \leq 5\ \mu m$.

(In Relational Expression 3, A denotes the hardness (Hv(≤50 μm)) within the depth of 50 μm in the plate

thickness direction of the hot stamping component, and B denotes the average hardness (Hv(avg.)) of the hot stamping component.)

(In Relational Expression 4, C denotes the depth of the inner oxide layer in the plate thickness direction of the hot stamping component.)

15. The hot stamping component of claim **14**, wherein the decarburization layer is softer than the base material and has an average hardness of 70% or less compared to the average hardness at an about ¼ plate thickness of the hot stamping component.

16. The hot stamping component of claim **14**, wherein the plating layer is a zinc (Zn)-based or aluminum (Al)-based layer with a thickness of about 10 μm to 30 μm, providing corrosion resistance and preventing toughness reduction.

17. The hot stamping component of claim **14**, wherein the depth of the decarburization layer is controlled to improve the toughness of the component, without increasing the risk of liquid metal embrittlement (LME) during high-temperature forming.

18. The hot stamping component of claim **14**, wherein the hardness ratio (A/B) ensures that the hot stamping component maintains high toughness and high-temperature formability, reducing surface cracks during forming.

19. The hot stamping component of claim **14**, wherein the component has a yield strength (YP) of about 900 MPa to 1300 MPa and an elongation (EL) of about 4% to 10%.

20. The hot stamping component of claim **14**, wherein the plating layer, decarburization layer, and inner oxide layer provide a layered structure, enhancing both corrosion resistance and bendability under VDA standards.

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