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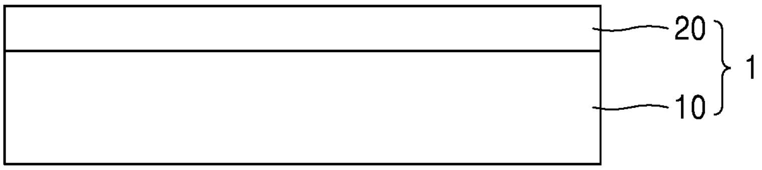
(54) HOT-STAMPED COMPONENT

(57) The present disclosure relates to a hot stamped component including a base steel plate including 0.15 to 0.27 wt% of carbon (C), 0.15 to 1.0 wt% of silicon (Si), 0.5 to 1.10 wt% of manganese (Mn), 0.018 wt% or less of phosphorus (P), 0.005 wt% or less of sulfur (S), 0.1 to 1.0 wt% of chromium (Cr), 0.1 to 1.0 wt% of aluminum (Al), 0.015 to 0.080 wt% of titanium (Ti), 0.015 to 0.080 wt% of niobium (Nb), 0.1 to 0.7 wt% of molybdenum (Mo), 0.001 to 0.008 wt% of boron (B), 0.005 wt% or less of nitrogen (N) and the remainder iron (Fe) and other unavoidable impurities, wherein the base steel plate includes a martensite structure, the nano-indentation hardness of the martensite structure is 3.0 GPa or more and 5.0 GPa or less, and the standard deviation of the nano-indentation hardness is 0.8 GPa or less.

FIG. 7



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Description

Technical Field

[0001] The present disclosure relates to a hot stamped component.

Background Art

[0002] High-strength steel is applied to automotive parts for light-weight and stability. On the other hand, high-strength steel may secure high strength characteristics for its weight, but as the strength increases, the press formability or bendability decreases, which may cause a material breakage during processing or cause a spring back phenomenon, and thus, there is a difficulty in forming products with complex and precise shapes.

[0003] As a method of improving these problems, a hot stamping method is proposed. As interest in the hot stamping method increases, research on materials for hot stamping is also actively being conducted. For example, as disclosed in Korean Patent Publication No. 10-2017-0076009, the hot stamping method is a forming technique that manufactures high-strength parts by heating a steel plate for hot stamping to a high temperature and then rapidly cooling the steel plate in a press mold at the same time as forming. Specifically, the hot stamping process generally consists of heating/forming/-cooling/trimming and may utilize a phase change and microstructure change of the material during the hot stamping process. The heating process during the hot stamping process is a process of heating a blank within a heating furnace, and the cooling process during the hot stamping process is a process of cooling the hot-stamped molded body within a mold. In addition, the blank heated through the heating process may be exposed to room temperature and air-cooled while being introduced from the heating furnace into the mold.

[0004] Related technologies include Korean Patent Registration Publication No. 10-2070579 (Title of the invention: Hot stamping method), etc.

Disclosure of Invention

Technical Problem

[0005] Embodiments of the present disclosure provide a hot stamped component having excellent mechanical properties such as high strength and high toughness by controlling the uniformity of nano-indentation hardness of a martensite structure. However, these technical problems are just examples, and the scope of the present inventive concept is not limited thereto.

Solution to Problem

[0006] An embodiment of the present disclosure provides a hot stamped component including a base steel plate including 0.15 to 0.27 wt% of carbon (C), 0.15 to 1.0 wt% of silicon (Si), 0.5 to 1.10 wt% of manganese (Mn), 0.018 wt% or less of phosphorus (P), 0.005 wt% or less of sulfur (S), 0.1 to 1.0 wt% of chromium (Cr), 0.1 to 1.0 wt% of aluminum (Al), 0.015 to 0.080 wt% of titanium (Ti), 0.015 to 0.080 wt% of niobium (Nb), 0.1 to 0.7 wt% of molybdenum (Mo), 0.001 to 0.008 wt% of boron (B), 0.005 wt% or less of nitrogen (N) and the remainder iron (Fe) and other unavoidable impurities, wherein the base steel plate includes a martensite structure, the nano-indentation hardness of the martensite structure is 3.0 GPa or more and 5.0 GPa or less, and the standard deviation of the nano-indentation hardness is 0.8 GPa or less.

Advantageous Effects of Invention

[0007] According to an embodiment of the present disclosure as described above, hot stamped components may secure excellent mechanical properties such as high strength and high toughness by controlling the uniformity of the nano-indentation hardness of the martensite structure. Of course, the scope of the present disclosure is not limited by these effects.

Brief Description of Drawings

[0008]

FIG. 1 is a flowchart schematically illustrating a method of manufacturing a hot stamped component according to an embodiment of the present disclosure.

FIG. 2 is a flowchart specifically illustrating a heating operation of a method of manufacturing a hot stamped component according to an embodiment of the present disclosure.

FIG. 3 is a diagram illustrating a heating furnace having multiple sections in a heating operation of a method of manufacturing a hot stamped component according to an embodiment of the present disclosure.

FIG. 4 is a diagram illustrating a rate of change in a temperature increase rate of multiple sections according to a heating time in a method of manufacturing a hot stamped component according to an embodiment of the present disclosure.

FIG. 5 is a diagram illustrating a heating time according to a material thickness and a heating time according to a heating temperature.

FIG. 6 is a flowchart specifically illustrating a method of manufacturing a blank for manufacturing a hot stamped component according to an embodiment of the present disclosure.

FIG. 7 is a cross-sectional view schematically illustrating a portion of a hot stamped component according to an embodiment of the present disclosure.

FIG. 8 is a micrograph showing a cross-section of a base steel plate of a hot stamped component according to an embodiment of the present disclosure.

FIG. 9 is a micrograph showing a cross-section of a base steel plate of a hot stamped component according to an embodiment of the present disclosure.

FIG. 10 is a micrograph showing a cross-section of a base steel plate of a hot stamped component according to a comparative example.

Best Mode for Carrying out the Invention

[0009] In the present embodiment, a bending angle of a hot stamped component may be 70° or more and 85° or less.

[0010] In the present embodiment, when a value obtained by dividing a standard deviation of the nano-indentation hardness by an average of the nano-indentation hardness is referred to as a coefficient of variation, the coefficient of variation may be 0.2 or less.

[0011] In the present embodiment, the standard deviation of carbon content of the martensite structure may be less than 0.04 wt%.

[0012] In the present embodiment, the hot stamped component may further include micro-precipitates distributed within the base steel plate, and the micro-precipitates may include at least one carbide of Ti, Nb, and Mo.

[0013] In the present embodiment, the number of micro-precipitates distributed per unit area (100 μm^2) may be 9,000 or more and 30,000 or less.

[0014] In the present embodiment, an average diameter of the micro-precipitates may be 0.003 μm or more and 0.006 μm or less.

[0015] In the present embodiment, the tensile strength of the hot stamped component may be 1,350 MPa or more and 1,650 MPa or less.

[0016] In the present embodiment, the yield strength of the hot stamped component may be 950 MPa or more and 1,200 MPa or less.

[0017] In the present embodiment, the elongation of the hot stamped component may be 6% or more.

[0018] In the present embodiment, the martensite structure may include multiple lath structures.

[0019] In the present embodiment, the hot stamped component may further include a plating layer arranged on the base steel plate.

[0020] Other aspects, features and advantages other than those described above will become apparent from the following detailed description, claims, and drawings for practicing the disclosure.

Mode for the Invention

[0021] The disclosure may be modified into various forms and may have various embodiments. In this regard, the disclosure will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings. The advantages, features, and methods of achieving the advantages may be clear when referring to the embodiments described below together with the drawings. However, the disclosure may have different forms and should not be construed as being limited to the descriptions set forth herein.

[0022] The terms "first", "second", etc., may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another.

[0023] In the following embodiments, the singular forms include the plural forms unless the context clearly indicates otherwise.

[0024] The terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features or constituent elements but do not preclude the presence or addition of one or more other features or constituent elements.

[0025] It will also be understood that when a film, a region, a constituent element is referred to as being "on" or "above" another element, the film, the region, or the constituent element may be in direct contact with the other element or other intervening film, region, or constituent element may be present.

[0026] In the drawings, thicknesses of layers and regions may be exaggerated or reduced for convenience of explanation. For example, the sizes and thicknesses of elements in the drawings are arbitrarily expressed for convenience of explanation, and thus, the current inventive concept is not limited to the drawings.

[0027] In the present disclosure, an expression such as "A and/or B" may include A, B, or A and B. Also, in the present disclosure, expressions such as "at least one of A and B" may include A, B, or A and B.

[0028] In the following embodiments, when referring to "planar", this means when a target portion is viewed from above, and when referring to "cross-sectional", this means when a cross-section cut vertically from the target portion is viewed from a side. In the following embodiments, when referring to "overlapping", this includes "planar" and "cross-sectional" overlapping.

[0029] Hereafter, the disclosure will be described more fully with reference to the accompanying drawings. In describing the disclosure with reference to drawings, like reference numerals are used for elements that are substantially identical or correspond to each other.

[0030] FIG. 1 is a flowchart schematically illustrating a method of manufacturing a hot stamped component according to an embodiment of the present disclosure. FIG. 2 is a flowchart specifically illustrating a heating operation of a method of manufacturing a hot stamped component according to an embodiment of the present disclosure. Hereinafter, a method of manufacturing a hot stamped component will be described with reference to FIGS. 1 and 2.

[0031] Referring to FIG. 1, in an embodiment, the method of manufacturing a hot stamped component may include a blank input operation (S100), a heating operation (S200), a transfer operation (S300), a forming operation (S400), and a cooling operation (S500). The method of manufacturing a hot stamped component according to the present disclosure may further include a blank preparation operation (S1). The blank preparation operation (S1) may be an operation for manufacturing a blank for hot stamping (hereinafter, referred to simply as a 'blank') for manufacturing a hot stamped component according to an embodiment of the present disclosure, which will be described in detail with reference to FIG. 6 described below.

[0032] First, the blank input operation (S100) may be an operation for inputting a blank into a heating furnace having a plurality of sections having temperature increase rate ranges different from each other. The blank may be provided in a form on which a plating layer is formed on at least one side of the base steel plate. The base steel plate may be a steel plate manufactured by performing a hot rolling process and/or a cold rolling process on a steel slab cast to include a predetermined alloy element in a predetermined content as the base steel plate.

[0033] In an embodiment, in the blank input operation (S100), a blank input into the heating furnace may be loaded onto a roller and then moved in a transfer direction.

[0034] Referring to FIGS. 1 and 2, a heating operation (S200) may be performed after the blank input operation (S100). In an embodiment, the heating operation (S200) may include a multiple heating operation (S210) and a soaking operation (S220). Therefore, the multiple heating operation (S210) and the soaking operation (S220) may be performed after the blank input operation (S100). The multiple heating operation (S210) and the soaking operation (S220) may be operations in which the blank is heated while passing through multiple sections provided in the heating furnace.

[0035] In an embodiment, the overall temperature of the heating furnace may be in a range from about 680 °C to about 1000 °C. Specifically, the overall temperature of the heating furnace in which the multiple heating operation (S210) and the soaking operation (S220) are performed may be in a range from about 680 °C to about 1000 °C. At this time, the temperature of the heating furnace in which the multiple heating operation (S210) is performed may be in a range from about 680 °C to Ac3, and the temperature of the heating furnace in which the soaking operation (S220) is performed may be in a range from about Ac3 to 1000 °C.

[0036] Specifically, in the multiple heating operation (S210), the blank may be multiple heated while passing through the multiple sections provided in the heating furnace. Among the plurality of sections provided in the heating furnace, there may be a plurality of sections in which the multiple heating operation (S210) is performed, and the temperature is set for each section so that the temperature increases from an inlet of the heating furnace into which the blank is input toward an outlet of the heating furnace from which the blank is taken out, and thus, the blank is heated stepwise.

[0037] The soaking operation (S220) may be performed after the multiple heating operation (S210). In the soaking operation (S220), the multiple heated blank may be heat-treated while passing through a section of the heating furnace set to a temperature of Ac3 to 1000 °C. Preferably, in the soaking operation (S220), the multiple heated blank may be soaked at a temperature in a range from about 830 °C to about 1000 °C. In addition, among the plurality of sections provided in the heating furnace, there may be at least one section in which the soaking operation (S220) is performed.

[0038] FIG. 3 is a diagram illustrating a heating furnace having multiple sections in a heating operation of a method of manufacturing a hot stamped component according to an embodiment.

[0039] Referring to FIG. 3, the heating furnace according to an embodiment may have multiple sections P1, P2, P3, and P4 having different temperature ranges. More specifically, the heating furnace may have a first heating section P1 having a first temperature range T1, a second heating section P2 having a second temperature range T2, a third heating section P3 having a third temperature range T3, and a fourth heating section P4 having a fourth temperature range T4. At this time, the third heating section P3 may have two sections having different temperature ranges. The third heating section P3 may include a third-first heating section P3-1 having a third-first temperature range T3-1 and a third-second heating section P3-2 having a third-second temperature range T3-2.

[0040] In an embodiment, the second heating section P2 may have multiple sections having different temperature ranges. For example, the second heating section P2 may include a second-first heating section P2-1 having a second-first temperature range T2-1 and a second-second heating section P2-2 having a second-second temperature range T2-2. However, the present disclosure is not limited thereto. The second heating section P2 may include a second-first heating section P2-1 having a second-first temperature range T2-1 to a second-n^{th} heating section P2-n having a second-n^{th} temperature range T2-n. At this time, n may be a natural number greater than or equal to 2.

[0041] In an embodiment, the first heating section P1 may also have multiple sections having different temperature ranges. For example, the first heating section P1 may include a first-first heating section P1-1 having a first-first temperature range T1-1 and a first-second heating section P1-2 having a first-second temperature range T1-2. However, the present disclosure is not limited thereto. The first heating section P1 may include a first-first heating section P1-1 having a first-first temperature range T1-1 to a first-n^{th} heating section P1-n having a first-n^{th} temperature range T1-n. At this time, n may be a natural number greater than or equal to 2.

[0042] In an embodiment, referring to FIGS. 2 and 3, in the multiple heating operation (S210), the blank may be heated (or multiple heated) stepwise while passing through the first heating section P1, the second heating section P2, and the third-first heating section P3-1 defined in the heating furnace. In addition, in the soaking operation (S220), the multiple heated blank may be soaked while passing through the third-second heating section P3-2 and the fourth heating section P4. That is, the first heating section P1, the second heating section P2, and the third-first heating section P3-1 correspond to sections in which the blank is multiple heated, and the third-second heating section P3-2 and the fourth heating section P4 correspond to sections in which the blank is soaked.

[0043] In an embodiment, the fourth heating section P4 may have multiple sections. For example, the fourth heating section P4 may be provided with two sections, three sections, or the like. At this time, the temperature ranges (or temperatures) of the multiple sections provided in the fourth heating section P4 may be the same.

[0044] The first heating section P1 to the fourth heating section P4 may be arranged in sequence within the heating furnace. The first heating section P1 may be adjacent to the inlet of the heating furnace into which the blank is input, and the fourth heating section P4 may be adjacent to the outlet of the heating furnace from which the blank is taken out. Therefore, the first heating section P1 having the first temperature range T1 may be the first section of the heating furnace, and the fourth heating section P4 having the fourth temperature range T4 may be the last section of the heating furnace. As described later, among the plurality of sections of the heating furnace, the third-second heating section P3-2 and the fourth heating section P4 may be sections in which soaking is performed, not sections in which multiple heating is performed.

[0045] The temperatures of the plurality of sections provided in the heating furnace, for example, the temperatures of the first heating section P1 to the fourth heating section P4, may increase from the inlet of the heating furnace into which the blank is input, toward the outlet of the heating furnace from which the blank is taken out. In addition, the temperature difference between two adjacent sections among the plurality of sections provided in the heating furnace may be greater than 0 °C and less than or equal to 100°C. For example, a temperature difference between the first heating section P1 and the second heating section P2 may be greater than 0 °C and less than or equal to 100 °C.

[0046] In an embodiment, the first temperature range T1 of the first heating section P1 may be in a range from about 680 °C to about 870 °C. The second temperature range T2 of the second heating section P2 may be in a range from about 700 °C to about 930 °C. The third-first temperature range T3-1 of the third-first heating section P3-1 may be in a range from about 800 °C to about 950 °C. The third-second temperature range T3-2 of the third-second heating section P3-2 may be in a range from about AC3 to about 1000 °C. The fourth temperature range T4 of the fourth heating section P4 may be in a range from about Ac3 to about 1,000 °C. Preferably, the fourth temperature range T4 of the fourth heating section P4 may be in a range from about 830 °C or more and 1,000 °C or less. The third-second temperature range T3-2 of the third-second heating section P3-2 and the fourth temperature range T4 of the fourth heating section P4 may be the same.

[0047] In an embodiment, when the second heating section P2 includes the second-first heating section P2-1 and the second-second heating section P2-2 having different temperature ranges as described above, the second-first temperature range T2-1 may be in a range from about 700 °C to about 900 °C, and the second-second temperature range T2-2 of the second-second heating section P2-2 may be in a range from about 750 °C to about 930 °C.

[0048] Boundary values defining the plurality of sections as described above will be described. The boundary values represent the heating time s as the horizontal axis of the graph. First, a first boundary value e1 located between the first heating section P1 and the second heating section P2 may be in a range from about 30 s to about 50 s, and may be about 40 s. A second boundary value e2 located between the second heating section P2 and the third heating section P3 may be in a range from about 80 s to about 130 s, and may be about 85 s. A third boundary value e3 located between the third-first heating section P3-1 and the third-second heating section P3-2 may be in a range from about 110 s to about 180 s, and may be about 120 s. A fourth boundary value e4 located between the third-second heating section P3-2 and the fourth heating section P4 may be in a range from about 140 s to about 230 s, and may be about 150 s.

[0049] In an embodiment, when the second heating section P2 includes the second-first heating section P2-1 and the second-second heating section P2-2 having different temperature ranges as described above, a second-first boundary value e2' located between the second-first heating section P2-1 and the second-second heating section P2-2 may be in a range from about 50 s to about 110 s, and may be about 60 s.

[0050] In FIG. 3, the heating furnace according to an embodiment of the present disclosure is illustrated as having five sections P1, P2, P3-1, P3-2, and P4 having different temperature ranges, but the present disclosure is not limited thereto. The heating furnace may be provided with six, seven, or eight sections having different temperature ranges.

[0051] In an embodiment, the heating furnace may have a length of 20 m to 40 m along a transport path of the blank. The heating furnace may have a plurality of sections having different temperature ranges, and a ratio of a length of a section in which the blank is multiple heated among the plurality of sections and a length of a section in which the blank is soaked among the plurality of sections may satisfy 1:1 to 4:1. If the length of the section in which the blank is soaked increases within the furnace, and a ratio of the length of the section in which the blank is multiple heated and the length of the section in which the blank is soaked exceeds 1:1, the amount of hydrogen penetration into the blank in the soaking section may increase, which may increase delayed fracture. On the other hand, if the length of the section in which the blank is soaked decreases, and a ratio of the length of the section in which the blank is multiple heated and the length of the section in which the blank is soaked is less than 4:1, the soaking section (time) may not be sufficiently secured, and thus the strength of the hot stamped component manufactured by the manufacturing process of the hot stamped component may be uneven.

[0052] In an embodiment, the length of the uniform heating section among the plurality of sections provided within the furnace may be 20% to 50% of the total length of the furnace.

[0053] FIG. 4 is a diagram showing the rate of change in the temperature increase rate of multiple sections according to the heating time in the method of manufacturing a hot stamped component according to an embodiment of the present disclosure. At this time, FIG. 4 is a graph showing the temperature increase rate °C/s of the blank according to the heating time s. The multiple sections and boundary values shown in FIG. 4 have the same content as described with reference to FIG. 3, and the explanation may be briefly described or omitted.

[0054] Referring to FIG. 4, the distribution of the temperature increase rate °C/s or the rate of change in the temperature increase rate °C /s^2 of multiple sections in which multiple heating of the blank is performed is as described below. Hereinafter, the term "temperature increase rate change rate" refers to an average slope of each section of the graph shown in FIG. 4 and may be described as the "average temperature increase rate change rate" hereinafter. FIG. 4 shows a first control curve 410 for the temperature increase rate according to an embodiment of the present disclosure and a second control curve 420 for the temperature increase rate according to a comparative example.

[0055] First, the first control curve 410 for the temperature increase rate according to an embodiment of the present disclosure will be described.

[0056] The first heating section P1 may have a first average temperature increase rate change rate r1. The second heating section P2 located after the first heating section P1 may have a second average temperature increase rate change rate r2 that is different from the first average temperature increase rate change rate r1. The third heating section P3 located after the second heating section P2 may have a third average temperature increase rate change rate r3 that is different from the first average temperature increase rate change rate r1 and the second average temperature increase rate change rate r2. At this time, the third average temperature increase rate change rate r3 may include a section in which a positive value is changed to a negative value. The fourth heating section P4 located after the third heating section P3 may have a fourth average temperature increase rate change rate r4 that is different from the first average temperature increase rate change rate r1, the second average temperature increase rate change rate r2, and the third average temperature increase rate change rate r3.

[0057] The first heating section P1 may be a general heating section, and in the second heating section P2, the temperature increase rate may be gradually reduced ($|r1|>|r2|$) compared to the first heating section P1, and thus, alloying of the plating layer may be performed. The third heating section P3 is a phase change section in which the base steel plate of the blank undergoes a phase change, the third-first heating section P3-1 may have a positive (+) temperature increase rate change rate, and the third-second heating section P3-2 may have a negative (-) temperature increase rate change rate. The fourth heating section P4 may be a stabilization section in which the blank is soaked to a uniform temperature.

[0058] Referring to the first control curve 410, the first average temperature increase rate change rate r1 and the second average temperature increase rate change rate r2 may each have negative values, and the absolute value of the first average temperature increase rate change rate r1 may be greater than the absolute value of the second average temperature increase rate change rate r2 ($|r1|>|r2|$). In an embodiment, the first average temperature increase rate change rate r1 may be about -0.5 °C/s^2 or more and 0 or less. For example, the first average temperature increase rate change rate r1 may be about -0.3 °C/s^2. In an embodiment, the second average temperature increase rate change rate r2 may be about -0.25 °C/s^2 or more and 0 or less. For example, the second average temperature increase rate change rate r2 may be about -0.07 °C/s^2.

[0059] In an embodiment, between the first heating section P1 and the second heating section P2, that is, around the first boundary value e1, the change from the first average temperature increase rate change rate r1 to the second average temperature increase rate change rate r2 may be discontinuous. Specifically, a temperature increase rate v1 at the first boundary value e1 defining the first average temperature increase rate change rate r1 in the first heating section P1 and a temperature increase rate v2 at the first boundary value e1 defining the second average temperature increase rate change rate r2 in the second heating section P2 may have different values. In other words, the final temperature increase rate v1 of the first average temperature increase rate change rate r1 and the initial temperature increase rate v2 of the second average temperature increase rate change rate r2 may be different values. When the temperature increase rate change rate changes discontinuously (r1 → r2) (410) near the first boundary value e1, the weldability of the hot stamped component may be improved compared to the case when the temperature increase rate change rate changes continuously (420).

[0060] Because a lot of energy is required for the change in the plating layer, the average temperature increase rate change rate may change discontinuously between the first heating section P1 and the second heating section P2. In order for Fe of the base steel plate to diffuse into the Al plating layer and for the Al-Fe phase to initially form and grow within the plating layer, the necessary energy must be supplied. In addition, Fe diffused into the base steel plate forms an Al-Fe-Si alloy layer over time, and the more discontinuous the change in the temperature increase rate change rate around the first boundary value e1, the more uniform the diffusion to a surface occurs, thereby obtaining good weldability. On the other hand, if the change is continuous, because the diffusion of Al-Fe-Si occurs rapidly and unevenly to the surface, phases with high welding resistance may exist on the surface, which results in a phenomenon in which weldability is reduced.

[0061] In an embodiment, the third heating section P3 may include the third-first heating section P3-1 having a third-first average temperature increase rate change rate r3-1 and the third-second heating section P3-2 having a third-second average temperature increase rate change rate r3-2. The third-first average temperature increase rate change rate r3-1 may have a positive value, and the third-second average temperature increase rate change rate r3-2 may have a negative value, and thus, the third average temperature increase rate change rate r3 may have a section in which the temperature increase rate change rate r3 changes from a positive value to a negative value. At this time, the absolute value of the third-first average temperature increase rate change rate r3-1 may be less than the absolute value of the third-second average temperature increase rate change rate r3-2 ($|r3\text{-}1|<|r3\text{-}2|$). In an embodiment, the third-first average temperature increase rate change rate r3-1 may be 0 or more and about 0.25 °C/s^2 or less. For example, the third-first average temperature increase rate change rate r3-1 may be about 0.07 °C/s^2. In an embodiment, the third-second average temperature increase rate change rate r3-2 may be about -0.3 °C/s^2 or more and 0 or less. For example, the third-second average temperature increase rate change rate r3-2 may be about -0.08 °C/s^2.

[0062] In the third-first heating section P3-1, the smaller the third-first average temperature increase rate change rate r3-1, the gentler the slope of the first control curve 410 may be, and the gentler the slope of the first control curve 410, the less the amount of hydrogen incorporated, and thus, the hydrogen embrittlement may be improved. In contrast, the second control curve 420 has a form in which the temperature increase rate change rate increases rapidly or discontinuously in the third-first heating section P3-1. In this case, the amount of hydrogen incorporated increases and hydrogen embrittlement may deteriorate accordingly. In this way, in the third heating section P3, unlike between the first heating section P1 and the second heating section P2, the phase change of the base steel plate is performed. If there is a rapid temperature change, problems such as hydrogen embrittlement and delayed fracture may occur. Therefore, the lower the temperature increase rate change rate is advantageous.

[0063] Between the second heating section P2 and the third-first heating section P3-1, that is, in the vicinity of the second boundary value e2, the change from the second average temperature increase rate change rate r2 to the third-first average temperature increase rate change rate r3-1 may change from a negative value to a positive value. In other words, the phase change of the base steel plate may occur as the temperature increase rate decreases and then increases. For example, during the phase change of the base steel plate, an endothermic reaction occurs in the corresponding section when transforming into austenite, and energy supply is required for the endothermic reaction, and thus, the temperature increase rate must be increased again in the third-first heating section P3-1 to induce a reasonable level of phase change into austenite.

[0064] Between the third-first heating section P3-1 and the third-second heating section P3-2, that is, around the third boundary value e3, the change from the third-first average temperature increase rate change rate r3-1 to the third-second average temperature increase rate change rate r3-2 may change from a positive value to a negative value. That is, the phase change of the base steel plate may occur as the temperature increase rate increases and then decreases again.

[0065] In an embodiment, the absolute value of the fourth average temperature increase rate change rate r4 may be less than each of the absolute values of the first average temperature increase rate change rate r1, the second average temperature increase rate change rate r2, and the third average temperature increase rate change rate r3. For example, the fourth average temperature increase rate change rate r4 may be a value close to 0, and the fourth heating section P4 may be a section in which soaking is performed at a uniform temperature.

[0066] The time t4 for heating the blank in the third-second heating section P3-2 and the fourth heating section P4 may be about 50% or less of the total heating time t. This is because the longer the time t4 for soaking in the third-second heating section P3-2 and the fourth heating section P4 compared to the time t1 for multiple heating in the first heating section P1, the second heating section P2, and the third-first heating section P3-1, the more the component properties such as weldability, hydrogen embrittlement, and bending performance may deteriorate.

[0067] Hereinafter, the characteristics of the second control curve 420 compared to the first control curve 410 described above will be described, focusing on the differences from the first control curve 410. Referring to the second control curve 420, a first' average temperature increase rate change rate r1' may continuously change between the first heating section P1 and the second heating section P2. Specifically, the temperature increase rate at the first boundary value e1 defining the first' average temperature increase rate change rate r1' in the first heating section P1 and a temperature increase rate v1' at the first boundary value e1 defining the first' average temperature increase rate change rate r1' in the second heating section P2 may have the same value.

[0068] In an embodiment, the first' average temperature increase rate change rate r1' may be about -0.26 °C/s^2 or more and 0 or less. For example, the first' average temperature increase rate change rate r1' may be about -0.2 °C/s^2.

[0069] The change characteristics of temperature increase rate change rates r3'; r3-1', and r3-2' in the third heating section P3 of the second control curve 420 may have the same characteristics as those described in the first control curve 410. However, the third-first' temperature increase rate change rate r3-1' may have a discontinuous and unstable value compared to the third-first average temperature increase rate change rate r3-1 of the first control curve 410. At this time, the third-first' temperature increase rate change rate r3-1' may denote the change rate in the previous section where the temperature increase rate shows an increasing trend during the third-first heating section P3-1. The third-first' temperature increase rate change rate r3-1' may be about 0.04 °C/s^2 or more and about 0.16 °C/s^2 or less. For example, the third-first' temperature increase rate change rate r3-1' may be about 0.1 °C/s^2. The third- second' temperature increase rate change rate r3-2' may be about -0.16 °C/s^2 or more and about -0.04 °C/s^2 or less. For example, the third-second' temperature increase rate change rate r3-2' may be about - 0.1 °C/s^2. The fourth heating section P4 of the second control curve 420 may be a soaking section in which the fourth average temperature increase rate change rate r4 has a value close to 0, similar to the first control curve 410.

[0070] In this way, in the method of manufacturing a hot stamped component according to an embodiment of the present disclosure, by controlling the temperature increase rate change rate for each section according to the multiple section characteristics as described above, the ultra-high strength characteristics, weldability, hydrogen embrittlement resistance, bending performance, etc. of the hot stamped component may be precisely controlled and improved.

[0071] The relationship between the heating time s and the boundary values shown on the horizontal axis of FIG. 4 is not limited to that shown in FIG. 4 and may be variously changed and applied within the scope of improving the performance of the hot stamped component of the present disclosure. In the above, it has been described that the multiple sections have five sections, but the multiple sections may be distinguished differently depending on the distribution of the temperature increase rate change rate.

[0072] FIG. 5 is a diagram illustrating a heating time according to a material thickness and a heating time according to a heating temperature. Specifically, FIG. 5 is a graph for explaining the minimum heating time according to the material thickness and the minimum heating time according to the heating temperature. In FIG. 5, the heating temperature denotes a soaking temperature of the soaking operation (S220), and the heating time denotes the total heating time of the heating operation (S200).

[0073] Referring to FIGS. 1, 2, and 5, when the material thickness is the same, it may be seen that the minimum heating time increases as the heating temperature decreases. In addition, when the heating temperature is the same, it may be seen that when the material thickness increases, the minimum heating time increases.

[0074] If the heating time (e.g., the total heating time) for heating the blank in the heating operation (S200) is short, sufficient phase change may not occur in the blank. On the other hand, if the heating time for heating the blank in the heating operation (S200) is excessive, the austenite grains may become coarser and the hydrogen embrittlement resistance may decrease, and also the thickness of the plating layer may increase, which may deteriorate the weldability. Therefore, it is necessary to control the heating time in the heating operation (S200). However, in order to control the heating time in the heating operation (S200), various variables must be considered, such as the heating temperature and the thickness of the blank (e.g., the thickness of the material), as well as the sealing of the heating furnace, the atmosphere, the heat source, the heat loss within the heating furnace, and the components of the blank.

[0075] In an embodiment, the heating time of the blank in the heating operation (S200) may satisfy the following [Equation 2].

[Equation 2]

$$\lambda_n = (a_n \times T_n + b_n) \times t^{c_n}$$

[0076] In Equation 2, λ_n is a heating time s, a_n is a heat loss correction factor of the heating furnace, T_n is a heating temperature (°C), b_n is an Ac3 temperature correction factor, c_n is a high-temperature material thickness sensitivity correction factor, and t is a material thickness (mm). At this time, the material may denote a blank, and the unit of the heating time, s, may denote seconds.

[0077] Because different heat sources are used for each heating furnace type, the heat loss that occurs for each heating furnace type may also be different. a_n is a correction factor that considers the heat loss of the heating furnace, and may have a value of about -0.60 or more and about -0.55 or less. At this time, a_n may have a unit of s/(°C x mm).

[0078] If the components of each material are different, the temperature at which the phase change occurs may be different. b_n is a correction factor that considers the Ac3 temperature difference according to the material components and may have a value of about 700 or more and about 900 or less. At this time, b_n may have a unit of s/mm.

[0079] The thermal conductivity transmitted inside the material may vary depending on the thickness of the material. c_n is a correction factor that considers the difference in thermal conductivity according to the thickness of the material at high temperatures and may have a value of about 0.7 or more and about 0.9 or less. At this time, the high temperature may denote 600 °C or more. However, the high temperature may mean 500 °C or more or 700 °C or more.

[0080] The heating temperature T_n refers to the soaking temperature of the soaking operation (S220), and the heating temperature T_n may have a value of about Ac3 or more and about 1000 °C or less. In addition, the material thickness may have a value of about 1 mm or more and about 2.6 mm or less.

[0081] In an embodiment, the heating time λ_n according to the mathematical formula may be about 100 s or more and about 900 s or less. If the heating time λ_n is less than 100 s, sufficient phase change may not occur in the blank. On the other hand, if the heating time λ_n exceeds 900 s, the austenite grains may become coarser and the hydrogen resistance may deteriorate, and also the thickness of the plating layer may become thicker, which may deteriorate the weldability. Therefore, when the heating time λ_n satisfies a range of about 100 s to about 900 s, sufficient phase change may occur in the blank, coarsening of austenite grains may be prevented or minimized, and deterioration of hydrogen embrittlement resistance and/or weldability may be prevented or minimized.

[0082] Referring back to FIG. 1, after the heating operation (S200), the transfer operation (S300), the forming operation (S400), and the cooling operation (S500) may be further performed.

[0083] In an embodiment, the transfer operation (S300) may be an operation of transferring the heated blank from the heating furnace to a mold. At this time, in the transfer operation (S300), the heated blank may be cooled at the ambient temperature (or room temperature) while being transferred to the mold. The heated blank may be air-cooled during the transfer. If the heated blank is not air-cooled, the mold entry temperature (e.g., the forming start temperature) may increase, which may cause wrinkles (or bends) on a surface of the manufactured hot stamped component. In addition, if a refrigerant is used, the subsequent process (hot stamping) may be affected, and thus, it may be desirable for the heated blank to be air-cooled during the transfer.

[0084] In an embodiment, the forming operation (S400) may be an operation of hot stamping the transferred blank to form a molded body. Specifically, in the forming operation (S400), the blank may be pressed by a mold to form a molded body.

[0085] In an embodiment, the cooling operation (S500) may be an operation of cooling the formed molded body. The cooling operation (S500) may be performed within the mold.

[0086] In an embodiment, the heated blank may be cooled at an ambient temperature (or, room temperature) in the transfer operation (S300). Specifically, in the transfer operation (S300), the blank heated through the heating operation (S200) may be cooled at an ambient temperature (or, room temperature) while being transferred to the mold after being taken out of the heating furnace. Thereafter, in the forming operation (S400), the forming of the blank cooled at an ambient temperature (or, room temperature) may be initiated. At this time, the temperature at which the forming of the blank starts may be referred to as the forming start temperature. That is, in the transfer operation (S300), the blank heated through the heating operation (S200) may be cooled from the ambient temperature to the forming start temperature after being taken out of the heating furnace.

[0087] In an embodiment, the forming start temperature may be 500 °C or higher and 700 °C or lower. If the forming start temperature is less than 500 °C, the forming start temperature may be too low, which may deteriorate the formability of the blank, and the manufactured hot stamped component may not have the target structure and properties. On the other hand, if the forming start temperature exceeds 700 °C, wrinkles (or bends) may occur on the surface of the manufactured hot stamped component. In addition, the plating layer of the blank may be adhered to the mold. Therefore, if the forming start temperature is 500 °C or higher and 700 °C or lower, the formability of the blank may be improved, the manufactured hot stamped component may have a targeted structure and properties, and the occurrence of wrinkles (or bends) on the surface of the manufactured hot stamped component may be prevented or minimized.

[0088] Afterwards, in an embodiment, in the forming operation (S400), the blank transferred to the mold through the transfer operation (S300) may be formed to form a molded body, and in the cooling operation (S500), the formed molded body may be cooled. At this time, the cooling operation (S500) for cooling the formed molded body may be performed within the mold.

[0089] Specifically, the molded body may be cooled at the same time as being formed into the final component shape in the mold, thereby forming a final product. The mold may be provided with a cooling channel through which a coolant circulates inside. The molded body may be rapidly cooled by circulating the coolant supplied through the cooling channel provided in the mold. At this time, in order to prevent the spring back phenomenon of the plate material and maintain a desired shape, rapid cooling may be performed while pressurizing in a closed state of the mold. In performing the forming and cooling operation of the molded body, the molded body may be cooled to a martensite end temperature at an average cooling rate of at least 10 °C /s or more.

[0090] In an embodiment, a mold cooling end temperature at which the cooling operation (S500) ends may be about room temperature or higher and about 200 °C or lower. If the mold cooling end temperature is lower than room temperature, the productivity of the manufacturing process may be reduced. On the other hand, if the mold cooling end temperature exceeds 200 °C, the manufactured hot stamped component is air-cooled at room temperature, and at this time, warping may occur in the hot stamped component, and it may be difficult to secure the target material. Therefore, if the mold cooling end temperature at which the cooling operation (S500) ends satisfies the range of about room temperature or higher and about 200 °C or lower, the productivity of the manufacturing process may be improved, and the manufactured hot stamped component may be air-cooled at room temperature, thereby preventing or minimizing warping in the hot stamped component.

[0091] In an embodiment, an air cooling time for cooling the blank in the transfer operation (S300) may be about 5 s or higher and about 20 s or lower. If the air cooling time is less than 5 s, the forming start temperature at which the blank is formed is too high, and thus, the blank is formed at a high temperature, which may cause wrinkles (or bends) in the manufactured hot stamped component, and it may be difficult to implement an air cooling time of less than 5 s in the equipment. On the other hand, if the air cooling time exceeds 20 s, the productivity may be reduced, and also, a phase change may occur in the blank during the process of transporting the blank, which may reduce the formability of the blank, and the manufactured hot stamped component may not have the target material. Therefore, if the air cooling time satisfies the range of about 5 s or more and about 20 s or less, the formability of the blank and the productivity of the process may be improved, and the manufactured hot stamped component may have the target material.

[0092] In an embodiment, the mold cooling time in the cooling operation (S500) may be about 6 s or more and about 40 s or less. If the mold cooling time is less than 6 s, the mold cooling may end at a high temperature, which may lead to a long air cooling, and thus, may cause warpage in the manufactured hot stamped component. Therefore, the target dimensions may not be secured. On the other hand, if the mold cooling time exceeds 40 s, the productivity may decrease. Therefore, if the mold cooling time satisfies the range of about 6 s or more and about 40 s or less, the mold cooling ends when the temperature of the blank is above room temperature and below 200 °C, the occurrence of warping in the manufactured hot stamped component may be prevented or minimized, and the productivity of the manufacturing process may be improved.

[0093] FIG. 6 is a flowchart specifically illustrating a method of manufacturing a blank for manufacturing a hot stamped component according to an embodiment of the present disclosure.

[0094] The size, density, and area fraction conditions of the pearlite region among the microstructure configurations of the blank may be controlled by adjusting the process conditions of the blank manufacturing processes according to the descriptions with reference to FIG. 6.

[0095] Specifically, the microstructure of the blank may include ferrite and pearlite. Carbon (C) and/or manganese (Mn) may be segregated in pearlite. That is, the microstructure of the blank may include pearlite having relatively high content of C and/or Mn. In addition, pearlite having relatively high content of C and/or Mn may be locally concentrated within the blank. That is, the microstructure of the blank may include a "pearlite region" having relatively high content of C and/or Mn. The pearlite region may denote a structure shape (stacked structure) in which different steel structures of ferrite and cementite (Fe_3C) alternately form layers. In an embodiment, the pearlite region may be formed in a belt shape (or band shape) within the hot-rolled steel plate. In the present specification, the term 'region where pearlite is locally concentrated' referring to a 'pearlite region' may mean a region where, when ferrite and cementite (Fe_3C) in the pearlite region are each formed in a band shape, the distinction between different bands is clear, resulting in a clearly visible lamellar structure.

[0096] The pearlite region may have different degrees of influence on the mechanical properties of the hot stamped component depending on the content of C and Mn included in the pearlite concentrated in the pearlite region. Specifically, the region where pearlite including 0.19 wt% or more of C and 0.8 wt% or more of Mn is locally concentrated affects the mechanical properties of the hot stamped component. On the other hand, the region where pearlite including less than 0.19 wt% of C or less than 0.8 wt% of Mn is locally concentrated has a minimal influence on the mechanical properties of the hot stamped component.

[0097] In an embodiment, the blank may include first regions in which pearlite including 0.19 to 0.55 wt% C and/or pearlite including 0.8 to 6.0 wt% Mn are locally concentrated. The size, density, and area fraction of these first regions may be controlled to satisfy predetermined conditions.

[0098] Specifically, when a long side of the first regions is defined as a length of the first regions, an average length of the first regions may be controlled to satisfy 0.01 μm or more and 300 μm or less. In addition, when the short side of the first regions is defined as a thickness of the first regions, an average thickness of the first regions may be controlled to satisfy

0.01 μm or more and 5 μm or less. The linear density in a short side direction of the first regions may be controlled to satisfy 0.001/μm or more and 0.1/μm or less. The area fraction of the first regions may be controlled to satisfy 0.01% or more and 15% or less.

[0099] The blank may further include second regions in which pearlite including C exceeding 0.55 wt% and/or pearlite including Mn exceeding 6.0 wt% are locally concentrated. Because the second regions may deteriorate the tensile strength and bending properties of the hot stamped component, the second regions may be controlled to be below a preset area fraction. Specifically, the area fraction of the second regions may be controlled to satisfy 0% or more and 5% or less.

[0100] That is, the pearlite included in the blank may be controlled to include the first regions having an area fraction of 0.01% or more and 15% or less and the second regions having an area fraction of 0% or more and 5% or less. Here, the first regions are regions where pearlite including 0.19 wt% to 0.55 wt% of C and/or pearlite including 0.8 wt% to 6.0 wt% of Mn are locally concentrated. In addition, the second regions are regions where pearlite including exceeding 0.55 wt% of C and/or pearlite including exceeding 6.0 wt% of Mn are locally concentrated. Among pearlite included in the blank, the pearlite in regions excluding the first regions and the second regions may be understood as pearlite including C of less than 0.19 wt% and Mn of less than 0.8 wt%.

[0101] Referring to FIG. 6, a method of manufacturing a blank (or blank preparation operation (S1)) according to an embodiment of the present disclosure may include a reheating operation (S10), a hot rolling operation (S20), a cooling/coiling operation (S30), a cold rolling operation (S40), an annealing heat treatment operation (S50), and a plating operation (S60).

[0102] For reference, although operations S10 to S60 are depicted as independent operations in FIG. 6, some of the operations S10 to S60 may be performed in one process, and some of the operations S10 to S60 may be omitted as needed.

[0103] First, a semi-finished slab that is a target of the process of forming a blank for hot stamping is prepared. The slab may include carbon (C), silicon (Si), manganese (Mn), phosphorus (P), sulfur (S), chromium (Cr), aluminum (Al), titanium (Ti), niobium (Nb), molybdenum (Mo), boron (B), nitrogen (N), and the remaining iron (Fe) and other inevitable impurities.

[0104] The reheating operation (S10) is an operation of reheating the slab having the above composition for hot rolling within a predetermined slab reheating temperature (SRT) range. In the reheating operation (S10), the slab obtained through a continuous casting process is reheated within a predetermined temperature range, thereby reusing components segregated during casting. The SRT may be controlled within a preset temperature range to maximize austenite refinement and precipitation hardening effects.

[0105] In an embodiment, the SRT may be controlled to a range from about 1,100 °C to about 1,300 °C. If the SRT is less than 1,100 °C, there is a problem that the components segregated during casting (e.g., Ti, Nb, Mo, etc.) are not sufficiently reused, and thus, it may be difficult to significantly secure the homogenization effect of alloy elements. On the other hand, the higher the SRT, the more advantageous for homogenization, but if it exceeds 1,300 °C, the grain size of austenite crystal may increase, and thus, it may be difficult to secure strength, and the manufacturing cost of the steel plate may increase due to the excessive heating process.

[0106] The hot rolling operation (S20) is an operation of manufacturing a steel plate by hot rolling the slab reheated in the reheating operation (S10) within a predetermined finishing delivery temperature (FDT) range.

[0107] In an embodiment, the FDT range may be controlled to a range from about 800 °C to about 1000 °C. If the FDT is less than 800 °C, it is difficult to secure the workability of the steel plate due to the occurrence of a mixed grain structure caused by abnormal region rolling, and there may be a problem of reduced workability due to microstructure non-uniformity, and a problem of sheetability during hot rolling may occur due to a rapid phase change. On the other hand, if the FDT exceeds 1,000 °C, the austenite grains become coarser, making it difficult to secure strength.

[0108] In an embodiment, a reduction ratio during hot rolling may be controlled to satisfy 90% or more. Through the above control, the size, density, and area fraction of a region (pearlite region) where pearlite having relatively high carbon content and/or manganese content of the manufactured blank is locally concentrated may be controlled to satisfy preset conditions.

[0109] In the reheating operation (S10) and the hot rolling operation (S20), some of the micro-precipitates may be precipitated at a grain boundary where energy is unstable. At this time, the micro-precipitates precipitated at the grain boundary may act as a factor that hinders the grain growth of austenite, thereby providing an effect of improving strength through austenite refinement.

[0110] The cooling/coiling operation (S30) may include an operation of cooling the hot-rolled steel plate in the hot rolling operation (S20) and an operation of coiling the cooled steel plate.

[0111] The operation of cooling the hot-rolled steel plate may be an operation of run out table (ROT) cooling the hot-rolled steel plate to a predetermined cooling end temperature range for a preset cooling time.

[0112] In one embodiment, the cooling end temperature range is a martensite change initiation temperature (Ms) to a pearlite change initiation temperature (Ps) + 40°C, and the preset time may be 30 seconds or less. The cooling end temperature range and cooling time in the operation of cooling the hot-rolled steel plate affect the size, density, and area fraction of a region (pearlite region) where pearlite with a relatively high carbon content and/or manganese content of the manufactured blank is locally concentrated. Specifically, if the cooling end temperature range and the cooling time are satisfied, the size, density, and area fraction of the pearlite region may be controlled to satisfy preset conditions, and a uniform hot-rolled structure of the ferrite matrix may be formed. On the other hand, if cooling is completed at a temperature range exceeding the cooling end temperature range or the cooling time is exceeded, the size, density, and/or area fraction of the pearlite region may not satisfy the preset conditions, resulting in deterioration of strength and bending characteristics.

[0113] The operation of coiling the cooled steel plate may be an operation of coiling the cooled steel plate at a predetermined coiling temperature (CT) range.

[0114] In an embodiment, the CT may be controlled to be Ms+50 °C or more and less than 650 °C. The CT affects the size, density, and area fraction of the region (pearlite region) where pearlite having relatively high carbon content and/or manganese content of the manufactured blank is locally concentrated. Specifically, when the CT satisfies Ms+50 °C or more and less than 650 °C, the size, density, and area fraction of the pearlite region may be controlled to satisfy preset conditions. On the other hand, if the CT is less than Ms+50 °C, a low-temperature phase fraction due to supercooling increases, which may increase strength and increase rolling load during cold rolling, and there is a problem of rapid deterioration of ductility. Conversely, if the coiling temperature is 650 °C or higher, the size, density, and/or area fraction of the pearlite region may not satisfy preset conditions, which may result in a decrease in strength and bending properties, and there is a problem in that formability and strength deterioration may occur due to abnormal crystal grain growth or excessive crystal grain growth.

[0115] Specifically, when the coiling temperature is 650 °C or higher, a pearlite band may be formed by forming a region (pearlite region) where pearlite having relatively high carbon content and/or manganese content is locally concentrated over an excessively large area. Accordingly, C and/or Mn may be distributed unevenly within the blank. This may also affect the uniformity of C and/or Mn within the molded component after hot stamping. Therefore, this may affect the uniformity of nano-indentation hardness within the martensite structure within the molded component after hot stamping, which may deteriorate the bending characteristics of the molded component after hot stamping.

[0116] In contrast, when the CT satisfies the range of Ms+50 °C or higher and less than 650 °C, a region (pearlite region) where pearlite having relatively high carbon content and/or manganese content is locally concentrated is formed in a relatively small area, so a pearlite band may not be formed or may be formed in a relatively small area. Accordingly, C and/or Mn may be uniformly distributed in the blank. This may also affect the uniformity of C and/or Mn in the molded component after hot stamping. Therefore, this may also affect the uniformity of nano-indentation hardness in the martensite structure in the molded component after hot stamping, and thus, the bending characteristics of the molded component after hot stamping may be improved.

[0117] On the other hand, when the CT is less than Ms+50 °C, the locally concentrated region (pearlite region) is formed in a relatively small area, but the low-temperature phase formation may cause plate shape problems during the cold rolling process, and the possibility of plate breakage may increase.

[0118] The cold rolling operation (S40) is an operation in which the steel plate coiled in the cooling/coiling operation (S30) is uncoiled, pickled, and then cold rolled. At this time, the pickling is carried out for the purpose of removing a scale of the rolled steel plate, i.e., the hot-rolled coil manufactured through the hot-rolling process.

[0119] In an embodiment, the reduction ratio during cold rolling may be controlled to a range from about 5% to about 80%. Through the reduction, the size, density, and area fraction of the region (pearlite region) where pearlite with relatively high carbon content and/or manganese content of the manufactured blank is locally concentrated may be controlled to satisfy preset conditions. For example, when the reduction ratio is less than 5%, a gap between pearlite may narrow, and thus, the region where pearlite is locally concentrated may increase, which may deteriorate the strength and bending characteristics.

[0120] The annealing operation (S50) is an operation of annealing the cold-rolled steel plate in the cold rolling operation (S40) at a temperature of 700 °C or higher. In an embodiment, the annealing operation (S50) may be an operation of annealing the cold-rolled steel plate at a temperature range of Ae3±200 °C. The annealing may include an operation of heating the cold-rolled plate and cooling the heated cold-rolled plate at a predetermined cooling rate. At this time, the cooling rate may be in a range from about 1 °C/sec to about 40 °C/sec.

[0121] The plating operation (S60) is an operation of forming a plating layer on the annealed steel plate. In an embodiment, the plating operation (S60) may include an operation of forming an Al-Si plating layer on the steel plate that has been annealed in the annealing operation (S50).

[0122] Specifically, the plating operation (S60) may include an operation of immersing the steel plate in a plating bath having a temperature in a range of Bs±150 °C to form a molten plating layer on a surface of the steel plate, and a cooling operation of cooling the steel plate on which the molten plating layer has been formed to form the plating layer. At this time, the plating bath may include, but is not limited to, Si, Fe, Al, Mn, Cr, Mg, Ti, Zn, Sb, Sn, Cu, Ni, Co, In, and/or Bi as additive elements. For example, the plating bath may include 5% to 12% of Si, 1% to 4% of Fe, and other Al. In addition, the plating amount for the front and rear surfaces may be controlled to satisfy in a range from about 40 g/m^2 to about 200 g/m^2.

[0123] By performing a hot stamping process on the blank for hot stamping manufactured through operations S10 to S60 in this way, a molded component after hot stamping that satisfies the required mechanical properties (e.g., tensile strength, yield strength, bending properties, elongation, etc.) may be manufactured.

[0124] FIG. 7 is a cross-sectional view schematically illustrating a part of a hot stamping component 1 according to an embodiment of the present disclosure, and FIG. 8 is a micrograph showing a cross-section of a base steel plate 10 of the hot stamped component 1 according to an embodiment of the present disclosure. The base steel plate 10 illustrated in FIG. 8 may be the base steel plate 10 of the hot stamped component 1 manufactured by the method of manufacturing a hot stamped component described above with reference to FIGS. 1 to 6 (for example, the first control curve 410 of FIG. 4).

[0125] Referring to FIG. 7, the hot stamped component 1 may include the base steel plate 10 and a plating layer 20 disposed on the base steel plate 10. The plating layer 20 is formed on at least one surface of the base steel plate 10 as an alloy layer and may include Al, Fe, etc. Although not shown, the plating layer 20 may include a plurality of layers (not shown) sequentially stacked on the base steel plate 10. In an embodiment, the plurality of layers may sequentially have an α-Fe phase, an Fe_2Al_5 phase, an AlFe phase, and an Fe_2Al_5 phase, but the composition of the plurality of layers is not limited thereto.

[0126] The base steel plate 10 may be a steel plate manufactured by performing a hot rolling process and/or a cold rolling process on a steel slab cast to include a predetermined alloy element in a predetermined content as a base steel plate.

[0127] In an embodiment, the base steel plate 10 may include carbon (C), silicon (Si), manganese (Mn), phosphorus (P), sulfur (S), chromium (Cr), aluminum (Al), titanium (Ti), niobium (Nb), molybdenum (Mo), boron (B), nitrogen (N), and the remainder iron (Fe) and other unavoidable impurities.

[0128] In an embodiment, the base steel plate 10 may include 0.15 to 0.27 wt% of C, 0.15 to 1.0 wt% of Si, 0.5 to 1.10 wt% of Mn, 0.018 wt% or less of P, 0.005 wt% or less of S, 0.1 to 1.0 wt% of Cr, 0.1 to 1.0 wt% of Al, 0.015 to 0.080 wt% of Ti, 0.015 to 0.080 wt% of Nb, 0.1 to 0.7 wt% of Mo, 0.001 to 0.008 wt% of B, 0.005 wt% or less of N and the remainder Fe and other unavoidable impurities.

[0129] As an embodiment, when the content of C, Mn, Cr, and Mo included in the base steel plate 10 is expressed in wt% as [C], [Mn], [Cr], and [Mo], the following mathematical Equation 1 may be satisfied.

[Equation 1]

$$370<539-423*[C]-30.4*[Mn]-12.1[Cr]-7.5[Mo]<470$$

[0130] Through this, the increase in brittleness may be prevented, the hardenability may be improved, and the welding strength of the molded component after hot stamping may be improved. For example, the cross-tension strength (CTS) of a welding portion may satisfy 10 kN/spot or more.

[0131] Carbon acts as an austenite stabilizing element in the base steel plate 10. Carbon is a major element that determines the strength and hardness of the base steel plate 10 and is added during heat treatment for the purpose of increasing hardenability and strength. Carbon may be included in an amount of 0.15 wt% to 0.27 wt% with respect to the total weight of the base steel plate 10. When the carbon content is less than 0.15 wt%, it is difficult to secure a hard phase (e.g., martensite, etc.), and thus, it is difficult to satisfy the mechanical strength of the molded component after hot stamping. On the other hand, if the carbon content exceeds 0.27 wt%, it may cause a decrease in the workability of the base steel plate 10 or a decrease in the bending performance of the molded component after hot stamping.

[0132] Silicon acts as a ferrite stabilizing element in the base steel plate 10. Silicon improves the strength of the base steel plate 10 as a solid solution strengthening element and improves the carbon concentration in austenite by suppressing the formation of low-temperature carbides. In addition, silicon is a key element for hot rolling, cold rolling, and hot press tissue homogenization and ferrite microdispersion. Silicon acts as a martensite strength heterogeneity control element and plays a role in improving a collision performance. Such silicon may be included in an amount range from about 0.15 wt% to about 1.0 wt% with respect to the total weight of the base steel plate 10. When the silicon content is less than 0.15 wt%, it is difficult to obtain the above-described effect, and cementite formation and coarsening may occur in the martensite structure of the molded component after hot stamping. On the contrary, if the content of silicon exceeds 1.0 wt%, the hot-rolled and cold-rolled loads increase, and the plating characteristics of the base steel plate 10 may deteriorate.

[0133] Manganese acts as an austenite stabilizing element in the base steel plate 10. Manganese is added during heat treatment for the purpose of increasing hardenability and strength. Such manganese may be included in an amount range from about 0.5 wt% to about 1.1 wt% based on the total weight of the base steel plate 10. When the content of manganese is less than 0.5 wt%, the hardenability effect is not sufficient, and the hard phase fraction in the molded component after hot stamping may be insufficient due to insufficient hardenability. On the other hand, if the manganese content exceeds 1.1 wt%, a pearlite concentrated area in which manganese is segregated may occur, which may reduce ductility and toughness, cause a decrease in the bending performance of the molded component after hot stamping, and cause an inhomogeneous microstructure.

[0134] Phosphorus is an element that contributes to improving strength. In order to prevent the deterioration of toughness of the base steel plate 10, phosphorus may be included in an amount greater than 0 and less than 0.018 wt% with respect to the total weight of the base steel plate 10. If the phosphorus content exceeds 0.018 wt%, a phosphorus iron compound is formed, which deteriorates the toughness and weldability, and cracks may be induced in the base steel plate 10 during the manufacturing process.

[0135] Sulfur is an element that contributes to improving workability. Such sulfur may be included in an amount greater than 0 and less than 0.005 wt% with respect to the total weight of the base steel plate 10. If sulfur content exceeds 0.005 wt%, hot workability, weldability, and impact characteristics deteriorate, and surface defects such as cracks may occur due to the generation of large inclusions.

[0136] Aluminum acts as a ferrite stabilizing element in the base steel plate 10. Aluminum improves the strength of the base steel plate 10 as a reinforcing element and improves the carbon concentration in the austenite by suppressing the formation of low-temperature carbides. Aluminum acts as a martensite strength heterogeneity control element to improve collision performance. Such aluminum may be included in an amount range from about 0.1 wt% to about 1.0 wt% with respect to the total weight of the base steel plate 10. If the content of aluminum is less than 0.1 wt%, it is difficult to obtain the effect described above, and cementite formation and coarsening may occur in the martensite structure of the molded component after hot stamping. On the other hand, if the content of aluminum exceeds 1.0 wt%, the hot rolling and cold rolling loads increase, and the plating characteristics of the steel plate may deteriorate.

[0137] As an embodiment, in order to improve the plating property, the sum of the contents of Si and Al included in the base steel plate 10 may be controlled to satisfy a preset range. For example, the sum of the contents of Si and Al included in the base steel plate 10 may satisfy 0.4 to 1.5 wt%.

[0138] Chromium is added to improve the hardenability and strength of the base steel plate 10 during heat treatment. Chromium enables grain refinement and strength acquisition through precipitation hardening. Chromium may be included in an amount range from about 0.1 wt% to about 1.0 wt% relative to the total weight of the base steel plate 10. When the content of chromium is less than 0.1 wt%, the precipitation hardening effect is low, and conversely, when the content of chromium exceeds 1.0 wt%, the Cr-based precipitate and matrix solid solution increase, which reduces the toughness and increases the production cost due to the increase in cost.

[0139] Titanium may effectively contribute to grain refinement by forming precipitates at high temperatures. Such titanium may be included in an amount range from about 0.015 wt% to about 0.080 wt% based on the total weight of the base steel plate 10. When titanium is included in the above content range, poor performance and coarsening of precipitates may be prevented, the physical properties of the steel may be easily secured, and defects such as cracks on the surface of the steel may be prevented. When the titanium content is less than 0.015 wt%, the above effect may not be properly obtained. On the other hand, when the titanium content exceeds 0.080 wt%, precipitates may be coarsened, resulting in a decrease in elongation and bendability.

[0140] Ti, Nb, and Mo form micro-precipitates in the form of nitrides or carbides, thereby securing the strength of hot stamped and quenched components. In addition, these are included in Fe-Mn based composite oxides, function as hydrogen trap sites effective in improving the delayed fracture properties, and are elements necessary for improving the delayed fracture properties.

[0141] More specifically, niobium may increase strength and toughness due to the reduction of a martensite packet size. The niobium may be included in an amount range from about 0.015 wt% to about 0.080 wt% based on the total weight of the base steel plate 10. When niobium is included in the above range, the grain refinement effect of the base steel plate 10 in the hot rolling and cold rolling processes is excellent, and cracks in the slab and brittle fracture of the product may be prevented during steelmaking/rolling, and the formation of coarse precipitates in a steelmaking process may be minimized. If the content of niobium is less than 0.015 wt%, the above effect may not be properly obtained. On the other hand, when the content of niobium exceeds 0.080 wt%, the strength and toughness due to the increase in the content of niobium no longer improve, and there is a risk that the strength is reduced because niobium exists in a solid solution state within ferrite.

[0142] Molybdenum is a substitutional element that improves the strength of steel by its solid solution strengthening effect. Molybdenum is added for the purpose of suppressing precipitate coarsening and improving hardenability. In addition, molybdenum may play a role in improving the hardenability of steel. Such molybdenum may be included in an amount range from about 0.1 wt% to about 0.7 wt% based on the total weight of the base steel plate 10. If the content of molybdenum is less than 0.1 wt%, the above effect cannot be properly obtained. On the other hand, if the content of molybdenum exceeds 0.7 wt%, there is a risk of a decrease in rolling productivity and elongation, and there is a problem of increasing manufacturing costs without additional effects.

[0143] Boron is added for the purpose of securing hardenability and strength during heat treatment by suppressing ferrite, pearlite, and bainite change to secure martensite structure. In addition, boron segregates at grain boundaries to lower grain boundary energy, thereby increasing hardenability, and has a grain refinement effect by increasing austenite grain growth temperature. Such boron may be included in an amount range from about 0.001 wt% to about 0.008 wt% with respect to the total weight of the base steel plate 10. When boron is included in the above range, hard phase grain boundary embrittlement may be prevented, and high toughness and bendability may be secured. When the boron content is less than 0.001 wt%, the hardenability effect is insufficient, and conversely, when the boron content exceeds 0.008 wt%, the solid solubility is low, and thus, it may easily precipitate at grain boundaries depending on the heat treatment conditions, which may deteriorate the hardenability or cause high-temperature embrittlement, and the toughness and bendability may be reduced due to the occurrence of hard grain boundary embrittlement. When the nitrogen content exceeds 0.005 wt%, coarse TiN inclusions may be generated, which may reduce the bendability.

[0144] The base steel plate 10 of the hot stamped component 1 according to one embodiment of the present disclosure may include micro-precipitates. That is, micro-precipitates may be distributed within the base steel plate 10. Some of elements included in the base steel plate 10 described above may be nitride or carbide-forming elements that contribute to the formation of micro-precipitates. Specifically, Ti, Nb, and Mo may form micro-precipitates in the form of nitride or carbide.

[0145] Accordingly, the hot stamped component 1 according to an embodiment of the present disclosure may include micro-precipitates distributed within the base steel plate 10, and these micro-precipitates may include a nitride or carbide of at least one of Ti, Nb, and Mo. These micro-precipitates may suppress the propagation of cracks when the hot stamped component 1 is bent. In other words, the movement of dislocations may be restricted by micro-precipitates in the process of moving the dislocations during bending deformation.

[0146] The number of micro-precipitates formed in the base steel plate 10 and the average diameter of the micro-precipitates may be controlled to satisfy a preset range. In an embodiment, micro-precipitates having a diameter of about 0.02 μm or less may be distributed in the base steel plate 10 at a rate of 9,000/100 μm^2 or more and 30,000/100 μm^2 or less per unit area (100 μm^2). In addition, in an embodiment, an average diameter of the micro-precipitates distributed in the base steel plate 10 may be 0.006 μm or less, preferably 0.003 μm or more and 0.006 μm or less.

[0147] The number and average diameter of such micro-precipitates may affect the inhibition of crack propagation. When the number and average diameter of the micro-precipitates are formed within the above-mentioned range, the required tensile strength after hot stamping may be secured and the bendability may be improved. If the number of micro-precipitates per unit area (100 μm^2) is less than 9,000/100 μm^2, the strength of the hot stamped component 1 may be reduced. If the number of micro-precipitates per unit area (100 μm^2) exceeds 30,000/100 μm^2, the bendability of the hot stamped component 1 may be reduced. On the other hand, if the average diameter of the micro-precipitates is less than about 0.003 μm, the size of the micro-precipitates may be small, and thus, it may be difficult to restrict the movement of dislocations. If the average diameter of the micro-precipitates exceeds about 0.006 μm, the number of micro-precipitates may be relatively reduced, and thus, it may be ineffective to limit the movement of dislocations.

[0148] On the other hand, the base steel plate 10 may include a martensite structure with a distributed microstructure. The martensite structure is a result of a diffusionless change of austenite γ below the martensitic change initiation temperature (Ms) during cooling. The microstructure within the martensite structure is a diffusionless change structure formed during rapid cooling within grains referred to as prior austenite grain boundary (PAGB), and may include a plurality of lath structures. The plurality of lath structures may further form a unit such as a block or a packet. More specifically, the plurality of lath structures may form a block, a plurality of blocks may form a packet, and a plurality of packets may form a PAGB.

[0149] As illustrated in FIG. 8, the base steel plate 10 of the hot stamped component 1 according to an embodiment of the present disclosure may include a martensite structure having a plurality of blocks. The plurality of blocks may form a packet, and each of the plurality of blocks may be formed by a long and thin rod-shaped lath oriented in one direction. In other words, the martensitic structure may include a plurality of lath structures.

[0150] Boundaries between unit structures may be formed within the martensitic structure by the plurality of blocks, the plurality of packets, or the plurality of laths. Specifically, a lath boundary, which is a boundary between laths, may be formed within the martensitic structure by the plurality of laths. Similarly, a block boundary, which is a boundary between blocks, may be formed within the martensitic structure by the plurality of blocks, and a packet boundary, which is a boundary between packets, may be formed within the martensitic structure by the plurality of packets. That is, in this specification, the boundary between unit structures may be a lath boundary, a block boundary, or a packet boundary. The boundary between these unit structures may have a characteristic of resisting external deformation.

[0151] Specifically, a crack generated during bending deformation of the hot stamped component 1 may be generated as one-dimensional defects, which is referred to as dislocations, move through interactions within the martensitic structure. Therefore, during a process of moving dislocations within the martensite structure during bending deformation, the movement of dislocations at the boundary between unit structures may be restricted.

[0152] In addition, if the hardness of regions within the martensite structure adjacent to the boundary between unit structures is different, the property of resisting external deformation at the boundary between these unit structures may be weakened. In other words, the greater the difference in hardness within the martensite structure, for example, the nano-indentation hardness, the weaker the property of resisting external deformation at the boundary between the unit structures. In other words, if the nano-indentation hardness within the martensite structure is uniformly formed above a certain level, the hot stamped component 1 may secure bendability. Therefore, it is necessary to appropriately control the uniformity of the nano-indentation hardness within the martensite.

[0153] [Table 1] shows the nano-indentation hardness, standard deviation of the nano-indentation hardness, mean of the nano-indentation hardness, coefficient of variation, and bending angle of the hot stamped components according to embodiments and comparative examples of the present disclosure.

[0154] The nanoindentation hardness was measured using a nanoindenter. Specifically, the nanoindentation hardness was measured at more than 20 different points within one PAGB using a cube-corner tip (centerline-to-face angle = 35.3°, indentation strain rate = 0.22) as a nanoindenter. However, the present disclosure is not limited thereto. For example, a Berkovich tip (centerline-to-face angle = 65.3°, indentation strain rate = 0.072) may also be used as a nanoindenter.

[0155] Using these nanoindentation hardnesses, the mean and standard deviation of the nanoindentation hardness were calculated. The coefficient of variation may be defined as the standard deviation of the nanoindentation hardness divided by the mean of the nanoindentation hardness. Therefore, the coefficient of variation may also represent the uniformity of nanoindentation hardness. Because the measurement of nanoindentation hardness using a nanoindenter is a common practice in the measurement of nanoindentation hardness, a detailed description thereof is omitted.

[0156] The nanoindentation hardnesses in [Table 1] were measured at one PAGB, but the same or similar nanoindentation hardnesses were measured at another PAGB other than the PAGB related to [Table 1]. Therefore, the nanoindentation hardness, standard deviation of nanoindentation hardness, mean and coefficient of variation of nanoindentation hardness in [Table 1] represent the nanoindentation hardness, standard deviation of nanoindentation hardness, mean and coefficient of variation of nanoindentation hardness in the martensite structure. The uniformity of the aforementioned nanoindentation hardness may be evaluated through the standard deviation or coefficient of variation of the nanoindentation hardness.

[0157] Furthermore, a bending performance of hot stamped component may be evaluated by the bending angle. In the specification, the "bending angle" may denote a V-bending angle in a rolling direction (RD). The V-bending angle is a parameter for evaluating the bending deformation properties in maximum load sections among the deformations that appear in the bending performance of hot stamped components. That is, when examining the tensile deformation area at the time of bending in the macroscopic and microscopic scales according to the load-displacement evaluation of the hot stamped component 1, if a micro-crack occurs and propagates in a local tensile area, the bending performance called the V-bending angle may be evaluated.

[Table 1]

	Nanoindentati on hardness (GPa)	Standard deviation of nanoindentatio n hardness (GPa)	Mean of nanoindentatio n hardness (GPa)	Coeff icient of variat ion	Bendi ng angle (°)
Embodi ment 1	4.00~4.81	0.28	4.43	0.06	81
Embodi ment 2	3.51~4.91	0.54	4.24	0.13	73
Embodi ment 3	3.56-4.76	0.38	4.33	0.09	78
Embodi ment 4	3.18~4.86	0.59	4.10	0.14	71
Embodi ment 5	4.02~4.82	0.28	4.46	0.06	82
Embodi ment 6	3.54~4.95	0.52	4.32	0.12	74
Compar ative example 1	2.46~5.09	1.00	4.00	0.25	68
Compar ative example 2	2.43~5.06	0.99	3.89	0.26	66
Compar ative example 3	2.75~5.14	0.89	4.16	0.21	69

[0158] Referring to [Table 1], in the embodiments of the present disclosure, the nanoindentation hardness may be 3.0 GPa or more and 5.0 GPa or less. Preferably, the nanoindentation hardness may be 3.05 GPa or more and 4.95 GPa or less. More preferably, the nanoindentation hardness may be 3.18 GPa or more and 4.95 GPa or less. The standard deviation of the nanoindentation hardness may be more than 0 GPa and less than 0.8 GPa. Preferably, the standard deviation of the nanoindentation hardness may be 0.2 GPa or more and 0.6 GPa or less. More preferably, the standard deviation of the nanoindentation hardness may be more than 0.28 GPa and less than 0.59 GPa. The coefficient of variation may be more than 0 and less than 0.2. Preferably, the coefficient of variation may be 0.05 or more and 0.15 or less. More preferably, the coefficient of variation may be 0.06 or more and 0.14 or less.

[0159] In the case of Comparative examples, it may be confirmed that the nano-indentation hardness is 2.4 GPa or more and 5.2 GPa or less, the standard deviation of the nano-indentation hardness exceeds 0.8 GPa, and the coefficient of variation exceeds 0.2. In other words, the Comparative examples have relatively lower uniformity of nano-indentation hardness within the martensite structure than the Embodiments, and thus, the characteristics of resisting external deformation at the boundary between the unit structures may be inferior. Therefore, because the occurrence and/or propagation of micro-cracks are easy, it may be confirmed that the Comparative examples have relatively low bendability characteristics of less than 70°.

[0160] That is, when the nano-indentation hardness within the martensite structure is uniformly formed above a certain level, the hot stamped component 1 may secure bendability. The bending angle of the hot stamped component 1 of the Embodiments of the present disclosure may be 70° or more and 85° or less. On the other hand, when the standard deviation or coefficient of variation of the nano-indentation hardness exceeds the above-mentioned range, the uniformity of the nano-indentation hardness within the martensite structure deteriorates, and thus, it may be difficult to secure sufficient bendability of the hot stamped component 1. When the standard deviation or coefficient of variation of the nano-indentation hardness is less than the above-mentioned range, the uniformity of the nano-indentation hardness within the martensite structure increases, but the manufacturing cost of the hot stamped component 1 may increase excessively.

[0161] The uniformity of nano-indentation hardness within the martensite structure may be affected by the uniformity of carbon content and manganese content within the martensite structure. That is, when the carbon content and manganese content within the martensite structure are formed uniformly, the nano-indentation hardness within the martensite structure may also be formed uniformly.

[0162] [Table 2] shows the carbon content and the standard deviation of the carbon content of the hot stamped components according to the Embodiments of the present disclosure and the Comparative examples.

[0163] The carbon content was measured at more than 20 different points within one PAGB. Moreover, the carbon contents in [Table 2] were measured at one PAGB, but the same or similar carbon contents were measured at a PAGB other than the PAGB related to [Table 2]. Therefore, the carbon content and the standard deviation of the carbon content in [Table 1] represent the carbon content and the standard deviation of the carbon content in the martensite structure. The uniformity of the carbon content mentioned above may be evaluated through the standard deviation of the carbon content.

[Table 2]

	Carbon content (wt%)	Standard deviation of carbon content (wt%)
Embodi ment 1	0.18~0.22	0.01
Embodi ment 2	0.16~0.22	0.03
Embodi ment 3	0.16~0.22	0.02
Embodi ment 4	0.14~0.22	0.03
Embodi ment 5	0.18~0.22	0.01
Embodi ment 6	0.16~0.22	0.03
Compa rative exampl e 1	0.11~0.23	0.05
Compa rative exampl e 2	0.11~0.23	0.05
Compa rative exampl e 3	0.12~0.23	0.04

[0164] Referring to [Table 2], in the embodiments of the present disclosure, the carbon content may be 0.14 wt% or more and 0.22 wt% or less. The standard deviation of the carbon content may be more than 0 wt% and less than 0.04 wt%. Preferably, the standard deviation of the carbon content may be 0.01 wt% or more and 0.03 wt% or less.

[0165] In the case of the comparative examples, it may be confirmed that the carbon content is 0.11 wt% or more and 0.23 wt% or less, and the standard deviation of the carbon content is 0.04 wt% or more. In other words, the comparative examples may have a relatively lower uniformity of the carbon content in the martensite structure than the embodiments.

[0166] FIG. 9 is a micrograph showing a cross-section of a base steel plate 10 of a hot stamped component 1 according to an embodiment of the present disclosure. FIG. 10 is a micrograph showing a cross-section of a base steel plate of a hot stamped component according to a comparative example. Specifically, FIG. 9 is a micrograph for explaining the uniformity of the manganese content of the base steel plate 10 of the hot stamped component 1 according to an embodiment of the present disclosure, and FIG. 10 is a micrograph for explaining the uniformity of the manganese content of the base steel plate of a hot stamped component according to a comparative example. FIG. 9 and FIG. 10 may have different brightness or contrast of corresponding areas depending on the manganese content. That is, the manganese content of the dark area may be relatively higher than the manganese content of the bright area.

[0167] In the base steel plate 10 of the hot stamped component 1 according to an embodiment of the present disclosure, a uniform brightness area as a whole as shown in FIG. 9 was observed. However, the base steel plate of the hot stamped component according to the comparative example was observed to have a darker area than the remaining area, as shown in FIG. 10 in some areas. Specifically, a line extending left and right and darker than the remaining area appears in the center of FIG. 10. That is, because the base steel plate of the hot stamped component according to the comparative example has a high manganese content in some areas, the comparative examples may have a relatively lower uniformity of manganese content in the martensite structure than the embodiments.

[0168] As described above, the comparative examples may have relatively lower uniformity of carbon content and manganese content within the martensite structure than the embodiments. Accordingly, because carbon and manganese are not uniformly distributed within the martensite structure, the comparative examples may have relatively lower uniformity of nano-indentation hardness within the martensite structure than the embodiments. When the standard deviation of the carbon content exceeds the above-mentioned range, the uniformity of nano-indentation hardness within the martensite structure is reduced, and it may be difficult for the hot stamped component 1 to secure sufficient bendability. When the standard deviation of the carbon content is less than the above-mentioned range, the uniformity of nano-indentation hardness within the martensite structure is increased, but the manufacturing cost of the hot stamped component 1 may increase excessively.

[0169] The nano-indentation hardness and the standard deviation of nano-indentation hardness of the base steel plate 10 may be controlled by adjusting the process conditions of the manufacturing processes of the hot stamped component 1 described above. Of course, because the carbon content and the standard deviation of the carbon content are related to the nano-indentation hardness and the standard deviation of the nano-indentation hardness, the carbon content and the standard deviation of the carbon content may also be controlled by adjusting the process conditions of the manufacturing processes of the hot stamped components.

[0170] [Table 3] shows the contents of C, Si, Mn, P, S, Cr, Al, Ti, Nb, Mo, B, and N included in each of the base steel plates of the hot stamped components according to the embodiments and comparative examples of the present disclosure.

[Table 3]

	Content (wt%)											
	C	Si	Mn	P	S	Cr	Al	Ti	Nb	Mo	B	N
Embodiment 1	0.1 9	0.5 0	0.8 0	0.00 64	0.00 04	0.3 9	0.1 6	0.0 34	0.0 50	0.1 8	0.00 24	0.00 36
Embodiment 2	0.1 9	0.5 0	0.8 0	0.00 64	0.00 04	0.3 9	0.1 6	0.0 34	0.0 50	0.1 8	0.00 24	0.00 36
Embodiment 3	0.2 1	0.4 5	0.8 5	0.00 6	0.00 1	0.3 7	0.1 5	0.0 33	0.0 47	0.1 9	0.00 27	0.00 39
Embodiment 4	0.2 1	0.4 5	0.8 5	0.00 6	0.00 1	0.3 7	0.1 5	0.0 33	0.0 47	0.1 9	0.00 27	0.00 39
Embodiment 5	0.2 0	0.4 8	0.7 8	0.00 57	0.00 05	0.3 9	0.1 7	0.0 36	0.0 53	0.2 1	0.00 23	0.00 35
Comparative example 6	0.2 0	0.4 8	0.7 8	0.00 57	0.00 05	0.3 9	0.1 7	0.0 36	0.0 53	0.2 1	0.00 23	0.00 35
Comparative example 1	0.1 9	0.5 0	0.8 0	0.00 64	0.00 04	0.3 9	0.1 6	0.0 34	0.0 50	0.1 8	0.00 24	0.00 36
Comparative example 2	0.2 1	0.4 5	0.8 5	0.00 6	0.00 1	0.3 7	0.1 5	0.0 33	0.0 47	0.1 9	0.00 27	0.00 39

(continued)

	Content (wt%)											
	C	Si	Mn	P	S	Cr	Al	Ti	Nb	Mo	B	N
Comparative example 3	0.2 0	0.4 8	0.7 8	0.00 57	0.00 05	0.3 9	0.1 7	0.0 36	0.0 53	0.2 1	0.00 23	0.00 35

[0171] The base steel sheets of the hot stamped components according to the embodiments and comparative examples of the present disclosure satisfy the ranges of the contents of C, Si, Mn, P, S, Cr, Al, Ti, Nb, Mo, B, and N described above. That is, each of the base steel plates of the hot stamped components according to the embodiments and comparative examples of the present disclosure includes 0.15 to 0.27 wt% of C, 0.15 to 1.0 wt% of Si, 0.5 to 1.10 wt% of Mn, 0.018 wt% or less of P, 0.005 wt% or less of S, 0.1 to 1.0 wt% of Cr, 0.1 to 1.0 wt% of Al, 0.015 to 0.080 wt% of Ti, 0.015 to 0.080 wt% of Nb, 0.1 to 0.7 wt% of Mo, 0.001 to 0.008 wt% of B, 0.005 wt% or less of N and the remainder Fe and other unavoidable impurities.

[0172] [Table 4] shows the process conditions of the manufacturing processes of hot stamped components according to the embodiments and comparative examples of the present disclosure. Specifically, [Table 4] shows the SRT in the reheating operation (S10), the FDT in the hot rolling operation (S20), the CT in the cooling/coiling operation (S30), and the annealing temperature in the annealing operation (S50) among the manufacturing processes of hot stamped components according to the embodiments and comparative examples of the present disclosure.

[Table 4]

	Slab reheating temperature (°C)	Finish rolling temperature (°C)	Coiling temperatur e (°C)	Annealing temperatu re (°C)
Embodime nt 1	1193	922	629	780
Embodime nt 2	1193	922	603	783
Embodime nt 3	1197	932	619	782
Embodime nt 4	1197	932	607	777
Embodime nt 5	1207	907	625	783
Embodime nt 6	1207	907	583	790
Comparati ve example 1	1193	922	782	785
Comparati ve example 2	1197	932	762	791
Comparati ve example 3	1207	907	752	762

[0173] The hot stamped components of the embodiments and comparative examples of the present disclosure are manufactured through a reheating operation (S10) having an SRT in a range from about 1,100 °C to about 1,300 °C, a hot rolling operation (S20) having an FDT in a range from about 800 °C to about 1,000 °C, and an annealing heat treatment operation (S50) having an annealing temperature of Ae3±200 °C. However, the hot stamped components according to the embodiments of the present disclosure are manufactured through a cooling/coiling operation (S30) having a CT of Ms+50 °C or more and less than 650 °C, while the hot stamped components according to the comparative examples are manufactured through a cooling/coiling operation (S30) having a CT of more than 650 °C. That is, the manufacturing processes of the hot stamped components according to the embodiments and comparative examples of the present disclosure are the same or similar in terms of process conditions other than the coiling temperature. Because both the hot stamped components of the embodiments and comparative examples of the present disclosure are manufactured through a plating operation (S60), both the hot stamped components of the embodiments and comparative examples of the present disclosure may include an Al-Si plating layer.

[0174] As described above, the size, density, and area fraction of a region (pearlite region) where pearlite with relatively high content of C and/or Mn is locally accumulated in the blank are affected by the CT. That is, the uniformity of the content of C and/or Mn in the blank is affected by the CT. Such a pearlite region may be absent or minimized in the hot stamped components by heating, etc. after the blank preparation operation (S1). However, the content of C and/or Mn in the blank may have a certain effect on the content of C and/or Mn in the stamped component 1. Accordingly, the content of C and/or Mn in the blank may also affect the nano-indentation hardness and bending angle in the stamped component 1. Therefore, by controlling the CT in the cooling/coiling operation (S30) among the manufacturing processes of hot stamped components, the martensite structure characteristics of the hot stamped component 1 may be optimized, thereby securing excellent mechanical properties of high strength and high toughness of the hot stamped component 1. However, the present disclosure is not limited thereto. For example, by controlling the process conditions of the manufacturing processes of the hot stamped component other than the CT, it is possible to manufacture a hot stamped component 1 having a nano-indentation hardness and a standard deviation of the nano-indentation hardness within the above-described range.

[0175] Through this, the mechanical properties of the hot stamped component 1, such as tensile strength, yield strength, bending characteristics, and elongation may be controlled. For example, the tensile strength of the hot stamped component 1 may satisfy 1,350 MPa or more, and preferably 1,350 MPa or more and 1,650 MPa or less. In addition, the yield strength of the hot stamped component 1 may satisfy 950 MPa or more, and preferably 950 MPa or more and 1,200 MPa or less. In addition, the hot stamped component 1 may satisfy a bending angle of 70° or more and 85° or less and have an elongation of 6% or more. Preferably, the hot stamped component 1 may have an elongation of 6% or more and 9% or less.

[0176] [Table 5] shows the tensile strength, yield strength, and elongation of the hot stamped components according to the embodiments and comparative examples of the present disclosure. As described above, each of the hot stamped components according to the embodiments of the present disclosure may have a tensile strength of 1,350 MPa or more and 1,650 MPa or less, a yield strength of 950 MPa or more and 1,200 MPa or less, and an elongation of 6% or more and 9% or less.

[Table 5]

	Tensile strength (MPa)	Yield strength (MPa)	Elongation (%)
Embodiment 1	1460	1050	7
Embodiment 2	1448	1041	8
Embodiment 3	1445	1056	8
Embodiment 4	1447	1046	8
Embodiment 5	1447	1045	8
Embodiment 6	1447	1059	9
Comparative example 1	1442	1060	8
Comparative example 2	1467	1064	7
Comparative example 3	1466	1060	8

[0177] While the disclosure has been described with reference to the embodiments shown in the drawings, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the inventive concept. Accordingly, the scope of the disclosure is defined not by the detailed description of the disclosure but by the appended claims.

Claims

1. A hot stamped component comprising a base steel plate comprising 0.15 to 0.27 wt% of carbon (C), 0.15 to 1.0 wt% of silicon (Si), 0.5 to 1.10 wt% of manganese (Mn), 0.018 wt% or less of phosphorus (P), 0.005 wt% or less of sulfur (S), 0.1 to 1.0 wt% of chromium (Cr), 0.1 to 1.0 wt% of aluminum (Al), 0.015 to 0.080 wt% of titanium (Ti), 0.015 to 0.080 wt% of niobium (Nb), 0.1 to 0.7 wt% of molybdenum (Mo), 0.001 to 0.008 wt% of boron (B), 0.005 wt% or less of nitrogen (N) and the remainder iron (Fe) and other unavoidable impurities,

   wherein the base steel plate includes a martensite structure,
   a nano-indentation hardness of the martensite structure is 3.0 GPa or more and 5.0 GPa or less, and
   the standard deviation of the nano-indentation hardness is 0.8 GPa or less.

2. The hot stamped component of claim 1, wherein
the bending angle of the hot stamped component is 70° or more and 85° or less.

3. The hot stamped component of claim 1, wherein
when a value obtained by dividing a standard deviation of the nano-indentation hardness by an average of the nano-indentation hardness is referred to as a coefficient of variation, the coefficient of variation is 0.2 or less.

4. The hot stamped component of claim 1, wherein
the standard deviation of carbon content of the martensite structure is less than 0.04 wt%.

5. The hot stamped component of claim 1, further comprising:

micro-precipitates distributed within the base steel plate, and
the micro-precipitates include at least one carbide of Ti, Nb, and Mo.

6. The hot stamped component of claim 5, wherein
the number of micro-precipitates distributed per unit area (100 μm^2) is 9,000 or more and 30,000 or less.

7. The hot stamped component of claim 5, wherein
an average diameter of the micro-precipitates is 0.003 µm or more and 0.006 µm or less.

8. The hot stamped component of claim 1, wherein
the tensile strength of the hot stamped component is 1,350 MPa or more and 1,650 MPa or less.

9. The hot stamped component of claim 1, wherein
the yield strength of the hot stamped component is 950 MPa or more and 1,200 MPa or less.

10. The hot stamped component of claim 1, wherein
the elongation of the hot stamped component is 6% or more.

11. The hot stamped component of claim 1, wherein
the martensite structure includes multiple lath structures.

12. The hot stamped component of claim 1, further comprising:
a plating layer arranged on the base steel plate.

FIG. 1

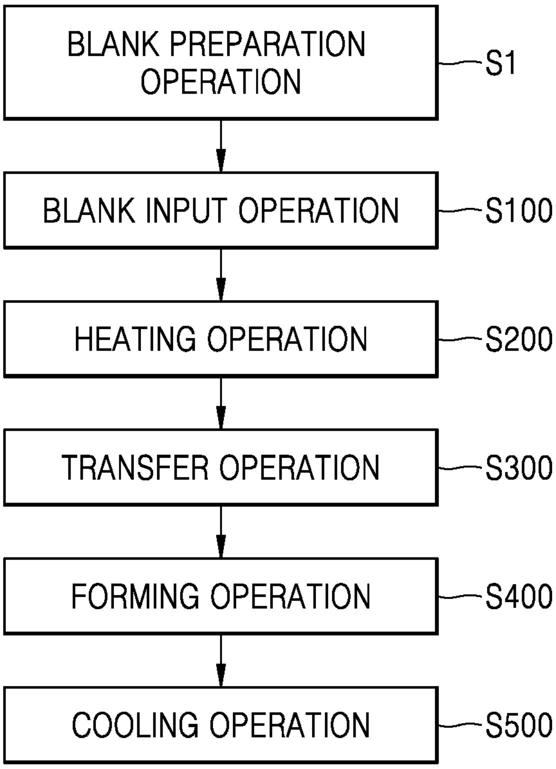

BLANK PREPARATION OPERATION
S1
BLANK INPUT OPERATION
S100
HEATING OPERATION
S200
TRANSFER OPERATION
S300
FORMING OPERATION
S400
COOLING OPERATION
S500

FIG. 2

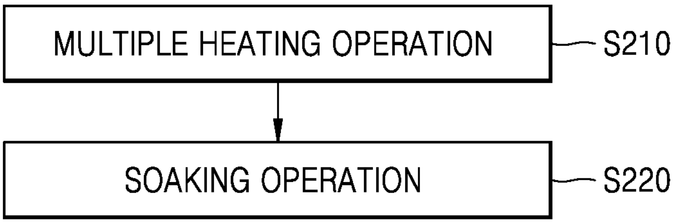

MULTIPLE HEATING OPERATION
S210
SOAKING OPERATION
S220

FIG. 3

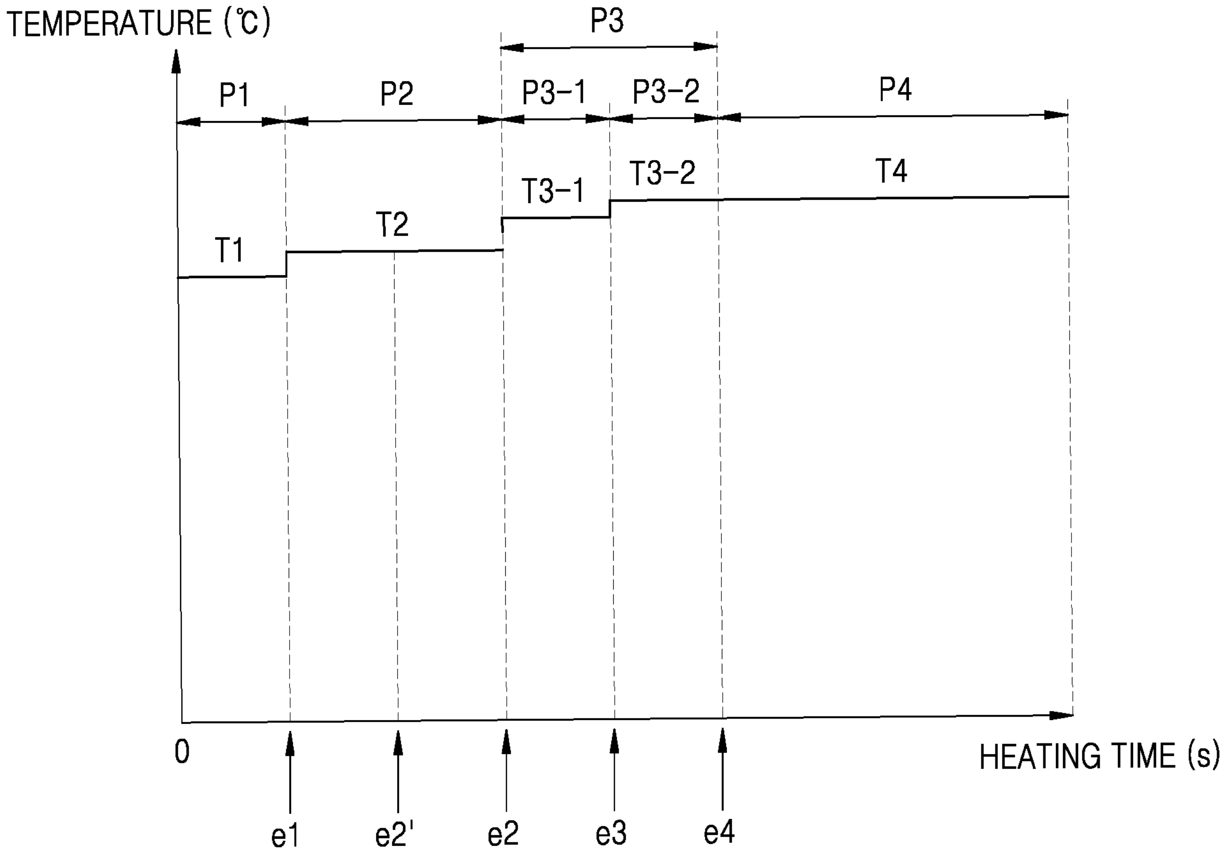

TEMPERATURE (℃)
P3
P1
P2
P3-1
P3-2
P4
T3-1
T3-2
T4
T1
T2
0
HEATING TIME (s)
e1
e2'
e2
e3
e4

FIG. 4

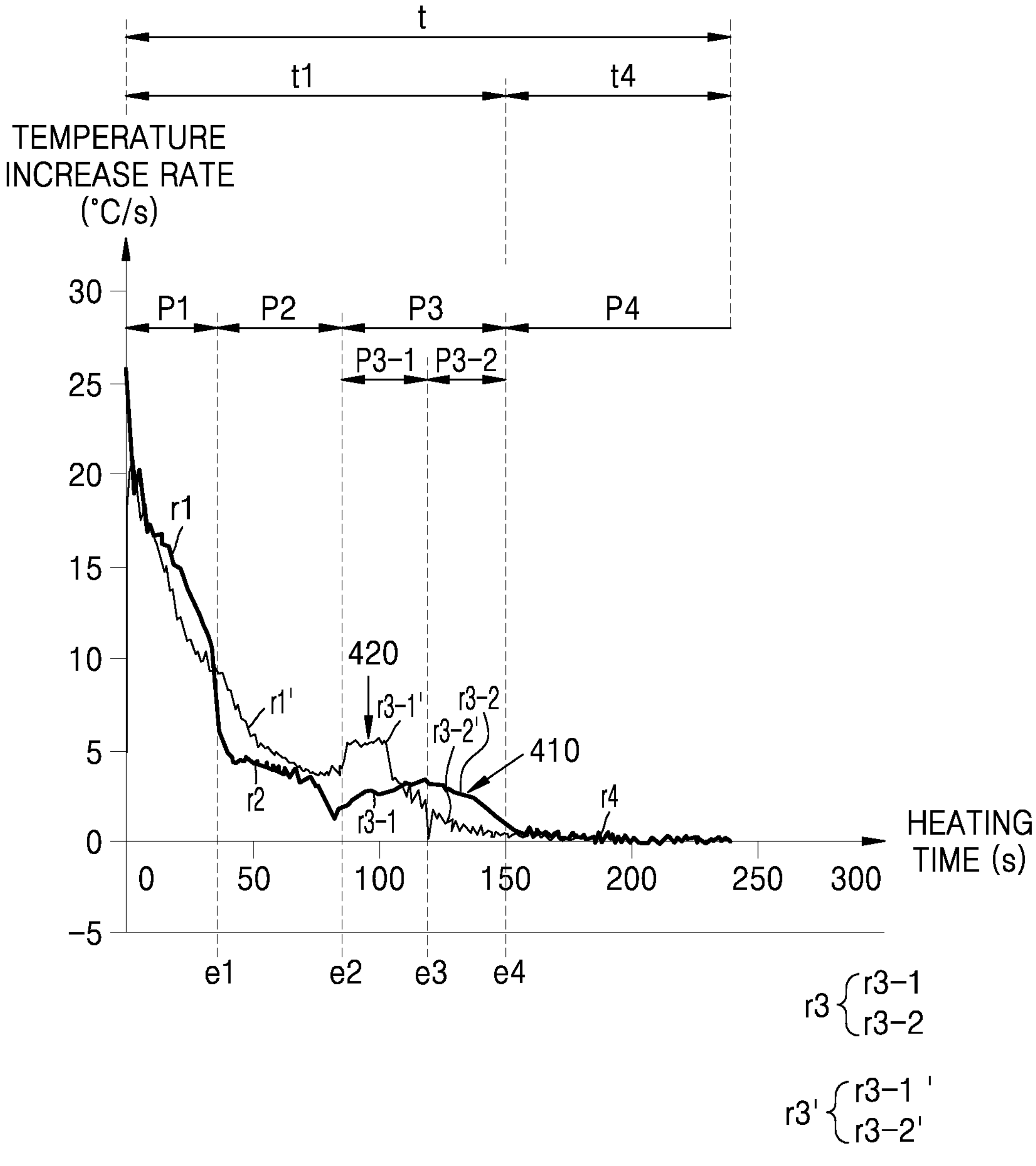

t
t1
t4
TEMPERATURE INCREASE RATE (°C/s)
30
25
20
15
10
5
0
−5
P1
P2
P3
P4
P3−1
P3−2
r1
r1'
r2
420
r3−1'
r3−2
r3−2'
410
r3−1
r4
HEATING TIME (s)
0
50
100
150
200
250
300
e1
e2
e3
e4
r3 { r3−1, r3−2
r3' { r3−1 ', r3−2'

FIG. 5

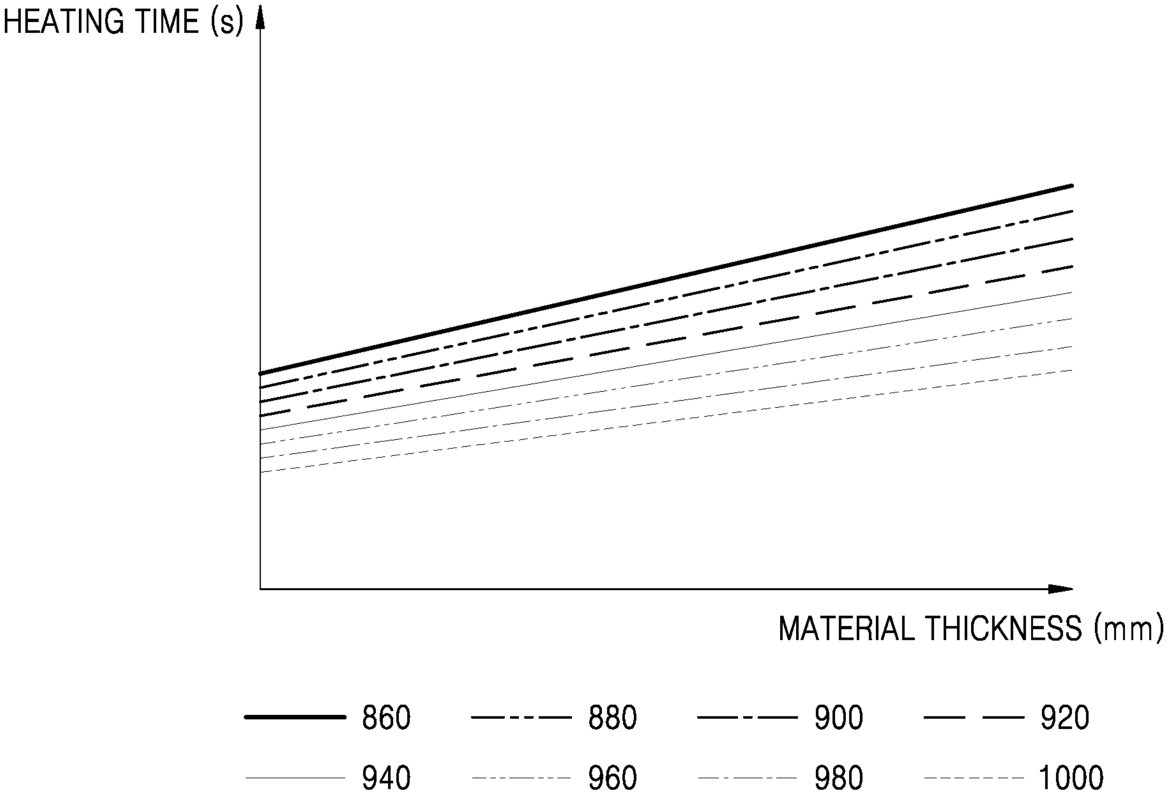

HEATING TIME (s)
MATERIAL THICKNESS (mm)
860
880
900
920
940
960
980
1000

FIG. 6

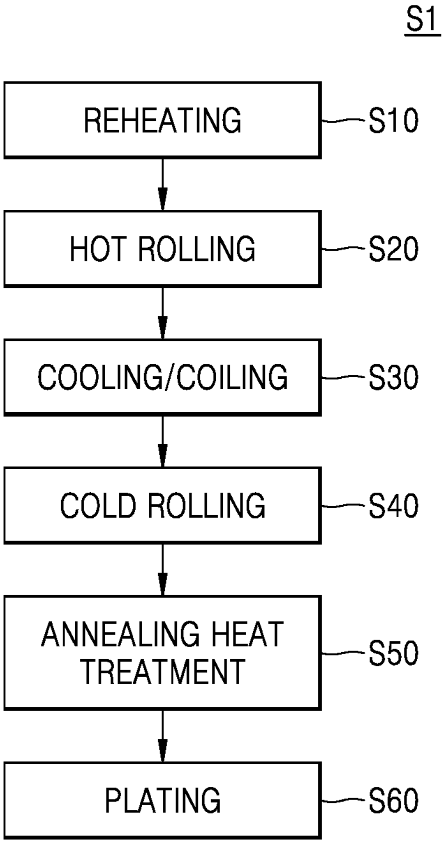

S1
REHEATING
S10
HOT ROLLING
S20
COOLING/COILING
S30
COLD ROLLING
S40
ANNEALING HEAT TREATMENT
S50
PLATING
S60

FIG. 7

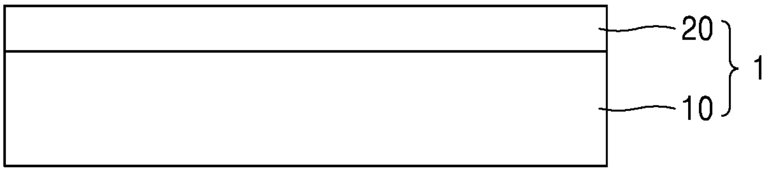

20
10
1

FIG. 8

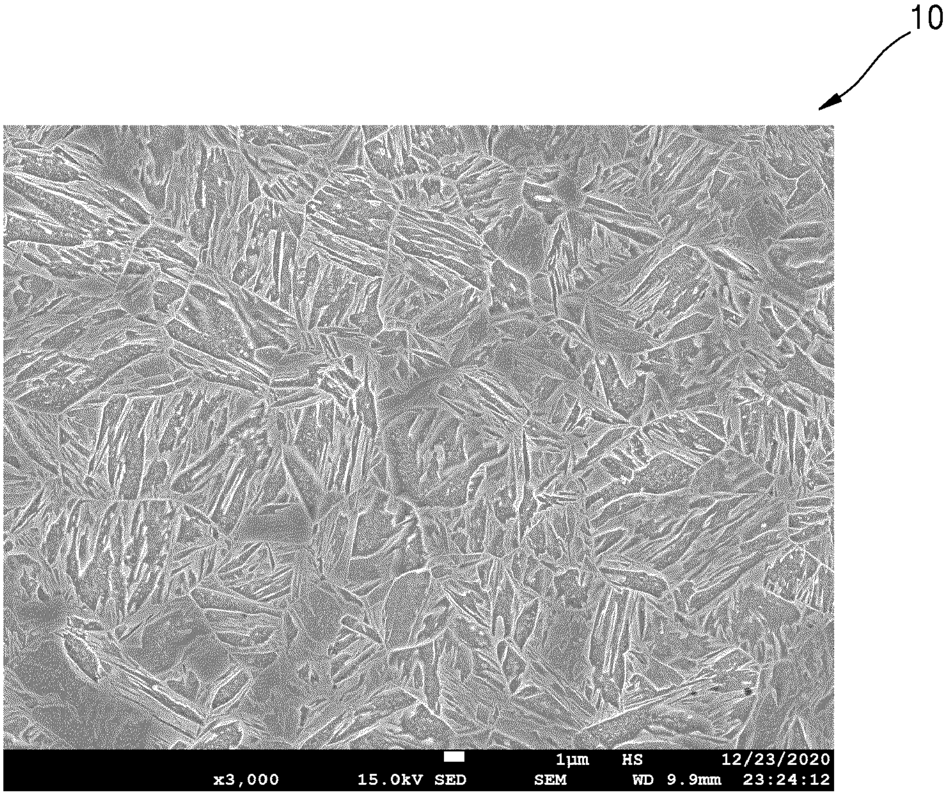


FIG. 9

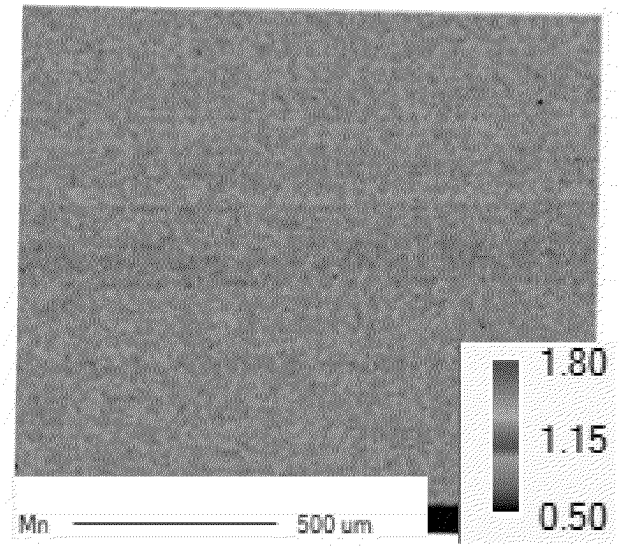
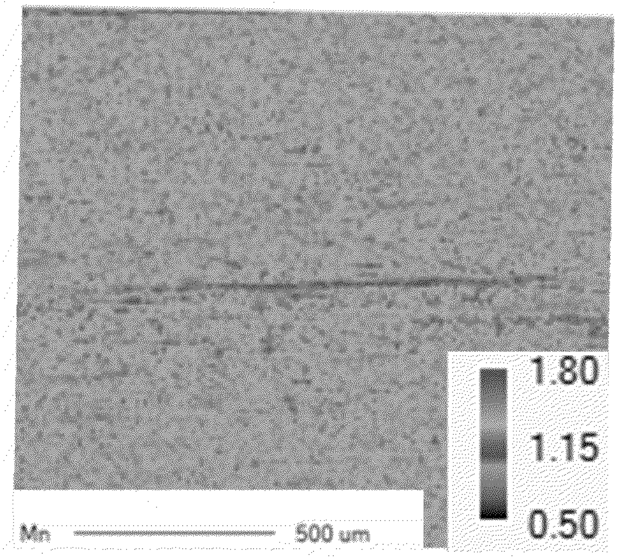


FIG. 10



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2022/020263

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/28(2006.01)i; **C22C 38/26**(2006.01)i; **B21D 37/16**(2006.01)i; **C21D 9/00**(2006.01)i; **C22C 38/06**(2006.01)i; **C22C 38/22**(2006.01)i; **C22C 38/00**(2006.01)i; **B21D 22/02**(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C22C 38/28(2006.01); B32B 15/01(2006.01); B32B 15/18(2006.01); C21D 1/18(2006.01); C21D 9/46(2006.01); C21D 9/68(2006.01); C22C 38/00(2006.01); C22C 38/38(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models: IPC as above
Japanese utility models and applications for utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS (KIPO internal) & keywords: 핫 스탬핑(hot stamping), 마르텐사이트(martensite), 경도(hardness), 탄소(carbon), 망간(manganese), 티타늄(titanium), 니오븀(niobium)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2021-155790 A (NIPPON STEEL CORP.) 07 October 2021 (2021-10-07) See paragraphs [0062], [0067], [0085], [0109] and [0117], claims 1, 3 and 9 and table 6.	1-12
A	KR 10-2012-0137511 A (NIPPON STEEL & SUMIKIN STAINLESS STEEL CORPORATION) 21 December 2012 (2012-12-21) See paragraph [0203] and claims 1-2.	1-12
A	WO 2022-080489 A1 (NIPPON STEEL CORPORATION) 21 April 2022 (2022-04-21) See claims 1-2 and table 1.	1-12
A	CN 113829697 A (BAOSHAN IRON & STEEL CO., LTD.) 24 December 2021 (2021-12-24) See claims 1 and 16.	1-12
A	KR 10-2237488 B1 (POSCO) 08 April 2021 (2021-04-08) See claims 1 and 7 and table 1.	1-12

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D"	document cited by the applicant in the international application	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E"	earlier application or patent but published on or after the international filing date	"&"	document member of the same patent family
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search **15 May 2023**	Date of mailing of the international search report **16 May 2023**
Name and mailing address of the ISA/KR **Korean Intellectual Property Office** **Government Complex-Daejeon Building 4, 189 Cheongsa-ro, Seo-gu, Daejeon 35208** Facsimile No. **+82-42-481-8578**	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2022/020263

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		MX 2012012954 A	07 February 2013
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		US 9238848 B2	19 January 2016
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		KR 10-2023-0029693 A	03 March 2023
		WO 2021-259278 A1	30 December 2021
KR 10-2237488 B1	08 April 2021	None	

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- KR 102070579 **[0004]**