ABSTRACT

Provided is a warm-pressed member comprising, by weight %, C: 0.01% to 0.5%, Si: 3.0% or less (excluding %), Mn: 3% to 15%, P: 0.0001% to 0.1%, S: 0.0001% to 0.03%, Al: 3.0% or less (excluding %), N: 0.03% or less (excluding %), and the balance of Fe and inevitable impurities. After a warm press forming process and a cooling process, the warm-pressed member has a microstructure comprising: 5 volume % to 50 volume % of retained austenite; and at least one of ferrite, martensite, tempered martensite, and bainite as a remainder.
Figure 2
STEEL SHEET FOR WARM PRESS FORMING, WARM-PRESSED MEMBER, AND MANUFACTURING METHODS THEREOF

TECHNICAL FIELD

[0001] The present disclosure relates to a steel sheet for automobile structural members or reinforcement members, and more particularly, to a steel sheet that may be increased in strength, elongation, shock-absorbing ability, and plating corrosion resistance after a warm press forming process. In addition, the present disclosure relates to a warm-pressed member formed of the steel sheet, and methods of manufacturing the steel sheet and the warm-pressed member.

BACKGROUND ART

[0002] Automobiles are increasingly required to have high fuel efficiency and crashworthiness in order to protect both the environment and automobile passengers. Thus, a great deal of research has been conducted to develop lightweight and crashworthy automobiles using high-strength chassis.

[0003] For example, hot pressing methods have been proposed to produce high-strength steel sheets improved in terms of formability and shape controllability. Such methods are disclosed in Patent Documents 1 and 2. In such methods, a steel sheet having a single phase of austenite that is low in strength but high in formability is subjected to a heat treatment process and a pressing process, and is then rapidly cooled by dies. Therefore, ultra-high-strength final products having martensite as a main microstructure phase are manufactured.

[0004] However, since a steel sheet having a single phase of austenite is heated at high temperature in the methods, oxide scale may have to be removed from the surfaces of the steel sheet after the heat treatment if the steel sheet is not a plated steel sheet, and high costs may be incurred in heating the steel sheet to a high temperature.

[0005] If Zn-plated or Al-plated steel sheets are processed by the methods, plating materials may be evaporated or fused to cause a decrease in productivity. Since the melting point of zinc (Zn) is 500°C or less and the melting point of aluminum (Al) is lower than 700°C, if a steel sheet plated with zinc (Zn) or aluminum (Al) is heat-treated at high temperature as described above, the zinc (Zn) or aluminum (Al) may be partially melted and thus may not properly function as a plating material. In addition, the zinc (Zn) or aluminum (Al) may be fused to dies or forming machines to deteriorate the formability of the steel sheet.

[0006] Furthermore, although the strength of a steel sheet is increased through such a high-temperature forming process, the elongation of the steel sheet is reduced to lower than 10% because 90% or more of the microstructure of the steel sheet is formed by martensite, and thus the steel sheet may not have sufficient crashworthiness. Therefore, the steel sheet may only be used to manufacture limited kinds of automotive components.

DISCLOSURE

Technical Problem

[0009] An aspect of the present disclosure may provide a steel sheet for warm press forming having high strength, good elongation, and thus improved crashworthiness after being warm pressed, and a member formed by warm-pressing the steel sheet.

[0010] An aspect of the present disclosure may also provide a plated steel sheet for warm press forming that can have good corrosion resistance even after a heat treatment such as a heat treatment of a warm press forming process, and a warm-pressed member.

Technical Solution

[0011] According to an aspect of the present disclosure, a steel sheet for warm press forming may include, by weight %, C: 0.01% to 0.5%, Si: 3.0% or less (excluding 0%), Mn: 3% to 15%, P: 0.0001% to 0.1%, S: 0.001% to 0.03%, Al: 3.0% or less (excluding 0%), Ni: 0.03% or less (excluding 0%), and the balance of Fe and inevitable impurities.

[0012] According to another aspect of the present disclosure, a method of manufacturing a steel sheet for warm press forming may include: heating a steel slab to a temperature within a temperature range of 100°C to 1400°C, the steel slab including the above-mentioned composition of the steel sheet; forming a hot-rolled steel sheet by performing a hot rolling process on the steel slab and then a finish-rolling process on the steel slab at a temperature within a temperature range of Ar3 to 1000°C; and coiling the hot-rolled steel sheet at a temperature higher than Ms but equal to or lower than 800°C.

[0013] According to another aspect of the present disclosure, a warm-pressed member may include the above-mentioned composition of the steel sheet, wherein after a warm press forming process and a cooling process, the warm-pressed member may have a microstructure formed by: 3 volume % to 50 volume % of retained austenite; and at least one of ferrite, martensite, tempered martensite, and bainite as a remainder.

[0014] According to another aspect of the present disclosure, a method of manufacturing a member by warm press forming may include: performing a warm press forming process on a steel sheet including the above-mentioned composition of the steel sheet; and cooling the steel sheet, wherein the warm press forming process may include a heat treatment process including: heating the steel sheet to a temperature within a temperature range of Ac1 to Ac3 at a heating rate of 1°C/sec to 1000°C/sec; and maintaining the steel sheet at the temperature within the temperature range for 1 second to 10000 seconds.

Advantageous Effects

[0015] The present disclosure relates a method of manufacturing an ultra-high-strength steel sheet that can be used for manufacturing structural members, reinforcement members, and shock-absorbing members of automobiles, and a member formed by warm-pressing the steel sheet. According to the method of the present disclosure, a steel sheet having a ultra-high tensile strength of 1000 MPa or greater and good elongation after a heat treatment of a warm press forming process can be manufactured, and a heat-treatment member formed of the steel sheet can be provided. That is, according to the present disclosure, the application of a heat treatment type ultra-high-strength steel sheet can be extended to impact members.
DESCRIPTION OF DRAWINGS

[0016] FIG. 1 is a graph illustrating a thermal history of a hot press forming process of the related art.

[0017] FIG. 2 is a graph illustrating a thermal history of a warm press forming process of the present disclosure.

BEST MODE

[0018] In the present disclosure, the term “warm press forming” refers to forming a steel sheet to have a certain shape after heat-treating the steel sheet at a temperature equal to or lower than the austenite single phase region. That is, the term “warm press forming” is contrasted with the term “hot press forming” referring to forming a steel sheet into a certain shape after heat-treating the steel sheet at a temperature higher than the austenite single phase region.

[0019] In the present disclosure, the warm press forming includes a heat treatment process and a forming process and may be performed in the order of a heat treatment process and a forming process or the order of a forming process and a heat treatment process.

[0020] The inventors have found that when a member (component) is manufactured through a warm press forming process, the elongation of the member can be improved by properly adjusting the composition, microstructure, and heat treatment temperature of the member, and have invented the present invention based on the knowledge.

[0021] In a hot press forming process of the related art, a steel sheet is heated to a temperature higher than the austenite single phase region so as to form martensite as a main microstructure phase of the steel sheet while suppressing the formation of ferrite, and then the steel sheet is formed to have a desired shape and rapidly cooled to a temperature lower than a Mf (martensite finishing point), so as to form a high-strength member having a martensite as a main microstructure phase.

[0022] However, in a warm press forming method of the present disclosure, a steel sheet is heat-treated at a temperature lower than the austenite single phase region and is subjected to a forming process and a cooling process. The warm press forming method of the present disclosure is proposed on the knowledge that if a steel sheet is heated and maintained at a temperature lower than the austenite single phase region, elements such as C and Mn can be concentrated in austenite formed in grains or grain boundaries, and thus the austenite can be stable at room temperature after the forming process and the cooling process.

[0023] Hereinafter, a steel sheet for warm press forming will be described in detail according to an embodiment of the present disclosure.

[0024] (Steel Sheet for Warm Press Forming)

[0025] First, the composition of the steel sheet for warm press forming will be described in detail (hereinafter, concentrations are expressed in weight % unless otherwise specified).

[0026] Carbon (C): 0.01% to 0.5%

[0027] Carbon (C) is an element for increasing the strength of the steel sheet, and the concentration of carbon (C) is properly adjusted to ensure the formation of retained austenite in the steel sheet. If the concentration of carbon (C) is less than 0.01%, the strength of the steel sheet may not be sufficient, and it may be difficult to maintain 3% or more of retained austenite in the steel sheet during a warm press forming process. Therefore, 0.01% or more (preferably, 0.05% or more) of carbon (C) is included in the steel sheet. If the concentration of carbon (C) is greater than 0.5%, it may be difficult to cold-roll the steel sheet after the steel sheet is hot-rolled, and due to excessively high strength of the steel sheet, it may be difficult to obtain a desired elongation of the steel sheet. In addition, the weldability of the steel sheet may be lowered. Therefore, 0.5% or less (preferably, 0.4% or less, and more preferably, 0.3% or less) of carbon (C) is included in the steel sheet.

[0028] Silicon (Si): 3.0% or Less (Excluding 0%)

[0029] Silicon (Si) functions as a deoxidizer during a steel making process and suppresses the formation of carbidies during a heat treatment process. If the concentration of silicon (Si) is greater than 3%, it may be difficult to plate the steel sheet. Thus, the concentration of silicon (Si) in the steel sheet may be 3% or less (preferably, 2.5% or less, and more preferably, 2% or less).

[0030] Aluminum (Al): 3.0% or Less (Excluding 0%)

[0031] Aluminum (Al) removes oxides during a steel making process, and thus a clean steel sheet may be obtained. In addition, like silicon (Si), aluminum (Al) suppresses the formation of carbides during a heat treatment process. If the concentration of aluminum (Al) is high, a two-phase region is extended, and thus the temperature range of the annealing process is widened. However, if the concentration of aluminum (Al) is greater than 3%, it may be difficult to plate the steel sheet, and the manufacturing cost of the steel sheet may be increased. Therefore, the concentration of aluminum (Al) in the steel sheet is set to be 3% or less (preferably, 2.5% or less, and more preferably, 2.0% or less).

[0032] Manganese (Mn): 3% to 15%

[0033] Manganese (Mn) has an important function in the embodiment of the present disclosure. Manganese (Mn) functions as a solid solution strengthening element and lowers the Ms (martensite start point) temperature for improving the stability of austenite at room temperature. In addition, since manganese (Mn) lowers the Ac1 and Ac3 temperatures, manganese (Mn) has an important function in a warm press forming process of the embodiment of the present disclosure. Furthermore, manganese (Mn) diffuses into austenite during a heat treatment performed at a temperature within the range of Ac1 to Ac3 in a warm press forming process, and thus the stability of the austenite may be further improved at room temperature. If the concentration of manganese (Mn) in the steel sheet is less than 3%, these effects may not be sufficiently obtained. Thus, the concentration of manganese (Mn) in the steel sheet may be 3% or greater (preferably, 4% or greater, and more preferably, 5% or greater). However, if the concentration of manganese (Mn) is greater than 15%, the manufacturing cost of the steel sheet is increased, and the amount of retained austenite may be too large. In this case, although the elongation of the steel sheet is increased, the strength of the steel sheet may be insufficient. Therefore, the concentration of manganese (Mn) in the steel sheet may be 15% or less (preferably, 13% or less, and more preferably 11% or less).

[0034] Phosphorus (P): 0.0001% to 0.1%

[0035] Like silicon (Si), phosphorus (P) suppresses the formation of carbidies when martensite is heat-treated. However, in the case that the amount of phosphorus (P) is excessive, the weldability and grain boundary characteristics of the steel sheet may be deteriorated. Therefore, the upper limit of the concentration of phosphorus (P) may be set to be...
0.1%. In addition, since manufacturing costs increase to maintain the concentration of phosphorus (P) at a level lower than 0.0001%, the lower limit of the concentration of phosphorus (P) may be set to be 0.0001%.

Sulfur (S): 0.0001% to 0.03%

Sulfur (S) exists in the steel sheet as an impurity lowering the ductility and weldability of the steel sheet. Such effects are not large if the concentration of sulfur (S) is 0.03% or less, the upper limit of the concentration of sulfur (S) is set to be 0.03%. Since manufacturing costs increase to maintain the concentration of sulfur (S) at a level lower than 0.0001%, the lower limit of the concentration of sulfur (S) is set to be 0.0001%.

Nitrogen (N): 0.03% or Less (Excluding 0%)

Nitrogen (N) exists in the steel sheet as an impurity. In the steel sheet, nitrogen (N) forms nitrides which improve resistance to delayed fractures caused by hydrogen. If the concentration of nitrogen (N) is greater than 0.03%, a steel slab may become sensitive to cracks during a continuous casting process, and pores may be easily formed in the steel slab. Therefore, the upper limit of the concentration of nitrogen (N) is set to be 0.03% (preferably 0.02%, and more preferably, 0.01%).

In addition to the above-mentioned elements, the steel sheet of the embodiment of the present disclosure may further include: at least one of chromium (Cr), molybdenum (Mo), and tungsten (W) as an element improving hardenability; at least one of titanium (Ti), niobium (Nb), zirconium (Zr), and vanadium (V) as a precipitation strengthening element; at least one of copper (Cu) and nickel (Ni) as an element improving strength; boron (B) as an element improving grain boundary strengthening and hardenability; and at least one of antimony (Sb) and tin (Sn) as an element improving plating characteristics.

Combination of at Least One of Chromium (Cr), Molybdenum (Mo), and Tungsten (W): 0.001% to 2.0%

Chromium (Cr), molybdenum (Mo), and tungsten (W) improve hardenability and precipitation strengthening, and thus increase the strength of the steel sheet. If the concentration of chromium (Cr), molybdenum (Mo), or tungsten (W) is lower than 0.001%, sufficient hardenability and precipitation strengthening may not be obtained, and if the concentration of chromium (Cr), molybdenum (Mo), or tungsten (W) is greater than 2.0%, such effects may not be further obtained although manufacturing costs increase. Therefore, the upper limit of the concentration of chromium (Cr), molybdenum (Mo), or tungsten (W) is set to be 2.0%.

Combination of at Least One of Titanium (Ti), Niobium (Nb), and Vanadium (V): 0.001% to 0.4%

Titanium (Ti), niobium (Nb), and vanadium (V) are effective in improving the strength, grain refinement, and heat-treatment characteristics of the steel sheet. If the concentration of titanium (Ti), niobium (Nb), or vanadium (V) is lower than 0.001%, such effects may not be obtained, and if the concentration of titanium (Ti), niobium (Nb), or vanadium (V) is greater than 0.4%, manufacturing costs increase. Therefore, the concentration of titanium (Ti), niobium (Nb), or vanadium (V) may be set to be within 0.001% to 0.4%.

Combination of at Least One of Copper (Cu) and Nickel (Ni): 0.005% to 2.0%

Copper (Cu) forms a fine Cu precipitate to improve the strength of the steel sheet. If the concentration of copper (Cu) is lower than 0.005%, the strength of the steel sheet may not be sufficiently increased, and if the concentration of copper (Cu) is greater than 2.0%, the processability of the steel sheet may be deteriorated. Therefore, it may be preferable that the concentration of copper (Cu) be set to be within 0.005% to 2.0%. Nickel (Ni) improves the strength and heat-treatment characteristics of the steel sheet. However, if the concentration of nickel (Ni) is less than 0.005%, such effects may not be obtained, and if the concentration of nickel (Ni) is greater than 2.0%, manufacturing costs increase. Therefore, the concentration of nickel (Ni) may be set to be within 0.005% to 2.0%.

Boron (B): 0.0001% to 0.01%

Boron (B) improves the hardenability of the steel sheet, and although a small amount of boron (B) is added to the steel sheet, the strength of the steel sheet may be markedly increased through a heat treatment. In addition, boron (B) enhances grain boundaries and thus suppresses grain boundary embrittlement of the steel sheet having a large amount of manganese (Mn). However, if the concentration of boron (B) in the steel sheet is less than 0.0001%, such effects may not be obtained. In addition, if the concentration of boron (B) is greater than 0.01%, such effects may not be further obtained, and the high-temperature processability of the steel sheet may be deteriorated. Therefore, the upper limit of the concentration of boron (B) may be set to be 0.01%.

Combination of at Least One of Antimony (Sb) and Tin (Sn): 0.0001% to 1.0%

Antimony (Sb) and tin (Sn) may be concentrated on the surface and grain boundaries of the steel sheet. Thus, antimony (Sb) and tin (Sn) may prevent the manganese (Mn) included in the steel sheet in a high concentration from concentrating on the surface of the steel sheet and generating oxides during annealing process of the steel sheet. Therefore, the steel sheet may be easily plated in a plating process. However, if the concentration of antimony (Sb) or tin (Sn) in the steel sheet is less than 0.0001%, such effects may not be obtained. In addition, if the concentration of antimony (Sb) or tin (Sn) is greater than 1.0%, the high-temperature processability of the steel sheet may be deteriorated. Therefore, the upper limit of the concentration of antimony (Sb) or tin (Sn) may be set to be 1.0%.

The steel sheet may include iron (Fe) and inevitable impurities as the remainder of constituents. However, the steel sheet may further include other elements as well as the above-mentioned elements.

In the embodiment of the present disclosure, the steel sheet for warm press forming may be one of a hot-rolled steel sheet, a cold-rolled steel sheet, and a plated steel sheet. However, the steel sheet of the present disclosure is not limited but may be any kind of steel sheet. The plated steel sheet may be a Zn-based plated steel sheet or an Al-based plated steel sheet.

The steel sheet for warm press forming may have a main microstructure formed by 30 volume % or more of martensite, bainite, or a combination thereof. If the steel sheet has a main microstructure formed by less than 30 volume % of martensite, bainite, or a combination thereof, austenite may not be sufficiently formed in the steel sheet during a heat treatment of a warm press forming process, and the strength of the steel sheet may not be sufficiently high.
Hereinafter, a method of manufacturing a steel sheet for warm press forming will be described in detail according to an embodiment of the present disclosure.

A steel slab including the above-described composition is heated to 1000°C to 1400°C, and is hot-rolled. If the heating temperature of the steel slab is lower than 1000°C, the microstructure of the steel slab formed after a continuous casting process may not be sufficiently homogenized, and if the heating temperature of the steel slab is higher than 1400°C, manufacturing costs may be increased.

Thereafter, the steel slab is subjected to a finish hot rolling process at a temperature within a temperature range of Ar3 to 1000°C to form a hot-rolled steel sheet. If the process temperature of the finish hot rolling process is lower than Ar3, two-phase rolling may occur to cause a mixed grain size distribution and lower processability. On the contrary, if the process temperature of the finish hot rolling process is greater than 1000°C, the grains of the steel slab may be coarseened, and a large amount of oxide scale may be generated.

Thereafter, the hot-rolled steel sheet is coiled at a temperature higher than Ms but equal to or lower than 800°C. If the hot-rolled steel sheet is coiled at a temperature equal to or lower than Ms, a large load may be applied to a hot-rolling coiler, and if the hot-rolled steel sheet is coiled at a temperature higher than 800°C, the thickness of an oxide layer of the hot-rolled steel sheet may be increased.

The hot-rolled steel sheet manufactured as described above may be used in a warm press forming process or may be additionally treated through a pickling process. Furthermore, after the hot-rolled steel sheet is pickled, the steel sheet may be plated with a Zn-based material or an Al-based material, and then the plated steel sheet may be used in a warm press forming process.

In addition, the hot-rolled steel sheet may be subjected to a pickling process and a cold rolling process to produce a cold-rolled steel sheet. The pickling process may be performed according to a general method, and the reduction ratio of the cold rolling process is not limited. For example, the reduction ratio of the cold rolling process may be selected from general values used in the related art.

For example, before the hot-rolled steel sheet is cold-rolled, the hot-rolled steel sheet may be batch annealed. Since the hot-rolled steel sheet manufactured as described above has a high degree of strength, the hot-rolled steel sheet may be batch-annealed to reduce the strength thereof and thus to reduce the load of the cold rolling process. That is, the cold rolling processability of the hot-rolled steel sheet may be improved. It may be preferable that the batch annealing be performed within the temperature range of Ac1 to Ac3. If the process temperature of the batch annealing is lower than Ac1, the strength of the hot-rolled steel sheet may not be sufficiently lowered. On the contrary, if the process temperature of the batch annealing is higher than Ac3, manufacturing costs may be increased, and a large amount of martensite may be formed in the hot-rolled steel sheet when the hot-rolled steel sheet is slowly cooled after the batch annealing. In this case, the strength of the hot-rolled steel sheet may not be sufficiently lowered. After the batch annealing, the hot-rolled steel sheet may be cold-rolled to produce a cold-rolled steel sheet.

The cold-rolled steel sheet may be treated through a continuous annealing process to produce an annealed steel sheet. Process conditions of the continuous annealing process are not limited. For example, preferably, the continuous annealing process may be performed at a temperature within the temperature range of 700°C to 900°C. If the process temperature of the continuous annealing process is lower than 700°C, the steel sheet may not be sufficiently recrystallized. If the process temperature of the continuous annealing process is greater than 900°C, manufacturing costs may be increased, and processability may be lowered. The annealed steel sheet may be plated through a Zn-Ni electroplating process to produce a Zn-Ni electroplated steel sheet.

Alternatively, the cold-rolled steel sheet may be plated with a Zn-based material or an Al-based material so as to improve the corrosion resistance and thermal resistance of the cold-rolled steel sheet. Heat-treatment and Zn-plating conditions for the cold-rolled steel sheet are not limited. For example, the cold-rolled steel sheet may be hot-dip galvanized to produce a product known as a GI (galvanized iron) sheet or may be hot-dip galvannealed to produce a product known as a GA (galvannealed) steel sheet. In addition, heat-treatment and Al-plating conditions for the cold-rolled steel sheet are not limited. For example, conditions generally used in the related art may be used.

Hereinafter, a warm-pressed member manufactured through a warm press forming process using the above-described steel sheet will be described according to an embodiment of the present disclosure.

(Warm-Pressed Member)

In the embodiment of the present disclosure, the warm-pressed member includes the above-described composition of the steel sheet for warm press forming. The microstructure of the warm-pressed member may include: 3 volume % to 50 volume % of retained austenite; and at least one of ferrite, martensite, tempered martensite, and bainite as a remainder.

If the volume fraction of retained austenite is lower than 3%, the warm-pressed member may not have an ultra high degree of strength and a high degree of elongation desired in the embodiment of the present disclosure. On the contrary, if the volume fraction of retained austenite is higher than 50%, it may be difficult to produce the warm-pressed member because large amounts of C and Mn have to be included in the warm-pressed member. In addition to the retained austenite, the microstructure of the warm press forming may include at least one of ferrite, martensite, tempered martensite, and bainite.

Ferrite may be formed in the warm-pressed member during a heat treatment of a warm press forming process (described later) or may be partially formed before the heat treatment. Preferably, the fraction of ferrite in the warm-pressed member may be 30% or less. If the fraction of ferrite is greater than 30%, the warm-pressed member may not have sufficient strength.

Martensite may be formed in the warm-pressed member during a heat treatment of a warm press forming process or may be partially formed before the heat treatment. At this time, carbides may be partially formed in the martensite. The fraction of martensite in the warm-pressed member may be within the range of 50% to 95%. If the fraction of martensite is lower than 50%, the warm-pressed member may not have sufficient strength, and if the fraction
of martensite is greater than 95%, retained austenite may not be sufficient included in the warm-pressed member. Therefore, the heat treatment may be performed at a temperature equal to or greater than \( A_c1 \) (preferably, \( A_c1+10^\circ C \). and more preferably, \( A_c1+20^\circ C \)). If the heat treatment is performed at a temperature greater than \( A_c3 \), carbon (C) and manganese (Mn) may not be sufficiently concentrated on austenite, and thus the stability of retained austenite may be low. That is, a sufficient amount of retained austenite may not be obtained, and thus the elongation of the steel sheet may not be sufficient even though the strength of the steel sheet may be increased. Therefore, the upper limit of the temperature range of the heat treatment may be set to be \( A_c3 \) (preferably, \( A_c3-10^\circ C \), and more preferably, \( A_c3-20^\circ C \)).

If the steel sheet is maintained within the heat-treatment temperature range for a period of time longer than 10,000 seconds, productivity may be decreased, and martensite may disappear to lower the strength of the steel sheet. Therefore, the upper limit of the period of time may be set to 10,000 seconds.

Thereafter, the steel sheet is warm-pressed and cooled. At this time, the cooling rate is not limited. For example, it may be preferable that the cooling rate range from 1\(^\circ\) C/sec to 1000\(^\circ\) C/sec. If the cooling rate is lower than 1\(^\circ\) C/sec, productivity may be lowered, and additional equipment may be used to control the cooling rate. Therefore, manufacturing costs may be increased. If the cooling rate is greater than 1000\(^\circ\) C/sec, additional equipment may be used to rapidly cool the steel sheet, and the microstructure of a warm-pressed member formed of the steel sheet may not be appropriate.

**MODE FOR INVENTION**

Hereinafter, examples of the present disclosure will be described in detail. The following examples are for illustrative purposes and are not intended to limit the scope of the present disclosure.

**Examples**

Steel slabs having compositions as shown in Table 1 were produced by a vacuum melting process, and the steel slabs were reheated in a heating furnace at 1200\(^\circ\) C. for 1 hour and were hot-rolled. The hot rolling of the steel slabs were finished at 900\(^\circ\) C., and the hot-rolled steel slabs (hot-rolled steel sheets) were cooled at 680\(^\circ\) C. in a furnace. A warm press forming process was performed on the hot-rolled steel sheets under simulated conditions.

Meanwhile, the hot-rolled steel sheets were pickled and then a cold rolling process was performed on the pickled hot-rolled steel sheets with a cold rolling reduction ratio of 50% so as to produce cold-rolled steel sheets. Particularly, steel sheets M and N were treated through a batch annealing process after the cold rolling process. In the batch annealing process, the steel sheets M and N were heated at a heating rate of 30\(^\circ\) C/h and maintained at 600\(^\circ\) C. for 10 hours. Thereafter, the steel sheets M and N were cooled at a cooling rate of 30\(^\circ\) C/h. A continuous annealing process was performed on the other steel sheets instead of the batch annealing process. The continuous annealing process was performed at 780\(^\circ\) C.

In addition, the pickled hot-rolled steel sheets and the cold-rolled steel sheets were plated through a zinc (Zn) or aluminum (Al) plating process so as to produce plated steel sheets. Specifically, in the zinc (Zn) or aluminum (Al)
plating process, the steel sheets were annealed at 780° C. and then were dipped in a zinc (Zn) or Aluminum (Al) plating bath.

[0085] The pickled hot-rolled steel sheets, the cold-rolled steel sheets, and the plated steel sheets were treated under simulated heat treatment conditions of the warm press forming process. The heat treatment conditions are shown in Table 2 below. The heating rate of the heat treatment was 3° C/sec.

[0086] Tension test specimens of the steel sheets processed through the warm press forming process under simulated conditions were prepared according to JIS Z 2201 #5, and mechanical properties of the tension test specimens were measured. In addition, the fraction of retained austenite in each of the steel sheets was measured by an X-ray diffraction test. In detail, the fraction of retained austenite was calculated by a 5 peak method expressed in Equation 1 using the areas of austenite (200), (220), and (311) peaks and the areas of ferrite (200) and (211) peaks obtained in the X-ray diffraction test. In Equation 1, V refers to an austenite fraction, I refers to a ferrite peak area, and I refers to an austenite peak area.

\[
V_{\text{A}} = \left[ \frac{[1/2.13(\theta_{200}^2/\theta_{200}^1) + 1] + [1/1.35(D_{200}/D_{200}) + 1]}{[1/1.5(D_{200}/D_{200}) + 1] + [1/1.12(D_{211}/D_{211}) + 1]} \right] \left[ \frac{[1/0.78(D_{211}/D_{211}) + 1] + [1/0.78(D_{211}/D_{211}) + 1]}{6} \right]
\]

[0087] Mechanical properties and retained austenite fractions of the steel sheets measured as described above are shown in Table 2 below.

<table>
<thead>
<tr>
<th>TABLE 1</th>
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<tbody>
<tr>
<td>Steel sheets</td>
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<td>A</td>
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</table>

*IS: Inventive Example, **CS: Comparative Example

[0088] Products produced using steel sheets A to P having compositions according to the present disclosure have retained austenite fractions of 3% or greater and good elongation. However, products produced using comparative steel sheets Q and R have retained austenite fractions of less than 3% regardless of heat treatment conditions and have poor elongation.

[0089] When the steel sheet A was heat-treated at 850° C. higher than Ac3 in the warm press forming process, the strength of the steel sheet A was sufficiently high but the elongation thereof was decreased because of insufficient amount of retained austenite.

1. A warm-pressed member comprising, by weight %, C: 0.01% to 0.5%, Si: 3.0% or less (excluding 0%), Mn: 3% to 15%, P: 0.0001% to 0.1%, S: 0.0001% to 0.03%, Al: 3.0% or less (excluding 0%), Ni: 0.03% or less (excluding 0%), and the balance of Fe and inevitable impurities,

wherein after a warm press forming process and a cooling process, the warm-pressed member has a microstructure comprising: 5 volume % to 50 volume % of retained austenite; and at least one of ferrite, martensite, tempered martensite, and bainite as a remainder.

2. The warm-pressed member of claim 1, wherein the warm-pressed member has a tensile strength of 1000 MPa or greater and an elongation of 10% or greater.

3. The warm-pressed member of claim 1, further comprising 0.001% to 0.4% of at least one selected from the group consisting of Ti, Nb, Zr, and V.

4. The warm-pressed member of claim 1, further comprising 0.005% to 2.0% of at least one of Cu and Ni.
5. The warm-pressed member of claim 1, further comprising 0.0001% to 1.0% of at least one of Sb and Sn.

6. The warm-pressed member of claim 1, further comprising 0.0001% to 0.01% of B.