(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 366 797 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
29.08.2018 Bulletin 2018/35

(21) Application number: **16857079.4**

(22) Date of filing: **03.10.2016**

(51) Int Cl.:
C22C 38/00 $^{(2006.01)}$
C21D 1/18 $^{(2006.01)}$
C21D 9/46 $^{(2006.01)}$
C22C 38/60 $^{(2006.01)}$
C22C 38/04 $^{(2006.01)}$
C22C 38/08 $^{(2006.01)}$
C22C 38/14 $^{(2006.01)}$
C22C 38/18 $^{(2006.01)}$
C21D 8/02 $^{(2006.01)}$
C23C 2/28 $^{(2006.01)}$
C23C 2/06 $^{(2006.01)}$
B21D 22/20 $^{(2006.01)}$
C21D 9/00 $^{(2006.01)}$
C22C 18/00 $^{(2006.01)}$
C22C 38/02 $^{(2006.01)}$
C22C 38/06 $^{(2006.01)}$
C22C 38/12 $^{(2006.01)}$
C22C 38/16 $^{(2006.01)}$
C21D 6/00 $^{(2006.01)}$
C23C 2/02 $^{(2006.01)}$
C23C 2/40 $^{(2006.01)}$
C23C 2/12 $^{(2006.01)}$

(86) International application number:
PCT/JP2016/004458

(87) International publication number:
WO 2017/068756 (27.04.2017 Gazette 2017/17)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **19.10.2015 JP 2015205751**

(71) Applicant: **JFE Steel Corporation**
Tokyo 100-0011 (JP)

(72) Inventors:
- **NAKAGAWA, Koichi**
  Tokyo 100-0011 (JP)
- **KANEKO, Shinjiro**
  Tokyo 100-0011 (JP)
- **YOKOTA, Takeshi**
  Tokyo 100-0011 (JP)
- **SETO, Kazuhiro**
  Tokyo 100-0011 (JP)

(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(54) HOT PRESS MEMBER AND METHOD FOR PRODUCING SAME

(57) A hot pressed member having all of: high strength of 1500 MPa or more in tensile strength TS; high ductility of 6.0 % or more in uniform elongation uEl; and excellent heat treatment hardenability of increasing in yield stress YS by 150 MPa or more when subjected to heat treatment (baking finish) is provided. A hot pressed member comprises: a predetermined chemical composition (in particular, low C of 0.090 % or more and less than 0.30 % and high Mn of 3.5 % or more and less than 11.0 %); a microstructure including a martensite phase of 70.0 % or more in volume fraction and a retained austenite phase of 3.0 % or more and 30.0 % or less in volume fraction; and a dislocation density of $1.0 \times 10^{16}/m^2$ or more.

EP 3 366 797 A1

Printed by Jouve, 75001 PARIS (FR)

Description

TECHNICAL FIELD

[0001] The present disclosure relates to a member obtained by hot press forming a thin steel sheet, i.e. a hot pressed member, and a method of manufacturing the same.

BACKGROUND

[0002] Recent years have seen strong demand to improve the fuel efficiency of vehicles, for global environment protection. This has led to intense need for lighter automotive bodies. To ensure safety even with thinner automotive members, steel sheets as blank sheets of such members needs to be strengthened. However, strengthening a steel sheet typically leads to lower formability. Hence, problems such as difficulty in forming and degraded shape fixability arise in the manufacture of members using high strength steel sheets as blank sheets.

[0003] In view of such problems, a technique of manufacturing a high strength automotive member by applying a hot press process to a steel sheet has been put into actual use. In the hot press process, after heating a steel sheet to an austenite region, the steel sheet is conveyed to a press machine. In the press machine, the steel sheet is formed into a member of a desired shape using a press tool, and simultaneously quenched. In this cooling process (quenching) in the press tool, the microstructure of the member undergoes phase transformation from austenite phase to martensite phase. A high strength member of a desired shape is thus obtained.

[0004] Demand to improve the anti-crash property of automotive members has also been growing recently, in order to ensure the safety of drivers and passengers. To meet this demand, increasing the uniform elongation of an automotive member is effective in enhancing the ability to absorb energy upon collision (collision energy absorbing performance). There has thus been strong demand for hot pressed members having excellent uniform elongation as well as high strength.

[0005] To meet this demand, JP 2013-79441 A (PTL 1) proposes a hot press formed part obtained by forming a thin steel sheet by a hot press forming method. The hot press formed part proposed in PTL 1 includes: a chemical composition containing, in mass%, C: 0.15 % to 0.35 %, Si: 0.5 % to 3 %, Mn: 0.5 % to 2 %, P: 0.05 % or less, S: 0.05 % or less, Al: 0.01 % to 0.1 %, Cr: 0.01 % to 1 %, B: 0.0002 % to 0.01 %, Ti: (N content) × 4 % to 0.1 %, and N: 0.001 % to 0.01 %, with a balance consisting of Fe and incidental impurities; and a microstructure including, in area ratio, martensite: 80 % to 97 %, retained austenite: 3 % to 20 %, and a balance: 5 % or less. PTL 1 states that, with the proposed technique, a metallic microstructure with an appropriate amount of retained austenite can be obtained, and a hot pressed member having higher ductility can be realized.

[0006] JP 2010-65293 A (PTL 2) proposes a hot pressed member having excellent ductility. The hot pressed member described in PTL 2 includes: a composition containing, in mass%, C: 0.20 % to 0.40 %, Si: 0.05 % to 3.0 %, Mn: 1.0 % to 4.0 %, P: 0.05 % or less, S: 0.05 % or less, Al: 0.005 % to 0.1 %, and N: 0.01 % or less, with a balance consisting of Fe and incidental impurities; and a microstructure in which the area ratio of ferrite phase is 5 % to 55 % and the area ratio of martensite phase is 45 % to 95 % with respect to the whole microstructure, and the mean grain size of ferrite phase and martensite phase is 7 μm or less. The hot pressed member has high strength of 1470 MPa to 1750 MPa in tensile strength TS, and high ductility of 8 % or more in total elongation El.

CITATION LIST

Patent Literatures

[0007]

PTL 1: JP 2013-79441 A
PTL 2: JP 2010-65293 A

SUMMARY

(Technical Problem)

[0008] With the techniques described in PTL 1 and PTL 2, high strength of 1500 MPa or more in tensile strength TS is achieved by strengthening martensite phase by C, but there is a problem of insufficient uniform elongation in terms of enhancing collision energy absorbing performance.

[0009] A hot pressed member is typically subjected to a baking finish after the production. Heat treatment in this baking finish increases yield stress YS. To enhance anti-crash property, not only high uniform elongation but also high YS is important. Accordingly, a hot pressed member that has excellent heat treatment hardenability so that YS increases as high as possible as a result of the heat treatment in the baking finish is desired. The techniques described in PTL 1 and PTL 2 are, however, not concerned with such heat treatment hardenability.

[0010] It could therefore be helpful to provide a hot pressed member having all of: high strength of 1500 MPa or more in tensile strength TS; high ductility of 6.0 % or more in uniform elongation uEl; and excellent heat treatment hardenability of increasing in yield stress YS by 150 MPa or more when subjected to heat treatment (baking finish), and an advantageous method of manufacturing the same. In this description, "excellent heat treatment hardenability" means a property that, when a hot pressed member is heat treated, the difference (hereafter denoted by "ΔYS") between the yield stress YS after the heat treatment and the yield stress YS before the heat treatment is 150 MPa or more.

(Solution to Problem)

[0011] As a result of conducting extensive study on various factors that influence yield stress YS and uniform elongation uEl in a hot pressed member having high strength of 1500 MPa or more in tensile strength TS, we discovered the following.

(A) To achieve high uniform elongation uEl of 6.0 % or more, a microstructure having an appropriate amount of retained austenite is necessary. To obtain a microstructure having an appropriate amount of retained austenite with less than 0.30 mass% C, the Mn content needs to be 3.5 % or more. Mn contributes to increased strength, so that high strength can be ensured even with less than 0.30 % C.

(B) The dislocation density and ΔYS of the hot pressed member correlate with each other. To achieve ΔYS of 150 MPa or more, the dislocation density of the hot pressed member needs to be $1.0 \times 10^{16}/m^2$ or more.

(C) An appropriate amount of retained austenite can be generated by, before hot pressing a steel sheet containing 3.5 % or more Mn as mentioned above, performing heat treatment of heating the steel sheet to a ferrite-austenite dual phase temperature range and retaining the steel sheet at a predetermined temperature in the temperature range for 1 hr or more and 48 hr or less beforehand to cause Mn to concentrate in austenite. Moreover, by subjecting the obtained steel sheet to a predetermined heating process and a hot press forming process, a hot pressed member having a dislocation density of $1.0 \times 10^{16}/m^2$ or more can be yielded.

[0012] The present disclosure is based on these discoveries. We thus provide:

(1) A hot pressed member comprising: a chemical composition containing (consisting of), in mass%, C: 0.090 % or more and less than 0.30 %, Mn: 3.5 % or more and less than 11.0 %, Si: 0.01 % to 2.5 %, P: 0.05 % or less, S: 0.05 % or less, Al: 0.005 % to 0.1 %, and N: 0.01 % or less, with a balance consisting of Fe and incidental impurities; a microstructure including a martensite phase of 70.0 % or more in volume fraction and a retained austenite phase of 3.0 % or more and 30.0 % or less in volume fraction; a tensile property of 1500 MPa or more in tensile strength TS and 6.0 % or more in uniform elongation uEl; and a dislocation density of $1.0 \times 10^{16}/m^2$ or more.

(2) The hot pressed member according to (1), wherein the chemical composition further contains, in mass%, one or more groups selected from A group: one or more selected from Ni: 0.01 % to 5.0 %, Cu: 0.01 % to 5.0 %, Cr: 0.01 % to 5.0 %, and Mo: 0.01 % to 3.0 %, B group: one or more selected from Ti: 0.005 % to 3.0 %, Nb: 0.005 % to 3.0 %, V: 0.005 % to 3.0 %, and W: 0.005 % to 3.0 %, C group: one or more selected from REM: 0.0005 % to 0.01 %, Ca: 0.0005 % to 0.01 %, and Mg: 0.0005 % to 0.01 %, D group: Sb: 0.002 % to 0.03 %, and E group: B: 0.0005 % to 0.05 %.

(3) The hot pressed member according to (1) or (2), comprising a coated layer on a surface thereof.

(4) The hot pressed member according to (3), wherein the coated layer is any of a zinc or zinc alloy coated layer and an aluminum or aluminum alloy coated layer.

(5) The hot pressed member according to (4), wherein the zinc or zinc alloy coated layer contains Ni: 10 mass% to 25 mass%.

(6) A method of manufacturing a hot pressed member, the method comprising: heating a slab and hot rolling the slab to obtain a hot rolled steel sheet, the slab having a chemical composition containing, in mass%, C: 0.090 % or more and less than 0.30 %, Mn: 3.5 % or more and less than 11.0 %, Si: 0.01 % to 2.5 %, P: 0.05 % or less, S: 0.05 % or less, Al: 0.005 % to 0.1 %, and N: 0.01 % or less, with a balance consisting of Fe and incidental impurities; heating the hot rolled steel sheet to a first temperature that is an Ac1 point or more and an Ac3 point or less, retaining the hot rolled steel sheet at the first temperature for 1 hr or more and 48 hr or less, and then cooling the hot rolled steel sheet to obtain a first blank steel sheet; performing a heating process of heating the first blank steel sheet to a second temperature that is the Ac3 point or more and 1000 °C or less and retaining the first blank steel sheet at the second temperature for 900 sec or less; and thereafter performing a hot press forming process of simultaneously press forming and quenching the first blank steel sheet using a press tool for forming, to obtain a hot pressed member.

(7) The method of manufacturing a hot pressed member according to (6), further comprising: cold rolling the first

blank steel sheet to obtain a cold rolled steel sheet, before the heating process; and annealing the cold rolled steel sheet to obtain a second blank steel sheet, the annealing including heating the cold rolled steel sheet to a temperature that is the Ac1 point or more and the Ac3 point or less, retaining the cold rolled steel sheet at the temperature, and then cooling the cold rolled steel sheet, wherein the heating process and the hot press forming process are performed on the second blank steel sheet instead of the first blank steel sheet.

(8) The method of manufacturing a hot pressed member according to (6) or (7), wherein the chemical composition further contains, in mass%, one or more groups selected from A group: one or more selected from Ni: 0.01 % to 5.0 %, Cu: 0.01 % to 5.0 %, Cr: 0.01 % to 5.0 %, and Mo: 0.01 % to 3.0 %, B group: one or more selected from Ti: 0.005 % to 3.0 %, Nb: 0.005 % to 3.0 %, V: 0.005 % to 3.0 %, and W: 0.005 % to 3.0 %, C group: one or more selected from REM: 0.0005 % to 0.01 %, Ca: 0.0005 % to 0.01 %, and Mg: 0.0005 % to 0.01 %, D group: Sb: 0.002 % to 0.03 %, and E group: B: 0.0005 % to 0.05 %.

(9) The method of manufacturing a hot pressed member according to any one of (6) to (8), further comprising forming a coated layer on a surface of the first blank steel sheet or the second blank steel sheet, before the heating process.

(10) The method of manufacturing a hot pressed member according to (9), wherein the coated layer is any of a zinc or zinc alloy coated layer and an aluminum or aluminum alloy coated layer.

(11) The method of manufacturing a hot pressed member according to (10), wherein the zinc or zinc alloy coated layer contains Ni: 10 mass% to 25 mass%.

(12) The method of manufacturing a hot pressed member according to any one of (9) to (11), wherein a coating weight of the coated layer is 10 g/m^2 to 90 g/m^2 per side.

(Advantageous Effect)

[0013] The hot pressed member according to the present disclosure has all of: high strength of 1500 MPa or more in tensile strength TS; high ductility of 6.0 % or more in uniform elongation uEl; and excellent heat treatment hardenability of increasing in yield stress YS by 150 MPa or more when subjected to heat treatment (baking finish). Such a hot pressed member can be advantageously obtained by the method of manufacturing a hot pressed member according to the present disclosure.

DETAILED DESCRIPTION

(Chemical composition)

[0014] The chemical composition of a hot pressed member according to one of the disclosed embodiments is described below. In the following description, "mass%" is simply written as "%" unless otherwise noted.

C: 0.090 % or more and less than 0.30 %

[0015] C is an element that increases the strength of the steel. In addition, in heat treatment for the hot pressed member, yield stress is increased by dislocation locking of solute C. To achieve the effects and ensure a tensile strength TS of 1500 MPa or more, the C content is 0.090 % or more. If the C content is 0.30 % or more, the degree of solid solution strengthening by C increases, which makes it difficult to adjust the tensile strength TS of the hot pressed member to less than 2300 MPa.

Mn: 3.5 % or more and less than 11.0 %

[0016] Mn is an element that increases the strength of the steel and also concentrates in austenite to improve the stability of austenite, and is the most important element in the present disclosure. To achieve the effects and ensure a tensile strength TS of 1500 MPa or more and a uniform elongation uEl of 6.0 % or more, the Mn content is 3.5 % or more. If the Mn content is 11.0 % or more, the degree of solid solution strengthening by Mn increases, which makes it difficult to adjust the tensile strength TS of the hot pressed member to less than 2300 MPa.

[0017] If the C content and the Mn content are in the respective ranges mentioned above, a hot pressed member having tensile property of 6.0 % or more in uniform elongation can be yielded stably, with a tensile strength TS of 1500 MPa or more and preferably less than 2300 MPa. In more detail, to ensure a strength of 1500 MPa or more and less than 1700 MPa in tensile strength TS, it is preferable to set C: 0.090 % or more and less than 0.12 % and Mn: 4.5 % or more and less than 6.5 %, or C: 0.12 % or more and less than 0.18 % and Mn: 3.5 % or more and less than 5.5 %. To ensure a strength of 1700 MPa or more and less than 1900 MPa in tensile strength TS, it is preferable to set C: 0.090 % or more and less than 0.12 % and Mn: 6.5 % or more and less than 8.5 %, or C: 0.12 % or more and less than 0.18 % and Mn: 5.5 % or more and less than 7.5 %. To ensure a strength of 1800 MPa or more and less than 1980 MPa in tensile strength TS, it is preferable to set C: 0.18 % or more and less than 0.30 % and Mn: 3.5 % or more and less than 4.5 %. To ensure a strength of 2000 MPa or more and less than 2300 MPa in tensile strength TS, it is preferable to set C: 0.090 % or more and less than 0.12 % and Mn: 8.5 % or more and less than 11.0 %, C: 0.12 % or more and less than 0.18 % and Mn: 7.5 % or more and less than 11.0 %, or C: 0.18 % or more and less than 0.30 % and Mn: 4.5 % or more and less than 6.5 %.

Si: 0.01 % to 2.5 %

[0018] Si is an element that increases the strength of the steel by solid solution strengthening. To achieve the effect, the Si content is 0.01 % or more. If the Si content is more than 2.5 %, surface defects called red scale occur significantly in hot rolling, and also the rolling load increases. The Si content is therefore 0.01 % or more and 2.5 % or less. The Si content is preferably 0.02 % or more. The Si content is preferably 1.5 % or less.

P: 0.05 % or less

[0019] P is an element that exists in the steel as an incidental impurity, and segregates to crystal grain boundaries and like and causes adverse effects such as a decrease in the toughness of the member. The P content is therefore desirably as low as possible, but 0.05 % or less P is allowable. Accordingly, the P content is 0.05 % or less, and more preferably 0.02 % or less. Excessive dephosphorization leads to higher refining cost, and so the P content is desirably 0.0005 % or more.

S: 0.05 % or less

[0020] S is contained in the steel incidentally. S exists in the steel as a sulfide inclusion, and decreases the ductility, toughness, and the like of the hot pressed member. The S content is therefore desirably as low as possible, but 0.05 % or less S is allowable. Accordingly, the S content is 0.05 % or less, and more preferably 0.005 % or less. Excessive desulfurization leads to higher refining cost, and so the S content is desirably 0.0005 % or more.

Al: 0.005 % to 0.1 %

[0021] Al is an element that acts as a deoxidizer. To achieve the effect, the Al content is 0.005 % or more. If the Al content is more than 0.1 %, Al combines with nitrogen to form a large amount of nitride. This causes a decrease in the blanking workability and quench hardenability of the steel sheet as a blank sheet. The Al content is therefore 0.005 % or more and 0.1 % or less. The Al content is preferably 0.02 % or more. The Al content is preferably 0.05 % or less.

N: 0.01 % or less

[0022] N is typically contained in the steel incidentally. If the N content is more than 0.01 %, nitrides such as AlN form during heating in hot rolling or hot press. This causes a decrease in the blanking workability and quench hardenability of the steel sheet as a blank sheet. The N content is therefore 0.01 % or less. The N content is more preferably 0.0030 % or more. The N content is more preferably 0.0050 % or less. In the case where N is contained incidentally without adjustment, the N content is approximately less than 0.0025 %. To prevent an increase in refining cost, the N content is desirably 0.0025 % or more.

[0023] In addition to the basic components described above, the chemical composition may contain the following optional components.

A group: one or more selected from Ni: 0.01 % to 5.0 %, Cu: 0.01 % to 5.0 %, Cr: 0.01 % to 5.0 %, and Mo: 0.01 % to 3.0 %

[0024] Ni, Cu, Cr, and Mo are each an element that increases the strength of the steel and improves quench hardenability. One or more of them may be selected and added according to need. To achieve the effect, the content of each element is 0.01 % or more. To prevent an increase in material cost, the Ni, Cu, and Cr contents are each 5.0 % or less, and the Mo content is 3.0 % or less. The content of each element is preferably 0.01 % or more and 1.0 % or less.

B group: one or more selected from Ti: 0.005 % to 3.0 %, Nb: 0.005 % to 3.0 %, V: 0.005 % to 3.0 %, and W: 0.005 % to 3.0 %

[0025] Ti, Nb, V, and W are each an element that increases the strength of the steel by precipitation strengthening, and also improves toughness by crystal grain refinement. One or more of them may be selected and added according to need.

[0026] Ti has not only the effect of increasing strength and improving toughness, but also the effect of forming a nitride more preferentially than B and improving quench hardenability by solute B. To achieve the effects, the Ti content is 0.005 % or more. If the Ti content is more than 3.0 %, the rolling load increases extremely in hot rolling, and also the toughness of the hot pressed member decreases. Accordingly, in the case of containing Ti, the Ti content is 0.005 % or more and 3.0 % or less. The Ti content is preferably 0.01 % or more. The Ti content is preferably 1.0 % or less.

[0027] To achieve the above-mentioned effect by Nb, the Nb content is 0.005 % or more. If the Nb content is more than 3.0 %, the amount of carbonitride increases, and ductility and lagging destruction resistance decrease. Accordingly, in the case of containing Nb, the Nb content is 0.005 % or more and 3.0 % or less. The Nb content is preferably 0.01 % or more. The Nb content is preferably 0.05 %.

[0028] V has not only the effect of increasing strength and improving toughness, but also the effect of precipitating as a precipitate or a crystallized product and improving hydrogen embrittlement resistance as a hydrogen trap site. To achieve the effects, the V content is 0.005 % or more. If the V content is more than 3.0 %, the amount of carbonitride increases considerably, and ductility decreases. Accordingly, in the case of containing V, the V content is 0.005 % or more and 3.0 % or less. The V content is preferably 0.01 % or more. The V content is preferably 2.0 % or less.

[0029] W has not only the effect of increasing strength and improving toughness, but also the effect of improving hydrogen embrittlement resistance. To achieve the effects, the W content is 0.005 % or more. If the W content is more than 3.0 %, ductility decreases. Accordingly, in the case of containing W, the W content is 0.005 % or more and 3.0 % or less. The W content is preferably 0.01 % or more. The W content is preferably 2.0 % or less.

C group: one or more selected from REM: 0.0005 % to 0.01 %, Ca: 0.0005 % to 0.01 %, and Mg: 0.0005 % to 0.01 %

[0030] REM, Ca, and Mg are each an element that improves ductility and hydrogen embrittlement resistance by morphological control of an inclusion. One or more of them may be selected and added according to need. To achieve the effect, the content of each element is 0.0005 % or more. To prevent a decrease in hot workability, the REM content and the Ca content are each 0.01 % or less. To prevent a decrease in ductility caused by the formation of a coarse oxide or sulfide, the Mg content is 0.01 % or less. The content of each element is preferably 0.0006 % to 0.01 %.

[0031] D group: Sb: 0.002 % to 0.03 %

[0032] Sb inhibits the formation of a decarburized layer in the steel sheet surface layer when heating or cooling the steel sheet, and so may be added according to need. To achieve the effect, the Sb content is 0.002 % or more. If the Sb content is more than 0.03 %, the rolling load increases, and productivity decreases. Accordingly, in the case of containing Sb, the Sb content is 0.002 % or more and 0.03 % or less. The Sb content is preferably 0.002 % or more and 0.02 % or less.

[0033] E group: B: 0.0005 % to 0.05 %

[0034] B improves quench hardenability during hot press and toughness after hot press, and so may be added according to need. To achieve the effect, the B content is 0.0005 % or more. If the B content is more than 0.05 %, the rolling load in hot rolling increases. Besides, martensite phase or bainite phase may form after hot rolling, and cause cracking in the steel sheet. Accordingly, in the case of containing B, the B content is 0.0005 % or more and 0.05 % or less, and preferably 0.0005 % or more and 0.01 % or less.

[0035] The balance other than the components described above consists of Fe and incidental impurities. As the incidental impurities, O (oxygen): 0.0100 % or less is allowable.

(Microstructure)

[0036] The microstructure of the hot pressed member in this embodiment is described below.

Martensite phase: 70.0 % or more in volume fraction

[0037] To ensure a tensile strength TS of 1500 MPa or more, martensite phase of 70.0 % or more in volume fraction needs to be the main phase. To contain the desired amount of retained austenite phase, martensite phase is preferably 97 % or less.

Retained austenite phase: 3.0 % to 30.0 % in volume fraction

[0038] Retained austenite phase enhances uniform elongation by a transformation induced plasticity (TRIP) effect upon deformation, and is the most important microstructure in the present disclosure. In this embodiment, the volume fraction of retained austenite phase is 3.0 % or more, to achieve a uniform elongation uEl of 6.0 % or more. If the volume fraction of retained austenite phase is more than 30.0 %, hard martensite phase transformed after the TRIP effect is developed increases excessively, and toughness decreases. The volume fraction of retained austenite phase is therefore

3.0 % or more and 30.0 % or less. The volume fraction of retained austenite phase is preferably 5.0 or more. The volume fraction of retained austenite phase is preferably 20.0 % or less.

[0039] For the formation of the above-mentioned appropriate amount of retained austenite phase, it is important to use a steel sheet containing an appropriate amount of Mn, subject the steel sheet to predetermined heat treatment before hot press to cause Mn to concentrate in austenite, and appropriately adjusting a heating process in hot press.

[0040] As the balance other than martensite phase and retained austenite phase, 10 % or less (including 0 %) bainite phase, ferrite phase, cementite, and pearlite in volume fraction in total is allowable.

[0041] In the present disclosure, the volume fraction of each phase is determined as follows.

[0042] The volume fraction of retained austenite is determined by the following method. An X-ray diffraction test piece is cut out of the hot pressed member, mechanically polished and chemically polished so that the measurement plane is at a position of 1/4 of the thickness, and then subjected to X-ray diffraction. Using CoKα radiation as an incident X-ray, the peak integrated intensity for the retained austenite (γ) planes of {200}, {220}, and {311} and the peak integrated intensity for the ferrite (α) planes of {200} and {211} are measured. For a total of six patterns of α\{200\} - γ\{200\}, α\{200\} - γ\{220\}, α\{200\} - γ\{311\}, α\{211\} - γ\{200\}, α\{211\} - γ\{220\}, and α\{211\} - γ\{311\}, the retained γ volume fraction obtained from each integrated intensity ratio is calculated. Their mean value is set as "the volume fraction of retained austenite phase".

[0043] The volume fraction of the balance is determined by the following method. A microstructure observation test piece is collected from the hot pressed member so that the observation plane is parallel to the rolling direction and perpendicular to the rolling plane. The observation plane is polished, and etched with a 3 vol% nital solution to expose the microstructure. The microstructure at a position of 1/4 of the sheet thickness is observed using a scanning electron microscope (at 1500 magnifications) and photographed. From the obtained micrograph, the microstructure is identified and the microstructure proportion is calculated by image analysis. A phase observed as black with a relatively smooth surface is identified as ferrite phase. A phase observed as white in film or lump form in crystal grain boundaries is identified as cementite. A phase in which ferrite phase and cementite form in layers is identified as pearlite. A phase in which a carbide forms between laths and a phase made of bainitic ferrite having no carbide in grains are identified as bainite phase. The occupancy area ratio of each phase in the micrograph is calculated, and the area ratio is set as the volume fraction on the assumption that the microstructure is homogeneous three-dimensionally.

[0044] The volume fraction of martensite phase is calculated by subtracting the volume fraction of the balance and the volume fraction of the retained austenite phase from 100 %.

(Dislocation density)

Dislocation density: $1.0 \times 10^{16}/m^2$ or more

[0045] The dislocation density of the hot pressed member influences ΔYS, and is the most important index in the present disclosure. It is considered that, when the hot pressed member is subjected to heat treatment (baking finish), solute C locks to mobile dislocations, as a result of which yield stress YS increases. To achieve ΔYS of 150 MPa or more, the dislocation density of the hot pressed member needs to be $1.0 \times 10^{16}/m^2$ or more. The upper limit of the dislocation density is substantially $5.0 \times 10^{16}/m^2$. The dislocation density of the hot pressed member is preferably $1.2 \times 10^{16}/m^2$ or more. The dislocation density of the hot pressed member is preferably $4.5 \times 10^{16}/m^2$ or less.

[0046] In the present disclosure, the dislocation density is determined by the following method. An X-ray diffraction test piece is cut out of the hot pressed member, mechanically polished and chemically polished so that the measurement plane is at a position of 1/4 of the thickness, and then subjected to X-ray diffraction. Using CoKα_1 radiation as an incident X-ray, the peak half-value widths of α\{110\}, α\{211\}, and α\{220\} are measured. The measured peak half-value widths of α\{110\}, α\{211\}, and α\{220\} are corrected to true half-value widths using a strain-free standard test piece (Si), and then strain (ε) is calculated based on the Willaimson-Hall method. The dislocation density (ρ) is calculated using the strain (ε) and the Burgers vector (b = 0.286 nm), according to the following expression:

$$\rho = 14.4 \times \varepsilon^2/b^2.$$

(Properties)

[0047] The hot pressed member in this embodiment has the following properties: high strength of 1500 MPa or more and preferably less than 2300 MPa in tensile strength TS; high ductility of 6.0 % or more and substantially 20 % or less in uniform elongation uEl; and ΔYS of 150 MPa or more and substantially 300 MPa or less.

(Coated layer)

[0048] The hot pressed member in this embodiment preferably has a coated layer.

[0049] In the case where the steel sheet used as a blank sheet of the hot pressed member is a coated steel sheet, a coated layer remains in the surface layer of the yielded hot pressed member. In such a case, scaling is suppressed during heating in hot press. The hot pressed member can thus be put to use without descaling the surface, which contributes to improved productivity.

[0050] The coated layer is preferably a zinc or zinc alloy coated layer or an aluminum or aluminum alloy coated layer. In the case where corrosion resistance is required, a zinc or zinc alloy coated layer is better than an aluminum or aluminum alloy coated layer, because the corrosion rate of the steel substrate can be reduced by the sacrificial protection effect of zinc. Moreover, in the case of hot pressing the coated steel sheet, a zinc oxide film forms in the initial stage of heating in the hot press process, so that evaporation of Zn can be prevented in the subsequent treatment of the hot pressed member.

[0051] Examples of the zinc or zinc alloy coating include typical hot-dip galvanizing (GI), galvannealing (GA), and Zn-Ni-based coating. Zn-Ni-based coating is particularly preferable. A Zn-Ni-based coated layer can remarkably suppress scaling during hot press heating, and also prevent liquid metal embrittlement cracking. To achieve the effects, the Zn-Ni-based coated layer preferably contains 10 mass% to 25 mass% Ni. If more than 25 % Ni is contained, the effects are saturated.

[0052] Examples of the aluminum or aluminum alloy coated layer include Al-10 mass% Si coating.

(Manufacturing method)

[0053] A method of manufacturing a hot pressed member in this embodiment is described below. First, a slab having the above-mentioned chemical composition is heated, and hot rolled to obtain a hot rolled steel sheet. The hot rolled steel sheet is then subjected to predetermined heat treatment (Mn concentration heat treatment) (described later), to obtain a first blank steel sheet. After this, the first blank steel sheet is optionally cold rolled to obtain a cold rolled steel sheet. The cold rolled steel sheet is then subjected to predetermined annealing, to obtain a second blank steel sheet.

[0054] The first blank steel sheet or the second blank steel sheet obtained in this way is subjected to a predetermined heating process and a hot press forming process, to obtain a hot pressed member. Each process is described in detail below.

<Obtainment of hot rolled steel sheet>

[0055] The obtainment of the hot rolled steel sheet is not limited, and may be performed according to a usual method. It is preferable to obtain molten steel having the above-mentioned chemical composition by steelmaking in a converter or the like, and process the molten steel into a slab by a continuous casting method in order to prevent macrosegregation. An ingot casting method or a thin slab continuous casting method may be used instead of the continuous casting method.

[0056] The obtained slab is cooled to the room temperature, and then charged into a heating furnace for reheating. Alternatively, an energy saving process such as a process of charging the slab into the heating furnace as a warm slab without cooling the slab to the room temperature or a process of heat-retaining the slab for a short time and then immediately hot rolling the slab may be used.

[0057] The obtained slab is heated to a predetermined heating temperature, and then hot rolled to obtain a hot rolled steel sheet. The heating temperature is, for example, 1000 °C to 1300 °C. The heated slab is typically hot rolled at a finisher entry temperature of 1100 °C or less and a finisher delivery temperature of 800 °C to 950 °C, cooled at an average cooling rate of 5 °C/s or more, and coiled at a coiling temperature of 300 °C to 750 °C, to obtain a hot rolled steel sheet.

<Mn concentration heat treatment>

[0058] Following this, the hot rolled steel sheet is heated to a first temperature that is Ac1 point or more and Ac3 point or less, retained at the first temperature for 1 hr or more and 48 hr or less, and then cooled to obtain the first blank steel sheet. This process causes Mn to concentrate in austenite, and is the most important process for manufacturing a hot pressed member that has the appropriate amount of retained austenite to achieve a uniform elongation uEl of 6.0 % or more and has a dislocation density of $1.0 \times 10^{16}/\mathrm{m}^2$ or more to achieve ΔYS of 150 MPa or more.

Heating temperature: Ac1 point or more and Ac3 point or less

[0059] The hot rolled steel sheet is heated to a ferrite-austenite dual phase temperature range, to cause Mn to concentrate in austenite. In Mn-concentrated austenite, the martensite transformation end temperature is the room temperature or less, and the formation of retained austenite is facilitated. If the heating temperature is less than Ac1 point, austenite does not form, and Mn cannot be concentrated in austenite. If the heating temperature is more than Ac3 point, the temperature is in an austenite single phase temperature range, and Mn does not concentrate in austenite. In both of the case where the heating temperature is less than Ac1 point and the case where the heating temperature is more than Ac3 point, a hot pressed member having a dislocation density of $1.0 \times 10^{16}/m^2$ or more cannot be obtained. The heating temperature is therefore Ac1 point or more and Ac3 point or less. The heating temperature is preferably (Ac1 point + 20 °C) or more. The heating temperature is preferably (Ac3 point - 20 °C) or less.

[0060] Ac1 point (°C) and Ac3 point (°C) are calculated according to the following expressions:

$$\text{Ac1 point } (^\circ\text{C}) = 751 - 16\text{C} + 11\text{Si} - 28\text{Mn} - 5.5\text{Cu} - 16\text{Ni} + 13\text{Cr} + 3.4\text{Mo}$$

$$\text{Ac3 point } (^\circ\text{C}) = 910 - 203\text{C}^{1/2} + 44.7\text{Si} - 4\text{Mn} + 11\text{Cr}$$

where C, Si, Mn, Ni, Cu, Cr, and Mo are each the content (mass%) of the corresponding element. In the case where the element is not contained, the content of the element is assumed to be 0.

Heating retention time: 1 hr or more and 48 hr or less

[0061] The concentration of Mn in austenite progresses with the passage of the heating retention time. If the heating retention time is less than 1 hr, the concentration of Mn in austenite is insufficient, and the desired uniform elongation cannot be obtained. Besides, if the heating retention time is less than 1 hr, the concentration of Mn is insufficient, and Ms point does not decrease in the hot press process, so that a hot pressed member having a dislocation density of $1.0 \times 10^{16}/m^2$ or more cannot be obtained. If the heating retention time is more than 48 hr, pearlite forms, making it impossible to achieve the desired uniform elongation. Moreover, a hot pressed member having a dislocation density of $1.0 \times 10^{16}/m^2$ or more cannot be obtained. The heating retention time is therefore 1 hr or more and 48 hr or less. The heating retention time is preferably 1.5 hr or more. The heating retention time is preferably 24 hr or less.

[0062] Ms point (°C) is calculated according to the following expression:

$$\text{Ms point } (^\circ\text{C}) = 539 - 423\text{C} - 30.4\text{Mn} - 17.7\text{Ni} - 12.1\text{Cr} - 7.5\text{Mo}$$

where C, Mn, Ni, Cr, and Mo are each the content (mass%) of the corresponding element. In the case where the element is not contained, the content of the element is assumed to be 0.

[0063] The cooling after the heating retention is not limited. It is preferable to appropriately perform the cooling by natural cooling (gradual cooling) or controlled cooling depending on the heating furnace used and the like.

[0064] The Mn concentration heat treatment is preferably performed in a batch annealing furnace or a continuous annealing furnace. The treatment conditions in the batch annealing furnace other than the above-mentioned conditions are not limited. For example, it is preferable to set the heating rate to 40 °C/hr or more and the cooling rate after the heating retention to 40 °C/hr or more, in terms of Mn concentration. The treatment conditions in the continuous annealing furnace other than the above-mentioned conditions are not limited. For example, it is preferable to, after performing the above-mentioned heating retention, cool the hot rolled steel sheet at an average cooling rate of 10 °C/s or more to a cooling stop temperature in a temperature range of 350 °C to 600 °C, cause the hot rolled steel sheet to stay in the temperature range for 10 sec to 300 sec, and then cool and coil the steel sheet, in terms of manufacturability.

[0065] The first blank steel sheet produced in this way can be used as a steel sheet for hot press. The microstructure of the first blank steel sheet has a feature that $\text{Mns}/\text{Mn}\alpha$ is 1.2 or more, where Mns is the Mn concentration in lath secondary phase and $\text{Mn}\alpha$ is the Mn concentration in lath ferrite. Here, "secondary phase" denotes the balance (austenite, martensite, pearlite, bainite) other than ferrite. If $\text{Mns}/\text{Mn}\alpha$ is less than 1.2, the concentration of Mn in austenite is insufficient, making it impossible to achieve sufficient uniform elongation and dislocation density after the hot press.

<Obtainment of cold rolled steel sheet>

[0066] After this, the first blank steel sheet may be cold rolled to obtain a cold rolled steel sheet, instead of performing the below-mentioned heating process and hot press forming process on the first blank steel sheet. To prevent abnormal grain growth in the subsequent annealing or the heating process immediately before the hot press, the reduction ratio in the cold rolling is preferably 30 % or more, and more preferably 50 % or more. To prevent an increase in rolling load and a decrease in productivity, the reduction ratio is preferably 85 % or less.

<Annealing>

[0067] After this, the cold rolled steel sheet is subjected to annealing of heating the cold rolled steel sheet to Ac1 point or more and Ac3 point or less, retaining it at the temperature, and then cooling it, to obtain the second blank steel sheet. The annealing temperature is preferably a predetermined temperature that is Ac1 point or more and Ac3 point or less. With this annealing temperature, the concentration of Mn in austenite is further facilitated in the annealing. The retention time at the predetermined temperature is not limited, but is preferably 30 sec or more and 300 sec or less. If the retention time is 30 sec or more, the effect of the concentration of Mn is sufficient. If the retention time is 300 sec or less, productivity is maintained.

[0068] Pickling and/or temper rolling may be performed as appropriate between the processes.

[0069] The second blank steel sheet produced in this way can be used as a steel sheet for hot press. The microstructure of the second blank steel sheet has a feature that the mean grain size of ferrite is 10 μm or less, the mean grain size of secondary phase is 10 μm or less, and Mns/Mnα is 1.5 or more, where Mns is the Mn concentration in secondary phase and Mnα is the Mn concentration in ferrite. The mean grain size of ferrite and the mean grain size of secondary phase are determined by the following method. A microstructure observation test piece is collected from the second blank steel sheet so that the observation plane is parallel to the rolling direction and perpendicular to the rolling plane. The observation plane is polished, and etched with a 3 vol% nital solution to expose the microstructure. The microstructure at a position of 1/4 of the sheet thickness is observed using a scanning electron microscope (at 1500 magnifications) and photographed. From the obtained micrograph, the microstructure is identified based on the above-mentioned criteria. The mean grain size of each of ferrite and secondary phase is calculated according to linear analysis described in JIS G 0551 (2005).

[0070] Mns/Mnα is determined by the following method. A microstructure observation test piece is collected. Its observation plane is then polished, and etched with a 3 vol% nital solution to expose the microstructure. The microstructure at a position of 1/4 of the sheet thickness is observed using an electron probe microanalyzer (EPMA), and quantitative analysis of Mn is performed on 30 particles for each of ferrite and secondary phase. Regarding the Mn quantitative analysis results, the mean value of ferrite is set as Mnα, the mean value of secondary phase is set as Mns, and the value obtained by dividing the mean value Mns of secondary phase by the mean value Mnα of ferrite is set as Mns/Mnα.

<Coating>

[0071] In the case where no coated layer is formed on the surface of the first blank steel sheet or the second blank steel sheet, descaling treatment such as shot blasting needs to be performed on the hot pressed member after the hot press. In the case where a coated layer is formed on the surface of the first blank steel sheet or the second blank steel sheet, on the other hand, scaling is suppressed during heating in the hot press, so that descaling treatment after the hot press is unnecessary. This improves productivity.

[0072] The coating weight of the coated layer is preferably 10 g/m^2 to 90 g/m^2 per side, and more preferably 30 g/m^2 to 70 g/m^2 per side. If the coating weight is 10 g/m^2 or more, the effect of suppressing scaling during heating is sufficient. If the coating weight is 90 g/m^2 or less, productivity is not hampered. The components of the coated layer are as described above.

<Heating process>

[0073] Following this, a heating process of heating the first blank steel sheet or the second blank steel sheet to a second temperature that is Ac3 point or more and 1000 °C or less and retaining it at the second temperature for 900 sec or less is performed.

Heating temperature: Ac3 point or more and 1000 °C or less

[0074] If the heating temperature is less than Ac3 point which is in an austenite single phase region, austenitization is insufficient. As a result, the desired amount of martensite in the hot pressed member cannot be ensured, and the desired tensile strength cannot be achieved. Besides, the hot pressed member cannot have a dislocation density of 1.0×10^{16}/m^2 or more, making it impossible to achieve ΔYS of 150 MPa or more. If the heating temperature is more than 1000 °C, Mn concentrated in austenite is made uniform. Consequently, the desired amount of retained austenite cannot be ensured, and the desired uniform elongation cannot be achieved. Moreover, uniform Mn makes it impossible to decrease Ms point, so that the hot pressed member cannot have a dislocation density of 1.0×10^{16}/m^2 or more and

ΔYS of 150 MPa or more cannot be achieved. The heating temperature is therefore Ac3 point or more and 1000 °C or less. The heating temperature is preferably (Ac3 point + 30) °C or more. The heating temperature is preferably 950 °C or less.

[0075] The heating rate to the heating temperature (second temperature) is not limited, but is preferably 1 °C/s to 400 °C/s, and more preferably 10 °C/s to 150 °C/s. If the heating rate is 1 °C/s or more, productivity is not hampered. If the heating rate is 400 °C/s or less, stable temperature control is ensured.

Retention time: 900 sec or less (including 0 sec)

[0076] With the passage of the retention time at the heating temperature (second temperature), concentrated Mn diffuses around and is made uniform. Accordingly, if the retention time is more than 900 sec, the desired amount of retained austenite cannot be ensured, and the desired uniform elongation cannot be achieved. Besides, uniform Mn makes it impossible to decrease Ms point, so that the hot pressed member cannot have a dislocation density of $1.0 \times 10^{16}/m^2$ or more and ΔYS of 150 MPa or more cannot be achieved. The retention time is therefore 900 sec or less. The retention time may be 0 sec, that is, the heating may be stopped immediately after the second temperature is reached.

[0077] The heating method is not limited, and may be any typical heating method such as an electric furnace, a gas furnace, infrared heating, high frequency heating, or direct current heating. The atmosphere is not limited, and may be any of an air atmosphere and an inert gas atmosphere.

<Hot press forming process>

[0078] In the hot press forming process, the first blank steel sheet or the second blank steel sheet which has undergone the heating process is simultaneously press formed and quenched using a press tool for forming, to obtain a hot pressed member of a predetermined shape. Hot press forming is a process of press forming a heated thin steel sheet using a press tool and simultaneously quenching it, and is also referred to as "hot forming", "hot stamping", "die quenching", etc.

[0079] The forming start temperature in the press machine is not limited, but is preferably Ms point or more. If the forming start temperature is less than Ms point, the load of press forming increases, and the load on the press machine increases. The conveyance of the blank steel sheet before the forming start is typically performed with air cooling. Accordingly, the upper limit of the forming start temperature is the heating temperature in the immediately previous heating process in the manufacturing process. In the case where the blank steel sheet is conveyed in an environment where the cooling rate is accelerated by a refrigerant such as gas or liquid, the cooling rate is preferably decreased by a heat insulation jig such as a heat retention box.

[0080] The cooling rate in the press tool is not limited. In terms of productivity, the average cooling rate to 200 °C is preferably 20 °C/s or more, and more preferably 40 °C/s or more.

[0081] The removal time from the press tool and the cooling rate after the removal are not limited. As the cooling method, for example, a punch press tool is held at the bottom dead center for 1 sec to 60 sec, and the hot pressed member is cooled using a die press tool and the punch press tool. After this, the hot pressed member is removed from the press tool, and cooled. The cooling in the press tool and the cooling after the removal from the press tool may be performed in combination with a cooling method using a refrigerant such as gas or liquid. This improves productivity.

EXAMPLES

[0082] Molten steel having the chemical composition (the balance consisting of Fe and incidental impurities) listed in Tables 1 and 4 was obtained by steelmaking in a small vacuum melting furnace, to yield a slab. The slab was heated to 1250 °C, and further subjected to hot rolling including rough rolling and finish rolling, to obtain a hot rolled steel sheet. The finisher entry temperature was 1100 °C, and the finisher delivery temperature was 850 °C. The cooling rate after the hot rolling end was 15 °C/s on average from 800 °C to 600 °C, and the coiling temperature was 650 °C.

[0083] The obtained hot rolled steel sheet was heated to the heating temperature T1 (first temperature) listed in Tables 2 and 5, retained at the temperature for the time listed in Tables 2 and 5, and then cooled to obtain a first blank steel sheet. In some test examples, the first blank steel sheet was pickled, and cold rolled at a reduction ratio of 54 %, to obtain a cold rolled steel sheet (sheet thickness: 1.6 mm). The cold rolled steel sheet was further heated to the heating temperature T2 listed in Tables 2 and 5, and retained for the time listed in Tables 2 and 5. The cold rolled steel sheet was then cooled at a cooling rate of 15 °C/s. The cooling was stopped at 500 °C, and the cold rolled steel sheet was retained at the temperature for 150 sec, to obtain a second blank steel sheet.

[0084] In the test examples not involving cold rolling, the first blank steel sheet was subjected to microstructure observation, and Mns/Mnα was calculated by the above-mentioned method. The results are listed in Tables 2 and 5. In the other test examples, the second blank steel sheet was subjected to microstructure observation, and the mean grain size of ferrite, the mean grain size of secondary phase, and Mns/Mnα were calculated by the above-mentioned methods.

The results are listed in Tables 2 and 5.

[0085] As listed in Tables 2 and 5, in some test examples, the second blank steel sheet was subjected to coating treatment. In Tables 2 and 5, "GI" denotes a hot-dip galvanized layer, "GA" denotes a galvannealed layer, "Zn-Ni" denotes a Zn-12 mass% Ni coated layer, and "Al-Si" denotes a Al-10 mass% Si coated layer. The coating weight of each coated layer was 60 g/m^2 per side.

[0086] The hot rolled steel sheet (first blank steel sheet) or the cold rolled steel sheet (second blank steel sheet) obtained in this way was subjected to a heating process under the conditions listed in Tables 3 and 6 and a hot press forming process, to obtain a hat-shaped hot pressed member. The hot press was performed using a punch press tool having a width of 70 mm and a shoulder radius R of 6 mm and a die press tool having a shoulder radius R of 7.6 mm, with a forming depth of 30 mm.

[0087] Regarding the heating process before the hot press forming process, in the case of performing the heating process using an electric heating furnace in the air atmosphere, the heating rate from the room temperature to 750 °C was 7.5 °C/s on average. The heating rate from 750 °C to the heating temperature was 2.0 °C/s on average. After reaching the heating temperature, the steel sheet was retained at the heating temperature in the case of keeping temperature. In the case of performing the heating process using a direct current heater in the air atmosphere, the heating rate from the room temperature to the heating temperature was 100 °C/s on average. The hot press starts at 750 °C. The steel sheet was cooled to 150 °C or less by a combination of: clamping the steel sheet using the die press tool and the punch press tool with the punch press tool being held at the bottom dead center for 15 sec; and air cooling on the die after release from the clamping. The average cooling rate from the hot pressing start temperature to 200 °C was 100 °C/s.

[0088] The obtained hot pressed member was heat treated (low temperature heat treatment) at 170 °C for 20 min. This corresponds to the baking finish condition in a typical automotive member manufacturing process. Before and after the low temperature heat treatment, a JIS No. 5 tensile test piece (parallel portion width: 25 mm, parallel portion length: 60 mm, GL = 50 mm) was collected from a hat top portion, and a tensile test was conducted according to JIS Z 2241 to determine the yield stress YS, the tensile strength TS, the total elongation tEl, and the uniform elongation uEl. The results are listed in Tables 3 and 6.

[0089] Moreover, the volume fraction of martensite phase, the volume fraction of retained austenite phase, the volume fraction of the balance, and the dislocation density in the obtained hot pressed member were measured by the above-mentioned methods. The results are listed in Tables 3 and 6.

Table 1

Steel No.	C (mass%)	Mn (mass%)	Si (mass%)	P (mass%)	S (mass%)	Al (mass%)	N (mass%)	Ac1 point (°C)	Ac3 point (°C)	Ms point (°C)	Category
A	0.210	4.22	0.26	0.012	0.0015	0.031	0.0025	632	812	322	Conforming steel
B	0.160	3.80	0.25	0.013	0.0014	0.030	0.0022	645	825	356	Conforming steel
C	0.220	8.20	0.02	0.011	0.0150	0.035	0.0030	518	783	197	Conforming steel
D	0.220	10.40	0.03	0.022	0.0220	0.037	0.0040	457	775	130	Conforming steel
E	0.292	4.50	0.03	0.015	0.0220	0.042	0.0041	621	784	279	Conforming steel
F	0.350	4.15	0.25	0.015	0.0300	0.035	0.0023	632	784	265	Comparative steel
G	0.083	4.20	0.25	0.010	0.0400	0.035	0.0025	634	831	356	Comparative steel
H	0.221	12.50	0.26	0.015	0.0350	0.030	0.0020	400	776	66	Comparative steel
I	0.165	2.50	0.26	0.010	0.0350	0.031	0.0032	653	825	363	Comparative steel

Table 2

Blank steel sheet No.	Steel No.	Heat treatment of hot rolled steel sheet		Microstructure after heat treatment	Heat treatment of cold rolled steel sheet (annealing)		Microstructure after annealing			Type of blank steel sheet	Surface treatment of blank steel sheet	Category
		Heating temperature T1 (°C)	Retention time (hr)	Mns /Mnα	Heating temperature T2 (°C)	Retention time (s)	Mean grain size of ferrite (μm)	Mean grain size of secondary phase (μm)	Mns /Mnα			
A1	A	675	2.0	-	675	32	2.3	2.7	2.0	Cold rolled steel sheet	Zn-Ni	Example
A2	A	640	2.0	-	675	30	2.5	2.8	1.9	Cold rolled steel sheet	Zn-Ni	Example
A3	A	715	2.0	-	675	30	2.3	2.6	2.0	Cold rolled steel sheet	Zn-Ni	Example
A4	A	750	2.0	-	675	31	26	2.8	1.8	Cold rolled steel sheet	Zn-Ni	Example
A5	A	675	2.0	1.4	-	-	-	-	-	Hot rolled steel sheet	None	Example
A6	A	835	2.0	-	675	30	2.5	8.9	0.8	Cold rolled steel sheet	None	Comparative Example

(continued)

Blank steel sheet No.	Steel No.	Heat treatment of hot rolled steel sheet		Microstructure after heat treatment	Heat treatment of cold rolled steel sheet (annealing)		Microstructure after annealing			Type of blank steel sheet	Surface treatment of blank steel sheet	Category
		Heating temperature T1 (°C)	Retention time (hr)	Mns /Mnα	Heating temperature T2 (°C)	Retention time (s)	Mean grain size of ferrite (μm)	Mean grain size of secondary phase (μm)	Mns /Mnα			
A7	A	600	2.5	-	675	32	3.5	5.2	0.6	Cold rolled steel sheet	GA	Comparative Example
A8	A	670	0.2	-	672	30	2.4	5.4	0.9	Cold rolled steel sheet	GI	Comparative Example
A9	A	675	50.0	-	674	30	2.9	5.9	0.8	Cold rolled steel sheet	None	Comparative Example
B1	B	675	2.5	-	680	35	3.2	3.6	1.6	Cold rolled steel sheet	None	Example
B2	B	675	2.5	1.3	-	-	-	-	-	Hot rolled steel sheet	None	Example
C1	C	620	5.5	-	625	100	3.5	3.9	2.5	Cold rolled steel sheet	None	Example

(continued)

Blank steel sheet No.	Steel No.	Heat treatment of hot rolled steel sheet		Microstructure after heat treatment	Heat treatment of cold rolled steel sheet (annealing)		Microstructure after annealing			Type of blank steel sheet	Surface treatment of blank steel sheet	Category
		Heating temperature T1 (°C)	Retention time (hr)	Mns /Mnα	Heating temperature T2 (°C)	Retention time (s)	Mean grain size of ferrite (μm)	Mean grain size of secondary phase (μm)	Mns /Mnα			
C2	C	620	5.3	-	625	100	3.5	3.8	2.5	Cold rolled steel sheet	None	Comparative Example
C3	C	620	5.5	-	624	100	3.4	3.9	2.5	Cold rolled steel sheet	None	Comparative Example
D1	D	600	10.5	-	615	105	3.2	3.6	2.4	Cold rolled steel sheet	None	Example
E1	E	650	10.5	-	665	102	4.5	5.0	2.3	Cold rolled steel sheet	Zn-Ni	Example
E2	E	650	10.5	-	665	102	4.5	5.0	2.3	Cold rolled steel sheet	Zn-Ni	Example
E3	E	650	10.5	-	665	102	4.5	5.0	2.3	Cold rolled steel sheet	Zn-Ni	Example

(continued)

Blank steel sheet No.	Steel No.	Heat treatment of hot rolled steel sheet		Microstructure after heat treatment	Heat treatment of cold rolled steel sheet (annealing)		Microstructure after annealing			Type of blank steel sheet	Surface treatment of blank steel sheet	Category
		Heating temperature T1 (°C)	Retention time (hr)	Mns /Mnα	Heating temperature T2 (°C)	Retention time (s)	Mean grain size of ferrite (μm)	Mean grain size of secondary phase (μm)	Mns /Mnα			
E4	E	650	10.5	-	665	102	4.5	5.0	2.3	Cold rolled steel sheet	Al-Si	Example
F1	F	673	2.0	-	675	32	2.5	2.9	2.1	Cold rolled steel sheet	Zn-Ni	Comparative Example
G1	G	673	2.0	-	675	30	2.2	2.6	2.2	Cold rolled steel sheet	Zn-Ni	Comparative Example
H1	H	602	10.5	-	620	105	3.1	3.5	2.5	Cold rolled steel sheet	None	Comparative Example
I1	I	675	2.5	-	685	35	3.1	3.5	1.7	Cold rolled steel sheet	None	Comparative Example
A10	A	675	2.0	-	675	32	2.3	2.7	2.0	Cold rolled steel sheet	Zn-Ni	Example

(continued)

Blank steel sheet No.	Steel No.	Heat treatment of hot rolled steel sheet		Microstructure after heat treatment	Heat treatment of cold rolled steel sheet (annealing)		Microstructure after annealing			Type of blank steel sheet	Surface treatment of blank steel sheet	Category
		Heating temperature T1 (°C)	Retention time (hr)	Mns /Mnα	Heating temperature T2 (°C)	Retention time (s)	Mean grain size of ferrite (μm)	Mean grain size of secondary phase (μm)	Mns /Mnα			
A11	A	675	2.0	-	675	32	2.3	2.7	2.0	Cold rolled steel sheet	Zn-Ni	Example
A12	A	675	2.0	-	675	32	2.3	2.7	2.0	Cold rolled steel sheet	Zn-Ni	Example
A13	A	675	2.0	-	675	32	2.3	2.7	2.0	Cold rolled steel sheet	Zn-Ni	Comparative Example

Table 3

Hot pressed member No.	Blank steel sheet No.	Heating process			Microstructure				Mechanical property before low temperature heat treatment				Mechanical property after low temperature heat treatment				ΔYS (MPa)	Scaling	Category
		Heating method	Heating temperature T3 (°C)	Retention time (s)	Volume fraction of RA (%)	Volume fraction of M (%)	Dislocation density ($\times 10^{16}/m^2$)	Volume fraction of balance (%)	YS (MPa)	TS (MPa)	Uniform elongation (%)	Total elongation (%)	YS (MPa)	TS (MPa)	Uniform elongation (%)	Total elongation (%)			
1	A1	Electric heating furnace	852	30	8.1	91.9	2.2	---	1025	1845	7.5	10.5	1217	1882	7.7	10.6	192	No scaling	Example
2	A2	Electric heating furnace	850	30	8.2	91.8	2.1	---	1021	1840	7.6	11.5	1206	1877	7.8	11.6	185	No scaling	Example
3	A3	Direct current heater	855	0	8.3	91.7	2.2	---	1029	1842	7.3	10.8	1218	1879	7.4	10.9	189	No scaling	Example
4	A4	Direct current heater	852	0	8.1	91.9	2.1	---	1028	1850	7.5	11.2	1211	1887	7.7	11.3	183	No scaling	Example
5	A5	Electric heating furnace	852	30	7.6	92.4	1.8	---	1018	1821	7.2	9.8	1203	1857	7.3	9.9	185	Scaling	Example
6	A6	Electric heating furnace	850	30	2.3	97.7	0.8	---	1230	1750	4.5	7.2	1350	1785	4.6	7.3	120	Scaling	Comparative Example
7	A7	Electric heating furnace	850	30	1.5	98.5	0.7	---	1221	1723	4.7	7.5	1346	1757	4.8	7.6	125	No scaling	Comparative Example
8	A8	Electric heating furnace	855	30	2.3	97.7	0.9	---	1240	1731	4.3	7.8	1359	1766	4.4	7.9	119	No scaling	Comparative Example
9	A9	Electric heating furnace	856	30	2.4	97.6	0.8	---	1236	1653	5.2	7.9	1338	1686	5.3	8.0	102	Scaling	Comparative Example
10	B1	Electric heating furnace	865	60	4.2	95.8	1.5	---	985	1520	6.5	9.2	1150	1550	6.6	9.3	165	Scaling	Example
11	B2	Electric heating furnace	865	60	3.5	96.5	1.2	---	982	1515	6.2	9.3	1134	1545	6.3	9.3	152	Scaling	Example
12	C1	Electric heating furnace	823	60	11.1	88.9	2.2	---	1026	2212	9.8	11.3	1226	2256	9.9	11.3	200	Scaling	Example
13	C2	Electric heating furnace	750	30	21.5	63.5	0.5	α: 15%	856	1182	25.2	28.3	938	1206	25.5	28.5	82	Scaling	Comparative Example
14	C3	Electric heating furnace	1150	30	1.2	98.8	0.9	---	1025	2010	4.8	7.2	1126	2050	4.5	7.0	101	Scaling	Comparative Example
15	D1	Electric heating furnace	815	0	23.8	76.2	2.3	---	1120	2200	11.2	13.7	1315	2244	11.3	14.0	195	Scaling	Example
16	E1	Electric heating furnace	824	30	8.0	92.0	1.9	---	1220	1920	8.3	10.8	1409	1958	8.4	11.1	189	No scaling	Example
17	E2	Electric heating furnace	870	30	8.1	91.9	1.9	---	1221	1910	8.2	10.7	1406	1948	8.3	11.0	185	No scaling	Example
18	E3	Electric heating furnace	910	30	8.0	92.0	1.8	---	1198	1913	8.6	11.1	1381	1951	8.7	11.4	183	No scaling	Example
19	E4	Electric heating furnace	910	30	8.2	91.8	1.9	---	1225	1915	8.5	11.0	1414	1953	8.6	11.3	189	No scaling	Example
20	F1	Electric heating furnace	824	30	8.2	91.8	2.3	---	1350	2554	7.2	8.9	1505	2605	7.3	8.5	155	No scaling	Comparative Example
21	G1	Electric heating furnace	871	30	8.5	91.5	2.2	---	932	1358	9.8	11.5	1097	1385	9.9	11.3	165	No scaling	Comparative Example
22	H1	Electric heating furnace	816	30	25.6	74.4	2.5	---	953	2652	12.3	13.5	1105	2705	12.4	14.1	152	Scaling	Comparative Example
23	I1	Electric heating furnace	865	30	2.2	97.8	0.8	---	953	1320	8.5	10.2	1068	1346	8.6	10.8	115	Scaling	Comparative Example
24	A10	Electric heating furnace	850	300	8.2	91.8	2.2	---	1022	1842	7.6	10.5	1222	1879	7.8	10.6	200	No scaling	Example
25	A11	Electric heating furnace	852	600	8.1	91.9	2.1	---	1020	1843	7.7	10.6	1215	1880	7.9	10.7	195	No scaling	Example
26	A12	Electric heating furnace	825	900	8.2	91.8	2.2	---	1023	1845	7.5	10.9	1233	1882	7.6	11.2	210	No scaling	Example
27	A13	Electric heating furnace	825	960	1.5	98.5	0.7	---	1220	1700	4.5	7.2	1342	1734	4.5	7.4	122	No scaling	Comparative Example

In the table, RA denotes retained austenite, M denotes martensite, and α denotes ferrite.

Table 4

Steel No.	C (mass%)	Mn (mass%)	Si (mass%)	P (mass%)	S (mass%)	Al (mass%)	N (mass%)	Ac1 point (°C)	Ac3 point (°C)	Ms point (°C)	Others (mass%)	Category
J	0.205	6.23	0.03	0.015	0.004	0.031	0.003	573	795	263	Ni: 0.02	Conforming steel
K	0.210	6.25	0.02	0.015	0.003	0.031	0.004	573	793	260	Cu: 0.02	Conforming steel
L	0.223	6.35	0.02	0.010	0.004	0.032	0.003	574	793	248	Cr: 0.30	Conforming steel
M	0.221	6.15	0.03	0.011	0.004	0.035	0.003	576	791	257	Mo: 0.25	Conforming steel
N	0.225	4.20	0.02	0.032	0.004	0.035	0.005	630	798	316	0.03	Conforming steel
O	0.215	4.31	0.03	0.034	0.003	0.035	0.004	627	800	317	Nb: 0.03	Conforming steel
P	0.205	4.15	0.04	0.035	0.005	0.035	0.003	632	803	326	V: 0.03	Conforming steel
Q	0.217	4.36	0.06	0.035	0.002	0.034	0.005	626	801	315	W: 0.03	Conforming steel
R	0.218	4.25	0.22	0.015	0.004	0.036	0.005	631	808	318	Ti: 0.02, B: 0.002	Conforming steel
S	0.213	6.25	0.27	0.016	0.003	0.036	0.005	576	803	259	Ti: 0.02, B: 0.002	Conforming steel
T	0.156	6.23	0.15	0.016	0.002	0.038	0.004	576	812	284	REM: 0.001	Conforming steel
U	0.224	6.20	0.16	0.025	0.002	0.050	0.003	576	796	256	B: 0.003	Conforming steel
V	0.152	6.22	0.22	0.025	0.005	0.065	0.004	577	816	286	Ca: 0.003	Conforming steel
W	0.148	6.22	0.16	0.035	0.004	0.058	0.003	576	814	287	Mg: 0.003	Conforming steel

(continued)

Steel No.	C (mass%)	Mn (mass%)	Si (mass%)	P (mass%)	S (mass%)	Al (mass%)	N (mass%)	Ac1 point (°C)	Ac3 point (°C)	Ms point (°C)	Others (mass%)	Category
X	0.203	4.31	0.13	0.035	0.003	0.065	0.006	629	807	322	Sb: 0.008	Conforming steel

Table 5

Blank steel sheet No.	Steel No.	Heat treatment of hot rolled steel sheet		Microstructure after heat treatment	Heat treatment of cold rolled steel sheet (annealing)		Microstructure after annealing			Type of blank steel sheet	Surface treatment of blank steel sheet	Category
		Heating temperature T1 (°C)	Retention time (hr)	Mns /Mnα	Heating temperature T2 (°C)	Retention time (s)	Mean grain size of ferrite (μm)	Mean grain size of secondary phase (μm)	Mns /Mnα			
J1	J	625	2.0	1.4	-	-	-	-	-	Hot rolled steel sheet	None	Example
K1	K	630	2.0	-	680	45	3.5	5.6	2.3	Cold rolled steel sheet	Zn-Ni	Example
L1	L	631	2.1	-	685	48	2.5	7.8	2.5	Cold rolled steel sheet	Zn-Ni	Example
M1	M	635	2.5	-	675	45	2.4	8.5	2.2	Cold rolled steel sheet	None	Example
N1	N	675	2.5	1.4	-	-	-	-	-	Hot rolled steel sheet	None	Example
O1	O	675	3.0	-	675	40	3.2	6.2	2.4	Cold rolled steel sheet	Zn-Ni	Example

(continued)

Blank steel sheet No.	Steel No.	Heat treatment of hot rolled steel sheet		Microstructure after heat treatment	Heat treatment of cold rolled steel sheet (annealing)		Microstructure after annealing			Type of blank steel sheet	Surface treatment of blank steel sheet	Category
		Heating temperature T1 (°C)	Retention time (hr)	Mns /Mnα	Heating temperature T2 (°C)	Retention time (s)	Mean grain size of ferrite (μm)	Mean grain size of secondary phase (μm)	Mns /Mnα			
P1	P	670	3.5	-	672	150	4.5	7.5	2.5	Cold rolled steel sheet	Zn-Ni	Example
Q1	Q	675	3.5	-	680	44	5.2	8.0	3.2	Cold rolled steel sheet	Zn-Ni	Example
R1	R	675	40.0	-	680	46	3.5	5.9	3.5	Cold rolled steel sheet	Zn-Ni	Example
S1	S	630	35.0	-	645	52	2.6	8.2	3.4	Cold rolled steel sheet	Zn-Ni	Example
T1	T	625	2.5	-	630	55	4.2	6.5	3.0	Cold rolled steel sheet	Zn-Ni	Example
U1	U	630	1.7	-	645	56	5.0	6.3	2.5	Cold rolled steel sheet	Zn-Ni	Example

(continued)

Blank steel sheet No.	Steel No.	Heat treatment of hot rolled steel sheet		Microstructure after heat treatment	Heat treatment of cold rolled steel sheet (annealing)		Microstructure after annealing			Type of blank steel sheet	Surface treatment of blank steel sheet	Category
		Heating temperature T1 (°C)	Retention time (hr)	Mns /Mnα	Heating temperature T2 (°C)	Retention time (s)	Mean grain size of ferrite (μm)	Mean grain size of secondary phase (μm)	Mns /Mnα			
V1	V	615	1.7	-	630	52	5.2	7.2	2.2	Cold rolled steel sheet	Zn-Ni	Example
W1	W	620	3.0	-	635	105	5.1	6.4	2.6	Cold rolled steel sheet	None	Example
X1	X	680	35.0	-	690	115	5.0	4.3	2.2	Cold rolled steel sheet	None	Example

Table 6

Hot pressed member No.	Blank steel sheet No.	Heating process			Microstructure				Mechanical property before low temperature heat treatment				Mechanical property after low temperature heat treatment				ΔYS (MPa)	Scaling	Category
		Heating method	Heating temperature T3 (°C)	Retention time (s)	Volume fraction of RA (%)	Volume fraction of M (%)	Dislocation density ($\times 10^{16}/m^2$)	Volume fraction of balance (%)	YS (MPa)	TS (MPa)	Uniform elongation (%)	Total elongation (%)	YS (MPa)	TS (MPa)	Uniform elongation (%)	Total elongation (%)			
28	J1	Electric heating furnace	830	30	10.1	89.9	2.3	---	1211	2115	9.2	12.5	1416	2157	9.4	12.6	205	Scaling	Example
29	K1	Electric heating furnace	850	30	11.2	88.8	2.4	---	1230	2121	10.1	13.4	1426	2163	10.3	13.5	196	No scaling	Example
30	L1	Electric heating furnace	855	30	12.5	87.5	2.2	---	1213	2123	11.1	13.5	1402	2165	11.3	13.6	189	No scaling	Example
31	M1	Direct current heater	845	30	11.5	88.5	2.0	---	1215	2095	11.2	14.0	1418	2137	11.4	14.1	203	Scaling	Example
32	N1	Direct current heater	850	30	9.5	90.5	1.8	---	1125	1923	7.8	12.0	1318	1961	8.0	12.1	193	Scaling	Example
33	O1	Electric heating furnace	855	30	9.4	90.6	1.9	---	1100	1890	8.2	11.1	1283	1928	8.4	11.2	183	No scaling	Example

(continued)

Hot pressed member No.	Blank steel sheet No.	Heating process			Microstructure				Mechanical property before low temperature heat treatment				Mechanical property after low temperature heat treatment				ΔYS (MPa)	Scaling	Category
		Heating method	Heating temperature T3 (°C)	Retention time (s)	Volume fraction of RA (%)	Volume fraction of M (%)	Dislocation density (x10^{16}/m^2)	Volume fraction of balance (%)	YS (MPa)	TS (MPa)	Uniform elongation (%)	Total elongation (%)	YS (MPa)	TS (MPa)	Uniform elongation (%)	Total elongation (%)			
34	P1	Direct current heater	855	30	9.6	90.4	1.9	---	1113	1860	8.1	11.5	1302	1897	8.3	11.6	189	No scaling	Example
35	Q1	Electric heating furnace	864	30	9.8	90.2	2.0	---	1145	1896	9.5	11.3	1337	1934	9.7	11.4	192	No scaling	Example
36	R1	Electric heating furnace	835	30	9.8	90.2	2.2	---	1052	1860	9.2	10.9	1245	1897	9.4	11.0	193	No scaling	Example
37	S1	Electric heating furnace	825	30	12.1	87.9	2.1	---	1045	2120	10.2	12.3	1258	2162	10.4	12.4	213	No scaling	Example
38	T1	Electric heating furnace	820	30	12.3	87.7	1.5	---	1023	2125	7.2	12.4	1199	2168	7.3	12.5	176	No scaling	Example

(continued)

Hot pressed member No.	Blank steel sheet No.	Heating process			Microstructure				Mechanical property before low temperature heat treatment				Mechanical property after low temperature heat treatment				ΔYS (MPa)	Scaling	Category
		Heating method	Heating temperature T3 (°C)	Retention time (s)	Volume fraction of RA (%)	Volume fraction of M (%)	Dislocation density ($\times 10^{16}$/m^2)	Volume fraction of balance (%)	YS (MPa)	TS (MPa)	Uniform elongation (%)	Total elongation (%)	YS (MPa)	TS (MPa)	Uniform elongation (%)	Total elongation (%)			
39	U1	Electric heating furnace	825	30	11.4	88.6	2.1	---	1040	2124	9.8	11.5	1255	2166	10.0	11.6	215	No scaling	Example
40	V1	Electric heating furnace	830	30	4.5	95.5	1.6	---	1020	1652	7.8	11.2	1195	1685	8.0	11.3	175	No scaling	Example
41	W1	Direct current heater	835	30	4.6	95.4	1.7	---	1025	1650	7.5	11.5	1203	1683	7.7	11.6	178	Scaling	Example
42	X1	Electric heating furnace	834	30	11.0	89.0	1.9	---	1115	1920	8.7	11.8	1310	1958	8.9	11.9	195	Scaling	Example

In the table, RA denotes retained austenite, M denotes martensite, and α denotes ferrite.

[0090] All Examples achieved a tensile strength TS of 1500 MPa or more, a uniform elongation uEl of 6.0 % or more, and ΔYS of 150 MPa or more. Comparative Examples, on the other hand, failed to satisfy at least one of the properties.

INDUSTRIAL APPLICABILITY

[0091] The hot pressed member according to the present disclosure is suitable as a structural member required to have high collision energy absorbing performance, such as an impact beam, a center pillar, or a bumper of a vehicle.

Claims

1. A hot pressed member comprising:

    a chemical composition containing, in mass%,
    C: 0.090 % or more and less than 0.30 %,
    Mn: 3.5 % or more and less than 11.0 %,
    Si: 0.01 % to 2.5 %,
    P: 0.05 % or less,
    S: 0.05 % or less,
    Al: 0.005 % to 0.1 %, and
    N: 0.01 % or less,

    with a balance consisting of Fe and incidental impurities;
    a microstructure including a martensite phase of 70.0 % or more in volume fraction and a retained austenite phase of 3.0 % or more and 30.0 % or less in volume fraction;
    a tensile property of 1500 MPa or more in tensile strength TS and 6.0 % or more in uniform elongation uEl; and
    a dislocation density of $1.0 \times 10^{16}/m^2$ or more.

2. The hot pressed member according to claim 1,
    wherein the chemical composition further contains, in mass%, one or more groups selected from
    A group: one or more selected from Ni: 0.01 % to 5.0 %, Cu: 0.01 % to 5.0 %, Cr: 0.01 % to 5.0 %, and Mo: 0.01 % to 3.0 %,
    B group: one or more selected from Ti: 0.005 % to 3.0 %, Nb: 0.005 % to 3.0 %, V: 0.005 % to 3.0 %, and W: 0.005 % to 3.0 %,
    C group: one or more selected from REM: 0.0005 % to 0.01 %, Ca: 0.0005 % to 0.01 %, and Mg: 0.0005 % to 0.01 %,
    D group: Sb: 0.002 % to 0.03 %, and
    E group: B: 0.0005 % to 0.05 %.

3. The hot pressed member according to claim 1 or 2, comprising a coated layer on a surface thereof.

4. The hot pressed member according to claim 3,
    wherein the coated layer is any of a zinc or zinc alloy coated layer and an aluminum or aluminum alloy coated layer.

5. The hot pressed member according to claim 4,
    wherein the zinc or zinc alloy coated layer contains Ni: 10 mass% to 25 mass%.

6. A method of manufacturing a hot pressed member, the method comprising:

    heating a slab and hot rolling the slab to obtain a hot rolled steel sheet, the slab having a chemical composition containing, in mass%,
    C: 0.090 % or more and less than 0.30 %,
    Mn: 3.5 % or more and less than 11.0 %,
    Si: 0.01 % to 2.5 %,
    P: 0.05 % or less,
    S: 0.05 % or less,
    Al: 0.005 % to 0.1 %, and
    N: 0.01 % or less,

with a balance consisting of Fe and incidental impurities;
heating the hot rolled steel sheet to a first temperature that is an Ac1 point or more and an Ac3 point or less, retaining the hot rolled steel sheet at the first temperature for 1 hr or more and 48 hr or less, and then cooling the hot rolled steel sheet to obtain a first blank steel sheet;
performing a heating process of heating the first blank steel sheet to a second temperature that is the Ac3 point or more and 1000 °C or less and retaining the first blank steel sheet at the second temperature for 900 sec or less; and thereafter performing a hot press forming process of simultaneously press forming and quenching the first blank steel sheet using a press tool for forming, to obtain a hot pressed member.

7. The method of manufacturing a hot pressed member according to claim 6, further comprising:

cold rolling the first blank steel sheet to obtain a cold rolled steel sheet, before the heating process; and
annealing the cold rolled steel sheet to obtain a second blank steel sheet, the annealing including heating the cold rolled steel sheet to a temperature that is the Ac1 point or more and the Ac3 point or less, retaining the cold rolled steel sheet at the temperature, and then cooling the cold rolled steel sheet,
wherein the heating process and the hot press forming process are performed on the second blank steel sheet instead of the first blank steel sheet.

8. The method of manufacturing a hot pressed member according to claim 6 or 7,
wherein the chemical composition further contains, in mass%, one or more groups selected from
A group: one or more selected from Ni: 0.01 % to 5.0 %, Cu: 0.01 % to 5.0 %, Cr: 0.01 % to 5.0 %, and Mo: 0.01 % to 3.0 %,
B group: one or more selected from Ti: 0.005 % to 3.0 %, Nb: 0.005 % to 3.0 %, V: 0.005 % to 3.0 %, and W: 0.005 % to 3.0 %,
C group: one or more selected from REM: 0.0005 % to 0.01 %, Ca: 0.0005 % to 0.01 %, and Mg: 0.0005 % to 0.01 %,
D group: Sb: 0.002 % to 0.03 %, and
E group: B: 0.0005 % to 0.05 %.

9. The method of manufacturing a hot pressed member according to any one of claims 6 to 8, further comprising forming a coated layer on a surface of the first blank steel sheet or the second blank steel sheet, before the heating process.

10. The method of manufacturing a hot pressed member according to claim 9,
wherein the coated layer is any of a zinc or zinc alloy coated layer and an aluminum or aluminum alloy coated layer.

11. The method of manufacturing a hot pressed member according to claim 10,
wherein the zinc or zinc alloy coated layer contains Ni: 10 mass% to 25 mass%.

12. The method of manufacturing a hot pressed member according to any one of claims 9 to 11,
wherein a coating weight of the coated layer is 10 g/m^2 to 90 g/m^2 per side.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/004458

A. CLASSIFICATION OF SUBJECT MATTER

C22C38/00(2006.01)i, *B21D22/20*(2006.01)i, *C21D1/18*(2006.01)i, *C21D9/00*(2006.01)i, *C21D9/46*(2006.01)i, *C22C18/00*(2006.01)i, *C22C38/60*(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)
C22C38/00-38/60

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2004-211147 A (Kobe Steel, Ltd.), 29 July 2004 (29.07.2004), (Family: none)	1-12
A	WO 2013/038637 A1 (JFE Steel Corp.), 21 March 2013 (21.03.2013), & US 2014/0230971 A1 & EP 2757169 A1 & CN 103797145 A & KR 10-2014-0060574 A & TW 201323625 A	1-12
A	WO 2013/047821 A1 (Nippon Steel & Sumitomo Metal Corp.), 04 April 2013 (04.04.2013), & US 2014/0234660 A1 & EP 2762582 A1 & CA 2850340 A1 & CN 103842541 A & KR 10-2014-0052072 A & MX 2014003718 A & RU 2014117645 A & TW 201329251 A	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
"E"	earlier application or patent but published on or after the international filing date	"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
"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)	"&"	document member of the same patent family
"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 01 December 2016 (01.12.16)	Date of mailing of the international search report 13 December 2016 (13.12.16)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/004458

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2015-503023 A (Posco), 29 January 2015 (29.01.2015), & US 2014/0308156 A1 & WO 2013/069937 A1 & EP 2778247 A1 & KR 10-2013-0050138 A & CN 103917681 A	1-12
A	JP 2008-144233 A (Kobe Steel, Ltd.), 26 June 2008 (26.06.2008), (Family: none)	1-12
A	JP 62-17125 A (Nippon Steel Corp.), 26 January 1987 (26.01.1987), (Family: none)	1-12
P,A	WO 2015/182596 A1 (Nippon Steel & Sumitomo Metal Corp.), 03 December 2015 (03.12.2015), & TW 201608039 A	1-12

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2013079441 A **[0005] [0007]**
- JP 2010065293 A **[0006] [0007]**