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(54) **HOT-STAMP-FORMED ARTICLE**

(57) Provided is a hot stamped body having a pre-determined chemical composition and a microstructure comprising, by area ratio, at least one of martensite, bainite, and tempered martensite: 90% or more in total, wherein a standard deviation in grain size distribution of

former austenite grains is 5.0 μm or less, and a total amount of segregation of at least one of Mo, W, Ta, Re, Os, Ir, and Tc at the former austenite grain boundaries is 0.10 atm% or more.

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Description

FIELD

5 **[0001]** The present invention relates to a hot stamped body.

BACKGROUND

10 **[0002]** In recent years, in the automobile industry, lighter weight of car bodies has been sought from the viewpoint of improvement of fuel economy. To achieve both lighter weight of car bodies and collision safety, one effective method is to increase the strength of the steel sheet used. A high strength steel sheet is being developed due to such a background.

15 **[0003]** If making a steel sheet high in strength, the formability falls, and therefore it is generally difficult to achieve both strength and formability in the steel sheet. Hot stamping (hot pressing) is known as a technique for press-forming a material, which is difficult to form, such as a high strength steel sheet. Hot stamping is a technique of hot forming which heats then forms a material to be formed. This technique heats then forms the material, and therefore at the time of forming, the steel material is soft and has good formability. Therefore, even a high strength steel material can be formed into a complex shape with a good precision. Further, it is hardened at the same time as being formed by the press dies, and therefore a formed steel material is known to have sufficient strength.

20 **[0004]** In relation to this, PTL 1 describes a hot stamped body characterized by having a predetermined chemical composition and a microstructure containing former austenite with an average grain size of 3 μm or less and, further, containing at least one of lower bainite, martensite, and tempered martensite in an area ratio of 90% or more, wherein a grain boundary solid solution ratio Z, defined by $Z = (\text{mass\% of one or both of Nb and Mo at the grain boundaries}) / (\text{mass\% of one or both of Nb and Mo at time of melting})$, is 0.3 or more. Further, PTL 1 describes that the hot stamped body has a tensile strength of 2000 MPa or more.

25 [CITATIONS LIST]

[PATENT LITERATURE]

30 **[0005]** [PTL 1] WO 2019/186928

SUMMARY

[TECHNICAL PROBLEM]

35 **[0006]** If the strength of a steel material becomes higher, in general, the phenomenon of the steel material fracturing before reaching its maximum stress (early fracture) easily arises. For this reason, there is a high need for a steel material enabling suppression of such early fracture. In relation to this, PTL 1 teaches that in a hot stamped body having the above feature, there will be a high tensile strength of 2000 MPa or more and, in addition, early fracture will be suppressed. On the other hand, in the automobile industry, etc., further reduction of weight of the steel material is sought. To achieve such lighter weight, a need arises to raise the strength more than the past. Therefore, there is still a great need for a steel material, more specifically a hot stamped body, able to solve the problem of early fracture even if raising the strength equal to the past or more than the same.

40 **[0007]** Therefore, the present invention has as its object to provide a hot stamped body which is high in strength and able to suppress early fracture by a novel constitution.

[SOLUTION TO PROBLEM]

50 **[0008]** The inventors discovered that, to achieve the above object, it is possible to reduce the variation in former austenite grain size in the microstructure of a hot stamped body so as to suppress the rise in local hardness acting as starting points of fracture and in addition possible to make specific elements segregate at the grain boundaries to reinforce the grain boundaries and further discovered that by the combination of such suppression of rise of local hardness and grain boundary strengthening, it is possible to sufficiently suppress early fracture regardless of the hot stamped body having a high tensile strength, and thereby completed the present invention.

55 **[0009]** The present invention able to achieve this object is as follows:

(1) A hot stamped body having a chemical composition comprising, by mass%,

C: 0.40 to 0.70%,
 Si: 0.010 to 3.00%,
 Mn: 0.50 to 3.00%,
 P: 0.100% or less,
 5 S: 0.0100% or less,
 N: 0.0200% or less,
 O: 0.0200% or less,
 Al: 0.0010 to 0.500%,
 Nb: 0.0010 to 0.100%,
 10 Ti: 0.010 to 0.200%,
 Cr: 0.010 to 1.00%,
 Mo: 0.0010 to 1.000%,
 B: 0.0005 to 0.0200%,
 Co: 0 to 4.00%,
 15 Ni: 0 to 3.00%,
 Cu: 0 to 3.00%,
 V: 0 to 3.00%,
 Ca: 0 to 1.000%,
 Mg: 0 to 1.000%,
 20 REM: 0 to 1.000%,
 Sb: 0 to 1.00%,
 Sn: 0 to 1.00%,
 Zr: 0 to 1.00%,
 As: 0 to 0.100%,
 25 at least one of W, Ta, Re, Os, Ir, and Tc: 0 to 1.00% in total, and
 balance: Fe and impurities, and
 a microstructure comprising, by area ratio, at least one of martensite, bainite, and tempered martensite: 90% or
 more in total, wherein
 a standard deviation in grain size distribution of former austenite grains is 5.0 μm or less, and
 30 a total amount of segregation of at least one of Mo, W, Ta, Re, Os, Ir, and Tc at former austenite grain boundaries is
 0.10 atm% or more.

(2) The hot stamped body according to the above (1), wherein the amount of segregation of Mo at the former austenite
 grain boundaries is 0.10 atm% or more.
 35 (3) The hot stamped body according to the above (1) or (2), wherein the total amount of segregation is 0.15 atm% or
 more.

[ADVANTAGEOUS EFFECTS OF INVENTION]

40 **[0010]** According to the present invention, it is possible to provide a hot stamped body which is high in strength and able
 to suppress early fracture.

DESCRIPTION OF EMBODIMENTS

45 <Hot Stamped Body>

[0011] The hot stamped body according to an embodiment of the present invention has a chemical composition
 comprising, by mass%,

50 C: 0.40 to 0.70%,
 Si: 0.010 to 3.00%,
 Mn: 0.50 to 3.00%,
 P: 0.100% or less,
 S: 0.0100% or less,
 55 N: 0.0200% or less,
 O: 0.0200% or less,
 Al: 0.0010 to 0.500%,
 Nb: 0.0010 to 0.100%,

Ti: 0.010 to 0.200%,
 Cr: 0.010 to 1.00%,
 Mo: 0.0010 to 1.000%,
 B: 0.0005 to 0.0200%,

Co: 0 to 4.00%,

Ni: 0 to 3.00%,

Cu: 0 to 3.00%,

V: 0 to 3.00%,

Ca: 0 to 1.000%,

Mg: 0 to 1.000%,

REM: 0 to 1.000%,

Sb: 0 to 1.00%,

Sn: 0 to 1.00%,

Zr: 0 to 1.00%,

As: 0 to 0.100%,

at least one of W, Ta, Re, Os, Ir, and Tc: 0 to 1.00% in total, and

balance: Fe and impurities, and

a microstructure comprising, by area ratio, at least one of martensite, bainite, and tempered martensite: 90% or more in total, wherein

a standard deviation in grain size distribution of former austenite grains is 5.0 μm or less, and

a total amount of segregation of at least one of Mo, W, Ta, Re, Os, Ir, and Tc at former austenite grain boundaries is 0.10 atm% or more.

[0012] As explained above, there is the problem that if the strength of a steel material becomes higher, in general, the phenomenon of the steel material fracturing before reaching the maximum stress (early fracture) easily occurs. Therefore, the inventors conducted studies focusing on the two viewpoints of the viewpoint of reducing hard regions able to become starting points for fracture and the viewpoint of strengthening the grain boundaries for preventing or suppressing fracture. More specifically, the inventors first discovered that if there is a large variation in former austenite grain size in the microstructure, the hardness becomes higher in a region with a smaller former austenite grain size and that such a local high hardness region can become a starting point of early fracture. As opposed to this, the inventors discovered that by controlling the standard deviation in a grain size distribution of former austenite grains to 5.0 μm or less, it is possible to reliably suppress such a rise in local hardness.

[0013] While not intending to be bound to any specific theory, it is believed that at the time of hot stamping, the starting temperature of martensite transformation changes in accordance with the size of the austenite grains. If explained in more detail, it is believed that austenite grains having larger size are higher in starting temperature of martensite transformation compared with austenite grains having smaller size, and therefore the hardness becomes lower. Austenite grains having smaller size rise in hardness since martensite transformation occurs at a lower temperature than large grains. Therefore, to suppress or reduce the rise in such local hardness, it becomes important to reduce the variation in the austenite grain size before martensite transformation. Due to such a reason, it is believed that by controlling the standard deviation in the grain size distribution of the former austenite grains to 5.0 μm or less to reduce the variation in former austenite grain size, it would become possible to remarkably suppress the rise in local hardness due to differences in timing of martensite transformation. If there is locally a region of a high hardness, it is believed that there will be a high possibility of such a region acting as a starting point triggering early fracture, and therefore reducing the variation in former austenite grain size would be extremely effective in suppressing early fracture.

[0014] In relation to this, as explained later in detail regarding the method of production of the hot stamped body, the inventors focused on the microstructure of a hot rolled steel sheet and discovered that by evenly dispersing the pearlite in the microstructure, it is possible to control the standard deviation of former austenite grains in the final microstructure of the hot stamped body to 5.0 μm or less. Along with the increasingly higher strength of steel materials, sometimes a relatively large amount of Mn is added so as to improve the hardenability of the steel material, but in the research by the inventors this time, it was learned that with such a high Mn content (for example, 0.50 mass% or more), pearlite is relatively easily formed and therefore compared with the case of a low Mn content, it is extremely difficult to evenly disperse the pearlite formed in large amounts in the microstructure of the hot rolled steel sheet. However, the inventors discovered that to deal with such a problem, it is possible to uniformly disperse the pearlite in the microstructure of the hot rolled steel sheet by relatively high reduction at the final stage of finish rolling and that as a result it is possible to remarkably reduce the variation in former austenite grain size in the final microstructure of the hot stamped body. On the other hand, with just reducing the variation in former austenite grain size and reducing the regions which can act as starting points of early fracture, there is a possibility that if a crack occurs, it will not be possible to reliably suppress its progression and prevent early fracture.

[0015] Therefore, next, the inventors engaged in further studies from the viewpoint of suppressing progression of cracks

along the grain boundaries and discovered that by causing specific elements, more specifically at least one of Mo, W, Ta, Re, Os, Ir, and Tc, to segregate at the former austenite grain boundaries in a total amount of segregation of these of 0.10 atm% or more, it is possible to strengthen the former austenite grain boundaries at the microstructure of the hot stamped body. As a result, the inventors discovered that by the combination of suppression of the rise in local hardness explained above and the strengthening of former austenite grain boundaries by such specific grain boundary strengthening elements, despite the hot stamped body having a high tensile strength, it is possible to sufficiently suppress early fracture. In the past, the fact that, for example, from the viewpoint of improvement of the hardenability, etc., while it is known to add some of these elements to a steel sheet for hot stamping use, it is possible to add at least one of Mo, W, Ta, Re, Os, Ir, and Tc in a predetermined total amount and, further, control the heat treatment conditions to make them segregate at the former austenite grain boundaries and possible to strengthen the former austenite grain boundaries in a superhigh strength steel material containing 0.40 mas% or more of carbon and thereby suppress the progression of cracks along the grain boundaries was clarified the first time by the inventors this time. In the hot stamped body according to an embodiment of the present invention, by combining the suppression of rise of local hardness and grain boundary strengthening by grain boundary segregation of such specific elements, it is possible to reduce the regions which act as starting points of early fracture and reliably suppress the progression of cracks along the grain boundaries even in the case of occurrence of cracks at the hot stamped body. For this reason, according to the hot stamped body according to an embodiment of the present invention, early fracture can be suppressed regardless of having a high tensile strength, for example, a high tensile strength of 2200 MPa or more.

[0016] Below, the hot stamped body according to the embodiment of the present invention will be explained in more detail. In the following explanation, the "%" of the units of content of the elements, unless otherwise indicated, means "mass%". Further, in this Description, "to" showing a numerical range, unless otherwise indicated, is used in the sense including the numerical values described before and after it as the upper limit value and lower limit value.

[C: 0.40 to 0.70%]

[0017] C is an element improving the strength of a hot stamped body. If the C content is less than 0.40%, it is not possible to obtain the desired strength at the hot stamped body. For this reason, the C content is 0.40% or more. The C content is preferably 0.42% or more, 0.44% or more, or 0.45% or more.

[0018] On the other hand, if the C content is more than 0.70%, the toughness of the martensite is too low and an excellent early fracture resistance cannot be obtained. For this reason, the C content is 0.70% or less. Preferably, the C content is 0.67% or less, 0.65% or less, or 0.60% or less.

[Si: 0.010 to 3.00%]

[0019] Si is an element improving the strength of a hot stamped body by solid solution strengthening. If the Si content is less than 0.010%, it is not possible to obtain the desired strength. For this reason, the Si content is 0.010% or more. The Si content is preferably 0.05% or more, 0.10% or more, 0.15% or more, or 0.20% or more.

[0020] On the other hand, if the Si content is more than 3.00%, the amount of ferrite increases and the desired metallographic structure cannot be obtained. For this reason, the Si content is 3.00% or less. The Si content is preferably 2.50% or less, 2.00% or less, 1.00% or less, or 0.70% or less.

[Mn: 0.50 to 3.00%]

[0021] Mn is an element which promotes the transformation from austenite to pearlite in a hot rolled steel sheet in the process of production of a hot stamped body according to the present embodiment and contributes to control of the former austenite grain size distribution of a hot stamped body. To make the standard deviation in the grain size distribution of former austenite grains the desired range, the Mn content is 0.50% or more. The Mn content is preferably 0.70% or more, 1.00% or more, or 1.30% or more.

[0022] On the other hand, if the Mn content is more than 3.00%, transformation from austenite to pearlite in a hot rolled steel sheet is promoted too much and the standard deviation in the grain size distribution of former austenite grains in a hot stamped body cannot be controlled to a desired range. For this reason, the Mn content is 3.00% or less. Preferably, the Mn content is 2.70% or less, 2.50% or less, 2.30% or less, or 2.00% or less.

[P: 0.100% or Less]

[0023] P is an impurity element and segregates at the grain boundaries to form starting points of fracture and cause the early fracture resistance to deteriorate. For this reason, the P content is 0.100% or less. The P content is preferably 0.050% or less or 0.010% or less.

[0024] The lower limit of the P content is not particularly prescribed, but if less than 0.0001%, the dephosphorization cost greatly rises making this not preferable economically. For this reason, the P content may also be 0.0001% or more.

[S: 0.0100% or Less]

[0025] S is an impurity element and forms inclusions in the steel. The inclusions become starting points of fracture and cause the early fracture resistance to deteriorate, therefore the S content is 0.0100% or less. The S content is preferably 0.0080% or less, 0.0050% or less, or 0.0030% or less.

[0026] The lower limit of the S content is not particularly prescribed, but if less than 0.0001%, the desulfurization cost greatly rises making this not preferable economically. For this reason, the S content may also be 0.0001% or more.

[N: 0.0200% or Less]

[0027] N is an impurity element and forms inclusions in the steel. The inclusions become starting points of fracture and cause the early fracture resistance to deteriorate, therefore the N content is 0.0200% or less. The N content is preferably 0.0150% or less, 0.0100% or less, 0.0060% or less, or 0.0040% or less.

[0028] The lower limit of the N content is not particularly prescribed, but if less than 0.0001%, the denitridation cost greatly rises making this not preferable economically. For this reason, the N content may also be 0.0001% or more.

[O: 0.0200% or Less]

[0029] O, if contained in a large amount in the steel, forms coarse oxides acting as starting points of fracture and causes the early fracture resistance of a hot stamped body to deteriorate. For this reason, the O content is 0.0200% or less. The O content is preferably 0.0100% or less, 0.0070% or less, or 0.0040% or less.

[0030] From the viewpoint of reducing the refining costs, the O content may also be 0.0001% or more. To make a large number of fine oxides disperse at the time of deoxidation of the molten steel, the O content may be 0.0005% or more.

[Al: 0.0010 to 0.500%]

[0031] Al is an element having the action of deoxidizing the molten steel and making the steel sounder. If the Al content is less than 0.0010%, deoxidation will not sufficiently proceed and coarse oxides will be formed causing the early fracture resistance to deteriorate. For this reason, the Al content is 0.0010% or more. The Al content is preferably 0.005% or more, 0.010% or more, or 0.030% or more.

[0032] On the other hand, if the Al content is more than 0.500%, coarse oxides will form in the steel causing the early fracture resistance of a hot stamped body to fall. For this reason, the Al content is 0.500% or less. The Al content is preferably 0.400% or less, 0.300% or less, 0.200% or less, or 0.100% or less.

[Nb: 0.0010 to 0.100%]

[0033] Nb is an element forming carbonitrides in steel and improving the strength of a hot stamped body by precipitation strengthening. If the Nb content is less than 0.0010%, the desired strength cannot be obtained. For this reason, the Nb content is 0.0010% or more. The Nb content is preferably 0.005% or more, 0.009% or more, or 0.015% or more.

[0034] On the other hand, if the Nb content is more than 0.100%, a large amount of coarse carbonitrides are formed in the steel and the early fracture resistance of a hot stamped body deteriorates. For this reason, the Nb content is 0.100% or less. The Nb content is preferably 0.080% or less, 0.060% or less, or 0.050% or less.

[Ti: 0.010 to 0.200%]

[0035] Ti is an element forming carbonitrides in steel and improving the strength of a hot stamped body by precipitation strengthening. If the Ti content is less than 0.010%, the desired strength cannot be obtained. For this reason, the Ti content is 0.010% or more. The Ti content is preferably 0.015% or more, 0.020% or more, or 0.025% or more.

[0036] On the other hand, if the Ti content is more than 0.200%, a large amount of coarse carbonitrides are formed in the steel and the early fracture resistance of a hot stamped body deteriorates. For this reason, the Ti content is 0.200% or less. The Ti content is preferably 0.150% or less, 0.100% or less, 0.080% or less, 0.060% or less, or 0.050% or less.

[Cr: 0.010 to 1.00%]

[0037] Cr is an element dissolving in the former austenite grains at the time of heating before hot stamping and thereby

raising the strength of a hot stamped body. If the Cr content is less than 0.010%, it is not possible to obtain the desired strength. For this reason, the Cr content is 0.010% or more. The Cr content is preferably 0.10% or more, 0.15% or more, or 0.20% or more.

[0038] On the other hand, if the Cr content is more than 1.00%, in a hot stamped body, coarse intermetallic compounds are formed and the early fracture resistance deteriorates. For this reason, the Cr content is 1.00% or less. The Cr content is preferably 0.80% or less, 0.70% or less, 0.50% or less, or 0.40% or less.

[Mo: 0.010 to 1.000%]

[0039] Mo is an element segregating at the austenite grain boundaries at the time of heating in the hot stamping step to thereby make the strength of the former austenite grain boundaries rise and raise the early fracture resistance in the hot stamped body. If the Mo content is less than 0.0010%, the desired early fracture resistance cannot be obtained. For this reason, the Mo content is 0.0010% or more. The Mo content is preferably 0.010% or more, 0.050% or more, or 0.100% or more.

[0040] On the other hand, if the Mo content is more than 1.000%, in a hot stamped body, coarse intermetallic compounds are formed and the early fracture resistance deteriorates. For this reason, the Mo content is 1.000% or less. The Mo content is preferably 0.800% or less, 0.600% or less, or 0.400% or less.

[B: 0.0005 to 0.0200%]

[0041] B is an element improving the hardenability of steel. If the B content is less than 0.0005%, the desired strength cannot be obtained. For this reason, the B content is 0.0005% or more. The B content is preferably 0.0010% or more, 0.0015% or more, or 0.0020% or more.

[0042] On the other hand, if the B content is more than 0.0200%, coarse intermetallic compounds are formed at a hot stamped body and the early fracture resistance of the hot stamped body falls. For this reason, the B content is 0.0200% or less. The B content is preferably 0.0150% or less, 0.0100% or less, 0.0080% or less, 0.0060% or less, or 0.0040% or less.

[0043] The basic chemical composition of a hot stamped body according to an embodiment of the present invention is as explained above. Furthermore, the hot stamped body may, if necessary, contain at least one of the following optional elements in place of part of the Fe of the balance. For example, the hot stamped body may contain at least one element selected from the group comprising Co: 0 to 4.00%, Ni: 0 to 3.00%, Cu: 0 to 3.00%, and V: 0 to 3.00%. Further, the hot stamped body may contain at least one element selected from the group comprising Ca: 0 to 1.000%, Mg: 0 to 1.000%, and REM: 0 to 1.000%. Further, the hot stamped body may also have at least one element selected from the group comprising Sb: 0 to 1.00%, Sn: 0 to 1.00%, and Zr: 0 to 1.00%. Further, the hot stamped body may contain As: 0 to 0.100%. Further, the hot stamped body may contain at least one element of W, Ta, Re, Os, Ir, and Tc in a total of 0 to 1.00%. Below, these optional elements will be explained in detail.

[Co: 0 to 4.00%]

[0044] Co is an element improving the strength of a hot stamped body by solid solution strengthening. The Co content may be 0.001% or more, but to reliably obtain this effect, the Co content is preferably 0.01% or more or 0.05% or more.

[0045] On the other hand, even if made to be contained in a large amount, the effect becomes saturated, therefore the Co content is preferably 4.00% or less. The Co content may also be 3.00% or less, 2.50% or less, 2.00% or less, or 1.50% or less.

[Ni: 0 to 3.00%]

[0046] Ni has the action of dissolving in the austenite grains at the time of heating in the hot stamping step and thereby raising the strength of a hot stamped body. The Ni content may be 0.001% or more, but to reliably obtain this effect, the Ni content is preferably 0.01% or more.

[0047] On the other hand, even if made to be contained in a large amount, the effect becomes saturated, therefore the Ni content is preferably 3.00% or less. The Ni content may also be 2.50% or less, 2.00% or less, 1.50% or less, 1.00% or less, or 0.80% or less.

[Cu: 0 to 3.00%]

[0048] Cu has the action of dissolving in the austenite grains at the time of heating in the hot stamping step and thereby raising the strength of a hot stamped body. The Cu content may be 0.001% or more, but to reliably obtain this effect, the Cu content is preferably 0.01% or more or 0.05% or more.

[0049] On the other hand, even if made to be contained in a large amount, the effect becomes saturated, therefore the Cu content is preferably 3.00% or less. The Cu content may also be 2.50% or less, 2.00% or less, 1.50% or less, 1.00% or less, or 0.80% or less.

[V: 0 to 3.00%]

[0050] V has the effect of forming carbonitrides in the steel to thereby improve the strength of the hot stamped body by precipitation strengthening. The V content may be 0.001% or more, but to reliably obtain this effect, the V content is preferably 0.01% or more or 0.05% or more.

[0051] On the other hand, the V content is more than 3.00%, sometimes a large amount of carbonitrides are formed in the steel and the early fracture resistance of the hot stamped body deteriorates. For this reason, the V content is preferably 3.00% or less. The V content may also be 2.50% or less, 2.00% or less, 1.50% or less, 1.00% or less, or 0.80% or less.

[Ca: 0 to 1.000%]

[0052] Ca suppresses the formation of oxides acting as starting points of fracture and contributes to improvement of the early fracture resistance. The Ca content may be 0.0001% or more, but to reliably obtain this effect, the Ca content is preferably 0.0005% or more or 0.001% or more.

[0053] On the other hand, even if made to be contained in a large amount, the effect becomes saturated, therefore the Ca content is preferably 1.000% or less. The Ca content may also be 0.100% or less, 0.050% or less, 0.010% or less, 0.005% or less, or 0.002% or less.

[Mg: 0 to 1.000%]

[0054] Mg forms oxides and sulfides in the molten steel to suppress the formation of coarse MnS, causes dispersion of large number of fine oxides, and contributes to increased fineness of the metallographic structure and improvement of the early fracture resistance. The Mg content may be 0.0001% or more, but to reliably obtain this effect, the Mg content is preferably 0.0005% or more or 0.001% or more.

[0055] On the other hand, even if made to be contained in a large amount, the effect becomes saturated, therefore the Mg content is preferably 1.000% or less. The Mg content may also be 0.100% or less, 0.050% or less, 0.010% or less, 0.005% or less, or 0.002% or less.

[REM: 0 to 1.000%]

[0056] REM suppresses the formation of oxides acting as starting points of fracture and contributes to improvement of the early fracture resistance. The REM content may be 0.0001% or more, but to reliably obtain this effect, the REM content is preferably 0.0005% or more or 0.001% or more.

[0057] On the other hand, even if made to be contained in a large amount, the effect becomes saturated, therefore the REM content is preferably 1.000% or less. The REM content may be 0.100% or less, 0.050% or less, 0.010% or less, 0.005% or less, or 0.002% or less.

[0058] In the present embodiment, "REM" is the general term for the 17 elements of atomic number 21 scandium (Sc), atomic number 39 yttrium (Y), and the lanthanoids of atomic number 57 lanthanum (La) to atomic number 71 lutetium (Lu). The REM content is the total content of these elements.

[Sb: 0 to 1.00%]

[0059] Sb suppresses the formation of oxides acting as starting points of fracture and contributes to improvement of the early fracture resistance. To reliably obtain this effect, the Sb content is preferably 0.001% or more.

[0060] On the other hand, even if made to be contained in a large amount, the effect becomes saturated, therefore the Sb content is preferably 1.00% or less. The Sb content may also be 0.80% or less, 0.50% or less, 0.20% or less, or 0.10% or less.

[Sn: 0 to 1.00%]

[0061] Sn suppresses the formation of oxides which act as starting points of fracture and contributes to the improvement of the early fracture resistance. To reliably obtain this effect, the Sn content is preferably 0.001% or more.

[0062] On the other hand, even if contained in a large amount, the above effect is saturated, therefore the Sn content is preferably 1.00% or less. The Sn content may also be 0.80% or less, 0.50% or less, 0.20% or less, or 0.10% or less.

[Zr: 0 to 1.00%]

[0063] Zr suppresses the formation of oxides which act as starting points of fracture and contributes to the improvement of the early fracture resistance. To reliably obtain this effect, the Zr content is preferably 0.001% or more.

[0064] On the other hand, even if contained in a large amount, the above effect is saturated, therefore the Zr content is preferably 1.00% or less. The Zr content may also be 0.80% or less, 0.50% or less, 0.20% or less, or 0.10% or less.

[As: 0 to 0.100%]

[0065] As causes the temperature for forming an austenite single phase to fall and thereby refines the former austenite grains and contributes to improvement of the early fracture resistance. If reliably obtaining this effect, the As content is preferably 0.001% or more.

[0066] On the other hand, even if contained in a large amount, the above effect is saturated, therefore the As content is preferably 0.100% or less. The As content may be 0.080% or less, 0.050% or less, 0.020% or less, or 0.010% or less.

[At Least One of W, Ta, Re, Os, Ir, and Tc: 0 to 1.00% in Total]

[0067] W, Ta, Re, Os, Ir, and Tc are elements segregating at the former austenite grain boundaries in the same way as Mo to raise the strength of the grain boundaries. The total of the content of the at least one element of W, Ta, Re, Os, Ir, and Tc may be 0%, but to obtain such an effect, is preferably 0.001% or more. The total of the content of the at least one element of W, Ta, Re, Os, Ir, and Tc is preferably 0.01% or more, more preferably 0.10% or more, still more preferably 0.15% or more. On the other hand, even if excessively containing these elements, the effect becomes saturated. Therefore, including these elements in the steel material more than necessary is liable to invite a rise in the production costs. Therefore, the total of the contents of the at least one of W, Ta, Re, Os, Ir, and Tc is preferably 1.00% or less and may also be 0.80% or less, 0.60% or less, or 0.40% or less.

[0068] The chemical composition of the above hot stamped body may be measured by a general analysis method. For example, it may be measured using ICP-AES (Inductively Coupled Plasma-Atomic Emission Spectrometry). C and S may be measured using the combustion-infrared absorption method, N may be measured using the inert gas melting-thermal conductivity method, and O may be measured by the inert gas melting-nondispersion type infrared absorption method.

[0069] If the surface of the hot stamped body is provided with a plating layer, mechanical polishing may be used to remove the plating layer, then the chemical composition may be analyzed.

[0070] In a hot stamped body according to an embodiment of the present invention, the balance besides the above elements is comprised of Fe and impurities. The "impurities" are constituents, etc., entering due to various factors in the production process starting from materials such as ore and scrap, etc., when industrially producing hot stamped bodies.

[At Least One of Martensite, Bainite, and Tempered Martensite: 90% or More in Total]

[0071] The microstructure of the hot stamped body preferably includes, by area ratio, at least one of martensite, bainite, and tempered martensite in a total of 90% or more. The remaining structure is not particularly limited, but may also be comprised of at least one of 10% or less of ferrite, retained austenite, and pearlite. Martensite, bainite, and tempered martensite are extremely hard structures, therefore by the hot stamped body containing at least one of martensite, bainite, and tempered martensite in an area ratio of a total of 90% or more, a high tensile strength, specifically a tensile strength of 2200 MPa or more, can be achieved. The total of the area ratios of the least one of martensite, bainite, and tempered martensite is preferably 94% or more, more preferably 97% or more. The upper limit of the total of the area ratios of the at least one of martensite, bainite, and tempered martensite is not particularly prescribed and may also be 100%.

[0072] The microstructure in a hot stamped body is identified and the area ratios are calculated in the following way.

[0073] A sample is cut out from any position 50 mm or more away from the ends of a hot stamped body (if not possible to obtain a sample from this position, a position away from the ends) so as to enable a cross-section of thickness vertical to the surface to be examined. The size of the sample depends on the measurement device, but is a size enabling 10 mm or so to be examined in a direction vertical to the thickness direction.

[0074] The cross-section of the sample is polished using #600 to #1500 silicon carbide paper, then a liquid comprised of particle size 1 to 6 μm diamond powder dispersed in alcohol or other diluent or pure water is used to polish the surface to a mirror finish. Next, the examined surface is finished by electrolytic polishing. An area of a length 50 μm and 50 μm in the sheet thickness direction centered at a 1/4 depth position of the sheet thickness at any position in the long direction of the sample cross-section is measured at 0.1 μm measurement intervals by electron backscatter diffraction to obtain crystal orientation information. For the measurement, an EBSD analysis apparatus comprised of a thermal field emission type scan electron microscope and EBSD detector may be used. For example, an EBSD analysis apparatus comprised of a JSM-7001F made by JEOL and a DVC5 model detector made by TSL may be used. At that time, the vacuum degree inside

the EBSD analysis apparatus may be 9.6×10^{-5} Pa or less, the acceleration voltage may be 15 kV, and the beam current level may be made 13.

[0075] The obtained crystal orientation information is analyzed using the "Phase Map" function included in the software "OIM Analysis®" attached to the EBSD analysis apparatus. Structures with fee crystal structures are judged to be retained austenite. The area ratio of the retained austenite is obtained by calculating the area ratio of this retained austenite. Next, regions with bcc crystal structures are judged to be bainite, tempered martensite, martensite, and ferrite. In these regions, using the "Grain Average Misorientation" function included in the software "OIM Analysis®" attached to the EBSD analysis apparatus, under conditions deeming a 5° grain boundary as a crystal grain boundary, a region having a "Grain Average Misorientation" of 0.5° or less is extracted as ferrite. The area ratio of ferrite is obtained by calculating the area ratio of the extracted ferrite.

[0076] Next, the remaining region (region with "Grain Average Misorientation" of more than 0.5°) is made the area ratio of the total of martensite, tempered martensite, and bainite. The area ratio of pearlite is calculated by subtracting from 100% the area ratio of the retained austenite and the area ratios of the bainite, tempered martensite, martensite, and ferrite.

[Standard Deviation at Grain Size Distribution of Former Austenite Grains: $5.0 \mu\text{m}$ or Less]

[0077] In an embodiment of the present invention, the standard deviation at the grain size distribution of the former austenite grains is $5.0 \mu\text{m}$ or less. If the variation of the former austenite grain size is large, sometimes a rise in the local hardness is invited and early fracture is caused. According to an embodiment of the present invention, by controlling the standard deviation at the grain size distribution of the former austenite grains to $5.0 \mu\text{m}$ or less to reduce the variation in former austenite grain size, it is possible to reliably suppress the rise in local hardness acting as the starting points of early fracture. Preferably, the standard deviation is $4.0 \mu\text{m}$ or less, $3.0 \mu\text{m}$ or less, or $2.5 \mu\text{m}$ or less. From the viewpoint of suppressing the rise in local hardness acting as the starting points of early fracture, the smaller the standard deviation at the grain size distribution of the former austenite grains, the better. For this reason, the lower limit does not particularly have to be prescribed. For example, the standard deviation at the grain size distribution of the former austenite grains may be $0.1 \mu\text{m}$ or more and may be $0.5 \mu\text{m}$ or more, $1.0 \mu\text{m}$ or more, $1.2 \mu\text{m}$ or more, $1.5 \mu\text{m}$ or more, or $1.7 \mu\text{m}$ or more.

[0078] In an embodiment of the present invention, as explained above, it is important to control the standard deviation at the grain size distribution of the former austenite grains to $5.0 \mu\text{m}$ or less to reduce the variation of the former austenite grain size. For this reason, it is not necessary to control the former austenite grain size itself to a specific range. Therefore, the former austenite grain size is not particularly limited, but for example may be $10 \mu\text{m}$ or less. The "former austenite grain size" means the average crystal grain size of former austenite grains in the measurement of the standard deviation explained below.

[0079] The standard deviation at the grain size distribution of the former austenite grains can be obtained by the following method.

[0080] A sample is cut out from any position 50 mm or more away from the ends of the hot stamped body (if not possible to obtain a sample from this position, a position away from the ends) so as to enable a cross-section of thickness vertical to the surface to be examined. The size of the sample depends on the measurement device, but is a size enabling 10 mm or so to be examined in a direction vertical to the thickness direction.

[0081] The cross-section of the sample is polished using #600 to #1500 silicon carbide paper, then a liquid comprised of particle size 1 to $6 \mu\text{m}$ diamond powder dispersed in alcohol or other diluent or pure water is used to polish the surface to a mirror finish. Next, the examined surface is finished by electrolytic polishing. An area of a length $50 \mu\text{m}$ and $50 \mu\text{m}$ in the sheet thickness direction centered at a $1/4$ depth position of the sheet thickness at any position in the long direction of the sample cross-section is measured at $0.1 \mu\text{m}$ measurement intervals by electron backscatter diffraction to obtain crystal orientation information. For the measurement, an EBSD analysis apparatus comprised of a thermal field emission type scan electron microscope and EBSD detector may be used. For example, an EBSD analysis apparatus comprised of a JSM-7001F made by JEOL and a DVC5 model detector made by TSL may be used. At that time, the vacuum degree inside the EBSD analysis apparatus may be 9.6×10^{-5} Pa or less, the acceleration voltage may be 15 kV, and the beam current level may be made 13.

[0082] The obtained crystal orientation information is used to calculate the crystal orientation of the former austenite grains from the relationship of crystal orientation between general former austenite grains and crystal grains having bcc structures after transformation. This is used to calculate the average crystal grain size of the former austenite grains.

[0083] For the method of calculating the crystal orientations of the former austenite grains, the following method is used. First, a crystal orientation map of the former austenite grains is prepared by the method described in Acta Materialia, 58(2010), 6393-6403. The average value between the shortest diameter and the longest diameter of one former austenite grain included in the examined field is calculated. That average value is made the size of the former austenite grain. The above operation is performed for all of the former austenite grains except for the former austenite grains where the crystal grains as a whole are not included in the captured field, such as at the end parts of the captured field, to find the sizes of all of

the former austenite grains in the captured field. From the obtained sizes of all former austenite grains, the average size is calculated whereupon the standard deviation at the grain size distribution of the former austenite grains is obtained.

[Total Amount of Segregation of at Least One of Mo, W, Ta, Re, Os, Ir, and Tc at Former Austenite Grain Boundaries: 0.10 Atm% or More]

[0084] In an embodiment of the present invention, the total amount of segregation of at least one of Mo, W, Ta, Re, Os, Ir, and Tc at the former austenite grain boundaries is 0.10 atm% or more. By making at least one of Mo, W, Ta, Re, Os, Ir, and Tc segregate at the former austenite grain boundaries to give a total amount of segregation of 0.10 atm% or more, it is possible to strengthen the former austenite grain boundaries at the microstructure of the hot stamped body. It is possible to not only suppress variation of the former austenite grain size to reduce the regions able to act as the starting points of early fracture, it is also possible to suppress the progression of cracks when they occur and thereby prevent early fracture. According to an embodiment of the present invention, by combining the suppression of the rise of local hardness and grain boundary strengthening by grain boundary segregation of such specific elements, it is possible to reduce the regions able to act as the starting points of early fracture and suppress the progression of cracks along the grain boundary even in the case of occurrence of cracks at the hot stamped bodies. For this reason, despite having a high tensile strength, for example, a high tensile strength of 2200 MPa or more, it is possible to suppress early fracture. The total amount of segregation of the at least one element of Mo, W, Ta, Re, Os, Ir, and Tc at the former austenite grain boundaries is preferably 0.13 atm% or more, more preferably 0.15 atm% or more, still more preferably 0.18 atm% or more, or 0.20 atm% or more. From the viewpoint of grain boundary strengthening, the higher the total amount of segregation of the at least one of Mo, W, Ta, Re, Os, Ir, and Tc at the former austenite grain boundaries, the more preferable. For this reason, the upper limit of the above total content is not particularly limited, but for example the total amount of segregation may be 3.00 atm% or less and may also be 2.00 atm% or less, 1.50 atm% or less, 1.00 atm% or less, 0.80 atm% or less, 0.60 atm% or less, 0.40 atm% or less, or 0.30 atm% or less.

[0085] In one embodiment, the amount of segregation of Mo at the former austenite grain boundaries may be 0.10 atm% or more, 0.13 atm% or more, 0.15 atm% or more, 0.18 atm% or more, or 0.20 atm% or more. Similarly, the amount of segregation of Mo at the former austenite grain boundaries may be 3.00 atm% or less, 2.00 atm% or less, 1.50 atm% or less, 1.00 atm% or less, 0.80 atm% or less, 0.60 atm% or less, 0.40 atm% or less, or 0.30 atm% or less. In another embodiment, the total amount of segregation of the amount of segregation of Mo and the amount of segregation of at least one of W, Ta, Re, Os, Ir and Tc at the former austenite grain boundaries may be 0.10 atm% or more, 0.13 atm% or more, 0.15 atm% or more, 0.18 atm% or more, or 0.20 atm% or more and/or may be 3.00 atm% or less, 2.00 atm% or less, 1.50 atm% or less, 1.00 atm% or less, 0.80 atm% or less, 0.60 atm% or less, 0.40 atm% or less, or 0.30 atm% or less.

[0086] The total amount of segregation of the at least one of Mo, W, Ta, Re, Os, Ir, and Tc at the former austenite grain boundaries is determined as follows: First, a test piece is taken from a position 50 mm or more away from the end faces of the hot stamped body. At that time, the front and back surfaces of the test piece are finished by machine polishing. Further, if there is a plating layer at the steel sheet surface, the plating layer is removed and then the front and back surfaces of the test piece of the steel sheet are finished by machine polishing. At that time, the sheet thickness is not particularly designated if the 1/4 depth position of the sheet thickness can be measured, but the same amounts of the front and back surfaces of the test piece may also be removed by machine grinding so that the sheet thickness becomes 1.2 mm. The test piece is worked to a length of 20 mm and a width of 3.2 mm and formed with a V-notch of an angle of 45° at a position of a length of 11.5 mm. The test piece is dipped in a 20%-ammonium thiocyanate solution. At this time, the dipping time is not particularly limited. It is sufficient that the former austenite grain boundaries are exposed when set inside an Auger electron emission spectrometer and fracturing. For example, it may be 48 hours. The front and back surfaces of the test piece are galvanized within 10 minutes after ending the dipping. After plating, the test piece is quickly subjected to Auger electron emission spectrometry and fractured. At that time, the time after plating to fracture of the test piece is preferably within 1.5 hours, more preferably within 0.5 hour. The test piece is set within the Auger electron emission spectrometer and fractures from the notch portion of the test piece to expose the former austenite grain boundaries. At this time, the apparatus may be an Auger electron emission spectrometer. The model is not particularly limited, but a PHI680 made by ULVAC-PHI may be used. As the measurement conditions, the accelerating voltage may be 10 keV and the beam current may be 10 nA. An electron beam is fired at the exposed former austenite grain boundaries by a 1 to 30 kV accelerating voltage and the atm% of specific elements at the grain boundaries (specifically at least one of Mo, W, Ta, Re, Os, Ir, and Tc) are measured. The measurement is performed at the former austenite grain boundaries at 10 locations at a position of 1/4 depth of the sheet thickness from the surface. To prevent contamination of the grain boundaries, quickly ending the measurement after fracture is preferable. The measurement should be ended within 30 minutes. The average value of the atm% of the obtained specific elements is calculated and determined as the total value of segregation of the at least one of Mo, W, Ta, Re, Os, Ir, and Tc.

[Plating]

[0087] The hot stamped body according to the present embodiment may have a plating layer at its surface. By having a plating layer at the surface, after the hot stamping, the corrosion resistance can be improved. As the plating layer, an aluminum plating layer, aluminum-zinc plating layer, aluminum-silicon plating layer, hot dip galvanized layer, electro-galvanized layer, hot dip galvanized layer, zinc-nickel plating layer, aluminum-magnesium-zinc based plating layer, etc., may be illustrated.

[Mechanical Properties]

[0088] According to the hot stamped body of an embodiment of the present invention, excellent mechanical properties, for example, a tensile strength of 2200 MPa or more, can be achieved. The tensile strength is preferably 2300 MPa or more, more preferably 2400 MPa or more, most preferably 2500 MPa or more. The upper limit is not particularly prescribed, but, for example, the tensile strength may be 3500 MPa or less, 3300 MPa or less, or 3000 MPa or less. The tensile strength of the hot stamped body is measured by preparing a No. 5 test piece and conducting a tensile test based on JIS Z 2241: 2011. At this time, for the purpose of removing roughness at the surface of the test piece, the surface layer parts of the front and back surfaces may be removed by machining or chemical polishing.

[0089] The hot stamped body according to an embodiment of the present invention, despite as explained above having, for example, a high tensile strength of 2200 MPa or more, can reliably suppress early fracture, and therefore is extremely useful for use as, for example, a frame member or bumper of an automobile or other structural member and reinforcing member where strength is required.

<Method of Production of Hot Stamped Body>

[0090] Next, a preferable method of production of the hot stamped body according to an embodiment of the present invention will be explained. The following explanation is intended to illustrate the characteristic method for producing the hot stamped body according to the embodiment of the present invention and is not intended to limit the hot stamped body to one produced by the method of production such as explained below.

[0091] In the method of production of the hot stamped body according to an embodiment of the present invention, in particular controlling the finish rolling conditions and preheating conditions is effective. Specifically, the method of production of the hot stamped body according to an embodiment of the present invention comprises:

hot rolling a slab having a chemical composition explained above relating to the hot stamped body, wherein the hot rolling includes heating the slab, then finish rolling it, and a rolling reduction of a final stage of the finish rolling is 40% or more (hot rolling step),
 coiling the obtained steel sheet at a temperature of 750°C or less (coiling step),
 preheating the steel sheet to a temperature of more than 1200°C, then cooling it by an average cooling speed of 10°C/s or more down to less than 350°C (preheating step), and
 hot stamping the steel sheet, wherein the hot stamping includes heating the steel sheet to a temperature region of 800 to 1000°C and then holding it there for 60 to 600 seconds (hot stamping step). Below, the steps will be explained in detail.

[Hot Rolling Step]

[Heating of Slab]

[0092] First, a slab having the chemical composition explained above in relation to the hot stamped body is heated. The method of casting the molten steel is not particularly limited. The slab may be produced by continuous casting, ingot forming, or thin slab casting. The heating before the hot rolling is not particularly limited, but the slab used contains a relatively large amount of alloying elements for obtaining a high strength steel sheet. For this reason, the slab may also be heated before being sent on for hot rolling. For the purpose of making the alloying elements dissolve in the slab, the heating temperature may be 1100°C or more.

[Rough Rolling]

[0093] In the present method, for example, the heated slab may be adjusted in thickness, etc., by rough rolling before finish rolling. The rough rolling need only secure the desired sheet bar dimensions. The conditions are not particularly limited.

[Finish Rolling]

[0094] The heated slab or the slab additionally rough rolled as needed is next finish rolled. In the present method, it is important that the rolling reduction of the final stage in the finish rolling be 40% or more. By making the rolling reduction of the final stage in the finish rolling 40% or more, the pearlite is evenly dispersed in the hot rolled steel sheet after rolling. This pearlite becomes starting points of austenite at the time of heating in the preheating step explained later in detail. For this reason, if the pearlite is evenly dispersed, at the hot stamped body, the standard deviation at the grain size distribution of the former austenite grains becomes smaller. As a result, the early fracture resistance of the hot stamped body can be improved. More preferably, the rolling reduction of the final stage in the finish rolling is 43% or more or 50% or more.

[0095] In a hot stamped body, for the purpose of securing a high hardenability, the amount of Mn added tends to be raised. For example, 0.50% or more of Mn is added. In relation to this, in research by the inventors, it was learned that with such a high Mn content, pearlite tends to be arranged relatively connected in a hot rolled steel sheet, and therefore compared with the case of low Mn content, it is extremely difficult to evenly disperse pearlite in the microstructure of a hot rolled steel sheet. Therefore, if finish rolling a steel material with such a high Mn content by a relatively low rolling reduction of less than 40%, it is believed that the presence of a part of connected pearlite at the microstructure becomes particularly prominent.

[0096] However, by making the rolling reduction of the final stage of finish rolling 40% or more, despite a high Mn content of 0.50% or more, it is possible to arrange pearlite sufficiently dispersed at the microstructure of the hot rolled steel sheet after the hot rolling step and coiling step. Therefore, in the microstructure of the hot rolled steel sheet rolled in this way, either there are no parts where pearlite is present connected or they are sufficiently reduced, therefore in the structure after the preheating step and hot stamping step, it is possible to reduce variation in the former austenite grain size. The upper limit of the rolling reduction in the final stage of the finish rolling is not particularly prescribed. Even in a steel material having such a high Mn content, in particular by suitable controlling the rolling reduction in the final stage of the finish rolling, it is possible to arrange the pearlite sufficiently dispersed in the microstructure of the hot rolled steel sheet and in turn possible to reduce the variation in the former austenite grain size and suppress a local rise in hardness.

[0097] The dominating factors in the morphology of this microstructure are the rolling reduction in the final stage of the finish rolling and the heating in the preheating step. The morphology is not particularly greatly affected by for example the heating in the hot stamping step after the preheating step, the optional cold rolling before the preheating step, the subsequent annealing, etc. This is because by forming the hot rolled steel sheet by a rolling reduction in the final stage of the finish rolling of 40% or more, even if the hot rolled steel sheet is cold rolled and then annealed at a relatively high temperature, there is a high tendency for formation of a microstructure where the carbides, grain boundaries, and retained austenite forming starting points of austenite after cooling are arranged dispersed. In general, if the rolling reduction in the final stage of the finish rolling is too high, fracture of the steel sheet at the time of rolling becomes a concern. Further, the preheating step explained in detail later is performed at an extremely high temperature compared with the hot stamping step, more specifically is performed at a temperature of more than 1200°C, and therefore generally this becomes a factor behind increased costs. Therefore, in particular the technical idea that by making the rolling reduction in the final stage of the finish rolling 40% or more and further by combining more than 1200°C preheating before the stamping step, the variation in former austenite grain size is reduced and a local rise in hardness is suppressed has not existed up to now and was first discovered this time by the inventors.

[Coiling Step]

[0098] Next, the finish rolled hot rolled steel sheet is coiled at a temperature of 750°C or less. By making the coiling temperature 750°C or less, it is possible to keep the ferrite from being arranged connected at the hot rolled steel sheet after rolling and the pearlite evenly disperses. This pearlite acts as starting points for austenite at the time of heating in the preheating step. For this reason, if the pearlite evenly disperses, in the hot stamped body, the standard deviation at the grain size distribution of the former austenite grains becomes smaller. As a result, the early fracture resistance of the hot stamped body can be improved.

[0099] Further, for the purpose of softening the hot rolled steel sheet, the coil after coiling may be heat treated to soften it. The method of heat treatment for softening is not particularly limited and may be made general conditions.

[Pickling Step]

[0100] After the coiling step and before the cold rolling step, optionally, pickling may be performed for removing the oxide scale formed on the surface of the hot rolled steel sheet. The pickling may be formed under conditions suitable for removing oxide scale. It may be performed at one time or may be performed divided into several times so as to reliably remove the oxide scale.

[Cold Rolling Step]

[0101] After the coiling step, the steel sheet may be optionally cold rolled. The cold rolling is not particularly limited and may be performed under any suitable conditions. For example, the rolling reduction of the cold rolling may be 30 to 80%. The number of rolling passes and the rolling reduction per pass are not particularly limited and may be suitably set so that the rolling reduction of the cold rolling as a whole becomes the above range.

[Annealing Step]

[0102] For example, after the cold rolling step, annealing may optionally be performed to adjust the microstructure and/or properties. The heating temperature of the annealing step is not particularly limited, but may for example be 800°C or less.

[Plating Step]

[0103] For the purpose of improving the corrosion resistance, etc., the surface of the hot rolled steel sheet or cold rolled steel sheet may also be plated. The plating may be hot dip coating, alloyed hot dip coating, electroplating, or other treatment. For example, as the plating, the steel sheet may be hot dip galvanized. After hot dip galvanization, alloying treatment may be performed. As the plating layer, an aluminum plating layer, aluminum-zinc plating layer, aluminum-silicon plating layer, hot dip galvanized layer, electrogalvanized layer, hot dip galvanized layer, zinc-nickel plating layer, aluminum-magnesium-zinc based plating layer, etc., may be illustrated. The specific conditions of the plating and alloying treatment are not particularly limited and may be any suitable conditions known to persons skilled in the art.

[Temper Rolling Step]

[0104] To correct the shape of the steel sheet or adjust the surface roughness, etc., it is possible, for example, to temper roll the steel sheet after the annealing step, or after the plating step.

[Preheating Step]

[0105] In the present method, the obtained hot rolled steel sheet or cold rolled steel sheet is preheated to a temperature of more than 1200°C before the hot stamping step, then is cooled by an average cooling speed of 10°C/s or more down to less than 350°C. In the hot stamped body according to an embodiment of the present invention, it is extremely important to make specific grain boundary strengthening elements, more specifically at least one type of Mo, W, Ta, Re, Os, Ir, and Tc, segregate at the former austenite grain boundaries in predetermined amounts. However, in the hot rolled steel sheet after the hot rolling step or in the cold rolled steel sheet after the optional cold rolling step or annealing step, these grain boundary strengthening elements are present as carbides and/or intermetallic compounds. Therefore, even if subjecting such steel sheet to the hot stamping step for usual heating and shaping without the preheating step, these grain boundary strengthening elements cannot be made to sufficiently segregate at the former austenite grain boundaries. In this case, it is no longer possible to sufficiently manifest the grain boundary strengthening action based on the grain boundary segregation of these elements. For this reason, in this method, it is extremely important to preheat the steel sheet before the hot stamping step to a relatively high temperature of more than 1200°C to thereby make the carbides and/or intermetallic compounds of the grain boundary strengthening elements sufficiently melt and make the grain boundary strengthening elements dissolve in the steel sheet. The upper limit of the heating temperature of the preheating is not particularly prescribed, but the heating temperature may for example be 1400°C or less. Further, after heating, the steel sheet is cooled by an average cooling speed of 10°C/s or more down to less than 350°C. By cooling by an average cooling speed of 10°C/s or more down to less than 350°C, it is possible to keep the grain boundary strengthening elements dissolved in the steel sheet from precipitating as compounds. The upper limit of the average cooling speed is not particularly prescribed, but for example the average cooling speed may be 3000°C/s or less, 1500°C/s or less, or 1200°C/s or less. The upper limit of the cooling speed is not particularly prescribed. The cooling method is also not particularly limited and may be die cooling, water cooling, oil cooling, or gas cooling. In particular, even with an extremely high average cooling speed, cooling can be relatively easily realized by utilizing die cooling or water cooled die cooling.

[Hot Stamping Step]

[0106] Finally, the preheated steel sheet is hot stamped in the hot stamping step to produce a hot stamped body having the desired chemical composition and microstructure. In particular, the grain boundary strengthening elements dissolved in the steel sheet in the previous preheating step disperse to the austenite grain boundaries and segregate there at the time

of heating in the hot stamping step. For this reason, due to the following shaping and cooling operation, it is possible to achieve the desired total amount of segregation of the grain boundary strengthening elements at the former austenite grain boundaries after the martensite transformation. The dispersion and segregation of the grain boundary strengthening elements can be achieved by the usual heating, shaping, and cooling operations in the hot stamping step. Therefore, from the viewpoint of the dispersion and segregation of the grain boundary strengthening elements, these operations may be performed under suitable conditions known to persons skilled in the art. However, in particular from the viewpoint of obtaining the desired area ratio of the hard structures and former austenite grain size distribution, the steel sheet for hot stamping use is preferably heated to a temperature region of 800°C to 1000°C and held at that temperature region for 60 to 600 seconds. If the heating temperature is less than 800°C, sometimes the austenization becomes insufficient and the area ratio of the desired hard structures (at least one of martensite, bainite, and tempered martensite) and former austenite grain size distribution cannot be obtained and the tensile strength and early fracture resistance deteriorate. On the other hand, if the heating temperature is more than 1000°C, sometimes the austenite grains excessively grow, the desired former austenite grain size distribution cannot be obtained, and the early fracture resistance deteriorates. If the holding time is less than 60 seconds, sometimes the austenization becomes insufficient, the desired former austenite grain size distribution cannot be obtained, and the early fracture resistance deteriorates. If the holding time is more than 600 seconds, sometimes the austenite grains excessively grow, the desired former austenite grain size distribution cannot be obtained, and the early fracture resistance deteriorates.

[0107] The heating atmosphere is not particularly limited. Usual conditions are enough. For example, it may be an air atmosphere, a gas combustion atmosphere controlled in ratio of air and fuel, and a nitrogen atmosphere. The dew points may also be controlled in these gases.

[0108] The steel sheet is held at a temperature region of 800°C to 1000°C, then hot stamped. After hot stamping, it may be cooled down to a temperature region of 250°C or less by an average cooling speed of 20°C/s or more.

[0109] As the heating method, for example, furnace heating by an electric furnace, gas furnace, etc., flame heating, ohmic heating, high frequency heating, induction heating, etc., may be mentioned.

[0110] The hot stamped body according to the present embodiment is obtained by the above method. After hot stamping, it may be tempered at 130 to 600°C or coated, then bake hardened (BH). Further, part of the hot stamped body may be tempered by being irradiated by a laser, etc., to partially form softened regions.

[0111] Below, examples will be used to explain the present invention in more detail, but the present invention is not limited to these examples in any way.

EXAMPLES

[0112] In the following examples, hot stamped bodies according to an embodiment of the present invention were produced under various conditions and the obtained tensile strengths and early fracture resistances of the hot stamped bodies were investigated.

[0113] First, molten steels having the chemical compositions shown in Table 1 were cast by continuous casting to produce slabs. The balances besides the constituents shown in Table 1 were Fe and impurities. These slabs were heated to a 1100°C or more temperature and rough rolled under predetermined conditions, then were finish rolled and coiled under the conditions shown in Table 2. After the coiling, some of the hot rolled steel sheets were subjected to predetermined heat treatment for softening. Next, the obtained hot rolled steel sheets were pickled to remove the oxide scale cold rolled by 30 to 80% predetermined rolling reductions. (In Invention Example 337, cold rolling was not performed.) Next, some of the steel sheets were subjected to annealing, plating, or temper rolling under predetermined conditions. Next, the obtained steel sheets were preheated under the conditions shown in Table 2, then were cooled and finally were similarly hot stamped under the conditions shown in Table 2. The heating atmosphere and heating method in the hot stamping step, except when clearly indicated otherwise, were a gas combustion atmosphere (air-fuel ratio 0.85) and furnace heating. After the hot stamping, some of the hot stamped bodies were tempered or partially softened.

[Table 1-1]

[0114]

Table 1-1

Steel	Chemical composition (mass%), bal.: Fe and impurities														
	C	Si	Mn	P	S	N	O	Al	Nb	Ti	Cr	Mo	B	Co	Ni
A1	0.37	0.44	1.32	0.007	0.0006	0.0024	0.0032	0.042	0.042	0.046	0.27	0.220	0.0019		
A2	0.41	0.44	1.23	0.008	0.0007	0.0023	0.0014	0.041	0.040	0.027	0.33	0.149	0.0028		
A3	0.43	0.45	1.32	0.006	0.0005	0.0032	0.0033	0.042	0.040	0.027	0.27	0.227	0.0023		
A4	0.44	0.41	1.22	0.006	0.0016	0.0019	0.0033	0.039	0.034	0.040	0.25	0.217	0.0028		
A5	0.45	0.44	1.34	0.009	0.0015	0.0027	0.0034	0.040	0.026	0.045	0.30	0.190	0.0024		
A6	0.46	0.42	1.22	0.005	0.0009	0.0025	0.0022	0.049	0.031	0.031	0.23	0.174	0.0020		
A7	0.47	0.44	1.24	0.007	0.0018	0.0030	0.0017	0.046	0.027	0.035	0.27	0.187	0.0028		
A8	0.48	0.45	1.22	0.008	0.0015	0.0034	0.0035	0.040	0.024	0.025	0.31	0.150	0.0028		
A9	0.53	0.44	1.21	0.006	0.0003	0.0024	0.0022	0.044	0.042	0.030	0.29	0.174	0.0031		
A10	0.57	0.44	1.35	0.008	0.0008	0.0032	0.0021	0.039	0.018	0.040	0.31	0.196	0.0029		
A11	0.58	0.41	1.29	0.005	0.0015	0.0021	0.0023	0.049	0.036	0.034	0.30	0.172	0.0019		
A12	0.62	0.44	1.23	0.005	0.0012	0.0022	0.0025	0.043	0.028	0.041	0.27	0.178	0.0027		
A13	0.67	0.40	1.34	0.007	0.0007	0.0029	0.0028	0.044	0.032	0.044	0.30	0.168	0.0025		
A14	0.73	0.41	1.28	0.007	0.0019	0.0028	0.0018	0.044	0.020	0.038	0.25	0.181	0.0018		
B1	0.47	0.006	1.30	0.005	0.0019	0.0032	0.0027	0.045	0.034	0.032	0.27	0.223	0.0025		
B2	0.46	0.012	1.24	0.005	0.0019	0.0030	0.0025	0.041	0.035	0.045	0.28	0.214	0.0032		
B3	0.45	0.04	1.31	0.009	0.0019	0.0023	0.0026	0.045	0.040	0.027	0.31	0.144	0.0018		
B4	0.45	0.07	1.28	0.007	0.0018	0.0034	0.0024	0.046	0.028	0.042	0.31	0.177	0.0028		
B5	0.47	0.12	1.26	0.004	0.0021	0.0024	0.0015	0.041	0.036	0.031	0.34	0.198	0.0018		
B6	0.46	0.22	1.24	0.004	0.0016	0.0021	0.0023	0.040	0.023	0.044	0.24	0.199	0.0023		
B7	0.47	0.26	1.33	0.008	0.0007	0.0022	0.0032	0.041	0.026	0.031	0.26	0.140	0.0032		
B8	0.45	0.34	1.26	0.007	0.0016	0.0021	0.0025	0.045	0.029	0.033	0.28	0.179	0.0030		
B9	0.46	0.41	1.35	0.009	0.0003	0.0019	0.0035	0.046	0.018	0.046	0.23	0.172	0.0025		
B10	0.46	0.64	1.34	0.005	0.0017	0.0030	0.0018	0.049	0.032	0.034	0.32	0.179	0.0024		

(continued)

Steel	Chemical composition (mass%), bal.: Fe and impurities														
	C	Si	Mn	P	S	N	O	Al	Nb	Ti	Cr	Mo	B	Co	Ni
B 11	0.46	0.83	1.25	0.004	0.0011	0.0032	0.0030	0.039	0.024	0.040	0.24	0.160	0.0019		
B12	0.45	1.72	1.32	0.006	0.0020	0.0031	0.0019	0.040	0.019	0.034	0.28	0.149	0.0020		
B13	0.46	2.37	1.22	0.005	0.0016	0.0023	0.0033	0.040	0.023	0.045	0.27	0.188	0.0028		
B14	0.47	2.81	1.25	0.007	0.0006	0.0024	0.0026	0.042	0.031	0.036	0.25	0.145	0.0026		
B15	0.45	3.20	1.24	0.009	0.0018	0.0033	0.0028	0.044	0.030	0.044	0.24	0.131	0.0033		
C1	0.45	0.42	0.45	0.008	0.0017	0.0033	0.0026	0.045	0.024	0.046	0.33	0.162	0.0020		
C2	0.45	0.40	0.52	0.005	0.0019	0.0030	0.0021	0.042	0.031	0.040	0.30	0.210	0.0033		
C3	0.46	0.44	0.64	0.009	0.0003	0.0024	0.0016	0.044	0.034	0.031	0.25	0.224	0.0024		
C4	0.46	0.41	0.81	0.007	0.0008	0.0029	0.0018	0.050	0.031	0.045	0.31	0.149	0.0030		
C5	0.47	0.43	1.21	0.004	0.0008	0.0028	0.0018	0.050	0.019	0.044	0.25	0.176	0.0030		
C6	0.47	0.40	1.32	0.006	0.0016	0.0023	0.0033	0.045	0.039	0.044	0.27	0.167	0.0032		
C7	0.45	0.45	1.59	0.005	0.0016	0.0023	0.0016	0.049	0.018	0.031	0.26	0.204	0.0018		
C8	0.47	0.40	1.82	0.009	0.0018	0.0024	0.0022	0.040	0.018	0.026	0.26	0.161	0.0033		
C9	0.47	0.45	2.1	0.008	0.0022	0.0027	0.0027	0.043	0.028	0.044	0.31	0.210	0.0020		
C10	0.47	0.45	2.29	0.008	0.0022	0.0027	0.0023	0.047	0.030	0.029	0.31	0.145	0.0032		
C11	0.45	0.44	2.42	0.007	0.0017	0.0019	0.0019	0.047	0.030	0.032	0.33	0.198	0.0028		
C12	0.45	0.44	2.67	0.007	0.0011	0.0019	0.0017	0.041	0.026	0.030	0.33	0.213	0.0028		
C13	0.47	0.45	2.91	0.006	0.0017	0.0026	0.0035	0.050	0.040	0.043	0.29	0.173	0.0018		
C14	0.45	0.43	3.12	0.004	0.0004	0.0022	0.0019	0.046	0.030	0.035	0.25	0.186	0.0029		
D1	0.47	0.42	1.23	0.0006	0.0008	0.0034	0.0034	0.050	0.026	0.036	0.30	0.194	0.0022		
D2	0.47	0.42	1.25	0.004	0.0013	0.0029	0.0022	0.050	0.036	0.030	0.33	0.134	0.0020		
D3	0.46	0.45	1.25	0.006	0.0020	0.0027	0.0016	0.050	0.026	0.044	0.30	0.229	0.0021		
D4	0.46	0.45	1.35	0.008	0.0005	0.0031	0.0014	0.046	0.036	0.031	0.24	0.130	0.0033		
D5	0.45	0.41	1.23	0.011	0.0003	0.0026	0.0031	0.050	0.018	0.032	0.25	0.173	0.0018		
D6	0.46	0.39	1.27	0.042	0.0009	0.0026	0.0017	0.042	0.030	0.046	0.25	0.165	0.0020		

(continued)

Steel	Chemical composition (mass%), bal.: Fe and impurities														
	C	Si	Mn	P	S	N	O	Al	Nb	Ti	Cr	Mo	B	Co	Ni
D7	0.46	0.41	1.29	0.069	0.0013	0.0028	0.0021	0.044	0.041	0.027	0.25	0.144	0.0030		
D8	0.45	0.39	1.22	0.087	0.0008	0.0024	0.0030	0.046	0.040	0.038	0.31	0.228	0.0030		
D9	0.47	0.45	1.35	<u>0.120</u>	0.0016	0.0031	0.0028	0.047	0.032	0.045	0.27	0.193	0.0020		
E1	0.45	0.42	1.25	0.007	0.0001	0.0034	0.0017	0.045	0.038	0.031	0.27	0.226	0.0020		
E2	0.45	0.40	1.24	0.009	0.0003	0.0032	0.0026	0.043	0.038	0.042	0.31	0.133	0.0026		
E3	0.47	0.45	1.25	0.009	0.0008	0.0020	0.0014	0.050	0.018	0.032	0.23	0.175	0.0020		
E4	0.47	0.42	1.29	0.007	0.0011	0.0030	0.0030	0.047	0.028	0.033	0.29	0.203	0.0019		
E5	0.46	0.42	1.33	0.005	0.0021	0.0032	0.0024	0.041	0.038	0.035	0.34	0.137	0.0028		
E6	0.47	0.42	1.21	0.009	0.0045	0.0033	0.0027	0.048	0.034	0.033	0.25	0.201	0.0022		
E7	0.47	0.45	1.34	0.006	0.0065	0.0020	0.0024	0.040	0.023	0.045	0.30	0.215	0.0031		
E8	0.46	0.43	1.31	0.004	0.0091	0.0033	0.0019	0.044	0.037	0.031	0.28	0.161	0.0030		
E9	0.46	0.44	1.35	0.008	<u>0.0151</u>	0.0019	0.0034	0.039	0.038	0.045	0.24	0.224	0.0022		
F1	0.45	0.42	1.27	0.007	0.0006	0.0002	0.0025	0.039	0.028	0.036	0.29	0.175	0.0019		
F2	0.47	0.41	1.31	0.005	0.0015	0.0008	0.0022	0.049	0.035	0.027	0.32	0.199	0.0021		
F3	0.45	0.45	1.32	0.004	0.0004	0.0018	0.0035	0.045	0.030	0.028	0.23	0.139	0.0021		
F4	0.46	0.42	1.33	0.005	0.0021	0.0031	0.0035	0.045	0.040	0.044	0.28	0.153	0.0022		
F5	0.47	0.41	1.33	0.005	0.0003	0.0047	0.0021	0.046	0.021	0.033	0.33	0.168	0.0028		
F6	0.45	0.39	1.28	0.004	0.0008	0.0067	0.0024	0.041	0.041	0.042	0.31	0.147	0.0021		
F7	0.45	0.41	1.31	0.009	0.0004	0.0102	0.0028	0.043	0.038	0.042	0.30	0.177	0.0029		
F8	0.47	0.45	1.35	0.004	0.0016	0.0179	0.0021	0.045	0.026	0.038	0.23	0.173	0.0031		
F9	0.47	0.40	1.25	0.007	0.0003	<u>0.0211</u>	0.0033	0.044	0.040	0.033	0.26	0.197	0.0023		
G1	0.47	0.42	1.30	0.004	0.0015	0.0030	0.0006	0.043	0.036	0.026	0.29	0.207	0.0020		
G2	0.46	0.42	1.32	0.007	0.0008	0.0023	0.0013	0.050	0.038	0.043	0.23	0.180	0.0020		
Underlines show outside scope of present invention.															

[Table 1-2]

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[0115]

Table 1-2

Steel	Chemical composition (mass%), bal.: Fe and impurities											
	C	Si	Mn	P	S	N	O	Al	Nb	Ti	Cr	Mo
G3	0.46	0.43	1.25	0.007	0.0012	0.0020	0.0022	0.045	0.039	0.039	0.32	0.196
G4	0.45	0.42	1.27	0.005	0.0021	0.0026	0.0034	0.049	0.024	0.026	0.32	0.203
G5	0.45	0.45	1.28	0.007	0.0013	0.0019	0.0051	0.044	0.022	0.029	0.27	0.156
G6	0.45	0.45	1.34	0.008	0.0013	0.0028	0.0083	0.049	0.036	0.043	0.28	0.171
G7	0.47	0.43	1.26	0.004	0.0003	0.0020	0.0197	0.045	0.032	0.041	0.26	0.149
G8	0.46	0.40	1.23	0.009	0.0012	0.0023	0.0237	0.039	0.038	0.041	0.26	0.147
H1	0.46	0.43	1.24	0.004	0.0004	0.0024	0.0034	0.0007	0.037	0.028	0.32	0.198
H2	0.46	0.44	1.35	0.005	0.0016	0.0024	0.0034	0.001	0.026	0.035	0.26	0.177
H3	0.46	0.43	1.26	0.006	0.0007	0.0021	0.0030	0.005	0.030	0.046	0.32	0.151
H4	0.46	0.39	1.23	0.009	0.0012	0.0024	0.0015	0.016	0.042	0.041	0.32	0.220
H5	0.46	0.43	1.30	0.006	0.0020	0.0021	0.0025	0.025	0.032	0.041	0.25	0.143
H6	0.45	0.41	1.25	0.008	0.0011	0.0022	0.0031	0.039	0.037	0.032	0.29	0.210
H7	0.46	0.43	1.35	0.009	0.0005	0.0026	0.0018	0.049	0.029	0.037	0.31	0.197
H8	0.45	0.39	1.27	0.006	0.0015	0.0027	0.0024	0.068	0.027	0.046	0.28	0.139
H9	0.47	0.44	1.32	0.006	0.0004	0.0027	0.0015	0.082	0.019	0.038	0.34	0.144
H10	0.47	0.39	1.27	0.006	0.0007	0.0021	0.0021	0.126	0.024	0.045	0.28	0.178
H11	0.46	0.43	1.33	0.008	0.0018	0.0019	0.0020	0.264	0.034	0.040	0.33	0.190
H12	0.47	0.44	1.24	0.009	0.0006	0.0019	0.0033	0.369	0.026	0.033	0.29	0.218
H13	0.46	0.39	1.23	0.007	0.0005	0.0024	0.0033	0.491	0.035	0.031	0.32	0.153
H14	0.45	0.45	1.30	0.006	0.0013	0.0029	0.0029	0.511	0.032	0.039	0.31	0.149
I1	0.46	0.40	1.22	0.009	0.0007	0.0024	0.0018	0.050	0.0006	0.036	0.33	0.133
I2	0.45	0.43	1.34	0.008	0.0015	0.0034	0.0031	0.045	0.0012	0.037	0.24	0.225
I3	0.46	0.43	1.30	0.005	0.0017	0.0025	0.0032	0.049	0.004	0.029	0.25	0.228
I4	0.47	0.45	1.34	0.005	0.0015	0.0028	0.0016	0.044	0.007	0.043	0.31	0.211

(continued)

Steel	Chemical composition (mass%), bal.: Fe and impurities														
	C	Si	Mn	P	S	N	O	Al	Nb	Ti	Cr	Mo	B	Co	Ni
I5	0.45	0.40	1.31	0.005	0.0008	0.0034	0.0016	0.045	0.012	0.041	0.27	0.218	0.0029		
I6	0.47	0.39	1.30	0.008	0.0010	0.0025	0.0034	0.040	0.018	0.034	0.30	0.143	0.0030		
I7	0.46	0.40	1.25	0.005	0.0012	0.0021	0.0022	0.046	0.025	0.036	0.33	0.136	0.0029		
I8	0.47	0.43	1.26	0.004	0.0010	0.0029	0.0019	0.043	0.037	0.037	0.27	0.183	0.0018		
I9	0.45	0.41	1.30	0.004	0.0017	0.0028	0.0023	0.041	0.041	0.029	0.29	0.140	0.0027		
I10	0.45	0.44	1.22	0.004	0.0006	0.0020	0.0029	0.050	0.056	0.025	0.26	0.158	0.0032		
I11	0.47	0.42	1.34	0.009	0.0021	0.0024	0.0027	0.043	0.065	0.042	0.28	0.228	0.0024		
I12	0.47	0.40	1.24	0.004	0.0021	0.0019	0.0014	0.047	0.081	0.045	0.31	0.199	0.0023		
I13	0.47	0.39	1.32	0.004	0.0009	0.0019	0.0030	0.040	0.091	0.033	0.31	0.146	0.0019		
I14	0.47	0.44	1.28	0.004	0.0010	0.0034	0.0028	0.049	<u>0.126</u>	0.037	0.29	0.156	0.0024		
J1	0.46	0.40	1.26	0.006	0.0016	0.0022	0.0027	0.049	0.042	<u>0.007</u>	0.29	0.206	0.0032		
J2	0.46	0.42	1.26	0.005	0.0013	0.0022	0.0026	0.048	0.032	0.011	0.31	0.189	0.0026		
J3	0.45	0.41	1.25	0.005	0.0017	0.0030	0.0022	0.047	0.042	0.017	0.27	0.194	0.0026		
J4	0.45	0.42	1.27	0.005	0.0014	0.0019	0.0019	0.049	0.021	0.023	0.31	0.210	0.0030		
J5	0.47	0.39	1.34	0.008	0.0008	0.0032	0.0029	0.042	0.023	0.027	0.25	0.134	0.0025		
J6	0.46	0.43	1.33	0.004	0.0022	0.0030	0.0017	0.047	0.030	0.031	0.25	0.170	0.0027		
J7	0.46	0.39	1.21	0.008	0.0003	0.0029	0.0014	0.047	0.028	0.048	0.34	0.136	0.0019		
J8	0.46	0.43	1.21	0.008	0.0019	0.0027	0.0033	0.048	0.034	0.055	0.27	0.194	0.0020		
J9	0.46	0.45	1.34	0.008	0.0014	0.0028	0.0025	0.049	0.041	0.077	0.23	0.140	0.0024		
J10	0.47	0.43	1.23	0.005	0.0014	0.0023	0.0020	0.045	0.023	0.111	0.28	0.224	0.0027		
J11	0.45	0.44	1.23	0.008	0.0013	0.0019	0.0026	0.050	0.041	0.181	0.30	0.132	0.0023		
I12	0.45	0.40	1.28	0.008	0.0009	0.0021	0.0018	0.041	0.024	<u>0.211</u>	0.29	0.175	0.0027		
K1	0.47	0.43	1.29	0.004	0.0007	0.0032	0.0020	0.041	0.038	0.045	<u>0.008</u>	0.188	0.0021		
K2	0.47	0.41	1.27	0.004	0.0006	0.0027	0.0023	0.039	0.024	0.030	0.012	0.211	0.0024		
K3	0.46	0.40	1.34	0.004	0.0006	0.0021	0.0022	0.039	0.039	0.037	0.049	0.229	0.0019		

(continued)

Steel	Chemical composition (mass%), bal.: Fe and impurities														
	C	Si	Mn	P	S	N	O	Al	Nb	Ti	Cr	Mo	B	Co	Ni
K4	0.45	0.41	1.30	0.009	0.0012	0.0027	0.0019	0.039	0.026	0.035	0.081	0.133	0.0033		
K5	0.45	0.40	1.31	0.007	0.0015	0.0019	0.0016	0.050	0.031	0.032	0.13	0.229	0.0018		
K6	0.46	0.40	1.35	0.004	0.0015	0.0021	0.0017	0.043	0.039	0.037	0.19	0.183	0.0024		
K7	0.47	0.45	1.24	0.008	0.0018	0.0031	0.0034	0.045	0.022	0.034	0.21	0.186	0.0025		
K8	0.45	0.42	1.35	0.008	0.0022	0.0019	0.0024	0.044	0.038	0.030	0.27	0.181	0.0025		
K9	0.45	0.43	1.34	0.004	0.0010	0.0027	0.0021	0.049	0.038	0.039	0.33	0.215	0.0026		
K10	0.45	0.40	1.31	0.006	0.0003	0.0032	0.0019	0.050	0.022	0.043	0.42	0.221	0.0019		
K11	0.46	0.43	1.31	0.007	0.0005	0.0030	0.0029	0.039	0.031	0.033	0.61	0.170	0.0031		
K12	0.45	0.40	1.25	0.006	0.0004	0.0023	0.0029	0.050	0.041	0.034	0.78	0.204	0.0029		
K13	0.47	0.43	1.30	0.006	0.0011	0.0027	0.0022	0.043	0.028	0.038	0.92	0.132	0.0020		
K14	0.45	0.45	1.32	0.006	0.0012	0.0032	0.0033	0.049	0.039	0.036	<u>1.12</u>	0.204	0.0022		
L1	0.47	0.41	1.22	0.009	0.0003	0.0025	0.0035	0.039	0.019	0.036	0.33	<u>0.0009</u>	0.0018		
L2	0.45	0.43	1.28	0.004	0.0014	0.0026	0.0028	0.050	0.029	0.035	0.26	0.0012	0.0032		
L3	0.46	0.43	1.29	0.004	0.0015	0.0022	0.0025	0.050	0.036	0.039	0.32	0.0051	0.0027		
L4	0.47	0.44	1.31	0.004	0.0008	0.0033	0.0035	0.039	0.019	0.041	0.25	0.023	0.0025		
L5	0.46	0.41	1.34	0.005	0.0008	0.0021	0.0023	0.039	0.030	0.028	0.31	0.072	0.0031		
L6	0.45	0.41	1.22	0.009	0.0015	0.0022	0.0034	0.041	0.025	0.029	0.29	0.137	0.0024		
L7	0.45	0.44	1.35	0.007	0.0008	0.0028	0.0023	0.046	0.036	0.029	0.31	0.193	0.0026		
L8	0.45	0.39	1.21	0.004	0.0022	0.0024	0.0028	0.040	0.038	0.026	0.23	0.231	0.0029		
L9	0.47	0.43	1.34	0.007	0.0009	0.0025	0.0017	0.050	0.020	0.041	0.28	0.351	0.0024		
L10	0.45	0.44	1.23	0.008	0.0020	0.0030	0.0035	0.044	0.040	0.040	0.28	0.496	0.0018		
L11	0.47	0.39	1.29	0.005	0.0019	0.0033	0.0016	0.042	0.032	0.031	0.26	0.673	0.0019		
L12	0.45	0.41	1.32	0.009	0.0010	0.0028	0.0022	0.050	0.037	0.028	0.28	0.877	0.0030		
Underlines show outside scope of present invention.															

[Table 1-3]

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Chemical composition (mass%), bal.: Fe and impurities

Steel	Chemical composition (mass%), bal.: Fe and impurities														
	C	Si	Mn	P	S	N	O	Al	Nb	Ti	Cr	Mo	B	Co	Ni
L13	0.46	0.40	1.28	0.006	0.0022	0.0032	0.0033	0.046	0.028	0.025	0.25	1.236	0.0019		
M1	0.47	0.42	1.26	0.007	0.0018	0.0032	0.0031	0.047	0.019	0.028	0.34	0.130	0.0002		
M2	0.46	0.40	1.24	0.007	0.0016	0.0020	0.0022	0.050	0.036	0.025	0.32	0.180	0.0006		
M3	0.46	0.42	1.21	0.008	0.0018	0.0024	0.0034	0.041	0.023	0.033	0.27	0.188	0.0011		
M4	0.47	0.40	1.24	0.004	0.0013	0.0027	0.0033	0.049	0.034	0.033	0.25	0.213	0.0017		
M5	0.47	0.42	1.25	0.006	0.0020	0.0020	0.0034	0.044	0.031	0.044	0.34	0.174	0.0022		
M6	0.46	0.45	1.21	0.005	0.0012	0.0020	0.0023	0.050	0.025	0.044	0.32	0.149	0.0031		
M7	0.45	0.39	1.29	0.004	0.0009	0.0024	0.0032	0.043	0.024	0.025	0.32	0.134	0.0045		
M8	0.45	0.45	1.35	0.007	0.0022	0.0021	0.0018	0.044	0.032	0.043	0.24	0.192	0.0072		
M9	0.45	0.42	1.21	0.008	0.0009	0.0034	0.0034	0.040	0.034	0.040	0.31	0.136	0.0119		
M10	0.45	0.45	1.33	0.007	0.0009	0.0023	0.0034	0.041	0.041	0.034	0.25	0.135	0.0178		
M11	0.45	0.44	1.30	0.009	0.0015	0.0030	0.0031	0.049	0.021	0.044	0.27	0.180	0.0221		
N1	0.45	0.44	1.27	0.007	0.0006	0.0029	0.0019	0.043	0.019	0.037	0.29	0.132	0.0033	0.05	
N2	0.45	0.45	1.27	0.004	0.0006	0.0024	0.0023	0.050	0.039	0.029	0.28	0.172	0.0018	0.12	
N3	0.46	0.40	1.29	0.005	0.0021	0.0031	0.0015	0.049	0.018	0.030	0.28	0.155	0.0032	0.22	
N4	0.47	0.39	1.34	0.005	0.0020	0.0032	0.0014	0.049	0.036	0.027	0.32	0.131	0.0033	0.42	
N5	0.46	0.42	1.21	0.007	0.0019	0.0032	0.0016	0.043	0.029	0.038	0.25	0.167	0.0023	0.61	
N6	0.45	0.41	1.21	0.006	0.0008	0.0027	0.0023	0.050	0.041	0.038	0.31	0.198	0.0024	0.85	
N7	0.47	0.45	1.27	0.007	0.0018	0.0029	0.0021	0.040	0.037	0.029	0.28	0.221	0.0025	1.11	
N8	0.46	0.40	1.35	0.006	0.0013	0.0033	0.0019	0.049	0.033	0.032	0.27	0.131	0.0020	1.35	
N9	0.46	0.45	1.35	0.005	0.0004	0.0031	0.0018	0.050	0.037	0.042	0.28	0.211	0.0031	1.57	
N 10	0.47	0.44	1.27	0.004	0.0008	0.0031	0.0026	0.046	0.025	0.041	0.24	0.152	0.0019	1.72	
N11	0.47	0.40	1.31	0.007	0.0006	0.0027	0.0025	0.050	0.038	0.027	0.28	0.210	0.0022	1.91	
N12	0.47	0.40	1.35	0.004	0.0015	0.0022	0.0028	0.045	0.028	0.034	0.32	0.191	0.0029	2.56	

(continued)

Steel	Chemical composition (mass%), bal.: Fe and impurities														
	C	Si	Mn	P	S	N	O	Al	Nb	Ti	Cr	Mo	B	Co	Ni
N13	0.47	0.44	1.23	0.008	0.0018	0.0020	0.0027	0.040	0.026	0.028	0.25	0.181	0.0027	3.55	
O1	0.46	0.43	1.22	0.006	0.0015	0.0030	0.0030	0.043	0.019	0.029	0.28	0.153	0.0026		0.02
O2	0.46	0.41	1.26	0.006	0.0015	0.0026	0.0032	0.047	0.035	0.041	0.31	0.130	0.0027		0.13
O3	0.46	0.39	1.27	0.004	0.0013	0.0030	0.0021	0.049	0.022	0.038	0.32	0.155	0.0021		0.23
O4	0.45	0.42	1.34	0.006	0.0017	0.0019	0.0026	0.048	0.026	0.043	0.26	0.150	0.0022		0.41
O5	0.46	0.45	1.25	0.004	0.0019	0.0033	0.0031	0.049	0.041	0.029	0.25	0.151	0.0027		0.84
O6	0.47	0.41	1.35	0.008	0.0022	0.0024	0.0025	0.043	0.019	0.045	0.27	0.200	0.0030		1.21
O7	0.46	0.44	1.21	0.005	0.0017	0.0021	0.0014	0.044	0.031	0.026	0.32	0.162	0.0028		1.62
O8	0.45	0.40	1.35	0.004	0.0011 1	0.0024	0.0028	0.045	0.041	0.035	0.30	0.168	0.0025		1.92
O9	0.45	0.40	1.30	0.009	0.0005	0.0023	0.0018	0.049	0.030	0.033	0.28	0.176	0.0030		2.11
O10	0.45	0.44	1.23	0.009	0.0018	0.0019	0.0024	0.039	0.020	0.036	0.32	0.164	0.0028		2.56
O11	0.47	0.39	1.35	0.008	0.0010	0.0025	0.0017	0.040	0.029	0.027	0.33	0.154	0.0030		2.79
O12	0.47	0.43	1.25	0.006	0.0018	0.0027	0.0033	0.047	0.022	0.026	0.33	0.220	0.0028		2.91
P1	0.47	0.42	1.26	0.005	0.0015	0.0032	0.0025	0.040	0.022	0.041	0.28	0.135	0.0032		
P2	0.45	0.40	1.33	0.005	0.0020	0.0029	0.0021	0.040	0.025	0.027	0.23	0.163	0.0026		
P3	0.45	0.45	1.27	0.006	0.0008	0.0028	0.0020	0.042	0.018	0.034	0.34	0.153	0.0021		
P4	0.46	0.39	1.35	0.004	0.0006	0.0033	0.0017	0.050	0.024	0.030	0.31	0.136	0.0025		
P5	0.45	0.45	1.33	0.007	0.0016	0.0024	0.0016	0.047	0.026	0.040	0.26	0.176	0.0021		
P6	0.45	0.39	1.24	0.008	0.0013	0.0027	0.0022	0.043	0.022	0.030	0.31	0.164	0.0024		
P7	0.45	0.43	1.25	0.006	0.0009	0.0029	0.0019	0.044	0.022	0.041	0.23	0.229	0.0027		
P8	0.45	0.45	1.26	0.007	0.0008	0.0019	0.0029	0.047	0.023	0.031	0.33	0.221	0.0022		
P9	0.45	0.44	1.28	0.008	0.0016	0.0033	0.0023	0.047	0.034	0.039	0.24	0.188	0.0032		
P10	0.46	0.45	1.22	0.008	0.0012	0.0022	0.0030	0.044	0.026	0.028	0.25	0.188	0.0022		
P11	0.46	0.44	1.22	0.004	0.0013	0.0034	0.0035	0.044	0.037	0.032	0.23	0.181	0.0019		
P12	0.45	0.42	1.27	0.009	0.0003	0.0025	0.0019	0.049	0.021	0.031	0.28	0.132	0.0023		

(continued)

Steel	Chemical composition (mass%), bal.: Fe and impurities														
	C	Si	Mn	P	S	N	O	Al	Nb	Ti	Cr	Mo	B	Co	Ni
Q1	0.47	0.45	1.34	0.006	0.0017	0.0026	0.0026	0.040	0.027	0.040	0.34	0.182	0.0027		
Q2	0.45	0.45	1.35	0.008	0.0003	0.0033	0.0028	0.045	0.020	0.027	0.30	0.136	0.0022		
Q3	0.47	0.39	1.24	0.009	0.0013	0.0019	0.0032	0.045	0.029	0.046	0.27	0.215	0.0020		
Q4	0.45	0.39	1.32	0.005	0.0012	0.0025	0.0017	0.048	0.019	0.032	0.23	0.230	0.0029		
Q5	0.46	0.43	1.32	0.007	0.0015	0.0021	0.0024	0.041	0.023	0.041	0.28	0.191	0.0032		
Q6	0.47	0.42	1.31	0.005	0.0022	0.0027	0.0025	0.048	0.034	0.026	0.26	0.203	0.0024		
Q7	0.47	0.43	1.32	0.005	0.0016	0.0029	0.0030	0.039	0.022	0.033	0.32	0.215	0.0027		
Q8	0.47	0.45	1.27	0.006	0.0007	0.0019	0.0031	0.049	0.021	0.035	0.29	0.141	0.0020		
Q9	0.47	0.41	1.29	0.004	0.0007	0.0034	0.0020	0.045	0.041	0.034	0.24	0.154	0.0030		
Q10	0.46	0.43	1.23	0.008	0.0010	0.0030	0.0015	0.042	0.028	0.026	0.26	0.154	0.0019		
Q11	0.45	0.44	1.26	0.006	0.0017	0.0019	0.0023	0.039	0.025	0.031	0.34	0.152	0.0029		
Q12	0.46	0.41	1.30	0.004	0.0007	0.0021	0.0023	0.045	0.035	0.042	0.27	0.148	0.0029		
R1	0.46	0.39	1.31	0.004	0.0008	0.0028	0.0026	0.047	0.030	0.030	0.34	0.165	0.0031		
R2	0.45	0.42	1.30	0.008	0.0009	0.0033	0.0025	0.044	0.026	0.042	0.26	0.140	0.0031		
R3	0.45	0.41	1.26	0.008	0.0005	0.0028	0.0020	0.040	0.037	0.028	0.30	0.178	0.0027		
R4	0.47	0.45	1.26	0.006	0.0009	0.0031	0.0032	0.044	0.038	0.036	0.27	0.218	0.0018		
R5	0.47	0.40	1.26	0.006	0.0022	0.0021	0.0022	0.048	0.026	0.033	0.29	0.161	0.0033		
R6	0.47	0.40	1.21	0.008	0.0018	0.0020	0.0021	0.042	0.042	0.035	0.30	0.152	0.0021		
R7	0.46	0.42	1.32	0.008	0.0008	0.0031	0.0016	0.043	0.034	0.028	0.30	0.162	0.0031		
R8	0.45	0.43	1.30	0.008	0.0019	0.0033	0.0033	0.039	0.036	0.044	0.30	0.219	0.0031		
S1	0.45	0.45	1.22	0.007	0.0003	0.0028	0.0017	0.046	0.025	0.040	0.32	0.161	0.0021		
S2	0.47	0.43	1.30	0.009	0.0014	0.0024	0.0029	0.039	0.028	0.031	0.25	0.173	0.0026		
S3	0.45	0.40	1.35	0.004	0.0013	0.0030	0.0032	0.042	0.029	0.043	0.24	0.180	0.0023		
Underlines show outside scope of present invention.															

[Table 1-4]

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Table 1-4

Steel	Chemical composition (mass%), bal.: Fe and impurities													Co	Ni
	C	Si	Mn	P	S	N	O	Al	Nb	Ti	Cr	Mo	B		
S4	0.46	0.44	1.25	0.008	0.0020	0.0029	0.0014	0.049	0.036	0.046	0.30	0.148	0.0025		
S5	0.47	0.44	1.22	0.004	0.0003	0.0021	0.0017	0.043	0.041	0.046	0.32	0.148	0.0026		
S6	0.45	0.41	1.25	0.005	0.0012	0.0024	0.0029	0.044	0.026	0.046	0.30	0.209	0.0029		
S7	0.46	0.45	1.32	0.009	0.0021	0.0032	0.0032	0.040	0.039	0.033	0.28	0.145	0.0025		
S8	0.45	0.43	1.25	0.004	0.0017	0.0030	0.0014	0.049	0.036	0.029	0.27	0.161	0.0027		
T1	0.46	0.45	1.27	0.004	0.0021	0.0026	0.0021	0.042	0.030	0.025	0.32	0.204	0.0024		
T2	0.46	0.42	1.34	0.009	0.0004	0.0021	0.0035	0.040	0.021	0.034	0.26	0.217	0.0020		
T3	0.46	0.39	1.21	0.007	0.0022	0.0023	0.0032	0.044	0.031	0.038	0.27	0.177	0.0025		
T4	0.45	0.41	1.29	0.007	0.0009	0.0023	0.0034	0.039	0.018	0.033	0.24	0.181	0.0033		
T5	0.47	0.42	1.30	0.004	0.0006	0.0027	0.0016	0.048	0.028	0.038	0.26	0.206	0.0019		
T6	0.45	0.45	1.24	0.005	0.0019	0.0032	0.0014	0.045	0.031	0.043	0.23	0.227	0.0020		
T7	0.47	0.41	1.29	0.009	0.0003	0.0030	0.0029	0.050	0.034	0.031	0.34	0.159	0.0032		
T8	0.45	0.42	1.25	0.008	0.0009	0.0025	0.0027	0.040	0.034	0.040	0.31	0.138	0.0022		
U1	0.46	0.45	1.23	0.008	0.0014	0.0029	0.0021	0.045	0.024	0.034	0.34	0.203	0.0022		
U2	0.47	0.42	1.33	0.004	0.0017	0.0020	0.0035	0.042	0.024	0.039	0.27	0.193	0.0032		
U3	0.47	0.39	1.32	0.009	0.0015	0.0029	0.0014	0.043	0.029	0.032	0.28	0.172	0.0024		
U4	0.45	0.40	1.28	0.006	0.0014	0.0028	0.0025	0.041	0.037	0.033	0.34	0.181	0.0029		
U5	0.46	0.45	1.32	0.005	0.0021	0.0030	0.0021	0.039	0.036	0.036	0.27	0.158	0.0023		
U6	0.46	0.40	1.31	0.006	0.0020	0.0023	0.0034	0.041	0.021	0.041	0.26	0.165	0.0030		
U7	0.45	0.43	1.28	0.005	0.0008	0.0032	0.0028	0.043	0.031	0.041	0.23	0.209	0.0022		
U8	0.46	0.43	1.32	0.004	0.0007	0.0021	0.0025	0.050	0.039	0.035	0.26	0.149	0.0023		
V1	0.45	0.45	1.35	0.006	0.0017	0.0032	0.0014	0.047	0.021	0.032	0.31	0.150	0.0021		
V2	0.47	0.41	1.32	0.007	0.0004	0.0022	0.0022	0.046	0.020	0.043	0.31	0.203	0.0028		
V3	0.45	0.44	1.34	0.009	0.0016	0.0032	0.0031	0.047	0.035	0.046	0.28	0.210	0.0025		

(continued)

Chemical composition (mass%), bal.: Fe and impurities															
Steel	C	Si	Mn	P	S	N	O	Al	Nb	Ti	Cr	Mo	B	Co	Ni
V4	0.46	0.45	1.35	0.009	0.0017	0.0025	0.0033	0.040	0.039	0.042	0.27	0.228	0.0023		
V5	0.47	0.42	1.31	0.007	0.0010	0.0028	0.0032	0.049	0.023	0.029	0.33	0.159	0.0021		
V6	0.46	0.43	1.33	0.005	0.0021	0.0028	0.0022	0.044	0.028	0.033	0.33	0.203	0.0025		
V7	0.46	0.45	1.25	0.009	0.0006	0.0026	0.0018	0.047	0.035	0.039	0.33	0.189	0.0024		
V8	0.46	0.40	1.22	0.004	0.0006	0.0025	0.0028	0.047	0.041	0.044	0.27	0.230	0.0031		
W1	0.46	0.45	1.35	0.008	0.0006	0.0025	0.0021	0.046	0.034	0.034	0.32	0.175	0.0028		
W2	0.46	0.41	1.23	0.007	0.0009	0.0032	0.0032	0.049	0.031	0.030	0.30	0.152	0.0023		
W3	0.46	0.41	1.30	0.005	0.0007	0.0026	0.0033	0.047	0.024	0.037	0.32	0.174	0.0023		
W4	0.46	0.41	1.34	0.007	0.0020	0.0032	0.0023	0.050	0.018	0.032	0.34	0.230	0.0033		
W5	0.45	0.42	1.24	0.005	0.0003	0.0023	0.0025	0.044	0.038	0.030	0.30	0.148	0.0024		
W6	0.47	0.45	1.24	0.009	0.0017	0.0024	0.0014	0.047	0.024	0.026	0.30	0.203	0.0028		
W7	0.46	0.40	1.32	0.005	0.0004	0.0025	0.0014	0.050	0.023	0.040	0.30	0.228	0.0019		
W8	0.46	0.44	1.31	0.006	0.0009	0.0030	0.0022	0.048	0.019	0.042	0.29	0.178	0.0018		
X1	0.45	0.40	1.21	0.006	0.0016	0.0030	0.0025	0.046	0.027	0.025	0.34	0.207	0.0021		
X2	0.46	0.39	1.22	0.008	0.0010	0.0028	0.0018	0.048	0.031	0.037	0.30	0.132	0.0024		
X3	0.46	0.45	1.24	0.006	0.0020	0.0022	0.0031	0.043	0.022	0.039	0.32	0.212	0.0033		
Y1	0.47	0.40	1.24	0.009	0.0007	0.0019	0.0019	0.040	0.038	0.026	0.33	0.202	0.0029		
Y2	0.46	0.44	1.21	0.007	0.0008	0.0026	0.0030	0.049	0.035	0.031	0.31	0.142	0.0018		
Y3	0.45	0.39	1.28	0.009	0.0013	0.0032	0.0024	0.043	0.039	0.041	0.29	0.161	0.0029		
Y4	0.46	0.39	1.32	0.008	0.0004	0.0019	0.0028	0.041	0.021	0.039	0.29	0.147	0.0021		
Y5	0.46	0.43	1.31	0.005	0.0013	0.0022	0.0020	0.041	0.042	0.027	0.33	0.174	0.0028		
Y6	0.46	0.41	1.35	0.004	0.0020	0.0031	0.0021	0.046	0.025	0.036	0.31	0.216	0.0033		
Y7	0.45	0.40	1.22	0.004	0.0005	0.0023	0.0020	0.045	0.039	0.037	0.31	0.173	0.0032		
Y8	0.47	0.42	1.31	0.006	0.0015	0.0031	0.0026	0.049	0.036	0.027	0.31	0.142	0.0025		
Y9	0.46	0.45	1.28	0.004	0.0017	0.0033	0.0018	0.045	0.029	0.030	0.24	0.170	0.0031		

(continued)

Chemical composition (mass%), bal.: Fe and impurities															
Steel	C	Si	Mn	P	S	N	O	Al	Nb	Ti	Cr	Mo	B	Co	Ni
Y10	0.45	0.42	1.34	0.004	0.0018	0.0022	0.0014	0.050	0.019	0.035	0.33	0.180	0.0029		
Z1	0.46	0.45	1.28	0.006	0.0020	0.0025	0.0020	0.039	0.021	0.037	0.24	0.147	0.0022		
Z2	0.45	0.40	1.35	0.005	0.0015	0.0019	0.0035	0.043	0.026	0.032	0.27	0.223	0.0026		
Z3	0.46	0.39	1.25	0.004	0.0019	0.0023	0.0031	0.042	0.035	0.041	0.32	0.206	0.0018		
Z4	0.47	0.43	1.24	0.005	0.0006	0.0019	0.0017	0.050	0.026	0.044	0.26	0.195	0.0032		
Z5	0.47	0.45	1.21	0.005	0.0008	0.0030	0.0033	0.048	0.030	0.026	0.32	0.138	0.0032		
Z6	0.46	0.44	1.23	0.007	0.0014	0.0032	0.0015	0.045	0.038	0.025	0.25	0.145	0.0026		
Z7	0.47	0.41	1.33	0.009	0.0016	0.0022	0.0015	0.044	0.026	0.036	0.33	0.224	0.0018		
Z8	0.46	0.42	1.26	0.006	0.0009	0.0029	0.0024	0.050	0.034	0.036	0.32	0.145	0.0031		
Z9	0.45	0.39	1.26	0.004	0.0006	0.0031	0.0017	0.046	0.034	0.037	0.24	0.208	0.0023		
Z10	0.46	0.44	1.35	0.006	0.0005	0.0029	0.0024	0.043	0.027	0.032	0.29	0.171	0.0031		
AA1	0.46	0.44	1.28	0.005	0.0020	0.0020	0.0030	0.048	0.018	0.026	0.25	0.181	0.0022		
AA2	0.47	0.43	1.23	0.004	0.0015	0.0027	0.0029	0.045	0.028	0.043	0.27	0.212	0.0022		
AA3	0.46	0.44	1.35	0.008	0.0015	0.0033	0.0019	0.043	0.023	0.030	0.23	0.148	0.0022		
AA4	0.47	0.45	1.26	0.004	0.0007	0.0028	0.0027	0.043	0.040	0.042	0.30	0.173	0.0019		
AA5	0.46	0.44	1.24	0.005	0.0009	0.0020	0.0020	0.046	0.031	0.040	0.34	0.174	0.0022		
AA6	0.47	0.45	1.24	0.005	0.0015	0.0027	0.0020	0.042	0.019	0.044	0.24	0.203	0.0020		
AA7	0.45	0.44	1.31	0.005	0.0004	0.0023	0.0025	0.044	0.029	0.029	0.25	0.191	0.0033		
AA8	0.47	0.41	1.24	0.006	0.0005	0.0028	0.0023	0.040	0.030	0.044	0.24	0.163	0.0025		
AA9	0.46	0.44	1.27	0.004	0.0013	0.0022	0.0018	0.039	0.028	0.032	0.27	0.182	0.0019		
AA10	0.47	0.42	1.34	0.009	0.0013	0.0022	0.0023	0.042	0.034	0.032	0.28	0.191	0.0023		
BB1	0.46	0.44	1.33	0.007	0.0009	0.0030	0.0032	0.041	0.019	0.034	0.26	0.145	0.0032		
BB2	0.47	0.43	1.24	0.008	0.0007	0.0029	0.0023	0.041	0.028	0.041	0.31	0.151	0.0022		
Underlines show outside scope of present invention.															

[Table 1-5]

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[0118]

Table 1-5

Steel	Chemical composition (mass%), bal.: Fe and impurities														
	C	Si	Mn	P	S	N	O	Al	Nb	Ti	Cr	Mo	B	Co	Ni
BB3	0.46	0.39	1.30	0.004	0.0014	0.0020	0.0030	0.048	0.025	0.040	0.31	0.171	0.0024		
BB4	0.45	0.40	1.24	0.008	0.0014	0.0019	0.0024	0.044	0.029	0.035	0.29	0.184	0.0019		
BBS	0.47	0.39	1.21	0.008	0.0018	0.0027	0.0017	0.044	0.039	0.031	0.34	0.219	0.0033		
BB6	0.46	0.42	1.31	0.006	0.0015	0.0030	0.0033	0.042	0.029	0.033	0.25	0.196	0.0032		
BB7	0.47	0.43	1.33	0.009	0.0017	0.0019	0.0023	0.039	0.035	0.045	0.30	0.225	0.0028		
BBS	0.47	0.44	1.27	0.006	0.0014	0.0019	0.0031	0.040	0.027	0.025	0.27	0.227	0.0024		
BB9	0.46	0.41	1.22	0.007	0.0009	0.0024	0.0031	0.050	0.029	0.043	0.34	0.162	0.0018		
BB10	0.45	0.45	1.34	0.008	0.0007	0.0027	0.0034	0.044	0.042	0.043	0.25	0.141	0.0022		
CC1	0.46	0.44	1.21	0.005	0.0013	0.0026	0.0015	0.047	0.020	0.043	0.34	0.140	0.0033		
CC2	0.45	0.40	1.24	0.009	0.0019	0.0025	0.0027	0.049	0.025	0.035	0.33	0.173	0.0031		
CC3	0.46	0.42	1.30	0.005	0.0006	0.0021	0.0031	0.039	0.025	0.046	0.25	0.230	0.0024		
CC4	0.47	0.41	1.31	0.007	0.0022	0.0021	0.0024	0.044	0.026	0.032	0.28	0.167	0.002 1		
CC5	0.46	0.45	1.24	0.007	0.0022	0.0024	0.0034	0.048	0.040	0.025	0.25	0.148	0.0032		
CC6	0.47	0.39	1.22	0.006	0.0013	0.0027	0.0026	0.042	0.026	0.027	0.23	0.171	0.0033		
CC7	0.46	0.39	1.29	0.008	0.002 1	0.0022	0.0030	0.043	0.026	0.040	0.27	0.200	0.0022		
CC8	0.46	0.39	1.22	0.008	0.0009	0.0020	0.0030	0.044	0.032	0.029	0.29	0.203	0.0018		
CC9	0.45	0.40	1.22	0.004	0.0005	0.0029	0.0028	0.044	0.030	0.038	0.25	0.148	0.0033		
CC10	0.47	0.43	1.28	0.009	0.0008	0.0031	0.0029	0.041	0.032	0.037	0.25	0.160	0.0020		
DD1	0.46	0.41	1.25	0.006	0.0011	0.0025	0.0029	0.048	0.025	0.025	0.23	0.192	0.0033		
DD2	0.46	0.42	1.26	0.007	0.0006	0.0033	0.0026	0.044	0.027	0.038	0.34	0.148	0.0027		
DD3	0.46	0.39	1.24	0.004	0.0017	0.0033	0.0023	0.047	0.018	0.026	0.32	0.141	0.0027		
DD4	0.45	0.45	1.22	0.007	0.0013	0.0026	0.0015	0.049	0.031	0.026	0.30	0.131	0.0022		
DD5	0.47	0.43	1.25	0.009	0.0012	0.0023	0.0019	0.045	0.019	0.035	0.24	0.230	0.0022		
DD6	0.46	0.41	1.26	0.006	0.0022	0.0023	0.0024	0.043	0.034	0.030	0.27	0.147	0.0027		

(continued)

Steel	Chemical composition (mass%), bal.: Fe and impurities										
	C	Si	Mn	P	S	N	O	Al	Nb	Ti	Cr
DD7	0.46	0.39	1.30	0.007	0.0014	0.0022	0.0026	0.044	0.028	0.040	0.24
DD8	0.45	0.44	1.35	0.008	0.0017	0.002 1	0.0035	0.047	0.018	0.037	0.25
DD9	0.47	0.42	1.24	0.004	0.0014	0.0032	0.0032	0.050	0.032	0.041	0.29
DD10	0.46	0.39	1.26	0.008	0.0016	0.0024	0.0015	0.050	0.027	0.034	0.31
EE1	0.46	0.40	1.22	0.007	0.0022	0.0030	0.0028	0.054	0.021	0.036	0.32
EE2	0.48	0.41	1.21	0.004	0.0024	0.0019	0.0023	0.046	0.032	0.045	0.35
EE3	0.47	0.41	1.29	0.003	0.0008	0.0032	0.0020	0.057	0.033	0.042	0.33
EE4	0.45	0.45	1.30	0.009	0.0021	0.0023	0.0019	0.053	0.030	0.034	0.35
EE5	0.46	0.45	0.81	0.007	0.0011	0.0020	0.0017	0.045	0.032	0.042	0.24
EE6	0.47	0.45	1.30	0.006	0.0005	0.0029	0.0015	0.048	0.020	0.029	0.27
EE7	0.45	0.43	2.05	0.003	0.0011	0.0022	0.0027	0.046	0.040	0.031	0.27
EE8	0.46	0.44	2.24	0.004	0.0005	0.0032	0.0035	0.040	0.023	0.029	0.32
Underlines show outside scope of present invention.											

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[Table 1-6]

[0119]

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Table 1-6

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Steel	Chemical composition (mass%), bal.: Fe and impurities															Remarks
	Cu	V	Ca	Me	REM	Sb	Zr	Sn	As	W	Ta	Re	Os	Ir	Tc	
A1																Comp. steel
A2																Inv. steel
A3																Inv. steel
A4																Inv. steel
A5																Inv. steel
A6																Inv. steel
A7																Inv. steel
A8																Inv. steel
A9																Inv. steel
A10																Inv. steel
A11																Inv. steel
A12																Inv. steel
A13																Inv. steel
A14																Comp. steel
B1																Comp. steel
B2																Inv. steel
B3																Inv. steel
B4																Inv. steel
B5																Inv. steel
B6																Inv. steel
B7																Inv. steel
B8																Inv. steel
B9																Inv. steel
B10																Inv. steel
B11																Inv. steel
B12																Inv. steel
B13																Inv. steel
B14																Inv. steel
B15																Comp. steel
C1																Comp. steel
C2																Inv. steel
C3																Inv. steel

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(continued)

Steel	Chemical composition (mass%), bal.: Fe and impurities															Remarks
	Cu	V	Ca	Me	REM	Sb	Zr	Sn	As	W	Ta	Re	Os	Ir	Tc	
5	C4															Inv. steel
	C5															Inv. steel
	C6															Inv. steel
10	C7															Inv. steel
	C8															Inv. steel
	C9															Inv. steel
	C10															Inv. steel
15	C11															Inv. steel
	C12															Inv. steel
	C13															Inv. steel
20	C14															Comp. steel
	D1															Inv. steel
	D2															Inv. steel
25	D3															Inv. steel
	D4															Inv. steel
	D5															Inv. steel
	D6															Inv. steel
30	D7															Inv. steel
	D8															Inv. steel
	D9															Comp. steel
35	E1															Inv. steel
	E2															Inv. steel
	E3															Inv. steel
40	E4															Inv. steel
	E5															Inv. steel
	E6															Inv. steel
	E7															Inv. steel
45	E8															Inv. steel
	E9															Comp. steel
50	F1															Inv. steel
	F2															Inv. steel
	F3															Inv. steel
	F4															Inv. steel
55	F5															Inv. steel
	F6															Inv. steel
	F7															Inv. steel

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(continued)

Steel	Chemical composition (mass%), bal.: Fe and impurities															Remarks
	Cu	V	Ca	Me	REM	Sb	Zr	Sn	As	W	Ta	Re	Os	Ir	Tc	
F8																Inv. steel
F9																Comp. steel
G1																Inv. steel
G2																Inv. steel
Underlines show outside scope of present invention.																

[Table 1-7]

[0120]

Table 1-7

Steel	Chemical composition (mass%), bal.: Fe and impurities															Remarks
	Cu	V	Ca	Mg	REM	Sb	Zr	Sn	As	W	Ta	Re	Os	Ir	Tc	
G3																Inv. steel
G4																Inv. steel
G5																Inv. steel
G6																Inv. steel
G7																Inv. steel
G8																Comp. steel
H1																Comp. steel
H2																Inv. steel
H3																Inv. steel
H4																Inv. steel
H5																Inv. steel
H6																Inv. steel
H7																Inv. steel
H8																Inv. steel
H9																Inv. steel
H10																Inv. steel
H11																Inv. steel
H12																Inv. steel
H13																Inv. steel
H14																Comp. steel
I1																Comp. steel
I2																Inv. steel
I3																Inv. steel

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(continued)

	Steel	Chemical composition (mass%), bal.: Fe and impurities														Remarks	
		Cu	V	Ca	Mg	REM	Sb	Zr	Sn	As	W	Ta	Re	Os	Ir		Tc
5	I4																Inv. steel
	I5																Inv. steel
	I6																Inv. steel
10	I7																Inv. steel
	I8																Inv. steel
	I9																Inv. steel
15	I10																Inv. steel
	I11																Inv. steel
	I12																Inv. steel
20	I13																Inv. steel
	I14																Comp. steel
	J1																Comp. steel
25	J2																Inv. steel
	J3																Inv. steel
	J4																Inv. steel
30	J5																Inv. steel
	J6																Inv. steel
	J7																Inv. steel
35	J8																Inv. steel
	J9																Inv. steel
	J10																Inv. steel
40	J11																Inv. steel
	J12																Comp. steel
	K1																Comp. steel
45	K2																Inv. steel
	K3																Inv. steel
	K4																Inv. steel
50	K5																Inv. steel
	K6																Inv. steel
	K7																Inv. steel
55	K8																Inv. steel
	K9																Inv. steel
	K10																Inv. steel
	K11																Inv. steel
	K12																Inv. steel

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(continued)

Steel	Chemical composition (mass%), bal.: Fe and impurities															Remarks
	Cu	V	Ca	Mg	REM	Sb	Zr	Sn	As	W	Ta	Re	Os	Ir	Tc	
5 K13																Inv. steel
K14																Comp. steel
10 L1																Comp. steel
L2																Inv. steel
L3																Inv. steel
15 L4																Inv. steel
L5																Inv. steel
L6																Inv. steel
L7																Inv. steel
20 L8																Inv. steel
L9																Inv. steel
L10																Inv. steel
25 L11																Inv. steel
L12																Inv. steel
Underlines show outside scope of present invention.																

30 [Table 1-8]

[0121]

Table 1-8

Steel	Chemical composition (mass%), bal.: Fe and impurities															Remarks
	Cu	V	Ca	Mg	REM	Sb	Zr	Sn	As	W	Ta	Re	Os	Ir	Tc	
35 L13																Comp. steel
40 M1																Comp. steel
M2																Inv. steel
45 M3																Inv. steel
M4																Inv. steel
M5																Inv. steel
M6																Inv. steel
50 M7																Inv. steel
M8																Inv. steel
M9																Inv. steel
55 M10																Inv. steel
M11																Comp. steel
N1																Inv. steel

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(continued)

	Steel	Chemical composition (mass%), bal.: Fe and impurities															Remarks
		Cu	V	Ca	Mg	REM	Sb	Zr	Sn	As	W	Ta	Re	Os	Ir	Tc	
5	N2																Inv. steel
	N3																Inv. steel
	N4																Inv. steel
	N5																Inv. steel
10	N6																Inv. steel
	N7																Inv. steel
	N8																Inv. steel
	N9																Inv. steel
15	N10																Inv. steel
	N11																Inv. steel
	N12																Inv. steel
	N13																Inv. steel
20	O1																Inv. steel
	O2																Inv. steel
	O3																Inv. steel
	O4																Inv. steel
25	O5																Inv. steel
	O6																Inv. steel
	O7																Inv. steel
	O8																Inv. steel
30	O9																Inv. steel
	O10																Inv. steel
	O1 1																Inv. steel
	O12																Inv. steel
35	P1	0.05															Inv. steel
	P2	0.11															Inv. steel
	P3	0.23															Inv. steel
	P4	0.42															Inv. steel
40	P5	0.83															Inv. steel
	P6	1.32															Inv. steel
	P7	1.63															Inv. steel
	P8	1.84															Inv. steel
45	P9	2.21															Inv. steel
	P 10	2.45															Inv. steel
	P11	2.74															Inv. steel
	P12	2.91															Inv. steel
50	Q1		0.05														Inv. steel
	Q2		0.11														Inv. steel

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(continued)

Steel	Chemical composition (mass%), bal.: Fe and impurities															Remarks
	Cu	V	Ca	Mg	REM	Sb	Zr	Sn	As	W	Ta	Re	Os	Ir	Tc	
5	Q3	0.21														Inv. steel
	Q4	0.47														Inv. steel
	Q5	0.84														Inv. steel
10	Q6	1.29														Inv. steel
	Q7	1.55														Inv. steel
	Q8	1.81														Inv. steel
	Q9	2.21														Inv. steel
15	Q10	2.46														Inv. steel
	Q11	2.63														Inv. steel
	Q12	2.88														Inv. steel
20	R1		0.001													Inv. steel
	R2		0.01													Inv. steel
	R3		0.13													Inv. steel
	R4		0.27													Inv. steel
25	R5		0.41													Inv. steel
	R6		0.65													Inv. steel
	R7		0.75													Inv. steel
	R8		0.91													Inv. steel
30	S1			0.003												Inv. steel
	S2			0.02												Inv. steel
	S3			0.12												Inv. steel
35	Underlines show outside scope of present invention.															

[Table 1-9]

[0122]

Table 1-9

Steel	Chemical composition (mass%), bal.: Fe and impurities															Remarks
	Cu	V	Ca	Mg	REM	Sb	Zr	Sn	As	W	Ta	Re	Os	Ir	Tc	
S4				0.25												Inv. steel
S5				0.47												Inv. steel
S6				0.63												Inv. steel
S7				0.74												Inv. steel
S8				0.96												Inv. steel
T1					0.001											Inv. steel
T2					0.04											Inv. steel
T3					0.12											Inv. steel
T4					0.25											Inv. steel
T5					0.39											Inv. steel
T6					0.63											Inv. steel
T7					0.75											Inv. steel
T8					0.91											Inv. steel
U1						0.002										Inv. steel
U2						0.03										Inv. steel
U3						0.13										Inv. steel
U4						0.25										Inv. steel
U5						0.41										Inv. steel
U6						0.64										Inv. steel
U7						0.71										Inv. steel
U8						0.92										Inv. steel
V1							0.002									Inv. steel
V2							0.04									Inv. steel
V3							0.14									Inv. steel

(continued)

Steel	Chemical composition (mass%), bal.: Fe and impurities															Remarks
	Cu	V	Ca	Mg	REM	Sb	Zr	Sn	As	W	Ta	Re	Os	Ir	Tc	
V4							0.25									Inv. steel
V5							0.39									Inv. steel
V6							0.57									Inv. steel
V7							0.76									Inv. steel
V8							0.93									Inv. steel
W1								0.002								Inv. steel
W2								0.03								Inv. steel
W3								0.12								Inv. steel
W4								0.27								Inv. steel
W5								0.44								Inv. steel
W6								0.64								Inv. steel
W7								0.75								Inv. steel
W8								0.92								Inv. steel
X1									0.004							Inv. steel
X2									0.021							Inv. steel
X3									0.077							Inv. steel
Y1										0.002						Inv. steel
Y2										0.008						Inv. steel
Y3										0.02						Inv. steel
Y4										0.06						Inv. steel
Y5										0.12						Inv. steel
Y6										0.17						Inv. steel
Y7										0.28						Inv. steel
Y8										0.51						Inv. steel
Y9										0.71						Inv. steel

(continued)

Steel	Chemical composition (mass%), bal.: Fe and impurities															Remarks
	Cu	V	Ca	Mg	REM	Sb	Zr	Sn	As	W	Ta	Re	Os	Ir	Tc	
Y10										0.88						Inv. steel
Z1											0.002					Inv. steel
Z2											0.007					Inv. steel
Z3											0.03					Inv. steel
Z4											0.06					Inv. steel
Z5											0.14					Inv. steel
Z6											0.18					Inv. steel
Z7											0.28					Inv. steel
Z8											0.52					Inv. steel
Z9											0.69					Inv. steel
Z10											0.87					Inv. steel
AA1												0.002				Inv. steel
AA2												0.006				Inv. steel
AA3												0.04				Inv. steel
AA4												0.07				Inv. steel
AA5												0.12				Inv. steel
AA6												0.19				Inv. steel
AA7												0.25				Inv. steel
AA8												0.51				Inv. steel
AA9												0.65				Inv. steel
AA10												0.84				Inv. steel
BB1													0.003			Inv. steel
BB2													0.006			Inv. steel
Underlines show outside scope of present invention.																

[Table 1-10]

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[0123]

Table 1-10

Steel	Chemical composition (mass%), bal.: Fe and impurities															Remarks
	Cu	V	Ca	Mg	REM	Sb	Zr	Sn	As	W	Ta	Re	Os	Ir	Tc	
BB3													0.05			Inv. steel
BB4													0.07			Inv. steel
BB5													0.15			Inv. steel
BB6													0.18			Inv. steel
BB7													0.25			Inv. steel
BB8													0.49			Inv. steel
BB9													0.63			Inv. steel
BB10													0.88			Inv. steel
CC1														0.002		Inv. steel
CC2														0.005		Inv. steel
CC3														0.04		Inv. steel
CC4														0.08		Inv. steel
CC5														0.15		Inv. steel
CC6														0.17		Inv. steel
CC7														0.21		Inv. steel
CC8														0.46		Inv. steel
CC9														0.66		Inv. steel
CC10														0.91		Inv. steel
DD1															0.002	Inv. steel
DD2															0.007	Inv. steel
DD3															0.03	Inv. steel
DD4															0.08	Inv. steel
DD5															0.11	Inv. steel
DD6															0.17	Inv. steel

(continued)

Steel	Chemical composition (mass%), bal.: Fe and impurities															Remarks
	Cu	V	Ca	Mg	REM	Sb	Zr	Sn	As	W	Ta	Re	Os	Ir	Tc	
DD7															0.23	Inv. steel
DD8															0.49	Inv. steel
DD9															0.61	Inv. steel
DD10															0.92	Inv. steel
EE1	0.24															Inv. steel
EE2																Inv. steel
EE3																Inv. steel
EE4	0.27							0.122								Inv. steel
EES																Inv. steel
EE6																Inv. steel
EE7																Inv. steel
EE8																Inv. steel
Underlines show outside scope of present invention.																

[Table 2-1]

[0124]

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Table 2-1

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Test No.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
1	A1	54	583	1288	473	912	366		Comp. ex.
2	A2	55	655	1279	591	910	348		Inv. ex.
3	A3	51	679	1266	525	903	368		Inv. ex.
4	A4	55	643	1275	518	913	373		Inv. ex.
5	A5	54	646	1265	444	912	358		Inv. ex.
6	A6	52	669	1253	561	922	350		Inv. ex.
7	A7	54	645	1246	411	924	366		Inv. ex.
8	A8	51	648	1248	539	922	368		Inv. ex.
9	A9	54	683	1276	507	908	357		Inv. ex.
10	A10	51	651	1288	539	897	374		Inv. ex.
11	A11	51	616	1263	666	901	370		Inv. ex.
12	A12	54	606	1262	648	911	371		Inv. ex.
13	A13	52	655	1259	625	915	366		Inv. ex.
14	A14	51	694	1276	629	910	351		Comp. ex.
15	B1	51	568	1279	445	912	358		Comp. ex.
16	B2	54	619	1283	421	919	350		Inv. ex.
17	B3	51	610	1256	504	912	366		Inv. ex.
is	B4	55	658	1272	560	915	355		Inv. ex.
19	B5	54	665	1265	507	920	355		Inv. ex.
20	B6	54	677	1261	610	899	375		Inv. ex.
21	B7	51	604	1249	532	897	373		Inv. ex.
22	B8	55	643	1249	434	910	373		Inv. ex.
23	B9	51	641	1281	575	897	372		Inv. ex.
24	B10	55	624	1288	618	910	364		Inv. ex.
25	B11	53	717	1252	660	912	345		Inv. ex.
26	B12	53	577	1261	422	897	360		Inv. ex.
27	B13	53	593	1280	685	902	365		Inv. ex.
28	B14	51	662	1255	697	920	353		Inv. ex.
29	B15	55	705	1251	411	915	361		Comp. ex.
30	C1	51	684	1254	491	915	346		Comp. ex.

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(continued)

Test No.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
31	C2	55	699	1251	645	898	375		Inv. ex.
32	C3	53	717	1286	679	902	368		Inv. ex.
33	C4	51	717	1249	474	913	369		Inv. ex.
34	C5	55	562	1250	502	918	365		Inv. ex.
35	C6	53	725	1244	502	905	354		Inv. ex.
36	C7	51	688	1270	595	909	366		Inv. ex.
37	C8	55	713	1261	697	898	371		Inv. ex.
38	C9	54	693	1271	670	911	364		Inv. ex.
39	C10	55	612	1283	499	898	370		Inv. ex.
40	C11	55	712	1270	462	923	369		Inv. ex.
41	C12	55	568	1259	527	901	349		Inv. ex.
42	C13	55	687	1290	677	901	346		Inv. ex.
43	C14	51	554	1244	688	895	372		Comp. ex.
44	D1	54	643	1243	458	910	368		Inv. ex.
45	D2	51	626	1268	686	919	374		Inv. ex.
46	D3	54	707	1274	611	925	368		Inv. ex.
47	D4	55	605	1271	618	925	372		Inv. ex.
48	D5	53	719	1247	421	916	357		Inv. ex.
49	D6	51	677	1256	655	901	372		Inv. ex.
50	D7	52	551	1286	623	925	362		Inv. ex.
51	D8	55	575	1246	406	900	361		Inv. ex.
Underlines show values of properties which are not preferable.									

[Table 2-2]

[0125]

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Table 2-2

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Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
52	D9	55	703	1271	481	905	355		Comp. ex.
53	E1	52	585	1242	684	921	355		Inv. ex.
54	E2	51	653	1249	438	918	375		Inv. ex.
55	E3	54	591	1289	539	911	348		Inv. ex.
56	E4	54	589	1250	496	916	357		Inv. ex.
57	E5	55	580	1245	640	918	374		Inv. ex.
58	E6	53	619	1253	402	915	373		Inv. ex.
59	E7	52	585	1253	538	907	361		Inv. ex.
60	E8	52	630	1281	467	897	356		Inv. ex.
61	E9	54	627	1273	515	904	346		Comp. ex.
62	F1	54	571	1287	680	922	348		Inv. ex.
63	F2	55	710	1254	424	904	367		Inv. ex.
G4	F3	53	566	1258	570	905	357		Inv. ex.
65	F4	52	627	1275	599	900	369		Inv. ex.
66	F5	55	721	1279	609	914	353		Inv. ex.
67	F6	51	675	1271	593	911	362		Inv. ex.
68	F7	53	602	1274	586	902	361		Inv. ex.
69	F8	51	679	1287	406	906	359		Inv. ex.
70	F9	55	580	1278	499	920	354		Comp. ex.
71	G1	55	619	1244	646	916	348		Inv. ex.
72	G2	52	650	1264	485	921	359		Inv. ex.
73	G3	52	675	1279	699	913	354		Inv. ex.
74	G4	51	696	1265	608	910	354		Inv. ex.
75	G5	52	587	1265	415	916	364		Inv. ex.
76	G6	54	590	1290	582	915	355		Inv. ex.
77	G7	54	595	1269	438	902	348		Inv. ex.
78	G8	55	623	1268	649	901	364		Comp. ex.
79	H1	51	586	1287	641	914	346		Comp. ex.
80	H2	52	674	1281	457	925	366		Inv. ex.
81	H3	54	690	1278	687	905	359		Inv. ex.
82	H4	55	701	1270	416	904	362		Inv. ex.
83	H5	54	603	1270	443	916	347		Inv. ex.
84	H6	51	607	1269	622	901	345		Inv. ex.

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(continued)

Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
85	H7	51	591	1271	680	916	345		Inv. ex.
86	H8	53	701	1262	636	914	345		Inv. ex.
87	H9	51	552	1252	651	899	345		Inv. ex.
88	H10	55	672	1283	483	909	367		Inv. ex.
89	H11	54	612	1259	490	920	350		Inv. ex.
90	H12	51	648	1253	645	903	372		Inv. ex.
91	H13	53	558	1281	466	925	362		Inv. ex.
92	H14	51	585	1266	559	920	372		Comp. ex.
93	I1	53	717	1266	526	924	355		Comp. ex.
94	I2	51	702	1264	556	897	367		Inv. ex.
95	I3	51	611	1269	527	901	366		Inv. ex.
96	I4	52	721	1274	556	895	374		Inv. ex.
97	I5	55	708	1282	698	897	346		Inv. ex.
98	I6	53	559	1272	491	896	363		Inv. ex.
99	I7	51	715	1254	576	907	363		Inv. ex.
100	I8	51	653	1262	579	903	374		Inv. ex.
101	I9	52	662	1263	466	911	361		Inv. ex.
102	I10	53	714	1269	678	923	375		Inv. ex.
Underlines show values of properties which are not preferable.									

[Table 2-3]

[0126]

Table 2-3

Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C/s	Heating temp. °C	Holding time s		
103	I11	54	671	1248	471	921	368		Inv. ex.
104	I12	52	566	1241	430	911	346		Inv. ex.
105	I13	55	629	1281	593	898	347		Inv. ex.

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Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C/s	Heating temp. °C	Holding time s		
106	I14	52	637	1252	687	903	351		Comp. ex.
107	J1	51	650	1284	613	914	348		Comp. ex.
108	J2	51	714	1267	651	910	375		Inv. ex.
109	J3	53	726	1255	665	923	369		Inv. ex.
110	J4	51	557	1277	418	903	354		Inv. ex.
111	J5	53	601	1282	571	920	349		Inv. ex.
112	J6	55	695	1255	553	923	365		Inv. ex.
113	J7	51	673	1267	575	910	355		Inv. ex.
114	J8	55	691	1280	474	922	357		Inv. ex.
115	J9	55	682	1264	510	925	356		Inv. ex.
116	J10	51	671	1265	541	924	346		Inv. ex.
117	J11	54	638	1285	631	910	368		Inv. ex.
118	J12	54	724	1244	503	904	375		Comp. ex.
119	K1	51	652	1272	569	906	347		Comp. ex.
120	K2	53	642	1249	637	917	363		Inv. ex.
121	K3	52	724	1284	471	897	353		Inv. ex.
122	K4	52	660	1240	689	921	360		Inv. ex.
123	K5	51	652	1280	417	902	350		Inv. ex.
124	K6	55	696	1247	671	919	348		Inv. ex.
125	K7	55	551	1259	566	921	372		Inv. ex.
126	K8	55	588	1256	596	912	372		Inv. ex.
127	K9	54	694	1242	664	915	368		Inv. ex.
128	K10	53	658	1284	529	899	362		Inv. ex.
129	K11	53	674	1263	696	925	352		Inv. ex.
130	K12	53	593	1289	493	897	374		Inv. ex.
131	K13	51	720	1258	636	896	359		Inv. ex.
132	K14	51	689	1268	501	895	359		Comp. ex.
133	L1	53	645	1254	410	913	355		Comp. ex.
134	L2	51	627	1260	628	925	353		Inv. ex.
135	L3	55	691	1282	679	905	352		Inv. ex.
136	L4	52	572	1257	559	913	365		Inv. ex.
137	L5	52	714	1259	562	917	358		Inv. ex.
138	L6	54	657	1264	443	917	367		Inv. ex.

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(continued)

Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C/s	Heating temp. °C	Holding time s		
139	L7	52	653	1281	433	917	368		Inv. ex.
140	L8	52	559	1273	454	897	354		Inv. ex.
141	L9	55	722	1265	565	912	362		Inv. ex.
142	L10	55	669	1250	476	919	349		Inv. ex.
143	L11	51	676	1286	541	915	365		Inv. ex.
144	L12	53	708	1243	676	904	363		Inv. ex.
145	L13	53	606	1259	556	898	356		Comp. ex.
146	M1	52	720	1289	414	896	372		Comp. ex.
147	M2	53	608	1272	514	918	347		Inv. ex.
148	M3	54	627	1267	464	914	348		Inv. ex.
149	M4	55	586	1275	589	921	361		Inv. ex.
150	M5	51	575	1266	571	899	350		Inv. ex.
151	M6	51	670	1259	427	921	353		Inv. ex.
152	M7	54	624	1267	433	919	358		Inv. ex.
153	M8	51	595	1276	462	915	359		Inv. ex.
Underlines show values of properties which are not preferable.									

[Table 2-4]

[0127]

Table 2-4

Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
154	M9	55	652	1277	630	909	358		Inv. ex.
155	M10	52	643	1256	662	912	357		Inv. ex.
156	M11	53	667	1251	516	896	372		Comp. ex.
157	N1	52	642	1256	552	915	354		Inv. ex.
158	N2	51	652	1276	439	908	364		Inv. ex.
159	N3	54	722	1278	663	898	370		Inv. ex.

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(continued)

5	Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
			Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
10	160	N4	55	687	1288	469	909	368		Inv. ex.
	161	N5	54	561	1265	504	918	374		Inv. ex.
15	162	N6	55	583	1279	492	895	366		Inv. ex.
	163	N7	54	618	1284	668	909	364		Inv. ex.
	164	N8	55	567	1270	490	912	357		Inv. ex.
	165	N9	53	719	1269	685	920	360		Inv. ex.
20	166	N10	55	635	1262	578	906	366		Inv. ex.
	167	N11	52	616	1273	466	921	357		Inv. ex.
	168	N12	54	673	1272	521	921	359		Inv. ex.
	169	N13	54	629	1282	442	909	366		Inv. ex.
25	170	O1	54	694	1290	434	919	356		Inv. ex.
	171	O2	54	581	1263	648	905	357		Inv. ex.
	172	O3	52	612	1279	495	923	348		Inv. ex.
	173	O4	52	609	1278	563	896	364		Inv. ex.
30	174	O5	51	599	1266	466	920	371		Inv. ex.
	175	O6	52	654	1249	695	913	365		Inv. ex.
35	176	O7	52	658	1256	544	899	375		Inv. ex.
	177	O8	53	601	1248	587	924	369		Inv. ex.
	178	O9	51	601	1274	403	908	345		Inv. ex.
	179	O10	54	716	1268	424	912	371		Inv. ex.
40	180	O11	55	581	1251	476	898	351		Inv. ex.
	181	O12	53	633	1271	642	901	372		Inv. ex.
	182	P1	54	672	1289	434	901	347		Inv. ex.
	183	P2	52	728	1249	420	899	357		Inv. ex.
45	134	P3	51	668	1281	525	904	370		Inv. ex.
	185	P4	51	584	1283	690	913	370		Inv. ex.
	186	P5	54	587	1275	420	910	356		Inv. ex.
	187	P6	55	570	1286	524	896	348		Inv. ex.
50	188	P7	51	649	1267	485	924	369		Inv. ex.
	189	P8	52	710	1240	611	909	356		Inv. ex.
55	190	P9	54	554	1276	697	916	360		Inv. ex.
	191	P10	51	715	1273	586	924	350		Inv. ex.
	192	P11	51	617	1280	677	906	371		Inv. ex.

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(continued)

Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
193	P12	51	612	1266	636	896	347		Inv. ex.
194	Q1	52	567	1287	672	896	351		Inv. ex.
195	Q2	53	625	1258	596	905	358		Inv. ex.
196	Q3	53	713	1288	615	914	348		Inv. ex.
197	Q4	54	667	1270	410	897	354		Inv. ex.
198	Q5	53	642	1288	565	899	349		Inv. ex.
199	Q6	54	689	1288	693	922	361		Inv. ex.
200	Q7	53	647	1268	463	922	366		Inv. ex.
201	Q8	51	616	1284	503	906	362		Inv. ex.
202	Q9	54	612	1280	472	922	352		Inv. ex.
203	Q10	52	716	1289	415	897	347		Inv. ex.
204	Q11	51	681	1259	471	912	345		Inv. ex.
Underlines show values of properties which are not preferable.									

[Table 2-5]

[0128]

Table 2-5

Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C/s	Heating temp. °C	Holding time s		
205	Q12	51	662	1249	696	906	345		Inv. ex.
206	R1	52	720	1260	492	897	359		Inv. ex.
207	R2	53	612	1261	550	914	370		Inv. ex.
208	R3	51	619	1261	584	912	348		Inv. ex.
209	R4	53	594	1254	487	898	346		Inv. ex.
210	R5	51	611	1259	698	900	355		Inv. ex.
211	R6	54	574	1255	601	901	368		Inv. ex.
212	R7	52	632	1267	503	917	372		Inv. ex.
213	R8	51	613	1244	531	910	349		Inv. ex.

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(continued)

	Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
			Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C/s	Heating temp. °C	Holding time s		
5										
10										
15										
20										
25										
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(continued)

Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C/s	Heating temp. °C	Holding time s		
247	W2	53	606	1257	517	914	345		Inv. ex.
248	W3	51	676	1289	456	903	357		Inv. ex.
249	W4	53	642	1253	653	907	354		Inv. ex.
250	W5	51	671	1256	510	913	373		Inv. ex.
251	W6	54	660	1287	692	897	357		Inv. ex.
252	W7	55	610	1270	694	909	374		Inv. ex.
253	W8	54	555	1269	698	896	358		Inv. ex.
254	X1	54	663	1246	629	903	368		Inv. ex.
255	X2	54	628	1240	473	918	375		Inv. ex.
Underlines show values of properties which are not preferable.									

[Table 2-6]

[0129]

Table 2-6

Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
256	X3	52	624	1282	508	895	356		Inv. ex.
257	Y1	55	657	1249	546	907	361		Inv. ex.
258	Y2	55	672	1277	480	919	358		Inv. ex.
259	Y3	53	667	1250	596	899	370		Inv. ex.
260	Y4	52	685	1243	650	910	349		Inv. ex.
261	Y5	53	555	1248	509	901	358		Inv. ex.
262	Y6	55	639	1288	466	914	350		Inv. ex.
263	Y7	54	644	1255	589	919	356		Inv. ex.
264	Y8	53	631	1266	690	911	366		Inv. ex.
265	Y9	54	653	1264	436	915	349		Inv. ex.
266	Y10	55	639	1265	553	914	364		Inv. ex.
267	Z1	51	653	1280	690	900	367		Inv. ex.

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(continued)

	Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
			Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
5										
10										
15										
20										
25										
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(continued)

Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
301	CC5	53	608	1266	464	919	354		Inv. ex.
302	CC6	55	607	1252	681	922	351		Inv. ex.
303	CC7	52	607	1253	584	909	349		Inv. ex.
304	CC8	54	647	1279	458	916	358		Inv. ex.
305	CC9	54	727	1256	634	901	371		Inv. ex.
306	CC10	54	668	1258	536	915	361		Inv. ex.
Underlines show values of properties which are not preferable.									

[Table 2-7]

[0130]

Table 2-7

Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
307	DD1	55	723	1275	692	920	371		Inv. ex.
308	DD2	51	656	1284	616	916	373		Inv. ex.
309	DD3	53	568	1246	681	901	345		Inv. ex.
310	DD4	52	696	1244	687	917	353		Inv. ex.
311	DD5	55	628	1273	503	917	370		Inv. ex.
312	DD6	55	584	1284	584	925	359		Inv. ex.
313	DD7	54	595	1260	680	895	365		Inv. ex.
314	DD8	52	647	1278	433	910	363		Inv. ex.
315	DD9	52	565	1252	413	896	348		Inv. ex.
316	DD10	55	680	1256	442	901	364		Inv. ex.
317	EE1	53	657	1261	687	925	345		Inv. ex.
318	EE2	51	612	1241	419	909	361		Inv. ex.
319	EE3	54	565	1241	656	911	359		Inv. ex.
320	EE4	51	596	1289	550	922	356		Inv. ex.
321	EE5	53	567	1279	698	895	366		Inv. ex.

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(continued)

5	Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
			Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
10	322	EE6	51	719	1246	619	924	354		Inv. ex.
	323	EE7	51	578	1256	508	898	373		Inv. ex.
15	324	EE8	51	704	1278	444	904	364		Inv. ex.
	325	EE6	<u>16</u>	609	1254	682	915	370		Comp. ex.
20	326	EE6	43	573	1244	470	914	346		Inv. ex.
	327	EE6	50	575	1246	640	914	375		Inv. ex.
25	328	EE6	54	547	1270	662	920	364		Inv. ex.
	329	EE6	55	612	1284	465	918	356		Inv. ex.
30	330	EE6	52	666	1243	561	902	364		Inv. ex.
	331	EE6	55	712	1274	571	922	375		Inv. ex.
35	332	EE6	51	728	1241	696	901	350		Inv. ex.
	333	EE6	54	<u>769</u>	1267	422	919	372		Comp. ex.
40	334	EE6	52	28	1249	419	915	362	Softening treatment	Inv. ex.
	335	EE6	51	261	1290	567	909	349	Softening treatment	Inv. ex.
45	336	EE6	54	421	1290	486	896	363	Softening treatment	Inv. ex.
	337	EE6	55	714	1278	568	916	349	No cold rolling	Inv. ex.
50	338	EE6	55	703	1289	550	902	357	Annealing	Inv. ex.
	339	EE6	51	612	1268	524	918	366	Al plating	Inv. ex.
55	340	EE6	55	723	1270	584	905	369	Al-Zn plating	Inv. ex.
	341	EE6	51	582	1245	689	908	368	Al-Si plating	Inv. ex.
60	342	EE6	54	575	1240	552	924	349	Hot dip galvanization	Inv. ex.
	343	EE6	51	576	1290	485	908	358	Electrogalvanization	Inv. ex.
65	344	EE6	54	720	1257	529	906	349	Hot dip galvannealing	Inv. ex.
	345	EE6	51	582	1275	677	916	345	Zn-Ni plating	Inv. ex.
70	346	EE6	54	702	1262	669	915	368	Al-Mg-Zn plating	Inv. ex.
	347	EE6	55	619	1281	455	905	352	Temper rolling	Inv. ex.
75	348	EE6	54	596	<u>1160</u>	617	906	351		Comp. ex.
	349	EE6	51	593	1220	657	914	374		Inv. ex.
80	350	EE6	51	579	1250	665	922	374		Inv. ex.
	351	EE6	55	614	1280	639	919	345		Inv. ex.
85	352	EE6	55	561	1320	418	904	361		Inv. ex.
	353	EE6	53	619	1390	686	897	353		Inv. ex.
90	354	EE6	51	665	1287	<u>6</u>	914	366		Comp. ex.

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(continued)

Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
355	EE6	53	679	1271	12	925	375		Inv. ex.
356	EE6	53	720	1248	53	915	361		Inv. ex.
357	EE6	51	681	1271	110	898	359		Inv. ex.
Underlines show values of properties which are not preferable.									

[Table 2-8]

[0131]

Table 2-8

Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
358	EE6	52	641	1276	230	906	354		Inv. ex.
359	EE6	55	615	1266	509	920	370		Inv. ex.
360	EE6	55	655	1241	1021	901	355		Inv. ex.
361	EE6	55	599	1275	530	<u>752</u>	370		Comp. ex.
362	EE6	53	579	1279	676	804	353		Inv. ex.
363	EE6	54	583	1266	402	824	374		Inv. ex.
364	EE6	53	617	1272	524	840	371		Inv. ex.
365	EE6	52	713	1279	660	854	362		Inv. ex.
366	EE6	55	577	1280	513	868	347		Inv. ex.
367	EE6	52	593	1290	612	879	358		Inv. ex.
368	EE6	54	633	1274	496	888	359		Inv. ex.
369	EE6	54	690	1269	611	904	359		Inv. ex.
370	EE6	54	619	1269	511	922	350		Inv. ex.
371	EE6	55	728	1251	542	936	364		Inv. ex.
372	EE6	53	607	1277	474	953	347		Inv. ex.
373	EE6	54	602	1290	573	971	370		Inv. ex.
374	EE6	53	616	1245	428	986	357		Inv. ex.
375	EE6	53	629	1275	678	<u>1021</u>	356		Comp. ex.

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(continued)

5	Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
			Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
10	376	EE6	53	573	1279	468	925	48		Comp. ex.
	377	EE6	53	571	1246	493	915	65		Inv. ex.
15	378	EE6	52	676	1247	679	925	87		Inv. ex.
	379	EE6	53	683	1281	685	910	102		Inv. ex.
	380	EE6	51	589	1284	430	903	143		Inv. ex.
20	381	EE6	51	633	1263	625	897	199		Inv. ex.
	382	EE6	55	566	1287	508	909	241		Inv. ex.
	383	EE6	52	643	1267	669	917	297		Inv. ex.
	334	EE6	54	605	1276	607	902	337		Inv. ex.
25	385	EE6	55	602	1264	430	920	371		Inv. ex.
	386	EE6	54	641	1248	405	897	396		Inv. ex.
	387	EE6	53	718	1269	566	921	444		Inv. ex.
30	338	EE6	53	595	1244	488	918	487		Inv. ex.
	389	EE6	51	568	1262	672	909	533		Inv. ex.
	390	EE6	51	559	1258	545	896	571		Inv. ex.
	391	EE6	53	716	1289	444	920	589		Inv. ex.
35	392	EE6	52	554	1252	461	922	631		Comp. ex.
	393	EE6	54	578	1264	491	907	352	Gas combustion atmosphere (air-fuel ratio 0.80)	Inv. ex.
40	394	EE6	53	600	1255	699	924	369	Gas combustion atmosphere (air-fuel ratio 0.85)	Inv. ex.
45	395	EE6	51	639	1260	432	908	370	Gas combustion atmosphere (air-fuel ratio 1.1)	Inv. ex.
50	396	EE6	54	689	1252	491	909	348	Ambient air	Inv. ex.
	397	EE6	51	722	1256	628	897	364	Nitrogen gas (dew point -30°C)	Inv. ex.
55	398	EE6	53	570	1256	577	914	374	Nitrogen gas (dew point 0°C)	Inv. ex.

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(continued)

Test no.	Steel	Hot rolling step	Coiling step	Preheating step		Hot stamping step		Others	Remarks
		Finish rolling final stage rolling reduction %	Coiling temp. °C	Heating temp. °C	Average cooling speed down to less than 350°C °C /s	Heating temp. °C	Holding time s		
399	EE6	55	617	1253	582	910	358	Nitrogen gas (dew point +10°C)	Inv. ex.
400	EE6	52	553	1246	532	911	361	Ohmic heating	Inv. ex.
401	EE6	51	671	1248	530	901	347	Tempering temp. 152°C	Inv. ex.
402	EE6	53	645	1259	685	901	347	Tempering temp. 170°C	Inv. ex.
403	EE6	54	591	1240	642	907	348	Tempering temp. 201°C	Inv. ex.
404	EE6	51	606	1273	467	920	353	Tempering temp. 341°C	Inv. ex.
405	EE6	51	565	1269	572	906	374	Tempering temp. 433°C	Inv. ex.
406	EE6	53	567	1258	607	913	366	Tempering temp. 521°C	Inv. ex.
407	EE6	52	568	1252	601	919	375	Tempering temp. 591°C	Inv. ex.
408	EE6	55	585	1244	698	901	355	Partial softening treatment	Inv. ex.
Underlines show values of properties which are not preferable.									

[0132] The properties of the obtained hot stamped bodies were measured and evaluated by the following methods:

[Tensile Strength (TS)]

[0133] The tensile strength (TS) of a hot stamped body was obtained from any position of the hot stamped body by preparing a No. 5 test piece, removing the surface layer parts of the front and back surfaces of the test piece by machine grinding, and conducting a tensile test based on JIS Z 2241: 2011. The crosshead speed was 1 mm/min. If early fracture occurred at the time of the tensile test, i.e., if fracture occurred before reaching the maximum stress, the tensile strength of the hot stamped body was made the stress at the time of fracture.

[Early Fracture Resistance]

[0134] The early fracture resistance was evaluated by the value of the tensile strength of the hot stamped body obtained by the above method divided by the value of the Vickers hardness obtained by the following method times 3.3 (tensile strength/(Vickers hardness×3.3)). If this value was 0.80 or more, the hot stamped body was deemed excellent in early fracture resistance and judged as passing while if it was less than 0.80, it was judged as failing. The "value of the Vickers hardness times 3.3" is the tensile strength estimated from the hardness. If the measured value of the tensile strength is 0.80 time or more of the estimated tensile strength, the hot stamped body can be judged to be excellent in early fracture resistance.

[0135] The Vickers hardness used for evaluation of early fracture resistance was obtained by the following method. First, a sample was cut out from any position 50 mm or more from the end faces of the hot stamped body so as to enable a cross-section vertical to the surface (sheet thickness cross-section) to be examined. The size of the sample, while depending also on the measuring device, was made a size enabling 10 mm or so to be examined in a direction vertical to the sheet thickness direction. The cross-section of the sample was polished using #600 to #1500 silicon carbide paper, then a liquid comprised of particle size 1 to 6 μm diamond powder dispersed in alcohol or other diluent or pure water was used to polish the surface to a mirror finish. The mirror finished cross-section was measured for hardness at a 1/4 depth position of the sheet thickness from the surface in a direction parallel to the sheet surface by a load of 1 kgf at intervals of 3 times or more the indents using a microVickers hardness tester. A total of 20 points were measured and the average value was calculated to thereby obtain the Vickers hardness.

[0136] A case where the tensile strength was 2200 MPa or more and the above numerical value relating to the early fracture resistance was 0.80 or more was evaluated as a hot stamped body which is high in strength and able to suppress early fracture. The results are shown in Table 3. The "area ratio of hard structures" in Table 3 means the total of the area ratios of the martensite, bainite, and tempered martensite. Further, the balance of the structures other than the hard structures was comprised of ferrite, retained austenite, and/or pearlite. While not shown in Table 3, when measuring the standard deviation in the grain size distribution of the former austenite grains, the grain size of the former austenite grains of the hot stamped bodies in the invention examples in Table 3 was 10 μm or less in all cases.

[Table 3-1]

[0137]

Table 3-1

Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
				Amount of segregation of Mo atm%	Total amount of segregation atm%			
1	A1	100	2.2	0.13	0.13	2173	0.93	Comp. ex.
2	A2	100	1.9	0.14	0.14	2251	0.92	Inv. ex.
3	A3	97	2.5	0.14	0.14	2347	0.92	Inv. ex.
4	A4	99	2.1	0.14	0.14	2423	0.94	Inv. ex.
5	A5	97	2.5	0.13	0.13	2472	0.92	Inv. ex.
6	A6	99	1.9	0.13	0.13	2497	0.93	Inv. ex.
7	A7	100	2.1	0.14	0.14	2517	0.94	Inv. ex.
8	A8	97	2.3	0.14	0.14	2600	0.88	Inv. ex.
9	A9	99	2.1	0.14	0.14	2697	0.87	Inv. ex.
10	A10	100	2.1	0.13	0.13	2802	0.88	Inv. ex.
11	A11	99	1.9	0.13	0.13	3001	0.88	Inv. ex.
12	A12	99	2.1	0.13	0.13	3097	0.81	Inv. ex.
13	A13	100	2.0	0.14	0.14	3203	0.80	Inv. ex.
14	A14	100	2.1	0.14	0.14	2517	0.48	Comp. ex.
15	B1	99	1.9	0.13	0.13	2170	0.91	Comp. ex.
16	B2	100	2.1	0.14	0.14	2252	0.94	Inv. ex.
17	B3	97	2.0	0.13	0.13	2289	0.93	Inv. ex.
18	B4	100	2.0	0.14	0.14	2347	0.94	Inv. ex.
19	B5	98	2.0	0.14	0.14	2388	0.91	Inv. ex.
20	B6	100	1.9	0.14	0.14	2417	0.93	Inv. ex.

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(continued)

5	Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
					Amount of segregation of Mo atm%	Total amount of segregation atm%			
10	21	B7	100	2.1	0.13	0.13	2468	0.93	Inv. ex.
	22	B8	98	2.2	0.13	0.13	2498	0.90	Inv. ex.
	23	B9	99	1.9	0.14	0.14	2518	0.91	Inv. ex.
	24	B10	99	2.3	0.14	0.14	2541	0.92	Inv. ex.
15	25	B11	96	1.9	0.14	0.14	2351	0.87	Inv. ex.
	26	B12	93	1.9	0.14	0.14	2290	0.80	Inv. ex.
	27	B13	91	2.5	0.13	0.13	2248	0.80	Inv. ex.
	28	B14	93	1.9	0.14	0.14	2212	0.85	Inv. ex.
20	29	B15	<u>74</u>	2.3	0.13	0.13	<u>2172</u>	0.80	Comp. ex.
	30	CL	97	<u>6.1</u>	0.14	0.14	2420	<u>0.73</u>	Comp. ex.
	31	C2	99	4.4	0.14	0.14	2412	0.81	Inv. ex.
	32	C3	99	3.8	0.13	0.13	2464	0.87	Inv. ex.
25	33	C4	98	3.4	0.13	0.13	2447	0.87	Inv. ex.
	34	C5	100	2.1	0.13	0.13	2401	0.92	Inv. ex.
	35	C6	99	2.4	0.13	0.13	2528	0.90	Inv. ex.
	36	C7	98	2.0	0.14	0.14	2536	0.94	Inv. ex.
30	37	C8	100	1.9	0.13	0.13	2518	0.90	Inv. ex.
	38	C9	98	2.1	0.14	0.14	2524	0.90	Inv. ex.
	39	C10	97	2.0	0.14	0.14	2410	0.92	Inv. ex.
	40	C11	100	2.8	0.14	0.14	2534	0.87	Inv. ex.
35	41	C12	99	2.9	0.13	0.13	2522	0.88	Inv. ex.
	42	C13	98	4.7	0.13	0.13	2476	0.80	Inv. ex.
	43	C14	97	<u>5.8</u>	0.13	0.13	2500	<u>0.51</u>	Comp. ex.
	44	D1	99	2.3	0.14	0.14	2472	0.93	Inv. ex.
40	45	D2	97	2.2	0.13	0.13	2438	0.94	Inv. ex.
	46	D3	98	2.0	0.14	0.14	2527	0.93	Inv. ex.
	47	D4	100	1.9	0.14	0.14	2502	0.91	Inv. ex.
	48	D5	97	2.4	0.14	0.14	2422	0.89	Inv. ex.
45	49	D6	99	2.4	0.14	0.14	2534	0.86	Inv. ex.
	50	D7	97	1.9	0.13	0.13	2464	0.88	Inv. ex.
	51	D8	97	2.4	0.14	0.14	2439	0.85	Inv. ex.
	Underlines show outside scope of present invention or values of properties which are not preferable.								

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[Table 3-2]

[0138]

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Table 3-2

5	Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
					Amount of segregation of Mo atm%	Total amount of segregation atm%			
10	52	D9	100	2.2	0.13	0.13	2510	0.76	Comp. ex.
	53	E1	100	2.0	0.14	0.14	2492	0.90	Inv. ex.
	54	E2	99	2.1	0.14	0.14	2469	0.94	Inv. ex.
	55	E3	97	2.5	0.13	0.13	2515	0.90	Inv. ex.
15	56	E4	99	2.5	0.13	0.13	2475	0.93	Inv. ex.
	57	E5	98	1.9	0.13	0.13	2467	0.93	Inv. ex.
	58	E6	100	2.0	0.14	0.14	2410	0.89	Inv. ex.
	59	E7	98	2.1	0.13	0.13	2485	0.87	Inv. ex.
20	60	E8	100	1.9	0.13	0.13	2522	0.80	Inv. ex.
	61	E9	97	2.0	0.14	0.14	2489	0.43	Comp. ex.
	62	F1	100	2.5	0.14	0.14	2448	0.93	Inv. ex.
	63	F2	97	2.1	0.14	0.14	2457	0.91	Inv. ex.
25	64	F3	100	2.2	0.14	0.14	2424	0.91	Inv. ex.
	65	F4	100	2.1	0.13	0.13	2507	0.94	Inv. ex.
	66	F5	97	2.5	0.13	0.13	2474	0.89	Inv. ex.
	67	F6	98	2.4	0.13	0.13	2406	0.88	Inv. ex.
30	68	F7	99	1.9	0.14	0.14	2473	0.80	Inv. ex.
	69	F8	97	2.3	0.13	0.13	2417	0.82	Inv. ex.
	70	F9	100	2.3	0.14	0.14	2486	<u>0.42</u>	Comp. ex.
	71	G1	100	2.1	0.14	0.14	2539	0.91	Inv. ex.
35	72	G2	97	1.9	0.13	0.13	2459	0.94	Inv. ex.
	73	G3	99	2.4	0.13	0.13	2432	0.91	Inv. ex.
	74	G4	98	2.3	0.13	0.13	2490	0.93	Inv. ex.
	75	G5	99	2.4	0.14	0.14	2452	0.86	Inv. ex.
40	76	G6	98	2.2	0.14	0.14	2451	0.86	Inv. ex.
	77	G7	98	2.4	0.13	0.13	2442	0.85	Inv. ex.
	78	G8	98	2.4	0.14	0.14	2540	<u>0.51</u>	Comp. ex.
	79	H1	100	2.0	0.14	0.14	2420	<u>0.66</u>	Comp. ex.
45	80	H2	97	2.4	0.13	0.13	2483	0.85	Inv. ex.
	81	H3	98	2.5	0.14	0.14	2540	0.87	Inv. ex.
	82	H4	97	2.0	0.13	0.13	2510	0.88	Inv. ex.
	83	H5	97	2.5	0.14	0.14	2496	0.88	Inv. ex.
50	84	H6	97	2.1	0.14	0.14	2405	0.93	Inv. ex.
	85	H7	97	1.9	0.14	0.14	2425	0.92	Inv. ex.
	86	H8	100	2.2	0.13	0.13	2427	0.90	Inv. ex.

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(continued)

Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
				Amount of segregation of Mo atm%	Total amount of segregation atm%			
87	H9	97	2.3	0.14	0.14	2500	0.90	Inv. ex.
88	H10	98	2.2	0.13	0.13	2478	0.86	Inv. ex.
89	H11	97	2.5	0.14	0.14	2539	0.88	Inv. ex.
90	H12	98	2.3	0.13	0.13	2452	0.87	Inv. ex.
91	H13	100	2.3	0.13	0.13	2413	0.80	Inv. ex.
92	H14	100	1.9	0.14	0.14	2471	<u>0.50</u>	Comp. ex.
93	I1	98	1.9	0.13	0.13	<u>2093</u>	0.90	Comp. ex.
94	I2	99	2.4	0.13	0.13	2218	0.94	Inv. ex.
95	I3	100	2.0	0.14	0.14	2400	0.94	Inv. ex.
96	I4	98	2.4	0.14	0.14	2318	0.90	Inv. ex.
97	I5	100	2.1	0.14	0.14	2398	0.92	Inv. ex.
98	I6	97	2.3	0.13	0.13	2466	0.94	Inv. ex.
99	I7	97	2.5	0.13	0.13	2488	0.93	Inv. ex.
100	I8	99	2.2	0.13	0.13	2412	0.91	Inv. ex.
101	I9	97	2.1	0.13	0.13	2496	0.90	Inv. ex.
102	I10	99	2.0	0.13	0.13	2434	0.94	Inv. ex.
Underlines show outside scope of present invention or values of properties which are not preferable.								

[Table 3-3]

[0139]

Table 3-3

Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
				Amount of segregation of Mo atm%	Total amount of segregation atm%			
103	I11	99	2.4	0.13	0.13	2446	0.88	Inv. ex.
104	I12	97	2.3	0.14	0.14	2466	0.89	Inv. ex.
105	I13	97	2.0	0.14	0.14	2480	0.81	Inv. ex.
106	I14	100	2.1	0.14	0.14	2460	<u>0.54</u>	Comp. ex.
107	J1	100	2.5	0.13	0.13	<u>2005</u>	0.92	Comp. ex.
108	J2	98	2.0	0.13	0.13	2230	0.94	Inv. ex.
109	J3	99	2.0	0.13	0.13	2303	0.92	Inv. ex.
I10	J4	100	2.1	0.14	0.14	2308	0.91	Inv. ex.
111	J5	98	2.0	0.13	0.13	2535	0.91	Inv. ex.

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(continued)

5	Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
					Amount of segregation of Mo atm%	Total amount of segregation atm%			
10	112	J6	100	2.4	0.13	0.13	2406	0.94	Inv. ex.
	113	J7	100	2.3	0.14	0.14	2515	0.92	Inv. ex.
	114	J8	98	1.9	0.13	0.13	2413	0.87	Inv. ex.
15	115	J9	97	2.2	0.14	0.14	2546	0.89	Inv. ex.
	116	J10	98	1.9	0.13	0.13	2521	0.82	Inv. ex.
	117	J11	98	2.4	0.13	0.13	2537	0.80	Inv. ex.
20	118	112	97	2.0	0.13	0.13	2523	<u>0.51</u>	Comp. ex.
	119	K1	98	2.4	0.14	0.14	<u>2008</u>	0.90	Comp. ex.
	120	K2	97	2.3	0.13	0.13	2295	0.92	Inv. ex.
25	121	K3	100	2.4	0.14	0.14	2337	0.93	Inv. ex.
	122	K4	99	1.9	0.13	0.13	2364	0.94	Inv. ex.
	123	K5	98	2.0	0.13	0.13	2351	0.92	Inv. ex.
30	124	K6	100	2.5	0.14	0.14	2321	0.94	Inv. ex.
	125	K7	99	2.0	0.14	0.14	2522	0.93	Inv. ex.
	126	K8	100	2.1	0.13	0.13	2534	0.90	Inv. ex.
35	127	K9	100	2.4	0.13	0.13	2407	0.93	Inv. ex.
	128	K10	100	1.9	0.13	0.13	2525	0.86	Inv. ex.
	129	K11	99	2.2	0.13	0.13	2434	0.86	Inv. ex.
40	130	K12	98	2.4	0.14	0.14	2450	0.87	Inv. ex.
	131	K13	100	1.9	0.14	0.14	2484	0.81	Inv. ex.
	132	K14	97	2.3	0.14	0.14	2518	<u>0.52</u>	Comp. ex.
45	133	L1	100	2.1	0.05	<u>0.05</u>	2522	<u>0.50</u>	Comp. ex.
	134	L2	98	2.2	0.11	0.11	2498	0.84	Inv. ex.
	135	L3	98	2.3	0.14	0.14	2510	0.87	Inv. ex.
50	136	L4	99	2.1	0.14	0.14	2452	0.89	Inv. ex.
	137	L5	97	2.3	0.14	0.14	2429	0.89	Inv. ex.
	138	L6	99	1.9	0.16	0.16	2528	0.94	Inv. ex.
55	139	L7	99	2.4	0.19	0.19	2467	0.94	Inv. ex.
	140	L8	100	2.4	0.15	0.15	2407	0.90	Inv. ex.
	141	L9	97	2.5	0.21	0.21	2493	0.88	Inv. ex.
	142	L10	98	2.5	0.13	0.13	2521	0.88	Inv. ex.
	143	L11	98	2.1	0.13	0.13	2426	0.89	Inv. ex.
	144	L12	98	2.3	0.11	0.11	2436	0.84	Inv. ex.
	145	L13	97	2.2	0.03	<u>0.03</u>	2446	<u>0.73</u>	Comp. ex.
	146	M1	100	2.4	0.14	0.14	<u>2098</u>	0.92	Comp. ex.

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(continued)

Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
				Amount of segregation of Mo atm%	Total amount of segregation atm%			
147	M2	99	2.4	0.13	0.13	2260	0.94	Inv. ex.
148	M3	99	1.9	0.14	0.14	2395	0.94	Inv. ex.
149	M4	99	1.9	0.13	0.13	2499	0.91	Inv. ex.
150	M5	99	2.3	0.14	0.14	2423	0.92	Inv. ex.
151	M6	97	2.3	0.13	0.13	2474	0.92	Inv. ex.
152	M7	98	2.1	0.13	0.13	2482	0.86	Inv. ex.
153	M8	100	2.4	0.14	0.14	2448	0.89	Inv. ex.
Underlines show outside scope of present invention or values of properties which are not preferable.								

[Table 3-4]

[0140]

Table 3-4

Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
				Amount of segregation of Mo atm%	Total amount of segregation atm%			
154	M9	98	2.1	0.14	0.14	2436	0.85	Inv. ex.
155	M10	97	2.1	0.13	0.13	2505	0.84	Inv. ex.
156	M11	97	2.5	0.14	0.14	2464	<u>0.66</u>	Comp. ex.
157	N1	97	2.5	0.13	0.13	2726	0.93	Inv. ex.
158	N2	98	2.5	0.13	0.13	2979	0.93	Inv. ex.
159	N3	100	2.1	0.14	0.14	2769	0.93	Inv. ex.
160	N4	99	2.1	0.13	0.13	2796	0.91	Inv. ex.
161	N5	98	1.9	0.14	0.14	2652	0.90	Inv. ex.
162	N6	98	2.2	0.14	0.14	2789	0.90	Inv. ex.
163	N7	100	2.2	0.14	0.14	2965	0.91	Inv. ex.
164	N8	99	2.2	0.14	0.14	2580	0.93	Inv. ex.
165	N9	97	2.0	0.13	0.13	2936	0.91	Inv. ex.
166	N10	99	2.0	0.13	0.13	2910	0.91	Inv. ex.
167	N11	100	2.4	0.14	0.14	2626	0.92	Inv. ex.
168	N12	100	2.2	0.13	0.13	2922	0.93	Inv. ex.
169	N13	100	1.9	0.13	0.13	2708	0.90	Inv. ex.
170	O1	97	2.1	0.14	0.14	2936	0.93	Inv. ex.
171	O2	98	2.2	0.14	0.14	2909	0.93	Inv. ex.

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(continued)

5	Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
					Amount of segregation of Mo atm%	Total amount of segregation atm%			
10	172	O3	99	2.4	0.13	0.13	2822	0.92	Inv. ex.
	173	O4	98	2.3	0.13	0.13	2850	0.92	Inv. ex.
	174	O5	100	2.5	0.14	0.14	2892	0.90	Inv. ex.
15	175	O6	98	2.1	0.14	0.14	2648	0.93	Inv. ex.
	176	O7	99	2.2	0.13	0.13	2810	0.91	Inv. ex.
	177	O8	99	2.0	0.13	0.13	2570	0.90	Inv. ex.
20	178	O9	99	2.2	0.13	0.13	2682	0.92	Inv. ex.
	179	O10	100	2.2	0.13	0.13	2735	0.92	Inv. ex.
	180	O11	97	2.5	0.14	0.14	2953	0.91	Inv. ex.
25	181	O12	98	2.1	0.14	0.14	2770	0.91	Inv. ex.
	182	P1	98	2.4	0.13	0.13	2764	0.91	Inv. ex.
	183	P2	98	2.1	0.13	0.13	2869	0.93	Inv. ex.
30	184	P3	100	2.4	0.13	0.13	2739	0.90	Inv. ex.
	185	P4	97	1.9	0.14	0.14	2623	0.90	Inv. ex.
	186	P5	97	2.5	0.14	0.14	2581	0.92	Inv. ex.
35	187	P6	100	1.9	0.13	0.13	2880	0.93	Inv. ex.
	188	P7	100	2.0	0.14	0.14	2603	0.91	Inv. ex.
	189	P8	99	2.4	0.14	0.14	2557	0.94	Inv. ex.
40	190	P9	100	2.4	0.14	0.14	2789	0.93	Inv. ex.
	191	P10	99	2.3	0.14	0.14	2885	0.93	Inv. ex.
	192	P11	98	2.0	0.14	0.14	2608	0.91	Inv. ex.
45	193	P12	98	2.5	0.13	0.13	2562	0.94	Inv. ex.
	194	Q1	100	2.1	0.14	0.14	2842	0.92	Inv. ex.
	195	Q2	100	2.3	0.14	0.14	2972	0.94	Inv. ex.
50	196	Q3	97	1.9	0.14	0.14	2593	0.93	Inv. ex.
	197	Q4	99	2.5	0.13	0.13	2909	0.91	Inv. ex.
	198	Q5	97	2.0	0.14	0.14	2621	0.91	Inv. ex.
55	199	Q6	98	2.4	0.14	0.14	2875	0.93	Inv. ex.
	200	Q7	98	2.4	0.14	0.14	2561	0.91	Inv. ex.
	201	Q8	97	2.3	0.13	0.13	2707	0.94	Inv. ex.
	202	Q9	97	2.0	0.13	0.13	2946	0.90	Inv. ex.
	203	Q10	99	2.3	0.13	0.13	2782	0.94	Inv. ex.
	204	Q11	100	2.1	0.13	0.13	2997	0.94	Inv. ex.
Underlines show outside scope of present invention or values of properties which are not preferable.									

[Table 3-5]

[0141]

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Table 3-5

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Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
				Amount of segregation of Mo atm%	Total amount of segregation atm%			
205	Q12	99	1.9	0.13	0.13	2677	0.92	Inv. ex.
206	R1	98	2.5	0.14	0.14	2404	0.90	Inv. ex.
207	P2	100	1.9	0.14	0.14	2528	0.92	Inv. ex.
208	R3	99	2.2	0.14	0.14	2465	0.92	Inv. ex.
209	R4	97	1.9	0.13	0.13	2504	0.90	Inv. ex.
210	R5	99	1.9	0.13	0.13	2509	0.90	Inv. ex.
211	R6	99	1.9	0.14	0.14	2433	0.94	Inv. ex.
212	R7	98	2.2	0.14	0.14	2512	0.92	Inv. ex.
213	R8	98	2.4	0.13	0.13	2524	0.93	Inv. ex.
214	S1	98	2.1	0.13	0.13	2491	0.91	Inv. ex.
215	S2	100	2.3	0.14	0.14	2462	0.94	Inv. ex.
216	S3	98	2.4	0.14	0.14	2427	0.90	Inv. ex.
217	S4	98	2.5	0.13	0.13	2513	0.93	Inv. ex.
218	S5	98	2.5	0.13	0.13	2472	0.94	Inv. ex.
219	S6	100	2.5	0.14	0.14	2420	0.92	Inv. ex.
220	S7	98	2.3	0.14	0.14	2490	0.91	Inv. ex.
221	S8	100	2.4	0.13	0.13	2534	0.90	Inv. ex.
222	T1	97	2.1	0.13	0.13	2407	0.92	Inv. ex.
223	T2	100	2.4	0.13	0.13	2411	0.91	Inv. ex.
224	T3	98	2.4	0.14	0.14	2406	0.91	Inv. ex.
225	T4	98	2.5	0.14	0.14	2526	0.93	Inv. ex.
226	T5	100	1.9	0.14	0.14	2481	0.90	Inv. ex.
227	T6	97	2.2	0.13	0.13	2509	0.92	Inv. ex.
228	T7	99	2.0	0.13	0.13	2540	0.92	Inv. ex.
229	T8	98	2.4	0.14	0.14	2413	0.92	Inv. ex.
230	U1	99	2.0	0.14	0.14	2538	0.92	Inv. ex.
231	U2	98	2.3	0.13	0.13	2446	0.92	Inv. ex.
232	U3	97	2.0	0.13	0.13	2541	0.90	Inv. ex.
233	U4	98	1.9	0.13	0.13	2510	0.93	Inv. ex.
234	U5	98	1.9	0.14	0.14	2406	0.94	Inv. ex.
235	U6	98	1.9	0.13	0.13	2407	0.93	Inv. ex.
236	U7	97	2.3	0.14	0.14	2444	0.92	Inv. ex.
237	U8	100	2.0	0.13	0.13	2422	0.91	Inv. ex.

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(continued)

Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
				Amount of segregation of Mo atm%	Total amount of segregation atm%			
238	V1	98	1.9	0.13	0.13	2413	0.92	Inv. ex.
239	V2	99	2.3	0.14	0.14	2493	0.92	Inv. ex.
240	V3	97	2.1	0.14	0.14	2511	0.90	Inv. ex.
241	V4	99	2.5	0.14	0.14	2488	0.92	Inv. ex.
242	V5	99	2.0	0.13	0.13	2496	0.90	Inv. ex.
243	V6	98	2.1	0.14	0.14	2474	0.93	Inv. ex.
244	V7	97	2.0	0.14	0.14	2548	0.92	Inv. ex.
245	V8	99	2.2	0.14	0.14	2435	0.90	Inv. ex.
246	W1	98	2.3	0.14	0.14	2471	0.90	Inv. ex.
247	W2	99	2.1	0.14	0.14	2446	0.94	Inv. ex.
248	W3	98	2.3	0.13	0.13	2530	0.92	Inv. ex.
249	W4	97	2.0	0.14	0.14	2550	0.92	Inv. ex.
250	W5	99	2.2	0.13	0.13	2537	0.93	Inv. ex.
251	W6	100	2.4	0.13	0.13	2439	0.92	Inv. ex.
252	W7	99	2.5	0.14	0.14	2412	0.92	Inv. ex.
253	W8	97	2.3	0.13	0.13	2470	0.94	Inv. ex.
254	X1	100	2.0	0.13	0.13	2430	0.91	Inv. ex.
255	X2	99	2.1	0.13	0.13	2476	0.93	Inv. ex.
Underlines show outside scope of present invention or values of properties which are not preferable.								

[Table 3-6]

[0142]

Table 3-6

Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
				Amount of segregation of Mo atm%	Total amount of segregation atm%			
256	X3	97	2.1	0.13	0.13	2522	0.90	Inv. ex.
257	Y1	100	2.0	0.13	0.16	2413	0.98	Inv. ex.
258	Y2	97	2.2	0.14	0.23	2474	0.95	Inv. ex.
259	Y3	99	2.2	0.14	0.19	2537	0.98	Inv. ex.
260	Y4	97	2.4	0.13	0.21	2479	0.96	Inv. ex.
261	Y5	97	2.0	0.13	0.21	2506	0.95	Inv. ex.
262	Y6	99	2.4	0.13	0.17	2501	0.96	Inv. ex.

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(continued)

5	Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
					Amount of segregation of Mo atm%	Total amount of segregation atm%			
10	263	Y7	97	2.2	0.13	0.24	2404	0.99	Inv. ex.
	264	Y8	100	2.0	0.14	0.24	2476	0.96	Inv. ex.
	265	Y9	98	2.1	0.14	0.23	2416	0.99	Inv. ex.
	266	Y10	100	2.5	0.13	0.15	2485	0.96	Inv. ex.
15	267	Z1	99	2.1	0.14	0.23	2437	0.97	Inv. ex.
	268	Z2	98	2.1	0.13	0.22	2543	0.95	Inv. ex.
	269	Z3	100	2.3	0.13	0.24	2538	0.98	Inv. ex.
	270	Z4	98	2.1	0.13	0.15	2526	0.96	Inv. ex.
20	271	Z5	99	2.3	0.13	0.21	2427	0.98	Inv. ex.
	272	Z6	100	1.9	0.14	0.25	2483	0.96	Inv. ex.
	273	Z7	100	2.0	0.14	0.19	2491	0.99	Inv. ex.
	274	Z8	100	2.5	0.14	0.25	2497	0.95	Inv. ex.
25	275	Z9	99	2.1	0.14	0.21	2468	0.97	Inv. ex.
	276	Z10	99	2.4	0.14	0.15	2425	0.98	Inv. ex.
	277	AA1	98	2.0	0.13	0.25	2463	0.98	Inv. ex.
	278	AA2	100	2.0	0.14	0.24	2414	0.97	Inv. ex.
30	279	AA3	98	2.3	0.14	0.19	2513	0.97	Inv. ex.
	280	AA4	99	2.5	0.13	0.23	2477	0.99	Inv. ex.
	281	AA5	100	2.5	0.13	0.23	2408	0.98	Inv. ex.
	282	AA6	100	2.3	0.13	0.15	2469	0.99	Inv. ex.
35	283	AA7	98	2.2	0.14	0.16	2496	0.95	Inv. ex.
	284	AA8	99	2.2	0.13	0.15	2404	0.98	Inv. ex.
	285	AA9	97	2.0	0.14	0.18	2432	0.97	Inv. ex.
	286	AA10	99	2.0	0.14	0.21	2432	0.95	Inv. ex.
40	287	BB1	98	2.1	0.13	0.19	2480	0.97	Inv. ex.
	288	BB2	98	2.4	0.13	0.18	2436	0.96	Inv. ex.
	289	BB3	100	2.2	0.13	0.20	2471	0.96	Inv. ex.
	290	BB4	100	2.4	0.14	0.15	2464	0.95	Inv. ex.
45	291	BB5	100	2.2	0.14	0.15	2525	0.95	Inv. ex.
	292	BB6	100	2.3	0.13	0.17	2531	0.98	Inv. ex.
	293	BB7	98	2.0	0.14	0.23	2461	0.99	Inv. ex.
	294	BB8	99	2.2	0.14	0.24	2425	0.95	Inv. ex.
50	295	BB9	97	2.1	0.14	0.17	2528	0.95	Inv. ex.
	296	BB10	98	1.9	0.14	0.20	2453	0.99	Inv. ex.
	297	CC1	98	2.3	0.14	0.20	2510	0.95	Inv. ex.

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(continued)

Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
				Amount of segregation of Mo atm%	Total amount of segregation atm%			
298	CC2	98	2.4	0.13	0.16	2425	0.97	Inv. ex.
299	CC3	97	2.0	0.13	0.19	2482	0.99	Inv. ex.
300	CC4	99	2.5	0.14	0.25	2448	0.96	Inv. ex.
301	CC5	98	2.1	0.13	0.18	2538	0.95	Inv. ex.
302	CC6	97	2.0	0.14	0.23	2550	0.95	Inv. ex.
303	CC7	98	2.0	0.13	0.16	2453	0.96	Inv. ex.
304	CC8	98	1.9	0.13	0.21	2410	0.96	Inv. ex.
305	CC9	98	2.1	0.13	0.18	2514	0.95	Inv. ex.
306	CC10	99	2.5	0.14	0.22	2499	0.99	Inv. ex.
Underlines show outside scope of present invention or values of properties which are not preferable.								

[Table 3-7]

[0143]

Table 3-7

Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
				Amount of segregation of Mo atm%	Total amount of segregation atm%			
307	DD1	97	2.0	0.14	0.16	2503	0.96	Inv. ex.
308	DD2	100	2.0	0.13	0.20	2427	0.97	Inv. ex.
309	DD3	100	2.4	0.14	0.18	2539	0.98	Inv. ex.
310	DD4	100	2.1	0.13	0.15	2538	0.99	Inv. ex.
311	DD5	98	2.1	0.14	0.20	2449	0.97	Inv. ex.
312	DD6	97	2.3	0.14	0.16	2461	0.99	Inv. ex.
313	DD7	97	2.2	0.14	0.23	2419	0.97	Inv. ex.
314	DD8	100	2.4	0.14	0.21	2540	0.98	Inv. ex.
315	DD9	100	2.5	0.14	0.23	2467	0.98	Inv. ex.
316	DD10	100	2.4	0.14	0.22	2468	0.96	Inv. ex.
317	EE1	97	2.3	0.13	0.13	2546	0.91	Inv. ex.
318	EE2	97	2.1	0.14	0.14	2427	0.96	Inv. ex.
319	EE3	97	1.9	0.13	0.13	2516	0.92	Inv. ex.
320	EE4	97	2.1	0.14	0.14	2541	0.94	Inv. ex.
321	EE5	98	3.7	0.14	0.14	2440	0.87	Inv. ex.
322	EE6	99	1.9	0.14	0.14	2419	0.92	Inv. ex.

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(continued)

5	Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
					Amount of segregation of Mo atm%	Total amount of segregation atm%			
10	323	EE7	97	2.3	0.13	0.13	2451	0.91	Inv. ex.
	324	EE8	99	2.1	0.13	0.13	2508	0.92	Inv. ex.
	325	EE6	99	5.7	0.13	0.13	2417	<u>0.50</u>	Comp. ex.
15	326	EE6	97	2.8	0.13	0.13	2474	0.88	Inv. ex.
	327	EE6	98	2.1	0.14	0.14	2413	0.93	Inv. ex.
	328	EE6	100	1.9	0.14	0.14	2477	0.90	Inv. ex.
20	329	EE6	98	2.4	0.14	0.14	2453	0.90	Inv. ex.
	330	EE6	98	2.8	0.14	0.14	2431	0.88	Inv. ex.
	331	EE6	97	3.4	0.14	0.14	2495	0.88	Inv. ex.
25	332	EE6	100	4.7	0.14	0.14	2417	0.82	Inv. ex.
	333	EE6	99	6.4	0.13	0.13	2495	0.65	Comp. ex.
	334	EE6	100	2.0	0.13	0.13	2532	0.94	Inv. ex.
30	335	EE6	99	2.3	0.13	0.13	2467	0.91	Inv. ex.
	336	EE6	97	2.3	0.13	0.13	2536	0.94	Inv. ex.
	337	EE6	99	2.3	0.13	0.13	2485	0.94	Inv. ex.
35	338	EE6	99	2.4	0.13	0.13	2480	0.94	Inv. ex.
	339	EE6	99	2.0	0.13	0.13	2491	0.91	Inv. ex.
	340	EE6	100	2.2	0.13	0.13	2542	0.94	Inv. ex.
40	341	EE6	97	2.5	0.13	0.13	2543	0.91	Inv. ex.
	342	EE6	99	2.1	0.14	0.14	2548	0.90	Inv. ex.
	343	EE6	99	2.2	0.14	0.14	2471	0.94	Inv. ex.
45	344	EE6	100	1.9	0.14	0.14	2413	0.92	Inv. ex.
	345	EE6	100	2.2	0.13	0.13	2424	0.90	Inv. ex.
	346	EE6	97	2.0	0.14	0.14	2527	0.90	Inv. ex.
50	347	EE6	100	2.4	0.14	0.14	2460	0.90	Inv. ex.
	348	EE6	99	2.3	0.04	<u>0.04</u>	2457	<u>0.74</u>	Comp. ex.
	349	EE6	99	2.2	0.12	0.12	2502	0.84	Inv. ex.
55	350	EE6	97	2.3	0.13	0.13	2415	0.86	Inv. ex.
	351	EE6	100	2.2	0.13	0.13	2454	0.86	Inv. ex.
	352	EE6	100	2.5	0.15	0.15	2548	0.98	Inv. ex.
	353	EE6	99	2.1	0.25	0.25	2441	0.95	Inv. ex.
	354	EE6	100	2.3	0.08	<u>0.08</u>	2493	<u>0.65</u>	Comp. ex.
	355	EE6	97	2.2	0.11	0.11	2506	0.83	Inv. ex.
	356	EE6	98	1.9	0.14	0.14	2407	0.88	Inv. ex.

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(continued)

Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
				Amount of segregation of Mo atm%	Total amount of segregation atm%			
357	EE6	99	2.0	0.13	0.13	2507	0.88	Inv. ex.

Underlines show outside scope of present invention or values of properties which are not preferable.

[Table 3-8]

[0144]

Table 3-8

Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
				Amount of segregation of Mo atm%	Total amount of segregation atm%			
358	EE6	97	2.4	0.14	0.14	2477	0.86	Inv. ex.
359	EE6	98	2.0	0.21	0.21	2530	0.98	Inv. ex.
360	EE6	100	2.1	0.25	0.25	2458	0.96	Inv. ex.
361	EE6	<u>77</u>	<u>5.2</u>	0.13	0.13	<u>2078</u>	<u>0.42</u>	Comp. ex.
362	EE6	91	1.9	0.13	0.13	2271	0.93	Inv. ex.
363	EE6	94	2.1	0.13	0.13	2396	0.93	Inv. ex.
364	EE6	99	2.5	0.14	0.14	2449	0.94	Inv. ex.
365	EE6	100	2.5	0.13	0.13	2403	0.91	Inv. ex.
366	EE6	98	2.4	0.14	0.14	2435	0.91	Inv. ex.
367	EE6	99	2.2	0.13	0.13	2496	0.91	Inv. ex.
368	EE6	100	2.0	0.13	0.13	2531	0.92	Inv. ex.
369	EE6	97	2.2	0.13	0.13	2519	0.90	Inv. ex.
370	EE6	97	2.2	0.14	0.14	2536	0.94	Inv. ex.
371	EE6	99	3.6	0.13	0.13	2522	0.88	Inv. ex.
372	EE6	100	2.7	0.14	0.14	2459	0.87	Inv. ex.
373	EE6	100	2.8	0.13	0.13	2523	0.87	Inv. ex.
374	EE6	99	4.1	0.13	0.13	2529	0.35	Inv. ex.
375	EE6	98	5.6	0.13	0.13	2402	<u>0.41</u>	Comp. ex.
376	EE6	100	6.2	0.14	0.14	2488	<u>0.59</u>	Comp. ex.
377	EE6	98	4.9	0.14	0.14	2433	0.83	Inv. ex.
378	EE6	98	3.0	0.14	0.14	2535	0.87	Inv. ex.
379	EE6	97	2.8	0.14	0.14	2418	0.88	Inv. ex.
380	EE6	99	2.2	0.13	0.13	2529	0.92	Inv. ex.
381	EE6	98	2.1	0.13	0.13	2425	0.92	Inv. ex.

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(continued)

5	Test no.	Steel	Area ratio of hard structures %	Standard deviation of grain size distribution of former γ grains μm	Amount of segregation of former γ grain boundaries		Tensile strength MPa	Early fracture resistance evaluation	Remarks
					Amount of segregation of Mo atm%	Total amount of segregation atm%			
10	382	EE6	99	2.1	0.13	0.13	2426	0.91	Inv. ex.
	383	EE6	97	2.3	0.14	0.14	2457	0.92	Inv. ex.
	384	EE6	97	2.2	0.14	0.14	2536	0.93	Inv. ex.
15	385	EE6	97	2.4	0.13	0.13	2425	0.93	Inv. ex.
	386	EE6	99	1.9	0.13	0.13	2456	0.91	Inv. ex.
	387	EE6	99	2.5	0.14	0.14	2457	0.93	Inv. ex.
20	388	EE6	97	1.9	0.14	0.14	2503	0.90	Inv. ex.
	389	EE6	98	2.7	0.13	0.13	2474	0.87	Inv. ex.
	390	EE6	100	3.7	0.13	0.13	2493	0.88	Inv. ex.
25	391	EE6	99	4.8	0.14	0.14	2497	0.80	Inv. ex.
	392	EE6	99	5.6	0.14	0.14	2466	<u>0.48</u>	Comp. ex.
	393	EE6	98	2.5	0.13	0.13	2458	0.91	Inv. ex.
30	394	EE6	98	2.2	0.13	0.13	2547	0.92	Inv. ex.
	395	EE6	97	2.1	0.13	0.13	2506	0.91	Inv. ex.
	396	EE6	97	2.5	0.14	0.14	2499	0.90	Inv. ex.
35	397	EE6	100	2.1	0.13	0.13	2495	0.93	Inv. ex.
	398	EE6	97	2.4	0.13	0.13	2444	0.93	Inv. ex.
	399	EE6	99	2.2	0.13	0.13	2522	0.94	Inv. ex.
40	400	EE6	99	2.0	0.14	0.14	2550	0.92	Inv. ex.
	401	EE6	98	2.5	0.14	0.14	2419	0.93	Inv. ex.
	402	EE6	97	2.5	0.14	0.14	2418	0.93	Inv. ex.
45	403	EE6	97	2.4	0.13	0.13	2351	0.90	Inv. ex.
	404	EE6	99	2.0	0.13	0.13	2349	0.90	Inv. ex.
	405	EE6	100	1.9	0.14	0.14	2247	0.94	Inv. ex.
50	406	EE6	99	2.0	0.13	0.13	2250	0.92	Inv. ex.
	407	EE6	98	2.2	0.14	0.14	2253	0.94	Inv. ex.
	408	EE6	97	2.3	0.13	0.13	2423	0.93	Inv. ex.
Underlines show outside scope of present invention or values of properties which are not preferable.									

50 **[0145]** Referring to Table 3, in Comparative Example 1, the C content was low, therefore the tensile strength fell. In Comparative Example 14, the C content was high, therefore the early fracture resistance fell. In Comparative Example 15, the Si content was low, therefore the tensile strength fell. In Comparative Example 29, the Si content was high, therefore the amount of ferrite increased, the desired metallographic structure was not obtained, and as a result the tensile strength similarly fell. In Comparative Example 30, the Mn content was low, therefore the standard deviation at the grain size distribution of the former austenite grains became greater and the early fracture resistance fell. In Comparative Example 43, the Mn content was high, therefore it is believed that in the hot rolled steel sheet, transformation from austenite to pearlite was promoted too much. As a result, in the hot stamped body, the standard deviation in the grain size distribution of the former austenite grains could not be made within the desired range and the early fracture resistance fell. In

Comparative Examples 52, 61, 70, 78, 79, and 92, the respective P, S, N, O, or Al contents were not suitable, therefore the early fracture resistances fell. In Comparative Examples 93, 107, and 119, the respective Nb, Ti, and Cr contents were low, therefore the strengths could not be sufficiently improved by precipitation strengthening or solid solution strengthening and the tensile strengths fell. In Comparative Examples 106, 118, and 132, the respective Nb, Ti, and Cr contents were high, therefore it is believed large amounts of carbonitrides were formed or coarse intermetallic compounds were formed and as a result the early fracture resistances fell. In Comparative Example 133, the Mo content was low, therefore the total amount of segregation of the grain boundary strengthening elements at the former austenite grain boundaries became lower and the early fracture resistance fell. In Comparative Examples 145 and 156, the respective Mo and B contents were high, therefore it is believed that coarse intermetallic compounds were formed at the hot stamped bodies and as a result the early fracture resistance fell. In Comparative Example 146, the B content was low, therefore the tensile strength fell.

[0146] In Comparative Example 325, the rolling reduction of the final stage in the finish rolling of the hot rolling step was low, therefore it is believed the pearlite could not be evenly dispersed at the hot rolled steel sheet after rolling. As a result, in the hot stamped body, the standard deviation at the grain size distribution of the former austenite grains became greater and the early fracture resistance fell. In Comparative Example 333, the coiling temperature was high, therefore it is believed the ferrite was arranged connected and the pearlite could not be evenly dispersed. As a result, in the hot stamped body, the standard deviation at the grain size distribution of the former austenite grains became larger and the early fracture resistance fell. In Comparative Example 348, the heating temperature at the preheating step was low, therefore it is believed the grain boundary strengthening elements could not sufficiently dissolve in the steel sheet. As a result, the total amount of segregation of the grain boundary strengthening elements at the former austenite grain boundaries became low and the early fracture resistance fell. In Comparative Example 354, the average cooling speed at the preheating step was slow, therefore it is believed the grain boundary strengthening elements dissolved in the steel sheet due to the preheating precipitated as compounds. As a result, the total amount of segregation of the grain boundary strengthening elements at the former austenite grain boundaries became low and the early fracture resistance fell. In Comparative Example 361, the heating temperature at the hot stamping step was low, therefore the austenization became insufficient, the area ratio of the hard structures and the standard deviation at the grain size distribution of the former austenite grains could not be controlled to within the desired ranges, and the tensile strength and early fracture resistance fell. In Comparative Example 375, the heating temperature at the hot stamping step was high, therefore austenite grains excessively grew, the standard deviation at the grain size distribution of the former austenite grains could not be controlled to within the desired range, and the early fracture resistance fell. In Comparative Example 376, the holding time at the hot stamping step was long, therefore austenization became insufficient, the standard deviation at the grain size distribution of the former austenite grains could not be controlled to within the desired range, and the early fracture resistance fell. In Comparative Example 392, the holding time at the hot stamping step was long, therefore austenite grains excessively grew, the standard deviation at the grain size distribution of the former austenite grains could not be controlled to within the desired range, and the early fracture resistance fell.

[0147] In contrast to this, the hot stamped bodies according to all of the invention examples have the predetermined chemical compositions and metallographic structures, have standard deviations at the grain size distributions of the former austenite grains controlled to 5.0 μm or less, and have total amounts of segregation of the grain boundary strengthening elements at the former austenite grain boundaries, i.e., at least one of Mo, W, Ta, Re, Os, Ir, and Tc, controlled to 0.10 atm% or more, whereby early fracture can be reliably suppressed regardless of having high tensile strengths of 2200 MPa or more.

Claims

1. A hot stamped body having a chemical composition comprising, by mass%,

C: 0.40 to 0.70%,
 Si: 0.010 to 3.00%,
 Mn: 0.50 to 3.00%,
 P: 0.100% or less,
 S: 0.0100% or less,
 N: 0.0200% or less,
 O: 0.0200% or less,
 Al: 0.0010 to 0.500%,
 Nb: 0.0010 to 0.100%,
 Ti: 0.010 to 0.200%,
 Cr: 0.010 to 1.00%,
 Mo: 0.0010 to 1.000%,

B: 0.0005 to 0.0200%,

Co: 0 to 4.00%,

Ni: 0 to 3.00%,

Cu: 0 to 3.00%,

V: 0 to 3.00%,

Ca: 0 to 1.000%,

Mg: 0 to 1.000%,

REM: 0 to 1.000%,

Sb: 0 to 1.00%,

Sn: 0 to 1.00%,

Zr: 0 to 1.00%,

As: 0 to 0.100%,

at least one of W, Ta, Re, Os, Ir, and Tc: 0 to 1.00% in total, and

balance: Fe and impurities, and

a microstructure comprising, by area ratio, at least one of martensite, bainite, and tempered martensite: 90% or more in total, wherein

a standard deviation in grain size distribution of former austenite grains is 5.0 μm or less, and

a total amount of segregation of at least one of Mo, W, Ta, Re, Os, Ir, and Tc at former austenite grain boundaries is 0.10 atm% or more.

2. The hot stamped body according to claim 1, wherein the amount of segregation of Mo at the former austenite grain boundaries is 0.10 atm% or more.

3. The hot stamped body according to claim 1 or 2, wherein the total amount of segregation is 0.15 atm% or more.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/007869

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/00(2006.01)i; **C22C 38/60**(2006.01)i; **C21D 1/18**(2006.01)n; **C21D 9/00**(2006.01)n; **C21D 9/46**(2006.01)n
FI: C22C38/00 301Z; C22C38/00 301S; C22C38/60; C21D1/18 C; C21D9/00 A; C21D9/46 G

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; C21D1/18; C21D9/00; C21D8/02; C21D9/46

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

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	WO 2019/186928 A1 (NIPPON STEEL CORP) 03 October 2019 (2019-10-03) claims, paragraphs [0011], [0083], [0087]	1-3
A	WO 2020/189767 A1 (NIPPON STEEL CORP) 24 September 2020 (2020-09-24) claims	1-3
A	JP 2021-181616 A (JFE STEEL CORP) 25 November 2021 (2021-11-25) claims, paragraphs [0044]-[0048]	1-3
P, A	WO 2022/239731 A1 (NIPPON STEEL CORP) 17 November 2022 (2022-11-17) claims	1-3

☐ Further documents are listed in the continuation of Box C.
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Date of the actual completion of the international search

10 May 2023

Date of mailing of the international search report

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Name and mailing address of the ISA/JP

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/007869

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2019/186928 A1	03 October 2019	EP 3778954 A1 claims, paragraphs [0011], [0075], [0079] US 2021/0102270 A1 CN 111448328 A	
WO 2020/189767 A1	24 September 2020	EP 3943623 A1 claims US 2022/0119929 A1 CN 113597474 A	
JP 2021-181616 A	25 November 2021	(Family: none)	
WO 2022/239731 A1	17 November 2022	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2019186928 A [0005]