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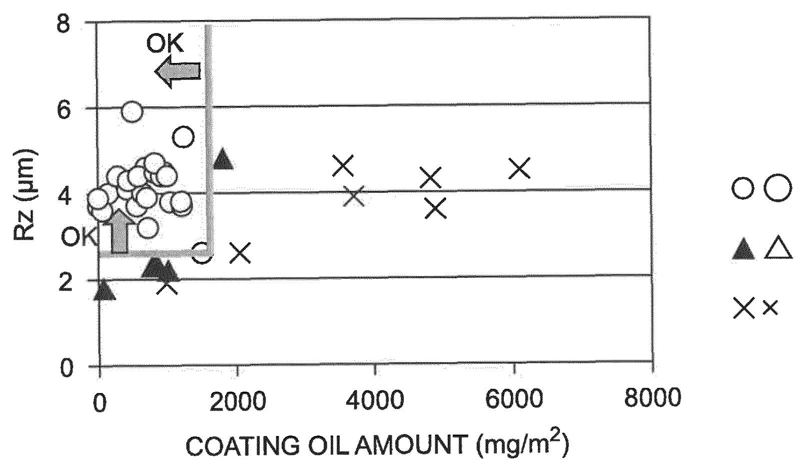
# (54) STEEL SHEET FOR HOT STAMPING, METHOD FOR MANUFACTURING SAME, AND HOT STAMP MOLDED ARTICLE

(57) A steel sheet for hot stamping includes a composition including at least, in mass%, C: 0.100% to 0.600%, Si: 0.50% to 3.00%, Mn: 1.20% to 4.00%, Ti: 0.005% to 0.100%, B: 0.0005% to 0.0100%, P: 0.100% or less, S: 0.0001% to 0.0100%, Al: 0.005% to 1.000%, and N: 0.0100% or less, with a balance of Fe and impurities, surface roughness of the steel sheet satisfies Rz>2.5 $\mu$m, and 50 mg/m$^2$ to 1500 mg/m$^2$ of coating oil is applied to a surface.

FIG. 1

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## Description

TECHNICAL FIELD

**[0001]** The present invention relates to a steel sheet for hot stamping excellent in scale adhesion at the time of hot stamping and a method for producing the steel sheet for hot stamping, and a hot stamp formed body that is a formed body of the steel sheet for hot stamping.

BACKGROUND ART

**[0002]** Weight reduction of the members such as door guard bars and side members of automobiles are being studied to cope with the recent trend of improvement in fuel efficiency, and in terms of a material, increase in strength of a steel sheet is promoted from the viewpoint of strength and crash safety that should be ensured even when the thickness is reduced. Hereinafter, strength means both tensile strength and yield strength. However, formability of a material deteriorates as the strength increases, and therefore in order to realize reduction in weight of the above described members, it is necessary to produce a steel sheet that satisfies both formability and high strength. As a method for obtaining high formability simultaneously with high strength, there are TRIP (TRansformation Induced Plasticity) steels taking advantage of martensitic transformation of retained austenite that are described in Patent Literature 1 and Patent Literature 2, and application of TRIP steels has been expanding in recent years. In the steel, however, although deep drawability and elongation are improved at the time of forming, due to a high steel sheet strength, it has a problem of low shape fixability of a member after press forming.

**[0003]** In order to form a high strength steel sheet, which is inferior in formability, with good shape fixability, there is a method called hot press that is described in Patent Literature 3 and Patent Literature 4. The method performs forming at a temperature of 200°C to about 500°C at which the steel sheet strength reduces. However, when forming of the high strength steel sheet of 780 MPa or more is considered, the method has problems in that even when the forming temperature is increased, the steel sheet strength may still be high in some cases and thus forming is difficult, and in that the steel sheet strength after forming is reduced by heating, and thus predetermined strength cannot be obtained in some cases.

**[0004]** As a method for solving the problems, there exists a method called hot stamping that cuts a soft steel sheet in a predetermined size, thereafter, heats the steel sheet to an austenite single phase region at 800°C or higher, thereafter performs press forming in the austenite single phase region as disclosed in Patent Literature 5, and thereafter performs hardening. As a result, it is possible to manufacture a member that has high strength of 980 MPa or more and is excellent in shape fixability.

**[0005]** However, in hot stamping, a steel sheet is inserted into a heating furnace, or is heated to a high temperature exceeding 800°C by electrical heating or far-infrared heating in the atmosphere, and thus hot stamping has a problem of scale generated on a steel sheet surface. A die may be worn out due to the generated scale released at the time of hot stamping, and therefore it is required that scale adhesion should be excellent at the time of hot stamping. As a technique that solves these problems, there is known a technique of restraining generation of scale by making an atmosphere in the heating furnace a non-oxidation atmosphere in Patent Literature 6, for example. However, it is necessary to implement atmosphere control in the heating furnace strictly, and thus facility cost increases, and productivity is reduced. Further, the steel sheet which is taken out is exposed to the atmosphere, and thus the technique has a problem of unavoidable formation of scale. In addition, in recent years, for the purpose of enhancing productivity of hot stamping, the method for electrically heating a steel sheet in the atmosphere has been developed. At the time of heating in the atmosphere, avoidance of oxidation of the steel sheet is difficult, and thus a problem of die wear due to loose scale at the time of hot stamping easily becomes evident. As a result, regular repair of the die is essential.

**[0006]** There is known a technique of restraining wear of a die caused by loose scale by using, in hot stamping, a steel sheet with zinc plating or Al plating applied to a steel sheet surface as the steel sheet that solves these problems. However, since zinc plating or Al plating are melted into a liquid phase at the time of heating, the technique has a problem of zinc or Al adhering to the inside of the heating furnace and the die at the time of conveyance of the steel sheet or the time of pressing. A deposit of adhering zinc or Al has a problem of causing indentation flaws of a hot stamp formed body, and adhering to the formed body to worsen the outer appearance. Consequently, it is necessary to repair the die regularly.

**[0007]** Consequently, it is required to develop a steel sheet for hot stamping in which scale does not detach at the time of hot stamping, and adhesion of a molten metal to a die does not occur.

CITATION LIST

PATENT LITERATURES

**[0008]**

Patent Literature 1: Japanese Laid-open Patent Publication No. 01-230715

Patent Literature 2: Japanese Laid-open Patent Publication No. 02-217425

Patent Literature 3: Japanese Laid-open Patent Publication No. 2002-143935

Patent Literature 4: Japanese Laid-open Patent Publication No. 2003-154413

Patent Literature 5: Japanese Laid-open Patent Publication No. 2002-18531

Patent Literature 6: Japanese Laid-open Patent Publication No. 2004-106034

Patent Literature 7: Japanese Laid-open Patent Publication No. 2002-18531

Patent Literature 8: Japanese Laid-open Patent Publication No. 2008-240046

Patent Literature 9: Japanese Laid-open Patent Publication No. 2010-174302

Patent literature 10: Japanese Laid-open Patent Publication No. 2008-214650

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

**[0009]** In the light of the aforementioned problems, the present invention has an object to provide a steel sheet for hot stamping that is excellent in scale adhesion at the time of hot stamping, without an occurrence of adhesion of a molten metal to a die, a method for manufacturing the steel sheet for hot stamping, and a hot stamp formed body.

SOLUTION TO PROBLEM

**[0010]** The present inventors have studied earnestly on methods to solve the above described problems. As a result, with the intention to improve scale adhesion of a steel sheet, 0.50 mass% to 3.00 mass% of Si is contained in the steel sheet, the amount of rust inhibiting oil that is applied to the steel sheet is set to be within a range of 50 mg/m$^2$ to 1500 mg/m$^2$, and surface roughness of the steel sheet is set as Rz>2.5 $\mu$m. Further, an S content included in the rust inhibiting oil is preferably set at 5 mass% or less. Thereby, it has been found that scale adhesion at the time of heating and at the time of hot stamping is improved. In general, enclosures in the coating oil concentrate into an interface between a base iron and scale, and thereby deteriorate scale adhesion. However, it has been found out that it is possible to ensure scale adhesion by using restriction on an enclosure amount, and an anchor effect using irregularities on the steel sheet surface in combination.

**[0011]** The present invention is made based on the above described knowledge, and the gist of the present invention is as follows.

(1) A steel sheet for hot stamping including a composition containing,

in mass%,
C: 0.100% to 0.600%;
Si: 0.50% to 3.00%;
Mn: 1.20% to 4.00%;
Ti: 0.005% to 0.100%;
B: 0.0005% to 0.0100%;
P: 0.100% or less;
S: 0.0001% to 0.0100%;

Al: 0.005% to 1.000%;
N: 0.0100% or less;
Ni: 0% to 2.00%;
Cu: 0% to 2.00%;
Cr: 0% to 2.00%;
Mo: 0% to 2.00%;
Nb: 0% to 0.100%;
V: 0% to 0.100%;
W: 0% to 0.100%, and
a total of one kind or two or more kinds selected from a group consisting of REM, Ca, Ce and Mg: 0% to 0.0300%,
with a balance being Fe and impurities,
wherein surface roughness of the steel sheet satisfies Rz>2.5 μm, and coating oil in an amount of 50 $mg/m^2$ to 1500 $mg/m^2$ is applied onto a surface.

(2) The steel sheet for hot stamping according to (1) described above,
wherein an amount of S contained in the coating oil which is applied onto the steel sheet is 5% or less in mass%.
(3) The steel sheet for hot stamping according to (1) or (2) described above,
wherein the composition of the steel sheet contains, in mass%,
one kind or two or more kinds selected from a group consisting of

Ni: 0.01% to 2.00%,
Cu: 0.01% to 2.00%,
Cr: 0.01% to 2.00%,
Mo: 0.01% to 2.00%,
Nb: 0.005% to 0.100%,
V: 0.005% to 0.100%, and
W: 0.005% to 0.100%.

(4) The steel sheet for hot stamping according to any one of (1) to (3) described above,
wherein the composition of the steel sheet contains, in mass %,
a total of 0.0003% to 0.0300% of one kind or two or more kinds selected from the group consisting of REM, Ca, Ce and Mg.
(5) A method for producing a steel sheet for hot stamping, including

a step of casting a slab containing,
in mass%,
C: 0.100% to 0.600%,
Si: 0.50% to 3.00%,
Mn: 1.20% to 4.00%,
Ti: 0.005% to 0.100%,
B: 0.0005% to 0.0100%,
P: 0.100% or less,
S: 0.0001% to 0.0100%,
Al: 0.005% to 1.000%,
N: 0.0100% or less,
Ni: 0% to 2.00%,
Cu: 0% to 2.00%,
Cr: 0% to 2.00%,
Mo: 0% to 2.00%,
Nb: 0% to 0.100%,
V: 0% to 0.100%,
W: 0% to 0.100%, and
a total of one kind or two or more kinds selected from a group consisting of REM, Ca, Ce and Mg: 0% to 0.0300%,
with a balance being Fe and impurities, and hot rolling the slab directly or by allowing the slab to cool and heating the slab to obtain a hot-rolled steel sheet,
a step of pickling the hot-rolled steel sheet for 30 seconds or more in an aqueous solution having a temperature of 80°C to lower than 100°C and including an inhibitor with a concentration of an acid being 3 mass% to 20 mass%, and

a step of applying a rust inhibiting oil to the steel sheet after carrying out the pickling,
wherein a rust inhibiting oil remaining amount on a steel sheet surface is limited to 50 $mg/m^2$ to 1500 $mg/m^2$.

(6) The method for producing a steel sheet for hot stamping according to (5) described above, wherein the rust inhibiting oil is applied to the hot-rolled steel sheet which has been pickled.
(7) The method for producing a steel sheet for hot stamping according to (5) described above, further including a step of cold rolling the hot-rolled steel sheet which has been pickled to obtain a cold-rolled steel sheet,
wherein the rust inhibiting oil is applied to the cold-rolled steel sheet.
(8) The method for producing a steel sheet for hot stamping according to (5) described above, further including a step of cold rolling the hot-rolled steel sheet which has been pickled, and further performing thermal treatment in a continuous annealing facility or a box type annealing furnace to obtain a cold-rolled steel sheet,
wherein the rust inhibiting oil is applied to the cold-rolled steel sheet.
(9) The method for producing a steel sheet for hot stamping according to any one of (5) to (8) described above, wherein an amount of S in the rust inhibiting oil that is applied to the steel sheet is 5% or less in mass%.
(10) The method for producing a steel sheet for hot stamping according to any one of (5) to (9),
wherein a composition of the slab contains, in mass%,
one kind or two or more kinds selected from a group consisting of

Ni: 0.01% to 2.00%,
Cu: 0.01% to 2.00%,
Cr: 0.01% to 2.00%,
Mo: 0.01% to 2.00%,
Nb: 0.005% to 0.100%,
V: 0.005% to 0.100%, and
W: 0.005% to 0.100%.

(11) The method for producing a steel sheet for hot stamping according to any one of (5) to (10) described above,
wherein a composition of the slab contains, in mass %,
a total of 0.0003% to 0.0300% of one kind or two or more kinds selected from the group consisting of REM, Ca, Ce and Mg.
(12) A hot stamp formed body, including a composition containing,

in mass%,
C: 0.100% to 0.600%,
Si: 0.50% to 3.00%,
Mn: 1.20% to 4.00%,
Ti: 0.005% to 0.100%,
B: 0.0005% to 0.0100%,
P: 0.100% or less,
S: 0.0001% to 0.0100%,
Al: 0.005% to 1.000%,
N: 0.0100% or less,
Ni: 0% to 2.00%,
Cu: 0% to 2.00%,
Cr: 0% to 2.00%,
Mo: 0% to 2.00%,
Nb: 0% to 0.100%,
V: 0% to 0.100%,
W: 0% to 0.100%, and
a total of one kind or two or more kinds selected from a group consisting of REM, Ca, Ce and Mg: 0% to 0.0300%,
with a balance being Fe and impurities,
wherein three or more irregularities in a range of 0.2 μm to 8.0 μm in depth are present per 100 μm in an interface between scale and a base iron, and tensile strength is 1180 MPa or more.

(13) The hot stamp formed body according to (12) described above,
wherein an Si oxide, FeO, $Fe_3O_4$ and $Fe_2O_3$ are included in a surface of the hot stamp formed body, and a thickness of the scale is 10 μm or less.
(14) The hot stamp formed body according to (12) or (13) described above,

wherein the composition of the hot stamp formed body contains, in mass%,
one kind or two or more kinds selected from a group consisting of

Ni: 0.01% to 2.00%,
Cu: 0.01% to 2.00%,
Cr: 0.01% to 2.00%,
Mo: 0.01% to 2.00%,
Nb: 0.005% to 0.100%,
V: 0.005% to 0.100%, and
W: 0.005% to 0.100%.

(15) The hot stamp formed body according to any one of (12) to (14) described above,
wherein the composition of the hot stamp formed body contains, in mass %,
a total of 0.0003% to 0.0300% of one kind or two or more kinds selected from the group consisting of REM, Ca, Ce and Mg.

ADVANTAGEOUS EFFECTS OF INVENTION

**[0012]** According to the present invention, the steel sheet for hot stamping excellent in scale adhesion at the time of hot stamping, in which adhesion of a molten metal to the die does not occur, the method for producing the steel sheet for hot stamping and the hot stamp formed body can be provided.

BRIEF DESCRIPTION OF DRAWINGS

**[0013]**

[Fig. 1] Fig. 1 is a diagram illustrating a relationship between a coating oil amount on a steel sheet and surface roughness Rz of the steel sheet.
[Fig. 2] Fig. 2 is a diagram for explaining that when an S concentration in coating oil increases, scale easily detaches.
[Fig. 3] Fig. 3 is a diagram illustrating a relationship between a pickling time period and the surface roughness Rz of the steel sheet.
[Fig. 4A] Fig. 4A is a photograph showing a microstructure of a surface layer of a hot-rolled steel sheet before pickling.
[Fig. 4B] Fig. 4B is a photograph showing the surface layer microstructure after pickling.
[Fig. 5] Fig. 5 is a diagram illustrating a relationship between an coating oil amount and a thickness of scale.
[Fig. 6A] Fig. 6A is a photograph showing a section of a hot stamp formed body surface of an example of the present invention.
[Fig. 6B] Fig. 6B is a photograph showing a section of a hot stamp formed body surface of a comparative example.
[Fig. 7] Fig. 7 is a diagram for explaining that when the surface roughness Rz before hot stamp thermal treatment is less than 2.5, a number density of irregularities after hot stamp thermal treatment is less than 3.

DESCRIPTION OF EMBODIMENTS

**[0014]** A steel sheet for hot stamping of the present invention contains from 0.5 mass% to 3.0 mass% of Si in the steel sheet, an amount of rust inhibiting oil applied to the steel sheet is in a range of 50 mg/m$^2$ to 1500 mg/m$^2$, and surface roughness of the steel sheet is Rz>2.5 μm. It is preferable that an S content contained in the rust inhibiting oil be 5 mass% or less.
**[0015]** First of all, the reason why the present inventors paid attention to the coating oil will be described.
**[0016]** With an objective of improving scale adhesion of the steel sheets to which no plating is applied (cold-rolled steel sheets or hot-rolled steel sheets), the present inventors have investigated the surface properties of the steel sheets, and influences of various kinds of treatment. As a result, the present inventors have found that although the steel sheets after degreasing show excellent scale adhesion, scale adhesion significantly deteriorates after rust inhibiting oil is applied. When the present inventors investigated the relationship between scale adhesion and rust inhibiting oil in more detail, it has been found that when an amount of S contained as impurities in the rust inhibiting oil increases, scale tends to detach easily. It is conceivable that S in the rust inhibiting oil has an influence on scale adhesion, although the detailed reason is unclear.
**[0017]** On the other hand, it is necessary to apply rust inhibiting oil such as mineral oil to a pickled hot-rolled steel sheet for hot stamping, and a cold-rolled steel sheet for hot stamping after cold rolling or annealing in order to restrain rust from occurring in the period from production to use. In particular, a steel sheet after pickling has been generally

coated with oil of more than 1500 mg/m$^2$, assuming that the period from delivery to a customer to use is long. When the present inventors investigated the influence of the coating oil amount for the purpose of making scale adhesion and rust inhibition properties compatible, the present inventors have found that as illustrated in Fig. 1, scale adhesion is enhanced by strictly controlling the range of the coating oil amount and the surface roughness of a steel sheet. The effect is exhibited by setting the coating oil amount at 50 mg/m$^2$ to 1500 mg/m$^2$. A lower limit of the coating oil amount is set at 50 mg/m$^2$, because it is difficult to ensure excellent rust inhibition properties with the coating oil amount less than the coating oil amount of 50 mg/m$^2$. The lower limit of the coating oil amount is preferably 100 mg/m$^2$ or more, and more preferably 200 mg/m$^2$ or more. An upper limit is set at 1500 mg/m$^2$ to obtain an effect of excellent scale adhesion. The upper limit of the coating oil amount is set at 1500 mg/m$^2$ because when the coating oil amount exceeds 1500 mg/m$^2$, scale adhesion deteriorates. The upper limit is preferably 1000 mg/m$^2$, is more preferably 900 mg/m$^2$, and far more preferably is 800 mg/m$^2$. Further, coated oil on the steel sheet surface burns at the time of heating, and therefore becomes the cause of generating soot. From this, a smaller coating oil amount is more preferable.

**[0018]** Scale adhesion illustrated in Fig. 1 was evaluated by a hot shallow drawing test in a cylindrical die of $\phi$70 mm and a depth of 20 mm. After a steel sheet was heated to a temperature range of 800°C to 1100°C at 50°C/s in an electrical heater, and was retained for 0 seconds to 120 seconds, energization was stopped, the steel sheet was cooled to 650°C by standing to cool, and hot shallow drawing was performed in the above described die. Specimens after forming were visually observed, and specimens in which an area where scale was detached accounted for 5% or less were determined as having good (circle) scale adhesion, specimens in which the area where scale was detached accounted for 5 to 15% were determined as poor (triangle), and specimens in which the area where scale was detached accounted for more than 15% were determined as very poor (X). The specimens in which the area where scale was detached accounted for 5% or less were determined as within the range of the present invention.

**[0019]** It is possible to evaluate scale adhesion without particularly limiting the heating method. For example, conditions of any of a heating furnace, far-infrared rays, near-infrared rays and electrical heating may be adopted. Further, when a steel sheet is heated in a heating furnace, more excellent scale adhesion can be obtained by thinning scale by controlling the atmosphere in the heating furnace and restraining oxidation of the steel sheet.

**[0020]** Note that a shallow drawing test temperature may be in any temperature region as long as a steel sheet can be processed, but in general, a steel sheet for hot stamping has high strength and excellent shape fixability by processing in an austenite region and subsequent die hardening. From this, characteristics evaluation was carried out by hot shallow drawing at 650°C exceeding Ar3.

**[0021]** As an oil coating method, electrostatic oil coating, spray, a roll coater and the like are generally used, but the oil coating method is not limited as long as the coating oil amount can be ensured.

**[0022]** Although the kind of oil is not specified, NOX-RUST530F (made by PARKER INDUSTRIES, INC.) or the like is generally used if the oil is mineral oil, for example, and if the coating oil amount satisfies the range of the present invention, the kind of oil is not limited.

**[0023]** Although the coating oil amount may be measured by any method as long as the coating oil amount can be measured, the present inventors measured the coating oil amount by the following method. The steel sheet coated with rust inhibiting oil was cut into 150 mm square first, and thereafter, a tape was applied so that a 100 mm by 100 mm region is exposed. Subsequently, the weights of the coating oil and the steel sheet to which seal was carried out (including the weight of the tape) were measured in advance. Subsequently, degreasing was performed by wiping off the rust inhibiting oil on the steel sheet surface with cloth containing acetone, the weight of the degreased steel sheet was measured, the weights before and after degreasing were compared, and thereby the coating oil amount per unit area was calculated. Measurement was carried out at three spots in each of the steel sheets, and an average value of the attached amounts was determined as a coating oil attaching amount of each of the steel sheets.

**[0024]** It is preferable to restrict the S content contained in the rust inhibiting oil to 5 mass% or less. When the present inventors investigated the relationship between the S content in the coating oil and a scale detached area ratio as illustrated in Fig. 2, the present inventors have found that as the S content in the coating oil becomes smaller, the scale adhesion increases, and especially when the S content in the coating oil is 5 mass% or less, the scale detached area becomes substantially 0%. It is conceivable that while the oil contained in the rust inhibiting oil is burned and eliminated during heating, S contained as an impurity remains on the steel sheet surface to concentrate into scale, and thereby deteriorates scale adhesion, although detailed mechanism is unclear. Hence, it is preferable to reduce the content of S contained in the rust inhibiting oil. The S content is preferably 4 mass% or less, and is more preferably 3 mass% or less. Although analysis of S in the rust inhibiting oil may be performed by any method as long as S can be analyzed, the present inventors extracted 5 mL of the rust inhibiting oil which is applied to the steel sheet, and carried out analysis by fluorescence X-rays (C-ray Fluorescence Sulfur-in-Oil Analyzer SLFA-2800/HORIBA). In measurement, measurement was carried out with n=3, and an average value thereof was defined as the S content.

**[0025]** The surface roughness of the steel sheet will be described next. In order to ensure scale adhesion, the surface roughness of the steel sheet needs to satisfy $Rz>2.5$ $\mu$m. A result obtained by investigating a relationship between the surface roughness Rz of the steel sheet and scale adhesion is as illustrated in Fig. 1 described above. By providing irregularities on an interface between scale that is generated at the time of hot stamping thermal treatment and a base iron, the irregularities are formed on the interface between the base iron and scale, and further increase in adhesion is brought about. The effect is generally referred to as an anchor effect. In particular, scale that is generated at the time of heating in the present steel sheet is thin. As a result, in the present steel sheet in which the thickness of the scale is thin, scale having irregularities is formed by receiving an influence of the base iron surface state. Hence, the surface roughness of the steel sheet before hot stamping needs to satisfy $Rz>2.5$ μm. When $Rz\leq 2.5$ μm, the surface roughness of the steel sheet is small, and the anchor effect is insufficient, and thus excellent scale adhesion at the time of hot stamping cannot be ensured. Although the effect of the excellent scale adhesion of the present invention can be obtained without particularly providing the upper limit, if scale adhesion is excessively increased, it becomes difficult to remove scale in a downstream process such as shot blast, for example. Thus, it is preferable to set $Rz<8.0$ μm. It is more preferable to set $Rz<7.0$ μm. However, even if $Rz\geq 8.0$ μm is set, it is possible to ensure excellent scale adhesion that is the effect of the present invention. Note that in the steel sheet in which an Si content is less than 0.50 mass%, even if the surface roughness of $Rz>2.5$ μm is set, thick Fe scale is formed at the time of heating, and thus even when the irregularities are on the steel sheet surface, the interface between the base iron and the scale becomes flat by excessive oxidation. As a result, the irregularities in the interface between the scale and the base iron are eliminated, and the effect of the excellent scale adhesion that is the effect of the present invention is not exhibited.

**[0026]** Although measurement of the surface roughness Rz may be performed by any method, the present inventors measured the region of a length of 10 mm with n=3, with use of a contact surface roughness measuring instrument (SURFCOM2000DX/SD3 made by TOKYO SEIMITSU CO., LTD) with a probe point angle of 60°, and a point R of 2 μm, and determined the average value as the surface roughness Rz of each of the steel sheets.

**[0027]** Next, a scale structure of the hot stamp formed body will be described. The steel sheet for hot stamping of the present invention ensures scale adhesion by control of the irregularities in the interface between the scale and the base iron. Hence, the scale can be scale mainly composed of an Si oxide, $Fe_3O_4$, $Fe_2O_3$ and FeO. An Si oxide exists in the interface between base iron and iron scale (FeO, $Fe_2O_3$, $Fe_2O_3$), and thereby controls a thickness of the iron scale. Hence, the scale needs to contain an Si oxide. Since the main object is to control the thickness of the iron oxide, even if the Si oxide is very thin, it is sufficient if the Si oxide exists, and even with 1 nm, the Si oxide exhibits the effect.

**[0028]** Composition analysis of the scale of the formed body was carried out by X-ray diffraction by cutting out the sheet from a bottom of the cylindrical portion of a shallow drawn specimen piece. From a peak intensity ratio of the respective oxides, volume ratios of the respective Fe oxides were measured. The Si oxide existed very thinly, and the volume ratio was less than 1%, and thus quantitative evaluation in X-ray diffraction was difficult. However, it is possible to confirm that an Si oxide exists in the interface between the scale and the base iron by line analysis of EPMA (Electron Probe Micro Analyzer).

**[0029]** The thickness of the scale is preferably 10 μm or less. When the thickness of the scale is 10 μm or less, scale adhesion is enhanced more. When the thickness of the scale exceeds 10 μm, the scale tends to detach easily due to a thermal stress that works at the time of cooling at the time of hot stamping. Thereafter, in a scale removing process such as shot blast or wet blast, fractures occur among Fe scales, and a scale existing on an outer side detaches. As a result, the scale also has a problem of being inferior in scale removability. Hence, the thickness of the scale is preferably 10 μm or less. The thickness of the scale is more preferably 7 μm or less, and is more preferably 5 μm or less. The thickness of the scale is achieved by controlling the coating oil amount within the predetermined range simultaneously with controlling the Si content of the steel sheet within a predetermined range. Fig. 5 illustrates a relationship between the coating oil amount and the scale thickness.

**[0030]** In the interface between the base iron and the scale in the hot stamp formed body of the present invention, three or more irregularities of 0.2 μm to 8.0 μm are present per 100 μm. Fig. 6A shows a photograph of an interface between a base iron and scale of a formed body excellent in scale adhesion, and Fig. 6B shows a photograph of an interface between a base iron and scale inferior in scale adhesion. Since the irregularities contribute to enhancement in scale adhesion at the time of hot stamping, and thus excellent scale adhesion can be ensured by controlling the irregularities within the above described range. Irregularities of less than 0.2 μm provide an insufficient anchor effect, and provide inferior scale adhesion. With irregularities of 8.0 μm or more, scale adhesion is so strong that scale is difficult to remove in the subsequent scale removal process, for example, by shot blast or wet blast, and therefore it is preferable to make the irregularities in the interface between scale and the base iron 8.0 μm or less. The irregularities are more preferably 6.0 μm or less, and more preferably 4.0 μm or less. Note that even if the irregularities exceed 8.0 μm, excellent scale adhesiveness that is the effect of the present invention can be ensured.

**[0031]** When the number of irregularities of 0.2 μm to 8.0 μm per 100 μm is less than three, an improvement effect of scale adhesion is not sufficient, and thus the number of irregularities per 100 μm is set at three or more. It is possible to ensure excellent scale adhesion which is the effect of the present invention without particularly setting an upper limit of the number of irregularities per 100 μm. Note that the irregularities of the formed body are correlated with the surface roughness Rz of the steel sheet as illustrated in Fig. 7, and are controllable by setting the steel sheet surface roughness as $Rz>2.5$ μm.

**[0032]** Next, chemical compositions of the steel sheet and the hot stamp formed body of the present invention will be described. Note that hereunder % means mass%.

C: 0.100% to 0.600%

**[0033]** C represents an element that is contained to enhance the strength of the steel sheet. If a C content is less than 0.100%, tensile strength of 1180 MPa or more cannot be ensured, and a formed body with high strength which is the object of hot stamp cannot be ensured. When the C content exceeds 0.600%, weldability and processibility become insufficient, and thus the C content is set at 0.100% to 0.600%. The C content is preferably 0.100% to 0.550%, and is more preferably 0.150% to 0.500%. However, if the strength of the formed body is not required, excellent scale adhesion can be ensured even if the C content is less than 0.150%.

Si: 0.50% to 3.00%

**[0034]** Si enhances scale adhesion by controlling the scale composition at the time of hot stamping, and therefore Si is an essential element. If the Si content is less than 0.50%, the thickness of Fe scale cannot be controlled, and excellent scale adhesion cannot be ensured. Consequently, it is necessary to set the Si content at 0.50% or more. Further, when application to a member which is difficult to form at the time of hot stamping is considered, it is preferable to increase the Si content. Accordingly, the Si content is preferably 0.70% or more, and is more preferably 0.90% or more. Meanwhile, Si increases an Ae3 point, and the heating temperature necessary to make martensite a main phase, and thus if the Si is excessively contained, productivity and economic efficiency are reduced. Hence, an upper limit of the Si content is set as 3.00%. The upper limit of the Si content is preferably 2.5%, and the upper limit is more preferably 2.0%. However, it is possible to ensure excellent scale adhesion excepting productivity and economic efficiency.

Mn: 1.20% to 4.00%

**[0035]** Mn delays ferrite transformation in a cooling process at the time of hot stamping, and makes a hot stamp formed body into a structure having a martensite main phase, and thus it is necessary to contain 1.20% or more of Mn. If the Mn content is less than 1.20%, martensite cannot be made a main phase, and it is difficult to ensure high strength which is an object of the hot stamp formed body, and thus a lower limit of the Mn content is set as 1.20%. However, if the strength of the formed body is not required, excellent scale adhesion can be ensured even if the Mn content is less than 1.20%. When the Mn content exceeds 4.00%, the effect is saturated, embrittlement is caused, and a fracture is caused at the time of casting, cold rolling or hot rolling, and thus an upper limit of the Mn content is set as 4.00%. The Mn content is preferably within a range of 1.50% to 3.50%, and is more preferably within a range of 2.00% to 3.00%.

Ti: 0.005% to 0.100%

**[0036]** Ti is an element that combines with N to form TiN, and thereby restrains B from being a nitride to enhance hardenability. The effect becomes remarkable when a Ti content is 0.005% or more, and thus the Ti content is set as 0.005% or more. However, when the Ti content exceeds 0.100%, a Ti carbide is formed, an amount of C that contributes to strengthening martensite is reduced, and reduction in strength is caused, and thus an upper limit of the Ti content is set as 0.100%. The C content is preferably within a range of 0.005% to 0.080%, and is more preferably within a range of 0.005% to 0.060%.

B: 0.0005% to 0.0100%

**[0037]** B enhances hardenability at the time of hot stamping, and contributes to making a main phase of martensite. The effect is remarkable when a B content is 0.0005% or more, and thus it is necessary to set the B content at 0.0005% or more. When the B content exceeds 0.0100%, the effect is saturated, an iron boride is precipitated, and the effect of hardenability of B is lost, and thus an upper limit of the B content is set at 0.0100%. The B content is preferably within a range of 0.0005% to 0.0080%, and is more preferably within a range of 0.0005% to 0.0050%.

P: 0.100% or less

**[0038]** P is an element that segregates in a central portion of a sheet thickness of the steel sheet, and is an element that embrittles a welded portion. Accordingly, an upper limit of a P content is set at 0.100%. A more preferable upper limit is 0.050%. The lower the P content, the more preferable, and although the effect of the present invention is exhibited without particularly setting the lower limit, but it is economically disadvantageous to reduce P to less than 0.001% from the viewpoint of productivity and cost of dephosphorization, and thus the lower limit is preferably set at 0.001%.

S: 0.0001% to 0.0100%

**[0039]** S exerts a large influence on scale adhesion, and thus it is necessary to restrict a content in the steel sheet. Accordingly, an upper limit of an S content is set at 0.0100%. A lower limit of the S content is set at 0.0001% because it is economically disadvantageous from the viewpoint of productivity and cost of dephosphorization. The S content is preferably within a range of 0.0001% to 0.0070%, and is more preferably within a range of 0.0003% to 0.0050%.

Al: 0.005% to 1.000%

**[0040]** Al acts as a deoxidizer, and thus an Al content is set as 0.005% or more. When the Al content is less than 0.005%, a sufficient deoxidization effect cannot be obtained, and a large amount of enclosure (oxide) exist in the steel sheet. These enclosures become starting points of destruction at the time of hot stamping, and the causes of breakage, and therefore are not preferable. The effect becomes remarkable when the Al content reaches 0.005% or more, and thus it is necessary to set the Al content at 0.005% or more. When the Al content exceeds 1.000%, the Ac3 point is increased and a heating temperature at the time of hot stamping is increased. That is, hot stamp is a technique of obtaining a formed body with high strength having a complicated shape by heating a steel sheet to an austenite single phase region, and subjecting the steel sheet to hot die press excellent in formability, and rapidly cooling by using a die. As a result, when a large amount of Al is contained, the Ac3 point is significantly increased, increase in the heating temperature required for austenite single phase region heating is caused, and productivity is reduced. Consequently, it is necessary to set an upper limit of the Al content at 1.000%. The Al content is preferably within a range of 0.005% to 0.500%, and is more preferably within a range of 0.005% to 0.300%.

N: 0.0100% or less

**[0041]** N is an element that forms coarse nitrides and deteriorates bendability and hole-expandability. When an N content exceeds 0.0100%, bendability and hole-expandability are significantly deteriorated, and thus an upper limit of the N content is set at 0.0100%. Note that N becomes a cause of generating a blowhole at the time of welding, and thus the smaller the N content is, the more preferable. Accordingly, the N content is preferably 0.0070 or less, and is more preferably 0.0050% or less. Although it is not necessary to particularly set a lower limit of the N content, manufacturing cost increases significantly when the N content is reduced to less than 0.0001%, and thus a practical lower limit is 0.0001%. From the viewpoint of manufacturing cost, the N content is more preferably 0.0005% or more.

**[0042]** Note that other unavoidable elements may be contained in extremely small amounts. For example, O forms an oxide and exists as an enclosure.

**[0043]** The steel sheet of the present invention further contains the following elements in accordance with necessity.

Ni: 0.01% to 2.00%

**[0044]**

Cu: 0.01% to 2.00%
Cr: 0.01% to 2.00%
Mo: 0.01% to 2.00%

**[0045]** Ni, Cu, Cr and Mo are elements that contribute to increase in strength by enhancing hardenability at the time of hot stamping, and making a main phase of martensite. The effect becomes remarkable by containing 0.01% or more of each one kind or two or more kinds selected from a group consisting of Ni, Cu, Cr and Mo, and thus contents of the elements are preferably 0.01% respectively. When the content of each of the elements exceeds a predetermined amount, weldability, hot workability and the like are deteriorated, or the strength of the steel sheet for hot stamping is so high as to be likely to cause a manufacturing trouble, and thus upper limits of the contents of these elements are preferably set at 2.00%.

Nb: 0.005 to 0.100%

**[0046]**

V: 0.005 to 0.100%

W: 0.005 to 0.100%

**[0047]** Nb, V and W are elements that strengthen fine grains by inhibiting growth of austenite at the time of hot stamping, and contribute to increase in strength and enhancement in tenacity. Hence, one kind or two or more kinds selected from a group consisting of these elements may be contained. The effect becomes more remarkable when 0.005% or more of each of the elements are contained, and thus it is preferable that 0.005% or more of each of the elements be contained. Note that when more than 0.100% of each of these elements is contained, it is not preferable because Nb, V and W carbides are formed, an amount of C that contributes to strengthening martensite is reduced, and reduction in strength is caused. Each of the elements is preferably in a range of 0.005% to 0.090%.

**[0048]** A total of one kind or two or more kinds selected from a group consisting of REM, Ca, Ce and Mg: 0.0003% to 0.0300%

**[0049]** In the present invention, 0.0003% to 0.0300% of one kind or two or more kinds selected from a group consisting of REM, Ca, Ce and Mg may be further contained in total.

**[0050]** REM, Ca, Ce and Mg are elements that enhance strength and contribute to improvement of the material. When the total of one kind or two or more kinds selected from the group consisting of REM, Ca, Ce and Mg is less than 0.0003%, a sufficient effect cannot be obtained, and thus it is preferable to set a lower limit of the total at 0.0003%. When the total of one kind or two or more kinds selected from the group consisting of REM, Ca, Ce and Mg exceeds 0.0300%, castability and hot workability are likely to be deteriorated, and thus it is preferable to set an upper limit of the total at 0.0300%. Note that REM is an abbreviation of Rare Earth Metal, and refers to an element belonging to a lanthanoid system. In the present invention, REM is often added in misch metal, and besides Ce, elements of a lanthanoid system are sometimes contained in combination.

**[0051]** In the present invention, the effect of the present invention becomes apparent even when elements of a lanthanoid system other than La and Ce are contained as unavoidable impurities, and the effect of the present invention becomes apparent even when the other elements such as metals are contained as impurities.

**[0052]** Next, features of microstructures of the steel sheet for hot stamping and hot stamp formed body of the present invention will be described.

**[0053]** Provided that the chemical composition, the surface roughness of the steel sheet, and the coating oil amount satisfy the ranges of the present invention, the effect of the present invention can be exhibited by any of a pickled hot-rolled steel sheet, a cold-rolled steel sheet obtained by cold-rolling a hot-rolled steel sheet, or a cold-rolled steel sheet to which annealing is applied after cold rolling.

**[0054]** These steel sheets are heated to an austenite region exceeding 800°C at the time of hot stamping, and therefore exhibit performance as steel sheets for hot stamping having excellent scale adhesion that is the effect of the present invention without particularly limiting the microstructure. However, when mechanical cutting of the steel sheets and cold punching are carried out prior to hot stamping, the strength of the steel sheets is preferably as low as possible in order to reduce wear and tear of dies, cutting edges of cutters, or punching dies. Consequently, the microstructure of the steel sheet for hot stamping is preferably ferrite and pearlite structures, or a bainite structure and a structure obtained by tempering martensite. However, if wear and tear of a punch and dies at the time of mechanical cutting and cold punching do not become a problem, it is possible to ensure excellent scale adhesion which is the effect of the present invention, even if one kind or two or more kinds of retained austenite, martensite in a hardened state, and bainite are contained. Further, in order to reduce the strength of the steel sheet, thermal treatment in a box type annealing furnace or a continuous annealing facility may be carried out. Alternatively, even when cold rolling is carried out after the above softening treatment, and the sheet thickness is controlled to a predetermined sheet thickness, excellent scale adhesion which is the effect of the present invention is ensured.

**[0055]** When formed body strength after hot stamping is enhanced, and high component strength is obtained, the microstructure of the formed body preferably has a martensite main phase. In particular, in order to ensure tensile strength of 1180 MPa or more, a volume ratio of martensite that is a main phase is preferably made 60% or more. Martensite may be subjected to tempering after hot stamping, and made tempered martensite. As the structure other than martensite, bainite, ferrite, pearlite, cementite and retained austenite may be contained. Further, even if the martensite volume rate is less than 60%, it is possible to ensure the excellent scale adhesion of the present invention.

**[0056]** The following methods are used in identification of the microstructures (tempered martensite, martensite, bainite, ferrite, pearlite, retained austenite and a remaining structure) composing the steel sheet structure, confirmation of existence positions, and measurement of area ratios. For example, it is possible to corrode a section in a steel sheet rolling direction or a section in a direction perpendicular to the rolling direction with a nital reagent and the reagent disclosed in Japanese Laid-open Patent Publication No. 59-219473, and observe the structure with a 1000 to 100000-power scanning electron microscope (SEM: Scanning Electron Microscope) and transmission electron microscope (TEM: Transmission Electron Microscope). The present inventors determined the sheet thickness section parallel with the rolling direction of the steel sheet as an observation surface, extracted a specimen, polished the observation surface, performed nital etching, observed a range of thickness of 1/8 to 3/8 with 1/4 of the sheet thickness as a center with a field emission scanning electron microscope (FE-SEM: Field Emission Scanning Electron Microscope), measured an area fraction, and the area fraction was taken as a volume fraction. As for the volume fraction of the retained austenite, the volume fraction was measured by performing X-ray diffraction with the surface which was parallel with the sheet surface of the parent steel sheet and had a 1/4 of thickness, used as the observation surface.

**[0057]** Next, a method for producing the steel sheet for hot stamping of the present invention will be described.

**[0058]** Although the other operation conditions are based on a usual method, the following conditions are preferable in terms of productivity.

**[0059]** In order to produce the steel sheet in the present invention, a slab having the same component composition as the component composition of the aforementioned steel sheet is cast first. As the slab provided for hot rolling, a continuously cast slab, the slab produced by a thin slab caster or the like can be used. The method for manufacturing the steel sheet of the present invention is adapted to a process like continuous casting-direct rolling (CC-DR) that performs hot rolling immediately after casting.

- Slab heating temperature: 1100°C or higher
- Hot-rolling completion temperature: Ar3 transformation point or higher
- Coiling temperature: 700°C or lower
- Cold rolling ratio: 30 to 70%

**[0060]** The slab heating temperature is preferably set at 1100°C or higher. The slab heating temperature in a temperature region of lower than 1100°C causes reduction in the finishing rolling temperature, and thus strength at the time of finishing rolling tends to be high. As a result, there is the possibility that rolling becomes difficult, a poor shape of the steel sheet after rolling is caused, and thus the slab heating temperature is preferably set at 1100°C or higher.

**[0061]** The finishing rolling temperature is preferably set at the Ar3 transformation point or higher. When the finishing rolling temperature becomes lower than the Ar3 transformation point, a rolling load becomes high, and there is the possibility that rolling becomes difficult, and a poor shape of the steel sheet after rolling is caused, and thus a lower limit of the finishing rolling temperature is preferably set at the Ar3 transformation point. An upper limit of the finishing rolling temperature does not have to be particularly set, but if the finishing rolling temperature is set to be excessively high, the slab heating temperature has to be made excessively high in order to ensure the temperature, and thus the upper limit of the finishing rolling temperature is preferably 1100°C.

**[0062]** The coiling temperature is preferably set at 700°C or lower. When the coiling temperature exceeds 700°C, the thickness of the oxides formed on the steel sheet surface is excessively increased, and the pickling property is deteriorated, and thus the coiling temperature higher than 700°C is not preferable. When cold rolling is performed thereafter, a lower limit of the coiling temperature is preferably set at 400°C. When the coiling temperature is lower than 400°C, the strength of the hot-rolled steel sheet extremely increases, and a sheet fracture and a poor shape at the time of cold rolling are easily caused, and thus the lower limit of the coiling temperature is preferably set at 400°C. However, if the hot-rolled steel sheet which is coiled is intended to be softened by heating the coiled hot-rolled steel sheet in the box type annealing furnace or the continuous annealing facility, the steel sheet may be coiled at a low temperature of lower than 400°C. Note that at the time of hot-rolling, rough-rolled sheets may be bonded to one another and finishing rolling may be continuously performed. Further, the rough-rolled sheet may be coiled temporarily.

**[0063]** Next, pickling is applied to the hot-rolled steel sheet which is produced in this way for 30 seconds or more in an aqueous solution with an temperature of 80°C to 100°C in which a concentration of acid is 3 mass% to 20 mass% and an inhibitor is included. In the present invention, pickling under the present conditions is extremely important, and in order to control the surface roughness Rz of the steel sheet to more than 2.5 μm, pickling under the above described conditions is necessary. Note that an aqueous solution of a hydrochloric acid, a sulfuric acid or the like as an acid is generally used, and an aqua regia or the like may be used.

**[0064]** The temperature of the aqueous solution is set at 80°C to lower than 100°C, because with a temperature lower than 80°C, a reaction rate is low, and it takes a long time to bring the surface roughness of the hot-rolled steel sheet into a proper range. Meanwhile, heating at a temperature of 100°C or higher is dangerous and is not preferable because the solution boils and splashes although the reaction of pickling has no problem.

**[0065]** Further, the reason why the concentration of the acid is set at 3 mass% to 20 mass% is to control the surface roughness Rz of the hot-rolled steel sheet within the proper range. When the concentration of the acid is less than 3 mass%, it takes a long time to control the irregularities on the surface by pickling. When the concentration of the acid exceeds 20 mass%, a pickling tank is damaged significantly and facility management becomes difficult, and thus it is not preferable. A preferable range of the concentration of the acid is a range of 5 mass% to 15 mass%.

**[0066]** Further, the reason why the pickling time period is set at 30 seconds or more is to stably give predetermined irregularities (irregularities of $Rz>2.5$ μm) to the steel sheet surface by pickling. When the pickling tank is divided into a plurality of tanks, if a pickling time period of some of the pickling tanks or a total pickling time period satisfies the above described conditions, the surface roughness Rz of the hot-rolled steel sheet can be brought into the range of the present invention, even if concentrations or temperatures of the individual pickling tanks differ from one another. Further, pickling may be carried out by being divided into a plurality of times. Note that in the experiment by the present inventors, a hydrochloric acid including an inhibitor was used, but the effect of the present invention can be obtained by using another acid such as hydrochloric acid using no inhibitor, a sulfuric acid, and a nitric acid, or a composite of these acids, as long as the surface roughness Rz can be controlled by pickling.

**[0067]** Further, the irregularities formed by pickling of the hot-rolled steel sheet also remain even after temper rolling, cold rolling or annealing is carried out, and thus it is extremely important to control the pickling conditions, and give irregularities to the sheet surface after pickling. Consequently, temper rolling may be carried out to the hot-rolled steel sheet after pickling.

**[0068]** Further, even with a cold-rolled steel sheet to which only cold rolling is performed, or a cold-rolled steel sheet thermally treated in a continuous annealing facility or a box type annealing furnace after cold rolling, irregularities are formed on the surface by performing pickling before cold rolling, and the predetermined effect can be obtained. Note that cold rolling is preferably performed with roll roughness Rz for cold rolling within a range of 1.0 $\mu$m to 20.0 $\mu$m, and the cold rolling roll also includes temper rolling roll.

**[0069]** Cold rolling is applied to the hot-rolled steel sheet pickled under the conditions as above at a draft of 30% to 80%, and the steel sheet may be passed through a continuous annealing facility. When the draft is less than 30%, it becomes difficult to keep the shape of the steel sheet flat, and ductility of the finished product deteriorates, and thus a lower limit of the draft is preferably set at 30%. When the draft exceeds 80%, a rolling load becomes excessively large, and cold rolling becomes difficult, and thus an upper limit of the draft is preferably set at 80%. The draft is more preferably 40% to 70%. The effect of the present invention becomes apparent even without particularly specifying the number of times of rolling pass and the draft of each pass, and thus it is not necessary to specify the number of times of rolling pass, and the draft at each pass.

**[0070]** Thereafter, the cold-rolled steel sheet may be passed through the continuous annealing line. An object of the treatment is to soften the steel sheet which is highly strengthened by cold-rolling, and thus any conditions may be adopted as long as the condition is such that the steel sheet is softened. For example, when the annealing temperature is in a range of 550°C to 750°C, dislocation introduced at the time of cold rolling is released by recovery, recrystalization, or phase transformation, and thus annealing is preferably performed in this temperature region.

**[0071]** By performing annealing by a box type furnace for the similar purpose, the steel sheet for hot stamping excellent in scale adhesion of the present invention can be obtained.

**[0072]** Thereafter, oil coating is carried out. As an oil coating method, electrostatic oiling, spray, a roll coater and the like are generally used, and as long as a coating oil amount in a range of 50 mg/m$^2$ to 1500 mg/m$^2$ can be ensured, the method is not limited. In the present invention, coating of a predetermined amount of oil was carried out by an electrostatic oiling machine. Further, as long as the coating oil amount in the range of 50 mg/m$^2$ to 1500 mg/m$^2$ can be ensured, a rust inhibitor in an amount equal to or larger than the coating oil amount may be applied, and degreasing may be performed.

**[0073]** The excellent scale adhesion that is the effect of the present invention and a rust inhibition property can be made compatible without particularly limiting the hot stamping conditions. For example, by producing by the production method shown as follows, compatibility of excellent performance of the tensile strength of 1180 MPa or more and productivity is achieved. At the time of performing hot stamping, heating is preferably performed to a temperature region of 800°C to 1100°C at a heating rate of 2°C/second or more. By heating at a rate of 2°C/second or more, scale generation at the time of heating can be restrained, and the effect of improvement in scale adhesion is provided. The heating rate is preferably 5°C/second or more, and is more preferably 10°C/second or more. Further, increase of the heating rate is also effective for the purpose of enhancing productivity.

**[0074]** The annealing temperature at the time of performing hot stamping is preferably within the range of 800°C to 1100°C. By performing annealing in this temperature region, it is possible to make the structure into an austenite single phase structure, and the structure can be made into a structure having martensite as a main phase by cooling that is performed subsequently. When the annealing temperature at this time is lower than 800°C, the structure at the time of annealing is made into a ferrite and austenite structures, the ferrite grows in the cooling process, the ferrite volume ratio exceeds 10%, and the tensile strength of the hot stamp formed body becomes lower than 1180 MPa. Consequently, a lower limit of the annealing temperature is preferably set at 800°C. When the annealing temperature exceeds 1100°C, not only the effect is saturated, but also the scale thickness is significantly increased, and there arises the fear that scale adhesion is reduced. Consequently, it is preferable to perform annealing at 1100°C or lower. The annealing temperature is more preferably in a range of 830°C to 1050°C.

**[0075]** After heating, retention may be performed in the temperature region of 800°C to 1100°C. When retention is carried out at a high temperature, melting of carbides included in the steel sheet is possible, and contribution is made to increase in the strength of the steel sheet and enhancement in hardenability. Retention includes residence, heating removal and cooling removal in the present temperature region. Since the object is to melt the carbides, the object is achieved as long as the residence time period in the present temperature region is ensured. Although the limitation on the retention time period is not particularly provided, 1000 seconds is preferably set as an upper limit, because when the retention time period is 1000 seconds or more, the scale thickness becomes excessively large, and scale adhesion is deteriorated.

**[0076]** Thereafter, a temperature of 800°C to 700°C is preferably reduced at an average cooling rate of 5°C/second or more. Here, 700°C is a die cooling start temperature, and the reason why the temperature of 800°C to 700°C is reduced at 5°C/second or more is to avoid ferrite transformation, bainite transformation and pearlite transformation, and make the structure into a martensite main phase. When the cooling rate is less than 5°C/second, these soft structures are formed, and it is difficult to ensure the tensile strength of 1180 MPa or more. Meanwhile, the effect of the present invention is exhibited without particularly setting the upper limit of the cooling rate. The reason why the temperature range which is reduced at 5°C/second or more is set from 800°C to 700°C is that in this temperature range, the structure of ferrite or the like that causes reduction in strength is likely to be formed. Cooling at this time is not limited to continuous cooling, and even when retention and heating in the temperature region are performed, the effect of the present invention is exhibited as long as the average cooling rate is 5°C/second or more. The effect of the present invention can be exhibited without particularly limiting the cooling method. That is, the effect of the present invention can be exhibited by either one of cooling using a die or die cooling using water cooling in combination.

EXAMPLES

**[0077]** Next, examples of the present invention will be described, and conditions in the examples are only one example of the conditions adopted to confirm implementability and the effect of the present invention, and the present invention is not limited to the one condition example. The present invention can adopt various conditions as long as the conditions achieve the object of the present invention without departing from the gist of the present invention.

**[0078]** First, slabs of the component compositions of A to S and a to n shown in Table 1 were cast, and after the slabs were temporarily cooled to a room temperature, heating was carried out for 220 minutes in a heating furnace with a furnace temperature = 1230°C, hot rolling was carried out with the finishing rolling temperature = 920°C to 960°C, and coiling was carried out under the temperature conditions shown in Table 2.

[Table 1]

**[0079]**

Table.1 Chemical component(mass%)

| | C | Si | Mn | P | S | Ti | B | N | Al | Others |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 0211 | 1.04 | 2.29 | 0.011 | 0.0009 | 0.025 | 0.0028 | 0.0023 | 0.023 | - |
| B | 0207 | 0.67 | 2.09 | 0.009 | 0.0012 | 0.023 | 0.0014 | 0.0027 | 0.019 | - |
| C | 0.189 | 1.83 | 2.55 | 0.007 | 0.0016 | 0.028 | 0.0029 | 0.0026 | 0.035 | - |
| D | 0207 | 121 | 1.44 | 0.012 | 0.0018 | 0.035 | 0.0009 | 0.0031 | 0.056 | Cr=0.68 |
| E | 0208 | 1.19 | 1.82 | 0.013 | 0.0022 | 0.045 | 0.0022 | 0.0024 | 0.045 | Mo=0.13 |
| F | 0.100 | 1.11 | 1.74 | 0.008 | 0.0019 | 0.029 | 0.0023 | 0.0022 | 0.024 | Ni=0.44, Cu=0.12 |
| G | 0203 | 1.05 | 227 | 0.009 | 0.0017 | 0.024 | 0.0020 | 0.0026 | 0.029 | Nb=0.068 |
| H | 0219 | 0.98 | 2.35 | 0.010 | 0.0033 | 0.021 | 0.0024 | 0.0037 | 0.018 | V=0.054 |
| I | 0228 | 124 | 2.19 | 0.011 | 0.0027 | 0.022 | 0.0021 | 0.0024 | 0.033 | W=0.033 |
| J | 0218 | 124 | 2.31 | 0.015 | 0.0045 | 0.026 | 0.0034 | 0.0034 | 0.027 | REM=0.0046 |
| K | 0234 | 1.05 | 2.37 | 0.016 | 0.0039 | 0.024 | 0.0025 | 0.0021 | 0.025 | Ca=0.0033 |
| L | 0219 | 1.03 | 2.19 | 0.009 | 0.0048 | 0.025 | 0.0021 | 0.0038 | 0.011 | Ce=0.0029 |
| M | 0246 | 1.11 | 2.27 | 0.013 | 0.0052 | 0.019 | 0.0021 | 0.0029 | 0.007 | Mg=0.0019 |
| N | 0309 | 1.09 | 2.19 | 0.008 | 0.0024 | 0.016 | 0.0026 | 0.0019 | 0.022 | - |
| O | 0314 | 0.78 | 2.11 | 0.013 | 0.0028 | 0.025 | 0.0018 | 0.0024 | 0.030 | - |
| P | 0311 | 1.32 | 1.87 | 0.011 | 0.0030 | 0.028 | 0.0020 | 0.0023 | 0.035 | Cr=0.18 |
| Q | 0356 | 1.24 | 2.09 | 0.015 | 0.0034 | 0.022 | 0.0034 | 0.0025 | 0.029 | - |

(continued)

| | C | Si | Mn | P | S | Ti | B | N | Al | Others |
|---|---|---|---|---|---|---|---|---|---|---|
| R | 0.349 | 1.06 | 1.43 | 0.016 | 0.0019 | 0.021 | 0.0032 | 0.0022 | 0.027 | Cr=0.46 |
| S | 0.412 | 0.99 | 222 | 0.007 | 0.0014 | 0.028 | 0.0023 | 0.0020 | 0.024 | - |
| a | 0.097 | 098 | 2.03 | 0.022 | 0.0022 | 0.033 | 0.0028 | 0.0023 | 0.021 | - |
| b | 0.698 | 1.49 | 1.68 | 0.007 | 0.0006 | 0.024 | 0.0026 | 0.0029 | 0.089 | - |
| c | 0203 | 034 | 2.11 | 0.015 | 0.0027 | 0.029 | 0.0026 | 0.0029 | 0.019 | - |
| d | 0.194 | 325 | 2.09 | 0.009 | 0.0018 | 0.021 | 0.0031 | 0.0025 | 0.023 | - |
| e | 0211 | 1.03 | 1.12 | 0.014 | 0.0016 | 0.026 | 0.0018 | 0.0021 | 0.026 | - |
| f | 0.199 | 123 | 7.39 | 0.024 | 0.0039 | 0.025 | 0.0049 | 0.0042 | 0.038 | - |
| g | 0205 | 0.78 | 231 | 0.009 | 0.0148 | 0.021 | 0.0012 | 0.0031 | 0.022 | - |
| h | 0209 | 1.16 | 2.31 | 0.007 | 0.0013. | - | 0.0018 | 0.0034 | 0.031 | - |
| I | 0.184 | 1.08 | 1.42 | 0.006 | 0.0037 | 0.139 | 0.0034 | 0.0037 | 0.022 | - |
| j | 0210 | 1.05 | 1.89 | 0.016 | 0.0035 | 0.022 | - | 0.0028 | 0.027 | - |
| k | 0201 | 0.98 | 1.45 | 0.011 | 0.0055 | 0.027 | 0.1180 | 0.0033 | 0.024 | - |
| l | 0.198 | 121 | 1.52 | 0.008 | 0.0042 | 0.033 | 0.0027 | 0.0191 | 0.046 | - |
| m | 0205 | 0.87 | 2.42 | 0.011 | 0.0057 | 0.021 | 0.0016 | 0.0082 | 0.001 | - |
| n | 0213 | 0.94 | 1.98 | 0.012 | 0.0019 | 0.023 | 0.0024 | 0.0024 | 1.285 | - |
| The underlined part means being outside the range of the present invention.<br>"-"= means that each element is not added. | | | | | | | | | | |

[Table 2]

[0080]

Table.2

| Steel number | Steel grade*1 | Colling temperature (°C) | Acid concentration (%) | Acid temperature (°C) | Pickling time period (s) | Kind of coating oll | Coating oil amount (mg/m2) | S content (mass%) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| A1 | FH | 580 | 8 | 83 | 160 | NOX503F | - | 0 | Comparative steel |
| A2 | FH | 600 | 6 | 87 | 200 | NOX503F | 60 | 0 | Present invention steel |
| A3 | FH | 590 | 8 | 85 | 160 | NOX503F | 140 | 1 | Present invention steel |
| A4 | FH | 680 | 7 | 90 | 680 | NOX503F | 270 | 1 | Present invention steel |
| A5 | FH | 590 | 9 | 89 | 160 | NOX503F | 480 | 1 | Present invention steel |
| A6 | FH | 600 | 9 | 86 | 160 | NOX503F | 780 | 1 | Present invention steel |
| A7 | FH | 580 | 8 | 84 | 240 | NOX503F | 1020 | 1 | Present invention steel |
| A8 | FH | 550 | 8 | 86 | 40 | NOX503F | 1480 | 5 | Present invention steel |
| A9 | FH | 510 | 6 | 82 | 18 | NOX503F | 1000 | 2 | Comparative steel |
| A10 | FH | 520 | 7 | 85 | 24 | NOX503F | 970 | 1 | Comparative steel |
| A11 | FH | 510 | 6 | 85 | 28 | NOX503F | B20 | 1 | Comparative steel |
| A12 | FH | 620 | 10 | 94 | 180 | NOX503F | 1790 | 6 | Comparative steel |
| A13 | FH | 560 | 8 | 89 | 65 | NOX503F | 2050 | 6 | Comparative steel |
| A14 | FH | 600 | 9 | 85 | 200 | NOX503F | | | Comparative steel |
| A15 | FH | 570 | 8 | 87 | 240 | NOX504F | 4880 | 9 | Comparative steel |
| B1 | HR | 580 | 12 | 85 | 230 | NOX503F | 490 | 1 | Present invention steel |
| C1 | OR | 590 | 8 | 86 | 160 | NOX503F | 420 | 1 | Present invention steel |
| D1 | FH | 560 | 8 | 85 | 100 | NOX503F | 550 | 1 | Present invention steel |
| E1 | FH | 560 | 7 | 83 | 100 | NOX503F | 1030 | 2 | Present invention steel |

(continued)

| Steel number | Steel grade*1 | Colling temperature (°C) | Acid concentration (%) | Acid temperature (°C) | Pickling time period (s) | Kind of coating oll | Coating oil amount (mg/m$^2$) | S content (mass%) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| F1 | FH | 570 | 6 | 88 | 140 | NOX503F | 1200 | 3 | Present invention steel |
| G1 | FH | 610 | B | 83 | 200 | NOX503F | 820 | 1 | Present invention steel |
| H1 | FH | 600 | 10 | 89 | 130 | NOX503F | 670 | 1 | Present invention steel |
| I1 | FH | 580 | 8 | 86 | 240 | NOX503F | 980 | 0 | Present invention steel |
| J1 | FH | 550 | 9 | 90 | 80 | NOX503F | 1180 | 2 | Present invention steel |
| K1 | FH | 570 | 8 | 84 | 160 | NOX503F | 630 | 1 | Present invention steel |
| L1 | FH | 590 | 9 | 88 | 220 | NOX503F | 940 | 0 | Present invention steel |
| M1 | FH | 600 | 6 | 90 | 200 | NOX503F | 430 | 1 | Present invention steel |
| N1 | FH | 590 | 8 | 83 | 200 | NOX503F | 570 | 1 | Present invention steel |
| N2 | FH | 560 | 8 | 89 | 80 | NOX503F | 690 | 1 | Present invention steel |
| N3 | FH | 550 | 11 | 92 | 70 | NOX503F | 700 | 1 | Present invention steel |
| N4 | FH | 000 | 10 | 94 | 120 | NOX503F | 800 | 1 | Present invention steel |
| N5 | FH | 520 | 7 | 82 | 18 | NOX503F | 760 | 1 | Comparative steel |
| N6 | FH | 530 | 7 | 83 | 26 | NOX503F | 80 | 1 | Comparative steel |
| N7 | FH | 590 | 8 | 86 | 210 | NOX503F | - | 0 | Comparative steel |
| N8 | FH | 570 | 9 | 87 | 190 | NOX504F | 3560 | 6 | Comparative steel |
| N9 | FH | 600 | 9 | 92 | 200 | NOX503F | 4320 | | Comparative steel |
| N10 | FH | 590 | 8 | 88 | 240 | NOX503F | | 7 | Comparative steel |
| O1 | HR | 590 | 8 | 94 | 240 | NOX503F | 1220 | 2 | Present invention steel |

(continued)

| Steel number | Steel grade*1 | Colling temperature (°C) | Acid concentration (%) | Acid temperature (°C) | Pickling time period (s) | Kind of coating oll | Coating oil amount (mg/m²) | S content (mass%) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| P1 | OR | 580 | 7 | 86 | 200 | NOX503F | 890 | 1 | Present invention steel |
| Q1 | FH | 580 | 9 | 86 | 180 | NOX503F | 800 | 1 | Present invention steel |
| R1 | HR | 590 | 8 | 83 | 200 | NOX503F | 1370 | 3 | Present invention steel |
| S1 | FH | 560 | 9 | 89 | 200 | NOX503F | 680 | 1 | Present invention steel |
| a1 | FH | 590 | 8 | 85 | 240 | NOX503F | 590 | 1 | Comparative steel |
| b1 | -*2 | -*2 | -*2 | -*2 | -*2 | -*2 | -*2 | -*2 | Comparative steel |
| c1 | FH | 560 | 8 | 84 | 240 | NOX503F | 1260 | 2 | Comparative steel |
| d1 | FH | 480 | 7 | 86 | 18 | NOX503F | 2450 | 2 | Comparative steel |
| e1 | FH | 570 | 9 | 90 | 270 | NOX503F | 990 | 1 | Comparative steel |
| f1 | -*2 | -*2 | -*2 | -*2 | -*2 | -*2 | -*2 | -*2 | Comparative steel |
| g1 | FH | 580 | 0.013 8 | 88 | 210 | NOX503F | 1210 | 1 | Comparative steel |
| h1 | FH | 560 | 8 | 92 | 180 | NOX503F | 1040 | 0 | Comparative steel |
| i1 | FH | 590 | 7 | 89 | 220 | NOX503F | 1300 | 1 | Comparative steel |
| j1 | FH | 570 | 8 | 88 | 200 | NOX503F | 1230 | 2 | Comparative steel |
| k1 | FH | 640 | 8 | 85 | 190 | NOX503F | 840 | 1 | Comparative steel |
| n | FH | 610 | 9 | 82 | 80 | NOX503F | 900 | 2 | Comparative steel |
| m1 | FH | 560 | 9 | 93 | 280 | NOX503F | 1000 | 1 | Comparative steel |
| n1 | FH | 560 | 9 | 86 | 180 | NOX503F | 570 | 1 | Comparative steel |

* 1 means that FH: left as cold rolled, HR: hot-rolled steel sheet, and CR: cold-rolled steel sheet annealed after cold rolling.
*2 means that Mn is excessively high many fractures occur in casting and hot rolling time, and no hot-rolled steel sheet was able to be produced.

**[0081]** The finished sheet thickness of the hot-rolled steel sheet provided for hot stamping as the hot-rolled steel sheet was made 1.6 mm. The sheet thickness of the hot-rolled steel sheet provided for cold rolling was made 3.2 mm. When pickling was carried out under the conditions in Table 2 thereafter, and cold rolling was performed, the sheet thickness was made 50% (3.2 mm $\rightarrow$ 1.6 mm). Thereafter, annealing was performed for some of the steel sheets in a continuous annealing facility, and the steel sheets were made into cold-rolled steel sheets. Thereafter, by using NOX-RUST503F (made by PARKER INDUSTRIES, INC.), NOX503F (made by PARKER INDUSTRIES, INC.) was applied to the hot-rolled steel sheets and the cold-rolled steel sheets by an electrostatic oiling machine, in a range of no coating oil to 6090 $mg/m^2$.

**[0082]** Thereafter, the steel sheets were cut into a predetermined size, after which, electrical heating was performed to 900°C at 50°C/second, retention for 10 seconds at 900°C was carried out, thereafter, standing to cool for 10 seconds was performed, and hardening was performed in the above described hot shallow drawing dies at a temperature of 650°C or higher. Visual observation of the obtained hot stamp formed bodies was performed, and the steel sheets without detachment of scale were determined as the steel sheets excellent in scale adhesion.

**[0083]** Concerting the rust inhibition property, retention for 30 days was carried out at a room temperature, and the steel sheets with no rust generated on the steel sheet surfaces were defined as the steel sheets excellent in rust inhibition property. In combination, with use of flat sheet test pieces, hot stamping was performed under the aforementioned conditions, and tensile characteristics were evaluated. The evaluation result is shown in Table 3.

[Table 3]

[0084]

Table.3

| Steel number | Steel grade*1 | Rz ($\mu$m) | Scale thickness ($\mu$m) | Irregularities in scale/ base iron interface | Scale detached area (%) | Scale adhesion | Presence or absence of rust generation | TS of formed body(MPa) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| A1 | FH | 3.7 | 4 | 6 | 0 | ○ | **Presence** | 1555 | **Comparative steel** |
| A2 | FH | 3.6 | 5 | 5 | 0 | ○ | **Absence** | 1562 | Present invention steel |
| A3 | FH | 4.0 | 4 | 8 | 0 | ○ | **Absence** | 1560 | Present invention steel |
| A4 | FH | 4.4 | 5 | 8 | 0 | ○ | **Absence** | 1559 | Present invention steel |
| A5 | FH | 4.2 | 4 | 6 | 0 | ○ | **Absence** | 1555 | Present invention steel |
| A6 | FH | 4.5 | 6 | 8 | 0 | ○ | **Absence** | 1550 | Present invention steel |
| A7 | FH | 3.8 | 6 | 7 | 0 | ○ | **Absence** | 1557 | Present invention steel |
| A8 | FH | 2.6 | 5 | 4 | 3 | ○ | **Absence** | 1562 | Present invention steel |
| A9 | FH | 2.2 | 2 | 0 | 11 | △ | **Absence** | 1562 | **Comparative steel** |
| A10 | FH | 1.9 | 3 | 1 | 16 | × | **Absence** | 1554 | **Comparative steel** |
| A11 | FH | 2.4 | 2 | 2 | 8 | △ | **Absence** | 1564 | **Comparative steel** |
| A12 | FH | 4.8 | 12 | 7 | 14 | △ | **Absence** | 1549 | **Comparative steel** |
| A13 | FH | 2.6 | 14 | 4 | 26 | × | **Absence** | 1556 | **Comparative steel** |
| A14 | FH | 3.9 | 15 | 8 | 44 | × | **Absence** | 1560 | **Comparative steel** |
| A15 | FH | 3.6 | 18 | 7 | 68 | × | **Absence** | 1567 | **Comparative steel** |

(continued)

| Steel number | Steel grade*1 | Rz ($\mu$m) | Scale thickness ($\mu$m) | Irregularities in scale/ base iron interface | Scale detached area (%) | Scale adhesion | Presence or absence of rust generation | TS of formed body(MPa) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| B1 | HR | 5.8 | 4 | 13 | 0 | ○ | **Absence** | 1549 | Present invention steel |
| C1 | CR | 4.1 | 4 | 6 | 0 | ○ | **Absence** | 1483 | Present invention steel |
| D1 | FH | 3.7 | 3 | 5 | 0 | ○ | **Absence** | 1529 | Present invention steel |
| E1 | FH | 3.8 | 3 | 8 | 0 | ○ | **Absence** | 1550 | Present invention steel |
| F1 | FH | 3.7 | 7 | 7 | 0 | ○ | **Absence** | 1625 | Present invention steel |
| G1 | FH | 4.5 | 4 | 8 | 0 | ○ | **Absence** | 1572 | Present invention steel |
| H1 | FH | 4.6 | 4 | 6 | 0 | ○ | **Absence** | 1645 | Present invention steel |
| n | FH | 4.4 | 5 | 6 | 0 | ○ | **Absence** | 1687 | Present invention steel |
| J1 | FH | 3.8 | 5 | 8 | 0 | ○ | **Absence** | 1639 | Present invention steel |
| K1 | FH | 4.0 | 3 | 7 | 0 | ○ | **Absence** | 1752 | Present invention steel |
| L1 | FH | 4.5 | 4 | 8 | 0 | ○ | **Absence** | 1624 | Present invention steel |
| M1 | FH | 4.3 | 4 | 7 | 0 | ○ | **Absence** | 1715 | Present invention steel |
| N1 | FH | 4.4 | 4 | 7 | 0 | ○ | **Absence** | 1834 | Present invention steel |
| N2 | FH | 3.9 | 3 | 6 | 0 | ○ | **Absence** | 1828 | Present invention steel |
| N3 | FH | 32 | 3 | 5 | 0 | ○ | **Absence** | 1833 | Present invention steel |
| N4 | FH | 4.5 | 4 | 10 | 0 | ○ | **Absence** | 1829 | Present invention steel |

(continued)

| Steel number | Steel grade*1 | Rz ($\mu$m) | Scale thickness ($\mu$m) | Irregularities in scale/ base iron interface | Scale detached area (%) | Scale adhesion | Presence or absence of rust generation | TS of formed body(MPa) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| N5 | FH | 2.3 | 2 | 0 | 9 | Δ | **Absence** | 1830 | **Comparative steel** |
| N6 | FH | 1.8 | 3 | 1 | 13 | Δ | **Absence** | 1826 | **Comparative steel** |
| N7 | FH | 3.9 | 4 | 8 | 0 | ○ | **Presence** | 1834 | **Comparative steel** |
| N8 | FH | 4.6 | 13 | 8 | 39 | × | **Absence** | 1823 | **Comparative steel** |
| N9 | FH | 4.3 | 13 | 7 | 47 | × | **Absence** | 1835 | **Comparative steel** |
| N10 | FH | 4.5 | 21 | 8 | 45 | × | **Absence** | 1830 | **Comparative steel** |
| O1 | HR | 5.3 | 4 | 13 | 0 | ○ | **Absence** | 1854 | Present invention steel |
| P1 | OR | 4.4 | 4 | 8 | 0 | ○ | **Absence** | 1847 | Present invention steel |
| Q1 | FH | 4.7 | 4 | 9 | 0 | ○ | **Absence** | 2108 | Present invention steel |
| R1 | HR | 6.0 | 4 | 12 | 0 | ○ | **Absence** | 2138 | Present invention steel |
| S1 | FH | 3.9 | 3 | 7 | 0 | ○ | **Absence** | 2505 | Present invention steel |
| a1 | FH | 4.3 | 4 | 8 | 0 | ○ | **Absence** | 1064 | **Comparative steel** |
| b1 | FH | -*2 | -*2 | -*2 | -*2 | -*2 | **-*2** | ->1<2 | **Comparative steel** |
| c1 | FH | 2.4 | 16 | 0 | 89 | X | **Absence** | 1483 | **Comparative steel** |
| d1 | FH | 1.8 | 1 | 0 | 84 | X | **Absence** | 1598 | **Comparative steel** |
| e1 | FH | 3.8 | 4 | 9 | 0 | ○ | **Absence** | 987 | **Comparative steel** |

(continued)

| Steel number | Steel grade*1 | Rz ($\mu$m) | Scale thickness ($\mu$m) | Irregularities in scale/ base iron interface | Scale detached area (%) | Scale adhesion | Presence or absence of rust generation | TS of formed body(MPa) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| f1 | FH | -*2 | -*2 | -*2 | -*2 | -*2 | **-*2** | -*2 1604 | **Comparative steel** |
| g1 | FH | 4.3 | 5 | 9 | 92 | × | **Absence** | 1604 | **Comparative steel** |
| h1 | FH | 4.1 | 4 | 9 | 0 | ○ | **Absence** | 1156 | **Comparative steel** |
| i1 | FH | 4.0 | 5 | 7 | 0 | ○ | **Absence** | 1095 | **Comparative steel** |
| j1 | FH | 4.6 | 4 | 7 | 0 | ○ | **Absence** | 1023 | **Comparative steel** |
| k1 | FH | 4.4 | 7 | 11 | 0 | ○ | **Absence** | 1154 | **Comparative steel** |
| l1 | FH | 4.1 | 5 | 9 | 0 | ○ | **Absence** | 1072 | **Comparative steel** |
| m1 | FH | 3.9 | 4 | 5 | 0 | ○ | **Absence** | -*3 | **Comparative steel** |
| n1 | FH | 45 | 4 | 7 | 0 | ○ | **Absence** | 1008 | **Comparative steel** |

*1 means that FH: left as cold rolled, HR: hot-rolled steel sheet, and CR: cold-rolled steel sheet annealed after cold rolling.
*2 means that Mn was excessively high, many fractures occurred in casting and hot rolling time, and no hot-rolled steel sheet was able to be produced.
*3 means that at the time of hot stemping, a feature with the enclosure as the starting point occurred, and the tenslie test was not be able to be carried out with the formed

**[0085]** As for the tensile characteristics, the tensile test pieces which were in conformity with JIS Z 2201 were extracted, the tensile test was performed in conformity with JIS Z 2241, and the maximum tensile strength was measured. The formed bodies having the maximum tensile strength of 1180 MPa or more were determined as the formed bodies of the present invention.

**[0086]** Composition analyses of the scales of the formed bodies were carried out by X-ray diffraction by cutting out sheets from the bottoms of the cylindrical portions of the shallow drawing test pieces. From the peak strength ratios of the respective oxides, the volume ratios of the respective Fe oxides were measured. The Si oxides were present very thinly and the volume ratio was less than 1%, and thus quantitative evaluation by X-ray diffraction was difficult. However, it could be confirmed that the Si oxides were present in the interface between the scale and the base iron by the line analysis of EPMA.

**[0087]** As for evaluation of the irregularities in the interfaces of the scales and the base irons formed in the formed bodies, embedded polishing was carried out for the steel sheets cut out from the above described position, and thereafter, SEM observation was performed by power of 3000 from the section perpendicular to the rolling direction. Five visual fields were observed in each of the test pieces, and the number density of the irregularities in the range of 0.2 μm to 1.0 μm per length of 100 μm was measured.

**[0088]** The formed bodies satisfying the conditions of the present invention were able to make excellent rust inhibition properties and excellent scale adhesion compatible. The formed bodies that do not satisfy the conditions of the invention were inferior in scale adhesion, or inferior in corrosion resistance.

INDUSTRIAL APPLICABILITY

**[0089]** According to the present invention, the steel sheet excellent in scale adhesion at the time of hot stamping can be provided, the problems of wear and tear of the die at the time of hot stamping, plating adhesion to the die, and indentation flaws accompanying it can be solved, and thus the present invention can bring about significant enhancement in productivity, and has an industrially large value.

**Claims**

**1.** A steel sheet for hot stamping, comprising a composition containing:

in mass%,
C: 0.100% to 0.600%;
Si: 0.50% to 3.00%;
Mn: 1.20% to 4.00%;
Ti: 0.005% to 0.100%;
B: 0.0005% to 0.0100%;
P: 0.100% or less;
S: 0.0001% to 0.0100%;
Al: 0.005% to 1.000%;
N: 0.0100% or less;
Ni: 0% to 2.00%;
Cu: 0% to 2.00%;
Cr: 0% to 2.00%;
Mo: 0% to 2.00%;
Nb: 0% to 0.100%;
V: 0% to 0.100%;
W: 0% to 0.100%, and
a total of one kind or two or more kinds selected from a group consisting of REM, Ca, Ce and Mg: 0% to 0.0300%, with a balance being Fe and impurities,
wherein surface roughness of the steel sheet satisfies Rz>2.5 μm, and coating oil in an amount of 50 mg/$m^2$ to 1500 mg/$m^2$ is applied onto a surface.

**2.** The steel sheet for hot stamping according to claim 1,
wherein an amount of S contained in the coating oil which is applied onto the steel sheet is 5% or less in mass%.

**3.** The steel sheet for hot stamping according to claim 1 or 2,
wherein the composition of the steel sheet contains, in mass%,

one kind or two or more kinds selected from a group consisting of

Ni: 0.01% to 2.00%,
Cu: 0.01% to 2.00%,
Cr: 0.01% to 2.00%,
Mo: 0.01% to 2.00%,
Nb: 0.005% to 0.100%,
V: 0.005% to 0.100%, and
W: 0.005% to 0.100%.

**4.** The steel sheet for hot stamping according to any one of claims 1 to 3,
wherein the composition of the steel sheet contains, in mass %,
a total of 0.0003% to 0.0300% of one kind or two or more kinds selected from the group consisting of REM, Ca, Ce and Mg.

**5.** A method for producing a steel sheet for hot stamping, comprising:

a step of casting a slab containing,
in mass%,
C: 0.100% to 0.600%;
Si: 0.50% to 3.00%;
Mn: 1.20% to 4.00%;
Ti: 0.005% to 0.100%;
B: 0.0005% to 0.0100%;
P: 0.100% or less;
S: 0.0001% to 0.0100%;
Al: 0.005% to 1.000%;
N: 0.0100% or less;
Ni: 0% to 2.00%;
Cu: 0% to 2.00%;
Cr: 0% to 2.00%;
Mo: 0% to 2.00%;
Nb: 0% to 0.100%;
V: 0% to 0.100%;
W: 0% to 0.100%, and
a total of one kind or two or more kinds selected from a group consisting of REM, Ca, Ce and Mg: 0% to 0.0300%, with a balance being Fe and impurities, and hot rolling the slab directly or by allowing the slab to cool and heating the slab to obtain a hot-rolled steel sheet;
a step of pickling the hot-rolled steel sheet for 30 seconds or more in an aqueous solution having a temperature of 80°C to lower than 100°C and including an inhibitor with a concentration of an acid being 3 mass% to 20 mass%; and
a step of applying a rust inhibiting oil to the steel sheet after carrying out the pickling,
wherein a rust inhibiting oil remaining amount on a steel sheet surface is limited to 50 mg/$m^2$ to 1500 mg/$m^2$.

**6.** The method for producing a steel sheet for hot stamping according to claim 5,
wherein the rust inhibiting oil is applied to the hot-rolled steel sheet which has been pickled.

**7.** The method for producing a steel sheet for hot stamping according to claim 5, further comprising:

a step of cold rolling the hot-rolled steel sheet which has been pickled to obtain a cold-rolled steel sheet,
wherein the rust inhibiting oil is applied to the cold-rolled steel sheet.

**8.** The method for producing a steel sheet for hot stamping according to claim 5, further comprising:

a step of cold rolling the hot-rolled steel sheet which has been pickled, and further performing thermal treatment in a continuous annealing facility or a box type annealing furnace to obtain a cold-rolled steel sheet,
wherein the rust inhibiting oil is applied to the cold-rolled steel sheet.

**9.** The method for producing a steel sheet for hot stamping according to any one of claims 5 to 8, wherein an amount of S in the rust inhibiting oil that is applied to the steel sheet is 5% or less in mass%.

**10.** The method for producing a steel sheet for hot stamping according to any one of claims 5 to 9, wherein a composition of the slab contains, in mass%, one kind or two or more kinds selected from a group consisting of

Ni: 0.01% to 2.00%,
Cu: 0.01% to 2.00%,
Cr: 0.01% to 2.00%,
Mo: 0.01% to 2.00%,
Nb: 0.005% to 0.100%,
V: 0.005% to 0.100%, and
W: 0.005% to 0.100%.

**11.** The method for producing a steel sheet for hot stamping according to any one of claims 5 to 10, wherein a composition of the slab contains, in mass %, a total of 0.0003% to 0.0300% of one kind or two or more kinds selected from the group consisting of REM, Ca, Ce and Mg.

**12.** A hot stamp formed body, comprising a composition containing:

in mass%,
C: 0.100% to 0.600%;
Si: 0.50% to 3.00%;
Mn: 1.20% to 4.00%;
Ti: 0.005% to 0.100%;
B: 0.0005% to 0.0100%;
P: 0.100% or less;
S: 0.0001% to 0.0100%;
Al: 0.005% to 1.000%;
N: 0.0100% or less;
Ni: 0% to 2.00%;
Cu: 0% to 2.00%;
Cr: 0% to 2.00%;
Mo: 0% to 2.00%;
Nb: 0% to 0.100%;
V: 0% to 0.100%;
W: 0% to 0.100%, and
a total of one kind or two or more kinds selected from a group consisting of REM, Ca, Ce and Mg: 0% to 0.0300%,
with a balance being Fe and impurities,
wherein three or more irregularities in a range of 0.2 μm to 8.0 μm in depth are present per 100 μm in an interface between scale and a base iron, and tensile strength is 1180 MPa or more.

**13.** The hot stamp formed body according to claim 12, wherein an Si oxide, FeO, $Fe_3O_4$ and $Fe_2O_3$ are included in a surface of the hot stamp formed body, and a thickness of the scale is 10 μm or less.

**14.** The hot stamp formed body according to claim 12 or 13, wherein the composition of the hot stamp formed body contains, in mass%, one kind or two or more kinds selected from a group consisting of

Ni: 0.01% to 2.00%,
Cu: 0.01% to 2.00%,
Cr: 0.01% to 2.00%,
Mo: 0.01% to 2.00%,
Nb: 0.005% to 0.100%,
V: 0.005% to 0.100%, and

W: 0.005% to 0.100%.

**15.** The hot stamp formed body according to any one of claims 12 to 14, wherein the composition of the hot stamp formed body contains, in mass %, a total of 0.0003% to 0.0300% of one kind or two or more kinds selected from the group consisting of REM, Ca, Ce and Mg.

FIG. 1

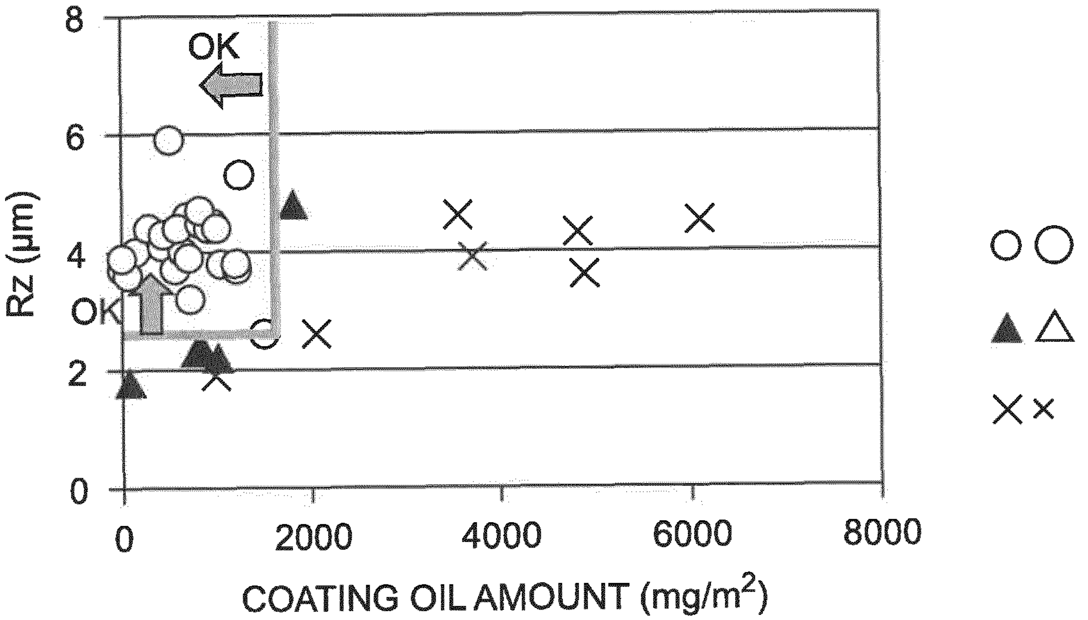

8
6
4
2
0
Rz (µm)
OK
OK
0
2000
4000
6000
8000
COATING OIL AMOUNT (mg/m2)

FIG. 2

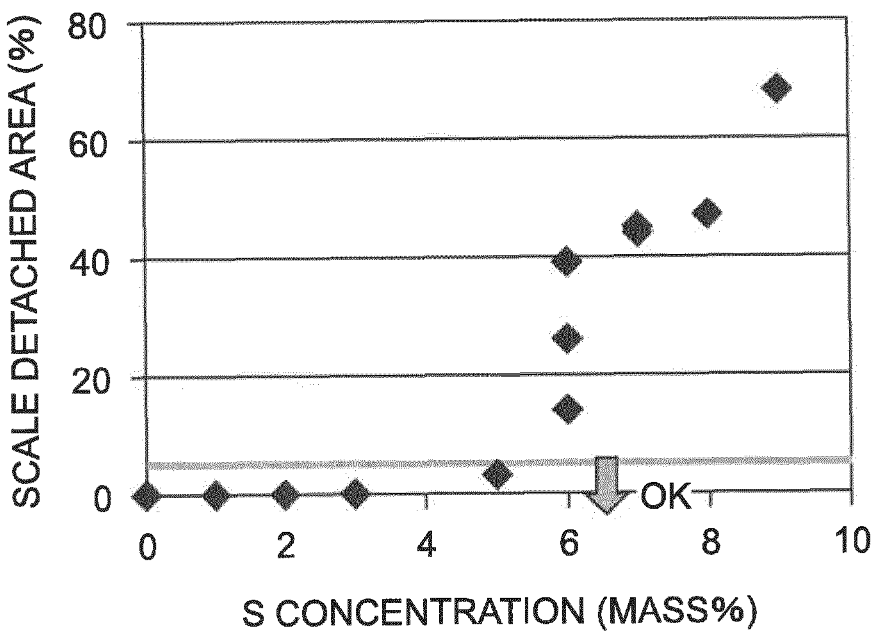

80
60
40
20
0
SCALE DETACHED AREA (%)
OK
0
2
4
6
8
10
S CONCENTRATION (MASS%)

FIG. 3

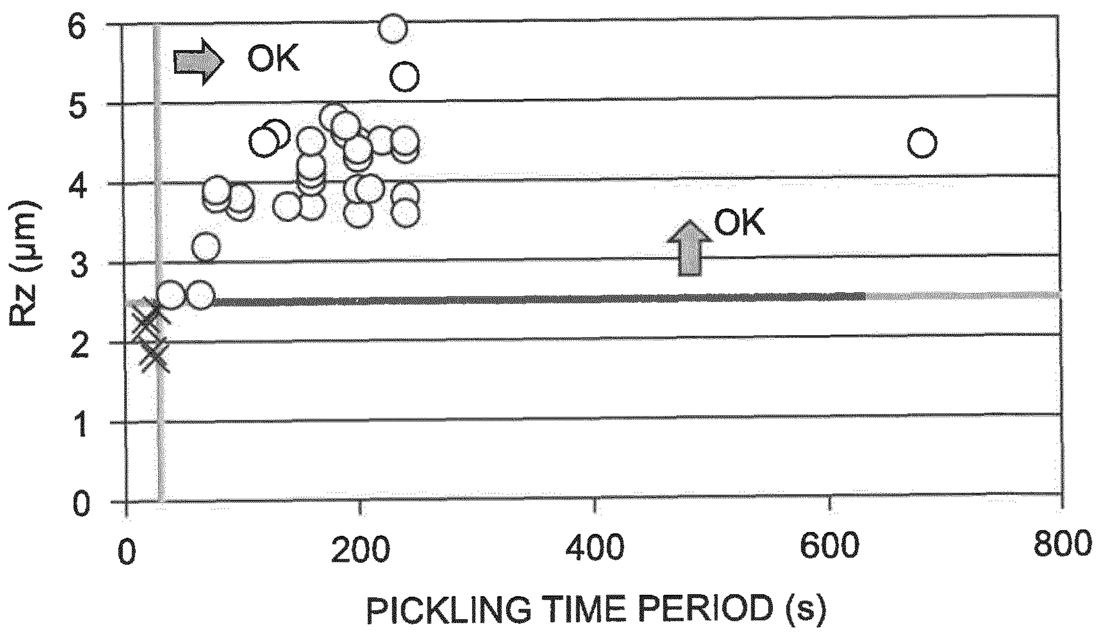
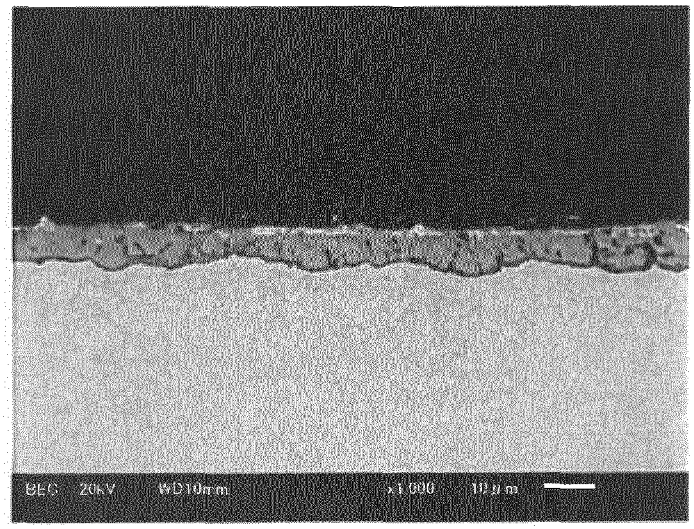
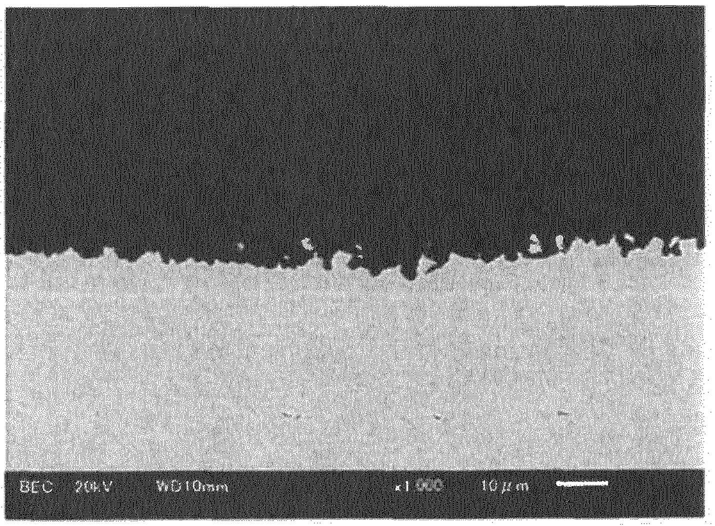


FIG. 4A




HOT−ROLLED STEEL SHEET (LEFT WITHOUT PICKLING)

FIG. 4B




PICKLED SHEET

FIG. 5

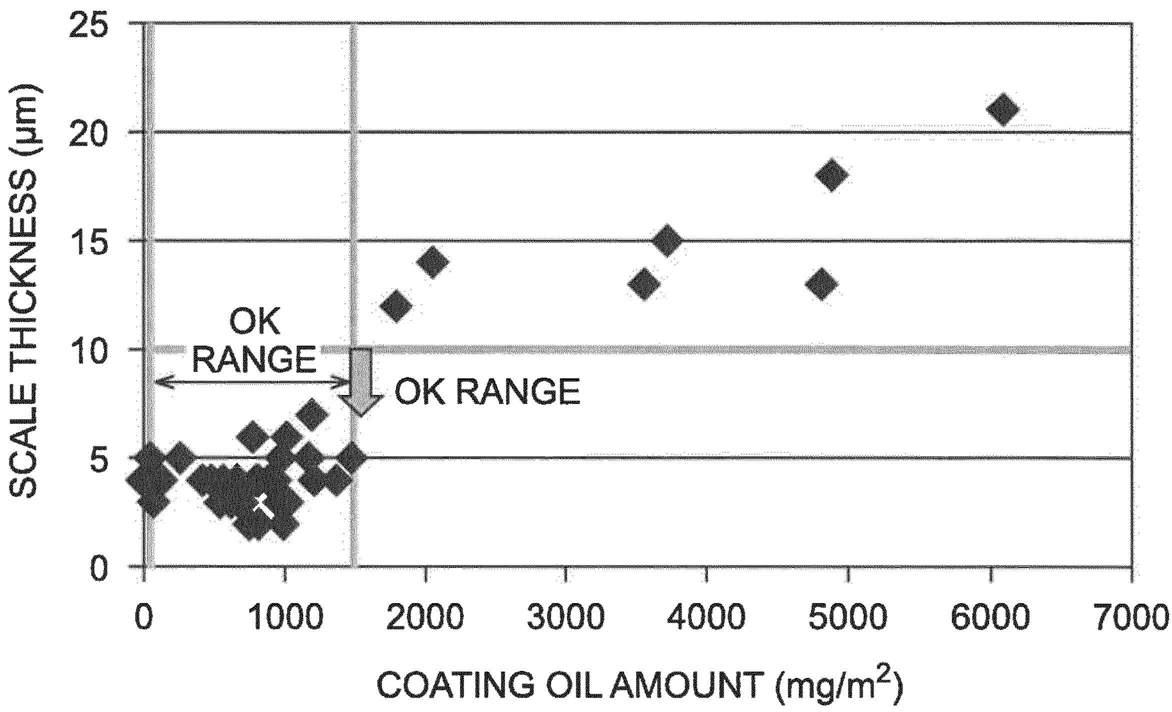

25
20
15
10
5
0
SCALE THICKNESS (μm)
OK
RANGE
OK RANGE
0
1000
2000
3000
4000
5000
6000
7000
COATING OIL AMOUNT (mg/m2)

FIG. 6A

INVENTION STEEL STEEL SHEET (GOOD ADHESION)

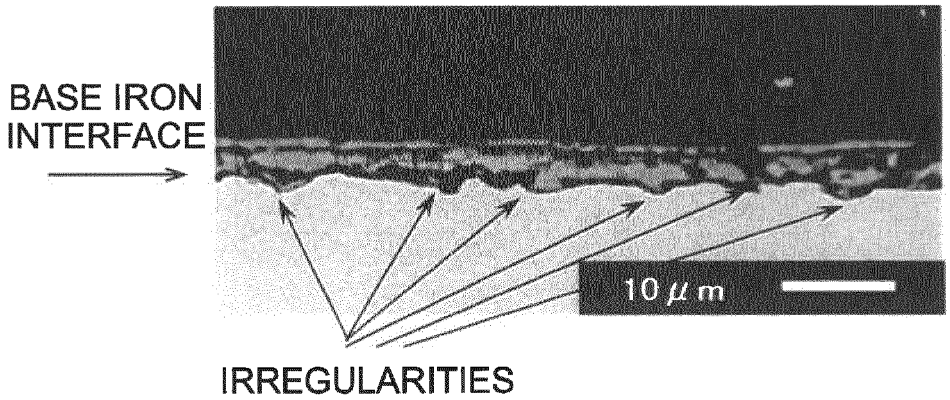



FIG. 6B

COMPARATIVE EXAMPLE STEEL SHEET
(ADHESION INFERIOR POSITION)

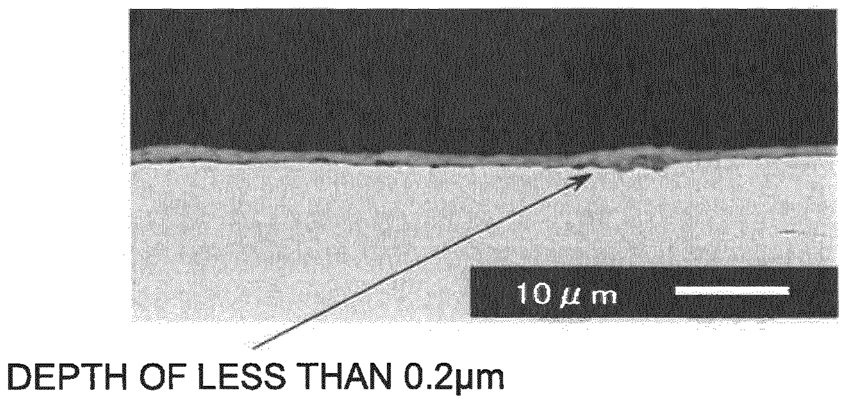
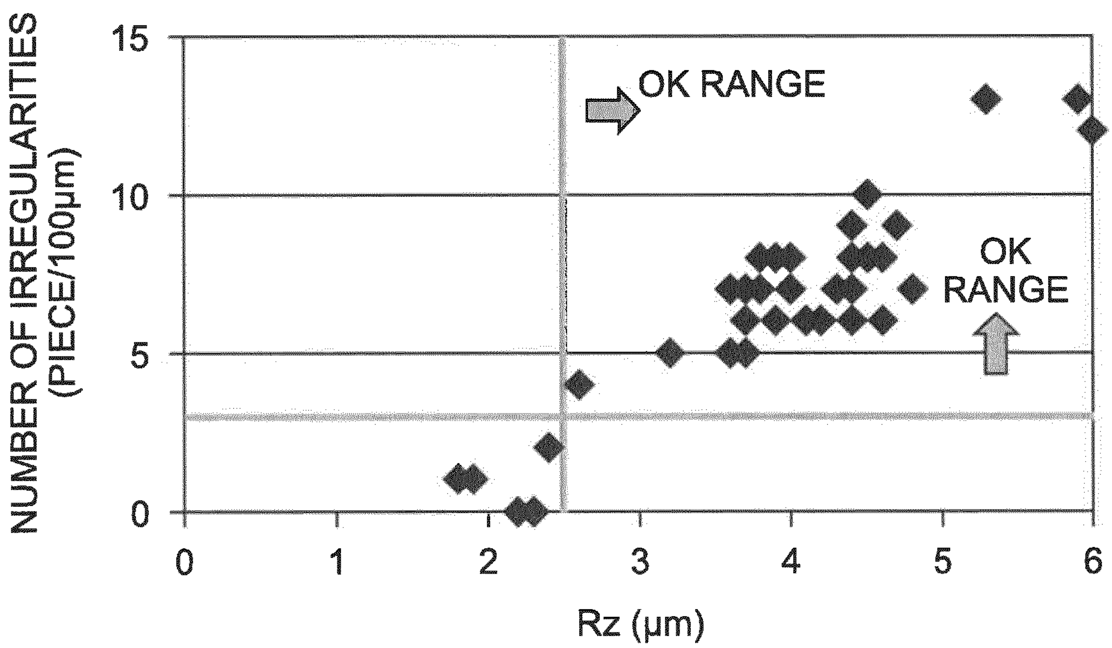


FIG. 7


NUMBER OF IRREGULARITIES
(PIECE/100µm)
15
10
5
0
OK RANGE
OK
RANGE
0
1
2
3
4
5
6
Rz (µm)

## INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/060145

A. CLASSIFICATION OF SUBJECT MATTER
*B21D22/20*(2006.01)i, *B21D24/00*(2006.01)i, *C21D9/46*(2006.01)i, *C22C38/00*(2006.01)i, *C22C38/14*(2006.01)i, *C22C38/58*(2006.01)i, *C23F11/00*(2006.01)i, *C23G1/08*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B21D22/20, B21D24/00, C21D9/46, C22C38/00, C22C38/14, C22C38/58, C23F11/00, C23G1/08

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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y<br>A | JP 2008-240046 A (Nippon Steel Corp.), 09 October 2008 (09.10.2008), claims; paragraphs [0023], [0038], [0049] to [0052]; table 7 (Family: none) | 1,3-8,10-15<br>2,9 |
| Y<br>A | JP 9-76004 A (Nisshin Steel Co., Ltd.), 25 March 1997 (25.03.1997), claim 1; paragraphs [0005], [0018] (Family: none) | 1,3-8,10-15<br>2,9 |

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

| | |
|---|---|
| Date of the actual completion of the international search<br>27 May 2016 (27.05.16) | Date of mailing of the international search report<br>07 June 2016 (07.06.16) |
| Name and mailing address of the ISA/<br>Japan Patent Office<br>3-4-3,Kasumigaseki,Chiyoda-ku,<br>Tokyo 100-8915,Japan | Authorized officer<br><br>Telephone No. |

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/060145

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y<br>A | WO 2012/053636 A1 (Nippon Steel & Sumitomo Metal Corp.),<br>26 April 2012 (26.04.2012),<br>claims 1, 2; paragraph [0033]<br>& US 2013/0292009 A1<br>claims 1, 2; paragraphs [0081] to [0084]<br>& EP 2631306 A1 & CA 2814630 A<br>& KR 10-2013-0069809 A & MX 2013004355 A | 4,8-11,15<br>1-3,5-7,<br>12-14 |
| Y<br>A | WO 2011/158818 A1 (Nippon Steel & Sumitomo Metal Corp.),<br>22 December 2011 (22.12.2011),<br>claims 2, 7; paragraph [0032]<br>& US 2013/0095347 A1<br>claims 2, 7; paragraphs [0062] to [0063]<br>& EP 2581465 A1 & CA 2802033 A<br>& KR 10-2013-0008639 A & MX 2012014594 A | 4,8-11,15<br>1-3,5-7,<br>12-14 |
| A | JP 2014-159624 A (Kobe Steel, Ltd.),<br>04 September 2014 (04.09.2014),<br>claims 1 to 6; paragraph [0057]<br>& US 2015/0125716 A1<br>claims 1 to 6; paragraph [0064]<br>& WO 2013/161831 A & EP 2843077 A1<br>& CN 104271789 A & KR 10-2014-0136509 A<br>& MX 2014012798 A | 1-15 |
| A | JP 2010-174302 A (JFE Steel Corp.),<br>12 August 2010 (12.08.2010),<br>claims 1 to 3; paragraphs [0010], [0031]<br>(Family: none) | 1-15 |

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## REFERENCES CITED IN THE DESCRIPTION

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- JP 2217425 A **[0008]**
- JP 2002143935 A **[0008]**
- JP 2003154413 A **[0008]**
- JP 2002018531 A **[0008]**
- JP 2004106034 A **[0008]**
- JP 2008240046 A **[0008]**
- JP 2010174302 A **[0008]**
- JP 2008214650 A **[0008]**
- JP 59219473 A **[0056]**