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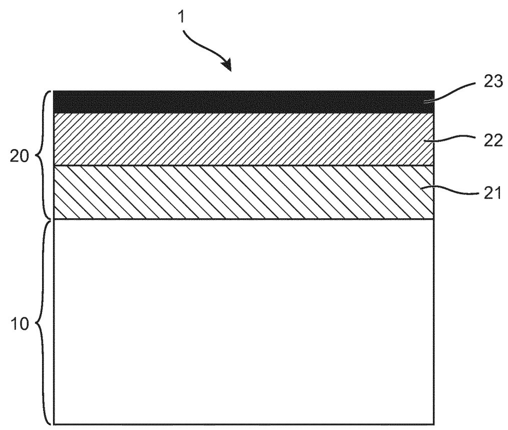
(54) **HOT STAMPED MOLDING**

(57) Provided is a hot stamped body which includes a base metal 10, and a plated layer 20 formed on a surface of the base metal 10, wherein the plated layer 20 includes an interface layer 21, an intermediate layer 22, and an oxide layer 23 in order from a base metal 10 side, the interface layer 21 contains an Fe-Al alloy having a microstructure which contains one or more kinds selected from αFe, Fe_3Al and FeAl, a total area fraction of the Fe-Al alloy being 99% or more, the intermediate layer 22 contains an Fe-Al-Zn phase which contains one or more kinds selected from Fe(Al, $Zn)_2$, Fe_2(Al, $Zn)_5$ and Fe(Al, $Zn)_3$, a total area fraction of the Fe-Al-Zn phase being 50% or more, an average composition of the intermediate layer contains, in mass%, Al: 30 to 50% and Zn: 15 to 30%, and an average film thickness of the oxide layer 23 is 3.0 μm or less, and Mg content in the oxide layer 23 is 0.05 to 0.50 g/m^2.

FIGURE 1



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Description

TECHNICAL FIELD

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

BACKGROUND ART

[0002] Structural members (formed bodies) used for automobiles or the like may be produced by performing hot stamping (hot pressing) so as to increase both strength and dimensional accuracy. In producing a formed body by performing hot stamping, a steel sheet is heated to the Ac_3 point or above, and is rapidly cooled while being subjected to pressing by press tooling. That is, in this production process, pressing and quenching are performed simultaneously. By performing hot stamping, it is possible to produce a formed body having high dimensional accuracy and high strength.
[0003] However, a formed body produced by performing hot stamping has been subjected to a high temperature and hence, scale is formed on the surface. Accordingly, a technique is proposed in which a plated steel sheet is used as a hot stamping steel sheet so that formation of scale is suppressed and, further, corrosion resistance is enhanced (see Patent Documents 1 to 3).
[0004] For example, Patent Document 1 discloses a steel sheet for hot pressing having a Zn plated layer. Patent Document 2 discloses an aluminum plated steel sheet for high strength automobile component having an Al plated layer. Further, Patent Document 3 discloses a Zn-based plated steel material for hot pressing where various elements, such as Mn, are added into the plated layer of a Zn plated steel sheet.

LIST OF PRIOR ART DOCUMENTS

PATENT DOCUMENT

[0005]

Patent Document 1: JP2003-73774A
Patent Document 2: JP2003-49256A
Patent Document 3: JP2005-113233A

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0006] In the technique disclosed in Patent Document 1, Zn remains in an outer layer of a steel material after hot stamping is performed and hence, high sacrificial anticorrosive action can be expected. However, a steel sheet is worked in a state where Zn is dissolved and hence, there is a possibility that molten Zn enters the steel sheet so that cracks occur in the steel material. This crack is referred to as Liquid Metal Embrittlement (hereinafter also referred to as "LME"). Fatigue properties of the steel sheet deteriorate due to LME.
[0007] At present, to avoid occurrence of LME, it is necessary to suitably control heating conditions for performing working on a steel sheet. To be more specific, a method or the like is adopted where heating is performed until all molten Zn is diffused in a steel sheet to form Fe-Zn solid solution. However, these methods require long time heating and, as a result, there is a problem that productivity declines.
[0008] In the technique disclosed in Patent Document 2, Al having a higher fusing point than Zn is used for a plated layer and hence, different from Patent Document 1, molten metal is less likely to enter a steel sheet. Accordingly, it is predicted that excellent fatigue property can be obtained and, eventually, the formed body subjected to hot stamping is excellent in fatigue property. However, a steel material on which an Al plated layer is formed has a problem that it is difficult to form a phosphate film at the time of performing phosphate treatment, which is performed before coating is applied to automobile components. In other words, some steel materials may not obtain sufficient phosphatability, thus degrading corrosion resistance after coating.
[0009] Further, in the technique disclosed in Patent Document 3, spot weldability is enhanced by modifying an outermost layer (oxide film) after hot stamping is performed. However, depending on an element to be added, LME still occurs so that there is a possibility that a hot stamp steel material cannot obtain sufficient fatigue property. Further, depending on an element to be added, there is also a possibility that phosphatability of the steel material is also degraded in addition to fatigue property.
[0010] An objective of the present invention, which has been made to overcome the above-mentioned problems, is

to provide a hot stamped body excellent in fatigue property, spot weldability, and corrosion resistance after coating.

SOLUTION TO PROBLEM

[0011] The present invention has been made to overcome the above-mentioned problems, and the gist of the present invention is the following hot stamped body.

(1) A hot stamped body including: a base metal and a plated layer formed on a surface of the base metal, wherein
the plated layer includes an interface layer, an intermediate layer, and an oxide layer in order from a base metal side,
the interface layer contains an Fe-Al alloy having a microstructure which contains one or more kinds selected from αFe, Fe_3Al and FeAl, a total area fraction of the Fe-Al alloy being 90% or more,
the intermediate layer contains an Fe-Al-Zn phase which contains one or more kinds selected from $Fe(Al, Zn)_2$, $Fe_2(Al, Zn)_5$ and $Fe(Al, Zn)_3$, a total area fraction of the Fe-Al-Zn phase being 50% or more,
an average composition of the intermediate layer contains, in mass%,
Al: 30 to 50% and
Zn: 15 to 30%, and
an average film thickness of the oxide layer is 3.0 μm or less, and Mg content in the oxide layer is 0.05 to 1.00 g/m^2.
(2) The hot stamped body described in the above-mentioned (1), wherein
an average film thickness of the interface layer is 1.0 μm or more.
(3) The hot stamped body described in the above-mentioned (1) or (2), wherein
a total content of Al and Zn in the plated layer is 20 to 100 g/m^2.
(4) The hot stamped body described in any one of the above-mentioned (1) to (3), wherein
a total area fraction of the Fe-Al-Zn phase in the intermediate layer is 90% or more.
(5) The hot stamped body described in any one of the above-mentioned (1) to (3), wherein
the plated layer further contains, in mass%, 0.1 to 15% of Si, and
the intermediate layer further contains an Fe-Al-Si phase which contains one kind or two kinds selected from $Fe_3(Al, Si)$ and Fe(Al, Si), a total area fraction of the Fe-Al-Zn phase and the Fe-Al-Si phase being 90% or more.

ADVANTAGEOUS EFFECTS OF INVENTION

[0012] According to the present invention, it is possible to obtain a hot stamped body excellent in fatigue property, spot weldability, and corrosion resistance after coating.

BRIEF DESCRIPTION OF DRAWINGS

[0013]

[Figure 1] Figure 1 is a view for describing a structure of a hot stamped body according to one embodiment of the present invention.
[Figure 2] Figure 2 is one example of an image of a cross section of the hot stamped body according to one embodiment of the present invention obtained by performing SEM observation.

DESCRIPTION OF EMBODIMENTS

[0014] Inventors of the present invention have conducted studies on a method for achieving both of LME resistance at the time of performing hot stamping forming and spot weldability and corrosion resistance after coating of a hot stamped body.

[0015] First, the inventors of the present invention have conducted studies on a method for enhancing corrosion resistance after coating of a formed body. As a result, the inventors of the present invention have found that corrosion resistance can be enhanced by causing a plated layer of the formed body to contain Mg. However, it is found that, in the case of producing a formed body whose plated layer contains Mg, LME easily occurs at the time of performing hot stamping forming, thus deteriorating fatigue property. Further, when Mg content in the plated layer is excessively high, spot weldability is also decreased.

[0016] Accordingly, the inventors of the present invention have conducted extensive studies on a method for enhancing corrosion resistance without deteriorating fatigue property and spot weldability. As a result, the following results are obtained. All of the above-mentioned properties can be ensured with a good balance by causing a plated layer to adopt a structure including a layer on the base metal side which contains an Fe-Al alloy as a main component, an oxide layer on the outer layer side, and a layer positioned between these layers, and by causing an appropriate amount of Mg to be concentrated in the oxide layer formed on the outer layer.

[0017] The present invention is made based on the above-mentioned findings. Hereinafter, the respective requirements of the present invention are described in detail.

(A) Overall configuration

[0018] Figure 1 is a view for describing the structure of the hot stamped body according to one embodiment of the present invention. Further, Figure 2 shows one example of an image of the cross section of the hot stamped body according to one embodiment of the present invention obtained by performing SEM observation. As shown in Figures 1 and 2, the hot stamped body 1 according to one embodiment of the present invention includes a base metal 10 and a plated layer 20 formed on the surface of the base metal 10.

(B) Base metal

[0019] Improvement of fatigue property, spot weldability, and corrosion resistance after coating, which is the task for the hot stamped body according to this embodiment, can be achieved by the configuration of the plated layer. Accordingly, the base metal of the hot stamped body according to this embodiment is not particularly limited. However, when the components of the base metal fall within ranges described hereinafter, it is possible to obtain the formed body having favorable mechanical properties in addition to fatigue property, spot weldability, and corrosion resistance after coating.

[0020] The reasons for limiting respective elements are as follows. In the description made hereinafter, symbol "%" for content refers to "mass%".

C: 0.05 to 0.4%

[0021] C (carbon) is an element which increases strength of a hot stamped body. When a content of C is excessively low, the above-mentioned effect cannot be obtained. On the other hand, when a content of C is excessively high, toughness of a steel material decreases. Accordingly, the C content is set to 0.05 to 0.4%. The C content is preferably 0.10% or more, and is more preferably 0.13% or more. Further, the C content is preferably 0.35% or less.

Si: 0.5% or less

[0022] Si (silicon) is an element which is inevitably contained, and has an action of deoxidizing steel. However, when a content of Si is excessively high, Si in steel is diffused during heating of a hot stamp and hence, oxide is formed on the surface of a steel sheet, thus degrading phosphatability. Si is also an element which raises the Ac_3 point of a steel sheet. When the Ac_3 point is raised, there is a possibility that a heating temperature at the time of performing hot stamping exceeds the evaporation temperature of Zn plating. Accordingly, the Si content is set to 0.5% or less. The Si content is preferably 0.3% or less, and is more preferably 0.2% or less. There is no limitation on the lower limit value of the Si content in terms of the above-mentioned properties of a product. However, as described above, Si is used for deoxidation and hence, there is a substantial lower limit value. Although the lower limit value of the Si content varies according to the required level of deoxidation, the lower limit value of the Si content is usually 0.05%.

Mn: 0.5 to 2.5%

[0023] Mn (Manganese) is an element which increases hardenability, thus increasing strength of a steel material on which hot stamping is performed. When a content of Mn is excessively low, this effect cannot be obtained. On the other hand, when a content of Mn is excessively high, this effect is saturated. Accordingly, the Mn content is set to a value within a range from 0.5 to 2.5%. The Mn content is preferably 0.6% or more, and is more preferably 0.7% or more. Further, the Mn content is preferably 2.4% or less, and is more preferably 2.3% or less.

P: 0.03% or less

[0024] P (phosphorus) is an impurity contained in steel. P segregates at crystal grain boundaries, thus decreasing toughness of the steel hence leading to degrading delayed fracture resistance. Accordingly, a content of P is set to 0.03% or less. It is preferable to reduce the P content as much as possible.

S: 0.01% or less

[0025] S (sulfur) is an impurity contained in steel. S forms sulfides, thus decreasing toughness of the steel hence leading to degrading delayed fracture resistance. Accordingly, a content of S is set to 0.01% or less. It is preferable to reduce the S content as much as possible.

sol. Al: 0.1% or less

[0026] Al (Aluminum) is an element which is generally used for deoxidizing steel, and is inevitably contained. However, when a content of Al is excessively high, although deoxidation is sufficiently performed, there is a possibility that the Ac_3 point of a steel sheet is raised so that a heating temperature at the time of performing hot stamping exceeds an evaporation temperature of Zn plating. Accordingly, the Al content is set to 0.1% or less. The Al content is preferably 0.05% or less. To obtain the above-mentioned advantageous effects, the Al content is preferably 0.01% or more. In this specification, the Al content means content of sol. Al (acid-soluble Al).

N: 0.01% or less

[0027] N (nitrogen) is an impurity which is inevitably contained in steel. N forms nitrides, thus decreasing toughness of the steel. Further, in the case where B is contained in steel, N is bonded to B, thus reducing the amount of dissolved B and, eventually, decreasing hardenability. Accordingly, a content of N is set to 0.01% or less. It is preferable to reduce the N content as much as possible.

B: 0 to 0.005%

[0028] B (boron) has an effect of increasing hardenability of the steel, thus increasing strength of a steel material on which hot stamping is performed. Accordingly, B may be contained when necessary. However, when a content of B is excessively high, this effect is saturated. Accordingly, the B content is set to 0.005% or less. To obtain the above-mentioned advantageous effects, the B content is preferably 0.0001% or more.

Ti: 0 to 0.1%

[0029] Ti (titanium) is bonded to N, thus forming nitrides. When Ti and N are bonded to each other in this manner, bonding between B and N is suppressed and hence, it is possible to suppress degrading hardenability caused by the formation of BN. Accordingly, Ti may be contained when necessary. However, when a content of Ti is excessively high, the above-mentioned effect is saturated and, further, an excessively large amount of Ti nitride precipitates, thus decreasing toughness of the steel. Accordingly, the Ti content is set to 0.1% or less. Ti makes a fine austenite grain size at the time of heating by a hot stamp by pinning effect of Ti, thus increasing toughness and the like of the steel material. To obtain the above-mentioned advantageous effects, the Ti content is preferably 0.01% or more.

Cr: 0 to 0.5%

[0030] Cr (chromium) has an effect of increasing hardenability of the steel. Accordingly, Cr may be contained when necessary. However, when a content of Cr is excessively high, Cr carbide is formed. This Cr carbide is not easily dissolved at the time of heating the hot stamp and hence, austenitization is prevented from easily progressing, thus degrading hardenability. Accordingly, the Cr content is set to 0.5% or less. To obtain the above-mentioned advantageous effects, the Cr content is preferably 0.1% or more.

Mo: 0 to 0.5%

[0031] Mo (molybdenum) has an effect of increasing hardenability of the steel. Accordingly, Mo may be contained when necessary. However, when a content of Mo is excessively high, the above-mentioned effect is saturated. Accordingly, the Mo content is set to 0.5% or less. To obtain the above-mentioned advantageous effects, the Mo content is preferably 0.05% or more.

Nb: 0 to 0.1%

[0032] Nb (niobium) forms carbides, thus having an effect of refining grains at the time of performing hot stamping hence leading to an increase in toughness of the steel. Accordingly, Nb may be contained when necessary. However, when a content of Nb is excessively high, not only that the above-mentioned effect is saturated, but also that hardenability is degraded. Accordingly, the Nb content is set to 0.1% or less. To obtain the above-mentioned advantageous effects, the Nb content is preferably 0.02% or more.

Ni: 0 to 1.0%

[0033] Ni (nickel) has an effect of increasing toughness of the steel. Further, Ni suppresses embrittlement attributable to the presence of molten Zn at the time of heating by the hot stamp. Accordingly, Ni may be contained when necessary. However, when a content of Ni is excessively high, these effects are saturated. Accordingly, the Ni content is set to 1.0% or less. To obtain the above-mentioned advantageous effects, the Ni content is preferably 0.1% or more.

[0034] In the chemical composition of the base metal which forms the hot stamped body of this embodiment, the balance consists of Fe and impurities. In this embodiment, "impurity" means a component which, in industrially producing steel materials, may be mixed in ores or scrap forming raw materials, or a component which may be mixed due to a production environment or the like, the component not being intentionally added.

(C) Plated layer

[0035] As shown in Figure 1, the plated layer 20 in this embodiment includes, in order from the base metal 10 side, an interface layer 21, an intermediate layer 22, and an oxide layer 23. The respective layers are described in detail. In this specification, an average film thickness means an average value between the maximum film thickness and the minimum film thickness of a target layer (film).

[0036] The interface layer 21 is formed adjacently to the base metal 10, and has a microstructure which contains an Fe-Al alloy as a main component. In the present invention, the term "Fe-Al alloy" is a collective term for αFe, Fe_3Al and FeAl. That is, the interface layer 21 has a microstructure which contains one or more kinds selected from αFe, Fe_3Al and FeAl. Further, the description "contains an Fe-Al alloy as a main component" means that the total area fraction of an Fe-Al alloy is 90% or more. The total area fraction of an Fe-Al alloy is preferably 95% or more, and more preferably 99% or more.

[0037] A content of Al in the interface layer 21 is 30% or less in mass%, and the Al content gradually decreases as a distance from the base metal 10 reduces. Forming the interface layer 21 adjacently to the base metal 10 can suppress LME. Further, there may be a case where Zn, Si or the like is dissolved in an Fe-Al alloy and hence, the interface layer 21 may contain Zn: 10% or less, or Si: 10% or less.

[0038] To enhance fatigue property or the like attributable to LME resistance, the average film thickness of the interface layer 21 is preferably 1.0 μm or more, and is more preferably 2.0 μm or more. The lower limit of the average film thickness of the interface layer 21 is further preferably 5.0 μm, 6.0 μm, or 7.0 μm.

[0039] It is unnecessary to specify the upper limit value of the average film thickness of the interface layer. However, the interface layer 21 having the average film thickness of 15.0 μm may deteriorate properties, such as corrosion resistance, and such an interface layer 21 is not preferable. Accordingly, the average film thickness of the interface layer 21 is preferably 15.0 μm or less. The upper limit of the average film thickness of the interface layer 21 is preferably 12.0 μm, 11.0 μm, or 10.0 μm.

[0040] The intermediate layer 22 has a microstructure which contains an Fe-Al-Zn phase as a main component. In the present invention, the term "Fe-Al-Zn phase" is a collective term for $Fe(Al, Zn)_2$, $Fe_2(Al, Zn)_5$, and $Fe(Al, Zn)_3$. That is, the intermediate layer 22 has a microstructure which contains one or more kinds selected from $Fe(Al, Zn)_2$, $Fe_2(Al, Zn)_5$ and $Fe(Al, Zn)_3$. Further, the description "contains an Fe-Al-Zn phase as a main component" means that the total area fraction of an Fe-Al-Zn phase is 50% or more. When the plated layer contains no Si, the total area fraction of an Fe-Al-Zn phase is preferably 90% or more, is more preferably 95% or more, and is further preferably 99% or more.

[0041] On the other hand, as described later, causing the plated layer to contain Si allows adhesiveness between the base metal and the plated layer to be enhanced. In this case, the intermediate layer 22 further contains an Fe-Al-Si phase. The term "Fe-Al-Si phase" is a collective term for $Fe_3(Al, Si)$ and Fe(Al, Si). That is, the intermediate layer 22 further contains one kind or two kinds selected from $Fe_3(Al, Si)$ and Fe(Al, Si). In this case, the total area fraction of an Fe-Al-Zn phase and an Fe-Al-Si phase is preferably 90% or more, is more preferably 95% or more, and is further preferably 99% or more.

[0042] Further, the intermediate layer 22 has an average composition containing, in mass%, Al: 30 to 50% and Zn: 15 to 30%.

[0043] By setting a content of Al in the intermediate layer 22 to 30% or more, LME can be suppressed, thus enhancing fatigue property. Further, setting the Al content to 50% or less allows excellent phosphatability to be ensured, thus enhancing corrosion resistance after coating. The Al content is preferably 32% or more, and is more preferably 35% or more. Further, the Al content is preferably 48% or less, and is more preferably 45% or less.

[0044] Setting a content of Zn in the intermediate layer 22 to 15% or more allows excellent phosphatability to be ensured, thus enhancing corrosion resistance after coating. Further, by setting the Zn content to 30% or less, LME can be suppressed, thus enhancing fatigue property. The Zn content is preferably 17% or more, and is more preferably 20% or more. Further, the Zn content is preferably 28% or less, and is more preferably 25% or less.

[0045] Further, reducing a content of Mg in the intermediate layer 22 can enhance LME resistance. Accordingly, the

Mg content is preferably 1.0% or less. In the case where the intermediate layer 22 contains an Fe-Al-Si phase, the intermediate layer 22 may contain Si: 25% or less.

[0046] The limitation is not particularly imposed on the film thickness of the intermediate layer. However, when the intermediate layer has a small film thickness, corrosion resistance property of a formed body is degraded. Accordingly, it is desirable to set the film thickness of the intermediate layer to 5.0 μm or more. On the other hand, when the intermediate layer has an excessively large film thickness, manufacturing cost increases and, further, there is a possibility that a heating time at the time of performing hot stamp increases. Accordingly, it is desirable that the film thickness of the intermediate layer be 30.0 μm or less.

[0047] The oxide layer 23 is an oxide layer which contains Zn as a main component, and the oxide layer 23 contains Mg. In this embodiment, the description "an oxide layer which contains Zn as a main component" specifically means that 50 mass% or more of a metal component contained in oxide is Zn. Due to the presence of the oxide layer 23, phosphatability is enhanced. However, excessively large thickness of the oxide layer 23 adversely affects corrosion resistance, weldability and the like of a formed body and hence, the average film thickness of the oxide layer 23 is set to 3.0 μm or less. To enhance properties of the hot stamped body, such as spot weldability and corrosion resistance after coating, the average film thickness of the oxide layer 23 is preferably set to 2.0 μm or less.

[0048] Causing the oxide layer 23 to contain Mg allows corrosion resistance after coating to be enhanced. To obtain such an effect, a content of Mg in the oxide layer 23 is set to 0.05 g/m^2 or more. However, Mg oxide has high electrical resistance and hence, when the Mg content increases, spot weldability is decreased. Accordingly, to ensure spot weldability, it is necessary to set the Mg content to 1.00 g/m^2 or less.

[0049] To cause oxide of the hot stamped body to contain Mg, Mg may be contained in a plated layer before hot stamping is performed, or a film which contains Mg may be formed on a plated steel sheet in the form of coating or the like.

[0050] Cr, Ca, Sr, Ti or the like is easily oxidized in the same manner as Mg and hence, Cr, Ca, Sr, Ti or the like is concentrated on the outer layer of a formed body as oxides. Accordingly, the oxide layer 23 may contain these elements. However, these oxides also have high electrical resistance in the same manner as Mg and hence, when these elements are excessively concentrated, weldability of a hot stamped body may be deteriorated. Accordingly, the total content of Mg, Cr, Ca, Sr and Ti in the oxide layer 23 is preferably 2.0 g/m^2 or less.

[0051] Further, the total content of Al and Zn in the plated layer 20 is preferably 20 to 100 g/m^2. By setting the total content of Al and Zn to 20 g/m^2 or more, it is possible to obtain advantageous effects brought about by forming the plated layer 20 on the surface of the base metal 10. On the other hand, by setting the total content to 100 g/m^2 or less, raw material cost of a hot stamped body can be suppressed, thus reducing manufacturing cost and, at the same time, weldability of the hot stamped body can be ensured. The total content is preferably 30 g/m^2 or more, and the total content is preferably 90 g/m^2 or less.

[0052] It is preferable that the plated layer 20 further contain, in mass%, 0.1 to 15% of Si. Setting a content of Si in the plated layer to 0.1% or more allows adhesiveness between the base metal and the plated layer to be enhanced. On the other hand, setting the Si content to 15% or less allows properties of a hot stamped body, such as corrosion resistance and weldability, to be ensured. The Si content is preferably 0.3% or more, and the Si content is preferably 10% or less.

[0053] The limitation is not particularly imposed on the film thickness of the entire plated layer 20. However, from a viewpoint of ensuring corrosion resistance, it is preferable to set the film thickness of the entire plated layer 20 to more than 6.0 μm. On the other hand, from a viewpoint of economic efficiency, it is preferable to set the film thickness of the entire plated layer 20 to 48.0 μm or less.

[0054] In the present invention, the microstructures, the average compositions and the thicknesses of the interface layer, the intermediate layer, and the oxide layer, and the chemical composition of the plated layer are obtained by the following method.

[0055] First, a formed body is cut perpendicular to the surface of the formed body, and the cross section is polished. Then, concentrations of respective elements in the region of the interface layer and in the region of the intermediate layer on the cross section are analyzed with an Electron Probe Micro Analyzer (EPMA). At this point of operation, mapping analysis is performed in a region which extends upward and downward in the film thickness direction of each layer by 25% or more from the film thickness center of the layer, and which extends in the width direction by 20 μm or more, and the average composition of the region is used. With such analysis, the Al content and the Zn content in the interface layer, and the contents of Al, Zn and Mg in the intermediate layer are measured.

[0056] Further, an average Si content in the entire plated layer is obtained by the following method. First, line analysis is performed by an EPMA at 0.2 μm pitch from the base metal side toward the surface side of the plated layer. Then, the average value of the measurement result in the plated layer is obtained, and the obtained value is set as the average composition of the entire plated layer. In performing continuous measurement from the base metal side to the surface side of the plated layer, a portion at which concentration of Fe is lower than average composition of base metal is assumed as one end portion of the plated layer, a portion at which concentration of Zn of metal components contained in the oxide layer becomes less than 50 mass% is assumed as the other end portion of the plated layer, and the region between one end portion and the other end portion of the plated layer is assumed as the plated layer. Further, line analysis is performed at five or more portions, and the average value of these line analyses is adopted.

[0057] The total content of Al and Zn contained in the plated layer can be measured such that a hot stamped body is dissolved with hydrochloric acid, and the dissolved solution is subjected to inductively coupled plasma emission spectrometry (ICP spectrometry). With the use of this method, the amount of Al and the amount of Zn can be obtained individually.

[0058] In dissolving a plated steel material before being heated by a hot stamp, to cause only a plated layer to be dissolved, inhibitor which suppresses dissolution of Fe in the base metal is generally added to a hydrochloric acid. However, the plated layer of the hot stamped body contains Fe and hence, the plated layer of the hot stamped body is not sufficiently dissolved with the above-mentioned method.

[0059] Accordingly, when amounts of Al and Zn in plating of the formed body are obtained by ICP spectrometry, it is appropriate to adopt a method where a plated layer is dissolved at a solution temperature of 40 to 50°C using a hydrochloric acid to which inhibitor is not added. Further, after the dissolution is performed, it is desirable to perform composition analysis using an EPMA on the surface of the hot stamped body after being dissolved so as to check for the presence or absence of undissolved plating component, such as Al or Zn. The above-mentioned analysis is required to be performed on an unworked region of the formed body.

[0060] Further, contents of Mg, Cr, Ca, Sr and Ti contained in the oxide layer are measured such that the hot stamped body is dissolved with an ammonium dichromate solution, and the dissolved solution is subjected to ICP spectrometry. With the use of the above-mentioned solution, only the oxide layer can be dissolved. With the use of this method, the content of each of Mg, Cr, Ca, Sr or Ti can be obtained individually.

[0061] Further, the microstructure of the interface layer and the microstructure of the intermediate layer can be obtained by performing crystal structure analysis using a TEM. Further, the thicknesses of the interface layer, the intermediate layer, and the oxide layer can be obtained such that the above-mentioned cross section is photographed by an SEM, and this microscope photograph is subjected to image analysis.

[0062] The configuration of the plated layer of the formed body according to this embodiment is not substantially uniform along the direction parallel to the surface of the formed body. Particularly, the thicknesses of the interface layer, the intermediate layer and the oxide layer vary in many cases between a worked region and an unworked region. Accordingly, the above-mentioned analysis is required to be performed on an unworked region of the formed body. A formed body where the state of an unworked region of the plated layer falls within the above-mentioned range is assumed as the formed body according to this embodiment.

(D) Production method

[0063] The method for producing a hot stamped body of this embodiment includes a step of producing a hot stamping plated steel material and a step of performing hot stamping on the hot stamping plated steel material. Further, the step of producing a hot stamping plated steel material includes a step of producing a base metal of the hot stamping plated steel material, and a step of forming an Al-Zn plated layer on the base metal of the hot stamping plated steel material. Further, a rust preventive oil film forming step and a blanking step may be performed before the step of performing hot stamping when necessary. Hereinafter, each step is described in detail.

[Base metal producing step]

[0064] In the base metal producing step, a base metal of a hot stamping plated steel material is produced. For example, molten steel is produced which has a chemical composition equal to the chemical composition of the base metal of the hot stamped body according to this embodiment exemplified above. Then, using this molten steel, a slab is produced by a casting process, or an ingot is produced by an ingot-making process.

[0065] Next, the slab or the ingot is subjected to hot rolling, thus obtaining a base metal (hot-rolled sheet) of the hot stamping plated steel material. It may be possible to adopt the configuration where pickling treatment is performed on the above-mentioned hot-rolled sheet, and cold rolling is performed on the hot-rolled sheet on which the pickling treatment is performed, thus obtaining a cold rolled sheet, and this cold rolled sheet is used as the base metal of the hot stamping plated steel material.

[Plating treatment step]

[0066] In the plating treatment step, an Al-Zn-Mg plated layer is formed on the base metal of the above-mentioned hot stamping plated steel material, thus producing a hot stamping plated steel material. As a method for forming the Al-Zn-Mg plated layer, hot dip plating treatment may be adopted. Alternatively, any other treatment may be adopted such as spraying plating treatment or vapor deposition plating treatment. To increase adhesiveness between the base metal and the plated layer, it is preferable to cause the plated layer to contain Si.

[0067] An example of forming the Al-Zn-Mg plated layer by hot dip plating treatment is as follows. That is, the base metal is immersed into a hot dipping bath consisting of Al, Zn, Mg and impurities to cause a plated layer to adhere to the surface of the base metal. Next, the base metal to which the plated layer is caused to adhere is pulled up from the plating bath.

[0068] As described above, it is preferable that the total content of Al and Zn in the plated layer of the hot stamped body be 20 to 100 g/m^2. To ensure this total content, it is important to set the total content of Al and Zn in the plated layer when the base metal is pulled up from the plating bath to 20 to 100 g/m^2 in this step.

[0069] In this step, by suitably adjusting a speed at which the steel sheet is pulled up from the plating bath and the flow rate of a wiping gas, the total content of Al and Zn in the plated layer can be adjusted.

[0070] Further, as described above, the intermediate layer of the plated layer of the hot stamped body contains, in mass%, 30 to 50% of Al and 15 to 30% of Zn. These contents of Al and Zn can be also controlled mainly in this step (plating treatment step). To be more specific, in this step, when Al content in the plating bath is set to 40 to 60%, and Zn content is set to 40 to 60%, it is possible to allow contents of Al and Zn in the hot stamped body to fall within the above-mentioned ranges.

[0071] In the case where the Al-Zn-Mg plated layer is formed by performing hot dip plating treatment, the Mg content in the plating bath is preferably set to 0.5 to 2.0%, and is more preferably set to 1.0 to 1.5%. Although the situation may vary depending on the adhesion amount on the plated steel sheet, when a concentration of Mg in the plating bath is high, the amount of Mg contained in plating increases and hence, the amount of Mg contained in oxide in the outer layer of the formed product increases, whereby there is a possibility that weldability is decreased. Further, when the amount of Mg which remains in the intermediate layer exceeds 1.0%, there is also a possibility that LME resistance is decreased. On the other hand, when a concentration of Mg in the plating bath is low, the amount of Mg contained in oxide in the outer layer of the formed product decreases so that there is a possibility that sufficient corrosion resistance after coating cannot be obtained.

[0072] In the case where a hot dipping bath which contains no Mg is used, Mg may be applied by coating such that treatment solution which contains Mg oxide is applied by coating on the plated layer by a bar coater, and the treatment solution is baked and dried by an oven. When Mg is applied by coating, it is preferable to set the content of Mg to be applied by coating to 0.050 to 1.00 g/m^2.

[Hot stamping step]

[0073] In the hot stamping step, hot stamping is performed on the above-mentioned hot stamping plated steel material. Normal hot stamping is performed such that a steel material is heated to a temperature within a hot stamping temperature range (hot working temperature range) and, then, the steel material is subjected to hot working and, further, the steel material is cooled. According to a normal hot stamping technique, it is preferable to increase a heating speed of a steel material as much as possible so as to shorten a production time. Further, when a steel material is heated to a temperature within a hot stamping temperature range, the plated layer is sufficiently alloyed. Accordingly, in the normal hot stamping technique, an importance is not placed on control of heating conditions of the steel material.

[0074] However, in the hot stamping step for producing the hot stamped body according to this embodiment, after alloying heat treatment is performed on a hot stamping plated steel material, the hot stamping plated steel material is heated to a hot stamping temperature (quenching heating temperature), and is subjected to hot working and cooling. When the temperature of the hot stamping plated steel material is increased to a hot stamping temperature, alloying heat treatment, where the hot stamping plated steel material is held for a fixed time within a predetermined temperature range, is performed and hence, a plated layer having the above-mentioned configuration can be formed.

[0075] In the hot stamping step, first, the hot stamping plated steel material is charged into a heating furnace (gas furnace, electric furnace, infrared furnace or the like). The hot stamping plated steel material is heated to a temperature range from 500 to 750°C in the heating furnace, and alloying heat treatment is performed, where the plated steel material is held for 10 to 450s within this temperature range. Performing alloying heat treatment causes Fe in the base metal to diffuse in the plated layer so that alloying process progresses. Due to such alloying process, the plated layer is changed to a layer which includes an interface layer, an intermediate layer, and an oxide layer in order from the base metal side. An alloying heating temperature is not necessarily set to a fixed temperature, and may vary within a range from 500 to 750°C.

[0076] When an alloying heating temperature is less than 500°C, a speed at which a plated layer is alloyed is extremely slow so that a heating time is extremely elongated and hence, such an alloying heating temperature is not preferable in terms of productivity. In addition to the above, there is a possibility that the intermediate layer is not sufficiently formed. On the other hand, when an alloying heating temperature exceeds 750°C, growth of an oxide layer is excessively promoted in this treatment process, thus degrading weldability of the hot stamped body.

[0077] Further, when an alloying heating time is less than 10s, alloying process of the plated layer is not completed and hence, a plated layer including the above-mentioned interface layer, intermediate layer, and oxidized layer cannot be obtained. On the other hand, when an alloying heating time exceeds 450s, the amount of growth of oxide increases excessively, and such a long time leads to declining of productivity.

[0078] Limitation is not particularly imposed on heating conditions at the time of heating a hot stamping plated steel material to the above-mentioned alloying heating temperature. However, a shorter heating time is desirable in terms of productivity.

[0079] After the alloying heat treatment is finished, the hot stamping plated steel material is heated to a temperature range from the Ac_3 point to 950°C and, then, is subjected to hot working. At this point of operation, a time during which the temperature of the hot stamping plated steel material falls within a temperature range (oxidation temperature range) from the Ac_3 point to 950°C is limited to 60s or less. When the temperature of the hot stamping plated steel material falls within the oxidation temperature range, the oxidized layer forming the outer layer of the plated layer grows. When the time during which the temperature of the hot stamping plated steel material falls within the oxidation temperature range exceeds 60s, there is a possibility that the oxide film excessively grows, thus degrading weldability of the formed body. On the other hand, a speed at which oxide coating is formed is extremely high and hence, the lower limit value of the time during which the temperature of the hot stamping plated steel material falls within the oxidation temperature range is more than 0s. However, when the hot stamping plated steel material is heated in a non-oxidizing atmosphere, such as 100% nitrogen atmosphere, an oxidized layer is not formed. Accordingly, the hot stamping plated steel material is heated in an oxidizing atmosphere, such as an air atmosphere.

[0080] Provided that the time during which the temperature of the hot stamping plated steel material falls within the oxidation temperature range is 60s or less, conditions, such as a heating speed and a maximum heating temperature, are not particularly defined, and various conditions under which hot stamping can be performed may be selected.

[0081] Next, the hot stamping plated steel material which is taken out from the heating furnace is subjected to press forming using press tooling. In this step, the steel material is quenched by the press tooling simultaneously with this press forming. A cooling medium (water, for example) circulates in the press tooling so that the press tooling promotes heat dissipation of the hot stamping plated steel material and hence, quenching is performed. With the above-mentioned steps, the hot stamped body can be produced.

[0082] The description has been made by exemplifying a method which heats a hot stamping plated steel material using a heating furnace. However, the hot stamping plated steel material may be heated by resistance heating. Also in this case, the steel material is heated for a predetermined time by resistance heating, and the steel material is subjected to press forming using press tooling.

[Rust preventive oil film forming step]

[0083] The rust preventive oil film forming step is a step which is performed after the plating treatment step and before the hot stamping step, and where rust preventive oil is applied by coating to the surface of a hot stamping plated steel material to form a rust preventive oil film. The rust preventive oil film forming step may be arbitrarily included in the production method. In the case where a long time is required before hot stamping is performed after a hot stamping plated steel material is produced, there is a possibility that the surface of the hot stamping plated steel material is oxidized. However, when a rust preventive oil film is formed on a hot stamping plated steel material by the rust preventive oil film forming step, the surface of the hot stamping plated steel material is not easily oxidized. Accordingly, performing the rust preventive oil film forming step can suppress the formation of scale on the formed body. Any known technique may be used as a method for forming a rust preventive oil film.

[Blanking step]

[0084] This step is a step which is performed after the rust preventive oil film forming step and before the hot stamping step, and where shearing and/or blanking is performed on the hot stamping plated steel material to form the steel material into a particular shape. The sheared surface of the steel material on which blanking is performed is easily oxidized. However, in the case where a rust preventive oil film is formed on the surface of the steel material in advance, rust preventive oil expands also to the above-mentioned sheared surface to some extent. With such expansion of the rust preventive oil, it is possible to suppress oxidization of the steel material on which blanking is performed.

[0085] One embodiment of the present invention has been described heretofore. However, the above-mentioned embodiment is for the sake of example of the present invention. Accordingly, the present invention is not limited to the above-mentioned embodiment, and design modifications can be made when necessary without departing from the gist of the present invention.

[0086] Hereinafter, the present invention is described more specifically with reference to examples. However, the present invention is not limited to these examples.

EXAMPLE 1

[0087] First, a base metal was prepared. That is, a slab was produced by continuous casting process using molten steel having the chemical composition shown in Table 1. Next, the slab was subjected to hot rolling so as to produce a hot rolled steel sheet, and the hot rolled steel sheet was further subjected to pickling. Thereafter, the hot rolled steel sheet was subjected to cold rolling, thus producing a cold rolled steel sheet. This cold rolled steel sheet was used as a base metal (sheet thickness: 1.4 mm) for producing a hot stamped body.

[Table 1]

[0088]

Table 1

Chemical composition of base metal (mass%, balance is Fe and impurities)									
C	Si	Mn	P	S	soL.Al	N	B	Ti	Cr
0.2	0.2	1.3	0.01	0.005	0.02	0.002	0.002	0.02	0.2

[0089] Next, hot stamping plated steel materials (materials No. 1 to 28) were prepared in accordance with production conditions shown in Table 2 using the base metals produced as described above. Further, the time during which each base metal is immersed in the plating bath at the time of performing plating treatment was set to 5s, and a cooling speed at which the plated steel material is cooled to 450°C after being pulled up from the plating bath was set to 10°C/s.

[Table 2]

[0090]

Table 2

Material No.	Plating treatment conditions						Coating conditions	
	Composition of plating bath (mass%)					Total content of Al, Zn in the plated layer (g/m^2)	Mg coating	Mg content (g/m^2)
	Al	Zn	Si	Mg	Cr+Ca+Sr+Ti			
1	55.0	44.5	0	0.5	0	60	absent	0
2	55.0	44.5	0	0.5	0	80	absent	0
3	55.0	44.0	0	1.0	0	60	absent	0
4	55.0	44.0	0	1.0	0	75	absent	0
5	55.0	42.4	1.6	1.0	0	60	absent	0
6	45.0	39.0	15.0	1.0	0	60	absent	0
7	55.0	44.0	0	2.0	0	40	absent	0
8	55.0	44.0	0	2.0	0	50	absent	0
9	60.0	39.0	0	1.0	0	60	absent	0
10	50.0	49.0	0	1.0	0	60	absent	0
11	55.0	45.0	0	0	0	60	present	0.05
12	55.0	45.0	0	0	0	60	present	0.25
13	55.0	45.0	0	0	0	60	present	0.5
14	55.0	45.0	0	0	0	60	present	1
15	55.0	43.0	0	1.0	1	60	absent	0
16	55.0	41.4	1.6	1.0	1	60	absent	0

(continued)

Material No.	Plating treatment conditions						Coating conditions	
	Composition of plating bath (mass%)					Total content of Al, Zn in the plated layer (g/m^2)	Mg coating	Mg content (g/m^2)
	Al	Zn	Si	Mg	Cr+Ca+Sr+Ti			
17	55.0	42.0	0	1.0	3	60	absent	0
18	55.0	40.4	1.6	1.0	3	60	absent	0
19	20.0	80.0	0	0	0	60	absent	0
20	80.0	20.0	0	0	0	60	absent	0
21	0.1	99.9	0	0	0	60	absent	0
22	90.0	0	10.0	0	0	60	absent	0
23	55.0	45.0	0	0	0	60	absent	0
24	55.0	43.4	1.6	0	0	60	absent	0
25	55.0	44.9	0	0.05	0	60	absent	0
26	55.0	42.0	0	3.0	0	60	absent	0
27	55.0	45.0	0	0	0	60	present	0.01
28	55.0	45.0	0	0	0	60	present	1.5

[0091] Thereafter, the above-mentioned hot stamping plated steel materials were heated under conditions (heating No. 1 to 9) shown in Table 3 and, immediately after the heating, were subjected to V-bending simulating a hot stamp using a hand press machine so as to produce hot stamped bodies of respective test examples. The shape of press tooling is set such that an outer side portion in the bending radius direction to which V-bending is applied is extended by approximately 15% at the time when bending is finished. Further, quenching was performed such that even a portion where a cooling speed at the time of performing working is slow has a cooling speed of 50°C/s or more until the portion is cooled to an approximate point (410°C) at which martensitic transformation starts.

[Table 3]

[0092]

Table 3

Heating No.	Alloying heating temperature (°C)	Alloying heating time (s)	Quenching heating temperature (°C)	Quenching heating time (s)
1	700	120	900	30
2	500	300	900	30
3	700	300	900	5
4	750	90	900	60
5	400	120	900	30
6	700	500	900	30
7	800	90	900	60
8	700	60	900	120
9	-		900	180

[0093] From the flat plate portion of the obtained hot stamped body of each test example, a test piece for observing the structure of the plated layer, a test piece for ICP spectrometry, a test piece for spot weldability evaluation test, and a test piece for corrosion resistance after coating evaluation test were cut out. Further, a test piece for LME resistance evaluation test was cut out from a portion to which bending is applied.

[0094] With respect to the test piece for observing the structure of the plated layer, the cross section perpendicular to the surface of the formed body was polished and, thereafter, the contents of Al and Zn in the interface layer and the contents of Al, Zn and Mg in the intermediate layer were measured using an EPMA. In EPMA analysis, mapping analysis was performed in a region which extends upward and downward in the film thickness direction of each layer by 25% or more from the film thickness center of the layer, and which extends in the width direction by 20 μm or more, and the average composition in the region was calculated.

[0095] Further, in obtaining the average Si content in the entire plated layer, line analysis was performed by an EPMA at 0.2 μm pitch from the base metal side toward the surface side of the plated layer, and the average value of the measurement result of the plated layer was calculated. Line analysis was performed at five portions, and the average value of the line analyses was used as the average composition of the entire plated layer.

[0096] Further, the above-mentioned cross section was photographed by an SEM, and the microscope photograph was subjected to image analysis so as to measure the thickness of each layer. The microstructure of each layer was determined by performing crystal structure analysis with a TEM on a thin piece obtained from the same place of each test piece.

[0097] With respect to the test piece for ICP spectrometry, a plated layer was dissolved with hydrochloric acid at a temperature of 50°C and, thereafter, the dissolved solution was subjected to ICP spectrometry so as to obtain the total content of Al and Zn contained in the plated layer. Further, in the same manner, only the oxide layer of the test piece for ICP spectrometry was dissolved with an ammonium dichromate solution, and the dissolved solution was subjected to ICP spectrometry so as to obtain the contents of Mg, Cr, Ca, Sr and Ti.

[0098] Next, LME resistance evaluation test, spot weldability evaluation test, and corrosion resistance after coating evaluation test were performed as described below.

[LME resistance evaluation test]

[0099] With respect to the cross section in the thickness direction of the test piece for LME resistance evaluation test of each test example, a reflected electron image was observed using an SEM and a reflected electron detector so as to observe the presence or absence of occurrence of LME. At this point of operation, the case where crack propagates to a base metal (a portion where a concentration of Fe is 98% or more) is assumed as occurrence of LME. Further, a test piece with no occurrence of cracks is evaluated as excellent (1), and a test piece with cracks which extend beyond the plated layer to a base metal is evaluated as fail (4).

[0100] When it is difficult to determine an end position of cracks with the above-mentioned observation, energy dispersive X-ray spectroscopy (EDS) is performed on a region around the end position of cracks using an energy dispersive X-ray microanalyzer so as to determine whether or not cracks extend to the base metal. In such an operation, a region where total content of Al and Zn exceeds 0.5% is identified as a plated layer, and a region of a steel material on the inner side of such a region is identified as a base metal.

[Spot weldability evaluation test]

[0101] Spot welding was performed on the test piece for weldability evaluation test of each test example using a DC power source at an applied pressure of 350 kgf. Tests were performed at various welding currents. A value of welding current at which the nugget diameter of a welding portion exceeds 4.7 mm was set to the lower limit value. A value of welding current was suitably increased, and a value of welding current at which dust is generated during welding was set to the upper limit value. Values between the upper limit value and the lower limit value are set as the proper current range, and the difference between the upper limit value and the lower limit value was used as an index of spot weldability. In the evaluation of spot weldability, a test piece with this value of 1.5 A or more is evaluated as excellent (1). A test piece with this value of 1.0 A or more and less than 1.5 A is evaluated as good (2). A test piece with this value of 0.5 A or more and less than 1.0 A is evaluated as fair (3). A test piece with this value of less than 0.5 A is evaluated as fail (4).

[Corrosion resistance after coating evaluation test]

[0102] Surface conditioning was performed on the test piece for corrosion resistance after coating evaluation test of each test example for 20s at a room temperature using a surface conditioning agent (product name: PREPALENE X) made by Nihon Parkerizing Co., Ltd. Next, phosphate treatment was performed using a zinc phosphate treatment solution (product name: PALBOND 3020) made by Nihon Parkerizing Co., Ltd. To be more specific, the temperature of the treatment solution was set to 43°C, and the formed body was immersed into the treatment solution for 120s. With such operations, a phosphate coating was formed on the surface of the steel material.

[0103] After the above-mentioned phosphate treatment was performed, cationic electrodeposition paint made by NIP-

PONPAINT Co., Ltd. was applied to each formed body by electrodeposition coating by slope energization at a voltage of 160 V and, further, was subjected to baking coating for 20 minutes at a baking temperature of 170°C. Control of the film thickness of the paint after the electrodeposition coating was performed under conditions that electrodeposition coating on a steel material before hot stamping forming is performed has a thickness of 15 μm.

[0104] A cross-cut was made on the formed body on which electrodeposition coating was performed such that the cross-cut reaches the steel material which is a base metal, and a composite corrosion test (JASO M610 cycle) was performed. Corrosion resistance was evaluated based on the width of coating blister. After a composite corrosion test of 180 cycles is performed on a formed body, the formed body with a width of coating blister of 2.0 mm or less is evaluated as excellent (1), the formed body with a width of coating blister of more than 2.0 mm and 3.0 mm or less is evaluated as good (2), the formed body with a width of coating blister of more than 3.0 mm and 4.0 mm or less is evaluated as fair (3), and the formed body with a width of coating blister of more than 4.0 mm is evaluated as fail (4).

[Evaluation result]

[0105] It is an objective of the present invention to provide a hot stamped body excellent in all of fatigue property (LME resistance), spot weldability, and corrosion resistance after coating with a good balance. Accordingly, by comprehensively taking these evaluation results into account, a hot stamped body which has an evaluation of excellent or good in either test, thus having a comprehensive evaluation of "A" and a hot stamped body which does not have an evaluation of fail in either test, thus having a comprehensive evaluation of "B" are assumed as acceptable. A hot stamped body which has an evaluation of fail in either test, thus having a comprehensive evaluation of "C" is assumed as defective. These results are shown in Table 4.

[Table 4]

Table 4

Test No.	Material No.	Heating No.	Interface layer: Average composition (mass%) Al	Interface layer: Average composition (mass%) Zn	Interface layer: Structure Judgement	Interface layer: Film thickenss (μm)	Intermediate layer: Average composition (mass%) Al	Intermediate layer: Average composition (mass%) Zn	Intermediate layer: Average composition (mass%) Mg	Intermediate layer: Structure Judgement	Intermediate layer: Film thickenss (μm)	Oxide layer: Mg content (g/m^2)	Oxide layer: Cr+Ca +Sr+Ti content (g/m^2)	Oxide layer: Film thickenss (μm)	Entire plated layer: Average composition (mass%) Si	Entire plated layer: Al, Zn total content (g/m^2)	Evaluation result: Fatigue property (LME resistance)	Evaluation result: Spot weldability	Evaluation result: Corrosion resistance after coating	Comprehensive evaluation	
1	1	1	15	3	OK	10	40	18	0	OK	20	0.30	0	2.0	0	57	1	2	2	A	Inventive example
2	2	1	17	5	OK	8	42	20	0	OK	30	0.40	0	2.5	0	77	1	2	1	A	
3	3	1	15	3	OK	10	40	18	0	OK	20	0.60	0	2.0	0	57	1	2	2	A	
4	4	1	16	4	OK	8	41	19	1.0	OK	27	0.75	0	2.5	0	72	1	2	1	A	
5	5	1	15	3	OK	10	40	18	0	OK	20	0.60	0	2.0	1	57	1	2	2	A	
6	6	1	15	3	OK	10	40	18	0	OK	20	0.60	0	2.0	8	58	1	2	2	B	
7	7	1	14	3	OK	12	40	15	1.0	OK	16	0.80	0	2.0	0	38	1	2	2	A	
8	8	1	14	3	OK	12	40	15	0	OK	18	1.0	0	2.0	0	48	1	2	2	A	
9	9	1	15	3	OK	10	43	17	0	OK	22	0.60	0	2.0	0	57	1	2	2	A	
10	10	1	15	3	OK	10	40	19	0	OK	22	0.60	0	2.0	0	57	1	2	2	A	
11	11	1	15	3	OK	10	40	18	0	OK	20	0.05	0	1.5	0	58	1	2	3	B	
12	12	1	15	3	OK	10	40	18	0	OK	20	0.25	0	1.5	0	58	1	2	2	A	
13	13	1	15	3	OK	10	40	18	0	OK	20	0.50	0	1.5	0	58	1	2	2	A	
14	14	1	15	3	OK	10	40	18	0	OK	20	1.0	0	1.5	0	58	1	3	2	B	
15	5	1	15	3	OK	10	40	18	0	OK	20	0.60	0	2.0	0	57	1	2	2	A	
16	5	2	15	3	OK	10	40	18	0	OK	20	0.60	0	2.0	0	57	1	2	2	A	
17	5	3	20	5	OK	5	42	22	0	OK	20	0.60	0	1.5	0	58	1	2	2	A	
18	5	4	15	3	OK	12	40	16	0	OK	20	0.60	0	2.5	0	56	1	2	2	A	
19	15	1	15	3	OK	10	40	18	0	OK	20	0.60	0.60	2.0	0	57	1	2	2	A	
20	16	1	15	3	OK	10	40	18	0	OK	20	0.60	0.60	2.0	1	57	1	2	2	A	
36	17	1	15	3	OK	10	40	18	0	OK	20	0.60	1.8	2.0	0	57	1	3	2	B	
37	18	1	15	3	OK	10	40	18	0	OK	20	0.60	1.8	2.0	1	57	1	3	2	B	
21	19	1	15	10	OK	10	20	45	0	NG	18	0	0	2.0	0	58	4	3	3	C	Comparative example
22	20	1	25	1	OK	10	40	10	0	NG	25	0	0	1.5	0	59	1	2	4	C	
23	21	1	0	40	NG	5	0	40	0	NG	17	0	0	2.0	0	56	4	3	3	C	
24	22	1	20	0	OK	10	40	0	0	NG	25	0	0	0.1	5	60	1	2	4	C	
25	23	1	15	3	OK	10	40	25	0	OK	20	0	0	2.0	0	57	1	1	4	C	
26	24	1	15	3	OK	10	40	25	0	OK	20	0	0	2.0	1	57	1	1	4	C	
27	25	1	15	3	OK	10	40	25	0	OK	20	0.03	0	2.0	0	57	1	2	4	C	
28	26	1	15	3	OK	10	40	25	1.2	OK	20	1.2	0	2.0	0	57	4	4	1	C	
29	27	1	15	3	OK	5	40	18	0	OK	20	0.01	0	1.5	0	57	1	2	4	C	
30	28	1	15	3	OK	5	40	18	0	OK	20	1.5	0	1.5	0	57	1	4	2	C	
31	5	5	20	3	NG	0.5	45	25	0	OK	20	0.40	0	2.0	1	58	4	2	2	C	
32	5	6	15	3	OK	15	38	12	0	OK	20	0.60	0	3.5	1	57	1	3	4	C	
33	5	7	15	3	OK	15	38	12	0	OK	20	0.60	0	4.0	1	56	1	4	4	C	
34	5	8	15	3	OK	10	35	12	0	OK	22	0.60	0	3.5	1	56	1	4	3	C	
35	5	9	15	3	OK	10	35	12	0	OK	22	0.60	0	4.0	1	55	1	4	3	C	

[0106] As can be clearly understood from Table 4, it is confirmed that the hot stamped bodies according to the present invention are excellent in all of fatigue property (LME resistance), spot weldability, and corrosion resistance after coating with a good balance.

INDUSTRIAL APPLICABILITY

[0107] According to the present invention, it is possible to obtain a hot stamped body excellent in fatigue property, spot weldability, and corrosion resistance after coating. Accordingly, the hot stamped body according to the present invention can be favorably used for a structural member or the like used in an automobile or the like.

Claims

1. A hot stamped body comprising: a base metal and a plated layer formed on a surface of the base metal, wherein
the plated layer includes an interface layer, an intermediate layer, and an oxide layer in order from a base metal side,
the interface layer contains an Fe-Al alloy having a microstructure which contains one or more kinds selected from αFe, Fe_3Al and FeAl, a total area fraction of the Fe-Al alloy being 90% or more,
the intermediate layer contains an Fe-Al-Zn phase which contains one or more kinds selected from $Fe(Al, Zn)_2$, $Fe_2(Al, Zn)_5$ and $Fe(Al, Zn)_3$, a total area fraction of the Fe-Al-Zn phase being 50% or more,
an average composition of the intermediate layer contains, in mass%,
Al: 30 to 50% and
Zn: 15 to 30%, and
an average film thickness of the oxide layer is 3.0 μm or less, and Mg content in the oxide layer is 0.05 to 0.50 g/m^2.

2. The hot stamped body according to claim 1, wherein
an average film thickness of the interface layer is 1.0 μm or more.

3. The hot stamped body according to claim 1 or claim 2, wherein
a total content of Al and Zn in the plated layer is 20 to 100 g/m^2.

4. The hot stamped body according to any one of claim 1 to claim 3, wherein
a total area fraction of the Fe-Al-Zn phase in the intermediate layer is 90% or more.

5. The hot stamped body according to any one of claim 1 to claim 3, wherein
the plated layer further contains, in mass%, 0.1 to 15% of Si, and
the intermediate layer further contains an Fe-Al-Si phase which contains one kind or two kinds selected from $Fe_3(Al, Si)$ and Fe(Al, Si), a total area fraction of the Fe-Al-Zn phase and the Fe-Al-Si phase being 90% or more.

FIGURE 1

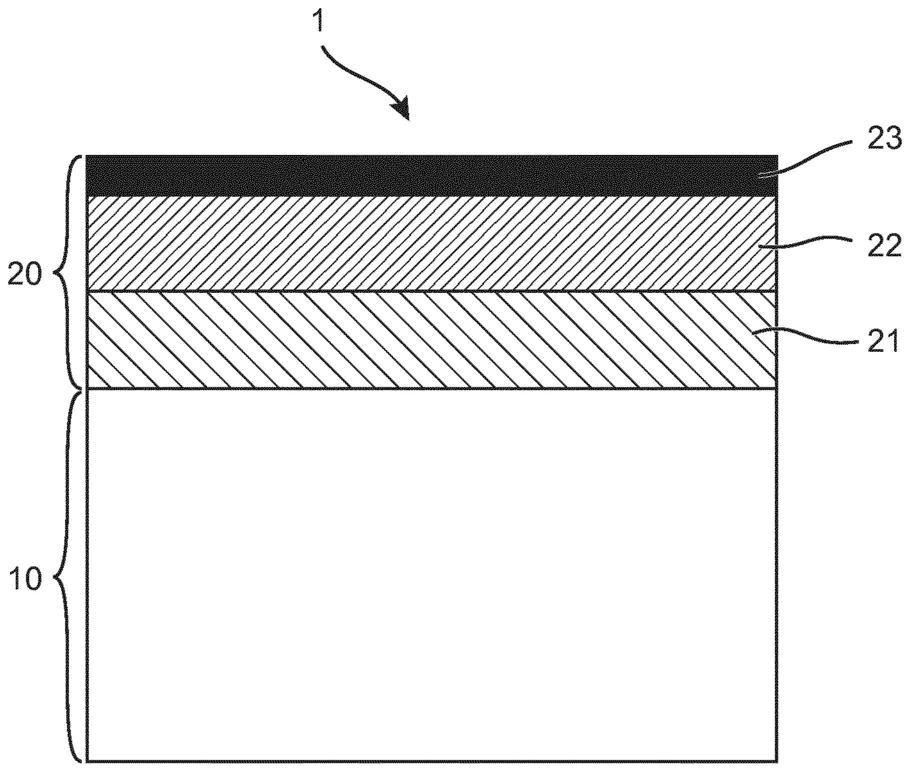
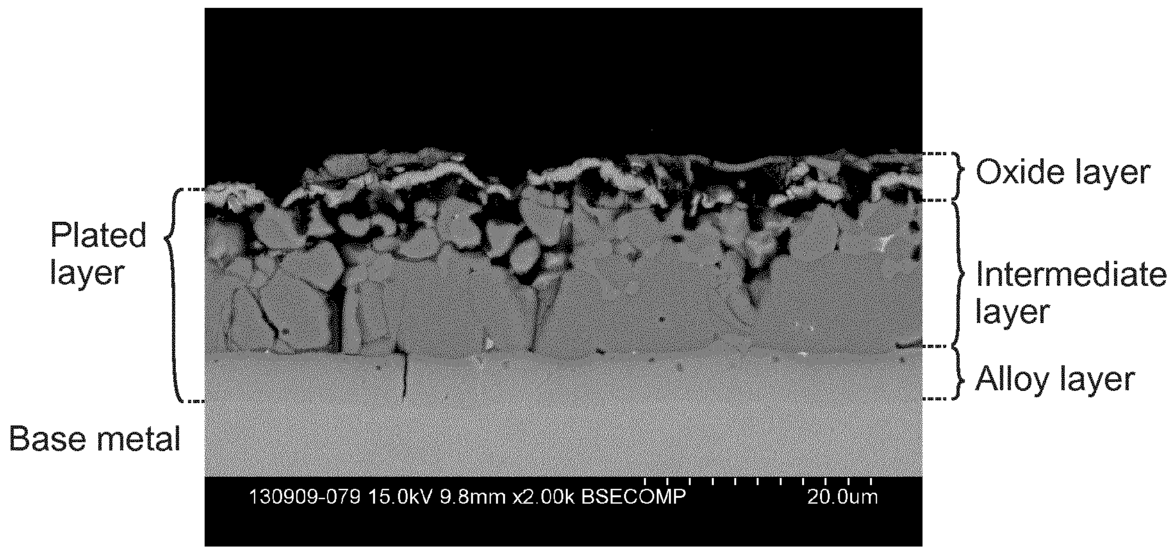


FIGURE 2



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/013760

A. CLASSIFICATION OF SUBJECT MATTER
C23C2/12(2006.01)i, *C21D1/18*(2006.01)i, *C21D9/00*(2006.01)i, *C22C18/04*(2006.01)i, *C22C21/10*(2006.01)i, *C22C38/00*(2006.01)i, *C22C38/06*(2006.01)i, *C22C38/58*(2006.01)i, *C23C2/28*(2006.01)i, *C23C2/40*(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)
C23C2/12, C23C2/28, C23C2/40, C21D9/00, C21D1/18

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	1996-2017
Kokai Jitsuyo Shinan Koho	1971-2017	Toroku Jitsuyo Shinan Koho	1994-2017

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.
X	JP 2012-112010 A (JFE Steel Corp.), 14 June 2012 (14.06.2012), claims 1 to 7; paragraph [0026]; paragraph [0049], No.13 (Family: none)	1-5
Y	JP 2005-113233 A (Nippon Steel Corp.), 28 April 2005 (28.04.2005), claims 1 to 7; paragraph [0021]; paragraphs [0029] to [0034], example 2 (Family: none)	1-5

☒ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 May 2017 (19.05.17)	30 May 2017 (30.05.17)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/013760

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Nisshin Steel Co., Ltd. Group Shohin Kaihatsu Senryaku Honbu Gijutsu Kenkyusho, Manabu OKU, Kenzaiyo Hyomen Shori Kohan no Kaihatsu Doko, Hyomen Shori Kohan no Gijutsu Tenkai, Dai 223·224 Kai Nishiyama Kinen Gijutsu Koza, The Iron and Steel Institute of Japan, 2015.10, 67 to 68	1-5

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003073774 A **[0005]**
- JP 2003049256 A **[0005]**
- JP 2005113233 A **[0005]**