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(54) CORROSON-RESISTANT STEEL MATERIAL FOR CRUDE OIL STORAGE TANK, AND CRUDE OIL STORAGE TANK

(57) A steel material is provided which can reduce local corrosion generated at a bottom plate and general corrosion generated at a roof plate and a side plate when the above steel material is used, for example, for an oil tank of an oil tanker, a tank for transporting crude oil, and a tank for storing crude oil. A steel material for a crude oil tank includes: 0.001 to 0.16 mass percent of C, 0.01 to 1.5 mass percent of Si, 0.1 to 2.5 mass percent of Mn, 0.025 mass percent or less of P, 0.01 mass percent or less of S, 0.005 to 0.1 mass percent of Al, 0.001 to 0.008 mass percent of N, 0.001 to 0.5 mass percent of W, and 0.06 to less than 0.20 mass percent of Cr, the balance being Fe and inevitable impurities.

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Description

Technical Field

[0001] The present invention relates to a corrosion resistant steel material and a crude oil tank including the steel material, the corrosion resistant steel material being capable of reducing local corrosion of a bottom plate and general corrosion of a roof plate and a side plate, which are generated when a steel material for a crude oil tank is used in a naked state or a primary coated state. The crude oil tank according to the present invention collectively includes, for example, an oil tank of an oil tanker, a tank for transporting crude oil, and a tank for storing crude oil, and the steel material for a crude oil tank includes a thick steel plate, a thin steel sheet, and shape steel.

Background Art

[0002] It has been known that at an inner surface (rear surface of an upper deck) of an upper part of a crude oil tank of a tanker, general corrosion occurs which is caused by O_2, CO_2, and SO_2 contained in an inert gas (exhaust gas from a boiler, an engine, or the like, having a representative composition including 5 percent by volume of O_2, 13 percent by volume of CO_2, 0.01 percent by volume of SO_2, and the balance being N_2) enclosed in a crude oil tank for explosion prevention and/or by corrosive gases, such as H_2S, evaporated from crude oil.

[0003] Furthermore, the above H_2S is oxidized by a catalytic effect of iron rust generated by corrosion to form solid S, and solid S having a layered shape is present in the iron rust. Subsequently, the corrosion products as described above are easily peeled off and are deposited on the bottom of a crude oil tank. Hence, by a dock inspection for a tanker, which is performed at every 2.5-year interval, a tremendous amount of cost is spent for repair of an upper part of the tank and removal of the deposits.

[0004] On the other hand, it has been believed that a steel material used for a bottom plate of a crude oil tank of a tanker generates no corrosion by a corrosion inhibition effect of crude oil itself and that of a protective film (hereinafter referred to as a "crude oil protective film) derived from crude oil and formed on an inner surface of the crude oil tank. However, in recent years, it was apparent that at a steel material used for a tank bottom plate, local corrosion in the form of a bowl is generated.

[0005] As the reasons the local corrosion in the form of a bowl occurs, the following are mentioned; however, these are all simply based on the estimation, and the exact causes have not been understood.

(1) The presence of condensed water which contains salts, such as sodium chloride, at a high concentration.
(2) Peeling off of a crude oil protective film by excessive washing operation.
(3) Increase in concentration of sulfide materials contained in crude oil.
(4) Increase in concentration of O_2, CO_2, SO_2 contained in an inert gas used for explosion prevention.
(5) Influences of microorganism.

[0006] A most effective method to suppress the corrosion as described above is a method in which thick coating is applied on a steel material surface so as to protect the steel material from a corrosive environment. However, it has been pointed out that when coating is applied to a crude oil tank, since the coating area is tremendous large, and the coating must be performed once per approximately 10 years, a large amount of cost is necessary for coating application and inspection, and in addition, it has also been pointed out that under a crude oil tank environment, when a thick coating is performed, corrosion generated from a damaged part of the coating film is adversely promoted.

[0007] Accordingly, corrosion resistant steel has been proposed which has corrosion resistant properties even under a crude oil tank environment or the like. For example, in Patent Document 1, corrosion resistant steel having general corrosion resistance and/or local corrosion resistance has been disclosed which has a composition in which to steel containing 0.01 to 0.3 mass percent of C, appropriate amounts of Si, Mn, P, and S are added, 0.05 to 3 mass percent of Ni is added, and at least one of Mo, Cu, Cr, W, Ca, Ti, Nb, V, and B is selectively added.

[0008] In addition, in Patent Document 2, corrosion resistant steel has been disclosed which has superior general corrosion resistance and local corrosion resistance and which can suppress the generation of corrosion products including solid S, the corrosion resistant steel being steel containing 0.001 to 0.2 mass percent of C, which includes appropriate amounts of Si, Mn, P, and S, 0.01 to 1.5 mass percent of Cu, 0.001 to 0.3 mass percent of Al, 0.001 to 0.01 mass percent of N, and at least one of 0.01 to 0.2 mass percent of Mo and 0.01 to 0.5 mass percent of W.

Patent Document 1: Japanese Unexamined Patent Application Publication No. 2003-082435
Patent Document 2: Japanese Unexamined Patent Application Publication No. 2004-204344

Disclosure of Invention

[0009] When the corrosion resistant steel disclosed in the above Patent Documents 1 and 2 is used as a steel material for a crude oil tank, superior inhibition effect for inhibiting general corrosion which occurs at an upper part of a crude oil tank can be obtained; however, it cannot be said that resistance (hereinafter referred to as "local corrosion resistance) against local corrosion which occurs at a bottom plate of a crude oil tank is sufficient.

[0010] Accordingly, an object of the present invention is to solve the above problems and to provide a steel material for a crude oil tank, which has superior general corrosion resistance when being used for an upper part (upper deck and side plate) of a crude oil tank, which also has superior local corrosion resistance when being used for a bottom plate of a crude oil tank, and which further has superior local corrosion resistance having an excellent effect of increasing a coating life even when being used in a primary coated state.

[0011] In order to achieve the above object, the inventors of the present invention extracted factors relating to local corrosion of the bottom plate of a crude oil tank and performed corrosion tests in which the above factors were variously used in combination, and finally, the local corrosion occurred at the bottom plate of a crude oil tank could be successfully reproduced. As a result, as for the dominant factors and corrosion mechanism of the local corrosion which occurs at the bottom plate of a crude oil tank, the following knowledge was obtained.

[0012] That is, in the local corrosion in the form of a bowl which occurs at the bottom plate of an actual crude oil tank, as dominant factors of the local corrosion, O_2 (oxygen) and H_2S (hydrogen sulfide) contained in the liquid have significant functions, and particularly, in an environment in which O_2 and H_2S are simultaneously present and in which both partial pressures of O_2 and H_2S are low, or in other words, in particular, in an aqueous solution in which gas containing O_2 at a partial pressure of 2 to 8 percent by volume and H_2S at a partial pressure of 5 to 20 percent by volume is saturated, the local corrosion occurs. That is, in the environment of a low O_2 partial pressure and a low H_2S partial pressure, H_2S is oxidized to precipitate solid S, a local cell is formed between the bottom plate of a crude oil tank and the solid S, and the local corrosion occurs at the surface of the steel material. In particular, in an acidic environment in which chloride ions (Cl^-) are present, the local corrosion is promoted to grow.

[0013] Accordingly, the inventors of the present invention intensively performed research on the influences of various alloy elements upon the local corrosion which occurs in the above environment of a low O_2 partial pressure and a low H_2S partial pressure. As a result, by addition of W and Cr, a rust layer formed on the surface of the steel material under the usage environment of a steel material for a crude oil tank is densified, so that local corrosion resistance and general corrosion resistance are improved, and in addition, by addition of Sn, Sb, or Mo, the generation of a dense rust layer containing W is assisted, so that local corrosion resistance and general corrosion resistant can be further improved. That is, it was found that when appropriate contents of W and Cr are primarily controlled, and appropriate contents of Sn, Sb, and Mo are also controlled, a steel material for a crude oil tank having superior local corrosion resistance and general corrosion resistance can be obtained.

[0014] Furthermore, it was also found that when the above steel material is used in the state in which a primer containing Zn is applied on the surface thereof, the coating layer life is significantly increased, and the local corrosion resistance and the general corrosion resistance are also improved.

[0015] Based on the above knowledge, the present invention was made through further intensive research.

[0016] That is, the present invention relates to a steel material for a crude oil tank, comprising: 0.001 to 0.16 mass percent of C, 0.01 to 1.5 mass percent of Si, 0.1 to 2.5 mass percent of Mn, 0.025 mass percent or less of P, 0.01 mass percent or less of S, 0.005 to 0.1 mass percent of Al, 0.001 to 0.008 mass percent of N, 0.001 to 0.5 mass percent of W, and 0.06 to less than 0.20 mass percent of Cr, the balance being Fe and inevitable impurities.

[0017] Besides the above component composition, the steel material of the present invention may further comprise at least one group selected from the following A to D groups.

A group: at least one of 0.005 to 0.3 mass percent of Sn and 0.005 to 0.3 mass percent of Sb
B group: 0.001 to 0.5 mass percent of Mo
C group: at least one of 0.001 to 0.1 mass percent of Nb, 0.002 to 0.1 mass percent of V, 0.001 to 0.1 mass percent of Ti, and 0.01 mass percent or less of B
D group: at least one of 0.0002 to 0.005 mass percent of Ca and 0.0005 to 0.015 mass percent of REM

[0018] In addition, in order to improve corrosion resistance, primer coating containing Zn may be applied to a surface of the steel material of the present invention.

[0019] In addition, the present invention relates to a crude oil tank formed of the steel material described above.

[0020] According to the present invention, not only in a naked state but also in a primer coated state, a steel material having superior local corrosion resistance and general corrosion resistance can be provided at an inexpensive price. Hence, the steel material of the present invention can be preferably used as a structural material, for example, for a tank for transporting or storing crude oil.

Brief Description of Drawings

[0021]

Fig. 1 is a view illustrating a test device used for a local corrosion test which was performed in Example 1.
Fig. 2 is a view illustrating a test device used for a general corrosion test which was performed in Example 2. Reference numerals in the figures indicate as follows.

1, 8	test piece
2, 9	corrosion test bath
3	constant-temperature bath
4, 11	gas supply
5, 12	gas exhaust
6	test liquid
7, 13	water
10	temperature-control plate

Best Modes for Carrying Out the Invention

[0022] The reasons for restricting the component composition of a steel material for a crude oil tank, according to the present invention, as described above will be described. C: 0.001 to 0.16 mass percent
C is an element to increase the strength of steel, and according to the present invention, in order to obtain a desired strength, a content of 0.001 mass percent or more is required. On the other hand, when the content is more than 0.16 mass percent, the weldability and toughness of a welding heat affected zone are degraded. Hence, the content of C is set in the range of 0.001 to 0.16 mass percent. In addition, in order to simultaneously obtain the two properties, strength and toughness, the content is preferably set in the range of 0.01 to 0.15 mass percent. Si: 0.01 to 1.5 mass percent

[0023] Although being generally added as a deoxidizing agent, Si is an element to increase the strength of steel, and according to the present invention, a content of 0.01 mass percent or more is required. However, the addition of more than 1.5 mass percent degrades the toughness of steel. Hence, the content of Si is set in the range of 0.01 to 1.5 mass percent. In addition, Si forms a corrosion resistant film in an acidic environment, so that the corrosion resistance is improved thereby. In order to obtain the above effect, the content is preferably set in the range of 0.2 to 1.5 mass percent. Mn: 0.1 to 2.5 mass percent

[0024] Mn is an element to increase the strength of steel, and according to the present invention, in order to obtain a desired strength, 0.1 mass percent or more of Mn is added. On the other hand, the addition of more than 2.5 mass percent degrades the toughness and weldability of steel. Hence, the content of Mn is set in the range of 0.1 to 2.5 mass percent. In addition, in order to ensure the strength and to suppress the formation of inclusions which degrades corrosion resistance, the content is preferably set in the range of 0.5 to 1.6 mass percent and more preferably set in the range of 0.8 to 1.4 mass percent. P: 0.025 mass percent or less

[0025] P segregates in grain boundaries and is a harmful element to degrade the toughness of steel; hence, the content thereof is preferably decreased as small as possible. In particular, when the content is more than 0.025 mass percent, since the toughness is seriously degraded, the P content is set to 0.025 mass percent or less. In addition, when the content is decreased to less than 0.005 mass percent, the production cost is increased; hence, the lower limit is preferably set to approximately 0.005 mass percent. S: 0.01 mass percent or less

[0026] S forms MnS which is a non-metallic inclusion and is a harmful element to degrade local corrosion resistance since functioning as an origin point of local corrosion; hence, the content thereof is preferably decreased as small as possible. In particular, when the content is more than 0.01 mass percent, since the local corrosion resistance is seriously degraded, the upper limit of S is set to 0.01 mass percent. In addition, when the content is decreased to less than 0.002 mass percent, the production cost is increased; hence, the lower limit of S is preferably set to approximately 0.002 mass percent. Al: 0.005 to 0.1 mass percent

[0027] Al is an element to be added as a deoxidizing agent, and according to the present invention, 0.005 mass percent or more is added. However, when more than 0.1 mass percent is added, since the toughness of steel is degraded, the upper limit of Al is set to 0.1 mass percent. The content is preferably set in the range of 0.01 to 0.05 mass percent. N: 0.001 to 0.008 mass percent

[0028] N is a component to degrade the toughness, and the content thereof is preferably decreased as small as possible. In particular, when the content is 0.008 mass percent or more, since the toughness is seriously degraded, the upper limit is set to 0.008 mass percent. However, from an industrial point of view, it is difficult to decrease the content to less than 0.001 mass percent. Hence, the content of N is set in the range of 0.001 to 0.008 mass percent. W: 0.001 to 0.5 mass percent

[0029] According to the present invention, W is an important and essential element to be added to improve the corrosion resistance. By addition of W, WO_4^{2-} ions formed under a corrosive environment show a barrier effect against negative ions, such as chloride ions, and also form insoluble $FeWO_4$, so that the progress of corrosion is suppressed. Furthermore, since a rust layer formed on a steel plate surface contains W, it is remarkably densified. The addition of W suppresses, by the chemical and physical effects as described above, the progress of general corrosion and the growth of local corrosion under a corrosive environment in which H_2S and Cl^- are present. Hence, a steel material for a crude oil tank is obtained which improves the local corrosion resistance and also has superior general corrosion resistance.

[0030] In addition, in the case in which a primer containing Zn is applied to a steel material surface, Zn in the primer is incorporated in a densified rust layer containing W to form composite oxides primarily composed of Fe with W and/or Zn, so that Zn can be made present at the steel material surface for a long period of time. Accordingly, compared to a steel material containing no W, the generation of local corrosion can be suppressed for a long period of time.

[0031] The effect of W to improve the corrosion resistance cannot be sufficiently obtained when the content is less than 0.001 mass percent, and when the content is more than 0.5 mass percent, the effect is not only saturated but the cost is also increased. Accordingly, the content of W is set in the range of 0.001 to 0.5 mass percent. Cr: 0.06 to less than 0.20 mass percent

[0032] As corrosion progresses, Cr migrates in a rust layer to inhibit the intrusion of Cl^- into the rust layer and to reduce the enrichment of Cl^- at the interface between the rust layer and base iron. In addition, in the case in which a primer containing Zn is applied, since composite oxides primarily composed of Fe with Cr and/or Zn are formed, Zn can be made present at the steel material surface for a long period of time. As a result, compared to a steel material containing no Cr, the generation of local corrosion can be suppressed for a long period of time. However, this effect cannot be sufficiently obtained when the content is less than 0.06 mass percent, and on the other hand, when the content is 0.20 mass percent or more, the toughness at a welded portion is degraded. Accordingly, the content of Cr is set in the range of 0.06 to less than 0.20 mass percent.

[0033] Although the steel material of the present invention contains the above components as the basic components, in order to further improve the corrosion resistance, at least one selected from Sn, Sb, and Mo may be contained at a concentration in the range described below. Sn: 0.005 to 0.3 mass percent

[0034] Sn has a function to improve acid resistance of a formed dense rust layer by a composite effect with W and Cr and also has a function to suppress corrosion. However, when the content is less than 0.005 mass percent, the above effect cannot be obtained, and on the other hand, when the content is more than 0.3 mass percent, hot workability and toughness are degraded. Hence, the content of Sn is preferably set in the range of 0.005 to 0.3 mass percent. Sb: 0.005 to 0.3 mass percent

[0035] Sb has a function, similar to that of Sn, to improve acid resistance of a formed dense rust layer by a composite effect with W and Cr and also has a function to suppress corrosion. However, when the content is less than 0.005 mass percent, the above effect cannot be obtained, and on the other hand, when the content is more than 0.3 mass percent, the above effect is saturated, and in addition, the workability is also degraded. Hence, the content of Sb is preferably set in the range of 0.005 to 0.3 mass percent. Mo: 0.001 to 0.5 mass percent

[0036] When Mo is contained together with W and Cr, Mo improves general corrosion resistance and local corrosion resistance, and in addition, by a composite effect with W, Cr, and Sn or Sb, it has a function to promote the formation of a dense rust layer and also has a function to further improve the corrosion resistance. The above effect can be obtained when the content is 0.001 mass percent or more; however, when the content is more than 0.5 mass percent, the effect is saturated, and in addition, the cost is increased. Hence, when Mo is contained, the content thereof is preferably set in the range of 0.001 to 0.5 mass percent.

[0037] In order to improve the steel material strength, besides the above components, the steel material of the present invention may contain at least one selected from Nb, V, Ti, and B at a concentration in the range described below. Nb: 0.001 to 0.1 mass percent

[0038] Nb is an element to be added in order to improve the strength of steel. The above effect is small when the content is less than 0.001 mass percent, and on the other hand, when the content is more than 0.1 mass percent, the toughness is degraded; hence, when Nb is added, the content thereof is preferably set in the range of 0.001 to 0.1 mass percent. V: 0.002 to 0.1 mass percent

[0039] V is an element to be added in order to improve the strength of steel. The effect of improving strength is small when the content is less than 0.002 mass percent, and on the other hand, when the content is more than 0.1 mass percent, the toughness is degraded; hence, when V is added, the content thereof is preferably set in the range of 0.002 to 0.1 mass percent. Ti: 0.001 to 0.1 mass percent

[0040] Ti is an element to be added in order to improve the strength and toughness of steel. The above effect is small when the content is less than 0.001 mass percent, and on the other hand, when the content is more than 0.1 mass percent, the effect is saturated; hence, when Ti is added, the content thereof is preferably set in the range of 0.001 to 0.1 mass percent. B: 0.01 mass percent or less

[0041] B is an element to be added in order to improve the strength of steel. When more than 0.01 mass percent is added, the toughness is degraded; hence, when B is added, the content thereof is preferably set to 0.01 mass percent or less.

[0042] In order to improve the ductility and toughness, besides the above components, the steel material of the present invention may contain at least one of Ca and REM at a concentration in the range described below. Ca: 0.0002 to 0.005 mass percent

[0043] Ca has a function to improve the ductility and toughness of steel through the shape control of inclusions. The above effect cannot be obtained when the content is less than 0.0002 mass percent, and on the other hand, when the content is more than 0.005 mass percent, the toughness is degraded; hence, the content is preferably set in the range of 0.0002 to 0.005 mass percent. REM: 0.0005 to 0.015 mass percent

[0044] REM has a function to improve the ductility and toughness through the shape control of inclusions. The above effect is small when the content is less than 0.0005 mass percent, and on the other hand, when the content is more than 0.015 mass percent, the toughness is degraded. Accordingly, when REM is added, the content thereof is preferably set in the range of 0.0005 to 0.015 mass percent.

[0045] In the steel material of the present invention, the balance other than the above components includes Fe and inevitable impurities. As long as the operation and effect of the present invention are not degraded, components other than those described above may also be contained, and for example, 0.008 mass percent or less of O, 0.05 mass percent or less of Cu, and 0.05 mass percent or less of Ni may be permissible.

[0046] Although it has been believed that Cu improves general corrosion resistance in an environment containing hydrogen sulfide, when it is added to the steel of the present invention, since an effect of improving local corrosion resistance is not only limited but hot workability is also seriously degraded, Cu is not added; however, as an inevitable impurity, 0.05 mass percent or less of Cu may be contained. In addition, even when Ni is added to the steel of the present invention, since functions to improve general corrosion resistance and local corrosion resistance are not observed, and the cost is merely increased thereby, Ni is not added; however, as an inevitable impurity, 0.05 mass percent or less of Ni may be contained.

[0047] Next, a preferable method for manufacturing a steel material, according to the present invention, will be described.

[0048] The steel material of the present invention has various finished shapes, such as a thick steel plate, a thin steel sheet, and shaped steel, each of which is formed from steel prepared to have the above component composition by a method similar to that used for general steel. For example, the steel of the present invention is preferably formed into a product such that after primary five elements (C, Si, Mn, P, and C) are adjusted to satisfy the ranges of the present invention by a general known method, such as a converter, an electric furnace, or a vacuum degassing apparatus, and in addition, other alloy elements are added in accordance with required properties and are melted, the above steel is formed into a steel slab by a continuous casting method or the like, and immediately after the above step or after cooling, this slab is then reheated and is processed by hot rolling.

[0049] Although the hot rolling conditions for corrosion resistant steel are not particularly limited, in order to ensure mechanical properties required for a steel material used for a crude oil tank or the like, it is preferable to appropriately control the hot rolling temperature, rolling reduction ratio, and the like. After hot rolling, in

[0050] accordance with desired mechanical properties, the cooling rate is preferably controlled. For example, in the case of a high strength steel material having a tensile strength level of 490 N/mm^2 or more, it is preferable that the finish hot rolling temperature be set at 750°C or more, and that cooling be then performed to 700°C or less at a cooling rate of 2°C/sec or more. When the finish temperature is less than 750°C, deformation resistance is increased, and it is difficult to perform the shape control. In addition, the reason for this is that when the cooling rate is less than 2°C/sec or a cooling stop temperature is more than 700°C, it is difficult to obtain a tensile strength level of 490 N/mm^2 or more.

[0051] When the steel material of the present invention obtained as described above is used as a steel material for a crude oil tank, by applying a primer containing Zn thereto, the local corrosion resistance and overall corrosion resistance can be significantly improved. In general, after a shot blast treatment is performed on a surface of a steel sheet, primer coating is performed thereon; however, in order to uniformly cover the entire surface of the steel sheet, a coating film having a certain thickness or more is required, and in order to improve the local corrosion resistance and overall corrosion resistance, a primer containing Zn is preferably applied to obtain a thickness of 5 μm or more. In addition, in view of the local corrosion resistance and general corrosion resistance, although the upper limit of the coating amount is not particularly limited, when the primer is applied to form a thick film, cutting properties, welding properties, and economical efficiency are degraded, and hence the upper limit is preferably set to 100 μm.

Examples

Example 1

[0052] After steel Nos. 1 to 33 having various component compositions shown in Table 1 were molten by a vacuum melting furnace or a converter to form steel slabs, the steel slabs were reheated to 1,200°C, followed by hot rolling performed at a finish temperature of 800°C, so that thick steel plates each having a thickness of 16 mm were obtained.

[0053] From each of steel plates Nos. 1 to 33 thus obtained, square small pieces each having a width of 50 mm, a length of 50 mm, and a thickness of 15 mm were cut out, and a shot blast treatment was performed on the surfaces thereof, followed by applying an inorganic-based zinc primer to obtain coating film thicknesses of 0 μm (no coating), 5 to 10 μm, 15 to 25 μm, and 50 to 70 μm, so that four types of test pieces were formed. Next, the end faces and the rear surface of each test piece were masked by a paint having corrosion resistance, and in addition, sludge containing crude oil components which were sampled from an actual tanker was uniformly applied only to the upper surface, which was a surface to be tested, so that a corrosion test piece was obtained. In this example, two types of test pieces having different surface conditions were formed as the corrosion test pieces. That is, there were prepared a test piece (test 1) formed by uniformly applying sludge on a test piece and a test piece (test 2) formed such that a compound (hereinafter referred to as "sulfur-mixed sludge) formed by mixing sulfur with the sludge at a weight ratio of 50% was provided on a central portion of a test piece having a diameter of 2 mm and the sludge was only applied on the other area other than that described above. By the test 2, the sulfur-mixed sludge portion functioned as an origin of local corrosion to promote the local corrosion. Accordingly, influences of steel material components, influences of primers, and influences of combinations between the steel material components and primers on local corrosion suppression can be more clearly grasped. In addition, it has been found that this test method has a closer relationship with an exposure test performed on an actual ship than that obtained by the test 1.

[0054] Subsequently, these test pieces were used for a corrosion test in which the test piece was immersed for 1 month in a test liquid 6 contained in a corrosion test device shown in Fig. 1. This corrosion test device is a double-bath type test device including a corrosion test bath 2 and a constant-temperature bath 3, and the corrosion test bath 2 contained the test liquid 6 which could generate local corrosion similar to that generated at a bottom plate of an actual crude oil tank. As the above test liquid 6, a liquid was used which was obtained such that artificial seawater defined by ASTMD1141 was used as a mother liquid for the test, and a mixed gas 4, in which the partial pressure ratio was adjusted to satisfy 5 percent by volume of O_2 and 10 percent by volume of H_2S and in which the balance was formed of N_2 gas, was supplied in the above mother liquid. The temperature of the test liquid 6 was maintained at 50°C by adjusting the temperature of water 7 contained in the constant-temperature bath 3. In addition, since the mixed gas 4 was continuously supplied, the test liquid 6 was always stirred.

[0055] After the corrosion test was performed, rust generated at the test piece surface was removed, the corrosion states were observed by the naked eye, and in addition, the corrosion depth at a local corrosion generation portion was measured by a dip meter and was evaluated in accordance with the following ranks.

1: No local corrosion
2: Local corrosion depth of less than 0.1 mm
3: Local corrosion depth of 0.1 mm to less than 0.2 mm
4: Local corrosion depth of 0.2 mm to less than 0.6 mm
5: Local corrosion depth of 0.6 mm to less than 1.0 mm
6: Local corrosion depth of 1.0 mm to less than 1.5 mm
7: Local corrosion depth of 1.5 mm to less than 2.0 mm
8: Local corrosion depth of 2.0 mm or more

[0056] The results of the above local corrosion test are shown in Table 2. According to the test 1, the steel sheets Nos. 1 to 25 which satisfy the component composition of the present invention are evaluated as ranks 1 to 3 of the local corrosion test, and the local corrosion depth is suppressed to less than 0.2 mm. In particular, the test pieces coated with a zinc primer having a thickness of 5 μm or more are all evaluated as rank 1, and no local corrosion is generated. On the other hand, among comparative steel sheets which are out of the range of the present invention, the steel sheet Nos. 26 to 31 other than the steel sheet Nos. 32 and 33 show results inferior to those of the invention examples.

[0057] Next, according to the test 2, although local corrosion is promoted as compared to that of the test 1, the difference in steel type, in particular, the difference in steel type in a zinc primer coated state, can be clearly obtained. That is, regardless of whether the zinc primer coating is present or not, local corrosion of the invention steel sheets Nos. 1 to 25 is suppressed as compared to that of the comparative steel sheets Nos. 26 to 31, as is the case of the test 1; however, it is found that the comparative steel sheets Nos. 32 and 33, which have local corrosion similar to that of the invention steel sheets by the test 1, are inferior to the invention steel sheets by this test.

[0058] Accordingly, it is found that the local corrosion resistance of the invention steel is superior.

Example 2

[0059] From each of steel sheets Nos. 1 to 33 which were the same as those used in Example 1, rectangular small pieces each having a width of 25 mm, a length of 48 mm, and a thickness of 4 mm were cut out, and a shot blast treatment was performed on the surfaces thereof, followed by applying an inorganic-based zinc primer to obtain coating film thicknesses of 0 μm (no coating), 5 to 10 μm, 15 to 25 μm, and 50 to 70 μm, so that four types of test pieces were formed. Next, in order to accelerate the corrosion test, cut scratches each having an X shape were formed from the coating film surface to the steel sheet surface to have a scratch area rate of 1.0%, so that each corrosion test piece was prepared.

[0060] By using a corrosion test device shown in Fig. 2, the test of overall corrosion which was liable to occur in an environment of the rear side of an upper deck of a crude oil tank was performed on the test pieces described above. This corrosion test device was formed of a corrosion test bath 9, and a temperature-control plate 10, and in the corrosion test bath 9, water 13 was contained and was maintained at a temperature of 40°C. In addition, in this overall corrosion test, in order to form a corrosive environment similar to that in a crude oil tank, a mixed gas including 12 percent by volume of CO_2, 5 percent by volume of O_2, 0.01 percent by volume of SO_2, 0.1 percent by volume of H_2S, and the balance being N_2 was fed in the above water 13. Furthermore, the inside of the corrosion test bath 9 was filled at a supersaturated vapor pressure, and in order to perform a simulation of corrosion caused by dew condensation water, the temperature of the test piece was repeatedly changed between 30°C×4 hours and 50°C×4 hours as one cycle for 20 days using a heater and a cooling device through the temperature-control plate 10.

[0061] After the overall corrosion test was performed, the individual test pieces were evaluated as described below.

<Test piece without zinc primer coating film>

[0062] From the change in weight before and after the test, a decrease in plate thickness caused by the corrosion was obtained and was then converted into a corrosion plate thickness per one year, and evaluation was then performed in accordance with the following ranks.

1: Corrosion rate of less than 0.10 mm/year
2: Corrosion rate of 0.10 mm/year to less than 0.25 mm/year
3: Corrosion rate of 0.25 mm/year to less than 0.50 mm/year
4: Corrosion rate of 0.50 mm/year to less than 1.00 mm/year
5: Corrosion rate of 1.00 mm/year or more

<Test piece with zinc primer coating film>

[0063] The ratio of a rust area generated on the surface of the test piece and under the coating film was measured, and evaluation was performed in accordance with the following ranks.

1: Rust area ratio of less than 5%
2: Rust area ratio of 5% to less than 15%
3: Rust area ratio of 15% to less than 25%
4: Rust area ratio of 25% to less than 50%
5: Rust area ratio of 50% or more

[0064] The results of the above overall corrosion test are also shown in Table 2. From the results shown in Table 2, it is found that the steel sheets Nos. 1 to 25 within the range of the present invention have superior overall corrosion resistance and are evaluated as ranks 1 and 2. On the other hand, not only in the case in which the inorganic zinc primer is not applied but also in the case in which it is applied, the evaluation of the comparative steel Nos. 26 to 33 is inferior to that of the invention steel. As a result, it is understood that the general corrosion resistance of the invention steel is superior.

TABLE 1

NO.	CHEMICAL COMPONENTS (mass%)																		REMARKS
	C	Si	Mn	P	S	Al	N	W	Cr	Sn	Sb	Mo	Nb	V	Ti	B	Ca	REM	
1	0.13	0.25	1.15	0.010	0.002	0.029	0.0025	0.08	0.10	-	-	-	-	-	-	-	-	-	INVENTION EXAMPLE
2	0.08	0.31	1.35	0.010	0.004	0.029	0.0031	0.04	0.06	-	-	-	-	-	-	-	-	-	INVENTION EXAMPLE
3	0.06	0.36	1.43	0.012	0.003	0.024	0.0027	0.08	0.15	-	-	-	-	-	-	-	-	-	INVENTION EXAMPLE
4	0.08	0.32	1.10	0.010	0.005	0.032	0.0045	0.04	0.12	0.07	-	-	-	-	-	-	-	-	INVENTION EXAMPLE
5	0.10	0.29	1.35	0.015	0.002	0.038	0.0030	0.01	0.08	0.04	0.10	-	-	-	0.012	-	-	-	INVENTION EXAMPLE
6	0.09	0.31	1.11	0.008	0.006	0.027	0.0028	0.05	0.09	0.04	0.08	-	-	-	-	-	-	-	INVENTION EXAMPLE
7	0.05	0.35	1.55	0.012	0.002	0.025	0.0028	0.35	0.10	0.03	0.09	-	-	-	-	-	-	-	INVENTION EXAMPLE
8	0.10	0.30	1.13	0.011	0.003	0.029	0.0045	0.05	0.08	-	0.12	-	-	-	-	-	-	-	INVENTION EXAMPLE
9	0.11	0.31	1.00	0.012	0.002	0.029	0.0055	0.04	0.19	-	-	0.02	-	-	-	-	-	-	INVENTION EXAMPLE
10	0.10	0.29	1.28	0.013	0.003	0.028	0.0031	0.06	0.07	0.01	0.12	-	-	-	-	-	-	-	INVENTION EXAMPLE
11	0.10	0.32	0.95	0.013	0.004	0.026	0.0015	0.03	0.12	0.02	0.08	0.06	-	-	-	-	-	-	INVENTION EXAMPLE
12	0.06	0.35	1.56	0.013	0.002	0.035	0.0031	0.05	0.06	0.18	0.01	-	-	-	0.016	-	-	-	INVENTION EXAMPLE
13	0.03	0.31	1.56	0.012	0.003	0.028	0.0029	0.07	0.12	0.03	0.20	-	0.010	-	0.010	-	-	-	INVENTION EXAMPLE
14	0.12	0.35	1.02	0.009	0.003	0.024	0.0028	0.12	0.07	-	0.11	-	-	0.005	-	-	-	-	INVENTION EXAMPLE

(continued)

NO.	CHEMICAL COMPONENTS (mass%)																		REMARKS
	C	Si	Mn	P	S	Al	N	W	Cr	Sn	Sb	Mo	Nb	V	Ti	B	Ca	REM	
15	0.10	0.37	1.12	0.010	0.003	0.027	0.0034	0.05	0.06	0.04	-	-	-	0.006	-	-	-	-	INVENTION EXAMPLE
16	0.12	0.26	1.12	0.011	0.006	0.026	0.0041	0.12	0.09	-	0.08	0.07		0.007	-	-	-	-	INVENTION EXAMPLE
17	0.08	0.39	1.05	0.011	0.008	0.028	0.0029	0.06	0.06	-	0.11	-	0.012	-	0.012	-	-	-	INVENTION EXAMPLE
18	0.10	0.28	0.98	0.012	0.002	0.032	0.0031	0.06	0.07	0.04	0.09	-	0.009	-	0.011	-	-	-	INVENTION EXAMPLE
19	0.13	0.27	0.83	0.009	0.006	0.032	0.0015	0.10	0.13	0.06	-	0.05	0.011	-	0.008	-	-	-	INVENTION EXAMPLE
20	0.12	0.26	0.85	0.007	0.004	0.031	0.0042	0.11	0.14	-	0.08	-	-	-	-	0.0009	-	-	INVENTION EXAMPLE
21	0.14	0.25	0.85	0.014	0.003	0.023	0.0036	0.05	0.08	0.05	-	-	-	0.006	-	0.0012	-	-	INVENTION EXAMPLE
22	0.13	0.35	0.92	0.015	0.005	0.025	0.0032	0.07	0.06	0.03	0.10	-	-	-	-	-	0.0017	-	INVENTION EXAMPLE
23	0.10	0.32	1.15	0.016	0.005	0.021	0.0034	0.05	0.09	0.03	0.11	0.02	-	-	-	-	0.0009	0.0025	INVENTION EXAMPLE
24	0.04	0.35	1.56	0.012	0.002	0.029	0.0033	0.05	0.20	0.07	0.08	-	-	-	0.008	0.0007	-	-	INVENTION EXAMPLE
25	0.07	0.34	1.45	0.010	0.003	0.03	0.0029	0.04	0.17	-	-	-	-	0.005	-	-	-	0.0017	INVENTION EXAMPLE
26	0.08	0.32	1.49	0.010	0.002	0.027	0.0031	-	-	-	-	-	-	-	-	-	-		COMPARATIVE EXAMPLE
27	0.06	0.27	1.42	0.010	0.004	0.029	0.0035	0.05	-	-	-	-	-	-	-	-	-	-	COMPARATIVE EXAMPLE
28	0.07	0.27	1.38	0.011	0.005	0.029	0.0036	-	0.07	-	0.10	-	-	-	-	-	-	-	COMPARATIVE EXAMPLE

(continued)

NO.	CHEMICAL COMPONENTS (mass%)																		REMARKS
	C	Si	Mn	P	S	Al	N	W	Cr	Sn	Sb	Mo	Nb	V	Ti	B	Ca	REM	
29	0.10	0.25	1.40	0.010	0.003	0.027	0.0024	-	-	-	0.02	-	-	-	-	-	-	-	COMPARATIVE EXAMPLE
30	0.11	0.31	1.29	0.012	0.006	0.024	0.0031	-	-	0.03	-	0.21	-	-	-	-	-	-	COMPARATIVE EXAMPLE
31	0.12	0.32	1.04	0.011	0.031	0.031	0.0032	0.04	0.08	-	0.12	-	-	-	-	-	-	-	COMPARATIVE EXAMPLE
32	0.09	0.28	1.31	0.013	0.002	0.035	0.0030	0.05	-	0.10	0.03	-	-	-	-	-	-	-	COMPARATIVE EXAMPLE
33	0.08	0.32	1.35	0.011	0.003	0.032	0.0028	0.03	0.03	0.04	0.12	-	-	-	-	-	-	-	COMPARATIVE EXAMPLE

TABLE 2

STEEL NO.	EXAMPLE 1 (TEST 1)				EXAMPLE 1 (TEST 2)				EXAMPLE 2				REMARKS
	ZINC PRIMER THICKNESS (µm)				ZINC PRIMER THICKNESS (µm)				ZINC PRIMER THICKNESS (µm)				
	0 (NO COATING)	5~10	15~25	50~70	0 (NO COATING)	5~10	15~25	50~70	0 (NO COATING)	5~10	15~25	50~70	
1	3	1	1	1	4	3	2	1	2	2	1	1	INVENTION EXAMPLE
2	3	1	1	1	4	3	2	1	2	2	1	1	INVENTION EXAMPLE
3	3	1	1	1	4	3	2	1	2	2	1	1	INVENTION EXAMPLE
4	2	1	1	1	4	3	2	1	2	2	1	1	INVENTION EXAMPLE
5	1	1	1	1	3	2	1	1	1	1	1	1	INVENTION EXAMPLE
6	1	1	1	1	3	2	1	1	1	1	1	1	INVENTION EXAMPLE
7	1	1	1	1	3	2	1	1	1	1	1	1	INVENTION EXAMPLE
8	1	1	1	1	3	3	2	1	2	2	1	1	INVENTION EXAMPLE
9	3	1	1	1	4	3	2	1	2	2	1	1	INVENTION EXAMPLE
10	1	1	1	1	3	2	1	1	1	1	1	1	INVENTION EXAMPLE
11	1	1	1	1	3	2	1	1	1	1	1	1	INVENTION EXAMPLE
12	1	1	1	1	3	2	1	1	1	1	1	1	INVENTION EXAMPLE

(continued)

STEEL NO.	EXAMPLE 1 (TEST 1)				EXAMPLE 1 (TEST 2)				EXAMPLE 2				REMARKS
	ZINC PRIMER THICKNESS (μm)				ZINC PRIMER THICKNESS (μm)				ZINC PRIMER THICKNESS (μm)				
	0 (NO COATING)	5~10	15~25	50~70	0 (NO COATING)	5~10	15~25	50~70	0 (NO COATING)	5~10	15~25	50~70	
13	1	1	1	1	3	2	1	1	1	1	1	1	INVENTION EXAMPLE
14	1	1	1	1	3	3	2	1	2	2	1	1	INVENTION EXAMPLE
15	2	1	1	1	4	3	2	1	2	2	1	1	INVENTION EXAMPLE
16	1	1	1	1	3	2	2	1	2	2	1	1	INVENTION EXAMPLE
17	1	1	1	1	3	3	2	1	2	2	1	1	INVENTION EXAMPLE
EVALUATION STANDARD	RANKS 1: No local corrosion 2: Local corrosion depth of less than 0.1 mm 3: Local corrosion depth of 0.1 mm to less than 0.2 mm 4: Local corrosion depth of 0.2 mm to less than 0.6 mm 5: Local corrosion depth of 0.6 mm to less than 1.0 mm 6: Local corrosion depth of 1.0 mm to less than 1.5 mm 7: Local corrosion depth of 1.5 mm to less than 2.0 mm 8: Local corrosion depth of 2.0 mm or more				RNAKS 1: No local corrosion 2: Local corrosion depth of less than 0.1 nm 3: Local corrosion depth of 0.1 mm to less than 0.2 mm 4: Local corrosion depth of 0.2 mm to less than 0.6 mm 5: Local corrosion depth of 0.6 mm to less than 1.0 mm 6: Local corrosion depth of 1.0 mm to less than 1.5 mm 7: Local corrosion depth of 1.5 mm to less than 2.0 mm 8: Local corrosion depth of 2.0 mm or more				<TEST PIECE WITHOUT COATING FILM> RANKS 1: Corrosion rate of less than 0.10 mm/year 2: Corrosion rate of 0.10 mm/year to less than 0.25 mm/year 3: Corrosion rate of 0.25 mm/year to less than 0.50 mm/year 4: Corrosion rate of 0.50 mm/year to less than 1.00 mm/year 5: Corrosion rate of 1.00 mm/year or more <TEST PIECE WITH PRIMER COATING> RANKS 1: Rust area ratio of less than 5% 2: Rust area ratio of 5% to less than 15% 3: Rust area ratio of 15% to less than 25% 4: Rust area ratio of 25% to less than 50% 5: Rust area ratio of 50% or more				
18	1	1	1	1	3	2	1	1	1	1	1	1	INVENTION EXAMPLE

(continued)

STEEL NO.	EXAMPLE 1 (TEST 1)				EXAMPLE 1 (TEST 2)				EXAMPLE 2				REMARKS
	ZINC PRIMER THICKNESS (μm)				ZINC PRIMER THICKNESS (μm)				ZINC PRIMER THICKNESS (μm)				
	0 (NO COATING)	5~10	15~25	50~70	0 (NO COATING)	5~10	15~25	50~70	0 (NO COATING)	5~10	15~25	50~70	
19	2	1	1	1	4	2	2	1	2	2	1	1	INVENTION EXAMPLE
20	1	1	1	1	3	3	2	1	2	2	1	1	INVENTION EXAMPLE
21	2	1	1	1	4	3	2	1	2	2	1	1	INVENTION EXAMPLE
22	1	1	1	1	3	2	1	1	1	2	1	1	INVENTION EXAMPLE
23	1	1	1	1	3	2	1	1	1	1	1	1	INVENTION EXAMPLE
24	1	1	1	1	3	2	1	1	1	1	1	1	INVENTION EXAMPLE
25	3	1	1	1	4	3	2	1	2	2	1	1	INVENTION EXAMPLE
26	6	6	6	5	8	8	8	7	5	5	5	5	COMPARATIVE EXAMPLE
27	6	5	5	4	8	7	6	5	5	5	5	4	COMPARATIVE EXAMPLE
28	6	5	5	3	8	7	6	4	5	5	4	4	COMPARATIVE EXAMPLE
29	6	6	5	5	8	8	7	7	5	5	5	5	COMPARATIVE EXAMPLE
30	6	5	4	4	8	8	6	6	5	5	4	4	COMPARATIVE EXAMPLE
31	6	5	4	3	8	7	5	5	5	5	4	4	COMPARATIVE EXAMPLE

(continued)

STEEL NO.	EXAMPLE 1 (TEST 1)				EXAMPLE 1 (TEST 2)				EXAMPLE 2				REMARKS
	ZINC PRIMER THICKNESS (μm)				ZINC PRIMER THICKNESS (μm)				ZINC PRIMER THICKNESS (μm)				
	0 (NO COATING)	5~10	15~25	50~70	0 (NO COATING)	5~10	15~25	50~70	0 (NO COATING)	5~10	15~25	50~70	
32	3	1	1	1	5	4	3	2	3	3	2	2	COMPARATIVE EXAMPLE
33	3	1	1	1	5	4	3	2	3	3	2	2	COMPARATIVE EXAMPLE
EVALUATION STANDARD	RANKS 1: No local corrosion 2: Local corrosion depth of less than 0.1 mm 3: Local corrosion depth of 0.1 mm to less than 0.2 mm 4: Local corrosion depth of 0.2 mm to less than 0.6 mm 5: Local corrosion depth of 0.6 mm to less than 1.0 mm 6: Local corrosion depth of 1.0 mm to less than 1.5 mm 7: Local corrosion depth of 1.5 mm to less than 2.0 mm 8: Local corrosion depth of 2.0 mm or more				RNAKS 1: No local corrosion 2: Local corrosion depth of less than 0.1 mm 3: Local corrosion depth of 0.1 mm to less than 0.2 mm 4: Local corrosion depth of 0.2 mm to less than 0.6 mm 5: Local corrosion depth of 0.6 mm to less than 1.0 mm 6: Local corrosion depth of 1.0 mm to less than 1.5 mm 7: Local corrosion depth of 1.5 mm to less than 2.0 mm 8: Local corrosion depth of 2.0 mm or more				<TEST PIECE WITHOUT COATING FILM> RANKS 1: Corrosion rate of less than 0.10 mm/year 2: Corrosion rate of 0.10 mm/year to less than 0.25 mm/year 3: Corrosion rate of 0.25 mm/year to less than 0.50 mm/year 4: Corrosion rate of 0.50 mm/year to less than 1.00 mm/year 5: Corrosion rate of 1.00 mm/year or more <TEST PIECE WITH PRIMER COATING> RANKS 1: Rust area ratio of less than 5% 2: Rust area ratio of 5% to less than 15% 3: Rust area ratio of 15% to less than 25% 4: Rust area ratio of 25% to less than 50% 5: Rust area ratio of 50% or more				

Claims

1. A steel material for a crude oil tank, comprising: 0.001 to 0.16 mass percent of C, 0.01 to 1.5 mass percent of Si, 0.1 to 2.5 mass percent of Mn, 0.025 mass percent or less of P, 0.01 mass percent or less of S, 0.005 to 0.1 mass percent of Al, 0.001 to 0.008 mass percent of N, 0.001 to 0.5 mass percent of W, and 0.06 to less than 0.20 mass percent of Cr, the balance being Fe and inevitable impurities.

2. The steel material for a crude oil tank, according to Claim 1, further comprising, besides the above component composition, at least one of 0.005 to 0.3 mass percent of Sn and 0.005 to 0.3 mass percent of Sb.

3. The steel material for a crude oil tank, according to Claim 1 or 2, further comprising, besides the above component composition, 0.001 to 0.5 mass percent of Mn.

4. The steel material for a crude oil tank, according to one of Claims 1 to 3, further comprising, besides the above component composition, at least one of 0.001 to 0.1 mass percent of Nb, 0.002 to 0.1 mass percent of V, 0.001 to 0.1 mass percent of Ti, and 0.01 mass percent or less of B.

5. The steel material for a crude oil tank, according to one of Claims 1 to 4, further comprising, besides the above component composition, at least one of 0.0002 to 0.005 mass percent of Ca and 0.0005 to 0.015 mass percent of REM.

6. The steel material for a crude oil tank, according to one of Claims 1 to 5, wherein primer coating containing Zn is applied on a surface of the steel material.

7. A crude oil tank comprising the steel material according to one of Claims 1 to 6.

FIG 1

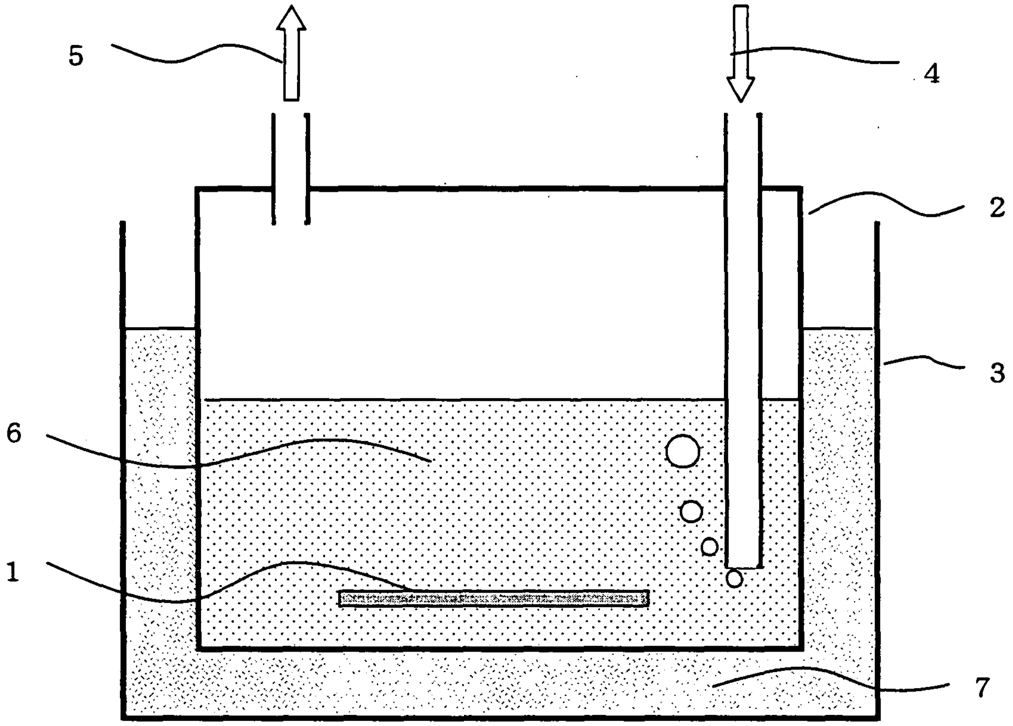
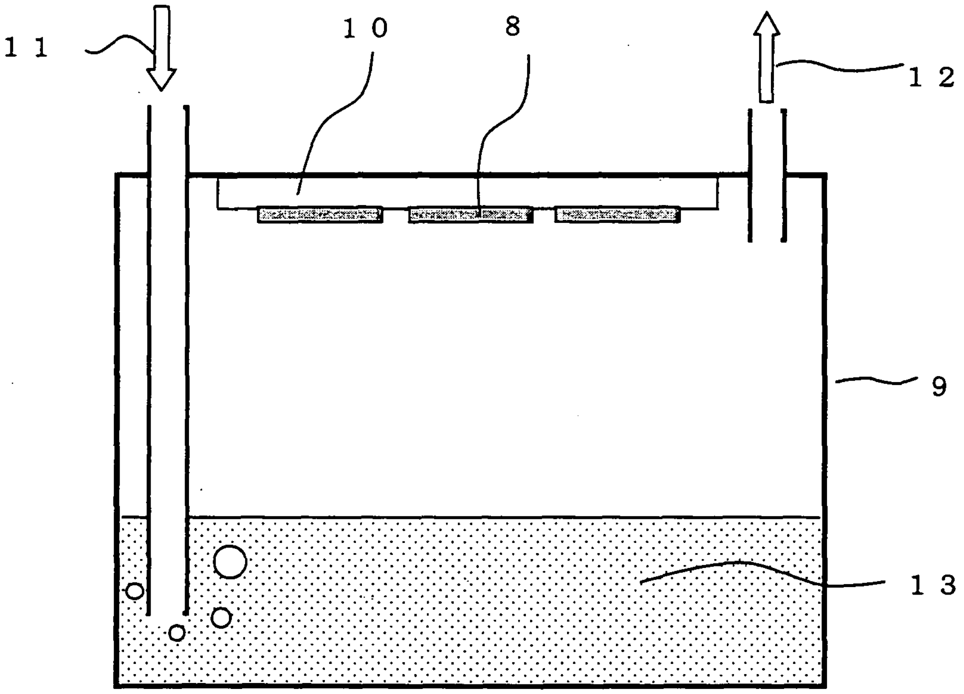


FIG 2



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/050735

A. CLASSIFICATION OF SUBJECT MATTER
C22C38/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C22C38/00

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	1996-2007
Kokai Jitsuyo Shinan Koho	1971-2007	Toroku Jitsuyo Shinan Koho	1994-2007

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	JP 2005-325439 A (Sumitomo Metal Industries, Ltd.), 24 November, 2005 (24.11.05), Claims; Par. Nos. [0001], [0057], [0058] & WO 2005/100625 A1	1-7
Y	JP 2002-266052 A (Kawasaki Steel Corp.), 18 September, 2002 (18.09.02), Claims; Par. Nos. [0001], [0019], [0027] (Family: none)	1-7
A	JP 7-34196 A (Sumitomo Metal Industries, Ltd.), 03 February, 1995 (03.02.95), Claims; Par. Nos. [0001], [0024] (Family: none)	1-7

☒ 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	"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
"E"	earlier application or patent but published on or after the international filing date	"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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"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 09 March, 2007 (09.03.07)	Date of mailing of the international search report 20 March, 2007 (20.03.07)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/050735

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2002-12940 A (NKK Corp.), 15 January, 2002 (15.01.02), Claims; Par. Nos. [0001], [0025], [0043] (Family: none)	1-7
A	JP 2002-332537 A (Kawasaki Steel Corp.), 22 November, 2002 (22.11.02), Claims; Par. Nos. [0001], [0020] to [0028] (Family: none)	1-7
A	JP 54-131522 A (Nippon Steel Corp.), 12 October, 1979 (12.10.79), Claims; page 2, upper right column, lines 10 to 18 (Family: none)	1-7

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

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- JP 2003082435 A **[0008]**
- JP 2004204344 A **[0008]**