WEATHER-RESISTANT HOT-ROLLED STEEL SHEET SUPERIOR HIGH-STRENGTH, AND MANUFACTURING METHOD

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Abstract
There are provided a high-strength hot-rolled steel sheet having excellent weather resistance used for containers and a method of manufacturing the same. A high-strength hot-rolled steel sheet having excellent weather resistance includes, by weight: C: 0.05 to 0.07%, Mn: 2.5% or less, Nb: 0.04 to 0.06%, Ti: 0.08 to 0.10%, Cu: 0.30 to 0.60%, Cr: 0.5 to 1.0%, and Ni: 0.15 to 0.30%, and the balance of Fe and other inevitable impurities. A method of manufacturing the hot-rolled steel sheet is also provided. A hot-rolled steel sheet provided has weather resistance by addition of Cu, Cr, and Ni and material characteristics of a tensile strength within the range of 800 to 900 MPa and a yield strength within the range of 700 to 800 MPa.
WEATHER-RESISTANT HOT-ROLLED STEEL SHEET SUPERIOR HIGH-STRENGTH, AND MANUFACTURING METHOD

TECHNICAL FIELD

[0001] The present invention relates to a high-strength hot-rolled steel sheet with excellent weather resistance used for a container and a method of manufacturing the same, and more particularly, to a hot-rolled steel sheet that maintains weather resistant characteristics and realizes high-strength characteristics, and a method of manufacturing the same.

BACKGROUND ART

[0002] Containers are used to transport contents at short and long distances. Recently, the function of steels has been reinforced to reduce transportation costs or increase life spans of containers. To this end, the weight of the containers has been reduced. In order to reduce the thickness of applied steels, the strength of the steels is increased and a weather-resistant function is required for long-term preservation.

[0003] In the past, aluminum was used to manufacture containers, but steels are now used due to low manufacturing costs. In particular, for the large-sized containers the strength of structural materials becomes an important factor. Therefore, there is an increasing need for high-strength products. Containers having a length of 6 m are manufactured as a base unit. However, in order to reduce transportation costs, the size of containers has gradually increased. Recently, large-sized containers having a length of 13 m or more are developed and manufactured. In the U.S., containers are used for transcontinental transportation, and thus, this trend of large-sized containers will increase. That is, large-sized containers are manufactured to reduce transportation costs. However, since the large-sized containers need to be structurally stabilized, high-strength steels are inevitably required. As a result, the conventional container having a length of 6 m has a strength of 500 MPa, while steel used to manufacture a container having a length of 13 m or more needs to have a strength of 800 MPa. At this time, weather resistance that prevents generation of rust at the surface of steel at the atmosphere needs to be maintained at the existing level. Therefore, there is a need for the development of steels that satisfy strength and weather resistance at the same time.

[0004] Since the containers are manufactured by bending process, the steels need to have appropriate workability. Further, the steels need to have impact strength having a predetermined level or more to prevent breakage during transportation of the containers. In addition, since the steels are welded to form container structures, the steels need to have sufficient weldability. Therefore, in order to develop high-strength materials, these characteristics need to be satisfied. That is, the above characteristics as well as an increase in strength need to be satisfied.

[0005] Metallurgical strengthening mechanisms for improving the strength of steels may include solid solution strengthening, precipitation strengthening, deformation strengthening, and transformation strengthening. The strengthening mechanisms are set in consideration of a chemical composition of steel and manufacturing conditions to satisfy characteristics according to the purpose of steels.

[0006] First, in a case of solid-solution strengthening, elements, such as carbon (C) and manganese (Mn) of a chemical composition of steel, are dissolved into a solid-solution in steel. In general, when the amount of these elements increases, the strength increases.

[0007] In a case of precipitation strengthening, strengthening is performed by precipitating basic elements and elements, such as carbon or nitrogen in steel, in singular or composite forms. The kind, size, and distribution of precipitates affect the increase in strength of steel. In general, niobium (Nb), titanium (Ti), vanadium (V), and molybdenum (Mo) are representative precipitation elements.

[0008] In a case of deformation strengthening, steels are physically deformed to accumulate energy therein. Without deformation, the strength does not increase. Further, in a case of transformation strengthening, a fine structure of steel is changed to perform the strengthening. The fine structure of the steel is transformed into a martensite or bainite structure to increase the strength of the steel.

[0009] Since high-strength steel materials are used as the steels used for containers to improve structural stiffness of the containers, yield strength as well as tensile strength is important. The stiffness of the container indicates resistance with respect to de-formation caused by its own weight or bending occurring when loading, and resistance with respect to the deformation of the containers when goods are contained. Therefore, the stiffness of the container can be considered as an important feature.

[0010] The yield strength affects the structural stiffness of the container. When processed into the same shape, containers having higher yield strength have higher stiffness. Therefore, preferably, among the above-described strengthening mechanisms, the solid-solution strengthening and the precipitation strengthening are used at the same time to satisfy the characteristics. That is, when the tensile strength increases by the solid-solution strengthening and the yield strength increases by the precipitation strengthening, the stiffness of the container structure can be satisfied.

DISCLOSURE OF INVENTION

Technical Problem

[0011] An aspect of the present invention provides a hot-rolled steel sheet that has weather resistance and characteristics of high-strength-steel with high tensile strength and high yield strength, and further provides a weather resistant hot-rolled steel sheet that satisfies a characteristic of no breakage occurring when the steel sheet is bent.

Technical Solution

[0012] According to an aspect of the present invention, there is provided a weather-resistant hot rolled steel sheet superior high-strength, including, by weight: C: 0.05 to 0.07%, Mn: 2.5% or less, Nb: 0.04 to 0.06%, Ti: 0.08 to 0.10%, Cu: 0.30 to 0.60%, Cr: 0.5 to 1.0%, and Ni: 0.15 to 0.30%, and the balance of Fe and other inevitable impurities.

[0013] A fine structure of the steel may include acicular ferrite. The steel may have material characteristics of a tensile strength within the range of 800 to 900 MPa and an yield strength within the range of 700 to 800 MPa.

[0014] According to another aspect of the present invention, there is provided a method of manufacturing a weather-resistant hot rolled steel sheet superior high-strength, method including: hot rolling steel including, by weight: C: 0.05 to 0.07%, Mn: 2.5% or less, Nb: 0.04 to 0.06%, Ti: 0.08 to 0.10%, Cu: 0.30 to 0.60%, Cr: 0.5 to 1.0%, and Ni: 0.15 to
0.30%, and the balance of Fe and other inevitable, and coiling the hot-rolled steel at the temperature within the range of 580 to 600°C.

Advantageous Effects

[0015] Recently, as steels used to manufacture containers, high-strength steel materials have been widely used to reduce the thickness of the materials. As large-sized containers are manufactured to reduce transportation costs, there is an increasing need for a technique to obtain high strength. The invention relates to a technique that improves strength of materials used in order to cope with a change in container manufacturing industries. When compared with materials having a tensile strength of 500 MPa and an yield strength of 350 MPa in the related art, a reduction in weight and an increase in size of containers can be obtained by using steel materials having a tensile strength of 800 MPa and an yield strength of 700 MPa, and the steel materials may be used for various purposes.

BEST MODE FOR CARRYING OUT THE INVENTION

[0016] Hereinafter, the invention will be described in detail.

[0017] In an embodiment of the invention, in order to increase the strength of steel materials, according to metallurgical characteristics, solid-solution strengthening and precipitation strengthening, which are strengthening mechanisms of steel, are used at the same time. The solid-solution strengthening is that the amounts of carbon and manganese in steel are appropriately controlled. The precipitation strengthening is that the contents of niobium and titanium are controlled. Further, the weather resistance prevents corrosion by adding copper (Cu) and chrome (Cr) and forming a dense oxide layer having anti-corrosion when the surface of steel is exposed to the atmosphere for a long period of time. Further, a fine structure of the steel having such composition is controlled to realize high-strength characteristics.

[0018] Strengthening mechanisms of steel may include the above-described methods. Characteristics vary according to the strengthening methods. First, when solid-solution strengthening is only used, the tensile strength is high but the yield strength is relatively low. Solid-solution elements contribute to an increase in tensile strength. However, an increase in yield strength by the solid-solution elements is limited. That is, since an yield ratio, which is a ratio between yield strength and tensile strength, is 80% or less, even though the tensile strength is approximately 800 MPa, the yield strength becomes approximately 640 MPa. Therefore, it can be seen that it is difficult to expect an increase in stiffness that is required for steel materials for containers. In a case of steels in the related art, the above-described solid-solution strengthening effect is used to increase the tensile strength. In the embodiment of the invention, preferably, since steel materials are used for containers, the high yield strength is required. Further, in order to increase the yield strength, the precipitation strengthening mechanism is used together with the solid-solution strengthening mechanism. That is, on the basis of the metallurgical background, the tensile strength is increased by the solid-solution strengthening, and the yield strength is additionally increased by the precipitation strengthening.

[0019] In this embodiment of the invention, for solid-solution strengthening, the amounts of carbon and manganese in steel are relatively increased to obtain high tensile strength. Further, a strengthening mechanism that adds special elements, such as niobium and titanium, to steel to form fine precipitates and allows the formed precipitates to increase resistance against initial deformation is used to increase the yield strength. According to an embodiment of the invention, material characteristics of a tensile strength within the range of 800 to 900 MPa, and an yield strength within the range of 700 to 800 MPa are obtained.

[0020] In the embodiment of the invention, for the solid-solution strengthening, the Mn content is in the range up to 2.5% weight % (hereinafter, simply indicated as %). More preferably, the Mn content is within the range of 2.0 to 2.5%. Preferably, the amount of carbon of 0.05% or more is added to sufficiently promote precipitation with the special elements.

[0021] Meanwhile, niobium and titanium are added as precipitation elements. The elements are added instead of molybdenum and vanadium, which are other precipitation strengthening elements. Niobium and titanium are metallurgically similar with molybdenum and vanadium in terms of precipitation behavior during hot rolling and increase the yield strength. However, when compared with molybdenum and vanadium, ferroalloys of niobium and titanium are cheap, which reduces manufacturing costs. Therefore, in the embodiment of the invention, a technique that adds niobium and titanium is used. According to an embodiment of the invention, when niobium and titanium are added, cooling temperature preferably optimized during hot rolling so that niobium and titanium can cause the maximum strengthening effect.

[0022] Therefore, according to the embodiment of the invention, as compared with weather resistance in the related art, the strengthening mechanism that increases the Mn content in steel by 2.5% to increase the tensile strength by solid-solution strengthening, and the strengthening mechanism that adds niobium and titanium to increases the yield strength by precipitation strengthening are used at the same time. Further, according to an embodiment of the invention, a fine structure of steel contains acicular ferrite to ensure strength.

[0023] Components of a hot rolled steel sheet according to the invention will now be described in detail.

[0024] Preferably, the C content is within the range of 0.05 to 0.07%.

[0025] C in steel is an element that is expected to show a solid-solution strengthening effect. As the C content increases, the tensile strength increases. Further, since the strengthening effect of fine precipitates formed by combining C with precipitation elements is used, C is added so that precipitation can be promoted and strength is ensured. For this reason, it is preferable that the C content be 0.05% or more. However, when the C content is excessive, the strength is excessively improved, which makes it difficult to control the shape of coils in a manufacturing process. For this reason, preferably, the C content is 0.07% or less. The Mn content is 2.5% or less, and more preferably, the Mn content is within the range of 2.0 to 2.5%.

[0026] Mn in steel is an element that is expected to show a solid-solution strengthening effect. As the Mn content increases, the tensile strength increases. For this reason, preferably, the Mn content is in the range up to 2.5%. Due to an increase in amount of manganese alloys, the price increases. The amount of ferroalloys injected increases during a steel-making process to cause a decrease in temperature, which makes it difficult to control the temperature necessary for continuous casting. For this reason, preferably, the Mn con-
tent is in the range up to 2.5%. Mn within an appropriate range is added to ensure target strength and not to cause a problem during a manufacturing process. More particularly, the Mn content is within the range of 2.0 to 2.5%, which is the optimum composition range for realizing the high strength. [0027] Preferably, the Nb content is within the range of 0.04 to 0.06%, and the Ti content is within the range of 0.08 to 0.1%.

[0028] Nb and Ti are representative precipitation elements that are added to improve strength. Nb and Ti dissolve and precipitate during hot rolling and finally form fine precipitates to thereby increase the yield strength. These elements are re-dissolved into solid-solution state at high temperature when re-heating a slab during hot rolling. During rolling, the temperature decreases, the elements precipitate again at relatively high temperature. Finally, in a coiling process, the remaining amounts of the elements in solid solution finally precipitate during the coiling process. The precipitates are so fine that they increase the yield strength during a process of deforming of steel materials, such as a tension test. Therefore, in order to increase the yield strength, a large amount of the fine precipitates is required. In general, when the precipitates are small and evenly distributed, the yield strength increases to the maximum value. In the embodiment of the invention, the content of niobium added is within the range of 0.04 to 0.06%, and the content of titanium is within the range of 0.08 to 0.11%. Since the content of carbon is sufficient, it is easy to combine with Nb and Ti. Further, Nb and Ti are within the range where the strength increases by precipitation.

[0029] Preferably, the Cu content is within the range of 0.3 to 0.6%, and the Cr content is within the range of 0.5 to 1.0%.

[0030] Cu and Cr are components that ensure weather resistance. Weather-resistant steel materials capable of reducing a corrosion speed at the atmosphere have characteristic by a different mechanism from mechanisms for the strength. In order to ensure weather resistance, the surface of the steel sheet needs to have characteristics with respect to corrosion. It is very important to form an oxide layer that prevents oxygen penetration. The dense oxide layer is obtained by adding anti-corrosion elements. Examples of anti-corrosion elements may include Cu and Cr. These elements are diffused into an oxide layer on Fe that is naturally formed when the steel sheet is at the atmosphere, and are substituted with Fe to thereby form the oxide layer on Fe that contains Cu and Cr. The oxide layer is amorphous, and thus very dense to prevent oxygen penetration. As a result, weather resistance is obtained. In the embodiment of the invention, in consideration of weather-resistant characteristics of Cu and Cr, the Cu content is within the range of 0.3 to 0.6%, and the Cr content is within the range of 0.5 to 1.0%.

[0031] Preferably, the Ni content is within the range of 0.15 to 0.3%.

[0032] Ni has anti-corrosion. However, Ni is used to prevent surface defects, such as scab defects generated when copper exists at the grain boundary during a process of manufacturing steel added with Cu, rather than to contribute to the formation of the oxide layer. In consideration of the above characteristics of Ni, in the embodiment of the invention, preferably, the Ni content is within the range of 0.15 to 0.30%.

[0033] Other components may be added to high-strength steel with weather resistance having the above-described composition. One of them may be Si. Si is known to be effective in solid-solution strengthening. However, when an excessive amount of Si is added, a red oxide layer is formed due to surface oxidization of silicon during a rolling process at high temperature. Therefore, when silicon (Si) is added, Si is preferably within the range of 0.25% or less. Meanwhile, phosphorous (P) and sulphur (S) in steel are known to be inevitably contained. P reinforces anti-corrosion and shows embrittlement at low temperature during rolling. Therefore, preferably, P is added as little as possible. S affects toughness. Since inventive steel is used for containers, toughness is required. Since the toughness is required at low temperature, S is preferably reduced to the minimum value. In the embodiment of the invention, the P content and the S content are 0.015% or less and 0.003% or less, respectively, which are smaller values than those of conventional steels.

[0034] As described above, a fine structure of steel that satisfies the above components has acicular ferrite while preventing the formation of martensite, so that the strength is increased by the fine structure.

[0035] According to an embodiment of the invention, inventive steel that satisfies the above components has characteristics of a tensile strength within the range of 800 to 900 MPa and an yield strength within the range of 700 to 800 MPa. Further, an yield ratio (yield strength/tensile strength) is 80% or more.

[0036] A method of manufacturing a hot rolled steel sheet according to an embodiment of the invention will now be described.

[0037] According to the embodiment of the invention, the steel having the above composition is manufactured by hot-rolled steel sheets. A hot-rolled steel sheet is manufactured according to a general method, but a coiling condition is particularly considered in consideration of the final material properties as well as the shape of coils during manufacturing process. Therefore, additional conditions of hot rolling except for a heating condition and cooling temperature are not limited, but general conditions are applied.

[0038] As described above, preferably, the coiling temperature is set so that elements that do not precipitate during hot rolling can additionally precipitate. At the same time, the coiling temperature is set to satisfy the shape. Meanwhile, the coiling temperature is an important factor for controlling the grain size. In a case of high-strength steel materials like the embodiment of the invention, the coiling temperature is set so that the growth of the grain is prevented as much as possible. When the coiling temperature is too high, the grain may excessively grow due to latent heat of the coil, which softens the material. When the coiling temperature is too low, a big difference is made between the finishing temperature and the cooling temperature. Here, the cooling speed increases to cause a change in structure. In general, a structure containing martensite is formed at high cooling speed. Since this structure has high tensile strength but low yield strength, it becomes difficult to ensure target material. Therefore, in the embodiment of the invention, the coiling temperature is within the range of 550 to 600°C, so that the formation of precipitates is promoted and the fine structure is maintained. On the other hand, the cooling temperature is set so that a change in structure due to quick cooling does not occur to thereby obtain the yield strength. As described above, the fine structure obtained after hot rolling has acicular ferrite while preventing the formation of martensite to thereby increase the strength by the fine structure.
MODE FOR THE INVENTION

Hereinafter, the present invention will be described in more detail by way of an Example.

Example

Hot rolled steel sheets are manufactured by hot rolling steels, shown in Table 1, under the conditions of Table 2. Mechanical properties and workability of the hot-rolled steel sheets are evaluated, and results of the evaluation are shown in Table 2.

### TABLE 1

<table>
<thead>
<tr>
<th>Chemical components (weight %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>A1</td>
</tr>
<tr>
<td>A2</td>
</tr>
<tr>
<td>B1</td>
</tr>
<tr>
<td>B2</td>
</tr>
<tr>
<td>B3</td>
</tr>
<tr>
<td>B4</td>
</tr>
<tr>
<td>C1</td>
</tr>
<tr>
<td>C2</td>
</tr>
<tr>
<td>C3</td>
</tr>
<tr>
<td>C4</td>
</tr>
<tr>
<td>C5</td>
</tr>
<tr>
<td>C6</td>
</tr>
<tr>
<td>C7</td>
</tr>
</tbody>
</table>

### TABLE 2

<table>
<thead>
<tr>
<th>Hot rolling conditions</th>
<th>Tensile characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finish temperature (°C)</td>
<td>Coiling temperature (°C)</td>
</tr>
<tr>
<td>A1</td>
<td>870</td>
</tr>
<tr>
<td>A2</td>
<td>865</td>
</tr>
<tr>
<td>B1</td>
<td>871</td>
</tr>
<tr>
<td>B2</td>
<td>864</td>
</tr>
<tr>
<td>B3</td>
<td>862</td>
</tr>
<tr>
<td>B4</td>
<td>855</td>
</tr>
<tr>
<td>C1</td>
<td>867</td>
</tr>
<tr>
<td>C2</td>
<td>871</td>
</tr>
<tr>
<td>C3</td>
<td>854</td>
</tr>
<tr>
<td>C4</td>
<td>867</td>
</tr>
<tr>
<td>C5</td>
<td>855</td>
</tr>
<tr>
<td>C6</td>
<td>863</td>
</tr>
<tr>
<td>C7</td>
<td>869</td>
</tr>
</tbody>
</table>

In Table 1, A1 is steel used for containers. A1 has a chemical composition that contains molybdenum, different from niobium and titanium, which are precipitation strengthening elements, used in the invention. However, a ferrous alloy of molybdenum is more expensive than that of niobium. Therefore, even though molybdenum has the same characteristics as niobium, molybdenum is not economical. In Table 2, A1 has a tensile strength of 800 MPa or more but an yield strength of 700 MPa or less.

When it comes to components added, A2 is similar with the inventive steel except for the contents of the components. A2, however, does not contain copper, chrome, and nickel, nor show weather-resistant characteristics. Even though these elements are used to ensure anti-corrosion, and do not directly affect the material of the steel, steels that have recently been applied to containers need to be weather resistant. Therefore, in terms of characteristics, A2 is very different from high-strength steels with weather resistance that is an object of the invention. In Table 2, A2 approaches the lowest in terms of the material. Since A2 does not have weather resistance due to exclusion of Cu, Ni, and Cr, A2 is very different from the steels according to the embodiment of the invention in terms of the purpose.

Meanwhile, in Table 1, B1 to B4 are steels that contain carbon within the range of 0.05 to 0.07% and manganese within the range of 2.0 to 2.5%, which are solid-solution strengthening elements, niobium within the range of 0.04 to 0.06% and titanium within the range of 0.08 to 0.10%, which are precipitation strengthening elements, and copper within the range of 0.30 to 0.60%, chrome within the range of 0.5 to 1.0%, and nickel within the range of 0.15 to 0.3%, which are weather resistant elements. B1 to B4 are different from the steels in the related art in that niobium is added instead of molybdenum added in the steel in the related art and a fine structure is obtained by temperature control during a process. The coiling temperature during hot rolling is within the range of 580 to 600°C. Referring to tensile characteristics shown in Table 2, tensile strength is 800 MPa or more, specifically, within the range of 850 to 880 MPa, and yield strength is 700 MPa or more, specifically within the range of 720 to 753 MPa, which exhibit high-strength characteristics. As described above, the high-strength characteristics can be obtained by appropriately controlling the contents of carbon and manganese, which are solid-solution elements, and niobium and titanium, which are precipitation elements. Further, the high-strength characteristics can be obtained by a fine acicular ferrite structure by controlling the coiling temperature during hot rolling. Therefore, according to an embodiment of the invention, the high-strength characteristics are obtained when the chemical composition and process factors of the steel are satisfied at the same time.

A description of C1 to C7 steels will now be described.

C1 is steel that has lower contents of carbon and manganese and a lower content of titanium than those of the inventive steel. C1 has lower tensile strength and yield strength than the inventive steel. C2 is steel that has a chemical composition in which manganese, the solid-solution element, is relatively high, that is, 2.6%, and niobium, the pre-
precipitation element, is slightly low. C1 has tensile strength almost the same as 800 MPa but low yield strength. C3 and C4 are steels that have relatively high contents of carbon and manganese, which are solid-solution elements, and a relatively low content of niobium, which is a precipitation element. Each of the steels C3 and C4 has sufficiently high tensile strength but low yield strength. C5 has low contents of carbon and manganese but high contents of niobium and titanium. C5 has increased yield strength but does not have high tensile strength. Therefore, when the strength increases by precipitation, yield strength increases rather than tensile strength, but when the strength increases by solid solution, tensile strength increases rather than yield strength. That is, there is a metallurgical characteristic that precipitation strengthening and solid-solution strengthening need to be appropriately used to ensure yield strength and tensile strength at the same time in the invention. C6 that shows the effect of process conditions has increased tensile strength but decreased yield strength when the cooling temperature is approximately 550°C, that is lower than 580 to 600°C during hot rolling. Similarly, C7 shows similar characteristics. It may be considered that when the cooling process is performed at predetermined temperature or less, a change in structure, that is, transformation, is involved due to an increase in cooling speed after rolling. In the example, from the facts that the yield strength decreases, it can be seen that the tensile strength increases, and the elongation increases, ferrite is transformed into martensite due to excessive cooling. As a result, high yield strength and high tensile strength cannot be achieved. This means that the structure is controlled by appropriately setting the cooling temperature during hot rolling to obtain desired levels of yield strength and tensile strength.

The reason for limiting the Claims of the invention will be described in detail by the above-described Example.

According to an embodiment of the invention, the inventive steel has characteristics of a tensile strength within the range of 800 to 900 MPa and an yield strength within the range of 700 to 800 MPa, and weather resistance. Therefore, the inventive steel can be applied to a structure when manufacturing a large-sized container. Strengthening mechanisms of steel include solid-solution strengthening and precipitation strengthening, in which components are appropriately controlled to maximize the strength increasing effect, and fine acicular ferrite formed by appropriately controlling the cooling temperature during hot rolling.

The carbon, Mn, steel is a basic solid-solution element that strengthens steel. As the C content increases, strength increases. In the inventive steel, as shown in the Example, when the C content is less than 0.05%, it is difficult to obtain sufficient tensile strength. When the C content exceeds 0.07%, carbon affects phase transformation of steel rather than contributes to precipitation by hot rolling. Strengthening that is performed by martensite transformation instead of acicular ferrite desired to be obtained in the invention results in steel materials having high tensile strength but low yield strength. Therefore, preferably, the C content in steel is limited to the range of 0.05 to 0.07%. Like the carbon, manganese in steel is a solid-solution strengthening element. In the embodiment of the invention, when the Mn content in steel is less than 2.0%, like C1, tensile strength is low. When the Mn content is 2.5% or more, steelmaking costs increase due to an increase in ferroalloy and the amount in ferroalloy injected increases to reduce the temperature of molten steel. Like carbon, Mn promotes transformation into martensite instead of ferrite, which reduces yield strength. Therefore, preferably, the Mn content is in the range up to 2.5%. Meanwhile, as shown in the results of C2, C3, and C4, when the content of niobium added to promote formation of precipitates in order to increase the yield strength is less than 0.04%, precipitates are not sufficiently formed due to the very low content of niobium. It is known that when the Nb content is generally in the range up to 0.06%, the strengthening effect using precipitates is the highest. When the Nb content exceeds 0.06%, any additional effect is not obtained. For this reason, preferably, the Nb content is limited to 0.06%. In the same manner, titanium is expected to additionally ensure the precipitation strengthening of niobium. In general, precipitates are formed when niobium and titanium are combined with each other, and carbon and nitrogen are additionally combined thereto. Therefore, titanium also contributes to precipitation of niobium. Niobium and titanium promote precipitation with respect to each other. Therefore, steel formed using precipitation strengthening is manufactured by a technique that adds niobium and titanium at the same time. As shown in C3, when the contents of these elements are low, the yield strength decreases. In the embodiment of the invention, when the Ti content is less than 0.07%, the yield strength is 700 MPa or less, which is much lower than a target value. When the Ti content is in the range up to 0.10%, targeted material characteristics are shown. Therefore, preferably, the Ti content is within the range of 0.08 to 0.10%.

As described above, the chemical composition to obtain weather-resistant characteristics basically contains copper, chrome, and nickel. Among them, the copper and chrome contribute to weather resistance, and the nickel is added to prevent surface defects caused by the addition of the copper in the process.

The steel that is provided according to the embodiment of the invention is high-strength steel that has a tensile strength within the range of 800 to 900 MPa and an yield strength of 700 to 800 MPa. The steel can be usefully applied as steel materials for containers. That is, the strength of structural (corners, the ends, and the like) steels is increased to reduce the material thickness, so that the weight of containers can be reduced and structural stiffness of the containers can be improved. In general, the thickness of steels used as structural materials for containers is within the range of 4.0 to 6.0 mm. When high-strength steels having the same thickness are used, it is possible to easily ensure structural stability and an increase in the stiffness by large-sized containers. When the same stiffness is ensured, the thickness of steels can be reduced, which may reduce manufacturing costs. Further, a hot-rolled steel sheet provided according to the embodiment of the invention satisfies other characteristics required for steels of containers, such as impact strength and no breakage when the steel sheet is bent.

While the present invention has been shown and described in connection with the exemplary embodiments, it will be apparent to those skilled in the art that modifications and variations can be made without departing from the spirit and scope of the invention as defined by the appended claims. The tensile strength within the range of 800 to 900 MPa and the yield strength within the range of 700 to 800 MPa are the optimum result in the embodiment of the invention. On the basis of the mechanical characteristics, the results of implementation are analyzed and the description is made. In the
present invention, components in which the tensile strength and the yield strength do not fall within the above-described optimum conditions in the embodiment of the invention are also analyzed.

1-7. (canceled)

8. A high-strength hot-rolled steel sheet having excellent weather resistance, comprising, by weight: C: 0.05 to 0.07%, Mn: 2.5% or less, Nb: 0.04 to 0.06%, Ti: 0.08 to 0.10%, Cu: 0.30 to 0.60%, Cr: 0.5 to 1.0%, and Ni: 0.15 to 0.30%, and the balance of Fe and other inevitable impurities.

9. The high-strength hot-rolled steel sheet having excellent weather resistance according to claim 8, the Mn content is within the range of 2.0 to 2.5%.

10. The high-strength hot-rolled steel sheet having excellent weather resistance according to claim 8, wherein the steel comprises acicular ferrite.

11. The high-strength hot-rolled steel sheet having excellent weather resistance according to claim 8, wherein the steel has material characteristics of a tensile strength within the range of 800 to 900 MPa and an yield strength within the range of 700 to 800 MPa.

12. The high-strength hot-rolled steel sheet having excellent weather resistance of claim 11, wherein the steel has an yield ratio (yield strength/tensile strength) of 80% or more.

13. A method of manufacturing a high-strength hot-rolled steel sheet having excellent weather resistance, method comprising:

hot rolling steel including, by weight: C: 0.05 to 0.07%, Mn: 2.5% or less, Nb: 0.04 to 0.06%, Ti: 0.08 to 0.10%, Cu: 0.30 to 0.60%, Cr: 0.5 to 1.0%, and Ni: 0.15 to 0.30%, and the balance of Fe and other inevitable impurities, and coiling the hot-rolled steel at the temperature within the range of 580 to 600°C.

14. The method of claim 13, wherein the Mn content is within the range of 2.0 to 2.5%.

15. The high-strength hot-rolled steel sheet having excellent weather resistance according to claim 9, wherein the steel has material characteristics of a tensile strength within the range of 800 to 900 MPa and an yield strength within the range of 700 to 800 MPa.

16. The high-strength hot-rolled steel sheet having excellent weather resistance according to claim 10, wherein the steel has material characteristics of a tensile strength within the range of 800 to 900 MPa and an yield strength within the range of 700 to 800 MPa.

17. The high-strength hot-rolled steel sheet having excellent weather resistance of claim 15, wherein the steel has an yield ratio (yield strength/tensile strength) of 80% or more.

18. The high-strength hot-rolled steel sheet having excellent weather resistance of claim 16, wherein the steel has an yield ratio (yield strength/tensile strength) of 80% or more.

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