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(54) COLD-ROLLED STEEL SHEET WITH EXCELLENT WELDABILITY AND METHOD FOR MANUFACTURING SAME

(57) The present invention relates to a cold-rolled steel sheet and a method for manufacturing same. A cold-rolled steel sheet according to one embodiment comprises, in weight%, 0.01~0.05% of carbon (C), 0.6~1.2% of manganese (Mn), 0.05% or less (excluding 0%) of silicon (Si), 0.0005~0.01% of phosphorus (P), 0.008% or less (excluding 0%) of sulfur (S), 0.0005~0.015% of aluminum (Al), 0.0005-0.003% of nitrogen (N), 0.1~0.4% of tungsten (W), 1.0~2.0% of chromium (Cr), 0.05~0.15% of zirconium (Zr), and the remainder of Fe and inevitable impurities, wherein the yield strength of a welding member may be 500 MPa or more.

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Description

[Technical Field]

[0001] The present invention relates to a steel sheet, and more particularly, to a cold-rolled steel sheet with excellent weldability and a method for manufacturing the same.

[Background Art]

[0002] In general, a welding method with the highest welding productivity and ease of welding in various positions is a flux cored welding (FCW) method. The welding material used in the FCW method is a flux cored wire, and a strip drawn using a cold-rolled steel sheet for welding rods is processed into a U shape, and a flux is added to the processed strip. The flux is added by mixing a flux component containing an oxidizing agent to ensure weldability with various alloy elements in the form of high-purity powder according to the purpose to improve the use properties of the welding rod, and then processed into an O shape to be manufactured into a welding wire. As such, the flux component is added to ensure welding workability, and the alloy elements are added to secure properties suitable for the use of the welding rod.

[0003] At this time, various properties required for a welding rod material are secured through changes in the type and amount of alloy elements in the core to be added in the form of high-purity powder. For example, in order to produce a welding member required with excellent low-temperature toughness, a mixture of alloying elements and a flux needs to be charged to a core of the processed wire to improve low-temperature toughness.

[0004] In addition, as cold-rolled steel for the wire used to manufacture the flux cored wire, low-carbon steel is used, and stainless steel is used for some special purposes. Since the cold-rolled steel for the low-carbon steel-based welding rod is low-alloy steel, it is necessary to add a large amount of alloying elements to the core in order to secure the properties of the welding rod according to a use environment of the welding rod. However, in the case of the material used in the welding rod, it is necessary to add an appropriate level of flux to ensure welding workability, so that there is a problem in that there is a limitation in adding a desired amount of alloy elements in the core. Specifically, a large amount of oxidizing agent, a slag former, an arc stabilizer, and an alloying component need to all be added to the center of the steel for the welding rod, but there is a limit to unilaterally fill the wire steel with about 30 to 60% of the volume including flux. Therefore, there is a difference depending on the alloy element to be filled, but there is a limit in terms of weight% of about 15 to 25%.

[0005] In this case, if the amount of alloy elements added is increased to secure the use characteristics of the welding rod, the flux component is limited, making it difficult to secure stable welding properties. In addition, since these alloy elements need to be added in the form of high-purity powder, there are problems that not only the manufacturing cost of the welding rod is increased, but also as the proportion of most alloy elements to be added increases, the molten adding components during welding work cause segregation in a weld zone to act as a factor in welding defects.

[0006] In the case of stainless steel for the welding wire, since the amount of nickel (Ni) alloy element present in the carbon steel component is fundamentally higher than that of general carbon steel, the amount of core alloy elements added with the flux may be reduced to a certain extent, but there is a problem that the stainless steel for the welding wire as high alloy steel has the high price of the raw material to be only applied for special purposes. In addition, in the case of the stainless steel-based welding rod steel, since disconnection often occurs due to work hardening during the processing of the welding rod wire, it is necessary to solve the problem of increased manufacturing costs due to additional processing such as requiring separate annealing to be performed.

[0007] Therefore, there has been commonly used a method in which as cold-rolled steel for a welding wire that currently requires processability, specifically drawing processability, strength, and toughness, low-carbon steel is pipe-formed and then expensive alloy elements are prepared in the form of high-purity powder to secure strength and low-temperature toughness when the flux is charged and added together with flux components. As described above, since the alloy powder added to secure properties is not only expensive due to high purity, but also high in added amount, there is also a problem that there is a limitation on the addition conditions of flux components to ensure welding stability.

[0008] In addition, there is a problem that the expensive alloy elements added cause segregation within the flux, thereby deteriorating welding workability. For example, as a method for manufacturing a steel sheet for the flux cored wire, a method of manufacturing steel for the welding rod with excellent impact toughness and strength properties was attempted by adding components such as titanium (Ti). However, the method has a problem in that as a large amount of expensive alloy elements is added, there is a problem of increased cost and difficulty in securing drawing toughness due to the low ductility of the steel.

[0009] In addition, a technology has been proposed to reduce welding defects by promoting a deoxidation reaction of molten metal by adding raw materials such as titanium (Ti) and magnesium (Mg) to the flux raw material. However, in order to sufficiently achieve the deoxidation effect of the molten metal, it is necessary to add a large amount of alloying elements to the flux. However, when the large amount of alloying elements is added to the flux, there is a problem that a spatter phenomenon in which fine particles fly out during welding frequently occurs so that welding workability deteriorates.

[0010] Therefore, a weld zone with excellent strength and low-temperature toughness may be obtained in a cryogenic environment, and there is a need for the development of welded steel and a manufacturing method thereof using a cold-rolled steel sheet for flux-cored wire welding rods with excellent welding workability and drawing processability.

[Disclosure]

[Technical Problem]

[0011] The present disclosure attempts to provide a cold-rolled steel sheet for a flux cored wire welding rod capable of obtaining a weld zone with excellent strength and low-temperature toughness in a cryogenic environment and having excellent welding workability and drawability. The present disclosure also attempts to provide a method for manufacturing a cold-rolled steel sheet having the advantages.

[Technical Solution]

[0012] According to an exemplary embodiment of the present invention, a cold-rolled steel sheet may include, in weight%, 0.01~0.05% of carbon (C), 0.6~1.2% of manganese (Mn), 0.05% or less (excluding 0%) of silicon (Si), 0.0005~0.01% of phosphorus (P), 0.008% or less (excluding 0%) of sulfur (S), 0.0005~0.015% of aluminum (Al), 0.0005~0.003% of nitrogen (N), 0.1~0.4% of tungsten (W), 1.0~2.0% of chromium (Cr), 0.05~0.15% of zirconium (Zr), and the remainder of Fe and inevitable impurities, wherein the yield strength of a welding member may be 500 MPa or more.

[0013] In an exemplary embodiment, the cold-rolled steel sheet may satisfy a $FCW_{,A}$ value of 40 to 150 in Equation 1 below.

$$FCW_{,A} = (2.5 \times [Mn] + 1.8 \times [Cr] + 25 \times [Al]) \times (18 \times [W]) \times (45 \times [Zr])/(34 \times [C]) \quad \text{<Equation 1>}$$

(In Equation 1, [Mn], [Cr], [Al], [W], [Zr], and [C] represent the contents of Mn, Cr, Al, W, Zr, and C in weight%, respectively.)

[0014] In an exemplary embodiment, the cold-rolled steel sheet may include 1-7% of a texture fraction consisting of at least one of cementite and bainite in area%, and the remainder of ferrite. In an exemplary embodiment, the cold-rolled steel sheet may have the elongation of 35% or more. In an exemplary embodiment, the cold-rolled steel sheet may have a weld zone segregation index of less than 0.15%. In an exemplary embodiment, the cold-rolled steel sheet may have impact energy at - 40°C of 50 J or more.

[0015] According to another exemplary embodiment of the present invention, a method for manufacturing a cold-rolled steel sheet may include heating a steel slab including, in weight%, 0.01~0.05% of carbon (C), 0.6~1.2% of manganese (Mn), 0.05% or less (excluding 0%) of silicon (Si), 0.0005~0.01% of phosphorus (P), 0.008% or less (excluding 0%) of sulfur (S), 0.0005~0.015% of aluminum (Al), 0.0005-0.003% of nitrogen (N), 0.1-0.4% of tungsten (W), 1.0-2.0% of chromium (Cr), 0.05-0.15% of zirconium (Zr), and the remainder of Fe and inevitable impurities; hot-rolling the heated slab at a finish rolling temperature of 820 to 880°C; winding the hot-rolled steel sheet at 580 to 700°C; cold-rolling the wound hot-rolled steel sheet to 50 to 90%; and annealing the cold-rolled steel sheet in a temperature range of 700 to 850°C.

[0016] In an exemplary embodiment, the slab may satisfy a $FCW_{,A}$ value of 40 to 150 in Equation 1 below.

$$FCW_{,A} = (2.5 \times [Mn] + 1.8 \times [Cr] + 25 \times [Al]) \times (18 \times [W]) \times (45 \times [Zr])/(34 \times [C]) \quad \text{<Equation 1>}$$

(In Equation 1, [Mn], [Cr], [Al], [W], [Zr], and [C] represent the contents of Mn, Cr, Al, W, Zr, and C in weight%, respectively.)

[0017] In an exemplary embodiment, the heating of the steel slab may be performed at 1,180°C or more. In an exemplary embodiment, before the cold-rolling of the wound hot-rolled steel sheet, the hot-rolled steel sheet may be pickled. In an exemplary embodiment, the method may further include temper-rolling the annealed cold-rolled steel sheet after the annealing of the cold-rolled steel sheet.

[Advantageous Effects]

[0018] According to an exemplary embodiment of the present invention, it is possible to provide a cold-rolled steel sheet with excellent strength, excellent low-temperature toughness, and excellent welding workability and processability by controlling the contents of key elements such as manganese, chromium, aluminum, tungsten, zirconium, and carbon, and to provide a cold-rolled steel sheet for a weldable flux cored wire used in a variety of industrial fields such as the shipbuilding industry, materials industry, and construction industry.

[0019] According to another exemplary embodiment of the present invention, it is possible to provide a method for manufacturing a cold-rolled steel sheet having the advantages.

[Mode for Invention]

[0020] Terms such as first, second and third are used to describe various parts, components, regions, layers and/or sections, but are not limited thereto. These terms are only used to distinguish one part, component, region, layer or section from another part, component, region, layer or section. Accordingly, a first part, component, region, layer or section to be described below may be referred to as a second part, component, region, layer or section without departing from the scope of the present invention.

[0021] The terms used herein is for the purpose of describing specific exemplary embodiments only and are not intended to be limiting of the present invention. The singular forms used herein include plural forms as well, if the phrases do not clearly have the opposite meaning. The "comprising" used in the specification means that a specific feature, region, integer, step, operation, element and/or component is embodied and other specific features, regions, integers, steps, operations, elements, components, and/or groups are not excluded.

[0022] When a part is referred to as being "above" or "on" the other part, the part may be directly above or on the other part or may be followed by another part therebetween. In contrast, when a part is referred to as being "directly on" the other part, there is no intervening part therebetween.

[0023] Unless defined otherwise, all terms including technical and scientific terms used herein have the same meaning as commonly understood by those skilled in the art to which the present invention belongs. Commonly used predefined terms are further interpreted as having a meaning consistent with the relevant technical literature and the present invention, and are not to be construed as ideal or very formal meanings unless defined otherwise.

[0024] In addition, unless otherwise specified, % means weight%, and 1 ppm is 0.0001 weight%.

[0025] In an exemplary embodiment of the present invention, the meaning of further including an additional element means replacing and including iron (Fe), which is the remainder by an additional amount of an additional element.

[0026] The present invention will be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. As those skilled in the art would realize, the described embodiments may be modified in various different ways, all without departing from the spirit or scope of the present invention.

[0027] According to an exemplary embodiment of the present invention, a cold-rolled steel sheet may include, in weight%, 0.01~0.05% of carbon (C), 0.6~1.2% of manganese (Mn), 0.05% or less (excluding 0%) of silicon (Si), 0.0005~0.01% of phosphorus (P), 0.008% or less (excluding 0%) of sulfur (S), 0.0005~0.015% of aluminum (Al), 0.0005~0.003% of nitrogen (N), 0.1~0.4% of tungsten (W), 1.0~2.0% of chromium (Cr), 0.05~0.15% of zirconium (Zr), and the remainder of Fe and inevitable impurities.

[0028] The reason for limiting the alloy components will be described below. Hereinafter, wt% may be represented by %.

Carbon(C): 0.01-0.05 %

[0029] Carbon (C) is an element added to ensure the strength of steel and to ensure that a heat affected zone (HAZ) has similar mechanical properties to a base material during welding. The carbon content may be in the range of 0.01 to 0.05%, specifically, 0.012 to 0.048%.

[0030] When the carbon content is out of the upper limit of the range, there is a problem of disconnection due to high work hardening in a drawing process. In addition, not only low-temperature cracks occur at a weld joint and impact toughness deteriorates, but there is also a process problem in that additional heat treatment needs to be performed due to the high strength. If the carbon content is out of the lower limit of the range, there is a problem in that the effect of ensuring the strength of the steel and ensuring that the heat affected zone has mechanical properties similar to the base material during welding is not realized.

Manganese (Mn): 0.6~1.2%

[0031] Manganese (Mn) is a representative solid-solution strengthening element and an element for increasing the strength of steel and improving hot workability. The manganese content may be in the range of 0.6 to 1.2%, specifically 0.65 to 1.15%.

[0032] If the manganese content is out of the upper limit of the range, a large amount of manganese-sulfide (MnS) precipitate is formed, so that there is a problem of not only reducing the ductility and workability of the steel, but also acting as a factor in the occurrence of center segregation to cause disconnection during drawing work in the welding rod manufacturing process. If the manganese content is out of the lower limit of the range, the manganese content becomes a cause of red shortness and has difficulty in contributing to the stabilization of austenite.

Silicon (Si): 0.05% or less

[0033] Silicon (Si) is bound with a specific element such as oxygen to form an oxide layer on the surface of the steel sheet, which may deteriorate surface properties and act as a factor in reducing corrosion resistance, and reduce impact properties by promoting hard phase transformation within the weld metal. The silicon content may be in the range of 0.0005 to 0.0045%.

Phosphorus (P): 0.0005 to 0.010%

[0034] Phosphorus (P) is an element that exists as a solid solution element in steel and improves strength and hardness by causing the solid solution strengthening. The phosphorus content may be in the range of 0.0005 to 0.01%, specifically 0.0008 to 0.0095%.

[0035] If the phosphorus content is out of the upper limit of the range, there is a problem that center segregation occurs during casting and ductility is reduced, thereby reducing wire processability. If the phosphorus content is out of the lower limit of the range, it is difficult to maintain a certain level of rigidity.

Sulfur (S): 0.008 % or less

[0036] Sulfur (S) is bound with manganese (Mn) in steel to form a non-metallic inclusion and may cause red shortness. The content of sulfur (S) may be 0.008% or less, specifically in the range of 0.0004 to 0.0075%.

[0037] If the sulfur content is out of the upper limit of the range, there is a problem that a large amount of non-metallic inclusion is formed, and the red shortness worsens. In addition, there is a problem of lowering the toughness of the base material of the steel sheet.

Aluminum (Al): 0.0005 to 0.0150%

[0038] Aluminum (Al) is an element added to aluminum killed steel for the purpose of preventing mechanical-property deterioration due to carbonization and aging, and is an element advantageous in securing ductility within an appropriate range, and the above-mentioned effects occur significantly at an extremely low temperature. The aluminum content may be in the range of 0.0005 to 0.015%, specifically, 0.0006 to 0.0148%.

[0039] If the content is out of the upper limit, there is a problem in that not only surface inclusions such as aluminum-oxide (Al_2O_3) rapidly increase to deteriorate the surface properties of the rolled material and reduce processability, but also ferrite is formed locally at the grain boundaries in the heat affected zone of the weld to deteriorate the mechanical properties and degrade the shape of the weld bead even after welding. If the content is out of the lower limit, there is a problem in that the adhesion of oxygen may decrease and mechanical-property deterioration may occur due to aging.

Nitrogen (N): 0.0005 to 0.003%

[0040] Nitrogen (N) is an element that exists in a solid solution state inside steel and strongly causes mechanical property strengthening. The nitrogen content may be in the range of 0.0005 to 0.003%, specifically, 0.0008 to 0.0029%.

[0041] If the nitrogen content is out of the upper limit of the range, the aging property may deteriorate excessively, and the burden due to denitrification in the steel manufacturing stage may increase, thereby worsening steelmaking workability. If the nitrogen content is out of the lower limit of the range, it is difficult to secure the target rigidity.

Tungsten (W): 0.1 to 0.4%

[0042] Tungsten (W) is effective in improving strength, high-temperature properties, and drawing processability, and is an element for improving low-temperature impact properties by forming a stable structure even at an extremely low temperature. The tungsten content may be in the range of 0.1 to 0.4%, specifically, 0.12 to 0.39%.

[0043] If the tungsten content is out of the upper limit of the range, processability is reduced due to increased strength and there is a problem of causing surface defects. If the tungsten content is out of the lower limit of the range, there is a problem that it is difficult to exhibit the effects on the high-temperature properties and drawing processability, and there is a problem that a stable operation of the flux composition may be difficult.

Chromium (Cr): 1.0 to 2.0%

[0044] Chromium (Cr) is an element that is advantageous to the strength of the weld joint and an element that plays a role in forming a stable rust layer and contributes to improving corrosion resistance. The chromium content may be in the range of 1.0 to 2.0%, specifically 1.10 to 1.85%.

[0045] If the chromium content is out of the upper limit of the range, there is a problem that chromium-based carbides are formed to cause brittleness, and processing is not easy. If the chromium content is out of the lower limit of the range, there is a problem that it is difficult to exhibit the effects of improving the strength of the weld joint, forming a stable rust layer, and improving corrosion resistance achieved by adding chromium.

Zirconium (Zr): 0.05 to 0.15%

[0046] Zirconium (Zr) is an element that is not only advantageous in terms of securing low-temperature toughness of the weld zone through the formation of precipitates, but also greatly contributes to improving the workability of the welding material. The zirconium content may be in the range of 0.05 to 0.15%, specifically, 0.07 to 0.14%.

[0047] If the zirconium content is out of the upper limit of the range, there is a problem that not only the amount of zirconium precipitates increases to reduce processability, but also the operating characteristics deteriorate depending on an increased working temperature. If the zirconium content is out of the lower limit of the range, there is a problem in that it is difficult to exhibit the effects of securing low-temperature toughness of the weld zone and improving the workability of the welding material through the formation of the above-mentioned precipitates.

[0048] The remainder includes iron (Fe). In addition, the remainder may include inevitable impurities. The inevitable impurities refer to impurities that are inevitably mixed during the manufacturing process of the cold-rolled steel sheet. Since the inevitable impurities are widely known, detailed descriptions are omitted. In an exemplary embodiment of the present invention, the addition of elements other than the above-described alloy components is not excluded, and various elements may be included within the scope that does not impair the technical spirit of the present invention. If additional elements are included, the additional elements are included by replacing the remainder Fe.

[0049] In an exemplary embodiment, the cold-rolled steel sheet may further include Cu, Ti, Nb, and Ni. The content of each component may be Cu 0.03% or less, Ti 0.002% or less, Nb 0.002% or less, and Ni 0.02% or less.

[0050] In an exemplary embodiment, the cold-rolled steel sheet satisfies the $FCW_{,A}$ value of 40 to 150 in Equation 1 below.

$$FCW_{,A} = (2.5 \times [Mn] + 1.8 \times [Cr] + 25 \times [Al]) \times (18 \times [W]) \times (45 \times [Zr])/(34 \times [C]) \qquad \text{<Equation 1>}$$

(in Equation 1, [Mn], [Cr], [Al], [W], [Zr], and [C] represent the contents of Mn, Cr, Al, W, Zr, and C in weight%, respectively.)

[0051] FCW,a, in Equation 1 relates to a correlation between respective elements on welding workability and drawing processability, and a cold-rolled steel sheet for a flux cored wire with excellent weldability may have a value of FCW,a,, an index of Equation 1, in the range of 40 to 150, specifically 45 to 145.

[0052] If the value of FCW,a, in Equation 1 is out of the upper limit of the range, there is a problem that the fraction of a temper transformation structure increases to cause the fracture of the welding member during pipe-forming and drawing. If the $FCW_{,A}$ value of Equation 1 is out of the lower limit of the range, it is advantageous in terms of workability because the room temperature structure has a small amount of transformation into the hard phase, but there is a problem that the amount of alloy elements in the flux increases to ensure strength and low temperature toughness, and thus welding workability is reduced and manufacturing cost is increased.

[0053] In an exemplary embodiment, the cold-rolled steel sheet has a texture fraction consisting of at least one of cementite and bainite, in area %, of 1 to 7 %, and includes the remainder of ferrite. Specifically, the cold-rolled steel sheet with excellent weldability of the present invention may have a texture fraction consisting of cementite and bainite of 1 to 7% in area% and may have a microstructure containing the remainder of ferrite. The texture fraction consisting of cementite and bainite may be in the range of 1 to 7%, specifically 1.1 to 6.8%, in area%.

[0054] If the texture fraction consisting of the cementite and the bainite is out of the upper limit of the range, there is a problem that the fracture occurs during drawing processing, and corrosion resistance is degraded. If the texture fraction consisting of the cementite and the bainite is out of the lower limit of the range, there is a problem that precipitation of carbides is not promoted to act as a factor in generating strain aging defects due to solid solution elements in the steel.

[0055] In an exemplary embodiment, a cold-rolled steel sheet with excellent weldability may have the elongation of 35% or more. Specifically, the elongation may be in the range of 37 % or more.

[0056] When the elongation satisfies the range, the cold-rolled steel sheet may be used as a cold-rolled steel sheet for a flux cored wire welding rod. When the elongation is out of the range, there is a problem that the cross-sectional reduction rate is lowered during drawing processing of the welding wire, resulting in deterioration of pipe-forming processability and the occurrence of cracks such as tears during processing.

[0057] In an exemplary embodiment, the cold rolled steel sheet with excellent weldability may have a weld zone segregation index of less than 0.15%. The weld zone segregation index refers to a segregation index of the weld zone welded with a flux cored wire manufactured using the cold-rolled steel sheet with excellent weldability according to an exemplary embodiment of the present invention.

[0058] The weld zone segregation index is expressed as a ratio of the area occupied by a segregation zone due to the added elements to the entire area of the weld zone. The weld zone segregation index may be in the range of 0.15% or less, specifically, 0.001 to 0.13%. When the weld zone segregation index is out of the range, there is a problem that the weldability of the cold-rolled steel sheet is deteriorated.

[0059] In an exemplary embodiment, the cold-rolled steel sheet may have low-temperature impact energy of 50 J or more at - 40°C. In the cold-rolled steel sheet, members such as a weld zone may be cracked due to low-temperature shock in a low-temperature environment, which may cause problems with the safety of the welding structure. The cold-rolled steel sheet satisfies impact energy of 50 J or more at low temperatures, thereby maintaining the safety even in the low-temperature environment.

[0060] In an exemplary embodiment, the cold-rolled steel sheet may have a yield strength of the welding member of 500 MPa or more. The yield strength of the welded member refers to the yield strength of the weld zone welded with a flux cored wire manufactured using the cold-rolled steel plate. The yield strength of the weld zone needs to be maintained within an appropriate range regardless of the base material. As the yield strength of the welding member satisfies 500 MPa or more, high-strength properties may be secured in terms of securing the stability of the weld zone when applied to a structural member.

[0061] According to another exemplary embodiment of the present invention, a method for manufacturing a cold-rolled steel sheet may include heating a steel slab including, in weight%, 0.01~0.05% of carbon (C), 0.6~1.2% of manganese (Mn), 0.05% or less (excluding 0%) of silicon (Si), 0.0005~0.01% of phosphorus (P), 0.008% or less (excluding 0%) of sulfur (S), 0.0005~0.015% of aluminum (Al), 0.0005-0.003% of nitrogen (N), 0.1-0.4% of tungsten (W), 1.0-2.0% of chromium (Cr), 0.05-0.15% of zirconium (Zr), and the remainder of Fe and inevitable impurities; hot-rolling the heated slab; winding the hot-rolled steel sheet; cold-rolling the wound hot-rolled steel sheet; and annealing the cold-rolled steel sheet. The detailed description of the steel slab is the same as that of the above-described cold-rolled steel sheet without contradiction, and thus overlapping descriptions will be omitted.

[0062] First, the steel slab is heated. The heating of the steel slab may be performed at 1,180°C or higher. The heating of the steel slab may be performed specifically in the temperature range of 1,180 to 1,280°C. Specifically, the steel slab may be heated in the temperature range of 1,190 to 1,270°C.

[0063] If the temperature range is out of the upper limit, not only energy costs increase, but also the amount of surface scale increases, which may lead to material loss. If the temperature range is out of the lower limit, there is a problem that the load increases rapidly during subsequent hot rolling.

[0064] Next, in the hot-rolling of the heated slab, a hot-rolled steel sheet may be obtained by hot-rolling the heated slab. In an exemplary embodiment, the finish rolling temperature may be in the range of 820 to 880°C. The finish rolling temperature may be specifically in the range of 830 to 875°C.

[0065] If the finish rolling temperature is out of the upper limit of the range, the peelability of surface scales decreases, and uniform hot rolling is not performed throughout the thickness, resulting in insufficient grain refinement and the deterioration of impact toughness may occur due to grain coarsening. If the finish rolling temperature is out of the lower limit of the range, as the hot rolling is finished in a low temperature region, agglomeration of grains rapidly progresses, which may result in a decrease in hot rolling properties and workability.

[0066] Next, the winding of the hot-rolled steel sheet may be performed by winding the hot-rolled steel sheet obtained through the hot rolling step. In an exemplary embodiment, the winding step may be performed in the temperature range of 580 to 700°C. Specifically, the winding step may be performed in the temperature range of 590 to 690°C.

[0067] If the winding temperature is out of the upper limit, the structure of the final product becomes coarse, which may cause problems such as softening of the surface texture and worsening of the pipe-forming properties. If the winding temperature is out of the lower limit, there is a problem that in the cooling and maintaining step, temperature unevenness in the width direction causes a difference in the formation behavior of low-temperature precipitates to cause mechanical-property deviation, thereby deteriorating processability.

[0068] Next, in the cold-rolling of the wound hot-rolled steel sheet, the cold-rolled steel sheet may be obtained by cold-rolling the hot-rolled steel sheet at a target thickness. In an exemplary embodiment, before the cold-rolling of the wound hot-rolled steel sheet, the hot-rolled steel sheet may be pickled.

[0069] In an exemplary embodiment, in the cold-rolling step, the cold reduction ratio may be in the range of 50 to 90%. Specifically, the cold reduction ratio may be in the range of 55 to 85%.

[0070] If the cold reduction ratio is out of the upper limit of the range, there is a problem that the material is hardened to reduce cold-rolling workability due to the load of a roller and cause cracks during drawing processing. When the cold reduction ratio is out of the lower limit of the range, there is a problem that it is difficult to secure a uniform mechanical property because local structure growth occurs due to low recrystallization driving force. In addition, considering the thickness of the final product, there is a problem that hot-rolling workability is significantly reduced because the thickness of the hot-rolled steel sheet needs to be reduced.

[0071] Next, in the annealing of the cold-rolled steel sheet, the target strength and workability may be secured by performing annealing from a state where the strength has been increased due to the strain introduced in cold rolling. The annealing of the cold-rolled steel sheet may be performed in the temperature range of 700 to 850°C. Specifically, the annealing of the cold-rolled steel sheet may be performed in the temperature range of 710 to 840°C.

[0072] If the annealing step is out of the upper limit of the temperature range, the risk of strip fracture due to heat-buckle increases, which may reduce the annealing passability. If the annealing step is out of the lower limit of the temperature range, there is a problem that workability is significantly reduced as the strain formed by cold rolling is not sufficiently removed.

[0073] After the annealing step, the temper-rolling of the annealed cold-rolled steel sheet may be further included. The temper-rolling of the annealed cold-rolled steel sheet may be applied at a reduction ratio of 3% or less. Specifically, the temper-rolling of the annealed cold-rolled steel sheet may be applied at the reduction ratio of 0.3 to 2.5% or less.

[0074] In the temper-rolling of the annealed cold-rolled steel sheet, the reduction ratio satisfies the range to control the shape of the material and obtain target surface roughness. If the reduction ratio is excessively high in the temper-rolling of the annealed cold-rolled steel sheet, there is a problem that the material is hardened, but the workability is deteriorated.

[0075] After the annealing step, the annealed sheet may be used to manufacture a flux cored wire. In an exemplary embodiment, the cold-rolled steel sheet for the flux cored wire may include a cover consisting of the above-described cold-rolled steel sheet or a cold-rolled steel sheet manufactured by a cold rolled steel sheet manufacturing method, and a flux filled in the cover.

[0076] The flux cored wire including the cold-rolled steel sheet of the present invention may exhibit an effect of the flux cored wire, and the effect is an effect exhibited by the above-described cold-rolled steel sheet or the cold-rolled steel sheet manufactured by the cold rolled steel sheet manufacturing method regardless of the type of flux. Therefore, since a flux commonly used in the field of flux cored wire may be used as the flux, the detailed description is omitted.

<Invention Steels 1 to 5, and Comparative Steels 1 to 6>

[0077] Table 1 below shows compositions of major components and $FCW_{,A}$ values for Invention Steels 1 to 5 and Comparative Steels 1 to 6. The $FCW_{,A}$ value was designed considering the correlation between respective elements affecting welding workability and drawing processability, and specifically, the $FCW_{,A}$ value was $(2.5 \times [Mn] + 1.8 \times [Cr] + 24 \times [Al]) \times (18 \times [W]) \times (45 \times [Zr]) / (34 \times [C])$ and [Mn], [Cr], [Al], [W], [Zr], and [C] represent the respective contents in weight%.

(Table 1)

Steel type	Chemical composition (wt%)									
	C	Mn	Si	P	S	Al	N	W	Cr	Zr	$FCW_{,A}$ value
Inventive Steel 1	0.024	0.76	0.019	0.005	0.005	0.012	0.0024	0.36	1.26	0.072	109.55
Inventive Steel 2	0.031	0.68	0.011	0.007	0.002	0.009	0.0018	0.21	1.78	0.096	75.80
Inventive Steel 3	0.038	0.94	0.008	0.004	0.004	0.011	0.0013	0.16	1.39	0.104	51.00
Inventive Steel 4	0.028	1.08	0.028	0.005	0.006	0.004	0.0025	0.23	1.49	0.124	127.02
Inventive Steel 5	0.041	0.82	0.009	0.003	0.003	0.003	0.0016	0.27	1.55	0.131	96.47
Comparative Steel 1	0.003	1.01	0.021	0.006	0.006	0.068	0.0015	0.25	1.60	0.002	26.70
Comparative Steel 2	0.021	0.31	0.016	0.005	0.004	0.012	0.0074	0.71	1.41	0.081	224.50
Comparative Steel 3	0.043	0.72	0.007	0.042	0.006	0.002	0.0026	0.01	1.32	0.270	6.04
Comparative Steel 4	0.027	1.54	0.008	0.006	0.034	0.007	0.0019	0.12	0.65	0.053	27.82
Comparative Steel 5	0.019	0.82	0.015	0.029	0.007	0.039	0.0022	0.25	0.03	0.024	21.85
Comparative Steel 6	0.086	0.90	0.540	0.005	0.004	0.005	0.0014	0.18	2.47	0.091	29.55

[0078] In Table 1, it can be seen that Invention Steels 1 to 5 satisfy the steel sheet composition of the present invention, thereby satisfying the $FCW_{,A}$ value of 40 to 150.

<Examples 1 to 4 and Comparative Examples 1 to 5>

[0079] Invention Steels 1 to 5 and Comparative Steels 1 to 6 of Table 1 above were processed under the process conditions shown in Table 2 below to manufacture Example Materials 1 to 9 and Comparative Materials 1 to 10. Specifically, after heating the slabs in Table 1 at 1,230°C, hot rolling, winding, cold rolling, and continuous annealing processes were performed under the manufacturing conditions shown in Table 2 below. At this time, a temper reduction ratio of 0.9% was applied to the annealed sheet.

(Table 2)

Classification	Steel type No.	Finish hot rolling temperature (°C)	Winding temperature (°C)	Cold reduction ratio (%)	Annealing temperature (°C)
Inventive Material 1	Inventive Steel 1	860	680	65	750
Inventive Material 2	Inventive Steel 1	860	680	70	790
Inventive Material 3	Inventive Steel 1	860	680	75	830
Inventive Material 4	Inventive Steel 2	840	600	75	780
Inventive Material 5	Inventive Steel 2	840	600	80	820
Inventive Material 6	Inventive Steel 3	840	660	75	800
Inventive Material 7	Inventive Steel 4	840	620	70	760
Inventive Material 8	Inventive Steel 5	870	640	65	760
Inventive Material 9	Inventive Steel 5	870	640	80	820
Comparative Material 1	Inventive Steel 1	700	680	75	580
Comparative Material 2	Inventive Steel 1	960	680	40	780
Comparative Material 3	Inventive Steel 2	840	500	93	820
Comparative Material 4	Inventive Steel 3	840	760	75	890
Comparative Material 5	Comparative Steel 1	880	640	70	820
Comparative Material 6	Comparative Steel 2	860	640	70	820
Comparative Material 7	Comparative Steel 3	860	640	70	820
Comparative Material 8	Comparative Steel 4	860	640	70	800

(continued)

Comparative Material 9	Comparative Steel 5	860	640	70	800
Comparative Material 10	Comparative Steel 6	860	660	70	800

[0080] In Table 2 above, Invention Materials 1 to 9 were used with steels included in the scope of Invention Steels in Table 1 and performed under the manufacturing conditions of the present invention. In comparison, Comparative Materials 1 to 4 were used with steels included in the scope of Invention Steels in Table 1 above, but the manufacturing conditions were outside the range of the manufacturing conditions of the present invention. In addition, in Comparative Materials 5 to 10, steel types of Comparative Steels 1 to 6 in Table 1 were performed under the manufacturing conditions of the present invention.

<Characteristics of cold-rolled steel sheet>

[0081] Table 3 below shows result values of measuring the type and fraction of microstructure, elongation, passability, and drawing processability of the cold-rolled steel sheet manufactured under the manufacturing conditions in Table 2 above. The passability was indicated as good (O) if there was no rolling load during cold and hot rolling and no defects such as heat-buckles occurred during continuous annealing, and poor (X) if a rolling load occurred or defects such as strip fracture occurred during continuous annealing.

[0082] The drawing processability was indicated as poor (X) if processing defects such as tearing occurred during the drawing process of the flux cored wire with a cross-section reduction rate of 61%, and good (O) if no processing defects occurred. In addition, the manufactured cold-rolled steel sheet was used and manufactured into a strip with a width of 14 mm, and then the strip was processed into a U shape to fill the flux component, and then an O-shaped welding material with a diameter of 3.1 mm was made. Thereafter, the welding material was drawn to manufacture a flux cored wire with a diameter of 1.2 mm, and as a result, the results of performing low-temperature impact and tensile tests were shown in Table 3 below.

[0083] In addition, the weld zone segregation index was measured using a scanning electron microscope for a welding member welded with the flux cored wire, and the measurement results were shown in Table 3 below. At this time, the welding member was drawn from a wire with a diameter of 1.2 mm, and a result of performing an experiment on the welding member worked under the conditions of a voltage of 29 volts, a current of 150 to 180 A, and a welding speed of 40 cm per minute using a pilot welder.

[0084] After measuring the weld zone segregation index for the welding member welded with the flux cored wire, the measurement result values were also shown in Table 3 below. At this time, the welding member was drawn from a wire with a diameter of 1.2 mm, and a result of evaluating the quality of the welding member worked using a pilot welder under the conditions of a voltage of 29 volts, a current of 150 to 180 A, and a welding speed of 40 cm per minute.

(Table 3)

Classification	Fraction of cementite and bainite (area%)	Passability	Elongation (%)	Weld zone segregation index (%)	Impact toughness (J, @-40°C)	Welding member yield strength (MPa)	Drawing workability
Inventive Material 1	3.1	○	41	0.07	92	578	Good
Inventive Material 2	2.8	○	43	0.09	88	584	Good
Inventive Material 3	2.1	○	43	0.06	101	567	Good
Inventive Material 4	4.8	○	39	0.03	79	592	Good
Inventive Material 5	4.2	○	42	0.05	94	599	Good

(continued)

Classification	Fraction of cementite and bainite (area%)	Passability	Elongation (%)	Weld zone segregation index (%)	Impact toughness (J, @-40°C)	Welding member yield strength (MPa)	Drawing workability
Inventive Material 6	5.2	○	40	0.02	106	604	Good
Inventive Material 7	4.7	○	42	0.04	69	592	Good
Inventive Material 8	6.4	○	44	0.08	113	574	Good
Inventive Material 9	5.2	○	40	0.05	109	632	Good
Comparative Material 1	0.4	X	15	0.10	42	392	Poor
Comparative Material 2	1.5	X	24	0.19	44	458	Poor
Comparative Material 3	0.5	X	31	0.09	38	409	Poor
Comparative Material 4	0.8	X	43	0.22	46	422	Good
Comparative Material 5	0.0	○	34	0.51	24	346	Poor
Comparative Material 6	0.8	○	29	0.32	35	401	Poor
Comparative Material 7	2.6	○	29	0.30	42	452	Poor
Comparative Material 8	3.4	○	27	0.21	39	397	Poor
Comparative Material 9	0.9	○	31	0.24	40	468	Poor
Comparative Material 10	9.2	X	24	0.33	47	471	Poor

[0085] As shown in Tables 2 and 3 above, Invention Materials 1 to 9 that satisfied all of the alloy compositions, microstructure characteristics, and manufacturing conditions not only satisfied good passability, but also the elongation of 35% or more as a standard mechanical property of the target cold-rolled steel sheet for the flux cored wire welding rod. In addition, the segregation index of the wire manufactured from the welding member is less than 0.15%, and thus tearing or cracking of the weld zone does not occur during secondary processing, thereby ensuring excellent processability. In addition, it can be confirmed that excellent strength and low-temperature toughness can be secured with impact energy of 50 J or more at - 40°C and yield strength of 500 MPa or more of the welding member.

[0086] In contrast, Comparative Materials 1 to 4 satisfied the range of alloy composition presented in the present invention, but did not satisfy the microstructure characteristics and manufacturing conditions, and in the case of Comparative Materials 1 to 3, the rolling passability was lowered, and in Comparative Examples 1 to 4, the annealing passability decreases. In addition, it can be confirmed that the elongation is lower than the target value, or the yield strength of the welding member is less than 500 MPa, the impact energy value at - 40°C is less than - 50 J, and the drawing processability of the welding member is poor, so that entirely targeted characteristics cannot be secured.

[0087] In addition, Comparative Materials 5 to 10 satisfied the manufacturing conditions presented in the present invention, but did not satisfy the alloy compositions, and it was confirmed that the characteristics such as target elongation, weld zone segregation index, impact energy, and weld zone yield strength of the present invention did not meet Invention Materials 1 to 9 above, and in most cases, it can be seen that tears or cracks occur during drawing processing.

[0088] The present invention can be manufactured in various different forms, not limited to the above embodiments, and it will be appreciated to those skilled in the present invention that the present invention may be implemented in other specific forms without changing the technical idea or essential features of the present invention. Therefore, it should be appreciated that the aforementioned exemplary embodiments are illustrative in all aspects and are not restricted.

Claims

1. A cold-rolled steel sheet comprising:

in weight%, 0.01~0.05% of carbon (C), 0.6~1.2% of manganese (Mn), 0.05% or less (excluding 0%) of silicon (Si), 0.0005~0.01% of phosphorus (P), 0.008% or less (excluding 0%) of sulfur (S), 0.0005~0.015% of aluminum (Al), 0.0005-0.003% of nitrogen (N), 0.1~0.4% of tungsten (W), 1.0~2.0% of chromium (Cr), 0.05~0.15% of zirconium (Zr), and the remainder of Fe and inevitable impurities,
wherein the yield strength of a welding member is 500 MPa or more.

2. The cold-rolled steel sheet of claim 1, wherein:

a $FCW_{,A}$ value in Equation 1 below satisfies 40 to 150.

$$FCW_{,A} = (2.5 \times [Mn] + 1.8 \times [Cr] + 25 \times [Al]) \times (18 \times [W]) \times (45 \times [Zr])/(34 \times [C]) \quad \text{<Equation 1>}$$

(In Equation 1, [Mn], [Cr], [Al], [W], [Zr], and [C] represent the contents of Mn, Cr, Al, W, Zr, and C in weight%, respectively.)

3. The cold-rolled steel sheet of claim 1, wherein:
the cold-rolled steel sheet includes 1-7% of a texture fraction consisting of at least one of cementite and bainite in area%, and the remainder of ferrite.

4. The cold-rolled steel sheet of claim 1, wherein:
an elongation is 35% or more.

5. The cold-rolled steel sheet of claim 1, wherein:
a weld zone segregation index is less than 0.15%.

6. The cold-rolled steel sheet of claim 1, wherein:
impact energy at - 40°C is 50 J or more.

7. A method for manufacturing a cold-rolled steel sheet comprising:

heating a steel slab including, in weight%, 0.01~0.05% of carbon (C), 0.6~1.2% of manganese (Mn), 0.05% or less (excluding 0%) of silicon (Si), 0.0005~0.01% of phosphorus (P), 0.008% or less (excluding 0%) of sulfur (S), 0.0005~0.015% of aluminum (Al), 0.0005~0.003% of nitrogen (N), 0.1-0.4% of tungsten (W), 1.0-2.0% of chromium (Cr), 0.05-0.15% of zirconium (Zr), and the remainder of Fe and inevitable impurities;
hot-rolling the heated slab at a finish rolling temperature of 820 to 880°C;

winding the hot-rolled steel sheet at 580 to 700°C;
cold-rolling the wound hot-rolled steel sheet to 50 to 90%; and
annealing the cold-rolled steel sheet in a temperature range of 700 to 850°C.

8. The method for manufacturing the cold-rolled steel sheet of claim 7, wherein:

the slab satisfies a $FCW_{,A}$ value of 40 to 150 in Equation 1 below.

$$FCW_{,A} = (2.5 \times [Mn] + 1.8 \times [Cr] + 25 \times [Al]) \times (18 \times [W]) \times (45 \times [Zr])/(34 \times [C]) \qquad \text{<Equation 1>}$$

(In Equation 1, [Mn], [Cr], [Al], [W], [Zr], and [C] represent the contents of Mn, Cr, Al, W, Zr, and C in weight%, respectively)

9. The method for manufacturing the cold-rolled steel sheet of claim 7, wherein:
the heating of the steel slab is performed at 1,180°C or more.

10. The method for manufacturing the cold-rolled steel sheet of claim 7, wherein:
before the cold-rolling of the wound hot-rolled steel sheet, the hot-rolled steel sheet is pickled.

11. The method for manufacturing the cold-rolled steel sheet of claim 7, further comprising:
temper-rolling the annealed cold-rolled steel sheet after the annealing of the cold-rolled steel sheet.

INTERNATIONAL SEARCH REPORT

International application No. **PCT/KR2022/020580**

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/22(2006.01)i; **C22C 38/28**(2006.01)i; **C21D 8/02**(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)

C22C 38/22(2006.01); C21D 8/02(2006.01); C22C 38/00(2006.01); C22C 38/04(2006.01); C22C 38/06(2006.01)

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

Korean utility models and applications for utility models: IPC as above
Japanese utility models and applications for utility models: IPC as above

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

eKOMPASS (KIPO internal) & keywords: 냉연강판(cold rolled steel plate), 용접(welding), 플럭스 코어드 와이어(flux cored wire), 냉간압연(cold rolling), 소둔(annealing)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 2013-209727 A (JFE STEEL CORP.) 10 October 2013 (2013-10-10) See paragraphs [0035]-[0039] and [0046]; and table 2.	1-11
A	KR 10-2018-0019743 A (NIPPON STEEL & SUMITOMO METAL CORPORATION) 26 February 2018 (2018-02-26) See paragraphs [0017]-[0102].	1-11
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☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 March 2023	**24 March 2023**

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