



(11)

EP 4 826 052 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
21.10.2026 Bulletin 2026/43

(51) International Patent Classification (IPC):
C22C 38/04 ^(2006.01) **C22C 38/12** ^(2006.01)
C22C 38/00 ^(2006.01) **C21D 8/02** ^(2026.01)
C21D 9/46 ^(2006.01)

(21) Application number: **24904100.5**

(22) Date of filing: **28.11.2024**

(52) Cooperative Patent Classification (CPC):
C21D 8/02; C21D 9/46; C22C 38/00; C22C 38/04;
C22C 38/12

(86) International application number:
PCT/KR2024/019127

(87) International publication number:
WO 2025/127535 (19.06.2025 Gazette 2025/25)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(72) Inventors:
• **LEE, Chul Won**
Incheon 22525 (KR)
• **LIM, Young Hoon**
Incheon 22525 (KR)

(74) Representative: **Viering, Jentschura & Partner**
mbB
Patent- und Rechtsanwälte
Am Brauhaus 8
01099 Dresden (DE)

(30) Priority: **14.12.2023 KR 20230181413**

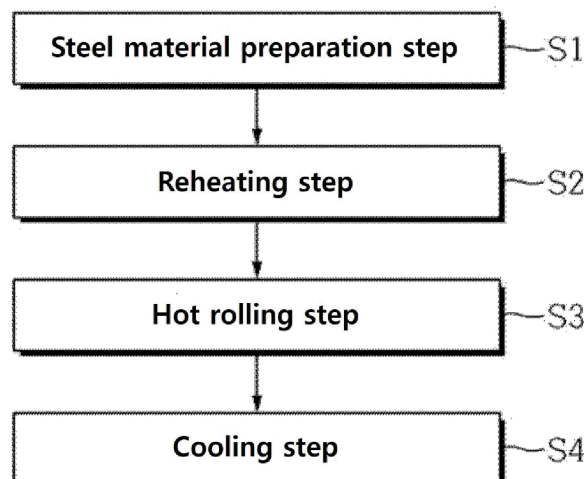
(71) Applicant: **Hyundai Steel Company**
Incheon 22525 (KR)

(54) **SECTION STEEL AND SECTION STEEL MANUFACTURING METHOD**

(57) Section steel according to one embodiment of the present disclosure includes 0.11-0.18 wt% of carbon (C), 1.0-1.65 wt% of manganese (Mn), 0.01-0.11 wt% of vanadium (V), 40-200 ppm of nitrogen (N), and

the balance of iron (Fe) and other inevitable impurities, in which the content ratio of vanadium (V) and nitrogen (N) satisfies relation 1 such that high strength and high impact toughness can be exhibited.

[FIG. 1]



Description**[Technical Field]**

5 **[0001]** The present disclosure relates to section steel and a section steel manufacturing method.

[Background Art]

10 **[0002]** With the recent trend toward large-scale, super-tall, or underground constructions, there is a growing need for a structural steel material with higher strength. As a structural steel material used in construction, generally, H-shaped section steel and thick plates have been mainly used, and there is a growing demand for technology to improve their strength.

15 **[0003]** Generally, in order to improve the strength of the structural steel material and ensure high impact toughness, a thermo-mechanical control process (TMCP) using quenching and self-tempering (QST) is performed. However, section steel is a steel material with a cross-sectional shape that changes multidirectionally, and it is difficult to apply the TMCP process due to a complex rolling method required to realize the cross-sectional shape.

20 **[0004]** For this reason, conventionally, methods for increasing the strength of section steel by adding alloy components such as manganese (Mn), vanadium (V), and niobium (Nb) are commonly used for inducing solid solution strengthening and precipitation strengthening. However, the addition of the alloy components may increase a carbon equivalent (Ceq). In addition, if the addition of alloy components is excessive, it may be difficult to satisfy the upper limit standard of the carbon equivalent limited in KS, EN standards, etc., and the range of strength increase is limited with an alloy component design that satisfies the carbon equivalent standard.

25 **[0005]** Therefore, in order to solve the aforementioned problem, there is a need for a technology for improving the strength of section steel without increasing the carbon equivalent or the TMCP process.

[Disclosure]**[Technical Problem]**

30 **[0006]** The present disclosure is directed to solve the problems, and an object of the present disclosure is to provide section steel and a section steel manufacturing method with high strength by designing alloy components.

[0007] The objects of the present disclosure are not limited to the aforementioned objects, and other objects, which are not mentioned above, will be apparent to those skilled in the art from the following description.

[Technical Solution]

35 **[0008]** According to an embodiment of the present disclosure, section steel includes 0.11 to 0.18 wt% of carbon (C), 1.0 to 1.65 wt% of manganese (Mn), 0.01 to 0.11 wt% of vanadium (V), 40 to 200 ppm of nitrogen (N), and the balance of iron (Fe) and other inevitable impurities, in which a content ratio of the vanadium (V) and the nitrogen (N) satisfies Equation 1.

[Equation 1]

$$45 \quad 3.0 \leq [V]/[N] \leq 4.5$$

(However, [V] and [N] represent wt% of V and N, respectively.)

[0009] In addition, yield strength (YS) may be 460 MPa or more, tensile strength (TS) may be 570 to 720 MPa, and elongation (EL) may be 17% or more.

50 **[0010]** In addition, Charpy impact absorption energy (CVN) at 0°C may be 130 J or more.

[0011] In addition, a carbon equivalent (Ceq) may be 0.38 to 0.45%.

[0012] In addition, the section steel may further include 0.10 to 0.55 wt% of silicon (Si), 0.02 wt% or less (excluding 0 wt%) of phosphorus (P), 0.007 wt% or less (excluding 0 wt%) of sulfur (S), and 0.015 to 0.055 wt% of aluminum (Al).

55 **[0013]** According to another embodiment of the present disclosure, a section steel manufacturing method includes a first step of preparing a steel material including 0.11 to 0.18 wt% of carbon (C), 1.0 to 1.65 wt% of manganese (Mn), 0.01 to 0.11 wt% of vanadium (V), 40 to 200 ppm of nitrogen (N), and the balance of iron (Fe) and other inevitable impurities; a second step of reheating the steel material; a third step of forming a hot rolled steel material by hot rolling the steel material that has undergone in the second step; and a fourth step of cooling the hot rolled steel material.

[0014] In addition, a reheating temperature may be 1150 to 1300°C.

[0015] In addition, a rolling start temperature may be 1000 to 1100°C and a rolling end temperature may be 890 to 930°C.

[0016] In addition, the steel material may further include 0.10 to 0.55 wt% of silicon (Si), 0.02 wt% or less (excluding 0 wt%) of phosphorus (P), 0.007 wt% or less (excluding 0 wt%) of sulfur (S), and 0.015 to 0.055 wt% of aluminum (Al).

[Advantageous Effects]

[0017] According to the section steel and the section steel manufacturing method according to an embodiment of the present disclosure, it is possible to manufacture section steel having high strength and high impact toughness by designing alloy compositions without increasing a carbon equivalent and controlling a content ratio of vanadium (V) and nitrogen (N).

[0018] The effects of the present disclosure are not limited to the aforementioned effect, and other effects not mentioned above will be clearly understood to those skilled in the art from the description of the appended claims.

[Description of Drawings]

[0019] FIG. 1 is a flowchart schematically illustrating a section steel manufacturing method according to an embodiment of the present disclosure.

[Best Mode]

[0020] Hereinafter, embodiments of the present disclosure will be described in detail so as to be easily implemented by those skilled in the art, with reference to the accompanying drawings. However, the present disclosure is not limited or restricted to the following embodiments.

[0021] In addition, when a component (or region, layer, part, etc.) is described as being "on", "connected to" or "coupled to" the other component, it means that the component may be directly displaced/connected/coupled on the other component, or a third component may also be displaced therebetween.

[0022] It should be understood that term "including" or "having" indicates that a feature, a number, a step, an operation, a component, a part or a combination thereof described in the specification is present, but does not exclude the possibility of presence or addition of one or more other features, numbers, steps, operations, components, parts or combinations thereof, in advance.

[0023] In order to clearly explain the present disclosure, detailed descriptions of known related arts that are irrelevant to the explanation or may unnecessarily obscure the gist of the present disclosure have been omitted, and in adding reference numerals to components of each drawing in this specification, like or similar reference numerals are designated to like or similar components throughout the specification.

[0024] Terms and words used in the present specification and claims should not be interpreted as being limited to typical or dictionary meanings, but should be interpreted as meanings and concepts which comply with the technical spirit of the present disclosure, based on the principle that the present inventor can appropriately define the concepts of the terms to describe his/her own invention in the best manner.

[0025] Unless otherwise specified, the expression 'A ~ B' for numerical values A and B means 'A or more and B or less'. In such expression, if a unit is attached only to numerical value B, the corresponding unit is also applied to numerical value A.

[0026] Also, unless specifically noted otherwise, 1 ppm is 0.0001 wt%.

[0027] Hereinafter, embodiments of the present disclosure will be described with reference to the accompanying drawings.

Section steel

[0028] Section steel according to an embodiment of the present disclosure includes 0.11 to 0.18 wt% of carbon (C), 1.0 to 1.65 wt% of manganese (Mn), 0.01 to 0.11 wt% of vanadium (V), 40 to 200 ppm of nitrogen (N), and the balance of iron (Fe) and other inevitable impurities.

[0029] Hereinafter, the roles and contents of alloy elements included in the section steel according to an embodiment of the present disclosure will be described in detail.

Carbon (C)

[0030] Carbon (C) is an effective element for improving the strength of steel, and it dissolves into austenite to form a

martensite structure during quenching. In addition, the carbon combines with iron (Fe), molybdenum (Mo), niobium (Nb), and titanium (Ti) to promote the generation of fine carbides and improve the strength of steel through precipitation hardening.

[0031] If the carbon content is less than 0.11 wt%, it may be difficult to secure sufficient strength. On the other hand, if the carbon content is more than 0.18 wt%, coarse carbides are formed, which may reduce impact toughness. Accordingly, the section steel according to an embodiment of the present disclosure may include 0.11 to 0.18 wt% of carbon.

Manganese (Mn)

[0032] Manganese (Mn) is a solid solution strengthening element and may not only contribute to securing the strength but also improve the hardenability of steel. As the manganese content increases, pearlite becomes finer and ferrite is solid-solution strengthened, thereby improving the yield strength. In addition, some of the manganese may react with sulfur (S) dissolved in the steel to form MnS, and the MnS is elongated in a processing direction during plastic working. In addition, the formation of MnS reduces the sulfur component in the steel, which may make crystal grains brittle, and may suppress the formation of FeS as a low-melting compound.

[0033] If the manganese content is less than 1.0 wt%, the aforementioned effect may be negligible. On the other hand, if the manganese content is more than 1.65 wt%, an austenite structure remains, which may rather lower strength and toughness. Accordingly, the section steel according to an embodiment of the present disclosure may include 1.0 to 1.65 wt% of manganese.

Vanadium (V)

[0034] Vanadium (V) may refine austenite crystal grains by hindering the movement of austenite grain boundaries during reheating and hot rolling. In addition, hardenability may be increased by suppressing nucleation in austenite grain boundaries during phase transformation, and strength may be increased by forming precipitates from austenite during phase transformation.

[0035] If the vanadium content is less than 0.01 wt%, it may be difficult to exhibit the aforementioned effect. On the other hand, if the vanadium content is more than 0.11 wt%, the vanadium may reduce processability to cause cracks in a material during rolling. Accordingly, the section steel according to an embodiment of the present disclosure may include 0.01 to 0.11 wt%, more preferably 0.05 to 0.11 wt% of vanadium.

Nitrogen (N)

[0036] Nitrogen (N) combines with other alloy elements such as vanadium (V), aluminum (Al), titanium (Ti), and niobium (Nb) to form nitride-based precipitates, thereby contributing to refinement of crystal grains. In addition, a precipitation strengthening effect may be increased by adding nitrogen (N) to a steel material added with vanadium (V). If the nitrogen content is less than 40 ppm, it is difficult to achieve the aforementioned effect. On the other hand, if the nitrogen content is more than 200 ppm, the toughness of welded joints may decrease and the impact value may decrease. Accordingly, the section steel according to an embodiment of the present disclosure may include 40 to 200 ppm of nitrogen.

[0037] In addition, the section steel according to an embodiment of the present disclosure satisfies the following Equation 1 for a content ratio of vanadium (V) and nitrogen (N).

[Equation 1]

$$3.0 \leq [V]/[N] \leq 4.5$$

[0038] However, the [V] and [N] represent the content of vanadium (V) and the content of nitrogen (N) in wt%, respectively.

[0039] If the [V]/[N] is less than 3.0, impact toughness may be reduced due to the generation of free nitrogen (Free N). On the other hand, if [V]/[N] is more than 4.5, a strength improvement effect caused by nitrogen addition is significantly reduced, and a decrease in impact toughness may occur due to the coarsening of precipitates.

[0040] As a result, by increasing a precipitation driving force through the addition of a predetermined level of nitrogen (N), the precipitate fraction and the degree of fine dispersion of precipitates are increased, thereby improving strength and impact toughness. In addition, through an appropriate content ratio of vanadium (V) and nitrogen (N) according to Equation 1 above, it is possible to achieve optimization of the added amount for operating and cost

efficiency.

[0041] The section steel according to an embodiment of the present disclosure may further include 0.10 to 0.55 wt% of silicon (Si), 0.020 wt% or less of phosphorus (P), 0.007 wt% or less of sulfur (S), and 0.015 to 0.055 wt% of aluminum (Al).

Silicon (Si)

[0042] Silicon (Si) is added as a deoxidizer to remove oxygen from steel during a steelmaking process. In addition, the silicon may also have a solid solution strengthening effect. The silicon may suppress the formation of carbides and prevent the degradation of materials caused by the formation of Fe_3C . In addition, ductility may be increased by increasing the ferrite fraction during cooling using a ferrite stabilizing element.

[0043] The silicon (Si) may be included in an amount of 0.10 to 0.55 wt% of the total weight of the section steel according to an embodiment of the present disclosure. If the silicon content is less than 0.10 wt%, the silicon addition effect described above cannot be properly exhibited. On the other hand, if the silicon content is more than 0.55 wt%, it is possible to reduce the weldability of steel and degrade the plastic workability.

Phosphorus (P)

[0044] Phosphorus (P) is not a significant problem when it is uniformly distributed in steel, but usually forms undesirable compounds such as Fe_3P . Fe_3P is extremely brittle and segregated, and thus does not become homogenized even after annealing, and may be elongated during processing such as rolling. In addition, if the phosphorus content is more than 0.02 wt%, there may be a problem that the low-temperature impact value is reduced due to precipitation behavior, and thus in the present disclosure, it is necessary to control the content to be as low as possible. Accordingly, the section steel according to an embodiment of the present disclosure may include 0.02 wt% or less (excluding 0 wt%) of phosphorus (P).

Sulfur (S)

[0045] Sulfur (S) combines with manganese (Mn) to form MnS inclusions, and if the manganese content is insufficient, the sulfur combines with iron to form FeS. FeS is brittle and has a low melting point to cause cracks during hot and cold working.

[0046] If the sulfur content is more than 0.007 wt%, the sulfur may deteriorate toughness and weldability and reduce a low-temperature impact value, and thus it is preferable to control the content to be as low as possible. Accordingly, the section steel according to an embodiment of the present disclosure may include 0.007 wt% or less (excluding 0 wt%) of sulfur (S).

Aluminum (Al)

[0047] Aluminum (Al) is an element added as a deoxidizer to remove oxygen from steel. The aluminum mainly plays a role in solid solution strengthening and inhibiting carbide formation. In addition, the aluminum may precipitate as AlN in steel to contribute to crystal grain refinement. If the aluminum content is less than 0.015 wt%, a deoxidation effect is insufficient, and the aforementioned effect may be negligible. On the other hand, if the aluminum content is more than 0.055 wt%, the aluminum may form non-metallic inclusions such as Al_2O_3 , which may reduce ductility and toughness. Accordingly, the section steel according to an embodiment of the present disclosure may include 0.015 to 0.055 wt% of aluminum (Al).

[0048] In addition to the aforementioned components of the steel, the balance may include Fe and inevitable impurities. The inevitable impurities are impurities to be added during a steelmaking step and a manufacturing process of non-oriented electrical steel sheets, and since the inevitable impurities are well known in the art, a detailed description thereof will be omitted.

[0049] In an embodiment of the present disclosure, the addition of elements other than the above-described alloy components is not excluded, but may be variously included within a range without impairing the technical spirit of the present disclosure. If additional elements are included, they may be included instead of the balance of iron (Fe).

[0050] The steel material having the alloy composition described above may have high yield strength and excellent mechanical properties without increasing a carbon equivalent (Ceq). More specifically, the section steel according to an embodiment of the present disclosure may have a carbon equivalent of 0.38 to 0.45% and may be section steel having excellent yield strength without exceeding a carbon equivalent standard for a steel material for construction structures.

[0051] The section steel having the alloy composition described above and manufactured by a section steel manu-

facturing method to be described below may have excellent mechanical properties and may ensure yield strength of 460 MPa grade. More specifically, the yield strength (YS) may be 460 MPa or higher, preferably 486 MPa or higher.

[0052] In addition, the section steel according to the present disclosure may satisfy tensile strength (TS) of 570 to 720 MPa and elongation (EL) of 17% or more, and may ensure impact toughness. More specifically, the Charpy impact absorption energy (CVN) at 0°C may be 130 J or more, more preferably 145 J or more.

[0053] Hereinafter, a section steel manufacturing method according to an embodiment of the present disclosure will be described in detail.

Section steel manufacturing method

[0054] Hereinafter, a section steel manufacturing method according to an embodiment of the present disclosure will be described with reference to the accompanying drawings.

[0055] FIG. 1 is a flowchart schematically illustrating a section steel manufacturing method according to an embodiment of the present disclosure.

[0056] Referring to FIG. 1, a section steel manufacturing method according to an embodiment of the present disclosure includes a first step (S1) of preparing a steel material including 0.11 to 0.18 wt% of carbon (C), 1.0 to 1.65 wt% of manganese (Mn), 0.01 to 0.11 wt% of vanadium (V), 40 to 200 ppm of nitrogen (N), and the balance of iron (Fe) and other inevitable impurities, a second step (S2) of reheating the steel material, a third step (S3) of forming a hot rolled steel material by hot rolling the steel material that has undergone step (S2), and a fourth step (S4) of cooling the hot rolled steel material.

[0057] In addition, the steel material may further include 0.10 to 0.55 wt% of silicon (Si), 0.020 wt% or less of phosphorus (P), 0.007 wt% or less of sulfur (S), and 0.015 to 0.055 wt% of aluminum (Al).

[0058] Since the content of the alloy components has been described above, a redundant description will be omitted. In addition, since the content of the alloy components does not substantially change during a manufacturing process to be described below, the composition of the steel material and the alloy composition of the section steel as a final product are substantially the same as each other.

[0059] Hereinafter, respective steps of the section steel manufacturing method according to an embodiment of the present disclosure will be described in detail.

[0060] First, the first step (S1) according to an embodiment of the present disclosure is a step of preparing a steel material having the alloy composition range described above. More specifically, the first step (S1) may be a step of manufacturing a semi-finished product by designing the alloy components in the aforementioned alloy composition range. The semi-finished product may be a beam blank, a bloom, a billet, etc., but is not necessarily limited thereto. In addition, the manufacturing of a slab may be performed through processes known in the art, such as steelmaking and continuous casting processes.

[0061] After the first step (S1), the second step (S2) of reheating the steel material may be performed. The reheating step is a step performed before the hot rolling step to be described below, and may be reheating the steel material for a subsequent process. More specifically, the reheating step may be a step of charging the steel material into a heating furnace and heating the steel material uniformly to facilitate plastic deformation.

[0062] At this time, the steel material is reheated and the segregated components may be redissolved. If the reheating temperature is lower than 1150°C, segregated components in the steel material cannot be sufficiently dissolved, and the rolling load increases, which may reduce rolling performance. If the reheating temperature is more than 1300°C, coarse austenite crystal grains may be formed, making it difficult to secure the strength, and the heating cost and processing time may increase, causing problems of increased manufacturing costs and reduced productivity.

[0063] The section steel manufacturing method according to the present disclosure may perform the third step (S3) of forming the hot rolled steel material by hot rolling the steel material that has undergone the second step (S2), after the second step (S2). The hot rolling may include rough rolling and finishing rolling processes. Here, the rough rolling process may mean making the steel material into a rolled material with a suitable shape, thickness, and width. In addition, the finishing rolling process may mean adjusting the steel material to a predetermined thickness and width and rolling the steel material with a good surface and shape at a finishing temperature suitable for an application.

[0064] At this time, a rolling temperature during hot rolling may be controlled to make a microstructure homogeneous and fine in order to secure low-temperature impact toughness. More specifically, a rolling start temperature may be controlled to 1000 to 1100°C and a rolling end temperature may be controlled to 890 to 930°C.

[0065] If the rolling start temperature is less than 1000°C, the load during rolling may increase, and if the rolling start temperature is more than 1100°C, a draft in an unrecrystallized region may become excessive, which may degrade the low-temperature impact characteristics of the section steel.

[0066] If the rolling end temperature is lower than 890°C, coarse proeutectoid ferrite is formed on the surface of the steel material, which may reduce the strength of the steel material. On the other hand, if the rolling end temperature is more than 930°C, crystal grain growth may occur due to a high temperature, which may reduce impact toughness.

When the rolling end temperature is controlled to 890 to 930°C, a strain induced precipitation effect occurs due to rolling deformation to increase the precipitate fraction and enhance crystal grain refinement and precipitation strengthening effects.

[0067] In the section steel manufacturing method according to an embodiment of the present disclosure, the fourth step (S4) of cooling the hot rolled steel material may be performed, after the third step (S3). More specifically, the fourth step (S4) may be a step of air-cooling the hot rolled steel material.

Comparative Examples and Experimental Examples

[0068] Hereinafter, preferred Comparative Examples and Experimental Examples will be presented in order to assist the understanding of the present disclosure. However, the following Comparative Examples and Experimental Examples are intended only to help in understanding the present disclosure, and the present disclosure is not limited by the following Experimental Examples.

[0069] Table 1 below shows main alloy compositions and content ratios of vanadium (V) and nitrogen (N) constituting Comparative Examples and Experimental Examples of the present disclosure. Alloy components not shown in Table 1 below were added in equal amounts within the alloy composition range according to an embodiment of the present disclosure.

[0070] In addition, Table 2 below shows results of measuring the mechanical properties of Comparative Examples and Experimental Examples, which were manufactured by the section steel manufacturing method according to an embodiment of the present disclosure, using steel materials having the alloy compositions shown in Table 1. At this time, the manufacturing process conditions of Comparative Examples and Experimental Examples were all controlled under the same conditions as control variables.

[0071] The mechanical properties of Comparative Examples and Experimental Examples were measured according to EN ISO 6892-1 tensile test standard, EN ISO 2566-1 conversion of elongation values, and EN ISO 148-1 Metallic material-Charpy pendulum impact test.

[0072] In Tables below, a 'V/N ratio' refers to a content ratio of vanadium (V) and nitrogen (N) in wt%. 'TS' and 'YS' represent tensile strength and yield strength, respectively, and the unit used is MPa. In addition, 'EL' refers to elongation, and the unit used is %. 'CVN' represents Charpy impact absorption energy measured at 0°C, and the unit used is J.

[Table 1]

Classification	Main chemical component				V/N ratio
	C (%)	Mn (%)	V (%)	N (ppm)	
Comparative Example 1	0.11	1.42	0.103	160	6.44
Comparative Example 2	0.11	1.44	0.093	162	5.74
Experimental Example 1	0.11	1.49	0.068	158	4.31
Experimental Example 2	0.11	1.46	0.056	166	3.38
Comparative Example 3	0.11	1.42	0.023	161	1.43
Comparative Example 4	0.11	1.4	0.005	150	0.33

[Table 2]

Classification	Mechanical property			Impact toughness
	TS (MPa)	YS (MPa)	EL (%)	CVN (J)
Comparative Example 1	618	520	48	88
Comparative Example 2	616	512	47	120
Experimental Example 1	625	510	46	153
Experimental Example 2	605	486	45	145
Comparative Example 3	569	449	45	76
Comparative Example 4	555	426	43	22

[0073] Referring to Tables 1 and 2, it can be confirmed that in Comparative Examples 1 and 2, the content ratio of vanadium (V) and nitrogen (N) does not satisfy Equation 1 above. In addition, it can be confirmed that Comparative Examples 3 and 4 do not satisfy the vanadium (V) content according to an embodiment of the present disclosure, and the content ratio of vanadium (V) to nitrogen (N) does not satisfy Equation 1 above.

[0074] At this time, it can be confirmed that the Charpy impact absorption energies at 0°C of Comparative Examples 1 to 4 are lower than those of Experimental Examples 1 and 2 according to an embodiment of the present disclosure. In addition, it can be confirmed that Comparative Examples 3 and 4 do not satisfy the tensile strength of 570 to 720 MPa, yield strength of 460 MPa or higher, and Charpy impact absorption energy at 0°C of 130 J or higher, which are mechanical properties targeted by the present disclosure.

[0075] On the other hand, in the case of Experimental Examples 1 and 2, it can be confirmed that all the mechanical strengths targeted by the present disclosure are satisfied, and the Charpy impact absorption energies at 0°C are higher than those of Comparative Examples 1 to 4.

[0076] As described above, the prepared embodiments of the present disclosure have been described and it will be apparent to those skilled in the art that the present disclosure can be materialized in other specific forms without departing from the gist or scope in addition to the above-described embodiments. Therefore, the aforementioned embodiments are not limited but should be considered to be illustrative, and accordingly, the present disclosure is not limited to the above description and may be modified within the scope of the appended claims and a range equivalent thereto.

Claims

1. Section steel comprising: 0.11 to 0.18 wt% of carbon (C), 1.0 to 1.65 wt% of manganese (Mn), 0.01 to 0.11 wt% of vanadium (V), 40 to 200 ppm of nitrogen (N), and a balance of iron (Fe) and other inevitable impurities,

wherein a content ratio of the vanadium (V) and the nitrogen (N) satisfies Equation 1:

[Equation 1]

$$3.0 \leq [V]/[N] \leq 4.5$$

(However, [V] and [N] represent wt% of V and N, respectively.).

2. The section steel of claim 1, wherein yield strength (YS) is 460 MPa or more, tensile strength (TS) is 570 to 720 MPa, and elongation (EL) is 17% or more.
3. The section steel of claim 1, wherein Charpy impact absorption energy (CVN) at 0°C is 130 J or more.
4. The section steel of claim 1, wherein a carbon equivalent (Ceq) is 0.38 to 0.45%.
5. The section steel of claim 1, further comprising:
0.10 to 0.55 wt% of silicon (Si), 0.020 wt% or less (excluding 0 wt%) of phosphorus (P), 0.007 wt% or less (excluding 0 wt%) of sulfur (S), and 0.015 to 0.055 wt% of aluminum (Al).
6. A section steel manufacturing method comprising:
a first step of preparing a steel material including 0.11 to 0.18 wt% of carbon (C), 1.0 to 1.65 wt% of manganese (Mn), 0.01 to 0.11 wt% of vanadium (V), 40 to 200 ppm of nitrogen (N), and a balance of iron (Fe) and other inevitable impurities;
a second step of reheating the steel material;
a third step of forming a hot rolled steel material by hot rolling the steel material that has undergone the second step; and
a fourth step of cooling the hot rolled steel material.
7. The section steel manufacturing method of claim 6, wherein a reheating temperature is 1150 to 1300°C.
8. The section steel manufacturing method of claim 6, wherein a rolling start temperature is 1000 to 1100°C and a

rolling end temperature is 890 to 930°C.

9. The section steel manufacturing method of claim 6, wherein the steel material includes 0.10 to 0.55 wt% of silicon (Si), 0.020 wt% or less (excluding 0 wt%) of phosphorus (P), 0.007 wt% or less (excluding 0 wt%) of sulfur (S), and 0.015 to 0.055 wt% of aluminum (Al).

5

10

15

20

25

30

35

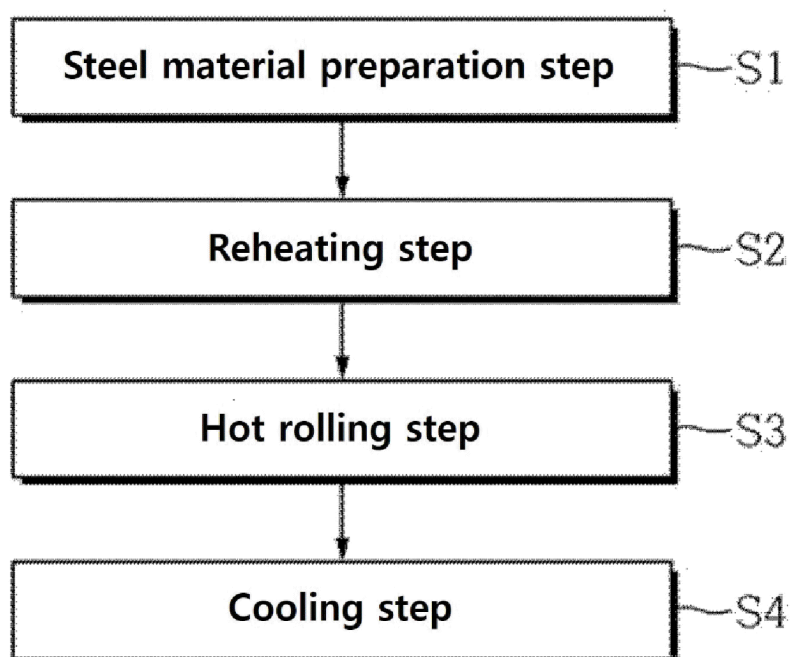
40

45

50

55

[FIG. 1]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2024/019127

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/04(2006.01)i; C22C 38/12(2006.01)i; C22C 38/00(2006.01)i; C21D 8/02(2006.01)i; C21D 9/46(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 38/04(2006.01); B21B 3/00(2006.01); C21D 8/00(2006.01); C21D 8/02(2006.01); C21D 9/00(2006.01);
C22C 38/00(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: 형강(Structural Steel), 탄소당량(Carbon Equivalent), 항복강도(Yield Strength), 인장강도(Tensile Strength), 바나듐(Vanadium), 질소(Nitrogen)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 10-088230 A (KAWASAKI STEEL CORP.) 07 April 1998 (1998-04-07) See claim 1 and table 2.	1-9
X	JP 10-306315 A (KAWASAKI STEEL CORP.) 17 November 1998 (1998-11-17) See claim 1.	1-9
A	KR 10-2015-0077550 A (HYUNDAI STEEL COMPANY) 08 July 2015 (2015-07-08) See paragraphs [0046]-[0066] and claim 1.	1-9
A	JP 2004-232091 A (JFE STEEL K.K.) 19 August 2004 (2004-08-19) See claims 1-7.	1-9
A	JP 2022-074057 A (JFE STEEL CORP.) 17 May 2022 (2022-05-17) See claims 1-7.	1-9

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

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“D” document cited by the applicant in the international application

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“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

06 March 2025

Date of mailing of the international search report

06 March 2025

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
Government Complex-Daejeon Building 4, 189 Cheongsaro, Seo-gu, Daejeon 35208

Facsimile No. +82-42-481-8578

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2024/019127

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
JP	10-088230	A	07 April 1998	JP	3635803	B2	06 April 2005
JP	10-306315	A	17 November 1998	JP	3369435	B2	20 January 2003
KR	10-2015-0077550	A	08 July 2015	None			
JP	2004-232091	A	19 August 2004	JP	3858907	B2	20 December 2006
JP	2022-074057	A	17 May 2022	None			

Form PCT/ISA/210 (patent family annex) (July 2022)