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(54) **V-N MICROALLOYED STEEL AND METHOD FOR PRODUCING V-N MICROALLOYED AND SURFACE-CRACK-FREE CONTINUOUS CASTING BLANK**

(57) Disclosed are a V-N microalloyed steel and a method for producing a V-N microalloyed and surface-crack-free continuous casting blank. The V-N microalloyed steel is composed of the following chemical components by mass percentage: 0.09%-0.13% of C, 0.1%-0.4% of Si, 1.0%-3.0% of Mn, less than or equal to 0.05% of P, less than or equal to 0.05% of S, 0.1%-0.4% of V, 0.011%-0.2% of N and the balance of Fe and unavoidable impurity elements. A continuous casting blank is subjected to component control according to the chemical components of the V-N microalloyed steel; and the production method therefor comprises converter smelt-

ing, LF refining and continuous casting steps in sequence. According to the present invention, by means of reasonable component design and smelting and continuous casting processes, the thermoplasticity of the continuous casting blank is improved, so that a high-temperature brittle region is prevented in a casting blank straightening region of the continuous casting blank or the thermoplasticity is good enough such that no surface crack appears, the casting blank is good in terms of surface quality and does not need to be cleaned, and the production efficiency is improved.

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Description**FIELD OF THE INVENTION**

5 [0001] The present invention belongs to the field of continuous casting technology and specifically relates to a method for producing V-N microalloyed and surface-crack-free continuous casting blank.

BACKGROUND OF THE INVENTION

10 [0002] Microalloyed steel is a kind of rapidly developing steel for engineering structures in nearly past half century. It plays a role in fine-grain strengthening and precipitation strengthening by adding various alloy elements (Nb, V, Ti, etc.) to the steel, thus improving the strength and toughness of the steel. It is widely used in various fields for example bridges, buildings, ships, automobiles, high-pressure vessels, etc., and has good application prospects. It is the main product in the modern steel industry. China has abundant reserves of microalloyed elements and has significant advantages in
15 developing microalloyed steel. Typical Q550 and Q460 grades low content alloy high-strength steel have good market applications.

[0003] In the industrial production process, microalloying is widely used due to the strengthening effect of microalloying elements. However, during the continuous casting process, the carbonitride precipitation of microalloying elements reduces the plasticity of steel, and the occurrence rate of surface cracks in continuous casting billets is significantly
20 higher than that of ordinary carbon steel casting blank. There are problems for example transverse cracks, longitudinal cracks, and shape cracks, so as to affect the quality of continuous casting billets and are not conducive to large-scale productions, which is a typical problem with microalloyed casting blank. Niobium, vanadium, and titanium are three relatively widely used elements in microalloyed steel, with niobium having the greatest impact on the plasticity of the steel and the most significant reduction in its thermoplastic properties. Researches have shown that the addition of Ti
25 element can reduce the brittleness of niobium and vanadium microalloyed steels, but it is not easy to control costs.

[0004] Therefore, taking into account both cost and the issue of cracks in microalloyed steel casting blanks, developing a low-cost, crack free production process for casting blanks is a typical process difficulty, which not only ensures the performance of microalloyed steel, ensures the normal operation of the continuous casting process, but also improves the surface quality of the casting blanks.
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SUMMARY

[0005] In response to the problem of prone to cracks on the surfaces of microalloyed steel casting blanks during continuous casting in existing technologies, the present invention provides a V-N microalloyed steel of surface-crack-free continuous casting blanks. Through reasonable composition design and smelting and continuous casting process,
35 a surface crack free continuous casting blanks with a cross-section of (150-350) mm * (1250-2400) mm is produced, which improves the surface quality of the continuous casting blanks.

[0006] To achieve the above objectives, the technical solution adopted by the present invention is as follows:
A V-N microalloyed steel composed by mass percentage of the following chemical components: C: 0.09-0.13%, Si:
40 0.1-0.4%, Mn: 1.0-3.0%, P: $\leq 0.05\%$, S: $\leq 0.05\%$, V: 0.1-0.4%, N: 0.011-0.2%, and the balance of Fe and unavoidable impurity elements.

[0007] The present invention takes the features of the low valley point of thermoplastic properties of vanadium containing steel, the chemical composition of microalloyed steel is reasonably designed, so as to reduce the occurrence of surface cracks on the casting blanks during continuous casting.

45 [0008] In the present invention, the V element has a very strong affinity with the N element, and combined with TMCP method in the later stage can play the role of increasing the strength and toughness of the structure through two typical strengthening mechanisms, fine grain strengthening and precipitation strengthening.

[0009] At the same time, some regions in China have abundant reserves of vanadium deposit, for example Chengde and Panzhihua, which have good cost advantages, and the price of N is relatively low. Therefore, using V-N microalloying
50 is beneficial for reducing the production cost of continuous casting blanks.

[0010] The present invention also provides a production method for V-N microalloyed surface-crack-free continuous casting blanks, wherein the casting blanks are produced according to the chemical composition of the V-N microalloyed steel mentioned above; and the method sequentially includes the following processes: converter smelting, LF refining, and continuous casting.

55 [0011] In the above production method, as a preferred embodiment (mode), the cross-sectional specification of the continuous casting blank is (150-350) mm * (1250-2400) mm.

[0012] In the above production method, as a preferred embodiment, in the converter smelting process, the molten iron proportion is controlled between 88.0% ~ 91.0% (for example, 88.0%, 89.0%, 90.0%, and 91.0%), and the top-

bottom combined blowing mode is used throughout the entire process, and nitrogen gas is blown first and then argon gas is blown later during the blowing process, to stir the molten steel and promote the chemical reaction in the furnace. Wherein, the argon blowing time shall not be less than 3 minutes (for example, 3 minutes, 5 minutes, 10 minutes, and 15 minutes).

[0013] In the above production method, as a preferred embodiment, in the converter smelting process, the blowing process adopts a one blow to end (one shot to bottom) blowing method without reblowing (supplementary blowing) process, so as to avoid excessive oxidation of molten steel and increase of inclusions during the reblowing process.

[0014] In the above production method, as a preferred embodiment, in the converter smelting process, the C content at the smelting endpoint is controlled between 0.09% ~ 0.13% (for example, 0.09%, 0.10%, 0.11%, 0.12%, and 0.13%), and the tapping temperature is between 1625 ~ 1645 °C (for example, 1625 °C, 1630 °C, 1635 °C, 1640 °C, and 1645 °C). The tapping temperature is determined based on the solidification temperature of the molten steel, the degree of superheat during the continuous casting process, and the process temperature drop, so as to ensure the smooth pouring of the continuous casting.

[0015] In the above production method, as a preferred embodiment, LF refining is performed after tapping without vacuum degassing; the purpose of not performing vacuum degassing is to ensure the content of N in the molten steel.

[0016] In the above production method, as a preferred embodiment, the continuous casting process adopts a weak water cooling method, so as to effectively reduce the occurrence of cracks on the casting blanks.

[0017] In the above production method, as a preferred embodiment, in the continuous casting process, protective casting is adopted, and the large ladle alarms at the end of casting and thus immediately close the nozzle. After the water port is closed, it is strictly prohibited to open it again. The intermediate ladle is covered with alkaline covering agent to ensure good liquid level coverage, and the crystallizer uses low-carbon steel casting powder.

[0018] In the above production method, as a preferred embodiment, the specific water flow of the continuous casting process is 0.7~1.25L/kg (for example, 0.7L/kg, 0.8Ukg, 1.0L/kg, 1.2L/kg, and 1.25Ukg).

[0019] In the above production method, as a preferred embodiment, in the continuous casting process, the degree of superheat of the continuous casting furnace is strictly controlled, and the degree of superheat of the molten steel is 10~25 °C (for example, 10 °C, 15 °C, 20 °C, and 25 °C).

[0020] In the above production method, as a preferred embodiment, in the continuous casting process, the casting speed is 1.0~1.3 m/minutes (for example, 1.0m/minute, 1.1m/minute, 1.2m/minute, and 1.3m/minute).

[0021] The control of low degree of superheat in the present invention is beneficial for improving casting speed (drawing speed), shortening pouring time, and reducing energy consumption; the tundish adopts alkaline covering agent to insulate the steel ladle and remove impurities from the steel ladle.

[0022] In the above production method, as a preferred embodiment, the protective slag in the continuous casting process is divided into powder slag layer, sintered layer, and liquid slag layer during the dissolution process.

[0023] In the above production method, as a preferred embodiment, deoxidation alloying is carried out during the tapping process in the converter smelting process, while slag washing is also carried out.

[0024] In the above production method, as a preferred embodiment, the specific operation method of deoxidation alloying during the tapping process in the converter smelting process is: during the tapping process, silicon containing substances are selected for deoxidation, with an addition amount of 3.5~4.0kg/ton of steel (for example, 3.5kg/ton of steel, 3.6kg/ton of steel, 3.8kg/ton of steel, and 4.0kg/ton of steel); silicon manganese and vanadium nitrogen alloys are selected for alloying, wherein the vanadium nitrogen alloy (V content not less than 75%) is added in amount of 1~2 kg/ton of steel (for example, 1kg/ton of steel, 1.2kg/ton of steel, 1.4kg/ton of steel, 1.6kg/ton of steel, 1.8kg/ton of steel, 2kg/ton of steel). The present invention does not use aluminum for deoxidation.

[0025] In the above production method, as a preferred embodiment, during the tapping process in the converter smelting process, the slag filtrating (washing) is carried out using a substance containing CaO (with a CaO content of not less than 90%), with an addition amount of 3.5~4.0kg/ton of steel (for example, 3.5kg/ton of steel, 3.6kg/ton of steel, 3.8kg/ton of steel, and 4.0kg/ton of steel). The substance containing CaO needs to be added before the molten steel reaches 3/4.

[0026] In the above production method, as a preferred embodiment, during the LF refining, in the early stage of LF refining, the argon blowing amount of argon stirring is 400~1000 L/minute (for example, 500 L/minute, 600 L/minute, 700 L/minute, 800 L/minute, and 900 L/minute), and the argon stirring time is 3~4 minutes (for example, 3 minutes, 3.2 minutes, 3.5 minutes, 3.8 minutes, and 4 minutes). During stirring, attention should be paid to not exposing the molten steel. And then silicon containing substances should be used for deoxidation, and fine tune the composition under the condition of argon stirring.

[0027] In the above production method, as a preferred embodiment, during the LF refining, weak argon stirring is adopted in the middle stage and end stage of LF refining, with the same argon blowing flow rate.

[0028] In the above production method, as a preferred embodiment, during the LF refining, in the end stage of LF refining, the argon blowing amount of argon stirring is 100~200 L/minute (for example, 120 L/minute, 140 L/minute, 160 L/minute, and 180 L/minute), and the time of argon stirring is ≥ 5 minutes; the total refining time is controlled within 40~50

minutes (for example, 40 minutes, 42 minutes, 45 minutes, 48 minutes, and 50 minutes), and the obtained N content is 100~2000 ppm (for example, 100 ppm, 500 ppm, 1000 ppm, 1500 ppm, 2000 ppm). The other component content meets the required molten steel composition content in the smelting process.

[0029] In the continuous casting process of the present invention, the different water volume distribution is selected based on the different specifications of the casting blanks and the composition of the steel grade during the continuous casting process.

[0030] In the above production method, as a preferred embodiment, during the continuous casting process, the specific distribution of water volume in the continuous casting process is as follows: the water volume in the inner and outer arcs of the wide-side foot-roller of the casting blank accounts for about 8.0~10.0% of the total water volume (for example, 8.0%, 8.5%, 9.0%, 9.5%, and 10.0%), the water volume in the narrow-side foot-roller accounts for 3.4~4.5% of the total water volume (for example, 3.4%, 3.8%, 4.0%, 4.2%, and 4.5%), and the water volume in the inner and outer arcs of the second zone of the vertical bending section accounts for 11.0~15.9% of the total water volume (for example, 11.0%, 12.0%, 13.0%, 14.0%, 15.0%, 15.5%, and 15.9%), the water volume in the inner and outer arcs of the third zone accounts for 13.0~15.9% of the total water volume (for example, 13.0%, 14.0%, 15.0%, 15.5%, and 15.9%), the water volume in the inner and outer arcs of the fourth zone accounts for 12.0~13.0% of the total water volume (for example, 12.0%, 12.2%, 12.5%, 12.6%, 12.8%, and 13.0%), the water volume in the inner and outer arcs of the fifth zone of arc section 1 accounts for 8.5~9.5% of the total water volume (for example, 8.0%, 8.5%, 9.0%, and 9.5%), the water volume in the inner and outer arcs of the sixth zone corresponding to arc sections 2 and 3 accounts for 12.0~14.0% of the total water volume (for example, 12.0%, 12.5%, 13.0%, 13.5%, 13.8%, and 13.0%), the water volume in the inner and outer arcs of the seventh zone of the sections 4~5 accounts for 8.0~11.5% of the total water volume (for example, 8.0%, 8.5%, 9.0%, 9.5%, 10.0%, 11.0%, 11.5%, and 10.0%), the water volume in the inner and outer arcs of the eighth zone of the straightening sections 6, section 7 and section 8 accounts for 8.0~11.5% of the total water volume (for example, 8.0%, 8.5%, 9.0%, 9.5%, 10.0%, 11.0%, 11.5%, and 10.0%), while the remaining water volume is allocated to the horizontal section.

[0031] In the present invention, the above technical features can be freely combined to form new technical solutions without conflicting with each other.

[0032] The steps and processes not detailed in the production methods provided by the present invention are conventional processes in the art.

[0033] Compared with the prior art, the beneficial effects of the present invention are:

the production method for V-N microalloyed and surface-crack-free continuous casting blank presented by the invention improves the thermoplastic properties of the continuous casting blanks through reasonable composition design of V-N microalloying, combined with appropriate smelting and continuous casting processes, avoiding high-temperature brittle zones or having sufficient thermoplastic properties in the straightening range of the blanks to prevent surface cracks from occurring. The surface quality of the billets is good, without the need for cleaning the casting blanks, and the production efficiency is improved.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0034] The following will provide a detailed explanation of the technical solution of the present invention in conjunction with embodiments. Each example is provided through the interpretation of the present invention rather than limiting it. In fact, those skilled in the art will be aware that modifications and variations can be made in the present invention without departing from the scope or spirit of the present invention. For example, features shown or described as part of one embodiment may be used in another embodiment to generate another embodiment. Therefore, it is expected that the present invention includes such modifications and variations within the scope of the accompanying claims and their equivalents.

[0035] According to the embodiment of the present invention, it provides a surface-crack-free continuous casting blanks V-N microalloyed steel. The V-N microalloyed steel is composed of the following chemical components by mass percentage: C: 0.09-0.13%, Si: 0.1-0.4%, Mn: 1.0-3.0%, P: $\leq 0.05\%$, S: $\leq 0.05\%$, V: 0.1-0.4%, N: 0.011-0.2%, and the balance of Fe and a small amount of unavoidable impurity elements. The present invention also provides a production method for preparing surface-crack-free microalloyed steel for continuous casting blanks with the above-mentioned chemical components, the method sequentially includes the following processes: converter smelting, LF refining, and continuous casting.

[0036] The alkaline covering agent and low-carbon steel protective slag used in the production process of the continuous casting blank of the present invention are commonly used commercial products for producing microalloyed steel.

[0037] Due to the carbonitride precipitates during continuous casting process, the plasticity of steel is decreased, the occurrence rate of surface cracks of continuous casting blank is significantly higher than that of ordinary carbon steel blank, and problems such as transverse cracks, longitudinal cracks, and shape cracks occur. In the smelting process of the invention, the contents of C are controlled, S is reduced, the use of a deoxidant is controlled, the inclusion

morphology is changed, and the purity of steel is improved. In combination with LF refining and reasonable continuous casting process, a microalloyed steel with fine grains and good plasticity is obtained, thereby reducing the occurrence of surface cracks in a continuous casting blank of microalloyed steel, improving the surface quality of a continuous casting blank.

Example 1

[0038] This example provides a V-N microalloyed continuous casting blank and its production method, and the chemical composition of the continuous casting blank is shown in Table 1 by mass percentage.

Table 1 The chemical component of the V-N microalloyed continuous casting blank from Example 1

Example	chemical component (wt%), the balance of Fe and unavoidable impurity elements						
	C	Si	Mn	P	S	V	N
1	0.10	0.23	1.62	0.014	0.007	0.12	0.012

[0039] The production method sequentially includes the following processes: converter smelting, LF refining and continuous casting.

(1) Converter smelting:

[0040] During a converter smelting process, a 120t converter is used for smelting, the smelting raw materials are molten iron and steel scrap, and the ratio of molten iron is controlled at 90%; nitrogen gas is used for blowing in the early stage of blowing and argon gas used for blowing in the later stage with 4 minutes of the argon gas blowing, and a gun-to-bottom type for blowing is carried out in the blowing process, absolutely eliminating the supplementary blowing process, thereby preventing the molten steel from being peroxidized so as to improve the cleanliness of the molten steel.

[0041] The C content at the smelting endpoint is controlled at 0.10wt%, and the tapping temperature is 1632 °C; deoxidation alloying and slag filtrating are carried out during tapping, silicon containing material is selected as deoxidizing agent with the addition amount of about 3.6kg/t steel; the alloyed raw material is vanadium nitrogen alloy (with a V content of 77 wt%) with an addition of about 1.6kg/ton of steel; and a substance containing CaO is selected for slag filtrating (with a CaO content of 90 wt%) with an added amount of 3.8kg/ton of steel.

(2) LF refining:

[0042] The steel ladle is directly transferred to the LF refining station for argon blowing refining after tapping; in the early stage of refining, the argon blowing rate at 400L/minute is selected for argon blowing stirring for 3 minutes, then silicon containing substances are added for deoxygenation, and a small amount of silicon manganese is added to adjust the Mn content; at the end stage of refining, the argon blowing rate is adjusted to 150L/minute and stirred for 6 minutes; the total refining time is controlled at 45 minutes, the N content obtained is 120 ppm and the content of other components meets the requirements of molten steel composition in the composition control process.

(3) Continuous casting:

[0043] In the protective casting process, the large ladle is protected with a long water port and a conical asbestos pad is added to ensure the air-tightness of the connection.

[0044] After the casting starts, a coal gas flame is firstly used to check air-tightness of the lower water port of the ladle and the bowl part of long water port. If the flame is sucked in, it indicates poor sealing at this location, and a new long water port is jointed. If the air-tightness meets the requirements, argon gas is introduced into the bowl part connection of the long water port to form an argon sealing state during the pouring process, further preventing oxygen and nitrogen increase in the molten steel caused by the loose connection between the bowl part of long water port and the lower water port of the ladle due to air intake.

[0045] Immediately close the water port when the large ladle alarmed at the end of pouring. It is strictly prohibited to reopen the water port after it is closed. The tundish is covered with alkaline covering agent, and the crystallizer is protected with low-carbon steel protective slag (special P0050 of Shinagawa 250).

[0046] This example is the third furnace for casting, that is, a third furnace steel which is cast after the start of continuous casting. The degree of superheat is 20 °C, and the actual drawing speed is 1.1m/minute.

[0047] During the continuous casting process, the specific distribution of water volume with a specific water flow

(specific amount of water) of 1.2 Ukg is as follows: the amount of water in the inner and outer arcs of the wide-side foot-roller of the casting blank accounts for about 8.6% of the total amount of water, the amount of water in the narrow-side foot-roller accounts for 3.5% of the total amount of water, and the amount of water in the inner and outer arcs of the second zone of the vertical bending section accounts for 15.8% of the total amount of water, the water volume in the inner and outer arcs of the third zone accounts for 15.6% of the total water volume, the water volume in the inner and outer arcs of the fourth zone accounts for 12.9% of the total water volume, the water volume in the inner and outer arcs of the fifth zone of arc section 1 accounts for 9.3% of the total water volume, the water volume in the inner and outer arcs of the sixth zone corresponding to arc sections 2 and 3 accounts for 12.4% of the total water volume, the water volume in the inner and outer arcs of the seventh zone of the sections 4~5 accounts for 8.1% of the total water volume, the water volume in the inner and outer arcs of the eighth zone of the straightening sections 6, section 7 and section 8 accounts for 8.9% of the total water volume, while the remaining water volume is allocated to the horizontal section.

[0048] Implementation effect: The continuous casting blank obtained from the multi furnace steel cast by the above method has a cross-sectional area of 200mm * 2000mm, good surface quality, no cracks detected at low magnification, and no cracks observed on the surface of the casting blank during hot state observation, without the need for casting blank cleaning.

Example 2

[0049] This example provides a V-N microalloyed continuous casting blank, and the chemical composition of the continuous casting blank is shown in Table 2 by mass percentage.

Table 2 The chemical component of the V-N microalloyed continuous casting blank from Example 2

Example	chemical component (wt%), the balance of Fe and unavoidable impurity elements						
	C	Si	Mn	P	S	V	N
2	0.09	0.40	1.00	0.014	0.006	0.25	0.032

[0050] The production method sequentially includes the following processes: converter smelting, LF refining, and continuous casting.

(1) Converter smelting:

[0051] During a converter smelting process, a 120t converter is used for smelting, the smelting raw materials are molten iron and steel scrap, and the ratio of molten iron is controlled at 89%; nitrogen gas is used for blowing in the early stage of blowing and argon gas used for blowing in the later stage with 3 minutes of the argon gas blowing, and a gun-to-bottom type for blowing is carried out in the blowing process, absolutely eliminating the supplementary blowing process.

[0052] The C content at the smelting endpoint is controlled at 0.09t%, and the tapping temperature is 1630 °C.

[0053] Deoxidation alloying and slag filtrating are carried out during tapping, and silicon containing material is selected as deoxidizing agent (that is, silicon carbide) with the addition amount of about 3.8 kg/t steel; the alloyed raw material is vanadium nitrogen alloy (with a V content of 77 wt%) with an addition of about 1.3 kg/ton of steel; and a substance containing CaO is selected for slag filtrating (with a CaO content of 90 wt%) with an added amount of 3.6 kg/ton of steel.

(2) LF refining:

[0054] The steel ladle is directly transferred to the LF refining station for argon blowing refining after tapping, in the early stage of refining, the argon blowing rate at 400 L/minute is selected for argon blowing stirring for 4 minutes, and then silicon containing substances are added for deoxygenation; at the end stage of refining, the argon blowing rate is adjusted to 150L/minute and stirred for 7 minutes; the total refining time is controlled at 48 minutes, the N content obtained is 100 ppm, and the content of other components meets the requirements of molten steel composition in the composition control process.

(3) Continuous casting:

[0055] In the protective casting process, the large ladle is protected with a long water port and a conical asbestos pad is added to ensure the air-tightness of the connection. After the casting starts, a coal gas flame is firstly used to check air-tightness of the lower water port and the bowl part of the long water port. If the flame is sucked in, it indicates poor

sealing at this location, and a new long water port is jointed. If the air-tightness meets the requirements, argon gas is introduced into the bowl part connection of the long water port to form an argon sealing state during the pouring process, further preventing oxygen and nitrogen increase in the molten steel caused by the loose connection between the long water port bowl part and the lower water port of the ladle due to air intake. Immediately close the water port when the large ladle alarmed at the end of pouring. It is strictly prohibited to reopen the water port after it is closed. The tundish is covered with alkaline covering agent, and the crystallizer is protected with low-carbon steel protective slag (special P0027-3 of Shinagawa 250).

[0056] This example is the fourth furnace of steel poured after the continuous casting start. The degree of superheat is 15 °C, and the actual drawing speed is 1.2m/minute.

[0057] During the continuous casting process, the specific distribution of water volume with a specific water flow of 1.0L/kg is as follows: the water volume in the inner and outer arcs of the wide-side foot-roller of the casting blank accounts for about 8.1% of the total water volume, the water volume in the narrow-side foot-roller accounts for 4.3% of the total water volume, and the water volume in the inner and outer arcs of the second zone of the vertical bending section accounts for 11.4% of the total water volume, the water volume in the inner and outer arcs of the third zone accounts for 13.1% of the total water volume, the water volume in the inner and outer arcs of the fourth zone accounts for 12% of the total water volume, the water volume in the inner and outer arcs of the fifth zone of arc section 1 accounts for 9.0% of the total water volume, the water volume in the inner and outer arcs of the sixth zone corresponding to arc sections 2 and 3 accounts for 13.6% of the total water volume, the water volume in the inner and outer arcs of the seventh zone of the sections 4~5 accounts for 11.2% of the total water volume, the water volume in the inner and outer arcs of the eighth zone of the straightening sections 6, section 7 and section 8 accounts for 11.3% of the total water volume, while the remaining water volume is allocated to the horizontal section.

[0058] Implementation effect: The continuous casting blank obtained from the multi furnace steel cast by the above method has a cross-sectional area of 250 mm * 1800 mm, good surface quality, no cracks detected at low magnification, and no cracks observed on the surface of the casting blank during hot state observation, without the need for casting blank cleaning.

[0059] The above is only a preferred embodiment of the present invention and is not intended to limit the present invention. For those skilled in the art, the present invention may undergo various modifications and variations. Any modifications, equivalent substitutions, improvements, etc. made within the spirit and principles of this invention shall be included within the scope of protection of this invention.

Claims

1. A V-N microalloyed steel, **characterized in that** the V-N microalloyed steel consists of the following chemical components by mass percentage: C: 0.09-0.13%, Si: 0.1-0.4%, Mn: 1.0-3.0%, P: $\leq 0.05\%$, S: $\leq 0.05\%$, V: 0.1-0.4%, N: 0.011-0.2%, and the balance of Fe and unavoidable impurity elements.
2. A production method for V-N microalloyed surface-crack-free continuous casting blanks, **characterized in that** the casting blanks are produced according to the chemical components of the V-N microalloyed steel according to claim 1; the method includes the following processes in sequence: converter smelting, LF refining and continuous casting.
3. The production method according to claim 2, **characterized in that** a cross-sectional specification of the continuous casting blanks is (150-350) mm * (1250-2400) mm.
4. The production method according to claim 2 or claim 3, **characterized in that** in the converter smelting process, a molten iron proportion is controlled between 88.0 wt% - 91.0 wt%, a top-bottom combined blowing mode is used throughout entire process, and nitrogen gas is blown first and then argon gas is blown later during blowing process, wherein an argon-blowing time shall not be less than 3 minutes;
preferably, the blowing process adopts a one blow to end blowing mode without reblowing process;
preferably, a C content at smelting endpoint is controlled between 0.09 - 0.13 wt%, and a tapping temperature is between 1625 - 1645 °C
5. The production method according to claim 4, **characterized in that** LF refining is performed after tapping, and the refining is without vacuum degassing.
6. The production method according to claim 5, **characterized in that** in the continuous casting process, a weak water cooling mode is adopted in continuous casting; in the continuous casting process, protective casting is adopted,

water port is closed immediately while large ladle alarms at the end of casting, reopening the water port is strictly prohibited after the water port is closed, an intermediate ladle is covered with alkaline covering agent, and a crystallizer uses low-carbon steel protective slag;

preferably, an specific amount of water in the continuous casting process is 0.7~1.25 L/kg;
preferably, a superheat degree of molten steel is 10~25 °C;
further preferably, a casting speed during continuous casting process is 1.0~1.3 m/minute.

7. The production method according to claim 4, **characterized in that** deoxidation alloying is carried out during tapping process in the converter smelting process, while slag filtrating is also carried out;

preferably, a specific operation method of the deoxidation alloying is as follows: during tapping process, a silicon containing substance is selected for deoxidation with an addition amount of 3.5~4.0kg/ton of steel; and silicon manganese and vanadium nitrogen alloys are selected for alloying, wherein an addition amount of the vanadium nitrogen alloy is 1~2 kg/ton of steel;
preferably, the slag filtrating is carried out using a substance containing CaO with an addition amount of 3.5~4.0 kg/ton of steel, and the substance containing CaO needs to be added before molten steel reaches 3/4.

8. The production method according to claim 5, **characterized in that** in the LF refining process, in an early stage of LF refining, an argon-blowing amount for argon-blowing stirring is 400~1000 L/minute, an argon-blowing stirring time is 3~4 minutes, a silicon containing substance should be used for deoxidation, and the components are fine-tuned under the condition of argon-blowing stirring,.

9. The production method according to claim 8, **characterized in that** in the LF refining process, at the end of LF refining, an argon-blowing amount for argon-blowing stirring is 100~200 L/minute, and a time of argon-blowing stirring is ≥ 5 minutes; a total refining time is controlled within 40~50 minutes, and N content obtained is 100~2000 ppm.

10. The production method according to claim 6, **characterized in that** in the continuous casting process, a specific distribution of water volume in the continuous casting process is as follows: a water volume in inner and outer arcs of a wide-side foot-roller of the casting blank accounts for about 8.0~10.0% of the total water volume, a water volume in a narrow-side foot-roller accounts for 3.4~4.5% of the total water volume, and a water volume in inner and outer arcs of a second zone of a vertical bending section accounts for 11.0~15.9% of the total water volume, a water volume in inner and outer arcs of a third zone accounts for 13.0~15.9% of the total water volume, a water volume in inner and outer arcs of a fourth zone accounts for 12.0~13.0% of the total water volume, a water volume in inner and outer arcs of a fifth zone of arc section 1 accounts for 8.5~9.5% of the total water volume, a water volume in inner and outer arcs of a sixth zone corresponding to arc sections 2 and 3 accounts for 12.0~14.0% of the total water volume, a water volume in inner and outer arcs of a seventh zone of sections 4~5 accounts for 8.0~11.5% of the total water volume, a water volume in inner and outer arcs of a eighth zone of straightening section 6, section 7 and section 8 accounts for 8.0~11.5% of the total water volume, and a remaining water volume is allocated to a horizontal section.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2021/118337

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/12(2006.01)i; C21C 5/30(2006.01)i; C21C 7/06(2006.01)i; C21C 7/072(2006.01)i; B22D 11/22(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; C21C; B22D

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

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

CNABS; CNTXT; DWPI; SIPOABS; CNKI; USTXT; EPTXT; WOTXT; ISI Web of Knowledge; 万方; 超星读秀; 莱钢钢铁集团银山型钢有限公司, 钒, 氮, 微合金, 连铸, 中间包, 大包, 浇铸, 覆盖剂, 转炉, LF精炼, V, N, vanadium, nitrogen, microalloy +, surface crack, continuous, casting, pouring, converter, refining

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 111996466 A (LAIWU STEEL GROUP YINSHAN SECTION STEEL CO., LTD.) 27 November 2020 (2020-11-27) claims 1-10	1-10
Y	杨应东 等 (YANG, Yingdong et al.). "氮含量控制对S450J0-T热轧H型钢表面裂纹的影响 (Effect of Nitrogen Content Control on Surface Cracks of S450J0-T Hot-rolled H-shaped steel)" 《上海金属》 (Shanghai Metals), Vol. 40, No. 3, 31 May 2018 (2018-05-31), ISSN: 1001-7208, page 70, 1.2 Procedure Standard, table 1, page 72, table 2	1-10
Y	CN 1405351 A (ANYANG IRON & STEEL CO., LTD.) 26 March 2003 (2003-03-26) description page 1 lines 6-20, 26-28, page 2 line 2- page 3 line 23	1-10
A	CN 109852891 A (SHANGHAI MEISHAN IRON & STEEL COMPANY et al.) 07 June 2019 (2019-06-07) entire document	1-10

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

* Special categories of cited documents:

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2021/118337

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)		Publication date (day/month/year)
CN	111996466	A	27 November 2020	None		
CN	1405351	A	26 March 2003	CN	1218060	C 07 September 2005
CN	109852891	A	07 June 2019	CN	109852891	B 08 January 2021

Form PCT/ISA/210 (patent family annex) (January 2015)