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(54) **REBAR AND PREPARATION METHOD THEREOF**

(57) The present invention relates to a steel rebar comprising the following ingredients: 0.005%-0.030% of C, 0.3%-0.6% of Si, 1.2%-2.5% of Mn, 0.01 % or less of P, 0.01 % or less of S, 8.0%-10.0% of Cr, 1.0%-3.0% of Mo, 0.2%-0.4% of Sn, 0.01 %-0.05% of Rare Earth element, and the remainder being Fe and unavoidable impurities. The present invention also provides a production method of steel rebar. The steel rebar of the present invention has excellent comprehensive mechanical properties and corrosion resistance performance, while meeting the requirements of anti-knock, the service life in sea water of the steel rebar is increased, thus it can be widely used in reinforced concrete structures in ocean environment.

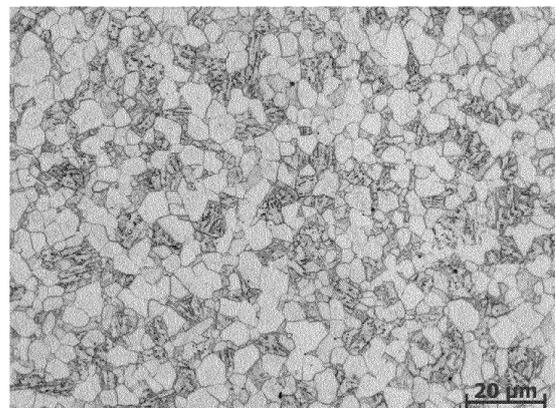


FIG. 1

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Description**Technical Field**

5 **[0001]** The present invention relates to a steel rebar and a production method thereof, which pertains to the field of alloy steel.

Background of the Invention

10 **[0002]** Along with consciousness enhancing of ocean strategy of various countries and development of modern ocean science and technology, constructions of infrastructure such as huge cross-river or cross-sea bridges, seaport wharfs, and offshore buildings are entering into a peak season. Meanwhile, the durability problem of steel rebar used as a main structural material becomes increasingly prominent. The ocean environment is a relatively harsh corrosion environment in the nature, with its special conditions of high temperature, high humidity, and high salinity easily causing corrosion of steel. Severe corrosion usually occurs in the reinforced concrete structures along the coast of China after 10-15 years on service, which results in damage to the structures, rendering the structures unable to meet their designed service life of 50 years.

15 **[0003]** There are two major ways to increase the corrosion resistance performance of steel rebar in a concrete structure: the first way is applying organic or inorganic coatings onto carbon steel rebar, while the second way is alloying or various processing techniques to obtain steel rebar materials with excellent corrosion resistance performance. Among coated corrosion resistant steel rebar products, epoxy coated steel rebar is researched earliest and used most widely, however, epoxy coated steel rebar has essential disadvantages reflected as: the coating has high brittleness, and is easily damaged and shed off during transporting and processing; defects in the coating might cause concentrated corrosion which leads to severe local corrosion; the bond stress between epoxy coated steel rebar and concrete is reduced as compared to ordinary steel rebar, etc. In European and American countries, in order to allow the service life of structures to reach the design requirement of 100 years, stainless steel rebar is developed, and because the critical concentration causing its corrosion is increased a lot compared to ordinary steel rebar, the durability of concrete structures is greatly increased. But its cost is expensive, at about 6-10 times that of ordinary carbon steel rebar, therefore, it cannot be used for large scale application in engineering, and is normally used only at key positions of structures or in relatively harsh environments. Furthermore, macro cell corrosion easily occurs when stainless steel rebar is overlapped with ordinary steel rebar, which also adversely affect the service life of structures.

20 **[0004]** Research and development of non-rebar low alloy corrosion resistant steel is relatively mature both at home and abroad. Marine Steel is developed in U. S. in 1950s, APS20A Steel is developed in France in 1960s, and sea water corrosion resistant 10CrMoAl steel is developed in China in 1970s. Corrosion resistance performances of these steels are enhanced to a great extent compared to ordinary carbon steel, but they still cannot meet the prolonged service life required in reinforced concrete structures. Therefore, all of these types of steels cannot be used in oceanic reinforced concrete structures.

25 **[0005]** Chinese patent literature CN102605255A disclosed a 400MPa level corrosion resistant steel rebar comprising element ingredients of: 0.1%-0.25% of C, 0.5%-0.90% of Si, 0.7%-1.5% of Mn, 0.04%-0.09% of P, 0.015% or less of S, 0.3%-0.6% of Cu, 0.1%-0.4% of Ni, 0.1% of Cr, and 0.03%-0.08% of V. Its corrosion resistance performance is increased by 2 times compared to ordinary steel rebar, but the increment is still too limited to meet the service life requirement of 50-100 years for oceanic reinforced concrete structures.

Summary of the Invention

30 **[0006]** Therefore, a technical problem to be solved by the present invention is to overcome the technical defects in prior art that steel rebar has poor corrosion resistance performance in ocean environment and cannot meet the designed service life of reinforced concrete structures, by providing a steel rebar with excellent corrosion resistance performance and comprehensive mechanical properties as well as a production method thereof.

35 **[0007]** In order to solve the above-mentioned technical problem, the present invention provides a steel rebar comprising the following ingredients calculated in weight percentage:

40 0.005%-0.030% of C,
0.3%-0.6% of Si,
45 1.2%-2.5% of Mn,
0.01% or less of P,
0.01% or less of S,
50 8.0%-10.0% of Cr,

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1.0%-3.0% of Mo,
0.2%-0.4% of Sn,
0.01%-0.05% of Rare Earth element, and
the remainder being Fe and unavoidable impurities.

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[0008] Preferably, there is provided a steel rebar with a 400MPa level yield strength comprising the following ingredients calculated in weight percentage:

0.005%-0.030% of C,
0.3%-0.6% of Si,
1.2%-1.8% of Mn,
0.01% or less of P,
0.01% or less of S,
8.0%-10.0% of Cr,
1.0%-1.6% of Mo,
0.2%-0.4% of Sn,
0.01%-0.05% of Rare Earth element, and
the remainder being Fe and unavoidable impurities.

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[0009] There is provided a steel rebar comprising the following ingredients calculated in weight percentage:

0.005%-0.030% of C,
0.3%-0.6% of Si,
1.2%-2.5% of Mn,
0.01% or less of P,
0.01% or less of S,
8.0%-10.0% of Cr,
1.0%-3.0% of Mo,
0.2%-0.4% of Sn,
0.01%-0.05% of Rare Earth element,
0.04%-0.18% of V and/or 0.010%-0.030% of Ti,
and the remainder being Fe and unavoidable impurities.

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[0010] Preferably, there is provided a steel rebar with a 500MPa level yield strength comprising the following ingredients calculated in weight percentage:

0.005%-0.030% of C,
0.3%-0.6% of Si,
1.7%-2.5% of Mn,
0.01% or less of P,
0.01% or less of S,
8.0%-10.0% of Cr,
1.5%-2.0% of Mo,
0.2%-0.4% of Sn,
0.01%-0.05% of Rare Earth element,
0.04%-0.08% of V, and
the remainder being Fe and unavoidable impurities.

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[0011] More preferably, there is provided a steel rebar with a 600MPa level yield strength comprising the following ingredients calculated in weight percentage:

0.005%-0.030% of C,
0.3%-0.6% of Si,
1.7%-2.5% of Mn,
0.01% or less of P,
0.01% or less of S,
8.0%-10.0% of Cr,
1.8%-3.0% of Mo,

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0.2%-0.4% of Sn,
 0.01%-0.05% of Rare Earth element,
 0.10%-0.18% of V,
 0.010%-0.030% of Ti, and
 the remainder being Fe and unavoidable impurities.

[0012] The steel rebar has a microscopic structure composed of ferrite and bainite, with the ferrite accounting for a percentage of 50%-70%.

the steel rebar has a ratio of tensile strength to yield strength at greater than 1.25, a maximum stress total elongation percentage greater than 9%, an after-fracture elongation percentage greater than 18%, a corrosion rate by cyclic immersion corrosion test at less than 0.45m²h, and a corrosion rate by salt spray corrosion test at less than 0.45m²h.

[0013] Moreover, the present invention also provides a production method of steel rebar comprising the following steps:

S1: performing preliminary desulfurization of molten iron to control the sulfur content at no more than 0.01%;

S2: performing smelting in a convertor, by feeding the molten iron processed by Step S1 together with steel scrap and/or pig iron into a convertor to be smelted, thus obtaining steel with a carbon content less than 0.05% and a phosphorus content less than 0.01% for steel tapping;

S3: performing steel tapping, during the process of which, alloying elements of Si and Mn are added for deoxygenation and carbon powder and slag former are also added;

S4: performing refining outside the convertor, by adding Cr element and meanwhile performing decarburization by blowing oxygen in an RH vacuum refining furnace so as to control the Cr and C contents within the required range; performing deoxygenation with an LF furnace, adding the required alloying elements of Mn, Mo, Sn, Rare Earth, as well as V and/or Ti, into the steel after deoxygenation, and then adding calcium-ferrum alloy under soft stirring by blowing inert gas, so as to control contents of these elements within the required range; raising the temperature of the molten steel and adding a cover agent;

S5: performing continuous casting, by casting the molten steel under protective casting with a continuous casting machine to form a continuous casting slab;

S6: performing rolling, by heating the continuous casting slab to a temperature higher than its austenitization temperature in a heating furnace, rough rolling, moderate rolling, precision rolling, and placing the rolled steel after precision rolling onto a cooling bed for air cooling, so as to produce a finished product of steel rebar with the required ingredients.

[0014] In Step S2, the steel for steel tapping has a temperature no higher than 1690°C.

[0015] In Step S4, the decarburization by blowing oxygen is performed at a temperature no lower than 1605°C during refining in the RH vacuum refining furnace, the deoxygenation is performed at a temperature no lower than 1575°C during refining in the LF furnace to control the oxygen content at 0.002%-0.005%, the soft stirring is performed for a duration no less than 5min, and the temperature of the molten steel is raised to 1570-1600°C.

[0016] In Step S6, the continuous casting slab is heated to 1100-1200°C in the heating furnace, the temperature when the rolled steel is initially placed onto the cooling bed is 900-960°C, the start rolling temperature before the rough rolling is 1030-1100°C, and the temperature during the precision rolling is 950-1050°C.

[0017] In the steel, C is an important strengthening element mainly existing in the form of carbide to provide functions of precipitation hardening and crystal grain refining. However, C has a strong affinity with Cr, and may form a series of complicated carbides with Cr. The formation of such carbides would reduce corrosion resistance of steel at the same time of increasing hardness of steel. Furthermore, too much content of C would reduce plasticity and toughness of steel, thus deteriorating welding performance of steel.

[0018] Si is an important reducing agent and deoxidizing agent, and when added into steel, Si can significantly increase elastic limit, yield point and tensile strength of steel. When Si is combined with Mo, W, Cr, etc., it has certain function to increase corrosion resistance and oxidation resistance. But increasing the content of Si would reducing welding performance of steel.

[0019] Mn is a good deoxidizing agent and desulfurizing agent, provides a function of solid solution strengthening in steel, is an important strengthening element, and at the same time is an austenite forming element. However, too much content of Mn would significantly increase hardenability of steel, thus reducing plasticity and weldability of steel. In the aspect of corrosion resistance performance, the function of Mn is not notable.

[0020] S and P are harmful impurity elements during steelmaking process, because they easily form harmful inclusions in steel, which reduces toughness and plasticity of steel. Some weathering resistant steel adopts an ingredient design of Cu-P system. but the increment of its corrosion resistance is limited, while P easily forms segregation at grain boundaries which increases brittleness of steel. Therefore, the present invention adopts very low contents of S and P within a range no more than 0.01%.

[0021] Cr is an important element which increases oxidation resistance and corrosion resistance, and by forming a stable passive film on the steel surface under suitable environmental conditions, Cr can increase corrosion resistance performance of steel. However, the function of Cr in a non-oxidative medium is not as notable as Mo or Ni. Solely adding Cr element cannot greatly enhance sea water corrosion resistance performance of steel, but instead would increase susceptibility to pitting corrosion tendency.

[0022] Mo may generally increase corrosion resistance performance of steel, by causing passivation of the steel surface in both reductive acids and strong oxidative salt solutions, and Mo can also prevent steel from pitting corrosion in chloride solutions. When the content of Mo is relatively high (>3%), oxidation resistance of steel deteriorates. In the aspect of structure property, Mo can promote crystal grain refining and increase hardenability and heat resistance of steel.

[0023] Sn is a corrosion resistant metal which does not oxidize in air at normal temperature and, when heated intensely, stabilizes by forming stannic oxide protective film on its surface. In addition, Sn is stable towards water, can slowly dissolve in a dilute acid, and quickly dissolves in a concentrated acid. Sn is mainly used for manufacturing alloy and producing tin plates. When added as an alloying element to form a solid solution in a matrix, Sn can increase the electrode potential of the matrix, reduce the driving force of electrochemical corrosion of steel itself, lower the corrosion rate, and also cause an increasing tendency of strength and hardness of steel. When Sn interacts with Cr and Mo, they can significantly increase corrosion resistance performance of steel.

[0024] Rare Earth element may notably increase the overall corrosion resistance performance of steel when added into steel at a proper amount. The important materialogy reasons for improvement on corrosion resistance performance of steel includes the functions of Rare Earth element in purifying molten steel, metamorphic inclusions, and improving microstructure conditions and grain boundary conditions. Solid solutions of Rare Earth element in steel can increase the polarization resistance and self-corrosion potential of steel matrix, which is beneficial for increasing corrosion resistance performance of steel matrix.

[0025] Compared to prior art, the aforementioned technical solution of the present invention has the following advantages:

(1) In the steel rebar of the present invention, the content of C is controlled at 0.005%-0.030%, the content of Si is controlled at 0.3%-0.6%, the content of Mn is controlled at 1.2%-2.5%, the contents of impurity elements S and P are both controlled at no more than 0.001%, and 8.0%-10.0% of Cr, 1.0%-3.0% of Mo, 0.01%-0.05% of Rare Earth element are added, accompanied by adding 0.2%-0.4% of Sn. By providing a reasonable ratio of element ingredients, as well as interaction between Cr and Sn, the corrosion resistance performance of the steel product is significantly increased, and the added Mo and Rare Earth element improve pitting corrosion resistance and inter-granular corrosion resistance of the steel product, thereby greatly improving the sea water corrosion resistance performance of the steel rebar and increasing the service life of the steel rebar in sea water.

(2) In the steel rebar of the present invention, there contains 0.005-0.030% of C, 0.3%-0.6% of Si, 1.2%-1.8% of Mn, 0.01 % or less of P, 0.01 % or less of S, 8.0%-10.0% of Cr, 1.0%-1.6% of Mo, 0.2%-0.4% of Sn, 0.01%-0.05% of Rare Earth element, and the remainder being Fe and unavoidable impurities. By providing a reasonable ingredient design, a 400MPa level corrosion resistant steel rebar is produced, so as to obtain a steel rebar which is low-cost, able to meet requirements of basic mechanical properties, and resistant to sea water corrosion.

(3) In the steel rebar of the present invention, there contains 0.005%-0.030% of C, 0.3%-0.6% of Si, 1.2%-2.5% of Mn, 0.01 % or less of P, 0.01 % or less of S, 8.0%-10.0% of Cr, 1.0%-3.0% of Mo, 0.2%-0.4% of Sn, 0.01%-0.05% of Rare Earth element, 0.04%-0.18% of V and/or 0.010%-0.030% of Ti, and the remainder being Fe and unavoidable impurities. Micro-alloying elements V and/or Ti are further added into steel. V is a micro-alloying element that can cause a V(C,N) compound to precipitate out during the rolling process, which prevents austenite and ferrite from growing and has relatively strong effects of precipitation strengthening and refined crystalline strengthening as well as certain effect of solid solution strengthening, thereby significantly increase the strength of steel and thus compensating for the defect of insufficient strength due to low carbon content. Ti is a strong forming element of carbonitride with effects of refining crystal grain structure and precipitation strengthening. Meanwhile, because carbon preferentially reacts with Ti to produce carbon titanium compounds, the precipitation of chromium carbide in chromium-containing steel which causes chromium depletion at grain boundaries is avoided, thereby effectively preventing inter-granular corrosion. By solid solution strengthening, refined crystalline strengthening, and precipitation strengthening as V(C,N) and/or Ti(C,N) are produced, the micro-alloying elements V and/or Ti increase the strength of steel and endow the steel rebar with excellent mechanical properties.

(4) In the steel rebar of the present invention, by controlling the element contents in steel, especially the contents of micro-alloying elements V and/or Ti, steel products that meet various strength requirements are produced. For instance, in a steel rebar with a 500MPa level yield strength, there contains 0.005%-0.030% of C, 0.3%-0.6% of Si,

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1.7%-2.5% of Mn, 0.01 % or less of P, 0.01 % or less of S, 8.0%-10.0% of Cr, 1.5%-2.0% of Mo, 0.2%-0.4% of Sn, 0.01%-0.05% of Rare Earth element, 0.04%-0.08% of V, and the remainder being Fe and unavoidable impurities; for another instance, in a steel rebar with a 600MPa level yield strength, there contains 0.005%-0.030% of C, 0.3%-0.6% of Si, 1.7%-2.5% of Mn, 0.01 % or less of P, 0.01 % or less of S, 8.0%-10.0% of Cr, 1.8%-3.0% of Mo, 0.2%-0.4% of Sn, 0.01%-0.05% of Rare Earth element, 0.10%-0.18% of V, 0.010%-0.030% of Ti, and the remainder being Fe and unavoidable impurities.

(5) In the steel rebar of the present invention, the percentage of ferrite is 50%-70%. While bainite has good strength and toughness, ferrite has better plasticity. By reasonably controlling a ratio of the two phases, the steel rebar can be endowed with excellent comprehensive mechanical properties, wherein, on the basis of obtaining the required yield strength and tensile strength, the after-fracture elongation percentage is greater than 18%, the ratio of tensile strength to yield strength is greater than 1.25, and the maximum stress total elongation percentage is greater than 9%, thereby endowing the steel product with good anti-knock performance.

(6) The production method of steel rebar of the present invention controls the content of S by a KR desulfurization method, controls the content of P in a convertor, adds alloying elements of Si and Mn during the steel tapping process for deoxygenation and meanwhile adds carbon powder and slag former to create a reductive atmosphere for the refining furnace, carries out decarburization by blowing oxygen in an RH vacuum refining furnace so as to control the contents of carbon and chromium elements, carries out deoxygenation in an LF furnace while adding the remaining alloying elements into steel so as to control the contents of oxygen and various alloying elements, as well as adding calcium-ferrum alloy to perform denaturation treatment on the inclusions, carries out soft stirring to make the ingredients uniformly distributed and remove inclusions, provides protective casting during the continuous casting process so as to control the gas content in steel, to prevent oxidization or secondary inclusions, heats the casting slab to 1100-1200°C before rolling in a heating furnace to ensure austenization and cause the elements therein to sufficiently enter a solid solution state, adopts rough rolling, moderate rolling and precision rolling during rolling can strictly control the deformation amount of the steel when rolled, while the precipitation strengthening effect of micro-alloying elements V(C,N) and/or Ti(C,N) can be brought into full play by controlling the rolling parameters, and places the rolled steel onto a cooling bed for air cooling so as to render the final microstructure of the steel product being bainite and ferrite.

(7) The production method of steel rebar of the present invention, by controlling the temperature of the steel for steel tapping at no higher than 1690°C, reduces the oxygen content in the steel, increases the element yield, reduces inclusions in the steel, increases the service life of the convertor, increases the quality of steel, and reduces production cost of steel.

(8) In the production method of steel rebar of the present invention, by controlling the temperature of decarburization by blowing oxygen during refining in the RH vacuum refining furnace to be no lower than 1605°C, the decarburization effect in the RH furnace can be increased, and it also facilitates controlling the contents of carbon and chromium elements in the steel. By controlling the temperature of deoxygenation during refining in the LF furnace, the refinement effect of deoxygenation in the LF furnace can be increased, which facilitates controlling the oxygen content within a predetermined range. And by controlling the oxygen content at 0.002%-0.005% through deoxygenation in the LF furnace, inclusions in the steel can be effectively controlled, and the quality of the steel is improved. By controlling the duration of soft stirring at no less than 5min, the ingredients and temperature of steel can be made more uniformly distributed, and it also facilitates removing the inclusions by floating. By raising the temperature of the molten steel to 1570-1600°C before continuous casting, smooth operation of the continuous casting is ensured.

(9) In the production method of steel rebar of the present invention, by heating the casting slab to 1100-1200°C in the heating furnace, the steel is heated to a temperature higher than its austenitization temperature, and a solid solution state of the alloying elements in the steel is ensured. By controlling the start rolling temperature at 1030-1100°C and controlling the temperature during the precision rolling at 950-1050°C, precipitation of a strengthening phase can be induced by deformation, so as to increase the strength of the steel. By controlling the temperature when the steel product is initially placed onto the cooling bed, the required microstructure of bainite plus ferrite can be obtained.

(10) The production method of steel rebar of the present invention, by accurately controlling the element contents and temperature of the molten steel during each procedure, greatly reduces the amount of harmful elements and inclusions in the steel, and improves the quality, mechanical properties and corrosion resistance performance of the steel.

(11) The steel rebar manufactured by using the steel rebar production method of the present invention, by means of reasonable processing steps, has a microscopic structure composed of ferrite and bainite, with the ferrite accounting for a percentage of 50%-70%. While bainite has good strength and toughness, ferrite has better plasticity. By reasonably controlling a ratio of the two phases, the steel rebar can be endowed with excellent comprehensive mechanical properties, wherein, on the basis of obtaining the required yield strength and tensile strength, the after-fracture elongation percentage is greater than 18%, the ratio of tensile strength to yield strength is greater than 1.25, and the maximum stress total elongation percentage is greater than 9%, thereby endowing the steel product with good anti-knock performance

Brief Description of the Drawings

[0026] In order to make the present invention easy and clear to understand, hereinafter, the present invention will be further described in detail according to specific embodiments of the present invention and with reference to the appended drawings, wherein:

FIG. 1 is a microstructure view of a steel rebar of the present invention.

Detailed Description of Embodiments

[0027]

Table 1 Steel rebar ingredients of Embodiments 1-10 as well as comparison examples 1-3 (wt.%)

	C	Si	Mn	Cr	Mo	RE	Sn	V	Ti	P	S
Embodiment 1	0.005	0.60	2.5	9.0	1.0	0.05	0.20	-	-	<0.01	<0.01
Embodiment 2	0.030	0.45	1.2	10.0	3.0	0.01	0.40	-	-	<0.01	<0.01
Embodiment 3	0.015	0.30	1.8	8.0	1.6	0.03	0.30	-	-	<0.01	<0.01
Embodiment 4	0.020	0.5	2.3	8.5	2.2	0.02	0.25	0.04	-	<0.01	<0.01
Embodiment 5	0.025	0.55	1.7	8.2	2.3	0.02	0.35	0.18	0.01	<0.01	<0.01
Embodiment 6	0.009	0.35	1.8	8.5	2.5	0.04	0.36	0.1	0.03	<0.01	<0.01
Embodiment 7	0.012	0.40	2.2	9.5	1.5	0.03	0.28	-	0.02	<0.01	<0.01
Embodiment 8	0.012	0.57	1.8	9.7	2.0	0.03	0.21	0.08	-	<0.01	<0.01
Embodiment 9	0.018	0.50	1.9	9.0	1.7	0.02	0.30	0.06	-	<0.01	<0.01
Embodiment 10	0.026	0.50	2.3	8.1	1.8	0.05	0.40	0.15	0.02	<0.01	<0.01
Comparison Example 1	0.23	0.54	1.5	-	-	-	-	-	-	<0.01	<0.01
Comparison Example 2	0.015	0.48	1.9	9.1	1.8	0.02	0.60	-	-	<0.01	<0.01
Comparison Example 3	0.024	0.52	2.0	9.8	2.0	0.02	-	-	-	<0.01	<0.01

Embodiment 1

[0028] The present embodiment provides a steel rebar, comprising the following elements: C, Si, Mn, P, S, Cr, Mo, Sn, Rare Earth element, Fe and unavoidable impurities, wherein, the weight percentages of the ingredients are as shown in Table 1, the mechanical properties are as shown in Table 2, and the corrosion resistance performance is as shown in Table 3.

[0029] The present embodiment also provides a production method of steel rebar comprising the following steps:

S1: performing preliminary desulfurization of molten iron by using a KR method to control the sulfur content at no more than 0.01%. Because sulfur element as an impurity element would reduce mechanical properties and corrosion resistance performance of steel and normally cannot be removed in a convertor, therefore, in order to reduce the sulfur content in steel, preliminary desulfurization treatment needs to be performed in molten iron. Before performing desulfurization, the blast furnace slag needs to be removed in order to increase the desulfurization efficiency. A mixture of lime powder and fluorite mixed at a mass ratio of 9:1 is adopted as the desulfurization agent. After still

standing of the desulfurated molten iron, the desulfurization residue is removed to prevent it from entering the converter and causing converter resulfurization. Thereby, the sulfur content in the steel is ensured to be controlled at less than 0.01%.

5 S2: performing smelting in a converter, by feeding the molten iron processed by Step S1 together with steel scrap and/or pig iron into a converter to be smelted, thus obtaining steel with a carbon content less than 0.05% and a phosphorus content less than 0.01% for steel tapping. The converter is a top and bottom combined blown converter.

10 S3: performing steel tapping step with a steel tapping temperature of 1680°C. During the steel tapping process, alloying elements of Si and Mn are added for deoxygenation, and carbon powder and slag former are also added. During the operation process of steel tapping, a protective gas is blown into the molten steel for stirring the molten steel at a pressure of 0.5MPa. The fluidity of the molten steel is utilized to make the deoxygenation of the added Si and Mn elements more thoroughly and to facilitate the removal of inclusions by floating. The carbon powder and slag former are added to increase the carbon content of steel and to produce reduced slag, so as to prepare for the
15 subsequent refining procedure outside the converter.

S4: performing refining outside the converter, by adding Cr element and meanwhile performing decarburization by blowing oxygen at 1605°C in an RH vacuum refining furnace, so that C element is partially removed by the decarburization process, thereby controlling the contents of Cr and C elements within the required range; performing
20 deoxygenation with an LF furnace at 1575°C until the oxygen content in the molten steel reaches 40ppm, and adding the required alloying elements of Mn, Mo, Sn, Rare Earth into the steel after deoxygenation, wherein, while the added alloying elements may be a pure metallic element, normally they are added in the form of iron alloy; and then adding calcium-ferrum alloy to perform denaturation treatment on the inclusions, performing soft stirring by blowing inert gas for 5min to make the ingredients and temperature of the steel uniformly distributed and to facilitate the
25 removal of inclusions by floating, so that the contents of the ingredients are controlled within the ranges as shown in data of Embodiment 1 in Table 1; raising the temperature of the molten steel to 1580°C during a later period of processing with the LF furnace, in order to ensure smooth operation of continuous casting, and then adding a cover agent which usually is carbonized rice husk.

30 S5: continuous casting, by casting the molten steel under protective casting with a continuous casting machine to produce small square billets of 150mm×150mm.

S6: performing rolling, by heating the continuous casting slab to 1100°C in a heating furnace, performing rough
35 rolling, moderate rolling and precision rolling by using a continuous rod and wire rolling machine with the start rolling temperature at 1030°C and the precision rolling temperature at 950°C, without passing water cooling after precision rolling, and placing the rolled steel after precision rolling onto a cooling bed for air cooling until room temperature, thereby producing a finished product of steel rebar as shown in Table 1, wherein, the temperature when the rolled steel is initially placed onto the cooling bed is 900°C. By means of the technique of controlled rolling and controlled
40 cooling, the microstructure of bainite plus ferrite is finally obtained.

Embodiment 2

[0030] The present embodiment provides a steel rebar, comprising the following elements: C, Si, Mn, P, S, Cr, Mo, Sn, Rare Earth element, Fe and unavoidable impurities, wherein, the weight percentages of the ingredients are as shown
45 in Table 1, the mechanical properties are as shown in Table 2, and the corrosion resistance performance is as shown in Table 3.

[0031] The present embodiment also provides a production method of steel rebar comprising the following steps:

S1: performing preliminary desulfurization of molten iron by using a KR method to control the sulfur content at no
50 more than 0.01%. Because sulfur element as an impurity element would reduce mechanical properties and corrosion resistance performance of steel and normally cannot be removed in a converter, therefore, in order to reduce the sulfur content in steel, preliminary desulfurization treatment needs to be performed in molten iron. Before performing desulfurization, the blast furnace slag needs to be removed in order to increase the desulfurization efficiency. A mixture of lime powder and fluorite mixed at a mass ratio of 9:1 is adopted as the desulfurization agent. After still
55 standing of the desulfurated molten iron, the desulfurization residue is removed to prevent it from entering the converter and causing converter resulfurization. Thereby, the sulfur content in the steel is ensured to be controlled at less than 0.01%.

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S2: performing smelting in a convertor, by feeding the molten iron processed by Step S1 together with steel scrap and/or pig iron into a convertor to be smelted, thus obtaining steel with a carbon content less than 0.05% and a phosphorus content less than 0.01% for steel tapping. The convertor is a top and bottom combined blown converter.

5 S3: performing steel tapping with a steel tapping temperature of 1690°C. During the steel tapping process, alloying elements of Si and Mn are added for deoxygenation, and carbon powder and slag former are also added. During the operation process of steel tapping, a protective gas is blown into the molten steel for stirring the molten steel at a pressure of 0.5MPa. The fluidity of the molten steel is utilized to make the deoxygenation of the added Si and Mn elements more thoroughly and to facilitate the removal of inclusions by floating. The carbon powder and slag former are added to increase the carbon content of steel and to produce reduced slag, so as to prepare for the subsequent refining procedure outside the convertor.

10 S4: performing refining outside the convertor, by adding Cr element and meanwhile performing decarburization by blowing oxygen at 1625°C in an RH vacuum refining furnace, so that C element is partially removed by the decarburization process, thereby controlling the contents of Cr and C elements within the required range; performing deoxygenation with an LF furnace at 1600°C until the oxygen content in the molten steel reaches 20ppm, and adding the required alloying elements of Mn, Mo, Sn, Rare Earth into the steel after deoxygenation, wherein, while the added alloying elements may be a pure metallic element, normally they are added in the form of iron alloy; and then adding calcium-ferrum alloy to perform denaturation treatment on the inclusions, performing soft stirring by blowing inert gas for 6min to make the ingredients and temperature of the steel uniformly distributed and to facilitate the removal of inclusions by floating, so that the contents of the ingredients are controlled within the ranges as shown in data of Embodiment 2 in Table 1; raising the temperature of the molten steel to 1600°C during a later period of processing with the LF furnace, in order to ensure smooth operation of continuous casting, and then adding a cover agent which usually is carbonized rice husk.

20 S5: continuous casting, by casting the molten steel under protective casting with a continuous casting machine to produce small square billets of 150mm×150mm.

25 S6: performing rolling, by heating the continuous casting slab to 1200°C in a heating furnace, performing rough rolling, moderate rolling and precision rolling by using a continuous rod and wire rolling machine with the start rolling temperature at 1100°C and the precision rolling temperature at 1050°C, without passing water cooling after precision rolling, and placing the rolled steel after precision rolling onto a cooling bed for air cooling until room temperature, thereby producing a finished product of steel rebar as shown in Table 1, wherein, the temperature when the rolled steel is initially placed onto the cooling bed is 960°C. By means of the technique of controlled rolling and controlled cooling, the microstructure of bainite plus ferrite is finally obtained.

Embodiment 3

30 **[0032]** The present embodiment provides a steel rebar, comprising the following elements: C, Si, Mn, P, S, Cr, Mo, Sn, Rare Earth element, Fe and unavoidable impurities, wherein, the weight percentages of the ingredients are as shown in Table 1, the mechanical properties are as shown in Table 2, and the corrosion resistance performance is as shown in Table 3.

[0033] The present embodiment also provides a production method of steel rebar comprising the following steps:

45 S1: performing preliminary desulfurization of molten iron by using a KR method to control the sulfur content at no more than 0.01%. Because sulfur element as an impurity element would reduce mechanical properties and corrosion resistance performance of steel and normally cannot be removed in a convertor, therefore, in order to reduce the sulfur content in steel, preliminary desulfurization treatment needs to be performed in molten iron. Before performing desulfurization, the blast furnace slag needs to be removed in order to increase the desulfurization efficiency. A mixture of lime powder and fluorite mixed at a mass ratio of 9:1 is adopted as the desulfurization agent. After still standing of the desulfurated molten iron, the desulfurization residue is removed to prevent it from entering the convertor and causing convertor resulfurization. Thereby, the sulfur content in the steel is ensured to be controlled at less than 0.01%.

55 S2: performing smelting in a convertor, by feeding the molten iron processed by Step S1 together with steel scrap and/or pig iron into a convertor to be smelted, thus obtaining steel with a carbon content less than 0.05% and a phosphorus content less than 0.01% for steel tapping. The convertor is a top and bottom combined blown converter.

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5 S3: performing steel tapping with a steel tapping temperature of 1685°C. During the steel tapping process, alloying elements of Si and Mn are added for deoxygenation, and carbon powder and slag former are also added. During the operation process of steel tapping, a protective gas is blown into the molten steel for stirring the molten steel at a pressure of 0.5MPa. The fluidity of the molten steel is utilized to make the deoxygenation of the added Si and Mn elements more thoroughly and to facilitate the removal of inclusions by floating. The carbon powder and slag former are added to increase the carbon content of steel and to produce reduced slag, so as to prepare for the subsequent refining procedure outside the convertor.

10 S4: performing refining outside the convertor, by adding Cr element and meanwhile performing decarburization by blowing oxygen at 1610°C in an RH vacuum refining furnace, so that C element is partially removed by the decarburization process, thereby controlling the contents of Cr and C elements within the required range; performing deoxygenation with an LF furnace at 1585°C until the oxygen content in the molten steel reaches 30ppm, and adding the required alloying elements of Mn, Mo, Sn, Rare Earth into the steel after deoxygenation, wherein, while the added alloying elements may be a pure metallic element, normally they are added in the form of iron alloy; and then
15 adding calcium-ferrum alloy to perform denaturation treatment on the inclusions, performing soft stirring by blowing inert gas for 6min to make the ingredients and temperature of the steel uniformly distributed and to facilitate the removal of inclusions by floating, so that the contents of the ingredients are controlled within the ranges as shown in data of Embodiment 3 in Table 1; raising the temperature of the molten steel to 1570°C during a later period of processing with the LF furnace, in order to ensure smooth operation of continuous casting, and then adding a cover agent which usually is carbonized rice husk.

20 S5: continuous casting, by casting the molten steel under protective casting with a continuous casting machine to produce small square billets of 150mm×150mm.

25 S6: performing rolling, by heating the continuous casting slab to 1120°C in a heating furnace, performing rough rolling, moderate rolling and precision rolling by using a continuous rod and wire rolling machine with the start rolling temperature at 1050°C and the precision rolling temperature at 960°C, without passing water cooling after precision rolling, and placing the rolled steel after precision rolling onto a cooling bed for air cooling until room temperature, thereby producing a finished product of steel rebar as shown in Table 1, wherein, the temperature when the rolled
30 steel is initially placed onto the cooling bed is 910°C. By means of the technique of controlled rolling and controlled cooling, the microstructure of bainite plus ferrite is finally obtained.

Embodiment 4

35 **[0034]** The present embodiment provides a steel rebar, comprising the following elements: C, Si, Mn, P, S, Cr, Mo, Sn, Rare Earth element, V, Fe and unavoidable impurities, wherein, the weight percentages of the ingredients are as shown in Table 1, the mechanical properties are as shown in Table 2, and the corrosion resistance performance is as shown in Table 3.

40 **[0035]** The present embodiment also provides a production method of steel rebar comprising the following steps:

45 S1: performing preliminary desulfurization of molten iron by using a KR method to control the sulfur content at no more than 0.01%. Because sulfur element as an impurity element would reduce mechanical properties and corrosion resistance performance of steel and normally cannot be removed in a convertor, therefore, in order to reduce the sulfur content in steel, preliminary desulfurization treatment needs to be performed in molten iron. Before performing desulfurization, the blast furnace slag needs to be removed in order to increase the desulfurization efficiency. A mixture of lime powder and fluorite mixed at a mass ratio of 9:1 is adopted as the desulfurization agent. After still standing of the desulfurated molten iron, the desulfurization residue is removed to prevent it from entering the convertor and causing convertor resulfurization. Thereby, the sulfur content in the steel is ensured to be controlled at less than 0.01%.

50 S2: performing smelting in a convertor, by feeding the molten iron processed by Step S1 together with steel scrap and/or pig iron into a convertor to be smelted, thus obtaining steel with a carbon content less than 0.05% and a phosphorus content less than 0.01% for steel tapping. The convertor is a top and bottom combined blown convertor.

55 S3: performing steel tapping with a steel tapping temperature of 1690°C. During the steel tapping process, alloying elements of Si and Mn are added for deoxygenation, and carbon powder and slag former are also added. During the operation process of steel tapping, a protective gas is blown into the molten steel for stirring the molten steel at a pressure of 0.5MPa. The fluidity of the molten steel is utilized to make the deoxygenation of the added Si and Mn

elements more thoroughly and to facilitate the removal of inclusions by floating. The carbon powder and slag former are added to increase the carbon content of steel and to produce reduced slag, so as to prepare for the subsequent refining procedure outside the convertor.

5 S4: performing refining outside the convertor, performed by adding Cr element and meanwhile performing decarburization by blowing oxygen at 1620°C in an RH vacuum refining furnace, so that C element is partially removed by the decarburization process, thereby controlling the contents of Cr and C elements within the required range; performing deoxygenation with an LF furnace at 1590°C until the oxygen content in the molten steel reaches 20ppm, and adding the required alloying elements of Mn, Mo, Sn, Rare Earth, V into the steel after deoxygenation, wherein, while the added alloying elements may be a pure metallic element, normally they are added in the form of iron alloy; and then adding calcium-ferrum alloy to perform denaturation treatment on the inclusions, performing soft stirring by blowing inert gas for 6min to make the ingredients and temperature of the steel uniformly distributed and to facilitate the removal of inclusions by floating, so that the contents of the ingredients are controlled within the ranges as shown in data of Embodiment 4 in Table 1; raising the temperature of the molten steel to 1585°C during a later period of processing with the LF furnace, in order to ensure smooth operation of continuous casting, and then adding a cover agent which usually is carbonized rice husk.

20 S5: continuous casting, by casting the molten steel under protective casting with a continuous casting machine to produce small square billets of 150mm×150mm.

S6: performing rolling, by heating the continuous casting slab to 1180°C in a heating furnace, performing rough rolling, moderate rolling and precision rolling by using a continuous rod and wire rolling machine with the start rolling temperature at 1040°C and the precision rolling temperature at 990°C, without passing water cooling after precision rolling, and placing the rolled steel after precision rolling onto a cooling bed for air cooling until room temperature, thereby producing a finished product of steel rebar as shown in Table 1, wherein, the temperature when the rolled steel is initially placed onto the cooling bed is 950°C. By means of the technique of controlled rolling and controlled cooling, the microstructure of bainite plus ferrite is finally obtained.

Embodiment 5

30 **[0036]** The present embodiment provides a steel rebar, comprising the following elements: C, Si, Mn, P, S, Cr, Mo, Sn, Rare Earth element, V, Ti, Fe and unavoidable impurities, wherein, the weight percentages of the ingredients are as shown in Table 1, the mechanical properties are as shown in Table 2, and the corrosion resistance performance is as shown in Table 3.

35 **[0037]** The present embodiment also provides a production method of steel rebar comprising the following steps:

S1: performing preliminary desulfurization of molten iron by using a KR method to control the sulfur content at no more than 0.01%. Because sulfur element as an impurity element would reduce mechanical properties and corrosion resistance performance of steel and normally cannot be removed in a convertor, therefore, in order to reduce the sulfur content in steel, preliminary desulfurization treatment needs to be performed in molten iron. Before performing desulfurization, the blast furnace slag needs to be removed in order to increase the desulfurization efficiency. A mixture of lime powder and fluorite mixed at a mass ratio of 9:1 is adopted as the desulfurization agent. After still standing of the desulfurated molten iron, the desulfurization residue is removed to prevent it from entering the convertor and causing convertor resulfurization. Thereby, the sulfur content in the steel is ensured to be controlled at less than 0.01%.

S2: performing smelting in a convertor, by feeding the molten iron processed by Step S1 together with steel scrap and/or pig iron into a convertor to be smelted, thus obtaining steel with a carbon content less than 0.05% and a phosphorus content less than 0.01% for steel tapping. The convertor is a top and bottom combined blown converter.

50 S3: performing steel tapping with a steel tapping temperature of 1675°C. During the steel tapping process, alloying elements of Si and Mn are added for deoxygenation, and carbon powder and slag former are also added. During the operation process of steel tapping, a protective gas is blown into the molten steel for stirring the molten steel at a pressure of 0.5MPa. The fluidity of the molten steel is utilized to make the deoxygenation of the added Si and Mn elements more thoroughly and to facilitate the removal of inclusions by floating. The carbon powder and slag former are added to increase the carbon content of steel and to produce reduced slag, so as to prepare for the subsequent refining procedure outside the convertor.

S4: performing refining outside the convertor, by adding Cr element and meanwhile performing decarburization by blowing oxygen at 1615°C in an RH vacuum refining furnace, so that C element is partially removed by the decarburization process, thereby controlling the contents of Cr and C elements within the required range; performing deoxygenation with an LF furnace at 1580°C until the oxygen content in the molten steel reaches 25ppm, and adding the required alloying elements of Mn, Mo, Sn, Rare Earth, V, Ti into the steel after deoxygenation, wherein, while the added alloying elements may be a pure metallic element, normally they are added in the form of iron alloy; and then adding calcium-ferrum alloy to perform denaturation treatment on the inclusions, performing soft stirring by blowing inert gas for 7min to make the ingredients and temperature of the steel uniformly distributed and to facilitate the removal of inclusions by floating, so that the contents of the ingredients are controlled within the ranges as shown in data of Embodiment 5 in Table 1; raising the temperature of the molten steel to 1580°C during a later period of processing with the LF furnace, in order to ensure smooth operation of continuous casting, and then adding a cover agent which usually is carbonized rice husk.

S5: continuous casting, by casting the molten steel under protective casting with a continuous casting machine to produce small square billets of 150mm×150mm.

S6: performing rolling, by heating the continuous casting slab to 1190°C in a heating furnace, performing rough rolling, moderate rolling and precision rolling by using a continuous rod and wire rolling machine with the start rolling temperature at 1095°C and the precision rolling temperature at 1030°C, without passing water cooling after precision rolling, and placing the rolled steel after precision rolling onto a cooling bed for air cooling until room temperature, thereby producing a finished product of steel rebar as shown in Table 1, wherein, the temperature when the rolled steel is initially placed onto the cooling bed is 950°C. By means of the technique of controlled rolling and controlled cooling, the microstructure of bainite plus ferrite is finally obtained.

Embodiment 6

[0038] The present embodiment provides a steel rebar, comprising the following elements: C, Si, Mn, P, S, Cr, Mo, Sn, Rare Earth element, V, Ti, Fe and unavoidable impurities, wherein, the weight percentages of the ingredients are as shown in Table 1, the mechanical properties are as shown in Table 2, and the corrosion resistance performance is as shown in Table 3.

[0039] The present embodiment also provides a production method of steel rebar comprising the following steps:

S1: performing preliminary desulfurization of molten iron by using a KR method to control the sulfur content at no more than 0.01%. Because sulfur element as an impurity element would reduce mechanical properties and corrosion resistance performance of steel and normally cannot be removed in a convertor, therefore, in order to reduce the sulfur content in steel, preliminary desulfurization treatment needs to be performed in molten iron. Before performing desulfurization, the blast furnace slag needs to be removed in order to increase the desulfurization efficiency. A mixture of lime powder and fluorite mixed at a mass ratio of 9:1 is adopted as the desulfurization agent. After still standing of the desulfurated molten iron, the desulfurization residue is removed to prevent it from entering the convertor and causing convertor resulfurization. Thereby, the sulfur content in the steel is ensured to be controlled at less than 0.01%.

S2: performing smelting in a convertor, by feeding the molten iron processed by Step S1 together with steel scrap and/or pig iron into a convertor to be smelted, thus obtaining steel with a carbon content less than 0.05% and a phosphorus content less than 0.01% for steel tapping. The convertor is a top and bottom combined blown converter.

S3: performing steel tapping with a steel tapping temperature of 1670°C. During the steel tapping process, alloying elements of Si and Mn are added for deoxygenation, and carbon powder and slag former are also added. During the operation process of steel tapping, a protective gas is blown into the molten steel for stirring the molten steel at a pressure of 0.5MPa. The fluidity of the molten steel is utilized to make the deoxygenation of the added Si and Mn elements more thoroughly and to facilitate the removal of inclusions by floating. The carbon powder and slag former are added to increase the carbon content of steel and to produce reduced slag, so as to prepare for the subsequent refining procedure outside the convertor.

S4: performing refining outside the convertor, by adding Cr element and meanwhile performing decarburization by blowing oxygen at 1610°C in an RH vacuum refining furnace, so that C element is partially removed by the decarburization process, thereby controlling the contents of Cr and C elements within the required range; performing deoxygenation with an LF furnace at 1580°C until the oxygen content in the molten steel reaches 20ppm, and adding

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the required alloying elements of Mn, Mo, Sn, Rare Earth, V, Ti into the steel after deoxygenation, wherein, while the added alloying elements may be a pure metallic element, normally they are added in the form of iron alloy; and then adding calcium-ferrum alloy to perform denaturation treatment on the inclusions, performing soft stirring by blowing inert gas for 7min to make the ingredients and temperature of the steel uniformly distributed and to facilitate the removal of inclusions by floating, so that the contents of the ingredients are controlled within the ranges as shown in data of Embodiment 6 in Table 1; raising the temperature of the molten steel to 1590°C during a later period of processing with the LF furnace, in order to ensure smooth operation of continuous casting, and then adding a cover agent which usually is carbonized rice husk.

S5: continuous casting, by casting the molten steel under protective casting with a continuous casting machine to produce small square billets of 150mm×150mm.

S6: performing rolling, by heating the continuous casting slab to 1185°C in a heating furnace, performing rough rolling, moderate rolling and precision rolling by using a continuous rod and wire rolling machine with the start rolling temperature at 1085°C and the precision rolling temperature at 1035°C, without passing water cooling after precision rolling, and placing the rolled steel after precision rolling onto a cooling bed for air cooling until room temperature, thereby producing a finished product of steel rebar as shown in Table 1, wherein, the temperature when the rolled steel is initially placed onto the cooling bed is 955°C. By means of the technique of controlled rolling and controlled cooling, the microstructure of bainite plus ferrite is finally obtained.

Embodiment 7

[0040] The present embodiment provides a steel rebar, comprising the following elements: C, Si, Mn, P, S, Cr, Mo, Sn, Rare Earth element, Ti, Fe and unavoidable impurities, wherein, the weight percentages of the ingredients are as shown in Table 1, the mechanical properties are as shown in Table 2, and the corrosion resistance performance is as shown in Table 3.

[0041] The present embodiment also provides a production method of steel rebar comprising the following steps:

S1: performing preliminary desulfurization of molten iron by using a KR method to control the sulfur content at no more than 0.01%. Because sulfur element as an impurity element would reduce mechanical properties and corrosion resistance performance of steel and normally cannot be removed in a converter, therefore, in order to reduce the sulfur content in steel, preliminary desulfurization treatment needs to be performed in molten iron. Before performing desulfurization, the blast furnace slag needs to be removed in order to increase the desulfurization efficiency. A mixture of lime powder and fluorite mixed at a mass ratio of 9:1 is adopted as the desulfurization agent. After still standing of the desulfurated molten iron, the desulfurization residue is removed to prevent it from entering the converter and causing converter resulfurization. Thereby, the sulfur content in the steel is ensured to be controlled at less than 0.01%.

S2: performing smelting in a converter, by feeding the molten iron processed by Step S1 together with steel scrap and/or pig iron into a converter to be smelted, thus obtaining steel with a carbon content less than 0.05% and a phosphorus content less than 0.01% for steel tapping. The converter is a top and bottom combined blown converter.

S3: performing steel tapping with a steel tapping temperature of 1685°C. During the steel tapping process, alloying elements of Si and Mn are added for deoxygenation, and carbon powder and slag former are also added. During the operation process of steel tapping, a protective gas is blown into the molten steel for stirring the molten steel at a pressure of 0.5MPa. The fluidity of the molten steel is utilized to make the deoxygenation of the added Si and Mn elements more thoroughly and to facilitate the removal of inclusions by floating. The carbon powder and slag former are added to increase the carbon content of steel and to produce reduced slag, so as to prepare for the subsequent refining procedure outside the converter.

S4: performing refining outside the converter, by adding Cr element and meanwhile performing decarburization by blowing oxygen at 1615°C in an RH vacuum refining furnace, so that C element is partially removed by the decarburization process, thereby controlling the contents of Cr and C elements within the required range; performing deoxygenation with an LF furnace at 1580°C until the oxygen content in the molten steel reaches 20ppm, and adding the required alloying elements of Mn, Mo, Sn, Rare Earth, Ti into the steel after deoxygenation, wherein, while the added alloying elements may be a pure metallic element, normally they are added in the form of iron alloy; and then adding calcium-ferrum alloy to perform denaturation treatment on the inclusions, performing soft stirring by blowing inert gas for 7min to make the ingredients and temperature of the steel uniformly distributed and to facilitate the

removal of inclusions by floating, so that the contents of the ingredients are controlled within the ranges as shown in data of Embodiment 7 in Table 1; raising the temperature of the molten steel to 1585°C during a later period of processing with the LF furnace, in order to ensure smooth operation of continuous casting, and then adding a cover agent which usually is carbonized rice husk.

S5: continuous casting, by casting the molten steel under protective casting with a continuous casting machine to produce small square billets of 150mm×150mm.

S6: performing rolling, by heating the continuous casting slab to 1180°C in a heating furnace, performing rough rolling, moderate rolling and precision rolling by using a continuous rod and wire rolling machine with the start rolling temperature at 1080°C and the precision rolling temperature at 1020°C, without passing water cooling after precision rolling, and placing the rolled steel after precision rolling onto a cooling bed for air cooling until room temperature, thereby producing a finished product of steel rebar as shown in Table 1, wherein, the temperature when the rolled steel is initially placed onto the cooling bed is 940°C. By means of the technique of controlled rolling and controlled cooling, the microstructure of bainite plus ferrite is finally obtained.

Embodiment 8

[0042] The present embodiment provides a steel rebar, comprising the following elements: C, Si, Mn, P, S, Cr, Mo, Sn, Rare Earth element, V, Fe and unavoidable impurities, wherein, the weight percentages of the ingredients are as shown in Table 1, the mechanical properties are as shown in Table 2, and the corrosion resistance performance is as shown in Table 3.

[0043] The present embodiment also provides a production method of steel rebar comprising the following steps:

S1: performing preliminary desulfurization of molten iron by using a KR method to control the sulfur content at no more than 0.01%. Because sulfur element as an impurity element would reduce mechanical properties and corrosion resistance performance of steel and normally cannot be removed in a converter, therefore, in order to reduce the sulfur content in steel, preliminary desulfurization treatment needs to be performed in molten iron. Before performing desulfurization, the blast furnace slag needs to be removed in order to increase the desulfurization efficiency. A mixture of lime powder and fluorite mixed at a mass ratio of 9:1 is adopted as the desulfurization agent. After still standing of the desulfurated molten iron, the desulfurization residue is removed to prevent it from entering the converter and causing converter resulfurization. Thereby, the sulfur content in the steel is ensured to be controlled at less than 0.01%.

S2: performing smelting in a converter, by feeding the molten iron processed by Step S1 together with steel scrap and/or pig iron into a converter to be smelted, thus obtaining steel with a carbon content less than 0.05% and a phosphorus content less than 0.01% for steel tapping. The converter is a top and bottom combined blown converter.

S3: performing steel tapping with a steel tapping temperature of 1680°C. During the steel tapping process, alloying elements of Si and Mn are added for deoxygenation, and carbon powder and slag former are also added. During the operation process of steel tapping, a protective gas is blown into the molten steel for stirring the molten steel at a pressure of 0.5MPa. The fluidity of the molten steel is utilized to make the deoxygenation of the added Si and Mn elements more thoroughly and to facilitate the removal of inclusions by floating. The carbon powder and slag former are added to increase the carbon content of steel and to produce reduced slag, so as to prepare for the subsequent refining procedure outside the converter.

S4: performing refining outside the converter, by adding Cr element and meanwhile performing decarburization by blowing oxygen at 1610°C in an RH vacuum refining furnace, so that C element is partially removed by the decarburization process, thereby controlling the contents of Cr and C elements within the required range; performing deoxygenation with an LF furnace at 1585°C until the oxygen content in the molten steel reaches 20ppm, and adding the required alloying elements of Mn, Mo, Sn, Rare Earth, V into the steel after deoxygenation, wherein, while the added alloying elements may be a pure metallic element, normally they are added in the form of iron alloy; and then adding calcium-ferrum alloy to perform denaturation treatment on the inclusions, performing soft stirring by blowing inert gas for 7min to make the ingredients and temperature of the steel uniformly distributed and to facilitate the removal of inclusions by floating, so that the contents of the ingredients are controlled within the ranges as shown in data of Embodiment 8 in Table 1; raising the temperature of the molten steel to 1590°C during a later period of processing with the LF furnace, in order to ensure smooth operation of continuous casting, and then adding a cover agent which usually is carbonized rice husk.

S5: continuous casting, by casting the molten steel under protective casting with a continuous casting machine to produce small square billets of 150mm×150mm.

S6: performing rolling, by heating the continuous casting slab to 1150°C in a heating furnace, performing rough rolling, moderate rolling and precision rolling by using a continuous rod and wire rolling machine with the start rolling temperature at 1065°C and the precision rolling temperature at 1025°C, without passing water cooling after precision rolling, and placing the rolled steel after precision rolling onto a cooling bed for air cooling until room temperature, thereby producing a finished product of steel rebar as shown in Table 1, wherein, the temperature when the rolled steel is initially placed onto the cooling bed is 965°C. By means of the technique of controlled rolling and controlled cooling, the microstructure of bainite plus ferrite is finally obtained.

Embodiment 9

[0044] The present embodiment provides a steel rebar, comprising the following elements: C, Si, Mn, P, S, Cr, Mo, Sn, Rare Earth element, V, Fe and unavoidable impurities, wherein, the weight percentages of the ingredients are as shown in Table 1, the mechanical properties are as shown in Table 2, and the corrosion resistance performance is as shown in Table 3.

[0045] The present embodiment also provides a production method of steel rebar comprising the following steps:

S1: performing preliminary desulfurization of molten iron by using a KR method to control the sulfur content at no more than 0.01%. Because sulfur element as an impurity element would reduce mechanical properties and corrosion resistance performance of steel and normally cannot be removed in a convertor, therefore, in order to reduce the sulfur content in steel, preliminary desulfurization treatment needs to be performed in molten iron. Before performing desulfurization, the blast furnace slag needs to be removed in order to increase the desulfurization efficiency. A mixture of lime powder and fluorite mixed at a mass ratio of 9:1 is adopted as the desulfurization agent. After still standing of the desulfurated molten iron, the desulfurization residue is removed to prevent it from entering the convertor and causing convertor resulfurization. Thereby, the sulfur content in the steel is ensured to be controlled at less than 0.01%.

S2: performing smelting in a convertor, by feeding the molten iron processed by Step S1 together with steel scrap and/or pig iron into a convertor to be smelted, thus obtaining steel with a carbon content less than 0.05% and a phosphorus content less than 0.01% for steel tapping. The convertor is a top and bottom combined blown convertor.

S3: performing steel tapping with a steel tapping temperature of 1675°C. During the steel tapping process, alloying elements of Si and Mn are added for deoxygenation, and carbon powder and slag former are also added. During the operation process of steel tapping, a protective gas is blown into the molten steel for stirring the molten steel at a pressure of 0.5MPa. The fluidity of the molten steel is utilized to make the deoxygenation of the added Si and Mn elements more thoroughly and to facilitate the removal of inclusions by floating. The carbon powder and slag former are added to increase the carbon content of steel and to produce reduced slag, so as to prepare for the subsequent refining procedure outside the convertor.

S4: performing refining outside the convertor, by adding Cr element and meanwhile performing decarburization by blowing oxygen at 1605°C in an RH vacuum refining furnace, so that C element is partially removed by the decarburization process, thereby controlling the contents of Cr and C elements within the required range; performing deoxygenation with an LF furnace at 1575°C until the oxygen content in the molten steel reaches 20ppm, and adding the required alloying elements of Mn, Mo, Sn, Rare Earth, V into the steel after deoxygenation, wherein, while the added alloying elements may be a pure metallic element, normally they are added in the form of iron alloy; and then adding calcium-ferrum alloy to perform denaturation treatment on the inclusions, performing soft stirring by blowing inert gas for 7min to make the ingredients and temperature of the steel uniformly distributed and to facilitate the removal of inclusions by floating, so that the contents of the ingredients are controlled within the ranges as shown in data of Embodiment 9 in Table 1; raising the temperature of the molten steel to 1580°C during a later period of processing with the LF furnace, in order to ensure smooth operation of continuous casting, and then adding a cover agent which usually is carbonized rice husk.

S5: continuous casting, by casting the molten steel under protective casting with a continuous casting machine to produce small square billets of 150mm×150mm.

S6: performing rolling, by heating the continuous casting slab to 1105°C in a heating furnace, performing rough

rolling, moderate rolling and precision rolling by using a continuous rod and wire rolling machine with the start rolling temperature at 1045°C and the precision rolling temperature at 1005°C, without passing water cooling after precision rolling, and placing the rolled steel after precision rolling onto a cooling bed for air cooling until room temperature, thereby producing a finished product of steel rebar as shown in Table 1, wherein, the temperature when the rolled steel is initially placed onto the cooling bed is 945°C. By means of the technique of controlled rolling and controlled cooling, the microstructure of bainite plus ferrite is finally obtained.

Embodiment 10

[0046] The present embodiment provides a steel rebar, comprising the following elements: C, Si, Mn, P, S, Cr, Mo, Sn, Rare Earth element, V, Ti, Fe and unavoidable impurities, wherein, the weight percentages of the ingredients are as shown in Table 1, the mechanical properties are as shown in Table 2, and the corrosion resistance performance is as shown in Table 3.

[0047] The present embodiment also provides a production method of steel rebar comprising the following steps:

S1: performing preliminary desulfurization of molten iron by using a KR method to control the sulfur content at no more than 0.01%. Because sulfur element as an impurity element would reduce mechanical properties and corrosion resistance performance of steel and normally cannot be removed in a converter, therefore, in order to reduce the sulfur content in steel, preliminary desulfurization treatment needs to be performed in molten iron. Before performing desulfurization, the blast furnace slag needs to be removed in order to increase the desulfurization efficiency. A mixture of lime powder and fluorite mixed at a mass ratio of 9:1 is adopted as the desulfurization agent. After still standing of the desulfurated molten iron, the desulfurization residue is removed to prevent it from entering the converter and causing converter resulfurization. Thereby, the sulfur content in the steel is ensured to be controlled at less than 0.01%.

S2: performing smelting in a converter, by feeding the molten iron processed by Step S1 together with steel scrap and/or pig iron into a converter to be smelted, thus obtaining steel with a carbon content less than 0.05% and a phosphorus content less than 0.01% for steel tapping. The converter is a top and bottom combined blown converter.

S3: performing steel tapping with a steel tapping temperature of 1685°C. During the steel tapping process, alloying elements of Si and Mn are added for deoxygenation, and carbon powder and slag former are also added. During the operation process of steel tapping, a protective gas is blown into the molten steel for stirring the molten steel at a pressure of 0.5MPa. The fluidity of the molten steel is utilized to make the deoxygenation of the added Si and Mn elements more thoroughly and to facilitate the removal of inclusions by floating. The carbon powder and slag former are added to increase the carbon content of steel and to produce reduced slag, so as to prepare for the subsequent refining procedure outside the converter.

S4: performing refining outside the converter, by adding Cr element and meanwhile performing decarburization by blowing oxygen at 1620°C in an RH vacuum refining furnace, so that C element is partially removed by the decarburization process, thereby controlling the contents of Cr and C elements within the required range; performing deoxygenation with an LF furnace at 1585°C until the oxygen content in the molten steel reaches 20ppm, and adding the required alloying elements of Mn, Mo, Sn, Rare Earth, V, Ti into the steel after deoxygenation, wherein, while the added alloying elements may be a pure metallic element, normally they are added in the form of iron alloy; and then adding calcium-ferrum alloy to perform denaturation treatment on the inclusions, performing soft stirring by blowing inert gas for 7min to make the ingredients and temperature of the steel uniformly distributed and to facilitate the removal of inclusions by floating, so that the contents of the ingredients are controlled within the ranges as shown in data of Embodiment 10 in Table 1; raising the temperature of the molten steel to 1595°C during a later period of processing with the LF furnace, in order to ensure smooth operation of continuous casting, and then adding a cover agent which usually is carbonized rice husk.

S5: continuous casting, by casting the molten steel under protective casting with a continuous casting machine to produce small square billets of 150mm×150mm.

S6: performing rolling, by heating the continuous casting slab to 1195°C in a heating furnace, performing rough rolling, moderate rolling and precision rolling by using a continuous rod and wire rolling machine with the start rolling temperature at 1095°C and the precision rolling temperature at 1045°C, without passing water cooling after precision rolling, and placing the rolled steel after precision rolling onto a cooling bed for air cooling until room temperature, thereby producing a finished product of steel rebar as shown in Table 1, wherein, the temperature when the rolled

steel is initially placed onto the cooling bed is 955°C. By means of the technique of controlled rolling and controlled cooling, the microstructure of bainite plus ferrite is finally obtained.

Experimental Example

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[0048] In order to prove the technical effects of the present invention, the following experiments are performed on the steel rebar produced by Embodiment 1-10 and comparison examples 1-3:

1. Experimental methods

10 1.1 mechanical property tests: performed according to "GB1499.2-2007, steel used in reinforced concrete, Part II: hot-rolled ribbed rebar". The yield strength ($R_{0.2}$), tensile strength (R_m), and after-fracture elongation percentage (A) are tested.

1.2 corrosion resistance performance tests:

15 1.2.1 cyclic immersion corrosion test: performed according to "corrosion test methods of steel rebar in a chloride ion environment, a draft for consultation" proposed by Steel Industry Association of China and drafted by institutes of Iron and Steel Research Institute and Metallurgical Industry Information Standardization Research Institute.

The test sample is a cylinder of $\phi 13\text{mm} \times 50\text{mm}$;

The test solution is a solution of sodium chloride with an initial concentration of $(0.34 \pm 0.009)\text{mol} \cdot \text{L}^{-1}$ (an initial mass percentage of $2.0\% \pm 0.05\%$). And the specific test conditions are as follows:

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Temperature: $45^\circ\text{C} \pm 2^\circ\text{C}$

Humidity: $70\% \pm 10\% \text{RH}$

PH value of solution: 6.5-7.2

Test time: 360h

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Each cyclic period: $60 \text{ min} \pm 5\text{min}$, with an immersion time of $12 \text{ min} \pm 2\text{min}$ Highest temperature of test sample surface after baking: $70^\circ\text{C} \pm 10^\circ\text{C}$

1.2.2 salt spray corrosion test: performed according to "GBT10125-1997, corrosion tests in an artificial atmosphere, salt spray test".

30 The test sample is a test plate of $3\text{mm} \times 15\text{mm} \times 40\text{mm}$;

The test solution is a solution of sodium chloride with a concentration of $(50 \pm 5)\text{g} \cdot \text{L}^{-1}$ (a mass percentage of $5.0\% \pm 0.5\%$). And the specific test conditions are as follows: Temperature: $35^\circ\text{C} \pm 2^\circ\text{C}$

PH value of solution: 6.5-7.2

Test time: 360h

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2. Experimental results

[0049] Table 2 shows the effects about mechanical properties of Embodiment 1-10 and comparison examples 1-3. Table 3 shows the effects about corrosion resistance performance of Embodiment 1-10 and comparison examples 1-3.

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Table 2 Effects about mechanical properties

	$R_{0.2}/\text{MPa}$	R_m/MPa	A/%	$R_m/R_{0.2}$	$A_{gt}/\%$
Embodiment 1	432	627	24.5	1.45	11.8
Embodiment 2	408	613	25.3	1.50	12.6
Embodiment 3	482	696	24.5	1.44	11.1
Embodiment 4	561	728	18.9	1.30	10.8
Embodiment 5	611	793	19.6	1.29	10.5
Embodiment 6	554	755	20.8	1.36	10.3
Embodiment 7	524	716	21.2	1.37	10.7
Embodiment 8	523	743	25.0	1.42	11.3
Embodiment 9	536	729	21.0	1.36	10.7
Embodiment 10	621	795	18.0	1.28	9.5
Comparison Example 1	435	632	22.0	1.45	12.0

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(continued)

	R _{0.2} /MPa	R _m /MPa	A/%	R _m /R _{0.2}	A _{gt} /%
Comparison Example 2	486	586	13.4	1.21	6.2
Comparison Example 3	477	687	24.8	1.44	11.0

Table 3 Effects about corrosion resistance performance

	cyclic immersion test			salt spray test		
	Corrosion rate (g/m ² -h)	Relative corrosion rate	Increase of corrosion resistance performance (%)	Corrosion rate (g/m ² -h)	Relative corrosion rate	Increase of corrosion resistance performance (%)
Embodiment 1	0.415	0.127	690	0.411	0.130	666
Embodiment 2	0.191	0.058	1616	0.205	0.065	1437
Embodiment 3	0.419	0.128	682	0.432	0.137	629
Embodiment 4	0.356	0.109	821	0.367	0.117	758
Embodiment 5	0.441	0.135	643	0.445	0.141	608
Embodiment 6	0.349	0.106	839	0.360	0.114	775
Embodiment 7	0.386	0.118	749	0.395	0.125	697
Embodiment 8	0.272	0.083	1105	0.288	0.091	994
Embodiment 9	0.370	0.113	786	0.381	0.121	727
Embodiment 10	0.433	0.132	657	0.435	0.138	624
Comparison Example 1	3.278	1	-	3.150	1	-
Comparison Example 2	0.365	0.111	798	0.377	0.120	736
Comparison Example 3	0.456	0.151	561	0.463	0.160	526

(The relative corrosion rates in Table 3 are all compared with Comparison Example 1, by setting the relative corrosion rate of Comparison Example 1 to be 1.000)

[0050] As known from Table 3, in Embodiment 1-10, because Cr, Sn, Mo, Rare Earth elements are added, the corrosion resistance performance of steel rebar is increased by more than 600% compared with Comparison Example 1. As can be seen from the corrosion resistance performance data of Comparison Example 3, the increment of the corrosion resistance performance of steel rebar which does not contain Sn element is not as great as that of steel rebar which contains Sn element. By comparing Embodiment 1, 2, 3 and Comparison Example 2, it can be concluded that, when the Sn content is within the range of 0.02-0.04%, along with the increase of the Sn content, the corrosion resistance performance of steel rebar increases, but its yield strength and tensile strength decrease. And when the Sn content surpasses 0.04%, the corrosion resistance performance of steel rebar presents no more notable increment, but the

mechanical properties are adversely affected, especially the after-fracture elongation percentage and the maximum stress total elongation percentage decrease significantly, while the ratio of tensile strength to yield strength also considerably decreases. In Embodiments 4-10, V and/or Ti elements are added into steel rebar, and it can be seen from Table 2, the adding of V and/or Ti elements improves the yield strength and tensile strength of steel rebar, and at the same time, the after-fracture elongation percentage is greater than 18%, the ratio of tensile strength to yield strength is greater than 1.25, and the maximum stress total elongation percentage is greater than 9%, thereby endowing the steel product with good anti-knock performance.

[0051] In the steel rebar of the present invention, by reasonably designing the ingredients and accurately controlling the element ingredients and temperature during the smelting process, in combination with the technique of controlled rolling and controlled cooling, the steel rebar is made to obtain a microstructure of bainite plus ferrite (with the ferrite accounting for a percentage of 50%-70%) as shown in FIG. 1, thereby endowing the steel rebar with excellent comprehensive mechanical properties as well as excellent corrosion resistance performance which is increased by more than 6 times compared to ordinary steel rebar, so that the service life requirement of reinforced concrete structures in oceanographic engineering can be fulfilled.

[0052] Apparently, the aforementioned embodiments are merely examples illustrated for clearly describing the present invention, rather than limiting the implementation ways thereof. For those skilled in the art, various changes and modifications in other different forms can be made on the basis of the aforementioned description. It is unnecessary and impossible to exhaustively list all the implementation ways herein. However, any obvious changes or modifications derived from the aforementioned description are intended to be embraced within the protection scope of the present invention.

Claims

1. A steel rebar, **characterized in** comprising the following ingredients calculated in weight percentage:

0.005%-0.030% of C,
 0.3%-0.6% of Si,
 1.2%-2.5% of Mn,
 0.01% or less of P,
 0.01% or less of S,
 8.0%-10.0% of Cr,
 1.0%-3.0% of Mo,
 0.2%-0.4% of Sn,
 0.01%-0.05% of Rare Earth element, and
 the remainder being Fe and unavoidable impurities.

2. The steel rebar in accordance with Claim 1, **characterized in** comprising the following ingredients calculated in weight percentage:

0.005%-0.030% of C,
 0.3%-0.6% of Si,
 1.2%-1.8% of Mn,
 0.01% or less of P,
 0.01% or less of S,
 8.0%-10.0% of Cr,
 1.0%-1.6% of Mo,
 0.2%-0.4% of Sn,
 0.01%-0.05% of Rare Earth element, and
 the remainder being Fe and unavoidable impurities.

3. A steel rebar, **characterized in** comprising the following ingredients calculated in weight percentage:

0.005%-0.030% of C,
 0.3%-0.6% of Si,
 1.2%-2.5% of Mn,
 0.01% or less of P,
 0.01% or less of S,

8.0%-10.0% of Cr,
 1.0%-3.0% of Mo,
 0.2%-0.4% of Sn,
 0.01%-0.05% of Rare Earth element, 0.04%-0.18% of V and/or 0.010%-0.030% of Ti, and the remainder being
 Fe and unavoidable impurities.

4. The steel rebar in accordance with Claim 3, **characterized in** comprising the following ingredients calculated in weight percentage:

0.005%-0.030% of C,
 0.3%-0.6% of Si,
 1.7%-2.5% of Mn,
 0.01% or less of P,
 0.01% or less of S,
 8.0%-10.0% of Cr,
 1.5%-2.0% of Mo,
 0.2%-0.4% of Sn,
 0.01%-0.05% of Rare Earth element,
 0.04%-0.08% of V, and
 the remainder being Fe and unavoidable impurities.

5. The steel rebar in accordance with Claim 3, **characterized in** comprising the following ingredients calculated in weight percentage:

0.005%-0.030% of C,
 0.3%-0.6% of Si,
 1.7%-2.5% of Mn,
 0.01% or less of P,
 0.01% or less of S,
 8.0%-10.0% of Cr,
 1.8%-3.0% of Mo,
 0.2%-0.4% of Sn,
 0.01%-0.05% of Rare Earth element,
 0.10%-0.18% of V,
 0.010%-0.030% of Ti, and
 the remainder being Fe and unavoidable impurities.

6. The steel rebar in accordance with any one of Claims 1-5, **characterized in that**, the steel rebar has a microscopic structure composed of ferrite and bainite, with the ferrite accounting for a percentage of 50%-70%.

7. The steel rebar in accordance with any one of Claims 1-6, **characterized in that**, the steel rebar has a ratio of tensile strength to yield strength at greater than 1.25, a maximum stress total elongation percentage greater than 9%, an after-fracture elongation percentage greater than 18%, a corrosion rate by cyclic immersion corrosion test at less than 0.45m²h, and a corrosion rate by salt spray corrosion test at less than 0.45m²h.

8. A production method of steel rebar, **characterized in** comprising the following steps:

S1: performing preliminary desulfurization of molten iron to control the sulfur content at no more than 0.01%;
 S2: performing smelting in a convertor, by feeding the molten iron processed by Step S1 together with steel scrap and/or pig iron into a convertor to be smelted, thus obtaining steel with a carbon content less than 0.05% and a phosphorus content less than 0.01% for steel tapping;
 S3: performing steel tapping, during the process of which, alloying elements of Si and Mn are added for deoxygenation and carbon powder and slag former are also added;
 S4: performing refining outside the convertor, by adding Cr element and meanwhile performing decarburization by blowing oxygen in an RH vacuum refining furnace so as to control the Cr and C contents within the range in accordance with Claim 1 or 2; carrying out deoxygenation with an LF furnace, adding the required alloying elements of Mn, Mo, Sn and Rare Earth into the steel after deoxygenation, and then adding calcium-ferrous alloy under soft stirring by blowing inert gas, so as to control contents of these elements within the range in

accordance with Claim 1 or 2; raising the temperature of the molten steel and adding a cover agent;
 S5: performing continuous casting, by casting the molten steel under protective casting with a continuous casting machine to form a continuous casting slab;
 S6: performing rolling, by heating the continuous casting slab to a temperature higher than its austenitization temperature in a heating furnace, rough rolling, moderate rolling, precision rolling, and placing the rolled steel after precision rolling onto a cooling bed for air cooling, so as to produce a finished product of steel rebar with ingredients in accordance with Claim 1 or 2.

9. A production method of steel rebar, **characterized in** comprising the following steps:

S1: performing preliminary desulfurization of molten iron to control the sulfur content at no more than 0.01%;
 S2: performing smelting in a convertor, by feeding the molten iron processed by Step S1 together with steel scrap and/or pig iron into a convertor to be smelted, thus obtaining steel with a carbon content less than 0.05% and a phosphorus content less than 0.01% for steel tapping;
 S3: performing steel tapping, during the process of which, alloying elements of Si and Mn are added for deoxygenation and carbon powder and slag former are also added;
 S4: performing refining outside the convertor, by adding Cr element and meanwhile performing decarburization by blowing oxygen in an RH vacuum refining furnace so as to control the Cr and C contents within the range in accordance with Claim 3 or 4 or 5 or 6; carrying out deoxygenation with an LF furnace, adding the required alloying elements of Mn, Mo, Sn, Rare Earth, as well as V and/or Ti, into the steel after deoxygenation, and then adding calcium-ferrum alloy under soft stirring by blowing inert gas, so as to control contents of these elements within the range in accordance with Claim 3 or 4 or 5 or 6; raising the temperature of the molten steel and adding a cover agent;
 S5: performing continuous casting, by casting the molten steel under protective casting with a continuous casting machine to form a continuous casting slab;
 S6: performing rolling, by heating the continuous casting slab to a temperature higher than its austenitization temperature in a heating furnace, rough rolling, moderate rolling, precision rolling, and placing the rolled steel after precision rolling onto a cooling bed for air cooling, so as to produce a finished product of steel rebar with ingredients in accordance with Claim 3 or 4 or 5 or 6.

10. The production method in accordance with Claim 8 or 9, **characterized in that**, in Step S2, the steel for steel tapping has a temperature no higher than 1690°C.

11. The production method in accordance with Claim 8 or 9 or 10, **characterized in that**, in Step S3, a protective gas is blown into the molten steel for stirring during the process of steel tapping.

12. The production method in accordance with any one of Claims 8-11, **characterized in that**, in Step S4, the decarburization by blowing oxygen is performed at a temperature no lower than 1605°C during refining in the RH vacuum refining furnace, the deoxygenation is performed at a temperature no lower than 1575°C during refining in the LF furnace to control the oxygen content at no more than 50ppm, the soft stirring is performed for a duration no less than 5min, and the temperature of the molten steel is raised to 1570-1600°C.

13. The production method in accordance with any one of Claims 8-12, **characterized in that**, in Step S6, the continuous casting slab is heated to 1100-1200°C in the heating furnace, the start rolling temperature before the rough rolling is 1030-1100°C, the temperature during the precision rolling is 950-1050°C, and the temperature when the rolled steel is initially placed onto the cooling bed is 900-960°C.

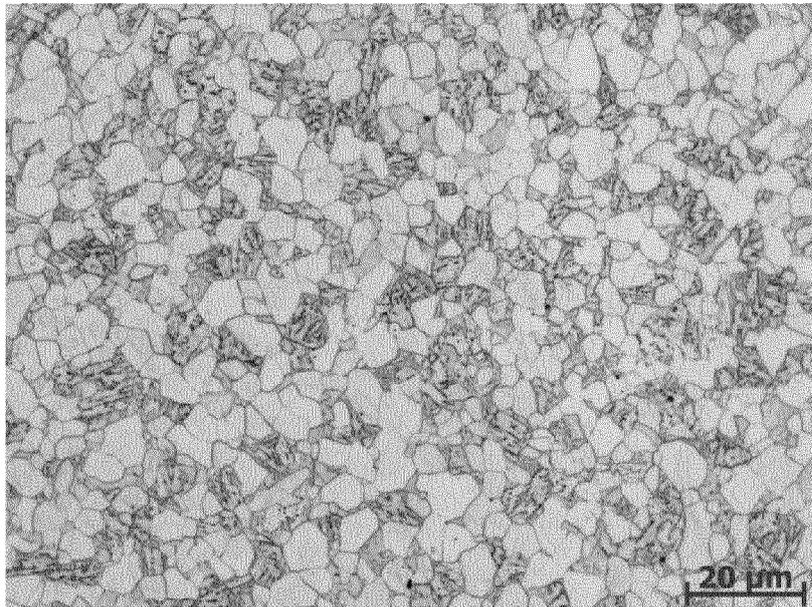


FIG. 1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2014/080994

A. CLASSIFICATION OF SUBJECT MATTER		
C22C 38/38 (2006.01) i; C22C 38/22 (2006.01) i; C22C 38/28 (2006.01) i; C22C 38/24 (2006.01) i; C21C 1/02 (2006.01) i; C21C 5/30 (2006.01) i; C21C 7/10 (2006.01) i; C21C 7/068 (2006.01) i; C21C 7/06 (2006.01) i; C21D 8/08 (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; C21D		
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)		
CNKI, WPI, EPODOC, CPRS, CR, chrome, chromium, mo, molybdenum, sn, tin, rem, re, rare earth, ferrolite, ferrite, bainite, continuous casting, desulfur+, refin+, cast+, roll+		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2001342548 A (KAWASAKI STEEL CORP.), 14 December 2001 (14.12.2001), claims 2, 3 and 5, paragraphs 0042-0049, and table 1	1-13
Y	JP 2004143496 A (KAWASAKI STEEL COR.), 20 May 2004 (20.05.2004), claims 1 and 2	1-13
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<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents:	“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	
“A” document defining the general state of the art which is not considered to be of particular relevance	“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	
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“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)	“&” document member of the same patent family	
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Date of the actual completion of the international search	Date of mailing of the international search report	
16 January 2015 (16.01.2015)	11 March 2015 (11.03.2015)	
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer WANG, Yu Telephone No.: (86-10) 62084745	

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2014/080994

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REFERENCES CITED IN THE DESCRIPTION

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