

80-mm-Thick Low-Cost FH420 Marine Engineering Steel Plate and Manufacturing Method Thereof

TECHNICAL FIELD

The present invention relates to marine engineering steel and specifically to an
5 80-mm-thick low-cost FH420 marine engineering steel plate and manufacturing method
thereof.

BACKGROUND ART

China started offshore oil development relatively late and didn't have its own offshore
oil platforms until the 1980s. In the past 10 years, domestic offshore platform steel plates
10 began to be widely used in Chinese offshore oil projects. At present, China has basically
realized localization of the steel below EH36 for offshore platforms, accounting for 90% of
the amount of platform steel. With the implementation of national “Made in China 2025”
and the “Mid- and Long-term Development Plan of the Marine Engineering Equipment
Manufacturing Industry” and the gradual implementation of the National Strategy of the
15 South China Sea, the field of marine engineering equipment and high-tech ships will
vigorously develop deep-sea exploration, resource development and utilization, offshore
operation support equipment and its key systems and special equipment; and promote the
development and engineering of deep-sea space stations and large floating structures.
Inevitably, the demand and requirements for offshore platform steel will be expanded
20 continuously and move towards the direction of high strength and thick specifications.

Invention patent CN 104674117 A provides a 420MPa-grade marine engineering steel
plate and manufacturing method thereof, and invention patent CN 104357742 A provides a
420MPa-grade thick and hot-rolled marine engineering steel plate and manufacturing
method thereof. The manufacturing method disclosed by the above two patents is rolling
25 and cooling control. Marine engineering equipment manufacturers have very high
requirements for the performance uniformity and performance fluctuation values of
420MPa-grade marine engineering steel, barely accept delivery of rolling and cooling
control and all require delivery in a quenched and tempered state; further, invention patent
CN 104674117 A is designed to contain noble elements Ni and Cu, and invention patent CN

104357742 A is designed to contain noble element Ni; still further, the above two invention patents only meet the requirements of grade-E steel and do not meet the requirements of grade-F ultra-high-strength marine engineering steel. Conventional FH420 marine engineering steel delivered in a quenched and tempered state contains a large amount of noble elements Ni, Mo and Cu, is expensive and will significantly raise the production cost of the marine engineering equipment companies.

SUMMARY OF THE INVENTION

A technical problem that the present invention intends to solve is how to address the disadvantages of the prior art and develop a low-cost (the steel does not contain noble elements: Ni, Mo and Cu) 80-mm-thick FH420 marine engineering steel plate within the scope of chemical composition specified in GB712 and the standards of top 10 classification societies, which on the one hand does not have high requirements for mill load and can be produced by an ordinary wide and heavy plate mill, and on the other hand, after heat treatment, is characterized by fine grains, uniform structure, low internal stress and good mechanical properties.

The present invention adopts the following technical solution to solve the above technical problem:

An 80-mm-thick low-cost FH420 marine engineering steel plate, comprising by weight: C: 0.07~0.11%, Si: 0.15~0.40%, Mn: 1.30~1.60%, P: $\leq$ 0.013%, S: $\leq$ 0.003%, Nb: 0.010~0.030%, V: 0.030~0.050%, Ti: 0.005~0.020%, Cr: 0.10~0.20%, Al: 0.0250~0.050%, O: $\leq$ 18 ppm, N: $\leq$ 38 ppm, H: $\leq$ 2.5ppm, and the balance: Fe and unavoidable impurities.

A manufacturing method of the foregoing 80-mm-thick low-cost FH420 marine engineering steel plate, comprising the following steps:

Steelmaking and continuous casting process: After molten iron desulfurization, the target sulfur is $\leq$ 0.004%; the converter smelting adopts dephosphorization by the high-blowing low-drawing method and slag is retained during tapping of the converter; refining adopts white slag operation, the holding time of white slag is 15~20 min and the total refining time is ensured to be 35~45 min; the holding time of vacuum treatment is 20~23 min; after vacuum treatment, seamless calcium line treatment is carried out; and

during continuous casting, the target temperature of the ladle is liquidus temperature + (5-15) °C, and the drawing speed is stable;

Rolling process: A rolling and cooling control process is adopted and the rolling is carried out at two stages; the heating temperature of the continuously cast blooms before rolling is 1,150°C~1,220°C; the rough rolling temperature is 980~1,080°C; the finish rolling starting temperature is 840~870°C; the cumulative reduction rate of the three passes after finish rolling is 30%; laminar cooling after rolling is carried out, the final cooling temperature is 600~660°C, and the cooling rate is 5~8°C/s; and air cooling is carried out afterwards;

Heat treatment process: Quenching treatment is carried out, the quenching temperature is 890~910°C, the heating rate is 1.4 min/mm, and the heat preservation time is 0~25 min; and tempering treatment is carried out, the tempering temperature is 550~650°C, the heating rate is 2.0 min/mm, and the heat preservation time is 80~120 min to obtain 80-mm-thick low-cost FH420 marine engineering steel.

In the 80-mm-thick low-cost FH420 marine engineering steel plate and manufacturing method thereof provided by the present invention, the steel plate does not contain Ni, Cu and Mo and the cost is reduced significantly because the steel does not contain noble elements; composition design is based on smelting and control of clean steel and the molten iron is pretreated to reduce sulfur content; the converter adopts dephosphorization by the high-blowing low-drawing method and slag is retained during tapping to prevent rephosphorization; the refining time of white slag is ensured to adsorb inclusions and reduce the content of elements S and O in the steel; seamless calcium line treatment is carried out to improve the morphology of the inclusions; vacuum treatment is carried out to reduce the content of H, N and other harmful elements; and eventually, continuously cast blooms with good internal quality are obtained.

The heating temperature of the continuously cast blooms before rolling is 1,150°C~1,220°C to ensure complete solid solution of microalloy elements and prevent grain growth caused by over-temperature; rough rolling adopts high temperature, low speed and large reduction to break columnar crystal, weld together the internal defects of the blanks and refine austenite grains; the cumulative reduction rate in the three passes after finish rolling is 30%, and through the mechanism of inducing ferrite not in the

crystallization region by large deformation at low temperature and a proper cooling control process (the final cooling temperature is 600~660°C, and the cooling rate is 5~8°C/s), the purpose of controlling the grain size is achieved;

The quenching temperature is 890~910°C, the heating rate is 1.4 min/mm and the heat preservation time is 0~25 min to ensure complete austenitizing and a fine and uniform structure of the steel plate before quenching; the tempering temperature is 550~650°C, the heating rate is 2.0 min/mm, and the heat preservation time is 80~120 min to eliminate stress of the steel plate through tempering and prevent cutting deformation during use of the steel plate.

Beneficial effects of the present invention: The present invention can develop a low-cost (the steel does not contain noble elements: Ni, Mo and Cu) 80-mm-thick FH420 marine engineering steel plate within the scope of chemical composition specified in GB712 and the standards of top 10 classification societies, which does not have high requirements for mill load (the finish rolling starting temperature is relatively high and the cumulative reduction rate of the last three passes is greater than 30% only) and can be produced by an ordinary wide and heavy plate mill, so the present invention has wide applicability and is suitable for the production of most domestic wide and heavy plate producers; the present invention reduces the segregation, looseness and other internal defects of the blanks through smelting of clean steel; rough rolling adopts high temperature, low speed and large reduction to break columnar crystal and refine austenite grains; the purpose of controlling the grain size after hot rolling is achieved through deformation accumulation and cooperative cooling control of finish rolling; after heat treatment, the steel plate is characterized by fine grains, uniform structure and low internal stress; the manufacturing method provided by the present invention has a stable production process, the steel plate has good mechanical properties and the obtained FH420 steel has the characteristics of high strength, high toughness, lamellar tearing resistance and the like.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a typical structural morphology of the 80-mm-thick low-cost FH420 marine engineering steel plate after quenching and tempering in Embodiment 1 under a metallographic microscope.

Fig. 2 is a typical structural morphology of the 80-mm-thick low-cost FH420 marine

engineering steel plate after quenching and tempering in Embodiment 2 under a metallographic microscope.

Fig. 3 is a typical structural morphology of the 80-mm-thick low-cost FH420 marine engineering steel plate after quenching and tempering in Embodiment 3 under a
5 metallographic microscope.

Fig. 4 is a typical structural morphology of the 80-mm-thick low-cost FH420 marine engineering steel plate after quenching and tempering in Embodiment 4 under a metallographic microscope.

DETAILED DESCRIPTION

10 Embodiments 1~4

The chemical compositions of the 80-mm-thick low-cost FH420 marine engineering steel plates in Embodiments 1~4 are as shown in Table 1:

Table 1

Embodiment	C	Si	Mn	P	S	Nb	V	Ti	Cr	Al _t
Embodiment 1	0.07	0.40	1.60	0.013	0.0025	0.030	0.040	0.020	0.20	0.050
Embodiment 2	0.09	0.25	1.50	0.012	0.0015	0.025	0.050	0.015	0.18	0.040
Embodiment 3	0.10	0.30	1.40	0.011	0.0030	0.020	0.035	0.010	0.15	0.025
Embodiment 4	0.11	0.15	1.30	0.008	0.0010	0.010	0.030	0.005	0.10	0.030
Embodiment	O	N	H				Fe and unavoidable impurities			
Embodiment 1	0.0018	0.0037	0.00025				Margin			
Embodiment 2	0.0011	0.0038	0.00017				Margin			
Embodiment 3	0.0010	0.0030	0.00022				Margin			
Embodiment 4	0.0016	0.0033	0.00013				Margin			

The manufacturing methods of the 80-mm-thick low-cost FH420 marine engineering steel plates in Embodiments 1~4 are as follows:

The manufacturing method of the 80-mm-thick low-cost FH420 marine engineering steel plate in Embodiment 1, specifically as follows:

5 Steelmaking and continuous casting process: After molten iron desulfurization, the target sulfur is 0.004%; the converter smelting adopts dephosphorization by the high-blowing low-drawing method and slag is retained during tapping of the converter; refining adopts white slag operation, the holding time of white slag is 15 min and the total refining time is 35 min; the holding time of vacuum treatment is 20 min; after vacuum
10 treatment, seamless calcium line treatment is carried out; and during continuous casting, the target temperature of the ladle is liquidus temperature +15°C, and the drawing speed is stable.

Rolling process: A rolling and cooling control process is adopted and the rolling is carried out at two stages; the heating temperature of the continuously cast blooms before
15 rolling is 1,150°C; the rough rolling temperature is 980°C, rolling is carried out at high temperature, low speed and large reduction, and the reduction of the first pass is 40 mm; the finish rolling starting temperature is 840°C, and the cumulative reduction rate of the last three passes is 34%; laminar cooling after rolling is carried out, the final cooling temperature is 600°C, and the cooling rate is 5°C/s; and air cooling is carried out afterwards.

20 Heat treatment process: Quenching treatment is carried out, the quenching temperature is 890°C, the heating rate is 1.4 min/mm, and the heat preservation time is 0 min; and tempering treatment is carried out, the tempering temperature is 550°C, the heating rate is 2.0 min/mm, and the heat preservation time is 80 min to obtain an 80-mm-thick low-cost FH420 marine engineering steel plate with a good plate shape (the unevenness is 2 mm/m).

25 The manufacturing method of the 80-mm-thick low-cost FH420 marine engineering steel plate in Embodiment 2, specifically as follows:

Steelmaking and continuous casting process: After molten iron desulfurization, the target sulfur is 0.0035%; the converter smelting adopts dephosphorization by the high-blowing low-drawing method and slag is retained during tapping of the converter;

refining adopts white slag operation, the holding time of white slag is 18 min and the total refining time is 40 min; the holding time of vacuum treatment is 21 min; after vacuum treatment, seamless calcium line treatment is carried out; and during continuous casting, the target temperature of the ladle is liquidus temperature +10°C, and the drawing speed is stable.

Rolling process: A rolling and cooling control process is adopted and the rolling is carried out at two stages; the heating temperature of the continuously cast blooms before rolling is 1,180°C; the rough rolling temperature is 1,000°C, rolling is carried out at high temperature, low speed and large reduction, and the reduction of the first pass is 38 mm; the finish rolling starting temperature is 850°C, and the cumulative reduction rate of the last three passes is 31%; laminar cooling after rolling is carried out, the final cooling temperature is 620°C, and the cooling rate is 8°C/s; and air cooling is carried out afterwards.

Heat treatment process: Quenching treatment is carried out, the quenching temperature is 900°C, the heating rate is 1.4 min/mm, and the heat preservation time is 10 min; and tempering treatment is carried out, the tempering temperature is 580°C, the heating rate is 2.0 min/mm, and the heat preservation time is 90 min to obtain an 80-mm-thick low-cost FH420 marine engineering steel plate with a good plate shape (the unevenness is 2 mm/m).

The manufacturing method of the 80-mm-thick low-cost FH420 marine engineering steel plate in Embodiment 3, specifically as follows:

Steelmaking and continuous casting process: After molten iron desulfurization, the target sulfur is 0.003%; the converter smelting adopts dephosphorization by the high-blowing low-drawing method and slag is retained during tapping of the converter; refining adopts white slag operation, the holding time of white slag is 19 min and the total refining time is 42 min; the holding time of vacuum treatment is 22 min; after vacuum treatment, seamless calcium line treatment is carried out; and during continuous casting, the target temperature of the ladle is liquidus temperature +8°C, and the drawing speed is stable.

Rolling process: A rolling and cooling control process is adopted and the rolling is carried out at two stages; the heating temperature of the continuously cast blooms before rolling is 1,200°C; the rough rolling temperature is 1,050°C, rolling is carried out at high temperature, low speed and large reduction, and the reduction of the first pass is 35 mm; the

finish rolling starting temperature is 860°C, and the cumulative reduction rate of the last three passes is 32%; laminar cooling after rolling is carried out, the final cooling temperature is 640°C, and the cooling rate is 7°C/s; and air cooling is carried out afterwards.

Heat treatment process: Quenching treatment is carried out, the quenching temperature is 905°C, the heating rate is 1.4 min/mm, and the heat preservation time is 15 min; and tempering treatment is carried out, the tempering temperature is 620°C, the heating rate is 2.0 min/mm, and the heat preservation time is 100 min to obtain an 80-mm-thick low-cost FH420 marine engineering steel plate with a good plate shape (the unevenness is 2 mm/m).

The manufacturing method of the 80-mm-thick low-cost FH420 marine engineering steel plate in Embodiment 4, specifically as follows:

Steelmaking and continuous casting process: After molten iron desulfurization, the target sulfur is 0.0033%; the converter smelting adopts dephosphorization by the high-blowing low-drawing method and slag is retained during tapping of the converter; refining adopts white slag operation, the holding time of white slag is 20 min and the total refining time is 45 min; the holding time of vacuum treatment is 23 min; after vacuum treatment, seamless calcium line treatment is carried out; and during continuous casting, the target temperature of the ladle is liquidus temperature +5°C, and the drawing speed is stable.

Rolling process: A rolling and cooling control process is adopted and the rolling is carried out at two stages; the heating temperature of the continuously cast blooms before rolling is 1,220°C; the rough rolling temperature is 1,080°C, rolling is carried out at high temperature, low speed and large reduction, and the reduction of the first pass is 33 mm; the finish rolling starting temperature is 870°C, and the cumulative reduction rate of the last three passes is 33%; laminar cooling after rolling is carried out, the final cooling temperature is 660°C, and the cooling rate is 8°C/s; and air cooling is carried out afterwards.

Heat treatment process: Quenching treatment is carried out, the quenching temperature is 910°C, the heating rate is 1.4 min/mm, and the heat preservation time is 25 min; and tempering treatment is carried out, the tempering temperature is 650°C, the heating rate is 2.0 min/mm, and the heat preservation time is 120 min to obtain an 80-mm-thick low-cost FH420 marine engineering steel plate with a good plate shape (the unevenness is 2 mm/m).

Fig. 1 is a typical structural morphology of the 80-mm-thick low-cost FH420 marine engineering steel plate after quenching and tempering treatment in Embodiment 1 under a metallographic microscope; Fig. 2 is a typical structural morphology of the 80-mm-thick low-cost FH420 marine engineering steel plate after quenching and tempering treatment in Embodiment 2 under a metallographic microscope; Fig. 3 is a typical structural morphology of the 80-mm-thick low-cost FH420 marine engineering steel plate after quenching and tempering treatment in Embodiment 3 under a metallographic microscope; and Fig. 4 is a typical structural morphology of the 80-mm-thick low-cost FH420 marine engineering steel plate after quenching and tempering treatment in Embodiment 4 under a metallographic microscope. From Fig. 1 to Fig. 4, it can be seen that the structure of the 80-mm-thick low-cost FH420 marine engineering steel plates is a fine and uniform bainite structure + a small amount of ferritic structure, thereby ensuring good properties of the steel plates.

After quenching and tempering, the transverse tensile properties and transverse cold bending properties of the steel plates in Embodiments 1~4 at 1/4 plate thickness and 1/2 plate thickness are as shown in Table 2 and the transverse impact properties and Z-direction properties are as shown in Table 3.

Table 2

Embodiment	Location	Yield strength MPa	Tensile strength MPa	Elongation %	Wide cold bending (b=5a)
Embodiment 1	At 1/4 of plate thickness	440	560	25	d=3a
	At 1/2 of plate thickness	422	533	23	Pass
Embodiment 2	At 1/4 of plate thickness	449	565	24	d=3a
	At 1/2 of plate thickness	433	541	24	Pass
Embodiment 3	At 1/4 of plate thickness	452	566	23	d=3a
	At 1/2 of plate thickness	426	551	22	Pass
Embodiment 4	At 1/4 of plate thickness	466	571	24	d=3a
	At 1/2 of plate thickness	429	558	22.5	Pass

Table 3

No.	Status	-60°C AKV.J				Z-direction reduction of area (%)			
		1	1	2	Average	1	2	3	Average
Embodiment 1	At 1/4 of plate thickness	222	282	213	239	73	67	66	69
	At 1/2 of plate thickness	152	145	106	134				
Embodiment 2	At 1/4 of plate thickness	202	216	222	213	72	75	68	72
	At 1/2 of plate thickness	140	138	111	130				
Embodiment 3	At 1/4 of plate thickness	201	187	234	207	69	65	66	67
	At 1/2 of plate thickness	99	108	137	115				
Embodiment 4	At 1/4 of plate thickness	159	202	177	179	68	66	66	67
	At 1/2 of plate thickness	88	129	150	122				

From Table 2 and Table 3, it can be seen that the mechanical properties of the steel plates in Embodiments 1~4 meet the requirements of the standards of large classification societies for the properties of class-420 grade-F ultra-high-strength marine engineering steel, the yield strength is $\geq 422\text{MPa}$, the tensile strength is $\geq 533\text{MPa}$, the elongation is $\geq 22\%$ and the Z-direction reduction of area is $\geq 53\%$, meeting the requirements of 80-mm-thick FH420 marine engineering steel plates. The steel plates have the characteristics of low cost of microalloy elements, a stable production process and low requirements for wide and heavy plate mills and corresponding heat treatment equipment.

In addition to the foregoing embodiments, the present invention may also have other embodiments. All the technical solutions formed by adopting identical replacements or equivalent transformations fall in the scope of protection required by the present invention.

Claims

1. An 80-mm-thick low-cost FH420 marine engineering steel plate, wherein the steel plate comprises by weight, C: 0.07-0.11%, Si: 0.15-0.40%, Mn: 1.30-1.60%, P: $\leq 0.013\%$, S: $\leq 0.003\%$, Nb: 0.010-0.030%, V: 0.030-0.050%, Ti: 0.005-0.020%, Cr: 0.10-0.20%, Al: 0.0250-0.050%, O: ≤ 18 ppm, N: ≤ 38 ppm, H: ≤ 2.5 ppm, and the balance: Fe and unavoidable impurities.
2. The 80-mm-thick low-cost FH420 marine engineering steel plate according to claim 1, wherein the steel plate comprises by weight, C: 0.07%, Si: 0.40%, Mn: 1.60%, P: 0.013%, S: 0.0025%, Nb: 0.030%, V: 0.040%, Ti: 0.020%, Cr: 0.20%, Al: 0.050%, O: 0.0018%, N: 0.0037%, H: 0.00025%, and the balance: Fe and unavoidable impurities.
3. The 80-mm-thick low-cost FH420 marine engineering steel plate according to claim 1, wherein the steel plate comprises by weight, C: 0.09%, Si: 0.25%, Mn: 1.50%, P: 0.012%, S: 0.0015%, Nb: 0.025%, V: 0.050%, Ti: 0.015%, Cr: 0.18%, Al: 0.040%, O: 0.0011%, N: 0.0038%, H: 0.00017%, and the balance: Fe and unavoidable impurities.
4. The 80-mm-thick low-cost FH420 marine engineering steel plate according to claim 1, wherein the steel plate comprises by weight, C: 0.10%, Si: 0.30%, Mn: 1.40%, P: 0.011%, S: 0.0030%, Nb: 0.020%, V: 0.035%, Ti: 0.010%, Cr: 0.15%, Al: 0.025%, O: 0.0010%, N: 0.0030%, H: 0.00022%, and the balance: Fe and unavoidable impurities.
5. The 80-mm-thick low-cost FH420 marine engineering steel plate according to claim 1, wherein the steel plate comprises by weight, C: 0.11%, Si: 0.15%, Mn: 1.30%, P: 0.008%, S: 0.0010%, Nb: 0.010%, V: 0.030%, Ti: 0.005%, Cr: 0.10%, Al: 0.030%, O: 0.0016%, N: 0.0033%, H: 0.00013%, and the balance: Fe and unavoidable impurities.
6. A manufacturing method of the 80-mm-thick low-cost FH420 marine engineering steel plate according to any of claims 1-5, wherein the method comprises the following steps:

steelmaking and continuous casting process: After molten iron desulfurization, the target sulfur is $\leq 0.004\%$; the converter smelting adopts dephosphorization by the high-blowing low-drawing method and slag is retained during tapping of the converter; refining adopts white slag operation, the holding time of white slag is 15~20 min and the total refining time is ensured to be 35~45 min; the holding time of vacuum treatment is

20~23 min; after vacuum treatment, seamless calcium line treatment is carried out; and during continuous casting, the target temperature of the ladle is liquidus temperature + (5-15) °C, and the drawing speed is stable;

rolling process: A rolling and cooling control process is adopted and the rolling is carried out at two stages; the heating temperature of the continuously cast blooms before rolling is 1,150°C~1,220°C; the rough rolling temperature is 980~1,080°C; and the finish rolling starting temperature is 840~870°C; the cumulative reduction rate of the three passes after finish rolling is greater than 30%; laminar cooling after rolling is carried out, the final cooling temperature is 600~660°C, and the cooling rate is 5~8°C/s; and air cooling is carried out afterwards;

heat treatment process: quenching treatment is carried out, the quenching temperature is 890-910°C, the heating rate is 1.4 min/mm, and the heat preservation time is 0-25 min; and tempering treatment is carried out, the tempering temperature is 550-650°C, the heating rate is 2.0 min/mm and the heat preservation time is 80-120 min to obtain 80-mm-thick low-cost FH420 marine engineering steel.

7. The manufacturing method of the 80-mm-thick low-cost FH420 marine engineering steel plate according to claim 6, wherein the method comprises the following steps:

steelmaking and continuous casting process: After molten iron desulfurization, the target sulfur is 0.004%; the converter smelting adopts dephosphorization by the high-blowing low-drawing method and slag is retained during tapping of the converter; refining adopts white slag operation, the holding time of white slag is 15 min and the total refining time is 35 min; the holding time of vacuum treatment is 20 min; after vacuum treatment, seamless calcium line treatment is carried out; and during continuous casting, the target temperature of the ladle is liquidus temperature +15°C, and the drawing speed is stable;

rolling process: A rolling and cooling control process is adopted and the rolling is carried out at two stages; the heating temperature of the continuously cast blooms before rolling is 1,150°C; the rough rolling temperature is 980°C, rolling is carried out at high temperature, low speed and large reduction, and the reduction of the first pass is 40 mm; the finish rolling starting temperature is 840°C, and the cumulative reduction rate of the last

three passes is 30%; laminar cooling after rolling is carried out, the final cooling temperature is 600°C, and the cooling rate is 5°C/s; and air cooling is carried out afterwards;

heat treatment process: Quenching treatment is carried out, the quenching temperature is 890°C, the heating rate is 1.4 min/mm, and the heat preservation time is 0 min; and
5 tempering treatment is carried out, the tempering temperature is 550°C, the heating rate is 2.0 min/mm, and the heat preservation time is 80 min to obtain an 80-mm-thick low-cost FH420 marine engineering steel plate.

8. The manufacturing method of the 80-mm-thick low-cost FH420 marine engineering steel plate according to claim 6, wherein the method comprises the following
10 steps:

steelmaking and continuous casting process: After molten iron desulfurization, the target sulfur is 0.0035%; the converter smelting adopts dephosphorization by the high-blowing low-drawing method and slag is retained during tapping of the converter; refining adopts white slag operation, the holding time of white slag is 18 min and the total
15 refining time is 40 min; the holding time of vacuum treatment is 21 min; after vacuum treatment, seamless calcium line treatment is carried out; and during continuous casting, the target temperature of the ladle is liquidus temperature +10°C, and the drawing speed is stable;

rolling process: A rolling and cooling control process is adopted and the rolling is
20 carried out at two stages; the heating temperature of the continuously cast blooms before rolling is 1,180°C; the rough rolling temperature is 1,000°C, rolling is carried out at high temperature, low speed and large reduction, and the reduction of the first pass is 38 mm; the finish rolling starting temperature is 850°C, and the cumulative reduction rate of the last three passes is 31%; laminar cooling after rolling is carried out, the final cooling
25 temperature is 620°C, and the cooling rate is 8°C/s; and air cooling is carried out afterwards;

heat treatment process: Quenching treatment is carried out, the quenching temperature is 900°C, the heating rate is 1.4 min/mm, and the heat preservation time is 10 min; and tempering treatment is carried out, the tempering temperature is 580°C, the heating rate is 2.0 min/mm, and the heat preservation time is 90 min to obtain an 80-mm-thick low-cost
30 FH420 marine engineering steel plate.

9. The manufacturing method of the 80-mm-thick low-cost FH420 marine engineering steel plate according to claim 6, wherein the method comprises the following steps:

steelmaking and continuous casting process: After molten iron desulfurization, the target sulfur is 0.003%; the converter smelting adopts dephosphorization by the high-blowing low-drawing method and slag is retained during tapping of the converter; refining adopts white slag operation, the holding time of white slag is 19 min and the total refining time is 42 min; the holding time of vacuum treatment is 22 min; after vacuum treatment, seamless calcium line treatment is carried out; and during continuous casting, the target temperature of the ladle is liquidus temperature +8°C, and the drawing speed is stable;

rolling process: A rolling and cooling control process is adopted and the rolling is carried out at two stages; the heating temperature of the continuously cast blooms before rolling is 1,200°C; the rough rolling temperature is 1,050°C, rolling is carried out at high temperature, low speed and large reduction, and the reduction of the first pass is 35 mm; the finish rolling starting temperature is 860°C, and the cumulative reduction rate of the last three passes is 32%; laminar cooling after rolling is carried out, the final cooling temperature is 640°C, and the cooling rate is 7°C/s; and air cooling is carried out afterwards;

heat treatment process: Quenching treatment is carried out, the quenching temperature is 905°C, the heating rate is 1.4 min/mm, and the heat preservation time is 15 min; and tempering treatment is carried out, the tempering temperature is 620°C, the heating rate is 2.0 min/mm, and the heat preservation time is 100 min to obtain an 80-mm-thick low-cost FH420 marine engineering steel plate.

10. The manufacturing method of the 80-mm-thick low-cost FH420 marine engineering steel plate according to claim 6, wherein the method comprises the following steps:

steelmaking and continuous casting process: After molten iron desulfurization, the target sulfur is 0.0033%; the converter smelting adopts dephosphorization by the high-blowing low-drawing method and slag is retained during tapping of the converter; refining adopts white slag operation, the holding time of white slag is 20 min and the total refining time is 45 min; the holding time of vacuum treatment is 23 min; after vacuum treatment, seamless calcium line treatment is carried out; and during continuous casting, the

target temperature of the ladle is liquidus temperature +5°C, and the drawing speed is stable;

5 rolling process: A rolling and cooling control process is adopted and the rolling is carried out at two stages; the heating temperature of the continuously cast blooms before rolling is 1,220°C; the rough rolling temperature is 1,080°C, rolling is carried out at high temperature, low speed and large reduction, and the reduction of the first pass is 33mm; the finish rolling starting temperature is 870°C, and the cumulative reduction rate of the last three passes is 33%; laminar cooling after rolling is carried out, the final cooling temperature is 660°C, and the cooling rate is 8°C/s; and air cooling is carried out afterwards;

10 heat treatment process: Quenching treatment is carried out, the quenching temperature is 910°C, the heating rate is 1.4 min/mm, and the heat preservation time is 25 min; and tempering treatment is carried out, the tempering temperature is 650°C, the heating rate is 2.0 min/mm, and the heat preservation time is 120 min to obtain an 80-mm-thick low-cost FH420 marine engineering steel plate.