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(54) **PROCESS FOR PRODUCING LS-CRNIMO30C STEEL FORGING USING CONTINUOUS CASTING BILLET FOR SUBSEA OIL PRODUCTION WELLHEAD DEVICE**

VERFAHREN ZUR HERSTELLUNG VON LS-CRNIMO30C-STAHLSCHMIEDESTÜCK MITTELS STRANGGIESSKNÜPPEL FÜR BOHRLOCHKOPFVORRICHTUNG ZUR UNTERWASSERÖLGEWINNUNG

PROCÉDÉ DE PRODUCTION DE PIÈCE FORGÉE EN ACIER LS-CRNIMO30C À PARTIR D'UNE BILLETTE DE COULÉE CONTINUE POUR DISPOSITIF DE TÊTE DE PUITS DE PRODUCTION SOUS-MARINE DE PÉTROLE

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(56) References cited:

EP-A1- 2 141 254	CN-A- 102 728 756
CN-A- 104 894 487	CN-A- 104 894 487

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CN-A- 104 975 235

CN-A- 106 591 680

JP-A- 2002 363 690

US-A1- 2015 158 079

Description

Technical Field

[0001] The present invention relates to a field of manufacturing forged steel, specially relates to a process for manufacturing CrNiMo30C forged steel for a wellhead device of deep-sea oil extraction by continuous casting.

Background Art

[0002] The wellhead device of deep-sea oil extraction consists of casing-head, tubing-head and production tree, and is an important device for producing gas-oil. The wellhead device is mainly used to control the pressure of production wellhead and to regulate the flow rate of oil (gas) and water wells, how good the performance is relates to whether the oil/gas wells can produce safely and efficiently or not.

[0003] At present the wellhead device of deep-sea oil extraction is usually forged by mold casting ingot, because the inner quality of steel ingot in manufacturing is better than that of continuous casting billet (especially the alloy containing a certain amount of Cr, Ni, Mo etc.), the forged bar can meet the higher requirements of ultrasonic flaw detection and mechanical property required by the wellhead device of deep-sea oil extraction. While the casting and solidification process of molten steel of continuous casting billet is different from those of mold casting ingot, the inner quality of continuous casting billet has problems of bad compactness and heavy segregation, therefore, the forged bar by continuous casting billet usually can not meet the requirements of use in the wellhead device of deep-sea oil extraction. However, each forged bar by mold casting ingot has to be cut in heads and tails, the production ratio in forging is only about 80%, whereas the forged bar by continuous casting billet is poured at one time with several stoves of steel. Because the billet yield in continuous casting is high, the production ratio in forging is up to 90% or more, the production efficiency is high and the cost is low. Thus, improving the inner quality of continuous casting billets, controlling the process of forging, and replacing the mold casting ingots by continuous casting billets for manufacturing the wellhead device of deep-sea oil extraction would be a better development tendency.

[0004] CN106591680A discloses a technology for producing an LS-CrNiMo30C steel for a subsea oil production wellhead device, using a continuous casting billet. The technology comprises the steps of smelting molten steel, continuously casting, forging, annealing, cooling, etc.; the heating speed is equal to or less than 200°C per hour, the heating temperature of forging is 1200-1250°C, ensuring that the billet is completely heated, the initial forging temperature is higher than 1150°C, and the final forging temperature is not lower than 850°C; after leaving the production line, the forged steel is at a high temperature of equal to or greater than 500°C, and is then slowly

cooled in sand; after the temperature drops to 200°C or lower, the forged steel is taken out of pit and slowly cooled.

Disclosure of Invention

[0005] Aiming at above prior arts, the object of the present invention is, by improving the inner quality of continuous casting of $\Phi 600\text{mm}$ CrNiMo30C steel and by adopting a reasonable forging process, to manufacture forged round steel of $\Phi 300\text{--}400\text{mm}$ via replacing mold casting ingot with continuous casting billet. The inner quality meets requirements of an ultrasonic test according to grade D/d of SEP 1921 standard and a mechanical property test according to APISPEC 6A standard.

[0006] The present invention provides a process for manufacturing CrNiMo30C forged steel as described in our claim 1.

[0007] Specifically, it relates to a process for manufacturing CrNiMo30C forged steel for a wellhead device of deep-sea oil extraction, by continuous casting, including the following steps

1) Smelting molten steel: CrNiMo30C steel of a medium-carbon low-alloy CrNiMo steel, its constituents and mass percentages are as follows: C: 0.25~0.40%, Si: 0.15~0.40%, Mn: 0.80~1.30%, P: $\leq 0.010\%$, S: $\leq 0.008\%$, Cr: 0.85~1.55%, Mo: 0.30~0.65%, Ni: 0.80~1.40%, V: 0.02~0.08%, Nb: 0.02~0.05%, Cu $\leq 0.25\%$, B $\leq 0.0005\%$, H $\leq 0.0002\%$, the balance is Fe and the unavoidable impurity elements, the molten steel is processed by KR pretreatment, BOF converter smelting, LF refining and RH vacuum degassing, thereby the CrNiMo30C steel with low H, S and P is obtained, and the steel is finally controlled according the requirements of P $\leq 0.010\%$, S $\leq 0.005\%$ and H $\leq 1.5\text{ppm}$;

2) Continuous casting: the molten steel is further processed by argon protection, mixed electromagnetic stirring with mold electromagnetic stirring (M-EMS) and final electromagnetic stirring (F-EMS), in cooperation with secondary cooling water and low speed casting, and strictly controlling a superheat degree of 20-35°C, thereby to decrease columnar crystals and enlarge equiaxed crystal, to prevent the development of columnar crystals to refine grains, to reduce segregation degree in steel crystallization process, to sufficiently ensure uniformity and compactness of inner structure; a continuous casting billet of $\Phi 600\text{mm}$ leaves the production line and is delivered to a slow cooling pit at a high temperature of equal to or more than 500°C, and is kept warm for equal to or more than 36h in the pit, and then the continuous billet is timely forged after outside the pit; the macrostructure of the continuous casting billet meets the requirements of appendix A of YB/T4149 standard: center porosity is equal to or less than grade 2.0, center crack is equal to or less than grade

1.0, shrinkage cavity is equal to or less than grade 1.0, defects of intermediate cracks, white flakes and upwarping defects are forbidden;

3) Forging: the billet is heated and the heating speed is equal to or less than 200°C per hour, the heating temperature of forging is 1200-1250°C, ensuring that the billet is completely heated, the initial forging temperature is higher than 1150°C, and the final forging temperature is not lower than 850°C, the continuous casting billet is freely forged by a 1400T double-station hydraulic machine, oxide coating of the continuous billet is timely removed during forging, the billet is drawn into square shape by a small reduction amount of 20-30mm at initial cogging, thereby to prevent surface cracks, and is drawn into square shape by a large reduction amount of 70-80mm at intermediate cogging, thereby to penetrate the forging force into the core so as to improve the inner quality, and the billet is further drawn and its outside shaped as a circle, and is finally finished to a finished size; after leaving the production line, the forged steel is at a high temperature of equal to or greater than 500°C and is then slowly cooled in sand; after the temperature drops to 200°C or lower, the forged steel is taken out of the pit and slowly cooled;

4) Performing stress relief annealing treatment on forged steel: the annealing temperature is 650-700°C, keeping warm for 12 hours or more, cooling to below 300°C along with the furnace, taking the forged billet outside the furnace, and air-cooling to room temperature;

5) Inspection: cutting head and tail parts of each piece of forged steel, and performing an ultrasonic test according to grade D/d of SEP 1921 standard to each piece of steel; performing a mechanical property test to a batch of the steel, wherein the tensile, the impact and the hardness should meet the requirements of APISPEC 6A standard.

[0008] Compared with the prior art, the advantages of the present invention focus on:

Compared with the prior process of manufacturing CrNiMo30C forged steel by mold casting ingot, the present invention has good benefits:

- Using "KR-BOF-LF-RH-CCM" in smelting and continuous casting, so that the degree of automation and mechanization is high, operating condition is therefore improved, and the production efficiency is improved.
- Using mixed electromagnetic stirring with mold electromagnetic stirring (M-EMS) and final electromagnetic stirring (F-EMS), to improve the inner quality of continuous quality; controlling forging heating process and the reduction amount at cogging, to obtain a forged bar of Cr, Ni, Mo with good inner quality for use in a wellhead device of deep-sea oil extraction; replacing casting ingot by continuous casting,

so that the yield ratio is improved, and the cost advantage is significant.

Brief Description of Figures in the Drawings

[0009]

Figure 1 illustrates macrostructure of $\Phi 350$ mm forged round steel by continuous casting billet in embodiment 1;

Figure 2 illustrates macrostructure of $\Phi 390$ mm forged round steel by continuous casting billet in embodiment 2.

Mode(s) for Carrying Out the Invention

[0010] The present invention further describes a process for manufacturing CrNiMo30C forged steel for a well-head device of deep-sea oil extraction by continuous casting billet in detail with reference to embodiments.

[0011] Chemical constituents of CrNiMo30C steel are as follows: C: 0.25~0.40%, Si: 0.15~0.40%, Mn: 0.80~1.30%, P: $\leq 0.010\%$, S: $\leq 0.008\%$, Cr: 0.85~1.55%, Mo: 0.30~0.65%, Ni: 0.80~1.40%, V: 0.02~0.08%, Nb: 0.02~0.05%, Cu $\leq 0.25\%$, B $\leq 0.0005\%$, H $\leq 0.0002\%$, the balance is Fe and the unavoidable impurity elements.

Embodiment 1

[0012] The steel is selected to be CrNiMo30C steel;

1) Smelting:

the molten steel is processed by KR pretreatment to perform desulphurization and desilication,

before the molten steel is delivered into converter, S=0.005%,

BOF converter smelting mainly performs dephosphorizing, decarbonizing and heating, alloy metal is added after tapping.

In LF refining process, the chemical constituents are fine tuned, deoxidation, desulphurization and removing impurity.

After degassing in RH vacuum and after breaking the vacuum, H is determined to be H=0.8ppm.

2) Continuous casting:

the molten steel is further processed by argon protection, the superheat degree is controlled to be 25°C, a continuous casting billet of $\Phi 600$ mm is produced by mixed electromagnetic stirring with mold electromagnetic stirring (M-EMS) and final electromagnetic stirring (F-EMS), and then it leaves the production line and is delivered to a slow cooling pit at 550°C, and is kept warm for 36h in the pit, then the continuous billet is taken outside the pit and the macrostructure is tested according to appendix A of

YB/T4149 standard: center porosity is grade 1.0, center crack is grade 0, shrinkage cavity is grade 0, free of intermediate cracks, white flakes or upwarping defects, etc.

3) Forging:

the continuous casting billet of $\Phi 600\text{mm}$ is cold delivered to the furnace and is heated to 1200°C , the heating speed is equal to or less than 200°C per hour, and is kept warm for 5 hours, the initial forging temperature is 1150°C , and the final forging temperature is not lower than 850°C , the continuous casting billet is freely forged by a 1400T double-station hydraulic machine, oxide coating of the continuous billet is timely removed during forging, the billet is drawn into about 550mm square by a small reduction amount of $20\text{-}30\text{mm}$ at initial cogging, and the billet is drawn into about 400mm square by a large reduction amount of $70\text{-}80\text{mm}$ at intermedia cogging, thereby to penetrate the forging force into the core, so as to improve the inner quality, and the billet is further drawn and its outside is shaped as a circle of $\Phi 370\text{mm}$, and is finally finished to a finished circle of $\Phi 350\text{mm}$; after leaving the production line, the forged steel is air-cooled to 550°C and then is slowly cooled in sand; after the temperature drops to 200°C or lower, the forged steel is taken out of the pit.

4) Annealing:

after the forged steel is taken out of the pit, performing stress relief annealing treatment, the annealing temperature is 660°C , keeping warm for 12 hours or more, cooling to below 300°C along with the furnace, taking the forged billet outside the furnace, and air-cooling to room temperature, the tested macrostructure is shown in figure 1.

5) Inspection:

cutting head and tail parts of each piece of forged steel, and performing an ultrasonic test according to grade D/d of SEP 1921 standard to each piece of steel; performing a mechanical property test to a batch of the steel, wherein the tensile, the impact and the hardness meet the requirements of APISPEC 6A standard.

Embodiment 2

[0013] The steel is selected to be CrNiMo30C steel.

1) Smelting:

the molten steel is processed by KR pretreatment to perform desulphurization and desilicication, before the molten steel is delivered into converter, $S=0.003\%$, BOF converter smelting mainly performs dephosphorizing, decarbonizing and heating, alloy metal is added after tapping.

In LF refining process, the chemical constituents are fine tuned, deoxidation, desulphurization and removing impurity.

After degassing in RH vacuum and after breaking the vacuum, H is determined to be $H=1.0\text{ppm}$.

2) Continuous casting:

the molten steel is further processed by argon protection, the superheat degree is controlled to be 27°C , a continuous casting billet of $\Phi 600\text{mm}$ is produced by mixed electromagnetic stirring with mold electromagnetic stirring (M-EMS) and final electromagnetic stirring (F-EMS), and then it leaves the production line and is delivered to a slow cooling pit at 580°C , and is kept warm for 40h in the pit, after slowly cooling the continuous billet is taken outside the pit and the macrostructure is tested according to appendix A of YB/T4149 standard: center porosity is grade 1.5, center crack is grade 0.5, shrinkage cavity is grade 0, free of intermediate cracks, white flakes or upwarping defects, etc..

3) Forging:

the continuous casting billet of $\Phi 600\text{mm}$ is cold delivered to the furnace and is heated to 1220°C , the heating speed is equal to or less than 200°C per hour, and is kept warm for 5 hours, the initial forging temperature is 1120°C , and the final forging temperature is not lower than 850°C , the continuous casting billet is freely forged by a 1400T double-station hydraulic machine, oxide coating of the continuous billet is timely removed during forging, the billet is drawn into about 550mm square by a small reduction amount of $20\text{-}30\text{mm}$ at initial cogging, and the billet is drawn into about 410mm square by a large reduction amount of $70\text{-}80\text{mm}$ at intermedia cogging, thereby to penetrate the forging force into the core so as to improve the inner quality, and the billet is further drawn and its outside shaped as a circle of $\Phi 400\text{mm}$, and is finally finished to a finished circle of $\Phi 390\text{mm}$; after leaving the production line, the forged steel is air-cooled to 550°C and then is slowly cooled in sand; after the temperature drops to 200°C or lower, the forged steel is taken out of the pit.

4) Annealing:

after the forged steel is taken out of the pit, performing stress relief annealing treatment, the annealing temperature is 660°C , keeping warm for 12 hours or more, cooling to below 300°C along with the furnace, taking the forged billet outside the furnace, and air-cooling to room temperature, the tested macrostructure is shown in figure 2;

5) Inspection:

cutting head and tail parts of each piece of forged steel, and performing an ultrasonic test according to grade D/d of SEP 1921 standard to each piece of steel; performing a mechanical property test to a batch of the steel, wherein the tensile, the impact and the hardness meet the requirements of APISPEC 6A standard.

Claims

1. A process for manufacturing CrNiMo30C forged steel for a wellhead device of deep-sea oil extraction, by continuous casting, **characterized in** including the following steps

1) Smelting molten steel: CrNiMo30C steel of a medium-carbon low-alloy CrNiMo steel, its constituents and mass percentages are as follows: C: 0.25~0.40%, Si: 0.15~0.40%, Mn: 0.80~1.30%, P: $\leq 0.010\%$, S: $\leq 0.008\%$, Cr: 0.85~1.55%, Mo: 0.30~0.65%, Ni: 0.80~1.40%, V: 0.02~0.08%, Nb: 0.02~0.05%, Cu $\leq 0.25\%$, B $\leq 0.0005\%$, H $\leq 0.0002\%$, the balance is Fe and the unavoidable impurity elements, wherein the molten steel is processed by Kanbara Reactor KR pretreatment, dephosphorizing and decarbonizing in Basic Oxygen Furnace BOF converter smelting and heating, adding alloy after tapping, Ladle Furnace LF refining and Ruhrstahl Heraeus RH vacuum degassing, thereby the CrNiMo30C steel with low H, S and P is obtained, and the steel is finally controlled according the requirements of P $\leq 0.010\%$, S $\leq 0.005\%$ and H $\leq 1.5\text{ppm}$;

2) Continuous casting: the molten steel is further processed by argon protection, mixed electromagnetic stirring with mold electromagnetic stirring (M-EMS) and final electromagnetic stirring (F-EMS), in cooperation with secondary cooling water and low speed casting, and strictly controlling a superheat degree of 20-35°C, thereby to decrease columnar crystals and enlarge equiaxed crystal, to prevent the development of columnar crystals to refine grains, to reduce segregation degree in steel crystallization process, to sufficiently ensure uniformity and compactness of inner structure; a continuous casting billet of $\Phi 600\text{mm}$ leaves the production line and is delivered to a slow cooling pit at a high temperature of equal to or more than 500°C, and is kept warm for equal to or more than 36h in the pit, and then the continuous billet is timely forged after outside the pit; the macrostructure of the continuous casting billet meets the requirements of appendix A of YB/T4149-2006 standard: center porosity is equal to or less than grade 2.0, center crack is equal to or less than grade 1.0, shrinkage cavity is equal to or less than grade 1.0, defects of intermediate cracks, white flakes and upwarping defects are forbidden;

3) Forging: the billet is heated and the heating speed is equal to or less than 200°C per hour, the heating temperature of forging is 1200-1250°C, ensuring that the billet is completely heated, the initial forging temperature is higher than 1150°C, and the final forging tem-

perature is not lower than 850°C, the continuous casting billet is freely forged by a 1400T double-station hydraulic machine, oxide coating of the continuous billet is timely removed during forging, the billet is drawn into square shape by a small reduction amount of 20-30mm at initial cogging, thereby to prevent surface cracks, and is drawn into square shape by a large reduction amount of 70-80mm at intermediate cogging, thereby to penetrate the forging force into the core so as to improve the inner quality, and the billet is further drawn and its outside shaped as a circle, and is finally finished to a finished size; after leaving the production line, the forged steel is at a high temperature of equal to or greater than 500°C, and is then slowly cooled in sand; after the temperature drops to 200°C or lower, the forged steel is taken out of pit and slowly cooled ;

4) Performing stress relief annealing treatment on forged steel: the annealing temperature is 650-700°C, keeping warm for 12 hours or more, cooling to below 300°C along with the furnace, taking the forged billet outside the furnace, and air-cooling to room temperature.

Patentansprüche

1. Herstellungsverfahren für CrNiMo30C-Schmiedestahl für eine Tiefseeölförderung -Bohrlochvorrichtung, **dadurch gekennzeichnet, dass** es die folgenden Schritte umfasst

1) geschmolzener Schmiedestahl: CrNiMo30C Stahl aus mittlerem Kohlenstoff und niedriglegiertem CrNiMo-Stahl mit Zusammensetzung und Massenprozentsatz wie folgt: C: 0,25~0,40%, Si: 0,15 ~ 0,40%, Mn: 0,80 ~ 1,30%, P: $\leq 0,010\%$, S: $\leq 0,008\%$, Cr: 0,85 ~ 1,55%, Mo: 0,30~0,65%, Ni: 0,80 ~ 1,40%, V: 0,02~0,08%, Nb: 0,02 ~ 0,05%, Cu $\leq 0,25\%$, B $\leq 0,0005\%$, H $\leq 0,0002\%$, Restmenge ist Fe und unvermeidliche Verunreinigungselemente, wobei der Schmiedestahl durch Kanbara-Reaktor KR Vorbehandlung, Entphosphorung und Entkohlung, Schmelzen und Wärmen im Alkali-Sauerstoff-Ofenkonverter, Legierung nach dem Stahlabgang, Pfannenofen LF-Raffination, Ruhrstahl Heraeus RH Vakuum Entgasung behandelt wird. Um CrNiMo30C-Stahl mit niedrigem H, S und P zu erhalten wird der Stahl schließlich auf die Anforderungen von P $\leq 0,010\%$, S $\leq 0,005\%$ und H $\leq 1,5\text{ ppm}$ kontrolliert;

2) Stranggießen: Der Schmiedestahl wird weiterhin durch Argon-Schutz, gemischtes elektromagnetisches Rühren mit elektromagnetisches Rühren der Form (M-EMS) und endgültiges

elektromagnetisches Rühren (F-EMS) mit Sekundärkühlwasser und Gießen mit niedriger Geschwindigkeit und strenger Kontrolle der Überhitzung von 20-35 ° C, um säulenförmige Kristalle zu verringern und gleichachsige Kristalle zu erhöhen, Entwicklung von säulenförmigen Kristallen zur Verfeinerung der Körner zu vermeiden, Grad der Segregation des Stahls während des Kristallisationsprozesses zu vermindern, Gleichförmigkeit und Kompaktheit der inneren Struktur vollständig zu gewährleisten; die Stranggussbramme von $\Phi 600$ mm verlässt die Produktionslinie und wird bei einer hohen Temperatur gleich oder größer als 500 ° C in die langsame kalte Grube geschickt und in der Grube gleich oder größer als 36 Stunden warm gehalten und rechtzeitig außerhalb der Grube geschmiedet; die makroskopische Struktur der Stranggussbramme erfüllt die Anforderungen des Anhangs A der Norm YB/T4149-2006: die zentrale Porosität ist gleich oder kleiner als 2,0, der zentrale Riss ist gleich oder kleiner als 1,0, die Schrumpfung ist gleich oder kleiner als 1,0, und Zwischenrissdefekte, weiße Plattendefekte und Aufwärtsdefekte sind verboten;

3) Schmieden: die Bramme wird mit einer Heizgeschwindigkeit von gleich oder größer als 200 °C pro Stunde erhitzt, und die Erwärmungstemperatur des Schmiedens beträgt 1200-1250°C, um die vollständige Erhitzung der Bramme sicherzustellen, und die Anfangsschmiedetemperatur ist über 1150°C, und die Endschmiedetemperatur beträgt nicht weniger als 850 ° C, die Stranggussbramme wird mit einer MOOT hydraulischen Maschine mit zwei Stationen freigeschmiedet, und die Oxidbeschichtung der Stranggussbramme wird rechtzeitig während des Schmiedeprozesses entfernt, und in der Anfangsphase des Ruckelns wird die Bramme mit einer kleinen Reduktion von 20-30 mm in ein Quadrat gezogen, um Oberflächenrisse zu verhindern, und in der Mitte des Ruckelns wird die Bramme mit einer großen Reduktion von 70-80 mm in ein Quadrat gezogen, damit die Schmiedekraft in den Kern eindringt, die innere Qualität verbessert wird und dann die Bramme weiter gezogen wird, ihre Außenseite zu einem Kreis geformt wird und schließlich zu einer fertigen Größe verarbeitet wird; nach dem Verlassen der Produktionslinie wird der geschmiedete Stahl einer hohen Temperatur von mindestens 500 °C ausgesetzt und anschließend langsam im Sand abgekühlt, und nachdem die Temperatur auf 200 ° C oder weniger gesunken ist, wird der geschmiedete Stahl aus der Grube ausgenommen und langsam abgekühlt;

4) Entspannungsglühen des geschmiedeten Stahls: Die Glühtemperatur beträgt 650-700 °

C, und die Wärmedämmung beträgt mehr als 12 Stunden, zusammen mit dem Ofen auf unter 300°C abkühlt, und die geschmiedete Bramme wird außerhalb des Ofens genommen und mit Luft auf Raumtemperatur gekühlt.

Revendications

1. Un procédé pour la fabrication de l'acier forgé CrNiMo30C destiné à un dispositif de la tête de puits d'extraction du pétrole en mer profonde, par la coulée continue, **caractérisé en ce qu'il** comporte les étapes suivantes

1) Acier fondu dans le cadre de la fusion : l'acier CrNiMo30C d'un acier CrNoMo faiblement allié en moyenne teneur en carbone, ses constituants et pourcentages massiques sont comme suit : C : 0,25-0,40%, Si : 0,15-0,40%, Mn : 0,80-1,30%, P : $\leq 0,010\%$, S : $\leq 0,008\%$, Cr : 0,85-1,55%, Mo : 0,30-0,65%, Ni : 0,80-1,40%, V : 0,02-0,08%, Nb : 0,02-0,05%, Cu $\leq 0,25\%$, B $\leq 0,0005\%$, H $\leq 0,0002\%$, le reste concerne Fe ainsi que les éléments des impuretés inévitables, dont l'acier fondu est traité par le prétraitement Kanbara Reactor KR, la déphosphoration et la décarbonisation dans la fusion et le chauffage du convertisseur du Four d'Oxygène Basique BOF, ajoutant l'alliage après le taraudage, le raffinage à la finerie LF et le dégazage à vide Ruhrstahl Heraeus RH, ainsi l'acier CrNiMo30C avec faible H, S et P est obtenu, et l'acier est enfin contrôlé en fonction des exigences de P $\leq 0,010\%$, S $\leq 0,005\%$ et H $\leq 1,5$ ppm ;

2) Coulée continue : par la suite, l'acier fondu est traité par la protection à l'argon, l'agitation électromagnétique mixte avec l'agitation électromagnétique du moule (M-EMS) et l'agitation électromagnétique finale (F-EMS), sous la coopération avec l'eau de refroidissement secondaire et la coulée de basse vitesse, afin de contrôler strictement un degré de surchauffe de 20°C à 35°C, le but est pour diminuer les cristal colonnaire et amplifier le cristal équiaxe, empêcher le développement des cristaux colonnaires afin de raffiner les grains, baisser le degré de ségrégation pendant le processus de cristallisation de l'acier, garantir suffisamment l'uniformité et la compacité de la structure interne ; une billette de coulée continue de $\Phi 600$ mm part la chaîne de production et elle est livrée dans une fosse à refroidissement lent sous une haute température égale ou supérieure à 500°C, et elle est gardée à chaud durant au moins 36h dans la fosse, ensuite, la billette continue est forgée ponctuellement après la sortie depuis la fosse; la macrostructure de la billette de coulée conti-

nue satisfait aux exigences de l'appendice A de la norme YB/T4149-2006 : la porosité centrale est égale ou inférieure au grade 2.0, la fissure centrale est égale ou inférieure au grade 1.0, la cavité de retrait est égale ou inférieure au grade 1.0, les vis des fissures intermédiaires, les flocons blancs et les vis de gauchissement vers le haut sont prohibés ;

3) Forgeage: la billette est chauffée et la vitesse de réchauffage est égale ou inférieure à 200°C par heure, la température de réchauffage du forgeage est de 1200 à 1250°C, assurant que la billette est entièrement réchauffée, la température initiale pour le forgeage est plus haute que 1 150°C, et la température finale pour le forgeage n'est pas en dessous de 850°C, la billette de coulée continue est forgée de façon libre par une machine hydraulique de double station MOOT, le revêtement en oxyde de la billette continue est enlevé à temps durant le forgeage, la billette est étirée sous la forme carrée à l'aide une petite quantité de réduction de 20 mm à 30 mm à l'engrenage initial, afin d'empêcher de générer les fissures sur la surface, et elle est tirée sous la forme carrée à l'aide une grande quantité de réduction de 70 à 80 mm à l'engrenage intermédiaire, afin de pénétrer la force de forgeage dans le noyau de façon à hausser la qualité intérieure, et la billette est étirée aussi et sa partie externe sous la forme de cercle, et elle est enfin finie à une taille finie ; après avoir quitté la chaîne de production, l'acier forgé est sous la haute température égale ou supérieure à 500°C, par la suite, elle est refroidie lentement dans le sable ; une fois que la température descendue à 200°C ou moins, l'acier forgé est sorti depuis la fosse et refroidie lentement ;

4) Réalisation du traitement de recuit de détente sur l'acier forgé : la température de recuit est de 650 °C à 700 °C, le maintien à chaud durant 12 heures ou plus, le refroidissement en dessous de 300 °C avec le four, la billette forgée est sortie à l'extérieur du four, et le refroidissement par air sous la température ambiante.

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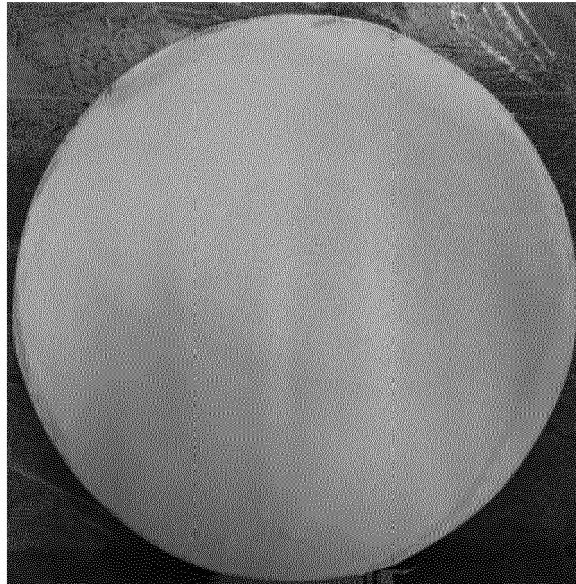


Figure 1

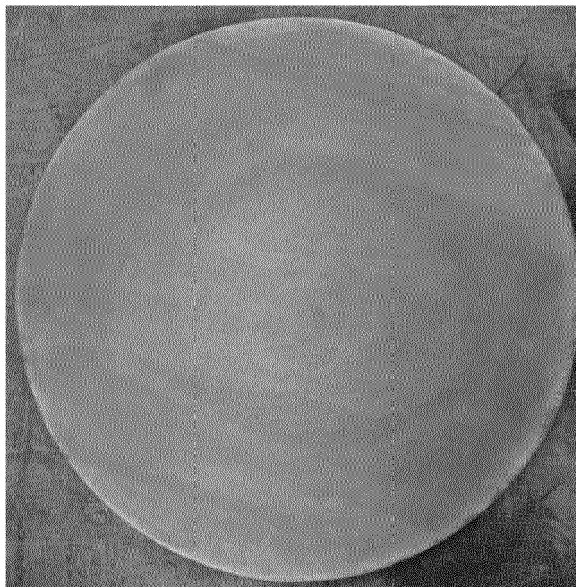


Figure 2

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 106591680 A [0004]