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(54) HIGHLY PROCESSABLE STEEL SHEET FOR THREE-PIECE WELDED CAN AND METHOD FOR PRODUCING SAME

HOCHVERARBEITBARES STAHLBLECH FÜR DREITEILIGE GESCHWEISSTE DOSE UND HERSTELLUNGSVERFAHREN DAFÜR

TÔLE D'ACIER QUI PEUT ÊTRE TRÈS FACILEMENT TRAITÉE POUR UNE BOÎTE DE CONSERVE SOUDÉE EN TROIS PARTIES ET PROCÉDÉ DE FABRICATION ASSOCIÉ

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(56) References cited:
WO-A1-03/031670
WO-A1-03/031670
JP-A- 5 271 755
JP-A- 10 237 585
JP-A- 10 237 585
JP-A- 10 245 655
JP-A- 10 245 655
JP-A- 2001 234 248
JP-A- 2001 234 248
JP-A- 2001 247 917
JP-A- 2001 247 917
JP-A- 2008 163 390
JP-A- 2010 180 423

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Description

Technical Field

[0001] The present invention relates to steel sheets for cans that can be made thinner while maintaining good workability and methods for manufacturing such steel sheets.

Background Art

[0002] Recently, some approaches to reducing can manufacturing costs have been taken to boost demand for steel cans. One such approach to reducing can manufacturing costs is to reduce material costs, and the thickness of steel sheets is being reduced for application to three-piece cans, which mainly involve cylinder forming, as well as to two-piece cans, which involve drawing.

[0003] Three-piece cans, which are manufactured by forming a cylindrical can body by welding and joining a bottom and a lid to the can body by seaming, are formed of single-reduced (SR) materials, which are manufactured by a single cold rolling process followed by annealing and temper rolling, and steel sheets about 0.175 mm thick are used for beverage cans such as coffee cans.

[0004] Another approach to reducing the thickness of steel sheets is to use double-reduced (DR) materials, which are manufactured by performing cold rolling again after annealing. The thickness of DR materials can be more easily reduced than that of SR materials. As steel sheets for cans, DR materials are mainly used, for example, for drawn cans.

[0005] If DR materials are used for three-piece cans, a problem arises with the workability of steel sheets. To seam a lid and a bottom, a three-piece can body is flanged such that each end is widened after cylinder forming. Cylinder forming is mainly performed by rolling up and electrically welding a rectangular steel sheet. If a DR material is used, the steel sheet may crack near the weld in flange forming. In particular, welding can bodies along the rolling direction of steel sheets is a prevailing method for manufacturing three-piece beverage cans nowadays. In flange forming, therefore, elongation occurs mainly in a direction perpendicular to the rolling direction of steel sheets; thus, the workability in this direction is important.

[0006] In addition, some beverage cans, such as coffee cans, undergo a retort sterilization process after being filled with the contents thereof. This retort sterilization process exposes the cans to the pressure of steam above 100°C, thus requiring can body strength sufficient to withstand the external pressure. In this case, the can body strength depends on the strength of the steel sheets in the circumferential direction of the can bodies. If the can bodies are welded along the rolling direction of the steel sheets, the strength of the steel sheets in the direction perpendicular to the rolling direction is important.

[0007] Under the above circumstances, PTL 1 discloses a method for improving workability at a weld by adding boron to an ultralow-carbon steel in the amount depending on the carbon content and thickness.

[0008] PTL 2 discloses a method for manufacturing a steel sheet having excellent weldability equivalent to temper grade T3 by appropriately controlling the weight ratio of boron to nitrogen in an ultralow-carbon steel. The steel sheet which is disclosed in PTL 2 undergoes two cold rolling reduction steps until a final thickness of about 0.22 mm.

[0009] PTL 3 discloses a method for manufacturing a steel sheet having high workability by controlling the forms, types, and amounts of nitride and sulfide in a boron-containing ultralow-carbon steel to appropriate ranges. In said document there are disclosed steel sheets having been subjected to a first cold rolling with a rolling reduction of 86 % and a second cold rolling with a rolling reduction of 10% to 35% such that the final thickness of the sheet is 0.15 mm. Further steel sheets are described in JP 10 245655 A, WO 03/031670 A1, JP 10 237585 A, JP 5 271755 A and JP 2008 163390 A.

Citation List

Patent Literature

[0010]

PTL 1: Japanese Patent No. 3379375
PTL 2: Japanese Unexamined Patent Application Publication No. 2001-247917
PTL 3: Japanese Unexamined Patent Application Publication No. 2003-231948

Summary of Invention

Technical Problem

[0011] The above known techniques, however, have the following problems.

[0012] The steel sheet disclosed in PTL 1 is unsuitable as a steel sheet for three-piece beverage cans because it has insufficient ductility in the direction perpendicular to the rolling direction due to a high second rolling reduction. Even if the steel sheet is acceptable for welding along the direction perpendicular to the rolling direction, it probably cracks in flange forming after being welded into a can body along the rolling direction.

[0013] The steel sheet manufactured by the method for manufacturing a steel sheet disclosed in PTL 2 has insufficient steel sheet strength for use as a thinner steel sheet for three-piece beverage cans because the hardness thereof is equivalent to temper grade T3. In addition, the specified rolling reduction in second rolling, namely, 3.5% to 6%, is excessive for temper rolling equipment, which is usually operated with a rolling reduction of 1% to 2%, thus overloading the equipment. Meanwhile, the rolling reduction is insufficient for second rolling equipment, which uses large amounts of lubricant, thus probably causing a problem with rolling, such as chattering.

[0014] The steel sheet manufactured by the method disclosed in PTL 3 lacks high-temperature ductility because it contains a large amount of sulfur, thus possibly suffering a crack in continuous casting of steel slabs.

[0015] An object of the present invention, which has been made in light of the above circumstances, is to provide a high-workability steel sheet for three-piece welded cans that is practical as a steel sheet for three-piece beverage cans with a tensile strength of 400 MPa or more in a direction perpendicular to a rolling direction and excellent flange formability, and a method for manufacturing such a steel sheet.

Solution to Problem

[0016] The inventors have conducted an intensive study to solve the above problems. As a result, the inventors have obtained the following findings.

[0017] DR materials are harder than SR materials because they are cold-rolled again after annealing. To have good workability, therefore, the steel sheets require sufficient fracture elongation, that is, softness. From this viewpoint, ultralow carbon steels are used in the present invention because carbon steels become softer with decreasing carbon content.

[0018] In addition, a DR material, which is strained after second cold rolling, is recrystallized by heat given during welding in a region near a weld. In flange forming, strain concentrates in the recrystallized region because it is softer than the other region, thus causing a crack. To prevent this, the steel sheet needs to be given hardenability. An appropriate amount of boron added increases hardenability in welding, thus preventing softening near the weld. If the second rolling reduction is low, however, strain concentrates in the base metal near the weld in flange forming because the hardening effect makes the strength of the weld higher than that of the surrounding base metal, thus causing a crack. Hence, the rolling reduction in second cold rolling needs to be limited to an appropriate range.

[0019] In view of the foregoing, the present invention provides a high workable steel sheet having the features defined in claim 1. Moreover, a method for manufacturing a high workable steel sheet for three-piece welded cans having the features in claim 2 is provided.

[0020] The percentages showing the steel compositions herein are all percentages by mass.

Advantageous Effects of Invention

[0021] According to the present invention, a high-workability steel sheet for three-piece welded cans is provided that has a tensile strength of 400 MPa or more in a direction perpendicular to a rolling direction and excellent flange formability.

[0022] Specifically, according to the present invention, a thin steel sheet with excellent workability for three-piece welded cans can be reliably manufactured through second cold rolling by adding boron to an ultralow carbon steel and setting an appropriate second cold rolling reduction.

[0023] As a result, the base sheet (steel sheet) with improved workability enables can forming using thin DR materials without causing a crack in flange forming of three-piece cans, thus achieving a significant reduction in the wall thickness of three-piece cans.

Description of Embodiments

[0024] The present invention will now be described in detail.

[0025] A high-workability steel sheet of the present invention for three-piece welded cans is characterized by a tensile strength of 400 MPa or more in a direction perpendicular to a rolling direction and a fracture elongation of 15% or more in the direction perpendicular to the rolling direction. The high-workability steel sheet of the present invention for three-piece welded cans is manufactured as an ultrathin steel sheet through second cold rolling with sufficient flange formability at a weld by adding boron to an ultralow carbon steel to impart hardenability while maintaining its softness and setting an appropriate second cold rolling reduction.

[0026] The composition of the high-workability steel sheet of the present invention for three-piece welded cans will now be described.

Carbon: more than 0.0015% to 0.0030%

[0027] In the present invention, the material needs to be a soft steel to ensure sufficient workability after second cold rolling. Because steels having higher carbon contents are generally harder, the upper limit of the carbon content is 0.0030%. A carbon content exceeding 0.0030% impairs the workability of the steel sheet, thus making it difficult to perform can forming processes such as flange forming. On the other hand, the lower limit of the carbon content is more than 0.0015% because reducing the carbon content to 0.0015% or less undesirably increases decarburization cost in a refining process.

Silicon: 0.10% or less

[0028] The silicon content is 0.10% or less because a silicon content exceeding 0.10% causes problems such as degraded surface treatment properties and corrosion resistance.

Manganese: 0.20% to 0.80%

[0029] Manganese, which has the effects of preventing red brittleness due to sulfur during hot rolling and refining crystal grains, is an element necessary to ensure the desired material properties. To achieve these effects, at least 0.20% of manganese needs to be added. On the other hand, the upper limit is 0.80% because an excessive amount of manganese added degrades the corrosion resistance and also degrades flange formability and neck formability by hardening the steel sheet.

Phosphorus: 0.001% to 0.020%

[0030] The upper limit of the phosphorus content is 0.020% because phosphorus is a harmful element that degrades the flange formability and neck formability by hardening the steel sheet and also degrades the corrosion resistance. On the other hand, reducing the phosphorus content to less than 0.001% involves excessive dephosphorization cost. Accordingly, the lower limit of the phosphorus content is 0.001%.

Sulfur: 0.001% to 0.020%

[0031] Sulfur, present as inclusions in the steel, is a harmful element that decreases the ductility and degrades the corrosion resistance. In addition, an excessive sulfur content results in insufficient high-temperature ductility, thus leading to slab cracking in continuous casting. The sulfur content is limited to 0.020% because a sulfur content exceeding 0.020% causes those adverse effects. On the other hand, reducing the sulfur content to less than 0.001% involves excessive desulfurization cost, and the steel sheet hardly suffers the above adverse effects at any lower sulfur content. Accordingly, the lower limit of the sulfur content is 0.001%.

Aluminum: more than 0.040% to 0.100%

[0032] Aluminum is an element necessary as a deoxidizing agent in steelmaking. An aluminum content of 0.040% or less results in insufficient deoxidization, thus increasing inclusions and degrading the flange formability. On the other hand, an aluminum content exceeding 0.100% results in an increased frequency of occurrence of surface defects due to, for example, alumina clusters. Accordingly, the aluminum content is more than 0.040% to 0.100%.

Nitrogen: 0.030% or less

[0033] A large amount of nitrogen added degrades hot ductility, thus causing slab cracking in continuous casting. Accordingly, the upper limit of the nitrogen content is 0.030%.

Boron: 0.0002% to 0.0050%

[0034] Boron, which is an element essential for preventing softening at a weld, fails to provide sufficient performance if the content thereof falls below 0.0002%. Accordingly, the lower limit of the boron content is 0.0002%. On the other hand, a boron content exceeding 0.0050% provides no further improvement in performance and only increases the cost. Accordingly, the upper limit of the boron content is 0.0050%, preferably 0.0011% to 0.0020%.

[0035] The balance is iron and incidental impurities.

[0036] Next, a method for manufacturing the high-workability steel sheet of the present invention for three-piece welded cans will be described.

[0037] The high-workability steel sheet of the present invention for three-piece welded cans is manufactured using a steel slab manufactured by continuous casting and having the above composition by hot rolling, first cold rolling, annealing, and second cold rolling. The steel sheet manufactured by the present invention is assumed to be used as a thinner steel sheet for three-piece beverage cans. Accordingly, the steel sheet is required to have a smaller product thickness than those used conventionally and therefore needs to be rolled to a thickness of about 0.15 mm or less. It is usually difficult to achieve a thickness of 0.15 mm or less by a single cold rolling process. That is, cold rolling to such a small thickness overloads a rolling mill. It is also possible to roll the steel slab to a smaller thickness than usual in hot rolling to reduce the thickness after cold rolling. However, a higher rolling reduction in hot rolling results in a greater decrease in the temperature of the steel sheet in the rolling, thus making it impossible to achieve a predetermined finish rolling temperature. In addition, a steel sheet having a smaller thickness before annealing is more likely to have problems such as fracture and deformation in continuous annealing. For these reasons, second cold rolling is performed after annealing in the present invention.

Finish rolling temperature: Ar_3 transformation temperature to 960°C

[0038] If the finish rolling temperature in hot rolling falls below the Ar_3 transformation temperature, the size of recrystallized grains after annealing becomes uneven. If the finish rolling temperature in hot rolling exceeds 960°C, the size of recrystallized grains after annealing becomes larger than necessary. Accordingly, the finish rolling temperature in hot rolling is the Ar_3 transformation temperature to 960°C, more preferably 890°C to 930°C.

Coiling temperature: 560°C to 750°C

[0039] If the coiling temperature after hot rolling falls below 560°C, the size of recrystallized grains after annealing becomes extremely small. On the other hand, a coiling temperature exceeding 750°C is undesirable because it results in uneven material properties over the entire steel sheet and formation of an excessive amount of scale. Accordingly, the coiling temperature after hot rolling is 560°C to 750°C, more preferably 600°C to 720°C.

[0040] First cold rolling at rolling reduction of 89% to 93% The first cold rolling reduction affects the grain size after annealing; the size of recrystallized grains becomes extremely large if the rolling reduction falls below 89% and becomes extremely small if the rolling reduction exceeds 93%. Accordingly, the first cold rolling reduction is 89% to 93%, more preferably 90% to 92%.

Annealing at 600°C to 790°C

[0041] The annealing temperature affects the recrystallization rate and the grain size. Specifically, if the annealing temperature falls below 600°C, an excessive number of unrecrystallized grains remain, thus impairing the workability. If the annealing temperature exceeds 790°C, the grain size becomes extremely large, thus making it difficult to ensure sufficient strength. Accordingly, the annealing temperature is 600°C to 790°C, more preferably 610°C to 700°C. It should be noted that some unrecrystallized grains may remain after annealing.

Second cold rolling at rolling reduction of more than 6.0% to less than 10.0%

[0042] If the second cold rolling reduction is 6.0% or less, the required steel sheet strength cannot be achieved because of insufficient work hardening in second cold rolling. In addition, a hardening effect in welding results in a great difference in strength between the weld, which has increased strength, and the base metal, thus causing a crack near the weld in flange forming. On the other hand, if the second cold rolling reduction is 10.0% or more, sufficient fracture elongation cannot be achieved because of excessive work hardening in second cold rolling. In addition, the proportion of crystal grains recrystallized near the weld (recrystallization rate) increases because large strain accumulates in second cold rolling, and the strength near the weld decreases accordingly, thus making the steel sheet prone to cracking in flange forming. Accordingly, the second cold rolling reduction is more than 6.0% to less than 10.0%.

[0043] The subsequent steps, such as coating, are performed in a conventional manner to complete a steel sheet for cans.

[0044] Thus, the high-workability steel sheet of the present invention for three-piece welded cans is produced. This high-workability steel sheet for three-piece welded cans has a tensile strength of 400 MPa or more in the direction perpendicular to the rolling direction and a fracture elongation of 15% or more in the direction perpendicular to the rolling direction. For application to a three-piece beverage can body welded along the rolling direction, the strength in the direction perpendicular to the rolling direction is important for withstanding external pressure in a retort sterilization process. With a tensile strength of 400 MPa or more in the direction perpendicular to the rolling direction, the steel sheet does not dent or buckle when exposed to a retort environment.

[0045] For application to a three-piece beverage can body welded along the rolling direction, additionally, the fracture elongation in the direction perpendicular to the rolling direction is important for preventing a crack in flange forming. With a fracture elongation of 15% or more in the direction perpendicular to the rolling direction, flange forming can be performed without causing a crack.

EXAMPLES

[0046] Steels having the compositions shown in Table 1, with the balance being iron and incidental impurities, were prepared in an actual converter and were continuously cast into steel slabs. The resulting steel slabs were then reheated at 1,250°C and were subjected to hot rolling, first cold rolling, continuous annealing, and second cold rolling under the conditions shown in Table 2 to a thickness of 0.14 to 0.15 mm. The hot rolling was followed by pickling. The steel sheets thus manufactured were continuously coated with tin on both sides to form tinplates having 2.8 g/m^2 of tin deposited on each side.

[Table 1]

Steel	Composition (% by mass)							
	C	Si	Mn	P	S	Al	N	B
1	0.0019	0.01	0.38	0.011	0.014	0.049	0.0023	0.0013
2	0.0022	0.01	0.31	0.010	0.011	0.050	0.0024	0.0009
3	0.0021	0.01	0.30	0.016	0.015	0.055	0.0028	0.0010
4	0.0019	0.01	0.41	0.013	0.018	0.043	0.0020	0.0015
5	0.0018	0.01	0.35	0.011	0.010	0.049	0.0022	0.0012
6	0.0025	0.01	0.33	0.015	0.012	0.048	0.0023	0.0016
7	0.0023	0.01	0.40	0.014	0.012	0.056	0.0024	0.0011
8	0.0211	0.01	0.30	0.010	0.010	0.044	0.0021	0.0010
9	0.0022	0.01	0.32	0.019	0.013	0.058	0.0025	-
10	0.0021	0.01	0.31	0.015	0.013	0.045	0.0028	0.0014
11	0.0024	0.01	0.28	0.013	0.014	0.051	0.0031	0.0024
12	0.0017	0.01	0.30	0.012	0.015	0.039	0.0025	0.0018
13	0.0020	0.01	0.29	0.008	0.017	0.061	0.0022	0.0015

[Table 2]

Steel	Finish rolling temperature (°C)	Coiling temperature (°C)	First cold rolling reduction	Annealing temperature (°C)	Second cold rolling reduction (%)
1	910	650	91.8	610	8.5
2	910	670	92.0	630	6.5
3	910	690	91.9	610	7.0

(continued)

Steel	Finish rolling temperature (°C)	Coiling temperature (°C)	First cold rolling reduction	Annealing temperature (°C)	Second cold rolling reduction (%)
4	915	650	91.7	630	9.5
5	915	670	91.8	610	8.0
6	920	690	91.8	630	9.0
7	920	650	92.0	610	6.5
8	910	650	91.8	610	8.0
9	910	650	91.7	610	9.5
10	910	650	90.6	610	20
11	910	650	91.7	610	10
12	910	650	92.0	610	6.0
13	910	650	92.3	610	2.0

[0047] The resulting coated steel sheets (tinplates) were subjected to heat treatment equivalent to coat baking at 210°C for 20 minutes before a tensile test. In the tensile test, JIS No. 5 tensile test pieces were used to measure the tensile strength (fracture strength) and the fracture elongation in the direction perpendicular to the rolling direction according to JIS Z2241.

[0048] The steel sheets subjected to the heat treatment equivalent to coat baking were formed into can bodies having an outside diameter of 52.8 mm by seam welding, and the ends thereof were necked in to an outside diameter of 50.4 mm and were flanged to an outside diameter of 55.4 mm before they were evaluated for flange cracks. The steel sheets were evaluated as being "poor" if the flanges cracked and as being "good" if the flanges did not crack.

[0049] The can bodies had a size equivalent to that of 190 g beverage cans and were welded along the rolling direction of the steel sheets. The necking-in was performed by die necking, and the flanging was performed by spin flanging.

[0050] A paneling test was conducted for evaluation of can body strength. Hollow can bodies were formed by the above processes and lid and bottom seaming and were externally pressurized by air pressure in a sealed chamber to measure the pressure at which the can bodies collapsed. The steel sheets were evaluated as being "poor" if the collapse pressure fell below 1.7 kg/cm^2 and as being "good" if the collapse pressure was 1.7 kg/cm^2 or more. This criterion was set as the strength with which a steel sheet can withstand the pressure of common retort treatment. Before necking-in, 15 beads were formed in the centers of the can bodies. The beads had a spacing of 4 mm and a depth of 0.5 mm.

[0051] The results thus obtained are shown in Table 3.

[Table 3]

Steel	Tensile strength in direction perpendicular to rolling direction (MPa)	Fracture elongation in direction perpendicular to rolling direction	Flange	Can body strength (paneling test)	Remarks
1	415	15.9	Good	Good	Invention example
2	405	17.2	Good	Good	Invention example
3	409	16.5	Good	Good	Invention example
4	421	15.0	Good	Good	Invention example
5	410	16.0	Good	Good	Invention example
6	418	15.2	Good	Good	Invention example

(continued)

Steel	Tensile strength in direction perpendicular to rolling direction (MPa)	Fracture elongation in direction perpendicular to rolling direction	Flange	Can body strength (paneling test)	Remarks
7	407	17.1	Good	Good	Invention example
8	422	2.8	Poor	*	Comparative example
9	420	15.2	Poor	*	Comparative example
10	425	4.1	Poor	-*	Comparative example
11	421	13.5	Poor	*	Comparative example
12	393	15.8	Poor	-*	Comparative example
13	385	17.0	Poor	-*	Comparative example
*Steels 8 to 13 were unable to be subjected to the paneling test because the flanges cracked and could not be seamed.					

[0052] According to Table 3, Nos. 1 to 7, which are examples of the present invention, achieved excellent strength, that is, a tensile strength of 400 MPa or more in the direction perpendicular to the rolling direction, which is required to reduce the wall thickness of three-piece can bodies by several percent. In addition, the fracture elongation in the direction perpendicular to the rolling direction was 15% or more. Furthermore, these steels had excellent workability and did not crack in flanging. The can body strength after can forming was also sufficient.

[0053] In contrast, No. 8, which is a comparative example, lost its ductility after second cold rolling and had poor workability because the carbon content was excessive.

[0054] In addition, No. 9, which is a comparative example, became extremely soft in the welding heat-affected zone and cracked in flanging because it contained no boron.

[0055] Nos. 10 and 11, which are comparative examples, lacked workability because the second cold rolling reduction was extremely high.

[0056] Nos. 12 and 13, which are comparative examples, lacked strength because the second cold rolling reduction was extremely low. In addition, these steels cracked in flanging because of the great difference in strength between the weld, which hardened after welding, and the base metal.

Industrial Applicability

[0057] A steel sheet of the present invention for three-piece welded cans has high workability and excellent flange formability and is suitable for applications such as beverage cans including coffee cans. In addition, a thin high-workability steel sheet for cans can be provided, thus enabling a significant reduction in the wall thickness of three-piece cans.

Claims

1. A high-workability steel sheet for three-piece welded cans, comprising, in percent by mass, more than 0.0015 % to 0.0030% of carbon, 0.10% or less of silicon, 0.20% to 0.80% of manganese, 0.001% to 0.020% of phosphorus, 0.001% to 0.020% of sulfur, more than 0.040% to 0.100% of aluminum, 0.030% or less of nitrogen, and 0.0002% to 0.0050% of boron, the balance being iron and incidental impurities, the steel sheet having a tensile strength of 400 MPa or more in a direction perpendicular to a rolling direction, a fracture elongation of 15% or more in the direction perpendicular to the rolling direction, and a thickness of 0.15 mm or less.

2. A method for manufacturing a high-workability steel sheet for three-piece welded cans, the method comprising forming a steel into a slab by continuous casting, the steel containing, in percent by mass, more than 0.0015% to

0.0030% of carbon, 0.10% or less of silicon, 0.20% to 0.80% of manganese, 0.001% to 0.020% of phosphorus, 0.001% to 0.020% of sulfur, more than 0.040% to 0.100% of aluminum, 0.030% or less of nitrogen, and 0.0002% to 0.0050% of boron, the balance being iron and incidental impurities; hot-rolling the slab at a finish rolling temperature of the Ar3 transformation temperature to 960°C and a coiling temperature of 560°C to 750°C; subjecting the steel sheet to first cold rolling at a rolling reduction of 89% to 93%; annealing the steel sheet at 600°C to 790°C; and subjecting the steel sheet to second cold rolling at a rolling reduction of more than 6.0% to less than 10.0% to form a steel sheet with a thickness of 0.15 mm or less.

Patentansprüche

1. Hochverarbeitbares Stahlblech für dreiteilige geschweißte Dosen, enthaltend in Massenprozent mehr als 0,0015% bis 0,0030% Kohlenstoff, 0,10% oder weniger Silicium, 0,20% bis 0,80% Mangan, 0,001% bis 0,020% Phosphor, 0,001% bis 0,020% Schwefel, mehr als 0,040% bis 0,100% Aluminium, 0,030% oder weniger Stickstoff, und 0,0002% bis 0,0050% Bor, wobei der Rest Eisen und unvermeidbare Verunreinigungen sind, wobei das Stahlblech eine Zugfestigkeit von 400 MPa oder mehr in einer Richtung senkrecht zu einer Walzrichtung, eine Bruchdehnung von 15% oder mehr in der Richtung senkrecht zur Walzrichtung, und eine Dicke von 0,15 mm oder weniger aufweist.

2. Verfahren zur Herstellung eines hochbearbeitbaren Stahlblechs für dreiteilige geschweißte Dosen, wobei das Verfahren umfasst: Bilden eines Stahls zu einer Bramme durch Stranggießen, wobei der Stahl in Massenprozent mehr als 0,0015% bis 0,0030% Kohlenstoff, 0,10% oder weniger Silicium, 0,20% bis 0,80% Mangan, 0,001% bis 0,020% Phosphor, 0,001% bis 0,020% Schwefel, mehr als 0,040% bis 0,100% Aluminium, 0,030% oder weniger Stickstoff, und 0,0002% bis 0,0050% Bor, und als Rest Eisen und unvermeidbare Verunreinigungen enthält; Warmwalzen der Bramme bei einer Endwalztemperatur von der Ar3-Umwandlungstemperatur bis zu 960°C und einer Wickeltemperatur von 560°C bis 750° C; Unterziehen des Stahlblechs einem ersten Kaltwalzen mit einer Walzreduktion von 89% bis 93%; Glühen des Stahlblechs bei 600°C bis 790°C; und Unterziehen des Stahlblechs einem zweiten Kaltwalzen bei einer Walzreduktion von mehr als 6,0% bis weniger als 10,0%, um ein Stahlblech mit einer Dicke von 0,15 mm oder weniger zu bilden.

Revendications

1. Tôle d'acier d'aptitude élevée au façonnage pour boîtes en trois morceaux soudés, comprenant, en pourcentage en masse, plus de 0,0015 % à 0,0030 % de carbone, de 0,10 % ou moins de silicium, de 0,20 % à 0,80 % de manganèse, de 0,001 % à 0,020 % de phosphore, de 0,001 % à 0,020 % de soufre, plus de 0,040 % à 0,100 % d'aluminium, de 0,030 % ou moins d'azote, et de 0,0002 % à 0,0050 % de bore, le reste étant du fer et des impuretés accidentelles, la tôle d'acier présentant une résistance à la traction de 400 MPa ou plus dans un sens perpendiculaire à un sens de laminage, un allongement à la rupture de 15 % ou plus dans le sens perpendiculaire au sens de laminage, et une épaisseur de 0,15 mm ou moins.

2. Procédé de fabrication d'une tôle d'acier à aptitude élevée au façonnage pour boîte en trois morceaux soudés, le procédé comprenant la mise en forme d'une tôle en une brame par coulée continue, la tôle contenant, en pourcentage en masse, plus de 0,0015 % à 0,0030 % de carbone, de 0,10 % ou moins de silicium, de 0,20 % à 0,80 % de manganèse, de 0,001 % à 0,020 de phosphore, de 0,001 % à 0,020 % de soufre, plus de 0,040 % à 0,100 % d'aluminium, de 0,030 % ou moins d'azote, et de 0,0002 % à 0,0050 % de bore, le reste étant du fer et des impuretés accidentelles ; laminage à chaud de la brame à une température finie de laminage de la température de transformation Ar3 à 960 °C et une température d'enroulage de 560 à 750 °C ; la soumission de la tôle d'acier à un premier laminage à froid à une réduction du laminage du 89 % à 93 % ; le durcissement de la tôle d'acier à 600 °C jusqu'à 790 °C ; et la soumission de la tôle d'acier à un second laminage à froid à une réduction de laminage de plus de 6,0 % à moins de 10,0 % pour former une tôle d'acier ayant une épaisseur de 0,15 mm ou moins.

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 10245655 A **[0009]**
- WO 03031670 A1 **[0009]**
- JP 10237585 A **[0009]**
- JP 5271755 A **[0009]**
- JP 2008163390 A **[0009]**
- JP 3379375 B **[0010]**
- JP 2001247917 A **[0010]**
- JP 2003231948 A **[0010]**