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(71) Applicant: **Yieh United Steel Corp.**
Kaohsiung Hsien (TW)

(72) Inventors:
- **Lin, I-Shou**
  Kaohsiung Hsien (TW)
- **Hsu, Wen-Chien**
  81150 Kaohsiung City (TW)
- **Huang, Chen-Hui**
  Kaohsiung Hsien (TW)

(74) Representative: **Anderson, James Edward George**
Elkington and Fife LLP
Prospect House
8 Pembroke Road
Sevenoaks, Kent TN13 1XR (GB)

(54) Method of producing thin steel sheet

(57) A method of producing a thin steel sheet (6) includes providing a hot-rolled black skin steel sheet (60) which is formed directly from a cast steel slab, cold rolling the black skin steel sheet (60) to form a cold-rolled steel sheet (61), annealing the cold-rolled steel sheet (61) to form a cold-rolled annealed steel sheet (62), and removing scale from the cold-rolled annealed steel sheet (62) by sandblasting and pickling to form a thin steel sheet (6).

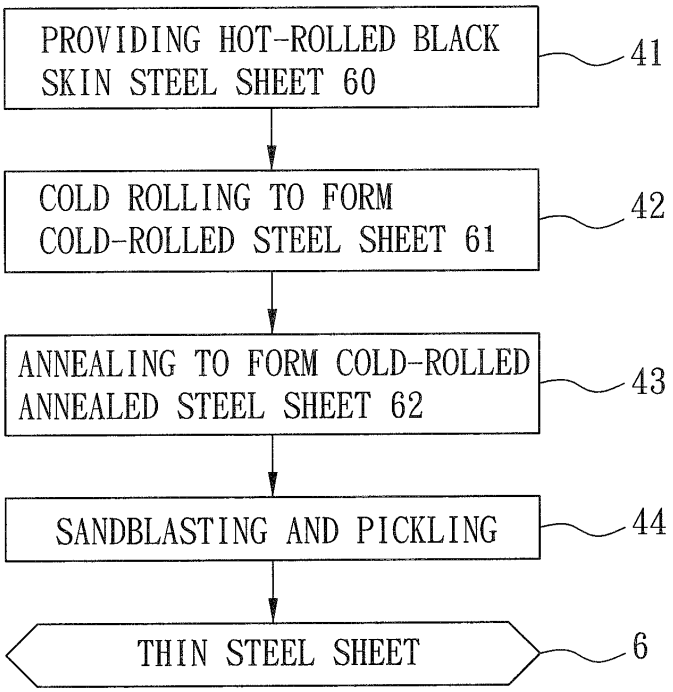

FIG. 4

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Description

[0001] This application claims priority of Taiwanese application no. 097130951, filed on August 14, 2008.

[0002] This invention relates to a method of producing a steel sheet, more particularly to a method of producing a thin steel sheet or coil.

[0003] Generally, there are three types of stainless steel sheets or coils which can be manufactured by the following methods:

[0004] Referring to FIG. 1, a slab 100 as a raw material is hot rolled in step 11 so as to form a black skin steel coil 200 that has a predetermined thickness. Successively, the black skin steel coil 200 is annealed in step 12, sandblasted in step 13, and pickled in step 14, thereby forming a white skin steel coil 300 (also known as a No. 1 steel coil).

[0005] The black skin steel coil 200 has scale with irregular thickness and is consequently regarded as a semi-finished product. Therefore, the black skin steel coil 200 generally is not selected as a raw material for directly manufacturing stainless steel goods such as buckets, water towers, kitchen utensils, etc. A thickness of the white skin steel coil 300 is similar to that of the black skin steel coil 200, and is usually greater than 2 millimeters. The slight difference between the thicknesses of the black and white skin steel coils 200, 300 resides in that an amount of scale on the white skin steel coil 300 is less than an amount of the scale on the black skin steel coil 200. Additionally, the white skin steel coil 300 has a modified quality due to the annealing step 12. Therefore, the white skin steel coil 300 is used as a raw material for further processing by few midstream and downstream manufacturers after evaluating their cost and suitability. Thus, the white skin steel coil 300 is one of practical steel coil products.

[0006] However, as the white skin steel coil 300 is more than 2 millimeters in thickness, like the black skin steel coil 200, average midstream and downstream manufacturers have less interest in using the white skin steel coil 300 for their manufacture. Referring to FIG. 2, thus, the white skin steel coil 300 as a raw material is cold rolled in step 21 so as to have a reduced thickness that is approximately smaller than 2 millimeters, annealed in step 22, and pickled in step 23 sequentially. A cold-rolled steel coil 400 is hence obtained.

[0007] The cold-rolled steel coil 400 is also known as a 2D steel coil. The number 2 indicates that the cold-rolled steel coil 400 was subjected to two processing steps, namely, hot rolling (forming the black skin steel coil 200 from the slab 100) and cold rolling (forming the cold-rolled steel coil 400 from the white skin steel coil 300). The letter D indicates that the surface of the cold-rolled steel coil 400 is dull and lacks metallic luster. The cold-rolled steel coil 400 has a thickness that meets the requirements of average midstream and downstream manufacturers for the production of their products. The cold-rolled steel coil 400 is thus regarded as an important practical stainless steel coil.

[0008] Nevertheless, the cold-rolled steel coil 400 is still not very appropriate to be directly manufactured into products, such as buckets and kitchen utensils, since the thickness of the cold-rolled steel coil 400 is about 2 millimeters. Referring to FIG. 3, accordingly, the cold-rolled steel coil 400 as a raw material is cold rolled in step 31 so as to have a reduced thickness that is not greater than 0.7 millimeter, annealed in step 32, and pickled in step 33 in sequence. Eventually, a thin cold-rolled steel coil 500 is formed.

[0009] It is noted that step 34 is an optional skin-passing step, and can be carried out after step 33. The thin cold-rolled steel coil 500 that is not skin-passed is called a 2D thin steel coil that has dull surfaces lacking metallic luster. On the other hand, the thin cold-rolled steel coil 500 that was skin-passed is referred to as a 2B thin steel coil that has bright surfaces possessing metallic luster.

[0010] The thin cold-rolled steel coil 500 (both 2D and 2B thin steel coils) can be directly manufactured into stainless steel goods, such as buckets, water pots, and kitchen utensils, or further used for producing a stainless steel foil that has a thickness ranging from several tens of micrometers to several hundreds of micrometers and that can be applied to an electronic device such as a monitor. Thus, the thin cold-rolled steel coil 500 is also an important stainless steel coil product.

[0011] Nowadays, stainless steel coils available for producing the stainless steel goods are limited to the white skin steel coil 300, the cold-rolled steel coil 400, and the thin cold-rolled steel coil 500 due to the following reasons.

[0012] Theoretically, a stainless steel coil may be produced by virtue of a combination of the conventional methods of producing a steel coil. For example, the slab 100 as a raw material may be successively hot rolled, annealed, sandblasted, pickled, coldrolled, annealed, pickled, cold rolled, annealed, and pickled in order to form the thin cold-rolled steel coil 500. In another example, the slab 100 as a raw material may be sequentially hot rolled, annealed, sandblasted, pickled, cold rolled, annealed, and pickled so as to produce the cold-rolled steel coil 400. In yet another example, the white skin steel coil 300 as a raw material may be cold rolled, annealed, pickled, cold rolled, annealed, and pickled in sequence such that the thin cold-rolled steel coil 500 is formed.

[0013] Practically, the examples given above may be problematic. Concerning the third example, wherein the white skin steel coil 300 is selected as a raw material to produce the thin cold-rolled steel coil 500, high reduction in thickness must be applied during each cold rolling step due to a large difference between the thicknesses of the white skin steel coil 300 and the thin cold-rolled steel coil 500, thereby excessively hardening the thin cold-rolled steel coil 500. A high rate of fracture of the thin cold-rolled steel coil 500 may be induced and further give rise to a low production rate. An

extra annealing step may be carried out in order to alleviate the excessive hardening of the thin cold-rolled steel coil 500, but an increased cost may hence lower market competitiveness of products. Many factors, such as production cost and capability of manufacturers, are required to be considered for each combination of the conventional methods.

[0014] Ideally, a stainless steel coil may be produced through a random combination of hot rolling, cold rolling, annealing, sandblasting, and pickling. However, the random combination without successful experimental support may be unavailable. Two examples are given. First, hot rolling a material directly after cold rolling the same is improper. Secondly, pickling a material and then annealing the same is not appropriate.

[0015] Capability of a facility for each of the hot rolling, cold rolling, annealing, sandblasting, and pickling steps must be taken into account for producing a stainless steel coil. A pickling device may be incapable of directly pickling a material so as to remove scale from the same without a pre-treatment. A cold rolling mill may be incapable of cold rolling the slab 100 so as to form a thin cold-rolled steel coil that has a thickness smaller than 0.7 millimeter.

[0016] Even though the white skin steel coil 300, the cold-rolled steel coil 400, and the thin cold-rolled steel coil 500 are available in the market, a new type of the stainless steel coil is still in demand for manufacturers because of several considerations. When a stainless steel coil is required to have a thickness smaller than 2.0 millimeters for further processing, the cold-rolled steel coil 400 instead of the white skin steel coil 300 is mostly chosen as a raw material by the manufacturers. However, the price of the cold-rolled steel coil 400 is higher than that of the white skin steel coil 300 owing to more steps that are necessary for producing the cold-rolled steel coil 400, thereby lowering competitiveness of manufacturers. Since the price of the thin cold-rolled steel coil 500 is higher than that of the cold-rolled steel coil 400, likewise, the thin cold-rolled steel coil 500 is not selected as a raw material by manufacturers.

[0017] A method of producing a new stainless steel sheet or coil that has a price lower than the price of the cold-rolled steel coil 400, that has a thickness smaller than 2.0 millimeters, and that can be more easily reduced and manufactured compared to the white skin steel coil 300 is strongly needed.

[0018] Therefore, the object of the present invention is to provide a method of producing a thin steel sheet or coil that can overcome the aforesaid drawbacks of the prior art.

[0019] According to this invention, a method of producing a thin steel sheet includes providing a hot-rolled black skin steel sheet which is formed directly from a cast steel slab, cold rolling the black skin steel sheet to form a cold-rolled steel sheet, annealing the cold-rolled steel sheet to form a cold-rolled annealed steel sheet, and removing scale from the cold-rolled annealed steel sheet by sandblasting and pickling to form a thin steel sheet.

[0020] Other features and advantages of the present invention will become apparent in the following detailed description of the preferred embodiment of this invention, with reference to the accompanying drawings, in which:

FIG. 1 is a flow chart to illustrate a conventional method of producing a white skin steel sheet;
FIG. 2 is a flow chart to illustrate a conventional method of producing a cold-rolled steel sheet;
FIG. 3 is a flow chart to illustrate a conventional method of producing a thin cold-rolled steel sheet; and
FIG. 4 is a flow chart of the preferred embodiment of a method of producing a thin steel sheet according to this invention.

[0021] According to the preferred embodiment of the present invention, a method of producing a thin steel sheet includes step 41 to step 44. Referring to FIG. 4, in step 41, a hot-rolled black skin steel sheet 60 is obtained by hot rolling directly a cast steel slab in a conventional manner.

[0022] In step 42, the black skin steel sheet 60 is cold rolled at least twice such that total reduction in thickness after cold rolling is not less than 50%. The black skin steel sheet 60 has a scale loss that is not less than 28% after cold rolling. The cold-rolled steel sheet 61 as formed has a thickness that can be 1.0 millimeter minimally.

[0023] In step 43, the cold-rolled steel sheet 61 is preheated in a preheating zone, annealed in a main heating zone that has a temperature ranging from 1000°C to 1200°C, and cooled in sequence. In the preheating zone, the cold-rolled steel sheet 61 is preheated by radiation heat from the main heating zone. Moisture from a surface of the cold-rolled steel sheet 61 is removed in a cooling zone that has a temperature not higher than 80°C. Therefore, the cold-rolled annealed steel sheet 62 is formed.

[0024] In step 44, the cold-rolled annealed steel sheet 62 is sandblasted and pickled so as to remove the scale from the same. The thin steel sheet 6 is formed and has a thickness that can reach a minimum of 1.0 millimeter. In this embodiment, the thin steel sheet 6 is a white skin steel sheet that has a thickness smaller than 2 millimeters. Thus, the thin steel sheet 6 has the thickness smaller than that of the conventional white skin steel sheet (or coil) 300, and can be easily reduced and manufactured by manufacturers.

[0025] Scale of the black skin steel sheet 60 is largely removed during the cold rolling step 42. Consequently, when the cold-rolled annealed steel sheet 62 is sandblasted, the sandblasting device is only required to operate at a speed ranging from 500 to 1000 revolutions per minute such that most of the scale of the cold-rolled annealed steel sheet 62 is removed. In contrast with a sandblasting device that operates at a speed faster than 1000 revolutions per minute and that is used in the conventional method of producing the white skin steel sheet (or coil) 300, the speed of the sandblasting

device required in the method of producing the thin steel sheet 6 of the present invention is reduced. Due to the reduced speed, the thin steel sheet 6 has reduced roughness compared to roughness of the conventional white skin steel sheet (or coil) 300. Less energy consumption is also achieved.

[0026] Since most of the scale of the cold-rolled annealed steel sheet 62 is removed after sandblasting, a mixed acid with a lower concentration can be used in order to pickle the cold-rolled annealed steel sheet 62 for removing the remaining scale of the same. Therefore, a production cost and an amount of required materials are decreased. A price of the thin steel sheet 6 is lowered as well.

[0027] The large amount of the scale loss of the black skin steel sheet 60 may also enhance a production rate of the thin steel sheet 6 by nearly 180% on account of less time needed for sandblasting and pickling the cold-rolled annealed steel sheet 62. In particular, the white skin steel sheet (or coil) 300 is produced at a production rate of 25 meters per minute, whereas the thin steel sheet 6 can be produced at the production rate of 70 meters per minute.

[0028] The present invention will be explained more clearly by means of examples.

EXAMPLES 1 and 2

[0029] Black skin stainless steel sheets used in Examples 1 and 2 were respectively grade 304 black skin stainless steel sheet and grade 430 black skin stainless steel sheet, which were obtained by hot rolling grade 304 stainless steel slab and grade 430 stainless steel slab, respectively. After the black skin stainless steel sheets were subjected to cold rolling, annealing, sandblasting, and pickling, white skin stainless steel sheets were obtained. Tests were conducted to investigate scale loss and roughness of Examples 1 and 2. The results are shown in Tables 1 and 2.

Table 1

	Weight of scale per unit area (g/m^2)	
Examples	1(grade 304)	2(grade 430)
Black skin steel sheet	57	85
Cold-rolled steel sheet (total reduction=50%)	40	25
Scale loss	29.8%	70.6%

[0030] As shown in Table 1, Example 1 has a scale loss of about 30% after cold rolling. Example 2 has a scale loss of about 70% after cold rolling. The time for sandblasting and pickling in each example was reduced due to the high scale loss or high amount of scale removal owing to cold rolling.

[0031] Table 2 shows the roughness of Examples 1 and 2, and Comparative Examples 1 and 2. Comparative Examples 1 and 2 are white skin steel sheets (or coils) 300 that are produced by the conventional method of Fig. 1 from grade 304 and grade 430 stainless steels, respectively.

Table 2

	Roughness, R_a (μm)	
	Grade 304	Grade 430
Comparative Example 1	5.48	
Comparative Example 2		4.50
Example 1	2.02	
Example 2		1.70

[0032] As shown in Table 2, Example 1 has much smaller roughness (2.02 μm) compared to the roughness (5.48 μm) of Comparative Example 1. Example 2 has much smaller roughness (1.70 μm) compared to the roughness (4.50 μm) of Comparative Example 2. Generally, when grade 430 stainless steel is used in the conventional method of producing the black skin steel sheet (or coil) 200, as the grade 430 stainless steel is batch annealed in a batch annealing furnace, the scale thereof contains a large amount of chromium which is hardly pickled. According to the present invention, since the black skin steel sheet of grade 430 is cold rolled at least twice to achieve a total reduction of not less than 50%, a large amount of scale is removed by cold rolling. Consequently, the subsequent pickling step can be carried out easily in the present invention compared to that in the conventional method. Therefore, the concentration of a pickling mixed acid used in the present invention may be at least 50% lower than the concentration of a pickling mixed acid used

in the conventional method.

Claims

1. A method of producing a thin steel sheet (6),
characterized by:

   (a) providing a hot-rolled black skin steel sheet (60) which is formed directly from a cast steel slab;
   (b) cold rolling the black skin steel sheet (60) to form a cold-rolled steel sheet (61);
   (c) annealing the cold-rolled steel sheet (61) to form a cold-rolled annealed steel sheet (62); and
   (d) removing scale from the cold-rolled annealed steel sheet (62) by sandblasting and pickling to form a thin steel sheet (6).

2. The method of claim 1, **characterized in that** the black skin steel sheet (60) is cold rolled at least twice such that total reduction in thickness after cold rolling is not less than 50 percent.

3. The method of claim 2, further **characterized in that** the black skin steel sheet (60) has a scale loss that is not less than 28 percent after cold rolling.

4. The method of any one of claims 1, 2, and 3, further **characterized in that** the annealing of the cold-rolled steel sheet (61) is carried out at a temperature ranging from 1000°C to 1200°C.

5. The method of claim 4, further **characterized by** cooling the cold-rolled steel sheet (61) and removing moisture from a surface of the cold-rolled steel sheet (61) at a temperature not higher than 80°C, after annealing the cold-rolled steel sheet (61) and before removing the scale from the cold-rolled annealed steel sheet (62).

6. The method of claim 1, **characterized in that** the thin steel sheet (6) is a white skin steel sheet that has a thickness smaller than 2 millimeters.

7. The method of claim 1, **characterized in that** the hot-rolled black skin steel sheet (60) is selected from the group consisting of grade 304 stainless steel and grade 430 stainless steel.

8. The method of claim 1, **characterized in that** the cold-rolled annealed steel sheet (62) is sandblasted by a sandblasting device operating at a speed that ranges from 500 to 1000 revolutions per minute.

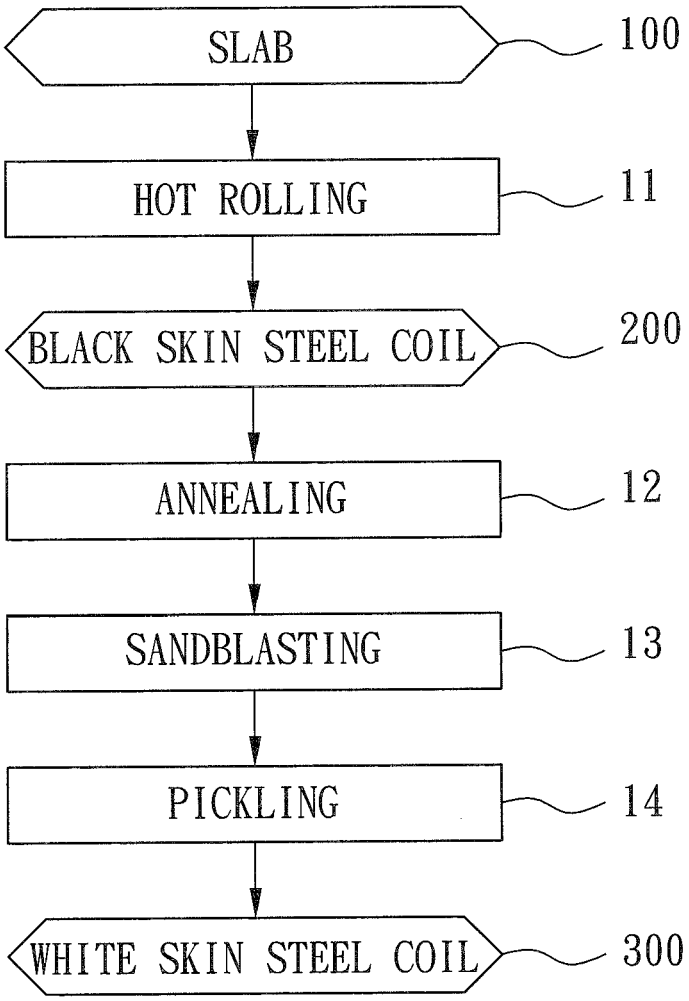

FIG. 1
PRIOR ART

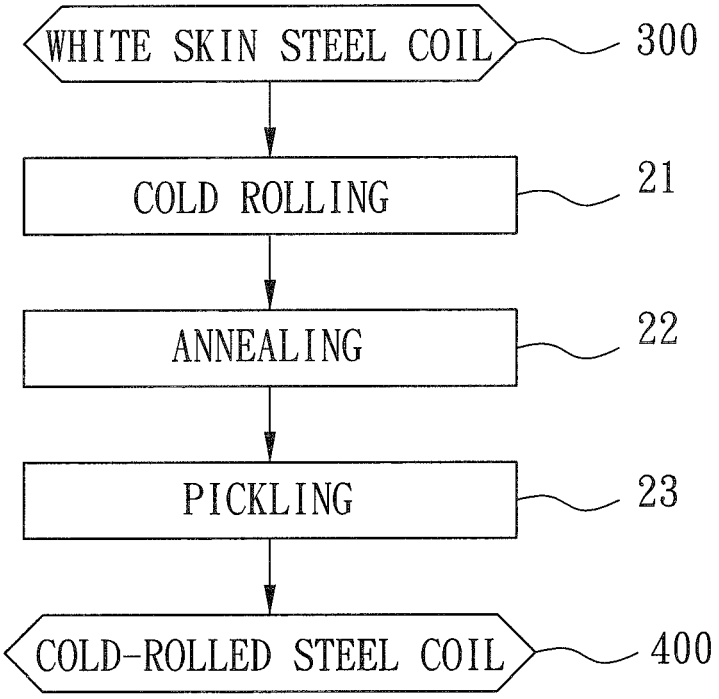

FIG. 2
PRIOR ART

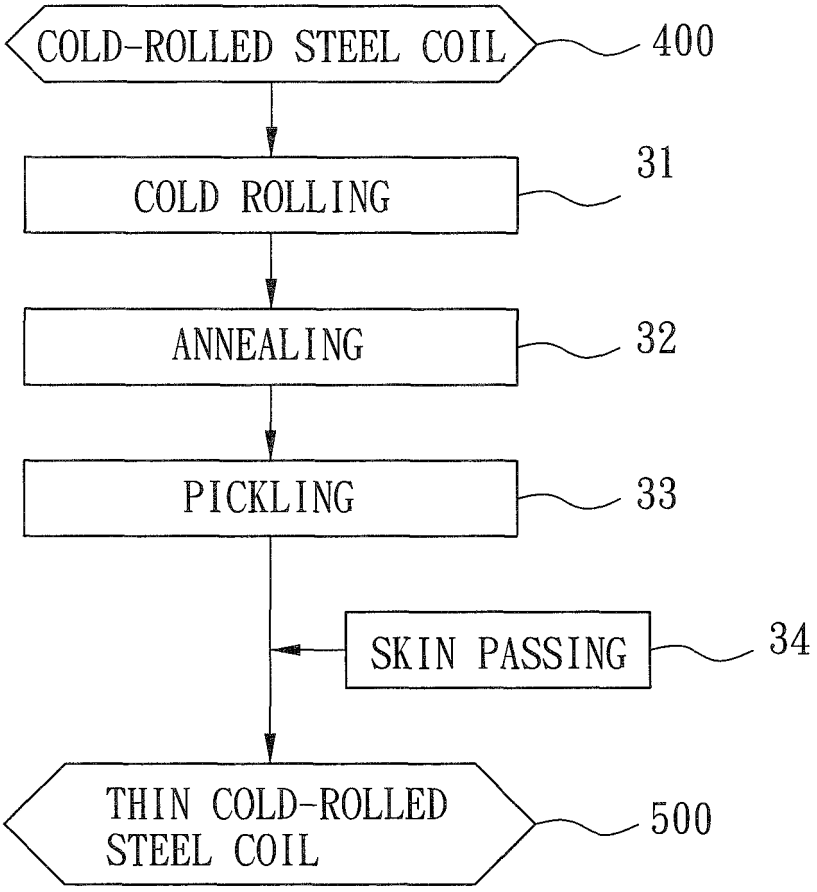

FIG. 3
PRIOR ART

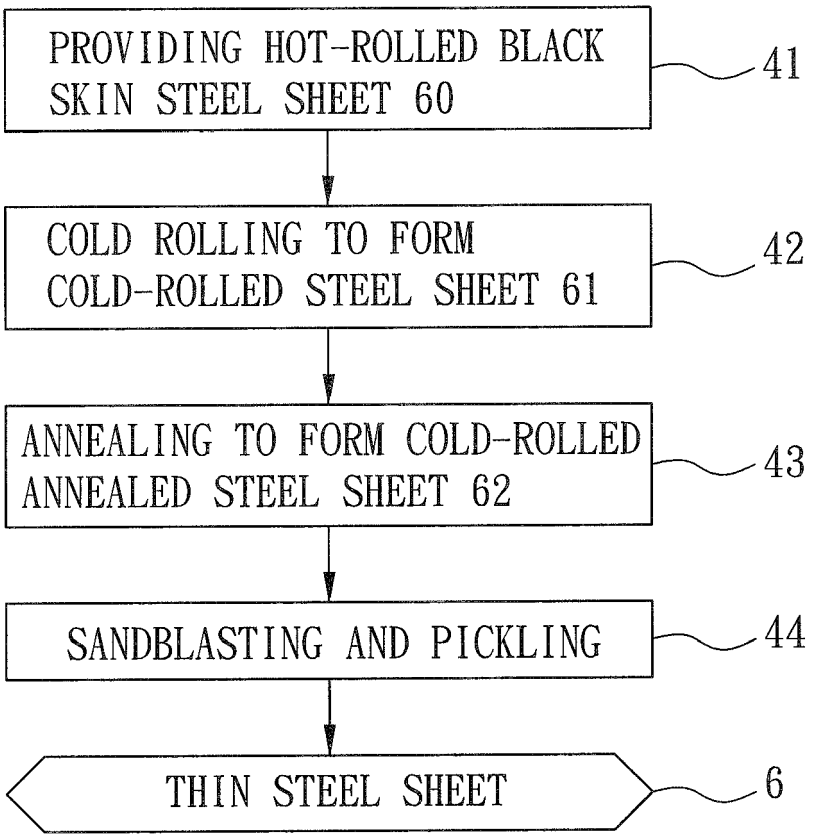
PROVIDING HOT-ROLLED BLACK SKIN STEEL SHEET 60
41
COLD ROLLING TO FORM COLD-ROLLED STEEL SHEET 61
42
ANNEALING TO FORM COLD-ROLLED ANNEALED STEEL SHEET 62
43
SANDBLASTING AND PICKLING
44
THIN STEEL SHEET
6

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 09 16 1588

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