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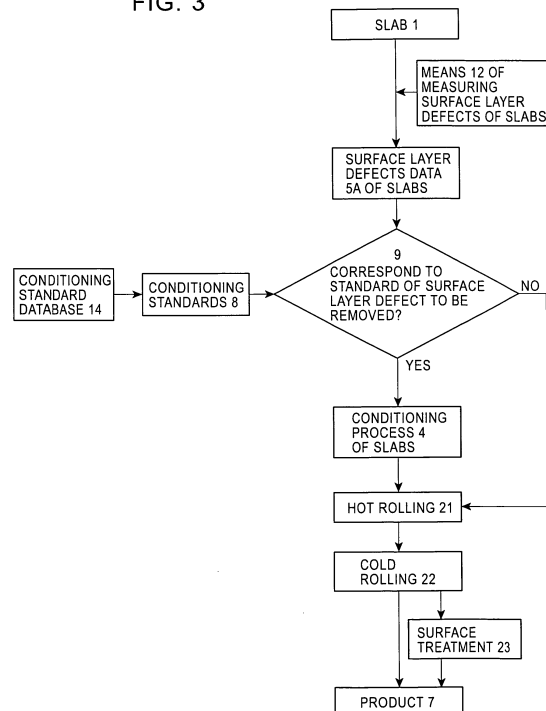
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(54) **PRODUCTION METHOD FOR STEEL CONTINUOUSLY CAST PIECE AND SYSTEM FOR CARING SURFACE DEFECT OF CAST PIECE**

(57) A method of producing continuous casting slabs, which can restrict the occurrence of surface defects in products to provide steel sheets having a required surface quality level is provided. More specifically, sizes and three-dimensional positions of surface layer defects in the slabs are determined. Regarding obtained data of the surface layer defects of the slabs, a determination is made as to whether there exists any surface layer defect that needs to be removed on the basis of a predetermined conditioning standard, so that any surface layer defect that needs to be removed is removed in a step of conditioning the slabs. The conditioning standard corresponds to features of the surface layer defects of the slabs, which become the surface defects of steel sheets, which are extracted as a result of comparing and checking data of the surface layer defects of the slabs, which determine the sizes and the three-dimensional positions of the surface layer defects of the slabs, with data of the surface defects of the steel sheets, which determines the sizes and two-dimensional positions of the surface defects in the sheets, obtained as materials of the slabs.

FIG. 3



Description

Technical Field

[0001] The present invention relates to a method of producing a continuous casting slab of steel, and, more particularly, to an improvement in a surface conditioning technique of a continuous casting slab, which is a material, for obtaining a rolled sheet having good surface quality.

Background Art

[0002] One important quality that is required of a continuous casting slab (hereunder simply referred to as "slab") that is produced by a continuous casting method of steel is that defects, such as inclusions of surface layers of slabs, are rarely produced. However, it is actually difficult to completely eliminate surface layer defects. Therefore, in steel sheets in which surface defects should not occur to the extent possible, an overall surface conditioning is widely performed on the slabs, which are materials.

[0003] In general, the surface conditioning of slabs is often performed by, for example, partial scarfing or overall scarfing using an oxygen torch, or partial grinding or overall grinding using a grinder. For example, in the surface conditioning of an ordinary steel slab, when defects still remain in the surface after overall scarfing using an oxygen torch, the defects are removed by further performing partial scarfing using an oxygen torch or partial grinding using a grinder.

[0004] However, although the surface conditioning operations using these methods can be used to remove defects up to a certain depth of a slab, the surface conditioning operations cannot be used to remove defects that are deeper than the certain depth. Therefore, for example, a defect in the slab remaining directly below a scarfed surface or a ground surface may become a surface defect of a thin sheet after the slab is rolled into the thin sheet. Consequently, even if the surface conditioning of the slab is performed, the occurrence of the surface defect in the rolled sheet, which is a product, cannot be prevented completely. In addition, when an attempt is made to remove a deep defect at a slab stage, even a flawless portion around the defect is removed, thereby increasing a decrease in yield ratio or increasing the conditioning work time.

[0005] To overcome this problem, for example, Japanese Unexamined Patent Application Publication No. 02-15806 proposes a method of producing a stainless steel sheet that does not have scabs. The technology discussed in Japanese Unexamined Patent Application Publication No. 02-15806 corresponds to a method of producing a stainless steel sheet which is subjected to hot rolling. In the technology, prior to starting the hot rolling, pinholes existing at at least portions near front and rear surfaces of side faces of slabs and existing in the front and rear surfaces of the slabs are detected, after which the portions pinholes having a diameter greater than or equal to 0.2 mm among the detected pinholes are conditioned and removed. According to the technology discussed in Japanese Unexamined Patent Application Publication No. 02-15806, it is possible to effectively prevent the production of scabs in the stainless steel without reducing rolling efficiency and yield ratio, by only detecting relatively large pinholes and simply preliminarily removing portions extending approximately 0.5 mm below the surface of the slab.

[0006] Japanese Unexamined Patent Application Publication No. 10-296306 proposes a method of producing a hot-rolled steel sheet. In this method, pinholes in a slab prior to rough rolling are detected. From the sizes of the pinholes, the depths of the pinholes from a slab surface, the slab thickness, and the finish rolling thickness, the pinholes that become surface scabs after the finish rolling are estimated. Then, conditioning is performed at a sheet bar stage or a slab stage prior to the finish rolling. In the technology discussed in Japanese Unexamined Patent Application Publication No. 10-296306, an artificial flaw is previously provided in a slab to perform a rolling test. From the result thereof, the depth from a slab surface and the size of pinholes that become surface flaws after the rolling, and rolling reduction are formulated as parameters. Based on this, the sizes of the pinholes to be removed prior to the rolling are determined. In the technology discussed in Japanese Unexamined Patent Application Publication No. 10-296306, pinholes that are formed at deep positions from the slab surface are ground after rough rolling because the grinding amount of the slab at the slab stage is large, thereby decreasing yield ratio.

[0007] In the technology discussed in Japanese Unexamined Patent Application Publication No. 02-15806, only pinholes of slabs are considered as being the cause of scabs (surface defects) of stainless steel. However, in a thin steel sheet, which is a material of an ordinary steel slab, in addition to pinholes of slabs, inclusions, formed of deoxidation products or mold power, cracks, etc., cause surface defects of thin steel sheets. For example, processes, such as surface treatment of thin steel sheets, in which ordinary steel slabs are materials, are significantly different from those of stainless steel sheets, and a criterion of surface quality greatly differs. Therefore, in the technology discussed in Japanese Unexamined Patent Application Publication No. 02-15806, it is not possible to completely prevent the occurrence of surface defects of thin steel sheets, in which ordinary steel slabs are materials.

[0008] In the technology discussed in Japanese Unexamined Patent Application Publication No. 10-296306, the sizes of pinholes to be removed are estimated on the basis of the result of a rolling test of artificial flaw. However, the slabs

according to the present invention are for ordinary steel sheets. In this case, surface layer defects, which cause surface defects, include, in addition to pinholes, inclusions, formed of deoxidation products or mold powder, and cracks. In addition, there are various specifications of a surface treatment process performed on rolled products (thin steel sheets). Depending upon the specification, surface defects may or may not be produced. Further, rolling conditions, etc., are expected to change considerably depending upon the steel type and use. Therefore, for the purpose of providing a standard of, for example, a size of a surface layer defect to be removed, it is necessary to perform a rolling test of artificial flaw each time. This is a complicated process, and lacks versatility in terms of process control standards.

[0009] The present invention can overcome such related art problems, and has as its object the provision of a method of producing a continuous casting slab of steel, which can restrict the occurrence of surface defects in a thin steel sheet (thin sheet), which is a product, so that the thin sheet (rolled product) has a required surface quality level. In addition, the present invention has as its object the provision of a conditioning system of surface layer defects of slabs, which can efficiently remove surface layer defects of slabs, which become surface defects of thin sheets (rolled products).

Disclosure of Invention

[0010] The gist of the present invention is as follows.

(1) A method of producing steel slabs 1 comprises a continuous casting process 2 of continuously casting molten steel to form the slabs 1, and a conditioning process 4 of the slabs of conditioning surfaces of the slabs 1 after the continuous casting process 2. After the continuous casting process 2 and prior to the conditioning process 4 of the slabs, an inspection process 3 of the slabs is performed on the slabs 1 to obtain surface layer defects data 5A of the slabs, which determines sizes and three-dimensional positions of surface layer defects 5 in the slabs 1, and, regarding the obtained surface layer defects data 5A of the slabs, a determination is made as to whether or not any surface layer defect 5B that needs to be removed on the basis of predetermined conditioning standards 8 exists, after which, if said any surface layer defect 5B that needs to be removed exists, said any surface layer defect 5B is removed in the conditioning process 4 of the slabs. Here, the three-dimensional positions of the surface layer defects 5 refer to a position in a production line direction (a slab longitudinal direction), a position perpendicular to the production line direction (slab widthwise direction) and a slab thickness direction. In addition, the size (diameter) of the surface layer defects 5 refers to a diameter of a circle of an area that is equivalent to the area obtained by image processing the defect. Hereunder, the size will be called the "diameter of the equivalent circle."

(2) In the method of producing steel slabs 1 according to (1), wherein the conditioning standards are composed of a step 9, in which the surface layer defects data 5A of the slabs 1, which determines the sizes and the three-dimensional positions of the surface layer defects 5 in the slabs 1, is compared with and checked against (9A) surface defects data 6A of sheets 7, which determines sizes (widths, lengths) and two-dimensional positions of the surface defects 6 in the sheets 7, obtained from the slabs 1, and in which features of the surface layer defects 5 of the slabs 1, which become the surface defects 6A of the sheets 7, are extracted (9B), is repeatedly performed on the slabs 1, so that said any surface layer defect 5B that needs to be removed in accordance with steel type and process is determined and classified so that the surface layer defects are capable of being indicated. Here, the two-dimensional positions of the surface defects 6 refer to a position in a production line direction (thin-sheet longitudinal direction), and a position perpendicular to the production line direction (thin-sheet widthwise direction). The width of the surface defects 6 refers to a maximum width in a direction perpendicular to a rolling direction of the thin sheets 7, and the length of the surface defects 6 refers to a maximum length in the rolling direction of the thin sheets 7.

(3) In the method of producing steel slabs 1 according to either (1) or (2), the surface layer defects 5 are any one of inclusions, blowholes, and cracks.

(4) A conditioning system 10 of surface layer defects of slabs, comprise means 12 of measuring the surface layer defects of the slabs, means 13 of measuring surface defects of sheets, a database 5C of the surface layer defects of the slabs, a database 6C of the surface defects of the sheets, a conditioning standard database 14, means 15 of calculation, and means 11 of conditioning the slabs. The database 5C of the surface layer defects of the slabs stores surface layer defects data 5A of the slabs 1, which is measured by the means 12 of measuring the surface layer defects of the slabs and which determines sizes and three-dimensional positions of the surface layer defects 5 of the slabs 1, so that the surface layer defects data 5A of the slabs 1 is capable of being input and output. The database 6C of the surface defects of the sheets stores surface defects data 6A of the sheets, which is measured by the means 13 of measuring the surface defects of the sheets and which determines sizes and two-dimensional positions of the surface defects 6 of the sheets 7, obtained as materials of the slabs 1, so that the surface defects data 6A of the sheets is capable of being input and output. The conditioning standard database 14 is obtained when a step 9, in which, using the means 15 of calculation, the surface layer defects data 5A of the slabs 1, which is stored in the database 5C of the surface layer defects of the slabs, is compared with and checked against (9A) the surface defects data 6A of the sheets 7, which is stored in the database 6C of the surface defects of the sheets,

obtained as materials of the slabs 1, and in which features of the surface layer defects 5B of the slabs, which become the surface defects 6 of the sheets, are extracted (9B), is repeatedly performed on the slabs 1, so that any surface layer defect 5B that needs to be removed is stored in the conditioning standard database so as to be capable of

being input and output as data 5B' of the surface layer defect that needs to be determined, classified, and removed. Regarding any conditioning slab, the means 12 of measuring the surface layer defects of the slabs measures the surface layer defect 5 thereof to form surface layer defect data 5A of said any conditioning slab; using the means 15 of calculation, said surface layer defect data 5A is compared with and checked against the data 5B' of the surface layer defect that needs to be removed, the data of the surface layer defect that needs to be removed being output from the conditioning standard database 14; and a determination is made as to whether or not there exists any surface layer defect 5B that needs to be removed in said any conditioning slab, so that, when said any surface layer defect 5B that needs to be removed exists in the slab 1, a signal 16 used to remove said any surface layer defect 5B that needs to be removed is output to the means 11 of conditioning the slabs.

(5) In the conditioning system 10 of surface layer defects of slabs according to (4), the means 12 of measuring the surface layer defects of the slabs is at least one of following defects measuring devices: an ultrasonic reflection type defects measuring device, a transmitting type defects measuring device using radiation, and a leakage magnetic flux type defects measuring device.

(6) In the conditioning system of surface layer defects of slabs according to either (4) or (5), the means 13 of measuring surface defects of sheets 7 (coils) is at least one of following defects measuring devices: a surface defects measuring device based on online continuous photography and image data processing and a leakage magnetic flux type defects measuring device.

Brief Description of Drawings

[0011]

Fig. 1 is a general flowchart of an example structure of a slab conditioning system 10 according to the present invention.

Fig. 2 is a general flowchart showing a procedure of forming a conditioning standard 8 used in the present invention.

Fig. 3 is a flowchart showing a procedure of determining whether or not slab conditioning is required in the present invention.

Fig. 4 is a general flowchart showing an example production process in the present invention.

Fig. 5 is a graph showing relationships between the depth and size of a surface layer defect 5 of a slab that causes a surface defect 6 of a thin sheet to be produced.

Fig. 6 illustrates an example of the conditioning standard 8.

Fig. 7 shows an example of a slab surface layer defects measuring device.

Fig. 8 is an example of a thin-sheet surface defects measuring device of an online continuous photography type.

Best Mode for Carrying Out the Invention

[0012] The inventors et al. have found out that, to obtain thin sheets 7 (rolled products) having a required surface quality level, it was important to efficiently and completely remove surface layer defects 5B of slabs 1, which become surface defects 6 of the thin sheets 7 (rolled products), which are products. To achieve this, the inventor et al. have found out that it was important to measure three-dimensional positions and sizes (diameters) of the surface layer defects 5 of the slabs 1, and to measure two-dimensional positions and sizes (widths, lengths) of the surface defects 6 of the thin sheets 7, which are materials of the slabs 1; to cause the surface layer defects 5 of the slabs 1 and the surface defects 6 of the thin sheet 7 to correspond on a one-to-one basis; and to identify, classify, and standardize (cause to become masters) the surface layer defects 5B, which become the surface defects 6 of the thin sheets 7, to be removed.

[0013] First, experimental results, which have become the base of the present invention, will be described.

[0014] Molten steel having an extra-low-carbon steel composition within a range, in mass percent, of C: less than or equal to 0.0020%, Si: less than or equal to 0.03%, Mn: 0.1 to 0.25%, P: less than or equal to 0.020%, S: 0.005 to 0.012%, sol.Al: 0.010 to 0.050%, and N: less than or equal to 0.0035%, was refined in a converter. Then, an ordinary continuous casting process 2 was performed to form the slabs 1 of extra-low-carbon steel for steel sheets. Thereafter, these slabs 1 were subjected to a hot rolling process 21 and a cold rolling process 22, to form the steel sheets 7 (rolled products) having various sheet thicknesses.

[0015] Regarding the slabs 1 prior to the rolling operations, means 12 of measuring surface layer defects of slabs (surface layer defects measuring device) of an ultrasonic reflection type defects measuring device was used to measure the size (diameter of the equivalent circle) and three-dimensional positions (position in a lengthwise direction of the slabs, position in the widthwise direction of the slabs, and a position from the slab surfaces) of the surface layer defects

5 of the slabs 1 (primarily inclusions). Then, the measured values were stored in a storage means so as to be retrievable. Then, regarding the steel sheets 7 (rolled products: coils), which are products, means 13 of measuring surface defects of steel sheets (surface defects measuring device) of an online continuous photography type was used to measure the sizes (width, length) and two-dimensional positions (position in a lengthwise direction of the steel sheets, and position in the widthwise direction of the steel sheets) of the surface defects 6 (surface scabs) of the steel sheets 7. Then, the measured values were stored in the storage means so as to be retrievable.

[0016] Then, stored surface layer defects data 5A of the slabs 1 and surface defects data 6A of the steel sheets 7, which are materials of the slabs, were extracted, and compared and checked (9A) to confirm the state of correspondence between the surface layer defects 5 and the surface defects 6. The results of the relationships between the depth (three-dimensional position) of the surface layer defects 5 at the slabs and the size of the surface layer defects are shown in Fig. 5. The symbol $\bigcirc$ stands for surface layer defects 5 that were not detected as surface defects 6 of the steel sheets 7; and the symbol Δ stands for surface layer defects 5 that were detected as the surface defects 6 of the steel sheets. In Fig. 5, the same scabs level ranges of the surface defects 6 were divided. From Fig. 5, it can be understood that boundary lines between the $\bigcirc$ and Δ , or division lines of the scab levels can be used as the features (three-dimension positions, sizes) of the surface layer defects 5B of the slabs to be removed.

[0017] The inventor et al. have conceived that setting the features of the surface layer defects 5 of the slabs, which become the surface defects 6 of such products, as predetermined conditioning standards in accordance with a surface quality demand degree of the products (steel sheets), indicating the surface layer defects 5B to be removed, and removing the matched surface layer defects 5 of the slabs at the slab stage can effectively and considerably reduce the occurrence of the surface defects 6 (scabs) of the products.

[0018] According to the present invention, since the surface layer defects 5, which cause the surface defects of the products (steel sheets 7), can be efficiently removed, the present invention is industrially considerably effective in making it possible to considerably reduce frequency of surface defects of the products and of considerably improving manufacturing yield ratio. In addition, according to the present invention, it is not necessary to perform overall scarfing and grinding conditioning of the entire slabs, so that the present invention is also effective in making it possible to easily and efficiently produce products required to satisfy strict surface quality level.

[0019] Further, the present invention makes it possible to efficiently remove all inclusions, which become scabs of the products, without a decrease in yield ratio caused by excessive conditioning or without any scabs remaining due to insufficient conditioning in overall conditioning to a certain thickness.

[0020] A method of producing a slab according to the present invention includes a continuous casting process 2, in which molten steel is continuously casted into slabs, and a conditioning process 4 of slabs 1, in which the slabs 1 are conditioned after the continuous casting process 2. After the continuous casting process 2 and prior to the conditioning process 4 of the slabs, the means 12 of measuring surface layer defects of the slabs measures the surface layer defects of the slabs 1, to extract the surface layer defects data 5A of the slabs. From the obtained results, the surface layer defects 5B that need to be removed are removed by the conditioning process 4 of the slabs. This procedure is schematically illustrated in Fig. 4.

[0021] In measuring the surface layer defects of the slabs in the present invention, the sizes (diameters of the equivalent circle) and the three-dimensional positions of the surface layer defects 5 of the slabs 1 to be measured are determined. Examples of the surface layer defects 5 of the slabs 1 are inclusions, blowholes, and cracks. By determining the three-dimensional positions of the surface layer defects 5, in the next process, conditioning places and depths of the slabs 1 become clear, so that conditioning is facilitated, and correspondences between the surface layer defects 5 and the occurrence of the surface defects of the steel sheets 7 after rolling can be easily made clear. The obtained surface layer defects data is, as the surface layer defects data 5A of the slabs 1, is stored in surface layer defects database 5C of the slabs so that it can be searched.

[0022] As shown in Fig. 3, on the basis of predetermined conditioning standards 8, that is, by comparing data (5B'), which is indicated in the conditioning standards 8, of the surface layer defects 5B that need to be removed with the surface layer defects data 5A of the slabs 1, a determination is made as to whether or not the surface layer defects 5 of the slabs correspond to the surface layer defects 5B that need to be removed. In the conditioning standards 8, it is desirable that the surface layer defects that need to be removed in accordance with steel type, sheet thickness, and process be classified (so that they can be indicated) so as to be searchable. Fig. 6 shows example conditioning standards 8. For example, in Fig. 6, when the depth of the surface layer defects of the slabs from the slab surfaces is greater than 2 mm and less than or equal to 4 mm, and the size (diameter of the equivalent circle) of the surface layer defects of the slabs is less than or equal to 600 μm and greater than 400 μm , $\bigcirc$ are indicated, so that local condition is not required. However, when the depth of the surface layer defects of the slabs from the slab surfaces is greater than 2 mm and less than or equal to 4 mm, and the size (diameter of the equivalent circle) of the surface layer defects of the slabs is less than or equal to 800 μm and greater than 600 μm , $\times$ are indicated in Fig. 6. Therefore, local conditioning is required. The slabs 1 having the surface layer defects 5 that are determined as corresponding to the surface layer defects 5B that need to be removed (in Fig. 6, the defects are indicated by $\times$) are immediately conveyed to the conditioning process

4 of the slabs, and are removed by means 11 of conditioning the slabs. Any means of conditioning the slabs may be used for the means 11 of conditioning the slabs as long as it is a device of a type that is connected to a process computer and that is automatically operated, and that can remove local defects. Accordingly, the means 11 is not particularly limited. Example means 11 may be those that perform scarfing using an oxygen torch or grinding using a grinder.

[0023] The slabs 1 whose surface layer defects 5B that need to be removed in the slab conditioning process 4 have been removed, or the flawless slabs 1 whose surface layer defects 5B do not need to be removed are subjected to the following processes, that is, the hot rolling process 21 and the cold rolling process 22, or are further subjected to a surface treatment process 23, so that they are formed as the products 7 (steel sheets). The procedure is shown in Fig. 3. As shown in Fig. 4, in a surface inspection process 24, the products 7 (steel sheets) are inspected by the means 13

of measuring surface layer defects to determine whether or not surface defects 6 exist.

[0024] In the method of producing the steel slabs 1 according to the present invention, since the surface layer defects 5B of the slabs 1, which become the surface defects 6 of the products 7, are removed in accordance with steel type, process, etc., it is possible to prevent the production of the surface defects 6. Therefore, it is possible to facilitate the production of the steel sheets 7 having a surface quality that conforms to use, so that product yield ratio is increased.

[0025] In the present invention, the conditioning standards 8 need to be such that the data (5B') of the surface layer defects 5B that need to be removed in accordance with steel type, process, use, sheet thickness, etc., can be classified, searched, checked, indicated, and updated. As shown in Fig. 2, it is desirable that it be predetermined by the following procedure.

[0026] First, in the inspection process 3 of the slabs, the means 12 of measuring the surface layer defects of the slabs is used to obtain the surface layer defects data 5A of the slabs that determines the sizes and the three-dimensional positions of the surface layer defects 6 of the slabs 1. For the means 12 of measuring the surface layer defects of slabs (slab surface layer defects measuring device), any one of the following surface layer defects measuring devices, that is, an ultrasonic reflection type defects measuring device, a transmitting type defects measuring device using radiation such as X rays or γ rays, and a leakage magnetic flux type defects measuring device, may be suitably used.

[0027] Then, the slabs 1 are subjected to the hot rolling process 21, the cold rolling process 22, or the surface treatment process 23 to form the steel sheets 7. Then, regarding the steel sheets 7, in the surface inspection process 24, the means 13 of measuring the surface layer defects of the steel sheets is used to determine the sizes (width, length) and two-dimensional positions of the surface defects 6 (surface scabs, etc.) of the steel sheets. Accordingly, the surface defects data 6A of the steel sheets obtained as the materials of the slabs is obtained. Examples of the surface defects 6 of the steel sheets may include scabs, sliver, and blisters. As examples of the means 13 of measuring surface defects of the steel sheets, any one of the following surface defects measuring devices, that is, a surface defects measuring device based on image data processing and online continuous photography of the surfaces of the steel sheets 7 (coils), and a leakage magnetic flux type measuring device, may be suitably used.

[0028] The obtained surface defects data 6A is stored in the storage means of the database 5C of the surface layer defects of the slabs and database 6C of surface layer defects of the steel sheets so that it can be retrieved, searched, and checked. It is desirable that the surface layer defects data 5A of the slabs 1 and the surface defects data 6A of the steel sheets 7, which are the materials of the slabs 1 be constantly collected and accumulated online.

[0029] Then, using means 15 of calculation (computer), the obtained surface layer defects data 5A of the slabs 1 and the surface defects data 6A of the steel sheets 7, which are the materials of the slabs 1, are compared with each other (9A), so that features regarding the sizes and the three-dimensional positions of the surface layer defects 5B of the slabs 1, which become the surface defects 6 of the steel sheets 7, are extracted (9B). This step is repeatedly performed on the plurality of slabs 1, to provide the conditioning standards 8 in which the features (the sizes (diameters of the equivalent circle), three-dimensional positions) of the surface layer defects 5 of the slabs 1, which need to be removed in accordance with steel type, process, use, sheet thickness, etc., because they become the surface defects 6 of the steel sheets 7, can be classified, searched, checked, and indicated. The obtained conditioning standards 8 are stored in the storage means of conditioning standard database 14 so that it can be retrieved and updated.

[0030] By this, the features (the sizes (diameters of the equivalent circle), three-dimensional positions) of the surface layer defects 6 of the slabs 1, which become the surface defects 6 of the steel sheet products 7, can be extracted and indicated as the conditioning standards 8 in accordance with, for example, steel type, process, or use, or the sizes (widths, lengths) of the surface defects 6 (surface scabs) of the steel sheets 7.

[0031] It is desirable that the surface layer defects data 5A of the slabs 1 and the surface defects data 6A of the steel sheets 7, which are the materials of the slabs 1, be constantly collected and accumulated online. This makes it possible for the conditioning standards 8 to be updated periodically or non-periodically on the basis of latest data. This makes it possible to constantly possess the latest conditioning standards 8 in accordance with changes in, for example, casting conditions and rolling conditions.

[0032] Next, the general structure of a surface layer defects conditioning system 10 of the slabs 1 used in the present invention will be described.

[0033] As shown in Fig. 1, the surface layer defects conditioning system 10 of the slabs 1 used in the present invention

comprises the means 12 of measuring surface layer defects of slabs, the means 13 of measuring surface defects of steel sheets, the means 15 of calculation, the means 11 of conditioning slabs, the database 5C of surface layer defects of slabs, the database 6C of surface defects of steel sheets, and the conditioning standard database 14.

[0034] The surface layer defects conditioning system 10 of the slabs 1 is connected to, for example, a high-end process computer and a low-end process computer. It goes without saying that the surface layer defects conditioning system 10 of the slabs 1 is formed so as to allow input of information of, for example, use and process of the steel sheets, which are products, or of the history of, for example, manufacturing conditions and slab composition.

[0035] In the surface layer defects conditioning system 10 of the slabs used in the present invention, the means 12 of measuring surface layer defects of slabs and the means 13 of measuring surface defects of steel sheets, and the means 11 of conditioning slabs 11 are connected to the means 15 of calculation. The database 5C of surface layer defects of slabs, the database 6C of surface defects of steel sheets, and the conditioning standard base 14 are also connected to the means 15 of calculation.

[0036] In the means 12 of measuring surface layer defects of slabs, the surface layer defects data 5A of the slabs regarding, for example, the three-dimensional positions and sizes of the surface layer defects 5 of the slabs 1 is measured. In the means 13 of measuring surface defects of steel sheets, the surface defects data 6A regarding the sizes (widths, lengths) and the two-dimensional positions of the surface defects 6 of the steel sheets 7, obtained as materials of the slabs 1 is measured. As described above, the database 5C of the surface layer defects of the slabs is a database in which the obtained surface layer defects data 5A of the slabs 1 is stored so that it can be input and output along with process-related information such as manufacturing conditions and composition. The database 5C of the surface layer defects of the steel sheets is a database in which the surface defects data 6A of the steel sheets 7, obtained as the materials of the slabs 1, is stored so that it can be input and output along with process-related information such as processes and steel type. The conditioning standard database 14 is a database in which the surface layer defects that need to be removed in accordance with, for example, steel type, process, and use is stored so that it can be input and output as the surface layer defects data 5B that need to be determined, classified, and removed.

[0037] In the surface layer defect conditioning system 10 of the slabs 1 used in the present invention, regarding the conditioning slabs 1, the surface layer defects data 5A of the slabs 1, measured by the means 12 of measuring surface layer defects of slabs, and the surface layer defects data 5B', which need to be removed in accordance with, for example, steel type, process, and use and is output from the conditioning standard database 14, are input. Using the means 15 of calculation, they are compared (9A), to determine the surface layer defects 5B that need to be removed in the conditioning slabs. Then, when the surface layer defects 5B that need to be removed exist in the slabs 1, a signal 16 used to remove the surface layer defects 5B is output to the means 11 of conditioning slabs.

Example

[0038] Molten steel having an extra-low-carbon steel composition within a range, in mass percent, of C: less than or equal to 0.0020%, Si: less than or equal to 0.03%, Mn: 0.1 to 0.25%, P: less than or equal to 0.020%, S: 0.005 to 0.012%, sol.Al: 0.010 to 0.050%, and N: less than or equal to 0.0035%, was refined in a converter. Then, after being formed into slabs 1 of extra-low-carbon steel for steel sheets in the continuous casting process 2 shown in Fig. 4, these slabs 1 were subjected to the hot rolling process 21 and the cold rolling process 22, to form steel sheets (products: coils) having sheet thicknesses of from 0.7 to 1.2 mm. Regarding the slabs 1 prior to the rolling operations, using the means of measuring surface layer defects of slabs (surface layer defects measuring device) of an ultrasonic reflection type shown in Fig. 7, the sizes and the three-dimensional positions (position in a lengthwise direction of the slabs, position in the widthwise direction of the slabs, and a depth from the front and back surfaces of the slabs) of the surface layer defects 5 (primarily inclusions) of the entire front and back surfaces of the slabs 1 (surface layer defects data 5A) were measured. Then, the surface layer defects data 5A was compared with the data 5A of the surface layer defects to be removed at a slab stage, the data 5A being indicated in the conditioning standards 8 output from the conditioning standard database 14 and used for the present purpose. Then, a slab conditioning operation was performed to selectively remove the surface layer defects 5B that need to be removed by the means 11 of conditioning slabs (a grinder that can perform local conditioning). This corresponds to the example (number of coils = 102) of the present invention. Some of the slabs 1 were subjected to overall grinding for a 2mm slab thickness. This corresponds to a comparative example (number of coils = 98).

[0039] Regarding obtained steel sheets 7 (products: coils), surface defects 6 (surface scabs) of the steel sheets were measured by the means 13 of measuring surface layer defects of steel sheets (surface defects measuring device) of the online continuous photography type shown in Fig. 8, to determine the frequency of the surface defects of the products 7 (coils). The frequency of the surface defects is calculated by the following formula:

frequency of surface defects = {(number of occurrences
 of surface defects/product) × (truncated length of product)/
 overall length of product}

[0040] The frequency of the surface defects in the example of the present invention was 0.1% on average. In contrast, in the comparative example, it was 1.0% on average.

Industrial Applicability

[0041] According to the present invention, since the surface layer defects, which cause the surface defects of the products (steel sheets), can be efficiently removed, the present invention is industrially considerably effective in making it possible to considerably reduce frequency of surface defects of the products and of considerably improving manufacturing yield ratio. In addition, according to the present invention, it is not necessary to perform overall scarfing and grinding conditioning of the entire slabs, so that the present invention is also effective in making it possible to easily and efficiently produce products required to satisfy strict surface quality level.

[0042] Further, the present invention makes it possible to efficiently remove all inclusions, which become scabs of the products, without a decrease in yield ratio caused by excessive conditioning or without any scabs remaining due to insufficient conditioning in overall conditioning to a certain thickness.

Claims

1. A method of producing steel slabs, comprising a continuous casting process of continuously casting molten steel to form the slabs, and a conditioning process of the slabs of conditioning surfaces of the slabs after the continuous casting process,
 wherein, after the continuous casting process and prior to the conditioning process of the slabs, an inspection process of the slabs is performed on the slabs to obtain surface layer defects data of the slabs, which determines sizes and three-dimensional positions of surface layer defects in the slabs, and, regarding the obtained surface layer defects data of the slabs, a determination is made as to whether or not any surface layer defect that needs to be removed on the basis of predetermined conditioning standards exists, after which, if said any surface layer defect that needs to be removed exists, said any surface layer defect is removed in the conditioning process of the slabs.
2. The method of producing steel slabs according to Claim 1, wherein the conditioning standards are composed of a step, in which the surface layer defects data of the slabs, which determines the sizes and the three-dimensional positions of the surface layer defects in the slabs, is compared with and checked against surface defects data of sheets, which determines sizes and two-dimensional positions of the surface defects in the sheets obtained from the slabs, and in which features of the surface layer defects of the slabs, which become the surface defects of the sheets are extracted, is repeatedly performed on the slabs, so that said any surface layer defect that needs to be removed in accordance with steel type and process is determined and classified so that the surface layer defects are capable of being indicated.
3. The method of producing steel slabs according to either Claim 1 or Claim 2, wherein the surface layer defects are any one of inclusions, blowholes, and cracks.
4. A conditioning system of surface layer defects of slabs, comprising means of measuring the surface layer defects of the slabs, means of measuring surface defects of sheets, a database of the surface layer defects of the slabs, a database of the surface defects of the sheets, a conditioning standard database, means of calculation, and means of conditioning the slabs,
 wherein the database of the surface layer defects of the slabs stores surface layer defects data of the slabs, which is measured by the means of measuring the surface layer defects of the slabs and which determines sizes and three-dimensional positions of the surface layer defects of the slabs, so that the surface layer defects data of the slabs is capable of being input and output,
 wherein the database of the surface defects of the sheets stores surface defects data of the sheets, which is measured by the means of measuring the surface defects of the sheets and which determines degrees and two-

dimensional positions of the surface defects of the sheets, obtained as materials of the slabs, so that the surface defects data of the sheets is capable of being input and output,

wherein the conditioning standard database is obtained when a step, in which, using the means of calculation, the surface layer defects data of the slabs, which is stored in the database of the surface layer defects of the slabs, is compared with and checked against the surface defects data of the sheets, which is stored in the database of the surface defects of the sheets, obtained as materials of the slabs, and in which features of the surface layer defects of the slabs, which become the surface defects of the sheets, are extracted, is repeatedly performed on the slabs, so that any surface layer defect that needs to be removed is stored in the conditioning standard database so as to be capable of being input and output as data of the surface layer defect that needs to be determined, classified, and removed,

wherein, regarding any conditioning slab, the means of measuring the surface layer defects of the slabs measures the surface layer defect thereof to form surface layer defect data of said any conditioning slab; using the means of calculation, said surface layer defect data is compared with and checked against the data of the surface layer defect that needs to be removed, the data of the surface layer defect that needs to be removed being output from the conditioning standard database; and a determination is made as to whether or not there exists any surface layer defect that needs to be removed in said any conditioning slab, so that, when said any surface layer defect that needs to be removed exists in the slab, a signal used to remove said any surface layer defect that needs to be removed is output to the means of conditioning the slabs.

5. The conditioning system of surface layer defects of slabs according to Claim 4, wherein the means of measuring the surface layer defects of the slabs is at least one of following defects measuring devices: an ultrasonic reflection type defects measuring device, a transmitting type defects measuring device using radiation, and a leakage magnetic flux type defects measuring device.

6. The conditioning system of surface layer defects of slabs according to either Claim 4 or Claim 5, wherein the means of measuring surface defects of sheets is at least one of following defects measuring devices: a surface defects measuring device based on online continuous photography and image data processing and a leakage magnetic flux type defects measuring device.

FIG. 1

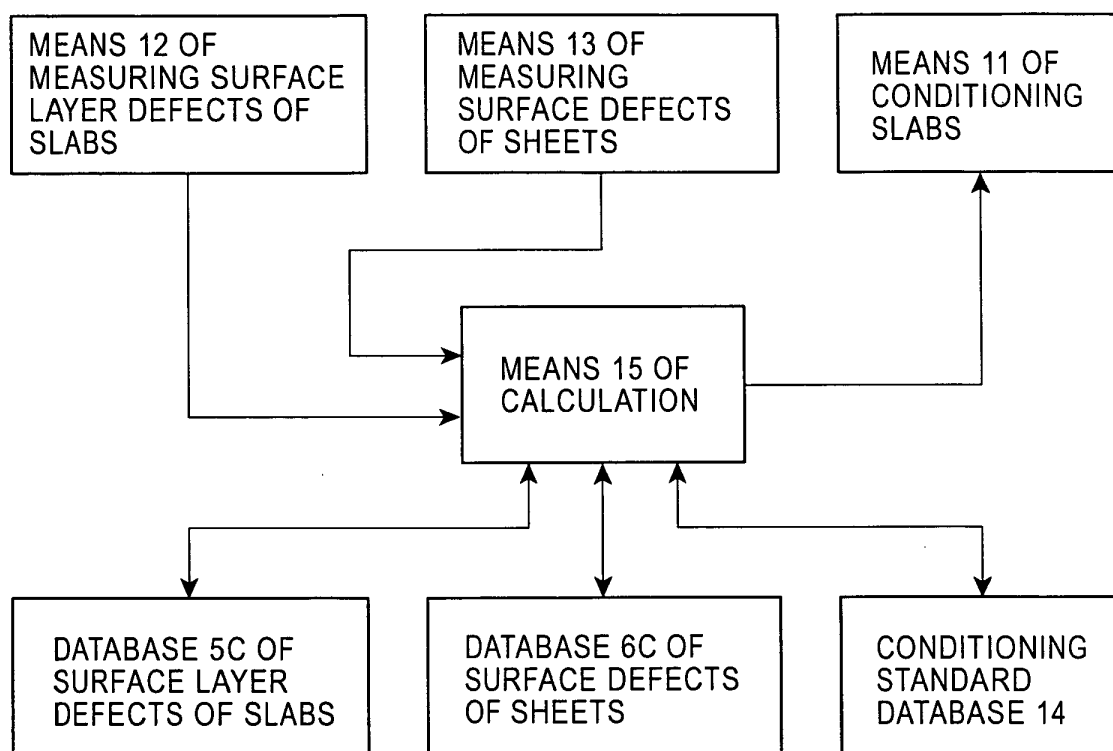


FIG. 2

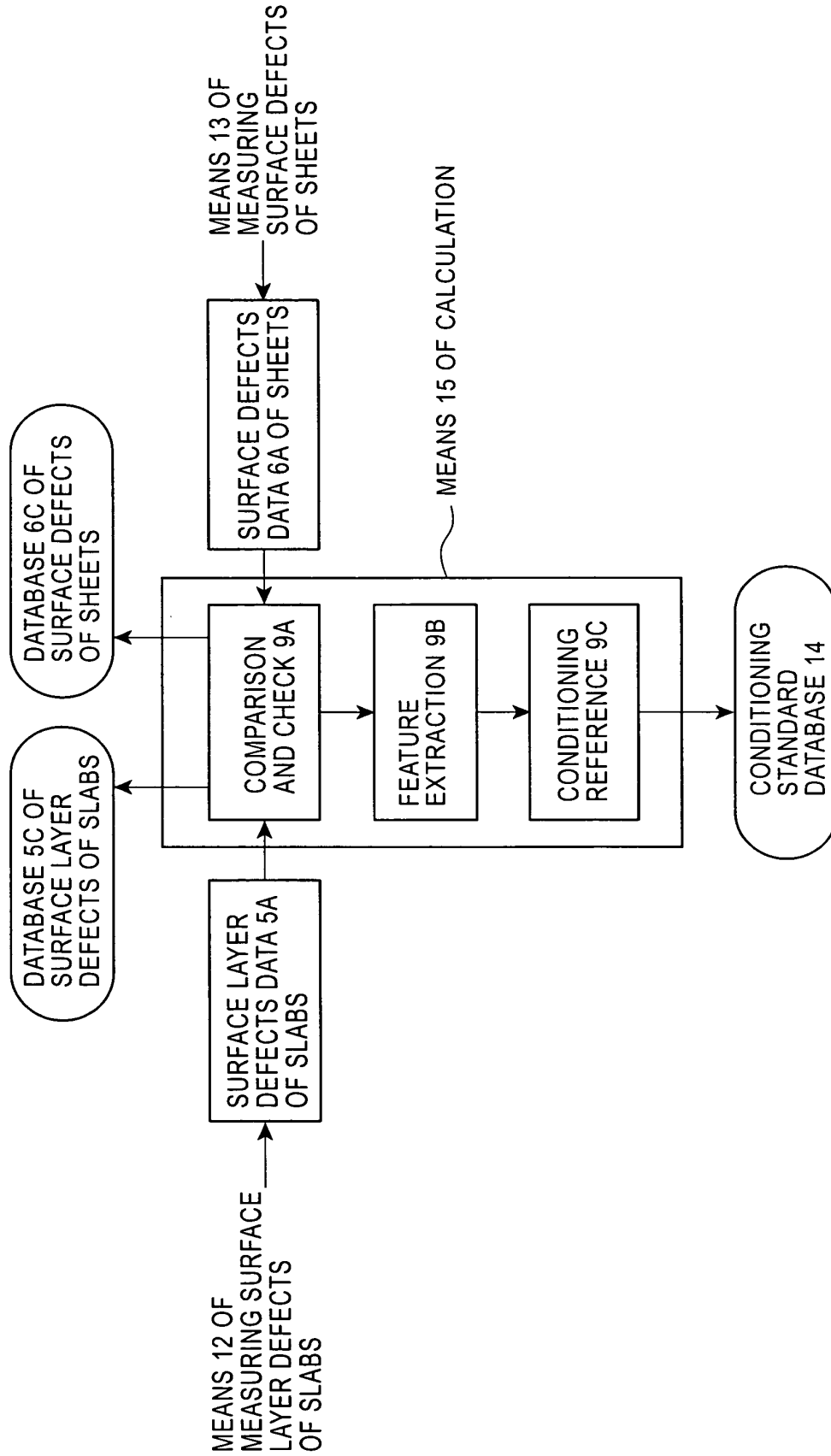


FIG. 3

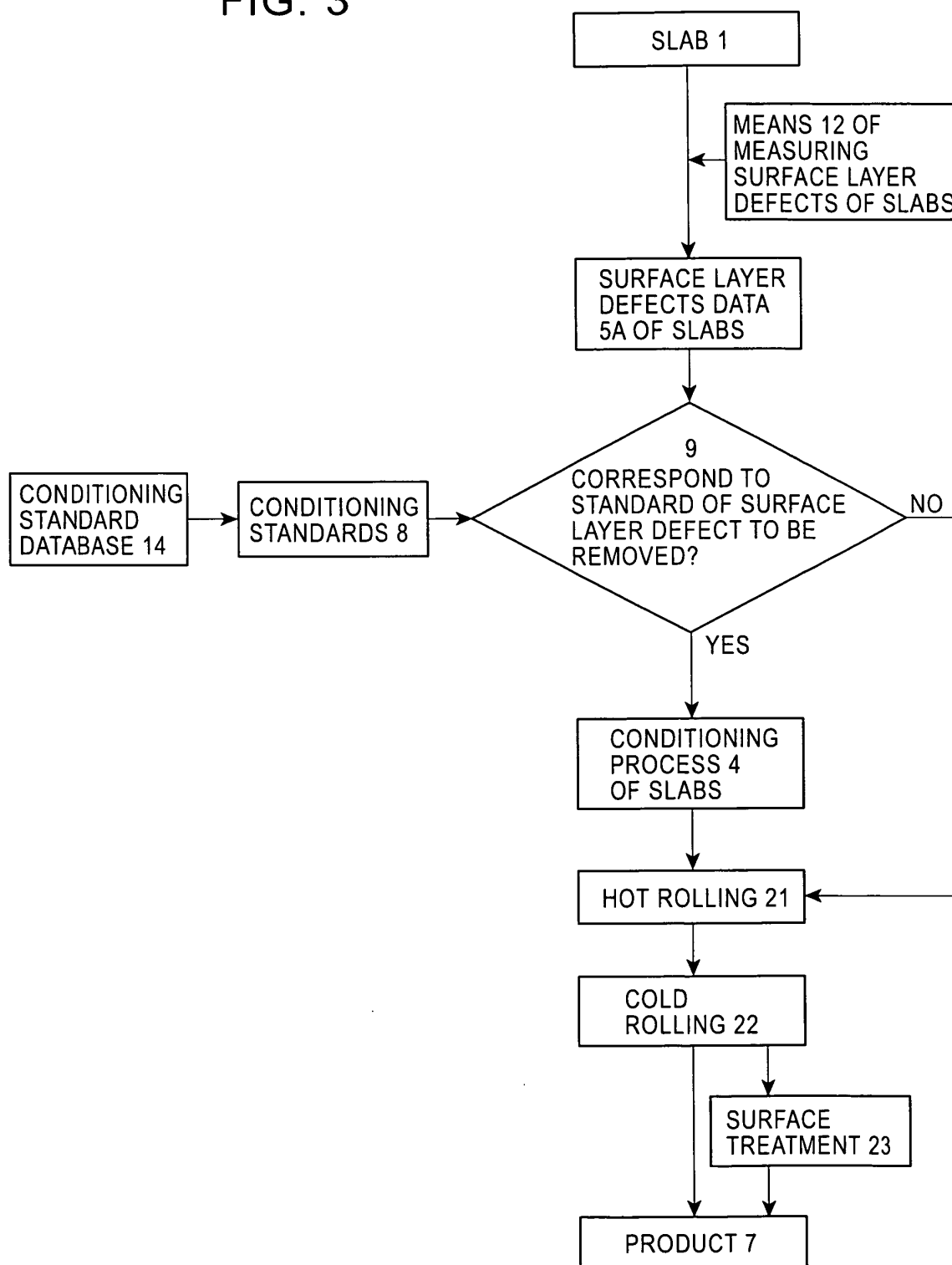


FIG. 4

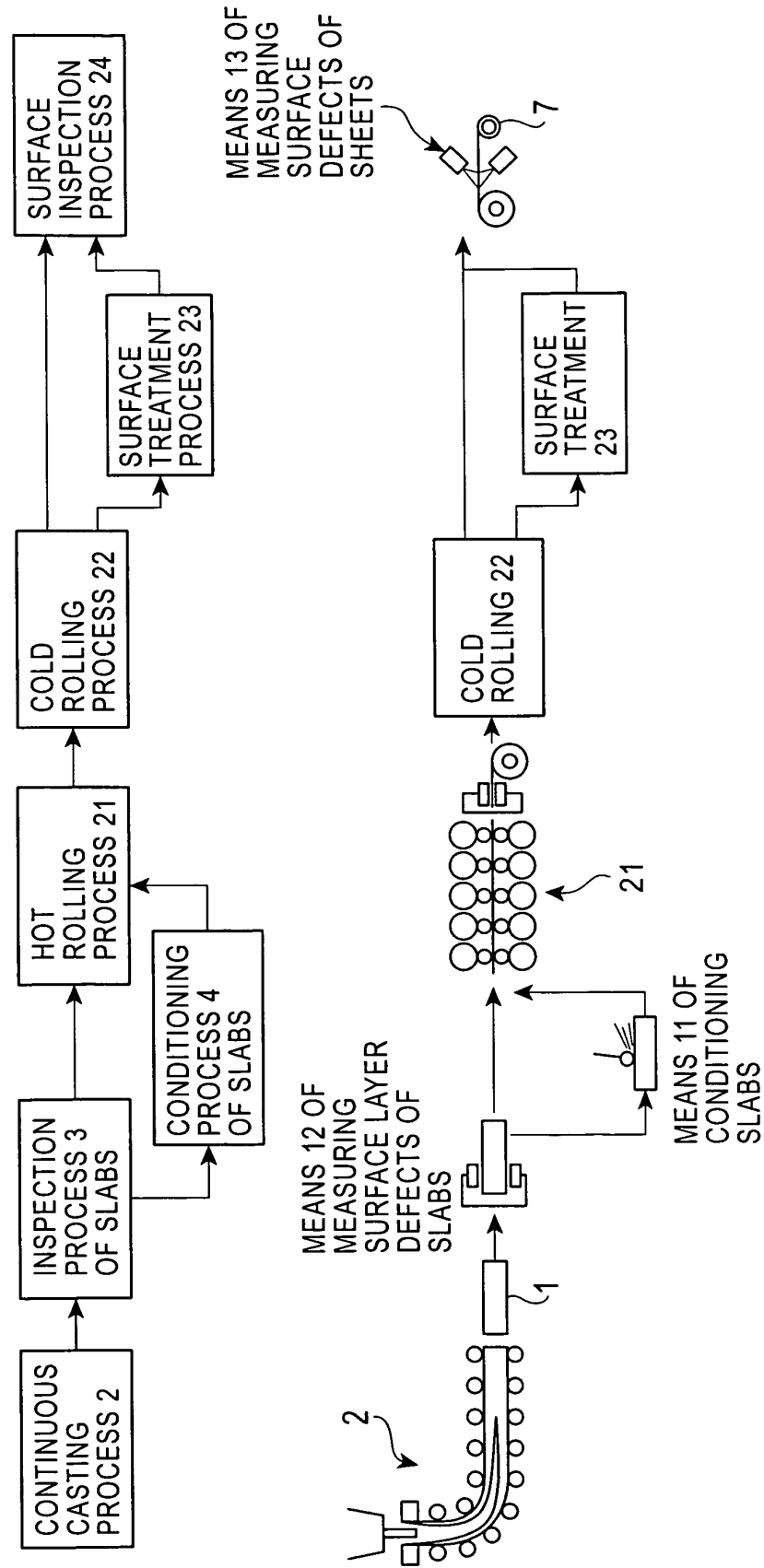


FIG. 5

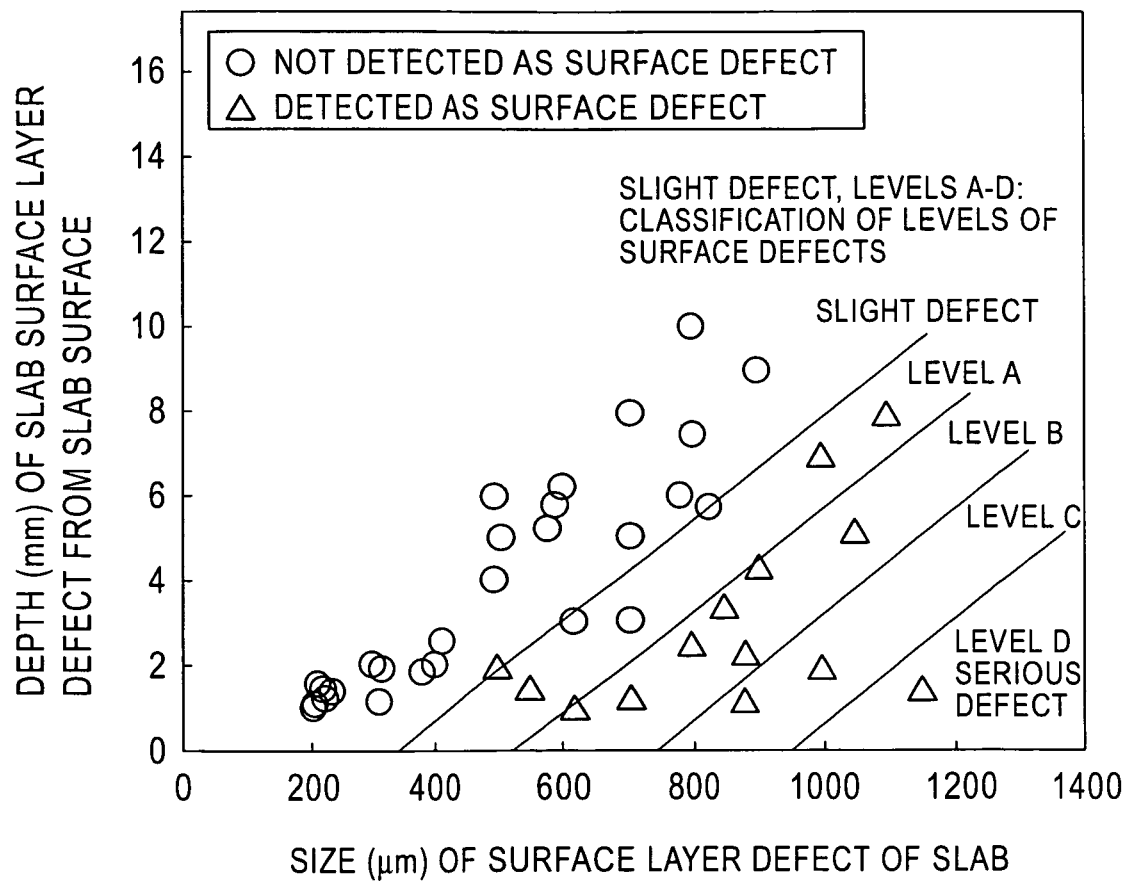


FIG. 6

STEEL TYPE = ULTRA LOW CARBON PRODUCT SHEET THICKNESS = LESS THAN 0.8 mm		SIZE (µm) OF SURFACE LAYER DEFECT OF SLAB							
DEPTH (mm) OF SLAB SURFACE LAYER DEFECT FROM SLAB SURFACE		200 OR LESS	400 OR LESS	600 OR LESS	800 OR LESS	1000 OR LESS	1200 OR LESS	1400 OR LESS	ABOVE 1400
		2 OR LESS	○	×	×	×	×	×	×
4 OR LESS	○	○	○	○	×	×	×	×	×
6 OR LESS	○	○	○	○	○	×	×	×	×
8 OR LESS	○	○	○	○	○	○	×	×	×
10 OR LESS	○	○	○	○	○	○	○	×	×
12 OR LESS	○	○	○	○	○	○	○	×	×
14 OR LESS	○	○	○	○	○	○	○	○	×
16 OR LESS	○	○	○	○	○	○	○	○	×
ABOVE 16	○	○	○	○	○	○	○	○	○

○ = LOCAL CONDITIONING NOT REQUIRED
 × = LOCAL CONDITIONING REQUIRED

FIG. 7

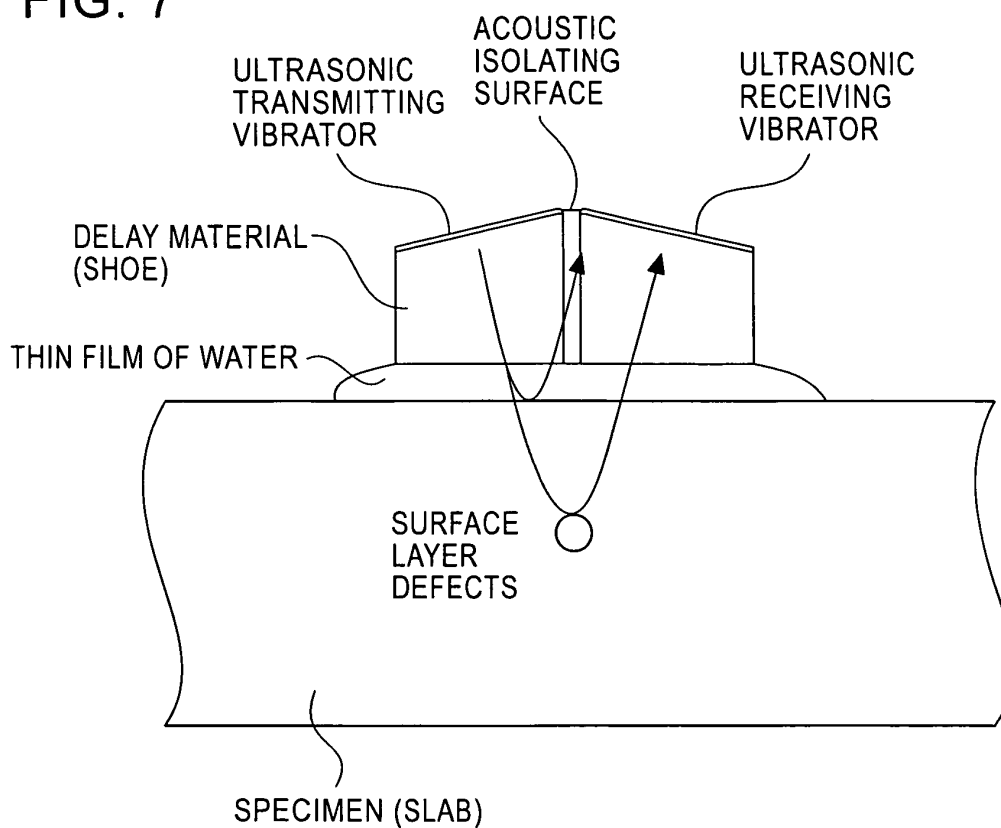
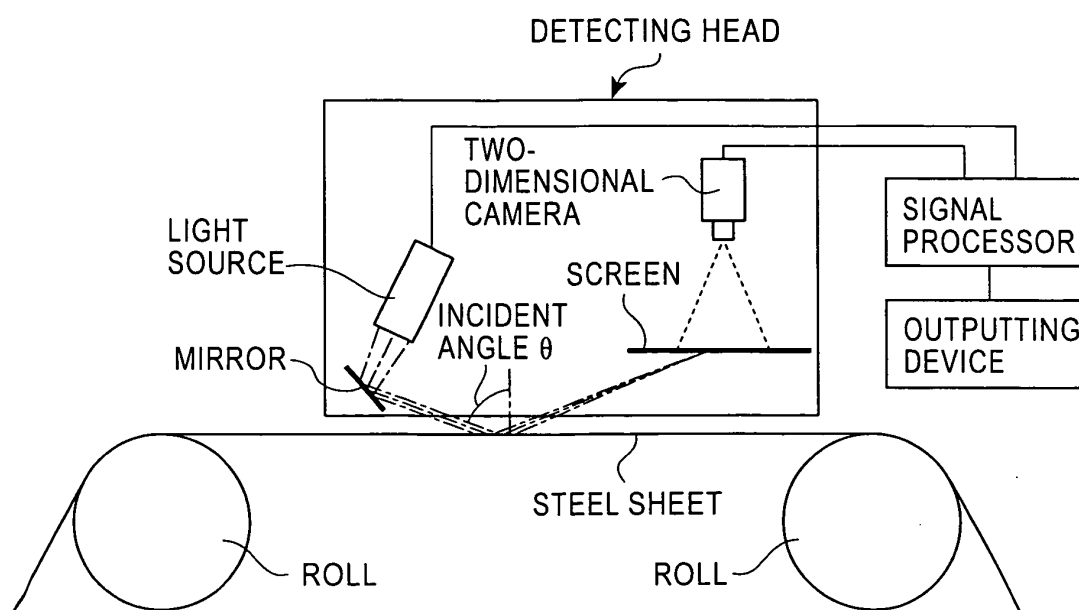


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2007/053701

A. CLASSIFICATION OF SUBJECT MATTER

B22D11/16(2006.01)i, B21B1/02(2006.01)i, B21C51/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B22D11/00-11/22, B21B1/00-1/46, B21C51/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2007
Kokai Jitsuyo Shinan Koho	1971-2007	Toroku Jitsuyo Shinan Koho	1994-2007

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y <u>A</u>	JP 2002-323481 A (Kawasaki Steel Corp.), 08 November, 2002 (08.11.02), Par. No. [0002]; examples (Family: none)	1, 3 <u>2, 4-6</u>
Y <u>A</u>	JP 2004-306085 A (JFE Steel Corp.), 04 November, 2004 (04.11.04), Par. No. [0002] (Family: none)	1, 3 <u>2, 4-6</u>

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
23 May, 2007 (23.05.07)Date of mailing of the international search report
05 June, 2007 (05.06.07)Name and mailing address of the ISA/
Japanese Patent Office

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Patent documents cited in the description

- JP 2015806 A [0005] [0005] [0005] [0007] [0007]
- JP 10296306 A [0006] [0006] [0006] [0008]