



US 20090178778A1

(19) **United States**(12) **Patent Application Publication**
Seidel et al.(10) **Pub. No.: US 2009/0178778 A1**(43) **Pub. Date: Jul. 16, 2009**(54) **METHOD AND DEVICE FOR PRODUCING A METAL STRIP BY CONTINUOUS CASTING****Publication Classification**(76) Inventors: **Jürgen Seidel**, Kreuztal (DE);
Peter Sudau, Hilchenbach (DE)(51) **Int. Cl.**
B22D 11/126 (2006.01)(52) **U.S. Cl.** **164/460; 164/263**(57) **ABSTRACT**

Correspondence Address:

FRIEDRICH KUEFFNER
317 MADISON AVENUE, SUITE 910
NEW YORK, NY 10017 (US)

The invention relates to a method for producing a metal strip (1) by continuous casting. According to said method, a slab (3), preferably a thin slab, is initially cast in a casting machine (2), said slab being deviated from a vertical direction (V) into a horizontal direction (H), and in the direction of transport (F) of the slab (3) arranged behind the casting machine (2), the slab (3) is subjected to a milling operation in a milling machine (4) and at least one milling operation in at least one rolling train (5, 6). According to the invention, in order to improve the quality of the strip, the rolling and milling operations are carried out immediately after the slab (3) is cast in the casting machine (2). The rolling operation is divided into at least two partial-rolling operations in at least one first rolling train (5) and one second rolling train (6). The milling operation in the milling machine (4) is carried out directly prior to the first rolling operation or between both rolling operations. The invention also relates to a device for producing a metal strip (1) by continuous casting.

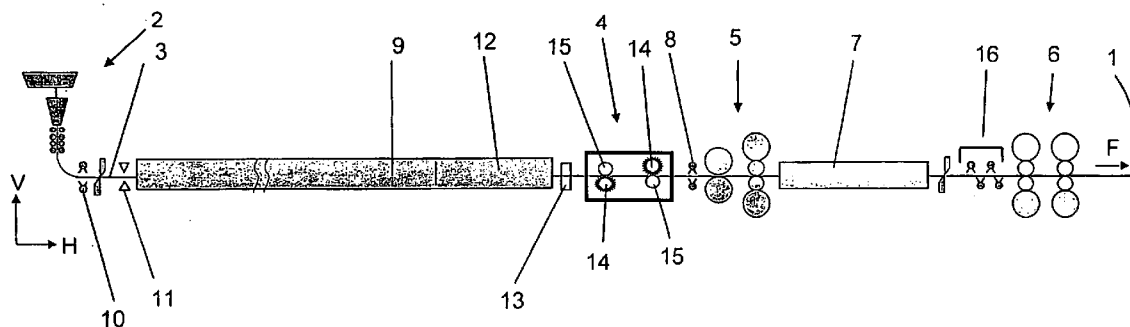
(21) Appl. No.: **12/227,531**(22) PCT Filed: **May 23, 2007**(86) PCT No.: **PCT/EP2007/004561**

§ 371 (c)(1),

(2), (4) Date: **Nov. 20, 2008**(30) **Foreign Application Priority Data**

Jun. 26, 2006 (DE) 10 2006 024 586.5

May 14, 2007 (DE) 10 2007 022 931.5



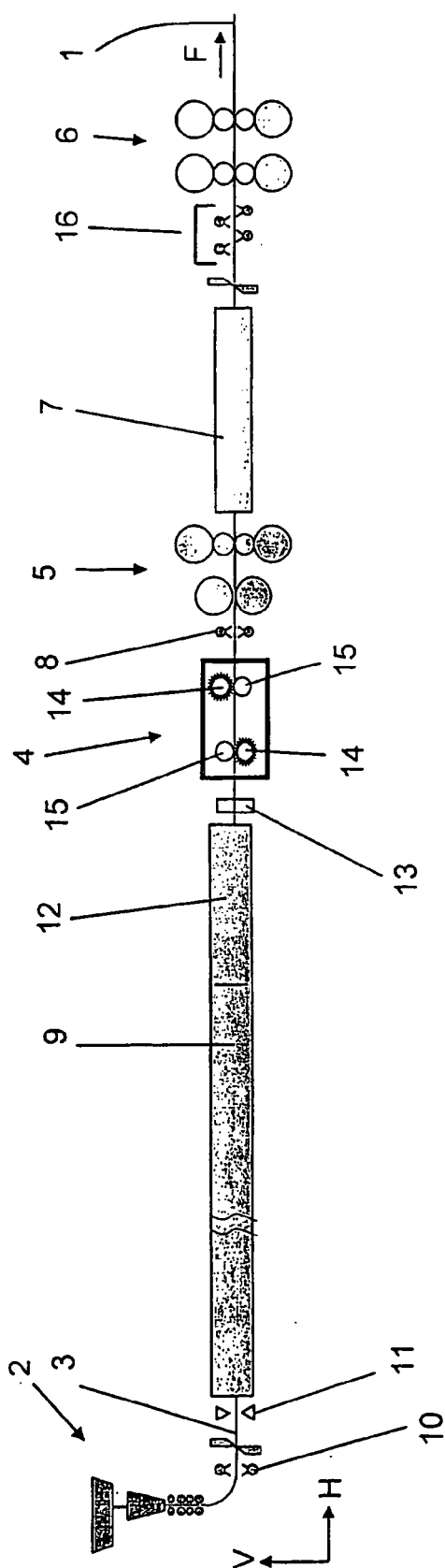


Fig. 1

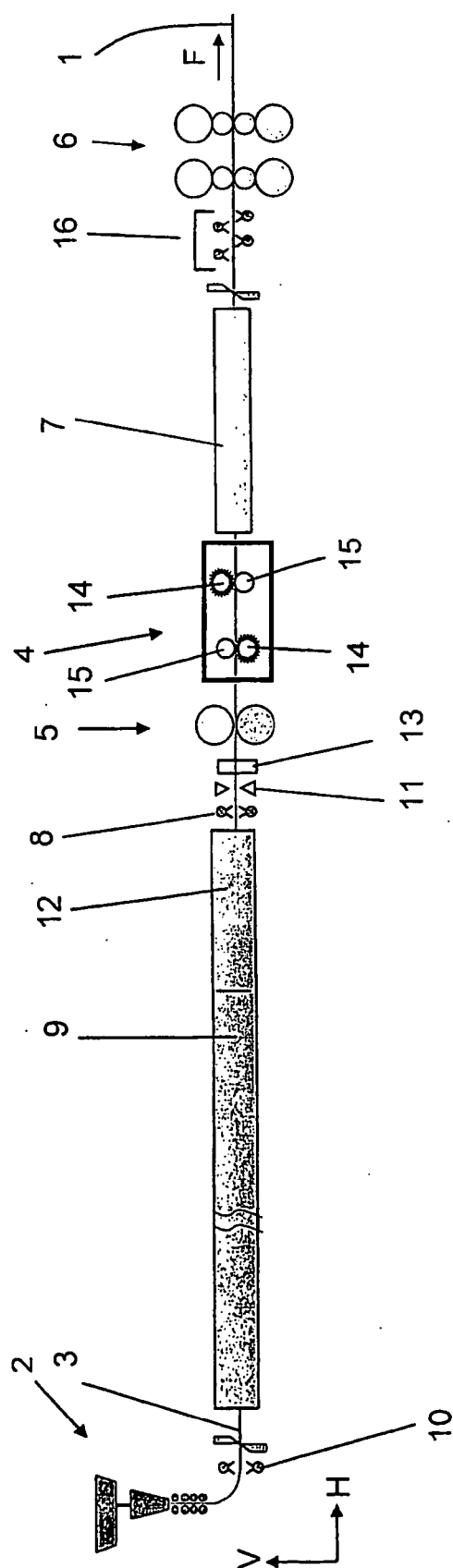


Fig. 2

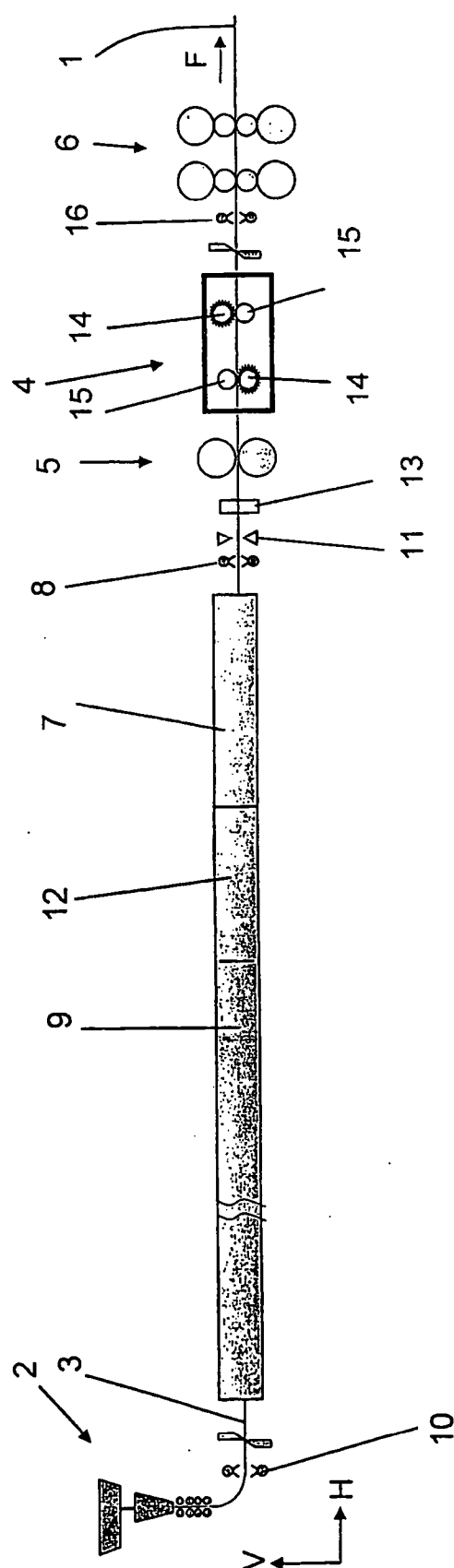


Fig. 3

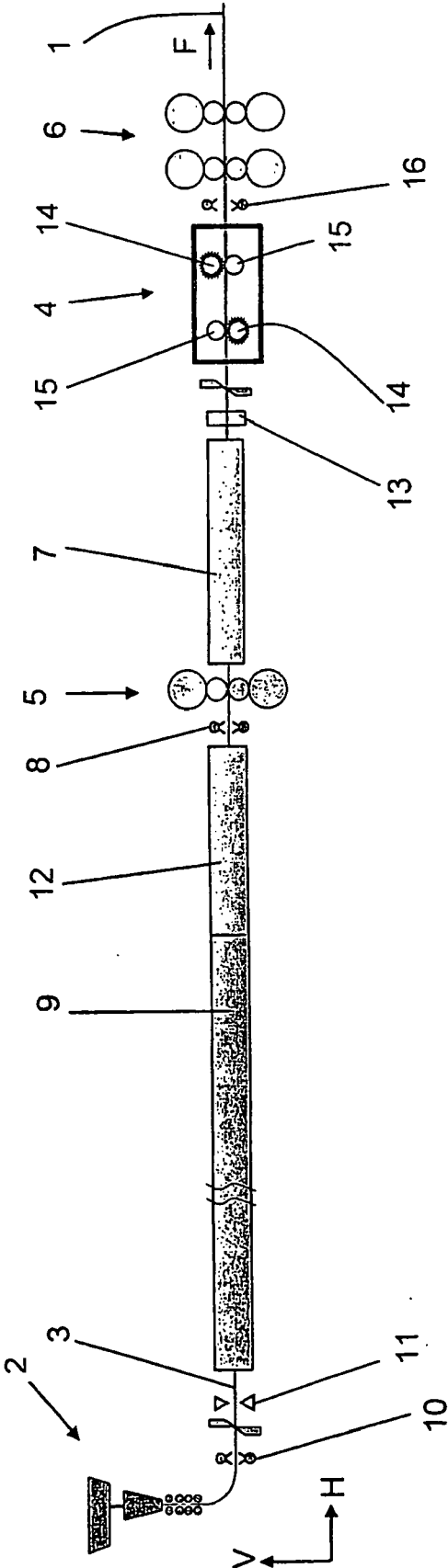


Fig. 4

METHOD AND DEVICE FOR PRODUCING A METAL STRIP BY CONTINUOUS CASTING

[0001] The invention concerns a method for producing a metal strip by continuous casting, where a slab, namely, a thin slab, is first cast in a casting machine and then deflected from a vertical orientation to a horizontal orientation, and where downstream of the casting machine in the direction of conveyance of the slab, the slab is subjected to a milling operation in a milling machine and at least one rolling operation in at least one rolling train. The invention also concerns a device for producing a metal strip by continuous casting.

[0002] In the continuous casting of slabs in a continuous casting installation, surface defects can develop, for example, oscillation marks, casting flux defects, or longitudinal and transverse surface cracks. These occur in both conventional and thin-slab casting machines. Therefore, the conventional slabs are subjected to flame descaling in some cases, depending on the intended use of the finished strip. Many slabs are subjected to flame descaling as a general rule at the customer's request. In this connection, the requirements on surface quality have been continuously increasing in thin-slab installations.

[0003] Flame descaling, grinding, and milling are available methods of surface treatment.

[0004] Flame descaling has the disadvantage that the material that has been flashed off cannot be melted down again without processing due to the high oxygen content. In the case of grinding, slivers of metal become mixed with the grinding wheel dust, so that the abraded material must be disposed of.

[0005] Therefore, surface treatment by milling must be considered. The hot millings are collected during the milling operation. They can then be briquetted and melted down again without processing and without any problems and thus returned to the production process. The method that constitutes the object of the invention and the corresponding device are thus focused chiefly on the use of milling.

[0006] A method and a device of the aforementioned type with a milling operation carried out downstream of a continuous casting installation and a milling machine arranged downstream of said continuous casting installation are already known from CH 584 085 and DE 199 50 886 A1.

[0007] A similar device is also disclosed by DE 71 11 221 U1. This document discloses the processing of aluminum strip with utilization of the casting heat, in which the machine is connected with the casting installation.

[0008] In-line removal of material from the surface of a thin slab (flame descaling, milling, etc.) shortly before a rolling train on the upper side and underside or on only one side has also already been proposed. EP 1 093 866 A2 is cited in this connection.

[0009] DE 197 17 200 A1 discloses another embodiment of a surface milling machine. This document describes, among other things, the adjustability of the milling contour of the milling device, which is installed downstream of the continuous casting installation or upstream of a rolling train.

[0010] Another embodiment and arrangement of an in-line milling machine in a conventional hot strip mill for treating a near-net strip are proposed by EP 0 790 093 B1, EP 1 213 076 B1, and EP 1 213 077 B1. Similar or other solutions are disclosed by EP 0 646 431 A1, U.S. Pat. No. 3,702,629, EP 1 097 764 A2, and DE 1 508 952 A1.

[0011] In the surface treatment of thin slabs in a so-called CSP plant, about 0.1-2.5 mm should be removed from the surface on one or both sides of the hot slab in the processing line ("in line"), depending on the surface defects that are detected. A thin slab that is as thick as possible is advisable ($H=60-120$ mm) so as not to lessen the output too much.

[0012] The in-line milling machine is not usually used for all products of a rolling program but rather only for those that have relatively high surface requirements. This is advantageous from the standpoint of output, reduces milling machine wear, and therefore is useful.

[0013] It is desired that the prior-art technology be used even more efficiently and thus cost-effectively. It is to be used preferably but not exclusively for the fast and high-quality production of thin slabs.

[0014] The method of production that constitutes the object of the invention is aimed especially, but not exclusively, at the production of tube-quality strip. This requires an absolutely crack-free slab surface. In addition, a preliminary group of rolling stands for forming the slab in a first rolling train is necessary for metallurgical reasons.

[0015] Therefore, the objective of the invention is to refine a method and a device of the aforementioned type in such a way that it is possible to ensure that a high degree of economy can be achieved and that, at the same time, an improved production process and treatment process can take place. In this regard, it is desired that optimization be achieved with respect to the necessary introduction of heat into the cast strand and into the production process and that a crack-free surface and the desired metallurgical and mechanical properties be obtained at the same time.

[0016] With respect to the method, the solution to this problem by the invention is characterized by the fact that the rolling and milling operations are carried out directly after the casting of the slab in the casting machine, where the rolling operation is divided into at least two partial rolling operations in at least a first rolling train and a second rolling train, and where the milling operation in the milling machine is carried out between the two rolling operations.

[0017] The slab is preferably heated, e.g., in a roller hearth furnace, upstream and/or downstream of the first rolling train and the milling machine.

[0018] In addition, the slab can be cleaned in a cleaning and/or descaling unit upstream of the first rolling train.

[0019] In accordance with the invention, the device for producing a metal strip by continuous casting with a casting machine in which a slab, namely, a thin slab, is cast, where a milling machine and at least one rolling train are installed downstream of the casting machine in the direction of conveyance of the slab, is characterized by the fact that a first rolling train and a second rolling train are installed directly downstream of the casting machine in the direction of conveyance, with the milling machine being installed between the two rolling trains.

[0020] If the casting installation is a twin-strand CSP installation, the milling machine and the first rolling train are installed downstream of the furnace transverse conveyor, so that they can process both strands.

[0021] A furnace is preferably installed between the first and second rolling trains. In addition, a cleaning and/or descaling unit can be installed before the first rolling train. Another furnace can be installed upstream of the first rolling train. Each rolling train can comprise at least one rolling stand; in this regard, it is especially contemplated that the first

rolling train has one or two rolling stands, which are realized as two-high or four-high stands.

[0022] Provision can also be made for the device to comprise means for adjusting the contact setting of the milling cutters of the milling machine as a function of the setting position, the thickness position, and/or the amount of swivel of the rolling stand or strong driver upstream of the milling machine.

[0023] In one embodiment of the invention, the slab is milled in the milling machine in such a way that the upper side and the underside of the slab are milled in the same place in the direction of conveyance. Alternatively, however, it can also be provided that the upper side of the slab and the underside of the slab are milled in two successive places in the direction of conveyance.

[0024] The pass carried out in the first rolling train can be a skin pass, especially when the rolling train is a single-stand rolling train. This provides the advantage that the milling is carried out on a slab that has already been subjected to a well-defined profiling and can thus be carried out more effectively (the specific values for the rolling forces to be set are determined as a function of the width of the slab). Scratches of the bottom rolls, oscillation marks, and similar surface defects can already be partially leveled by the rolling process in the first rolling train, so that only a relatively small milling offset must be removed in order nevertheless to obtain a clean slab surface after the milling.

[0025] The proposal of the invention also eliminates any transverse bending of the slab that may be present.

[0026] It is hoped that the relatively small amount of material removed in the milling process will result in a straight slab rather than strip turn-up.

[0027] The proposal of the invention can also be used to advantage for spraying the head of the slab before milling in order to facilitate its threading into the milling machine.

[0028] The speeds of rotation of the rolls in the rolling stand can also be different on the upper side and underside of the slab.

[0029] The overall result is qualitatively improved production of slabs, especially thin slabs.

[0030] Specific embodiments of the invention are illustrated in the drawings.

[0031] FIGS. 1 to 4 are schematic side views of a device for producing a metal strip by continuous casting, in which a casting machine is followed especially by rolling trains and a milling machine.

[0032] FIG. 1 shows a device for producing a metal strip 1 by continuous casting. The metal strip 1 and the corresponding slab 3 are continuously cast by well-known means in a casting machine 2. The slab 3 is preferably a thin slab. In the strand guide (casting segments), the cast strand is deflected or bent by well-known means from a vertical orientation (V) to a horizontal orientation (H). After it has been deflected into the horizontal orientation (H), the slab 3 can be cleaned by cleaning means 10, and then a profile measurement or surface inspection can be performed by measuring means 11. The condition of the surface of the slab and its geometric formation can be determined in this way.

[0033] These units are followed in the direction of conveyance F first by a furnace 9 and then a transverse conveyor 12. After the profile measurement 13, surface machining in a milling machine 4 is carried out immediately downstream of the heated transverse conveyor 12 at high slab temperature

and thus low stress. In the milling machine 4, the upper and lower surfaces of the slab 3 are milled down.

[0034] The upper side and the underside of the slab 3 are milled down in two successive places—with respect to the direction of conveyance F—with two plain milling cutters 14 being used. The slab 3 is supported by corresponding support rolls 15 during this milling operation.

[0035] It is especially advantageous that the conveyance speed through the milling machine 4 can be determined independently of the casting speed (in the casting machine 2) and independently of the second rolling train 6 (finish rolling). The milling machine 4 upstream of the rolling train 5 determines the conveyance speed of the slab 3. The first rolling train 5 adjusts itself to this speed.

[0036] The milling operation is followed by a slab descaling unit 8, whose use is optional. This is followed in direction of conveyance F by the rolling train 5, which in the case illustrated in FIG. 1 comprises two rolling stands. The two rolling stands can carry out a high degree of deformation.

[0037] The temperature loss by the milling process and the rolling process in the first rolling train can be largely compensated by the second furnace 7 that follows the first rolling train, so that the subsequent deformation in the second rolling train 6 can advantageously take place at sufficiently high temperatures in the rolling train 6. The second furnace 7 can also be realized as an unheated roller table enclosure, which reduces the temperature loss of the deformed slab 3. The furnace 7 is followed by a descaling system 16 and the aforementioned rolling train 6.

[0038] The rolling train 6 can comprise at least one stand (including a reversing stand). As a rule, however, the rolling train 6 comprises 4 to 7 rolling stands. The further processing downstream of the rolling train 6 by cooling and coiling of the metal strip 1 or the stacking of thicker metal plates is not explained in detail here.

[0039] FIG. 2 shows another embodiment of the invention. As in the embodiment of FIG. 1, the slab 3 is cast in a casting machine 2 and heated in a furnace 9 and a transverse conveyor 12. A cleaning and descaling unit 8, in which the prepared slab 3 is cleaned and descaled, is positioned downstream of the transverse conveyor 12. The slab then enters a first rolling train 5. In the present case, it is equipped with one rolling stand, which can be realized as a two-high or four-high rolling stand. In the first rolling train 5, a skin pass is carried out for the purpose of removing geometric variations on the surface of the slab. In addition, a systematic thickness reduction can already be undertaken in the first rolling train 5. The slab 3 then passes from there to the milling machine 4.

[0040] In this connection, the first rolling train 5 upstream of the milling machine 4 can also be designed as a strong driver to ensure reliable conveyance of the slab 3 through the milling machine 4. As in the embodiment illustrated in FIG. 1, after the milling machine 4, the slab is subjected to further processing in a second furnace 7, a descaling unit 16, and a rolling train 6 to obtain a finished product 1.

[0041] FIG. 3 shows yet another embodiment of the invention. The arrangement and function of this embodiment are similar to those of the installation according to FIG. 2. The only difference is that here a first rolling operation 5 and a surface machining operation by milling in the milling machine are carried out downstream of the furnace, which consists of the first furnace section 9, the transverse conveyor

12, and the second furnace section 7. In this application, reheating of the slab 3 upstream of the second rolling train 6 is dispensed with.

[0042] In the installation variant according to FIG. 4, the installation consists of two rolling trains. After the casting in the casting installation 2 and heating in the first furnace 9 and in the transverse conveyor 12, a first rolling process 5 takes place. After reheating of the deformed slab 3 in the second furnace 7, the surface machining is carried out just before the finishing train.

[0043] FIG. 4 thus shows another variant of a device for producing a metal strip 1 by continuous casting. The metal strip 1 or the corresponding slab 3 is again continuously cast by well-known means in a casting machine 2. After the slab 3 has been deflected into the horizontal orientation (H), the slab can be cleaned by cleaning means 10, and this can be followed by profile measurement or surface inspection by measuring means 11. The condition of the surface of the slab and its geometric formation can again be determined in this way.

[0044] These units are followed in the direction of conveyance F first by a furnace 9 and then a transverse conveyor 12.

[0045] A cleaning and descaling unit 8, in which the prepared slab 3 is cleaned and descaled, is positioned downstream of the transverse conveyor 12. The slab then enters a first rolling train 5. In the present case, it is equipped with one rolling stand, which can be realized as a two-high or four-high rolling stand. In the first rolling train 5, a skin pass is carried out for the purpose of removing geometric variations on the surface of the slab. In addition, a systematic thickness reduction can already be undertaken in the first rolling train 5.

[0046] After the first rolling train 5, the slab 3 enters a holding furnace 7 and from there a milling machine 4. Measuring means 13 for profile measurement are installed between the holding furnace 7 and the milling machine 4.

[0047] The upper and lower surfaces of the slab 3 are milled down in the milling machine 4.

[0048] The upper side and the underside of the slab 3 are milled down in two successive places—with respect to the direction of conveyance F—with two plain milling cutters 14 being used. The slab 3 is supported by corresponding support rolls 15 during this milling operation.

[0049] Downstream of the milling machine 4, a second rolling train 6 is installed, which can have several rolling stands. In the second rolling train 6, the slab 3 is brought to the final form of the metal strip 1.

[0050] The essential aspect is that the rolling and milling operations are carried out directly following (i.e., by the in-line process) the casting of the slab 3 in the casting machine 2, with the rolling operations being divided into at least two partial rolling operations in at least a first rolling train 5 and a second rolling train 6, and with the milling of the slab 3 in the milling machine 4 being carried out between the two rolling operations.

[0051] A deformation of the slab 3 is thus carried out before the milling.

[0052] The first rolling train 5 can thus be arranged upstream or downstream of the second furnace 7. The surface machining can also be carried out upstream or downstream of the furnace 7.

[0053] To summarize, the proposal can be formulated as follows:

[0054] The surface machining is carried out immediately before the first forming step or, alternatively, between two forming steps (groups of rolling stands). According to the

illustration in FIG. 1, the milling machine 4 and the rolling train 5 are positioned immediately upstream of the second furnace 7 to ensure good surface quality of the slab as it enters the finishing train 6, in which the remainder of the deformation to the desired final thickness takes place. The rolling stand 5 can also be arranged downstream of the holding furnace 7. It is also possible for the surface machining to be carried out directly between the rolling train 5 and the holding furnace 7, so that reheating can be carried out after preliminary deformation and surface machining.

[0055] In the illustrated embodiments, the upper side and the underside of the slab are each assigned a plain milling cutter. When a large amount of material must be milled from each side or when very hard materials are to be milled, it is possible to arrange two milling units one after the other on both the upper side and the underside.

[0056] Alternatively to the use of plain milling cutters, it is possible to use other types of milling cutters in the intended places, such as face milling cutters, or even grinding tools or other surface-removing tools (e.g., for flame descaling of the surfaces). As an alternative to the use of plain milling cutters or face milling cutters, it is thus possible to use other types of material-removing tools.

[0057] Especially the following can be provided as cutting materials for the cutting tips of the milling cutters: HSS; uncoated or preferably coated cemented carbide alloys; polycrystalline cutting materials. As a rule, commercially available indexable cutter inserts can be used.

[0058] The milling machine can consist of two or more milling units, which can be arranged one after the other, for each side of the slab.

[0059] The milling machine can set the conveyance speed upstream of the first rolling stand, independently of the casting machine and the second rolling train.

[0060] The furnace downstream of the milling machine serves primarily to compensate the temperature loss in the area of the milling machine and the first rolling train.

[0061] Systematic tapering of the head of the slab is preferably carried out with the first rolling train.

[0062] To achieve optimum adaptation of the milling machine to the input conditions (especially to the slab thickness and slab thickness taper), not only the measurement of the slab geometry can be used but also the setting position of the rolling stand or strong driver upstream of the milling machine. That is, the thickness position and the amount of swivel of the rolling stand or driver are used for adjusting the milling cutters, especially the plain milling cutter setting positions. If, for example, a tilted position is detected, it can be decided to adjust to this and to mill down the slab uniformly over the width or to mill out the slab taper.

LIST OF REFERENCE SYMBOLS

[0063]	1 metal strip
[0064]	2 casting machine
[0065]	3 slab
[0066]	4 milling machine
[0067]	5 first rolling train
[0068]	6 second rolling train
[0069]	7 second furnace/roller table enclosure
[0070]	8 cleaning and/or descaling unit
[0071]	9 first furnace
[0072]	10 cleaning means
[0073]	11 measuring means
[0074]	12 transverse conveyor

- [0075] 13 measuring means
- [0076] 14 milling cutter
- [0077] 15 support roll
- [0078] 16 descaling sprayer
- [0079] F direction of conveyance
- [0080] V vertical orientation
- [0081] H horizontal orientation

1. A method for producing a metal strip (1) by continuous casting, where a slab (3), namely, a thin slab, is first cast in a casting machine (2) and then deflected from a vertical orientation (V) to a horizontal orientation (H), and where downstream of the casting machine (2) in the direction of conveyance (F) of the slab (3), the slab (3) is subjected to a milling operation in a milling machine (4) and at least one rolling operation in at least one rolling train (5, 6), wherein the rolling and milling operations are carried out directly after the casting of the slab (3) in the casting machine (2), where the rolling operation is divided into at least two partial rolling operations in at least a first rolling train (5) and a second rolling train (6), and where the milling operation in the milling machine (4) is carried out between the two rolling operations.

2. A method in accordance with claim 1, wherein the slab (3) is heated in a furnace (7) between the first rolling train (5) and the second rolling train (6).

3. A method in accordance with claim 1, wherein the slab (3) is cleaned in a cleaning and/or descaling unit (8) upstream of the first rolling train (5).

4. A method in accordance with claim 1, wherein the slab (3) is brought to a desired temperature in a furnace (9) upstream of the first rolling train (5).

5. A device for producing a metal strip (1) by continuous casting with a casting machine (2) in which a slab (3), namely, a thin slab, is cast, where a milling machine (4) and at least one rolling train (5, 6) are installed downstream of the casting machine (2) in the direction of conveyance (F) of the slab (3), especially for carrying out the method in accordance with

claim 1, wherein a first rolling train (5) and a second rolling train (6) are installed directly downstream of the casting machine (2) in the direction of conveyance (F), with the milling machine (4) being installed between the two rolling trains (5, 6).

6. A device in accordance with claim 5, wherein a furnace (7) is installed between the first rolling train (5) and the second rolling train (6).

7. A device in accordance with claim 6, wherein the furnace (7) is constructed as a thermally insulated roller table enclosure.

8. A device in accordance with claim 5, wherein a cleaning and/or descaling unit (8) is installed upstream of the first rolling train (5).

9. A device in accordance with claim 5, wherein a furnace (9) is installed upstream of the first rolling train (5).

10. A device in accordance with claim 5, wherein each rolling train (5, 6) has at least one rolling stand.

11. A device in accordance with claim 5, wherein the first rolling train (5) has one or two rolling stands, which are realized as two-high or four-high stands.

12. A device in accordance with claim 5, wherein the milling machine (4) comprises plain milling cutters.

13. A device in accordance with claim 12, wherein the milling machine (4) has one or more plain milling cutters on each side of the slab.

14. A device in accordance with claim 5, wherein the milling machine (4) comprises face milling cutters.

15. A device in accordance with claim 5, wherein it comprises means for adjusting the contact setting of the milling cutters of the milling machine (4) as a function of the setting position, the thickness position, and/or the amount of swivel of the rolling stand or strong driver upstream of the milling machine (4).

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