US 20080135203A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2008/0135203 A1
(43) Pub. Date: Jun. 12, 2008
Doll et al.

(54) CONTINUOUS CASTING AND ROLLING INSTALLATION FOR PRODUCING A STEEL STRIP

(76) Inventors: **Rudiger Doll**, Nurnberg (DE); **Klaus Pronold**, Dusseldorf (DE); **Albrecht Sieber**, Mohrendorf (DE)

Correspondence Address:
SIEMENS CORPORATION
INTELLECTUAL PROPERTY DEPARTMENT
170 WOOD AVENUE SOUTH
ISELIN, NJ 08830

(21) Appl. No.: 10/548,551

(22) PCT Filed: Feb. 20, 2004

(86) PCT No.: PCT/EP2004/001694

§ 371 (c)(1),
(2), (4) Date: Feb. 7, 2008

(30) Foreign Application Priority Data

Mar. 10, 2003 (DE) 103 10 357.0

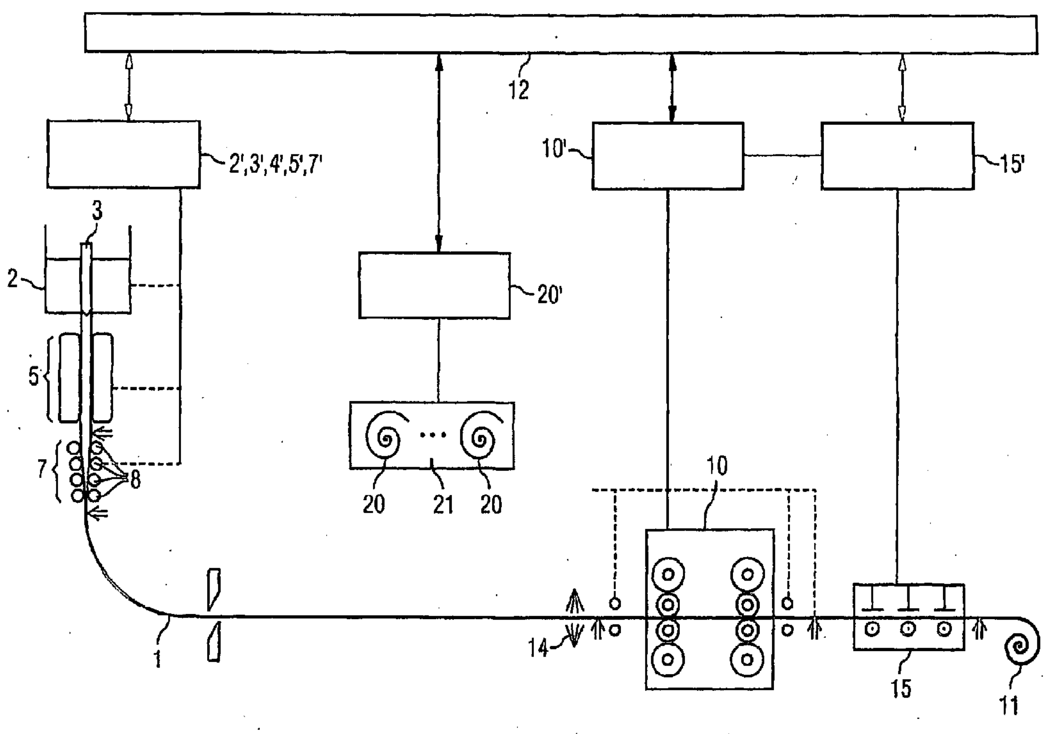
Publication Classification

(51) Int. Cl.
B22D 45/00 (2006.01)
B22D 11/16 (2006.01)

(52) U.S. Cl. 164/157

(57) ABSTRACT

In order to produce a steel strip (**1**), a continuous casting and rolling installation comprises a liquid steel storage device (**2**), a liquid steel charging device (**3**), a vertically operating casting device (**5**) with a revolving mold (**6**), a reduction device (**7**) with a plurality of roll pairs (**8**), a diverting device (**9**) for diverting the cast steel strip (**1**) into a horizontal position, a horizontally operating rolling mill (**10**) and a winding device (**11**), which are controlled via individual technological control loops (**2'** to **11'**). In order to adjust the technological control loops (**2'** to **11'**) in an integrated manner, it also comprises a control system (**12**) which connects the installation parts (**2** to **11**) or components with regard to control, operates on the basis of mathematical models (**17**), and coordinates the individual installation parts (**2** to **11**) with regard to the interaction thereof, while taking into consideration the effects of the control steps of an installation part (**2** to **11**) upon installation parts (**2** to **11**) following in the direction of mass flow. The control system (**12**) contains a material model (**17**), by means of which a thermal behavior of the steel or steel strip (**1**) from the steel storage device (**2**) to the winding device (**11**) can be modeled using path tracking. The technological control loops (**2'** to **11'**) are controlled at the correct times according to the modeled thermal behavior of the steel or steel strip (**1**).



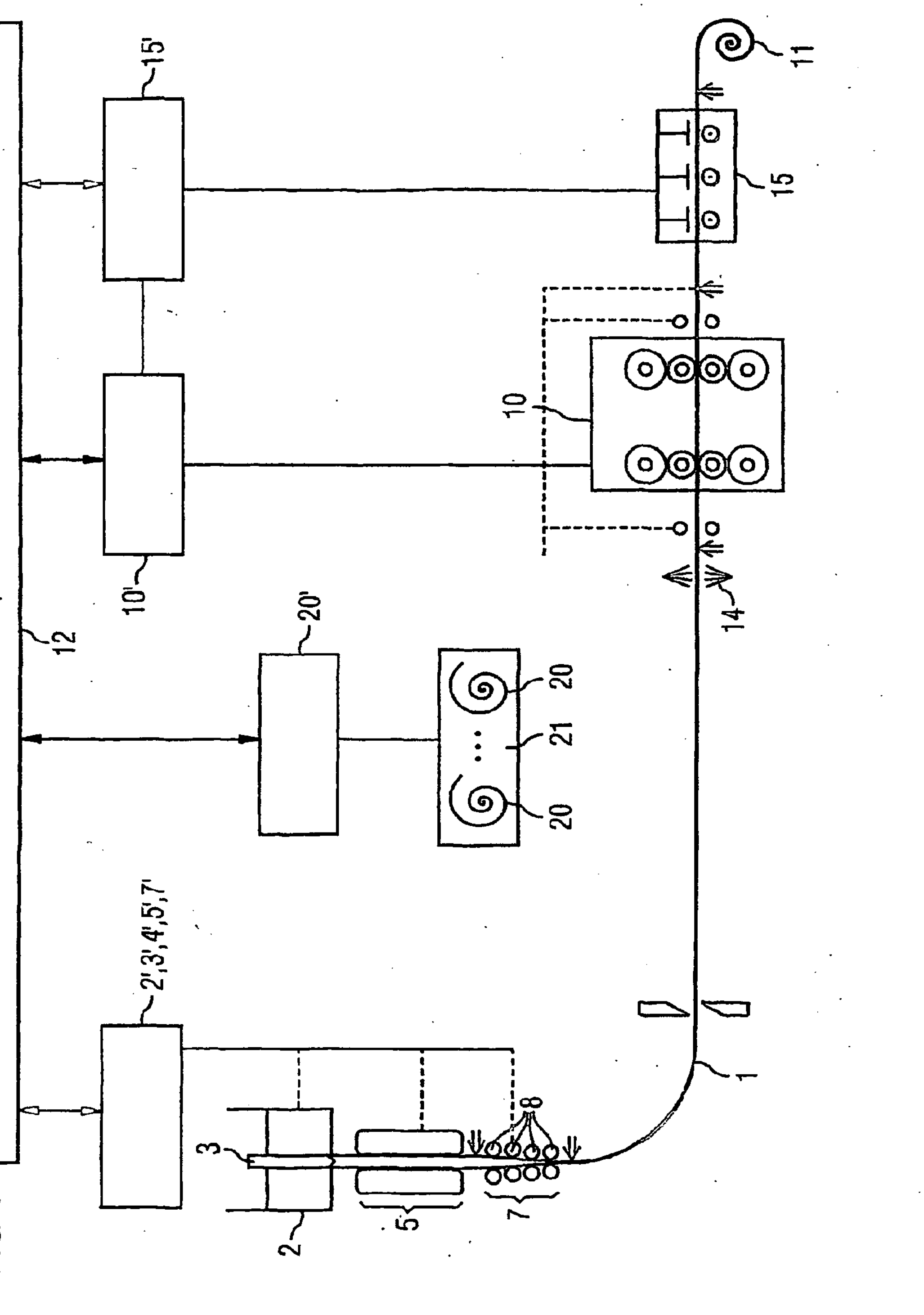


FIG 1

FIG 2

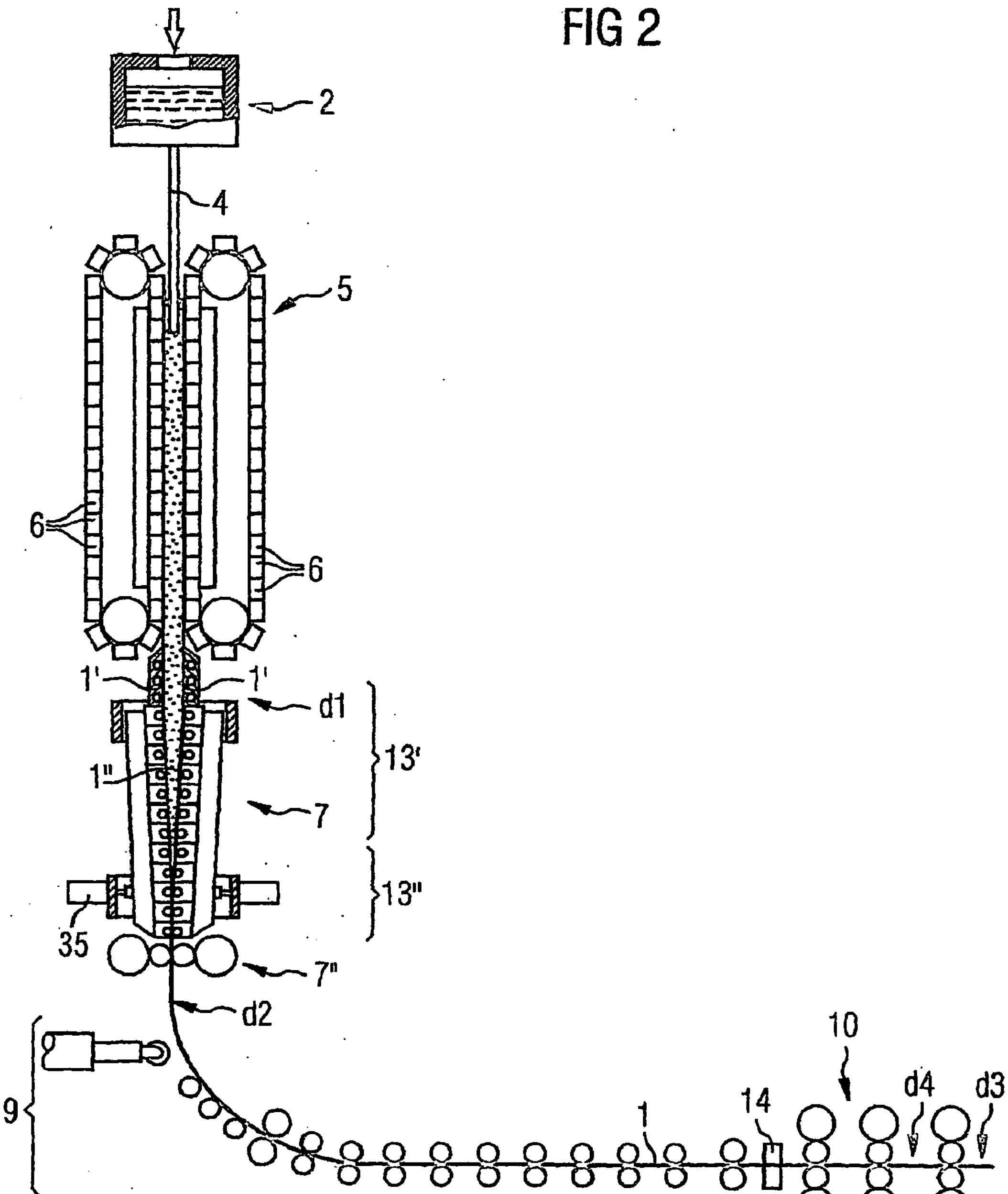
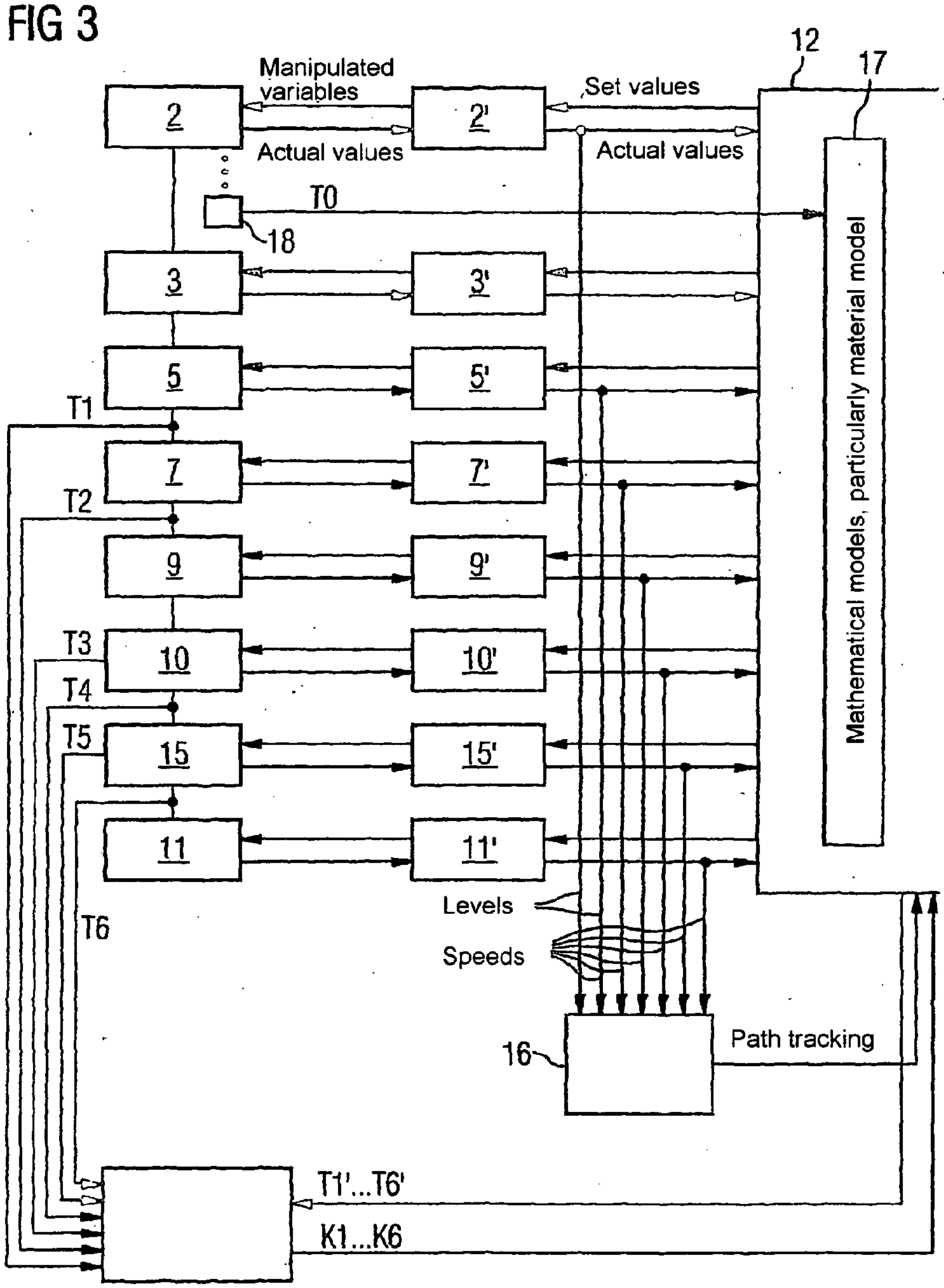


FIG 3



12
17
Manipulated variables
Set values
Actual values
Actual values
2
2'
T0
18
3
3'
5
5'
T1
7
7'
T2
9
9'
T3
10
10'
T4
T5
15
15'
11
11'
Mathematical models, particularly material model
Levels
Speeds
T6
16
Path tracking
T1'...T6'
K1...K6

CONTINUOUS CASTING AND ROLLING INSTALLATION FOR PRODUCING A STEEL STRIP

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is the US National Stage of International Application No. PCT/EP2004/001694, filed Feb. 20, 2004 and claims the benefit thereof. The International Application claims the benefits of German application No. 10310357.0, filed Mar. 10, 2003, both applications are incorporated by reference herein in their entirety.

FIELD OF INVENTION

[0002] The present invention relates to a continuous casting and rolling installation for producing a steel strip, comprising a liquid steel storage device, a liquid steel charging device, a vertically operating casting device with a revolving mold, a diverting device for diverting the cast steel strip into a horizontal position, a horizontally operating rolling mill and a winding device, all components being guided and/or controlled via individual technological control loops, the continuous casting and rolling installation comprising, in order to adjust the technological control loops in an integrated manner, a control system which connects the liquid steel storage device, the liquid steel charging device, the casting device, the diverting device, the rolling mill and the winding device with regard to control, operates on the basis of mathematical models and coordinates the individual installation parts with regard to the interaction thereof, while taking into consideration the effects of the control steps of an installation part upon installation parts following in the direction of mass flow.

[0003] A continuous casting and rolling installation of this type is known e.g. from patent application WO-A-95/15233 by the applicant.

[0004] From DE-C1-100 57 876, a continuous casting and rolling installation is known in which a revolving caterpillar-track mold with downstream reduction device and vertically operating roll stand is used. The strip thickness of the cast strip upon leaving the reduction device is maximally approx. 10 mm. The reduction occurs until the end of the reduction device.

[0005] From EP-A-1 059 125, a continuous casting and rolling installation is known in which the cast strip is reduced in thickness by up to 50% before the actual rolling.

[0006] From U.S. Pat. No. 5,727,127, a continuous casting and rolling installation is known in which the continuous casting and rolling installation is guided using previously established expert knowledge. Similar contents are also disclosed in and can be seen from U.S. Pat. No. 6,085,183.

[0007] From DE-A-198 32 762, a continuous casting and rolling installation is known in which the sequence of processing of slabs cast by means of a plurality of continuous casting installations arranged in parallel is redefined according to predetermined criteria.

SUMMARY OF THE INVENTION

[0008] The object of the present invention is to further develop a continuous casting and rolling installation of the type specified in the introduction such that qualitatively high-grade steel strips can be produced with it in a simple manner.

[0009] The object is achieved in that

- **[0010]** the continuous casting and rolling installation comprises a reduction device, arranged between the mold and the diverting device, with a plurality of roll pairs,
- **[0011]** the reduction device is guided by a technological control loop which is also guided by the control system,
- **[0012]** the control system contains a material model by means of which a thermal behavior of the steel or steel strip from the steel storage device to the winding device can be modeled using path tracking, and
- **[0013]** the technological control loops are guided at the correct times in accordance with the modeled thermal behavior of the steel or steel strip.

[0014] The invention is therefore based on the creation of a control system covering all installation parts, which extends from storage of the liquid steel to winding and which takes into consideration the fact that the characteristics of a steel or of a steel strip depend not only on its chemical composition and its mechanical treatment, but also on the thermal history. If the steel strip cast by means of the mold has a casting thickness of between 40 and 100 mm upon exit from the mold, the steel strip already has a reduced casting thickness compared with conventional continuous casting installations, so that less forming work has to be done in order to produce the finished product, i.e. the rolled steel strip.

[0015] If the steel strip can be reduced in the reduction device to a rolling mill input thickness of between 10 and 40 mm, in particular between 15 and 35 mm, a significant reduction in strip thickness will already have been made even before the actual rolling. Since this reduction takes place at high temperatures, possibly even before complete solidification of the steel strip, only a limited amount of re-forming work is likewise required for this reduction. This applies most particularly if the steel strip can be reduced in the reduction device by at least 25% in relation to the casting thickness.

[0016] The reduction device preferably comprises an upper part in which the steel strip is re-formed and a lower part in which the steel strip retains its form.

[0017] If the continuous casting and rolling installation can be guided by the control system such that the steel strip does not solidify completely until it is in the reduction device, only a particularly limited amount of re-forming work has to be performed in order to re-form the steel strip in the reduction device. This applies most particularly if the steel strip does not solidify completely until it is in the lower part, in which it retains its form.

[0018] The rolling mill can either be just a hot rolling mill or be a hot rolling mill with a cold rolling mill arranged downstream. In the one case, the steel strip will have a final thickness of between 1.0 and 6.0 mm at which it is wound up by the winding device, in the other case, the final thickness will lie between 0.3 and 2.0 mm.

[0019] If the steel strip is reduced in the reduction device to a rolling mill input thickness which is determined according to the final thickness, the scope of reduction in the reduction device will already have been determined such that subsequent installation parts can be operated efficiently taking into account technologically advantageous boundary conditions.

[0020] If a cooling section or stretch is arranged between the rolling mill and the winding device, if the cooling section or stretch is also guided by a technological control loop and if this control loop is also guided by the control system, an even more comprehensive installation will emerge, in which the cooling section or stretch is integrated under the overall guidance of the control system.

[0021] In an analogous manner, upstream of the rolling mill there is preferably arranged a descaler which is also guided by a technological control loop, this control loop also being guided by the control system.

[0022] Preferably, end-to-end processing of the steel strip is carried out by means of the continuous casting and rolling installation according to the invention. The steel strip is thus immediately rolled and wound, directly after casting, reducing and diverting. Alternatively, however, it is also possible for an intermediate winder and an equalizing furnace to be arranged between the diverting device and the rolling mill, these installation parts also being guided by a technological control loop and this control loop in turn being guided by the control system.

[0023] The control system preferably contains a material model by means of which a thermal behavior of the steel or steel strip from the steel storage device to the winding device can be modeled using path tracking, the technological control loops being guided at the correct times in accordance with the modeled thermal behavior of the steel or steel strip, as the characteristics of a steel or a steel strip depend not only on its chemical composition and its mechanical treatment but also on the thermal history.

[0024] If, within the framework of the material model, phase changes in the steel or steel strip (e.g. from liquid to solid or from austenite to ferrite) are also modeled, even better modeling results. It is even possible for structural characteristics of the steel strip to be modeled within the framework of the material model.

[0025] If the melting temperature of the steel is measured and fed to the material model as an initial parameter, the material model works particularly well.

[0026] If downstream of the mold, downstream of the reduction device, within the rolling mill and/or downstream of the rolling mill, possibly also within and/or downstream of the cooling section or stretch an actual temperature of the steel strip is recorded and used for adapting the material model, a (gradual) adaptation of the model to reality results.

[0027] The individual installation parts usually comprise locally active devices for influencing the temperature of the steel or steel strip. In particular, these devices are regulated via the technological control loops assigned to the individual installation parts in accordance with guidance by the control system. Possible locally active devices for influencing temperature are, in particular, cooling devices, e.g. with water, and (inductive) heating devices.

[0028] The control system preferably determines (in addition) at least one reference variable for influencing, in a manner effective across all installation parts, the temperature of the steel or steel strip and guides the installation parts concerned according to this reference variable.

[0029] The mass flow, in particular, can be used as a reference variable active across all the installation parts, for a change in the mass flow, in particular, influences all the component parts which are arranged in direct succession and in which the steel strip is continuously processed. Where there is a change in the mass flow, all subsequent locally active devices have therefore to be guided in an appropriately adapted manner in order to ensure that the thermal behavior of the steel strip remains unchanged.

[0030] Particularly in the rolling mill, changes in cross-section, which influence the transport speed of the steel strip, can also be considered. In this case also, appropriate adaptation of subsequent installation parts, particularly adaptation of the cooling section, to the reduction in the throughput time brought about by this is required in order to continue to achieve an unchanged thermal behavior.

[0031] Further advantages and details will emerge from the description below of an exemplary embodiment in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] FIG. **1** shows a schematic representation of a continuous casting and rolling installation,

[0033] FIG. **2** shows a schematic representation of a section taken from FIG. **1**, and

[0034] FIG. **3** shows a schematic representation of a control system with underlying technological control loops for a continuous casting and rolling installation.

DETAILED DESCRIPTION OF INVENTION

[0035] According to FIG. **1**, a continuous casting and rolling installation for producing a steel strip **1** comprises firstly a liquid steel storage device **2**. This device **2** is usually designed as a so-called tundish. Liquid steel passes from the tundish **2** via a liquid steel charging device **3**, indicated only schematically, (e.g. a liftable plug) and an immersion tube **4** into a casting device **5**. The casting level is precisely controlled in a known manner to an accuracy of a few mm, e.g. ±3 mm.

[0036] The casting device **5** in the present case is fashioned as a vertically operating casting device **5**. It comprises a plurality of plates **6** which are connected to one another to form a continuous chain and revolve with the cast steel strip **1**. The plates **6** thus together form a revolving mold **6**. The steel strip **1** flows out of the mold **6** with a casting thickness d1 and a strip width b.

[0037] Arranged downstream of the casting device **5** is a reduction device **7**. The reduction device **7** comprises a plurality of roll pairs **8**, by means of which the steel strip **1** is guided and reduced to a rolling mill input thickness d**2**.

[0038] Arranged downstream of the reduction device **7** is a diverting device **9**. This diverts the steel strip **1** into a horizontal position. Finally, downstream of the diverting device **9**, there is arranged a rolling mill **10** in which the steel strip **1** is rolled down to a final thickness d**3**. After rolling, the steel strip **1** is wound up by means of a winding device **11**.

[0039] A technological control loop **2'**, **3'**, **5'**, **7'**, **9'** to **11'** is assigned to each of the installation parts **2**, **3**, **5**, **7**, **9** to **11**. The technological control loop **2'** guides the liquid steel storage device **2**, the control loop **3'** the liquid steel charging device **3**, etc. All the components **2** to **11** are thus guided via their respective control loop **2'** to **11'**.

[0040] In order to adjust the technological control loops **2'** to **11'** in an integrated manner, a control system **12** is assigned to the continuous casting and rolling installation. The control system **12** operates on the basis of mathematical models. The models can optionally be implemented in neuronal networks, possibly also in fuzzy-neuro networks. The control system connects the control loops **2'** to **11'** in respect of the individual installation parts **2**, **3**, **5**, **7**, **9**, **10** and **11** with regard to control. In this way, it is in particular possible to coordinate the individual installation parts **2**, **3**, **5**, **7**, **9**, **10** and **11** with regard to the interaction thereof, while taking into consideration the effects of the control steps of an installation part, e.g. of the reduction device **7**, upon installation parts following in the direction of mass flow, in the example given on the diverting device **9**, the rolling mill **10** and the winding device **11**.

[0041] FIG. **2** again shows, in more detail, the liquid steel storage device **2**, the liquid steel charging device **3**, the casting device **5**, the reduction device **7** and the rolling mill **10**. In particular, the design of the mold **6** with individual plates **6** can be seen clearly.

[0042] According to the representation shown in FIG. **2**, the broad sides of the mold **6** consist of the plates **6**. Optionally, however, the narrow sides, not visible in FIG. **2**, could also be fashioned in this manner.

[0043] The steel billet **1** produced by the casting device **5** already has a casting thickness d**1** of just 40 to 100 mm. The strip width b lies preferably between 500 and 2000 mm. The continuous casting and rolling installation is guided by the control system **12** in such a manner that the steel strip **1** exits the mold **6** as a billet with a rigid (solidified) billet shell **1'** and a liquid billet core **1"**. Complete solidification of the steel strip **1** does not occur until it is in the reduction device **7**.

[0044] In the reduction device **7**, the steel strip **1** is reduced to the rolling mill input thickness d**2**. The rolling mill input thickness d**2** is preferably between 10 and 40 mm but usually lies between 15 and 35 mm. In any case, the steel strip **1** is reduced to a rolling mill input thickness d**2** which lies at least 25% below the casting thickness d**1**.

[0045] According to FIG. **2**, the reduction device **7** comprises an upper part **13'** and a lower part **13"**. In the upper part **13'**, the steel strip **1** is reduced in thickness, in the lower part **13"** it retains its form. Guidance of the continuous casting and rolling installation by the control system **12** is designed such that the steel strip **1** does not solidify completely until it is in the lower part **13"** of the reduction device **7**. In the upper part **13'**, in which the steel strip **1** is re-formed, by contrast, it still has the liquid billet core **1"**.

[0046] According to FIG. **3**, a single vertically operating roll stand **7"**, here a four-high stand, can be arranged downstream of the reduction device. The billet shells are pressed against one another by means of the roll stand **7"** and thus weld together even better. A structural conversion is also already occurring. The roll stand **7"**, if present, is preferably also guided by the control loop **7'** assigned to the reduction device **7**.

[0047] The diverting device **9**—see FIG. **1**—can in a conventional manner comprise so-called arc segments with guiding rolls in which the steel strip **1** is diverted into the horizontal. However, the diversion can also be carried out in a different manner, in particular through the exertion of electromagnetic forces.

[0048] Emerging from the diverting device **9**, the steel strip **1** is fed as per FIG. **1** directly to the rolling mill **10**. A descaler **14** is arranged between the diverting device **9** and the rolling mill **10**. The descaler **14** is generally assigned to the technological control loop **10'** of the rolling mill **10** and is thus also guided by this control loop **10'**. As a result, the descaler **14** is thus also guided by a technological control loop, namely the control loop **10'** for the rolling mill **10**, this control loop **10'** being guided in turn by the control system **12**.

[0049] The rolling mill **10** can comprise up to 10 roll stands. It can be fashioned either as just a hot rolling mill or as a hot rolling mill with a cold rolling mill downstream. If the rolling mill **10** is fashioned as just a hot rolling mill, the steel strip **1** is rolled in the rolling mill **10** down to a final thickness d**3** of from 1.0 to 6.0 mm. If the rolling mill **10** is fashioned as a hot rolling mill with a cold rolling mill downstream, the steel strip **1** is rolled in the hot rolling mill down to an intermediate thickness d**4** of from 1.0 to 6.0 mm and in the cold rolling mill downstream to the final thickness d**3**, which in this case lies between 0.3 and 2.0 mm. At the final thickness d**3**, the steel strip **1** is then wound up by the winding device **11**.

[0050] The final thickness d**3** influences the rolling mill input thickness d**2**. In the embodiment of the rolling mill **10** as just a hot rolling mill, the rolling mill input thickness d**2** for a final rolled thickness d**3** of 1.0 mm, for example, is fifteen to twenty times the final thickness d**3**, while for a final rolled thickness d**3** of 6.0 mm it is six or seven times the final thickness d**3**. In this case, it lies between 15 and 42 mm. In the embodiment of the rolling mill **10** as a hot rolling mill with cold rolling mill downstream, the transitional thickness d**4** is firstly determined from the final thickness d**3**—e.g. through a linear projection according to the formula d**4**=3d**3**. The rolling mill input thickness d**2** emerges in this case in an analogous manner from the transitional thickness d**4**.

[0051] According to FIG. **1**, a cooling section **15** is arranged between the rolling mill **10** and the winding device **11**. A (separate) technological control loop **15'** is assigned to the cooling section **15**, by which control loop the cooling section **15** is guided. This control loop **15'** is also guided by the control system **12**.

[0052] FIG. **3** represents schematically once again the components or installation parts **2**, **3**, **5**, **7**, **9** to **11** and **15** of the continuous casting and rolling installation. The control loops **2'** to **11'**, **15'** assigned to them and the control system **12** are also shown.

[0053] According to FIG. **3**, actual values which are characteristic of a material flow of the steel or steel strip **1** are recorded continuously—e.g. at a 0.2 second cycle—by the control loops **2'** to **11'**, **15'**. With regard to the liquid steel storage device **2**, for example, the quantity inflow, i.e. the mass change per unit time, is recorded. The recorded inflow is transmitted to a path tracker **16**.

[0054] With regard to the casting device **5**, the casting level and an exit velocity with which the steel strip **1** exits the mold **6** are recorded in a known manner and transmitted to the path tracker **16**. In conjunction with the known cross-section of the mold, the material flow entering the mold **6** and the material flow exiting the mold **6** can thus readily be determined.

[0055] From the other components **7**, **9**, **10**, **11** and **15**, the material velocities of the steel strip **1** are in each case transmitted to the path tracker **16**.

[0056] On the basis of the information fed to it, the path tracker **16** is able to implement in a known manner path tracking of the steel or steel strip **1** through the entire continuous casting and rolling installation. The result of this path tracking is transmitted by the path tracker **16** to the control system **12**.

[0057] The control system **12** contains inter alia a material model **17**. At least the pure thermal behavior of the steel or steel strip **1** can be modeled by means of the material model **17**. Preferably, however, phase changes in the steel or steel strip **1** (e.g. the solidification behavior, i.e. the phase change from liquid to solid, or phase changes within the solid phase, e.g. from austenite to ferrite) can also be modeled within the framework of the material model **17**. In this case, it is even possible for structural characteristics of the steel strip **1** such as e.g. the grain size and the structural proportions also to be modeled within the framework of the material model **17**. Thus, mechanical characteristics of the steel strip **1** such as e.g. the yield strength and tensile strength, can then also be determined.

[0058] In particular, in the control system **12** (or in the material model **17**) both the temperature movements and the structural development of the steel strip **1** are calculated in real time across the entire installation—from the tundish **2** to the winding device **11**—while tracking the path of the steel strip **1**. In this way, deviations in upstream installation parts, e.g. the casting device **5**, can be deliberately corrected in subsequent installation parts, e.g. the cooling section **15** or the diverting device **7**.

[0059] Temperature models capable of running in real time are known. DE 196 12 420 A1, DE 199 31 331 A1 and DE 101 29 565 A1 and the earlier applications "Control method for a finishing train, arranged upstream of a cooling section, for rolling hot metal strip" dated 15 Nov. 2001, with official application no. 101 56 008.7, and "Modeling method for a metal" dated 6 Nov. 2002, official application no. 102 51 716.9, are cited by way of example.

[0060] The material model **17** preferably also models the re-forming behavior of the steel strip **1** in the rolling mill **10**, including temperature influences effected thereby. Models of this type are also generally known. The reader is referred in this respect by way of example to the earlier application "Computer-aided determination process in respect of set values for profile and surface evenness actuators" dated 15 Mar. 2002, official application no. 102 11 623.7, and to the prior art cited there.

[0061] In order to model the thermal behavior correctly, the material model **17** needs a series of input variables.

[0062] Firstly, the chemical composition of the molten steel is needed, since, among other things, conversion temperatures and structural characteristics depend on the chemical composition. This composition is fed to the material model **17** either by a user or else—e.g. if the charging of a steel production device is recorded by the control loop assigned to it—automatically.

[0063] The melting temperature, hereinafter designated T**0**, is then needed. This temperature T**0** is recorded by means of a measuring device **18**, known in the art, in the liquid steel storage device **2** and fed via the control loop **2'** or else directly to the control system **12** and then to the material model **17** as an initial parameter. Alternatively or additionally, the melting temperature T**0** could also be recorded downstream of the liquid steel charging device **3**. This is indicated in FIG. **3** by a dashed line.

[0064] The individual installation parts **5**, **7**, **9**, **10**, **11** and **15** comprise locally active devices for influencing the temperature of the steel or steel strip **1**. As a general rule, these devices comprise cooling devices, e.g. for spraying water on the steel strip **1** or for cooling the mold plates **6**. Optionally, heating devices, in particular inductively acting heating devices, can also be provided. These devices are controlled via the corresponding control loops **5'**, **7'**, **9'**, **10'**, **11'**, **15'**. Their manipulated variables are likewise fed to the material model **17**.

[0065] On the basis of the information about the material flow which is fed to the material model **17** from the path tracker **16** and the information about influencing the temperature of the steel or steel strip **1**, the material model **17** is therefore able to model the thermal behavior of the steel or steel strip **1** while path tracking from the steel storage device **2** to the winding device **11**. The technological control loops **2'** to **11'**, **15'** can therefore be guided at the correct time by the control system **12** according to the modeled thermal behavior of the steel or steel strip **1**. In particular, the locally active devices for influencing the temperature of the steel or steel strip **1** can be regulated via the technological control loops **2'** to **11'**, **15'** assigned to the individual installation parts **2** to **11**, **15** in accordance with guidance by the control system **12**. Also, the material hardness and the rolling temperature can be determined from the model prior to the tapping of the steel strip **1** in a roll stand. The material hardness, in particular, depends inter alia on the rolling temperature and the thermo-mechanical pretreatment of the steel strip **1**. The material hardness can be used in particular for determining the spring-back of the roll stand and the compensation thereof.

[0066] As can further be seen from FIG. **3**, actual temperatures T**1** to T**6** of the steel strip **1** are recorded downstream of the mold **6**, downstream of the reduction device **7**, within the rolling mill **10**, downstream of the rolling mill **10** and within and downstream of the cooling section **15** and are fed to an adaptation element **19**. Corresponding expected temperatures T**1'** to T**6'**, which should be available on the basis of the modeling of the thermal behavior by the material model **17**, are also fed to the adaptation element **19**. From any deviations between the actual temperatures T**1** to T**6** and the expected temperatures T**1'** to T**6'**, the adaptation element **19** can thus determine in a manner known in the art correction factors K**1** to K**6** by means of which the material model **17** is (gradually) adapted to the actual behavior of the steel or steel strip **1**.

[0067] In addition to the devices by means of which influence can be exerted locally on the course of the temperature of the steel or steel strip **1**, it is of course also possible to vary the material flow. For example, the exit velocity with which the steel strip **1** exits from the mold **6** can be varied. This influences the subsequent installation parts up to and including the winding device **11**. Also, for example, a setting of a roll stand of the rolling mill **10** can be modified. This influences all subsequent roll stands of the rolling mill **10** as well as the cooling section **15** and the winding device **11**. Variations of this type in the material flow thus have an effect which extends across all installation parts.

[0068] The control system **12** also determines reference variables for measures of this kind which extend across all installation parts. These reference variables also influence indirectly the thermal behavior of the steel or steel strip **1** because they change the period of time during which the locally acting devices can act upon the steel strip **1**. If such reference variables which act across all installation parts are therefore changed and these changes are transmitted to the technological control loops **2'** to **11'**, **15'**, the relevant installation parts **2** to **11**, **15** are guided in accordance with this reference variable. Simultaneously, however, the set values in respect of the locally acting devices for influencing temperature further down the material flow are adapted correspondingly by the control system **12** so that the overall thermal behavior of the steel strip **1** remains unchanged.

[0069] According to FIG. **1**, the rolling mill **10** is arranged immediately downstream of the diverting device **9**. A cast steel strip **1** must thus be rolled without delay in the rolling mill **10**. As indicated by a dashed line in FIG. **1**, it is, however, also possible to arrange an intermediate winder **20** and an equalizing furnace **21** between the diverting device **9** and the rolling mill **10**. A decoupling of casting process and rolling process emerges in this case. However, the modeling of the steel strip **1** also takes this decoupling into account. Naturally, a further technological control loop **20'**, which is also guided by the control system **12**, is assigned to the intermediate winder **20** and the equalizing furnace **21** in this case. Optionally, the rolling mill **10**, the winding device **11**, the intermediate winder **20** and the equalizing furnace **21** can be grouped together into a so-called Steckel mill.

[0070] By means of the control system according to the invention, end-to-end guidance of the production process from melting of the steel to winding up of the finished strip is possible in a simple manner, the thermal behavior of the steel strip **1**, in particular, being modeled end-to-end.

1.-**19**. (canceled)

20. A continuous casting and rolling installation for producing a steel strip, comprising the following components:

- a liquid steel storage device;
- a liquid steel charging device;
- a vertically operating casting device with a revolving mold;
- a diverting device for diverting a cast steel strip into a horizontal position;
- a horizontally operating rolling mill;
- a winding device, wherein the components are controlled by a plurality of technological control loops, each control loop assigned to one of the components;
- a control system for adjusting the technological control loops in an integrated manner, wherein the control system connects the liquid steel storage device, the liquid steel charging device, the casting device, the diverting device, the rolling mill, and the winding device, wherein the control system operates on the basis of mathematical models, and wherein the control system coordinates an interaction between the components, wherein the coordination of the interaction takes into consideration effects of a control step applied to one of the components on a component arranged downstream of the one component relative to a mass flow direction; and
- a reduction device arranged between the mold and the diverting device, wherein the reduction device has a plurality of roll pairs, and wherein the reduction device is controlled by one of the technological control loops which is also controlled by the control system, wherein
- the control system contains a material model for modeling a thermal behavior of the steel or steel strip on a transportation path from the steel storage device to the winding device using path tracking, and wherein
- the technological control loops are controlled using the modeled thermal behavior of the steel or steel strip according to a correct control timing.

21. The continuous casting and rolling installation according to claim **20**, wherein the steel strip cast by means of the mold has a casting thickness of between 40 and 100 mm upon exit from the mold.

22. The continuous casting and rolling installation according to claim **20**, wherein

- the steel strip can be reduced in the reduction device to a rolling mill input thickness of between 10 and 40 mm.

23. The continuous casting and rolling installation according to claim **22**, wherein

- the steel strip can be reduced in the reduction device to a rolling mill input thickness of between 15 and 35 mm.

24. The continuous casting and rolling installation according to claim **21**, wherein the steel strip can be reduced in the reduction device by at least 25% in relation to the casting thickness.

25. The continuous casting and rolling installation according to claim **20**, wherein

- the reduction device comprises an upper part in which the steel strip is re-formed and a lower part in which the steel strip retains its form.

26. The continuous casting and rolling installation according to claim **20**, wherein the installation can be controlled by the control system such that the steel strip does not solidify completely until it is in the reduction device.

27. The continuous casting and rolling installation according to claim **25**, wherein the steel strip does not solidify completely until it is in the lower part.

28. The continuous casting and rolling installation according to claim **20**, wherein

- the steel strip has a final thickness of between 0.3 and 6.0 mm at which it is wound up by the winding device.

29. The continuous casting and rolling installation according to claim **20**, wherein

- the steel strip is reduced in the reduction device to a rolling mill input thickness which is determined according to a final thickness at which the steel strip is wound up by the winding device.

30. The continuous casting and rolling installation according to claim **20**, further comprising a cooling stretch arranged between the rolling mill and the winding device, wherein the cooling stretch is controlled by a technological control loop controlled by the control system.

31. The continuous casting and rolling installation according to claim **20**, further comprising a descaler arranged upstream of the rolling mill, wherein the descaler is controlled by a technological control loop controlled by the control system.

32. The continuous casting and rolling installation according to claim **20**, further comprising an intermediate winder and an equalizing furnace both arranged between the diverting device and the rolling mill, wherein the intermediate winder and the equalizing furnace are controlled by a technological control loop controlled by the control system.

33. The continuous casting and rolling installation according to claim **20**, wherein phase changes in the steel or steel strip are modeled within the framework of the material model.

34. The continuous casting and rolling installation according to claim **33**, wherein phase changes comprise phase changes from liquid to solid or from austenite to ferrite.

35. The continuous casting and rolling installation according to claim **20**, wherein structural characteristics of the steel strip are modeled within the framework of the material model.

36. The continuous casting and rolling installation according to claim **20**, wherein

- the melting temperature of the steel is measured and fed into the material model as an initial parameter.

37. The continuous casting and rolling installation according to claim **20**, wherein

- downstream of the mold, downstream of the reduction device, within the rolling mill and/or downstream of the rolling mill, within and/or downstream of the cooling stretch an actual temperature of the steel strip is recorded and used for adapting the material model.

38. The continuous casting and rolling installation according to claim **20**, wherein the components of the installation comprise locally active devices for influencing the temperature of the steel or of the steel strip, and wherein the locally active devices are regulated via the technological control loops assigned to the components in accordance with guidance by the control system.

39. The continuous casting and rolling installation according to claim **20**, wherein

the control system determines at least one reference variable for influencing the temperature of the steel and/or steel strip, wherein the influencing is effective across all the components, and wherein the control system controls the components concerned according to this reference variable.

40. The continuous casting and rolling installation according to claim **20**, wherein

the thermal behavior of the steel or steel strip is also calculated in real time in the material model, and wherein deviations in components arranged upstream are deliberately corrected in components arranged downstream.

* * * * *