

(19) AUSTRALIAN PATENT OFFICE

(54) Title

Process for hot rolling and for heat treatment of a steel strip

(51)⁶ International Patent Classification(s)**C21D** 8/02 (2006.01) **1BHEP** **C21D****B21B** 1/26 (2006.01) 8/04**C21D** 8/04 (2006.01) 20060101ALI2008123**C21D** 9/46 (2006.01) **1BHEP** **C21D****C21D** 9/48 (2006.01) 9/46**C21D** 8/02 20060101ALI200812320060101AFI2008123 **1BHEP** **C21D****1BHEP** **B21B** 9/48

1/26 20060101ALI2008123

20060101ALI2008123 **1BHEP**

PCT/EP2008/004435

(21) Application No: 2008267505

(22) Application Date: 2008 .06 .04

(87) WIPO No: W009/000387

(30) Priority Data

(31) Number (32) Date (33) Country

10 2007 029 280.7 2007 .06 .22 **DE**10 2008 010 062.5 2008 .02 .20 **DE**

(43) Publication Date : 2008 .12 .31

(71) Applicant(s)

SMS Siemag AG

(72) Inventor(s)

Ohlert, Joachim, Sudau, Peter, Schuster, Ingo, Seidel, Jurgen

(74) Agent/Attorney

Freehills Patent & Trade Mark Attorneys, Level 38 MLC Centre Martin Place, Sydney, NSW, 2000

(56) Related Art

JP 58-009919

JP 04-358022

EP 1764423

JP 04-358023

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES
PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro



(43) Internationales Veröffentlichungsdatum
31. Dezember 2008 (31.12.2008)

PCT

(10) Internationale Veröffentlichungsnummer
WO 2009/000387 A1

(51) Internationale Patentklassifikation:

C21D 8/02 (2006.01) C21D 9/48 (2006.01)
C21D 8/04 (2006.01) B21B 1/26 (2006.01)
C21D 9/46 (2006.01)

(21) Internationales Aktenzeichen: PCT/EP2008/004435

(22) Internationales Anmeldedatum:
4. Juni 2008 (04.06.2008)

(25) Einreichungssprache: Deutsch

(26) Veröffentlichungssprache: Deutsch

(30) Angaben zur Priorität:

10 2007 029 280.7 22. Juni 2007 (22.06.2007) DE
10 2008 010 062.5
20. Februar 2008 (20.02.2008) DE

(71) Anmelder (für alle Bestimmungsstaaten mit Ausnahme von
US): **SMS DEMAG AG** [DE/DE]; Eduard-Schloemann-
Strasse 4, 40237 Düsseldorf (DE).

(72) Erfinder; und

(75) Erfinder/Anmelder (nur für US): **OHLERT, Joachim**
[DE/DE]; Weissenburgstrasse 61, 50670 Köln (DE).

SCHUSTER, Ingo [DE/DE]; Bonnenring 83,
47877 Willich (DE). **SUDAU, Peter** [DE/DE]; Wil-
helm-Münker-Strasse 8, 57271 Hilschenbach (DE).
SEIDEL, Jürgen [DE/DE]; Feuertromweg 8, 57223
Kreuztal (DE).

(74) Anwalt: **KLÜPPEL, Walter**; Hemmerich & Kollegen,
Hammerstrasse 2, 57072 Siegen (DE).

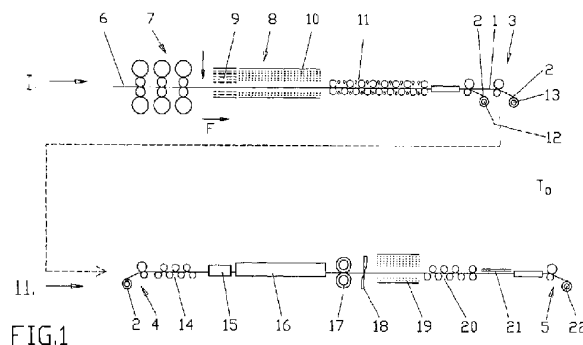
(81) Bestimmungsstaaten (soweit nicht anders angegeben, für
jede verfügbare nationale Schutzrechtsart): AE, AG, AL,
AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ,
CA, CH, CN, CO, CR, CU, CZ, DK, DM, DO, DZ, EC, EE,
EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID,
IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC,
LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN,
MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH,
PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV,
SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN,
ZA, ZM, ZW.

(84) Bestimmungsstaaten (soweit nicht anders angegeben, für
jede verfügbare regionale Schutzrechtsart): ARIPO (BW,

[Fortsetzung auf der nächsten Seite]

(54) Title: PROCESS FOR HOT ROLLING AND FOR HEAT TREATMENT OF A STEEL STRIP

(54) Bezeichnung: VERFAHREN ZUM WARMWALZEN UND ZUR WÄRMEBEHANDLUNG EINES BANDES AUS STAHL



(57) Abstract: The invention relates to a process for hot rolling and for heat treatment of a strip (1) of steel. To make it possible to produce high-strength and very high-strength strips having satisfactory toughnesses more economically in a continuous production plant, the process provides the steps: a) heating of the slab to be rolled; b) rolling of the slab to the desired strip thickness; c) cooling of the strip (1), with the strip (1) having a temperature above ambient temperature (T_0) after cooling; d) rolling up of the strip (1) to produce a coil (2); e) rolling off of the strip (1) from the coil (2); f) heating of the strip (1); g) cooling of the strip (1) and h) transport of the strip (1) to a further destination, with the strip (1) having a temperature above ambient temperature (T_0) before heating as per step T).

[Fortsetzung auf der nächsten Seite]



GH, GM, KP, LS, MW, MZ, NA, SD, SI, SZ, TZ, UG, ZM, ZW), eurasisches (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), europäisches (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF,

BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NF, SN, TD, TG).

Veröffentlicht:

— mit internationalem Recherchebericht

(57) Zusammenfassung: Die Erfindung betrifft ein Verfahren zum Warmwalzen und zur Wärmebehandlung eines Bandes (1) aus Stahl. Um eine wirtschaftlichere Herstellung von hoch- und höchstfesten Bändern mit ausreichenden Zähigkeiten in einer Bandanlage zu ermöglichen, sieht das Verfahren die Schritte vor: a) Erwärmen der zu walzenden Bramme; b) Walzen der Bramme auf die gewünschte Banddicke; c) Kühlen des Bandes (1), wobei das Band (1) nach dem Kühlen eine über der Umgebungstemperatur (T_0) liegende Temperatur aufweist; d) Aufhaspeln des Bandes (1) zu einem Coil (2); e) Abhaspeln des Bandes (1) vom Coil (2); f) Erhitzen des Bandes (1); g) Kühlen des Bandes (1) und h) Abtransport des Bandes (1), wobei das Band (1) vor der Erwärmung gemäß Schritt f) eine über der Umgebungstemperatur (T_0) liegende Temperatur aufweist.

2008267505 24 Dec 2009

METHOD FOR HOT ROLLING AND FOR HEAT TREATMENT OF A STRIP OF STEEL

The invention relates to a method for hot rolling and for heat treatment of a strip of steel.

- 5 The hardening and subsequent tempering of steel components is common practice. This has the result that a desired combination of strength and toughness of the material can be specifically adjusted. This technology is also used in principle in the production of high-strength steel sheets in sheet plants. It is described in **EP 1 764 423 A1**. In this case, after heating the slab and rolling down to the final thickness on the heavy plate stand in a plurality of reversing passes, the sheet is cooled for example to room temperature at high speed, ie. the hardening process is carried out. This is followed by the tempering process,
- 0 ie. re-heating of the strip to, for example, 600°C followed by renewed cooling. Thus, sheets having different properties can be produced flexibly in small batch sizes in a sheet stand.

Similar methods are disclosed in **JP 04 358022 A**, in **JP 04 358023 A** and in **JP 58 009919 A**.

- 5 As in the sheet production sector, the demand for types of steel having very high strength is also increasing continuously in strip production, ie. the demand for so-called high-strength and ultrahigh-strength steels. These materials are used, inter alia, in motor vehicles, cranes, containers and in pipes.

- 20 Reference to any prior art in the specification is not, and should not be taken as, an acknowledgment or any form of suggestion that this prior art forms part of the common general knowledge in Australia or any other jurisdiction or that this prior art could reasonably be expected to be ascertained, understood and regarded as relevant by a person skilled in the art.

- 25 It is thus the object of the present invention to provide a method whereby high-strength and ultrahigh-strength strips having sufficient toughness can be produced more economically in a strip plant. In particular, it should advantageously be possible to produce QT steels by this method.

2008267505 24 Dec 2009

The solution of this object by the invention is characterised in that the method comprises the steps:

- a) heating the slab to be rolled;
- b) rolling the slab to the desired strip thickness;
- 5 c) cooling the strip, wherein after cooling the strip generally has a temperature above the ambient temperature;
- d) coiling the strip into a coil;
- e) uncoiling the strip from the coil;
- f) heating the strip;
- 0 g) cooling the strip and
- h) removing the strip,

wherein before heating according to step f), the strip has a temperature above the ambient temperature and wherein, when carrying out step d), the coil is located at a coiling station and, when carrying out step e), the coil is located at an uncoiling station spatially remote
15 from the coiling station, wherein the coil is transported from the coiling station to the uncoiling station between steps d) and e) in a thermally insulated manner.

Step e) can directly follow step d).

During cooling or after cooling according to step c) and/or according to step g), the strip can be subjected to a straightening process. It can also be subjected to a straightening
20 process between the uncoiling according to step e) and the heating according to step f). It can also be subjected to a straightening process between the heating according to step f) and the removal according to step h). Said straightening process can be effected by deflecting the strip around base, deflecting, driving or other rollers.

2008267505 24 Dec 2009

The straightening process is usually carried out by means of a roller straightening machine or screwed-down strip deflecting rollers or, according to a special embodiment of the invention, on a so-called skin-pass frame.

5 The strip can also be subjected to a straightening process during the heating according to above step f).

The cooling of the strip according to step c) can comprise a laminar cooling and downstream intensive cooling. The cooling of the strip according to step g) can also comprise a laminar cooling or alternatively or additively air cooling.

0 At least parts of the cooling device can be configured as zone cooling which acts in zones over the width of the strip.

The cooling of the strip can also be carried out by means of a high-pressure bar so that cleaning and/or descaling of the strip is possible at the same time.

5 The heating of the strip according to step f) can comprise inductive heating. Alternatively, direct flame impingement of the strip can be effected. In the latter case, it is preferably provided that the direct flame impingement of the strip is effected by a gas jet comprising at least 75% oxygen, preferably comprising almost pure oxygen, in which a gaseous or liquid fuel is mixed.

A further development provides that the inductive heating of the strip may take place in inert gas (protective gas).

20 The removal of the strip according to step h) can comprise coiling the strip. The removal of the strip according to step h) according to claim 1 can also comprise pushing off plate-like cut portions of the strip.

Before the cooling according to step c) the strip preferably has a temperature of at least 750°C.

2008267505 24 Dec 2009

After the cooling according to step c) and before coiling according to step d), the strip preferably has a temperature of at least 25°C and at most 400°C, preferably between 100°C and 300°C.

- 5 A further development furthermore provides that after the heating according to step f), the strip preferably has a temperature of at least 400°C, preferably between 400°C and 700°C. Meanwhile, after the cooling according to step g) and before the removal according to step h), the strip can preferably have a temperature of at most 200°C, preferably between 25°C and 200°C.

The heating of the strip can take place at different intensity over the strip width.

- 0 It can be provided that the steps e) to g) are carried out in reversing mode for which a coiling station located after the cooling according to step g) is used.

It can furthermore be provided that the flatness of the strip and/or the temperature of the strip (the latter preferably by means of a temperature scanner) is measured at least at two locations in the strip treatment installation for monitoring the quality of the strip.

- 5 The running speed of the strip through the strip treatment installation, the, in particular, zone-related strip heating, the adjustment of the straightening rolls and/or the in particular zone-related cooling can be controlled or regulated by a process model.

- 20 During passage through the strip treatment installation, the strip can be held under a defined strip tension at least in sections by means of drivers. This applies particularly in the area of the intensive cooling section.

In order to ensure that the strip runs centrally in the driver, in the roller straightening unit or in the intensive cooling section, a strip lateral guide is preferably located in front thereof.

An alternative embodiment of the method for hot rolling and for heat treatment of a strip of steel comprises the steps:

- 25 a) heating the slab to be rolled;

2008267505 24 Dec 2009

- b) rolling the slab to the desired strip thickness;
- c) cooling the strip, wherein after cooling the strip has a temperature above the ambient temperature;
- d) coiling the strip on a first coiler;
- 5 e) reversing the strip between the first coiler and a second coiler wherein the strip is subject to heating between the coilers,

wherein before the heating according to step e), the strip has a temperature above the ambient temperature.

This method can also be combined with the aforesaid embodiments.

- 0 In the case of materials for which no tempering is required, i.e. for which the strength and toughness properties already meet the requirements after step d), process steps a) to d) can be used by themselves alone.

The following further developments have proved successful:

A strip tension can be built up by means of drivers before and after the cooling of the strip.

- 15 The strip can be guided transversely to its longitudinal axis by means of a lateral guidance. The lateral guidance can preferably take place in the area of the cooling of the strip, in particular in the area of the laminar cooling of the strip.

The lateral guidance of the strip can furthermore take place before the driver and can open after passing the strip head and close again at the strip end for the purpose of guidance.

- 20 Measurement of the strip temperature can be made by means of a low-temperature radiation pyrometer. The measurement of the strip temperature can preferably be made before, inside and/or after the cooling and/or heating devices.

2008267505 24 Dec 2009

5 The production spectrum of a hot wide strip mill differs appreciably from that of a heavy plate mill. A plurality of high-strength and ultrahigh strength types of steel newly developed over the last few decades now exist, whose properties can be adjusted by specific rolling and/or cooling strategies. A suitable method for this is quenching of the strip at a high cooling rate after rolling, followed by re-heating to temperatures above the phase transformation temperature.

The classical QT steels (Q: quenched; T: tempered) which can be produced in this way are already produced on heavy plate stands. However, they can be produced substantially more economically in hot wide strip mills.

0 Moreover, thinner, ultrahigh-strength strips having lower temperature and thickness tolerance as well as strip flatness can be produced more reliably on hot strip mills. It is therefore appropriate and advantageous to shift parts of production from heavy plate stands to strip mills.

5 In addition, there are many new types of steel which cannot be produced on heavy plate stands. The method presented here is particularly suitable for the group of multi-phase steels. By means of a significantly enlarged spectrum of temperature-time profiles and in particular, by means of the possibility of interrupting the cooling and temporarily increasing the temperature again, it is possible to produce structures having almost any combinations of phase constituents which cannot be envisaged at the present time. In addition, it is possible to make precipitation processes take place and thus specifically introduce second phases which are a characteristic of modern types of steels.

In addition, properties required for the higher alloy contents in conventional production can be adjusted by the method presented.

25 Advantages of the separate arrangement of the rolling and cooling process on the one hand and the tempering process on the other hand are the flexibility of the method (no mixed rolling is necessary), the flexible adjustment of the temperature time profile of the strip and that one's own coils or coils from other installations can be processed. Coils or plates can also be cut depending on the intended use of the strip or the coilability. The plates are preferably cut at higher temperature, i.e. at the tempering temperature.

2008267505 24 Dec 2009

Advantages of the coupled arrangement of the rolling and cooling process and the tempering process are the particularly large energy saving and in the case of coils which are difficult to coil and bind, the use of a special coiler with direct transfer to avoid the so-called watch-spring problem. Furthermore, rapid further processing or delivery of the strip in the case of direct further processing is achieved. Finally, mention should be made of the greater possibility for influencing the microstructure of the strip in the arrangements mentioned.

Exemplary embodiment of the invention are shown in the drawings. In the figures:

Fig. 1 shows schematically a hot strip mill for producing a steel strip according to a first embodiment of the invention,

Fig. 2 shows an alternative embodiment of the hot strip mill to Fig. 1,

Fig. 3 shows an exemplary temperature profile of the strip over the conveying direction of the hot strip mill,

Fig. 4 shows the fundamental structure of a straightening machine with integrated intensive cooling as a section from the hot strip mill according to Figs. 1 or 2,

Fig. 5 shows the fundamental structure of a straightening machine with integrated heating as a section from the hot strip mill according to Figs. 1 or 2,

Fig. 6 shows schematically a hot strip mill with an alternative embodiment of a first process step.

Figure 1 shows a hot strip mill in which a strip 1 is initially processed in a first process stage (given by I) and then in a second process stage (given by II).

In the first process stage, i.e. in a rolling and cooling process, a slab is first rolled in a multi-stand rolling mill. Of the rolling mill, only the last three finishing stands 7 are shown in which the strip 6 having an intermediate thickness has been rolled. The temperature distribution in the strip or the flatness can then be measured. The strip 1 then passes in the conveying direction F into a strip cooling system 8 which is divided here into an

24 Dec 2009

2008267505

5

0

intensive laminar cooling system 9 with so-called edge masking and a laminar strip cooling system 10. The conveying speed is, for example, 6 m/s. The cooled strip 1 then enters into an intensive cooling system 11 in which, according to a preferred embodiment of the invention, a straightening machine and driver are integrated (details in Fig. 4). Drivers can be provided before and after the intensive cooling system 11.

The intensive cooling system 11 can be followed by another measurement of the temperature distribution and the flatness of the strip. A low-temperature radiation pyrometer is preferably used at these low temperatures. A temperature measurement is also feasible inside the intensive cooling system between two squeeze or driver rolls for the purpose of temperature-coolant regulation.

The strip 1 is then coiled in a coiling station 3 by a coiler 12 or 13.

The coil 2 then enters the second process stage, i.e. the tempering process.

Here the coil 2 is initially uncoiled in an uncoiling station 4 and then fed to a straightening machine 14 (this can be located before and/or after the following furnace). After a temperature equalisation has taken place over the length and width of the strip in a zone 15, the strip 1 enters into a furnace 16. It is possible and advantageous to integrate a straightening machine in the furnace 16 similarly to the cooling (details in Fig. 5). Here the strip 1 can be heated in continuous or in reversing mode. An oxyfuel furnace or an induction furnace are preferably used, the heating time being between 10 and 600 seconds.

This is followed by trimming shears 17 or shears 18. The strip 1 then enters into a laminar strip cooling system or alternatively into an air cooling system 19. This can be followed by a straightening machine 20. A plate pushing unit 21 or a coiler 22 in a coiling station 5 are then furthermore indicated in Fig. 1.

25 A skin-pass stand can also be arranged here instead of a straightening machine 14 or 20.

Coils from other hot strip mills can also be introduced instead of the uncoiling station 4.

2008267505 24 Dec 2009

5 In contrast, a direct connection of the two process stages I and II can be seen in Fig. 2 (the installation is not shown fully fitted). The last stands of a hot wide strip mill (finishing mill 7), the strip cooling system 8, and the coilers 12 and 13 of the first process stages are shown similarly here. The last coiler 23 is provided for winding the higher-strength strips. In this case, this can advantageously comprise a special coiler for simple winding of the high-strength steels. In this case, the coiler 23 is a so-called transfer coiler. The coil does not need to be bound there. Pivotal pinch rolls hold the strip under tension during turning into the unwinding position. The winding is therefore directly followed by further processing in the tempering line (second process stage). The further transport takes place similarly to the solution according to Fig. 1.

Particular advantages here are the energy saving for strips of higher winding temperature and the rapid further transport of the coils from the first to the second process stage. It is thus provided that the strip 1 already has a temperature above the ambient temperature T_0 before the heating in the furnace 16.

5 In addition, for special strip it is also possible to provide reversing of the strip between the two coilers 23 and 22 in to be able to carry desired temperature profiles or treatments of the strip.

20 Preferably in the case of shorter strip and/or sufficiently dimensioned component spacings, direct further transport of the strip 1 from the first process stage to the second process stage is provided without intermediate coiling of the strip 1 and/or subsequent reversing from coiler 22 to coiler 23. In this case, therefore the coiler 23 is not used but after the strip end runs out from the roll mill the tempering process is carried out directly at low or initially high and then lower speed.

25 Alternatively, this operating mode is applied to strip independently of the thickness and the speed. Then the coiler 23 is initially not used and the furnace is also not operating. The strip is wound on coiler 22. The tempering process is then carried out reversingly between coiler 22 and 23.

2008267505 24 Dec 2009

A preferred temperature profile for the strip 1 along the strip mill is shown in Fig. 3 in correspondence with Fig. 2. The cooling at the end of the line is preferably water or air cooling.

5 However, cooling can also be effected by means of a high-pressure beam. Cleaning or descaling of the strip surface is thereby carried out at the same time.

The production quantity of the rolling plant is usually higher than in the tempering process since the rolling speed of the strip is greater than the tempering speed. A so-called mixing rolling operation is therefore possible to optimally utilise the rolling mill. This means that a number of strips is wound on coilers 12 and 13 whilst the further processing of the higher-
0 strength strip takes place in the tempering line.

The production of the strip is therefore divided according to the invention substantially into two process stages which will be specified subsequently as an example with further optional steps.

First process stage:

- 5 - Heating of slabs (thick or thin slabs) and subsequent rolling in a multi-stand hot wide strip mill;
- Intensive cooling of the strip on the delivery roller table;
- Passing through a straightening machine;
- Winding the strip into a coil.

20 In order to improve the flatness of the high-strength strip, strip edge heating before a conventional finishing train, edge masking in the first cooling section units and a straightening machine are advantageous.

At higher winding temperatures, fast coil transport to the subsequent second process stage is advantageous to save heating energy during tempering. The coil can then be

2008267505 24 Dec 2009

transported under a heat insulating hood to reduce the temperature loss and ensure more uniform material properties.

Second process stage:

- Unwinding the coil,
- 5 - Optionally straightening the strip in a straightening machine if lack of flatness is present;
- Optionally equalising the strip temperature by zonal cooling or heating before the actual tempering treatment for making the strip temperature uniform over the strip length and width;
- 0 - Tempering the strip, i.e. continuous re-heating by means of induction heating or energetically advantageously in a gas-heated continuous furnace (e.g. oxyfuel furnace using so-called DFI method);
- Trimming the strip;
- Subsequent cooling of the strip;
- Renewed straightening of the strip;
- 15 - Renewed winding of the strip into a coil.

Alternatively, the strips can be cut into plates before the furnace, after the furnace and/or directly before the plate pushing unit. The cutting of plates is particularly advantageous in the case of strip which is difficult to wind. Cutting at the tempering temperature is advantageous since the strip has a lower strength there.

- 20 In the case of thicker strip and/or high-strength steels which can no longer be cut, a flame cutting machine, a laser cutting machine or a thermal cutting machine can be provided for cutting.

2008267505 24 Dec 2009

5 The said oxyfuel furnace in which the so-called DFI oxyfuel method (direct flame impingement) is carried out for tempering comprises a special furnace in which (almost) pure oxygen instead of air and gaseous or liquid fuel are mixed and the resulting flame is directed directly onto the strip. This not only optimises the combustion process but also reduces the nitrogen oxide emissions. The scale properties are also favourable or the scale growth is very small (operated with air undershooting). The high flow rate of the gases even has a cleaning effect on the strip surface. This type of heating is particularly advantageous with regard to strip surface quality. High heat densities with as good efficiency as in inductive heating can be achieved with this method.

0 Instead of a successively arranged cooling section and inline straightening machine in the first or second process stage, the straightening machine and the strip cooling can also be accommodated combined in one unit. The straightening rollers are then at the same time used as water squeeze rollers and thus ensure a cooling effect which is as uniform as possible over the width of the strip since any strip transverse curvature and lack of flatness is eliminated directly it forms. The straightening rollers are adjusted individually depending on the strip temperature and the material quality with the assistance of a straightening machine model so that overstretching of the strip surface is avoided. Drivers before and after the cooling section unit ensure strip tension for as long as possible even when the stand or the coiler tension is not built up. Part of the strip cooling can be carried out in the form of strip zone cooling in order to be able to actively influence the temperature distribution. The cooling-straightening unit is indicated in Figures 1 and 2. Details on this are deduced from Fig. 4. Possible arbitrary combinations for straightening, cooling and squeezing can be seen in this figure. For the secure threading-in process of the strip head particularly in the case of thinner strip, the cooling-straightening unit is executed as raisable and pivotable as indicated in Fig. 4 (see double arrow). The straightening rolls are individually adjustable.

30 A temperature scanner for the strip can be provided before and/or after the joint arrangement of straightening machine and cooling which can be seen in Fig. 4. A strip head form detector (for detecting a ski or waves) can be positioned in front of the installation shown.

2008267505 24 Dec 2009

Drivers 24, a pure cooler unit 25, straightening rolls 26 and combined squeeze rolls/drivers 27 can be identified in detail in Fig. 4. Furthermore, nozzles of intensive cooling system can be seen.

5 In this case, an alternating arrangement of cooling, straightening and drive roller units is possible. The amount of straightening is adjusted individually depending on the material of the strip and the temperature. The straightening-cooling unit is raisable and pivotable.

0 As can be seen in Fig. 5, the straightening and heating process 14, 16 of the second process stage can also be combined with the installation shown. Similarly, the amount of straightening can be adapted to the present strip temperature and the strip material. In this case, the skin effect (higher surface temperature) of the induction heating (or a direct flame impingement in the DFI oxyfuel method) has a positive effect. At the same time, the straightening rolls hold the strip in position and avoid lack of flatness so that (inductive) heating which is as efficient as possible is possible in the long fillet portion of the strip. Drivers 29 before and after the heating- straightening unit hold the strip under tensile stress 30. For secure threading in of the strip head, the induction coils 32 as well as the straightening and transfer rollers 31 are designed as vertically adjustable.

5 The use of the cooling- straightening unit (Fig. 4) or the heating- straightening unit (Fig. 5) is not restricted to a strip installation but can also be provided in a heavy plate installation.

20 A temperature scanner for the strip can be provided before and/or after the joint arrangement of straightening machine and heating which can be seen in Fig. 5.

In order to be able to influence the temperature distribution over the strip width in the second process stage during the inductive heating, transverse field inductors are used, inter alia, which can be displaced transversely to the strip running direction or conveying direction F. By this means, if necessary, the strip edges for example can be heated more strongly or heated less intensively.

25 Equalisation of the strip temperature over the length and the width of the strip by specific cooling (zone cooling) or heating at warm or cold strip sections can optionally take place before heating the strip to the tempering temperature. This should be provided in particular when coils not completely cooled to ambient temperature are to be handled. By this

2008267505 24 Dec 2009

means the passage of the coil through the coil store can be shortened. A coil tracking system (model) as well as the measured temperature distributions during unwinding of the coil are used for optimum control of the heating or cooling systems.

5 Welded-to-order, high wear-resistant roller materials are used for the straightening rolls in order to ensure a long life and good strip quality.

Temperature scanners and flatness meters within the line indirectly monitor the quality of the strip and serve as a signal for adjusting and regulating members such as, for example, for the throughput speed, the heating power, the adjustment of the straightening rolls and the cooling which are controlled by a process model.

0 Figure 6 shows the first process stage in a somewhat modified embodiment. By analogy with Fig. 1, Fig. 6 shows the rear part of the finishing train 7, laminar strip cooling units 9, 10 as well as an intensive cooling system 11 and the coiling stations 3. In this embodiment the intensive cooling system 11 and a strip straightening unit 36.1, 36.2 are located at various positions. Drivers 34 and 35 are located before and after the intensive cooling
5 system 11. A strip tension can hereby be maintained within the intensive cooling system 11 for almost the entire strip length without the strip being clamped in the stand or coiler system. Thus, any strip waves which may occur are pulled out and a cooling effect which is as uniform as possible is achieved.

20 In order to ensure that the strip runs centrally in the drivers 34, 35 and/or in the intensive cooling system 11, a strip lateral guide 33.1 is particularly advantageously located in front thereof. After the strip head has passed the driver 33.1 and the intensive cooling system 11, the lateral guide 33.1 is opened again so that the water flow in the laminar strip cooling system 10 is not hindered. The guide 33.2 then takes over the guiding task for the remainder of the strip. Similarly for the strip end the guide 33.1 is briefly adjusted again
25 after the end has left the finishing train to counteract any straying of the strip end. In order to minimise the cooling section length, the lateral guide 33.1 is therefore preferably located inside the strip cooling unit 10.

The straightening rolls 36.1, 36.2 before the respective coiling stations 3 are dipped into the strip plane after building up the strip tension and provide a strip straightening effect by

2008267505 24 Dec 2009

looping around the base, deflecting or drive rollers. A similar operating mode is practised when deflecting rollers 26 (see Fig. 4) are located inside the intensive cooling section 11.

As used herein, except where the context requires otherwise, the term "comprise" and variations of the term, such as "comprising", "comprises" and "comprised", are not
5 intended to exclude further additives, components, integers or steps.

REFERENCE LIST

2008267505 24 Dec 2009

- 1 Strip (after the finishing train with final thickness)
- 2 Coil
- 3 Coiling station
- 5 4 Uncoiling station
- 5 Coiling station
- 6 Strip (inside the finishing train with intermediate thickness)
- 7 Finishing train
- 8 Strip cooling
- 0 9 Intensive laminar strip cooling
- 10 Laminar strip cooling
- 11 Intensive cooling
- 12 Coiler
- 13 Coiler
- 15 14 Straightening machine
- 15 Zone
- 16 Furnace
- 17 Trimming shears

24 Dec 2009

2008267505

- 18 Shears
- 19 Air cooling or laminar strip cooling
- 20 Straightening machine
- 21 Plate pushing unit
- 5 22 Coiler
- 23 Coiler
- 24 Driver
- 25 Pure cooling unit
- 26 Straightening roll
- 0 27 Squeeze roll/driver
- 28 Nozzles of intensive cooling system
- 29 Driver
- 30 Tensile stress
- 31 Transfer roller
- 15 32 Induction coil
- 33.1 Lateral guide before the first driver/before the intensive cooling

2008267505 24 Dec 2009

- 33.2 Lateral guide before the coiler driver
- 34 Driver before the intensive cooling
- 35 Driver after the intensive cooling
- 36.1 Straightening roll before the first winding station
- 5 36.2 Straightening roll before the second winding station
- I. First process stage
- II. Second process stage
- 0 F Conveying direction
- T_0 Ambient temperature

CLAIMS

2008267505 24 Dec 2009

1. A method for hot rolling and for heat treatment of a strip of steel, comprising the steps:
- a) heating the slab to be rolled;
 - b) rolling the slab to the desired strip thickness;
 - c) cooling the strip, wherein after cooling the strip has a temperature above the ambient temperature (T_0);
 - d) coiling the strip into a coil ;
 - e) uncoiling the strip from the coil;
 - f) heating the strip;
 - g) cooling the strip and
 - h) removing the strip

wherein before the heating according to step f), the strip has a temperature above the ambient temperature (T_0) and

- wherein when carrying out step d), the coil is located at a coiling station and that when carrying out step e), said coil is located at an uncoiling station spatially remote from the coiling station, wherein the coil is transported from the coiling station to the uncoiling station between steps d) and e) in a thermally insulated manner.

2008267505 24 Dec 2009

2. The method according to claim 1, wherein
step e) of claim 1 directly follows step d) of claim 1.
3. The method according to claim 1 or 2, wherein during cooling or after cooling according to step c) and/or according to step g) of claim 1, the strip (1) is subjected to a straightening process.
4. The method according to any one of claims 1 to 3, wherein between the uncoiling according to step e) of claim 1 and the heating according to step f) of claim 1, the strip (1) is subjected to a straightening process.
5. The method according to any one of claims 1 to 4, wherein between the heating according to step f) of claim 1 and the removal according to step h) of claim 1, the strip (1) is subjected to a straightening process.
6. The method according to any one of claims 3 to 5, wherein the straightening process is effected by deflecting the strip (1) around base, deflecting, driving or other rollers.
7. The method according to any one of claims 4 to 6, wherein
the straightening process is carried out by means of a skin-pass frame.
8. The method according to any one of claims 1 to 7, wherein
the strip is subjected to a straightening process during the heating according to step f) of claim 1.
9. The method according to any one of claims 1 to 8, wherein
the cooling of the strip according to step c) of claim 1 comprises a laminar cooling and intensive cooling.
10. The method according to any one of claims 1 to 9, wherein

2008267505 24 Dec 2009

- the cooling of the strip according to step g) of claim 1 comprises a laminar cooling.
11. The method according to any one of claims 1 to 10, wherein
- the cooling of the strip according to step c) and/or according to step g) of claim 1 takes place in zones over the width of the strip.
- 5 12. The method according to any one of claims 1 to 9, wherein
- the cooling of the strip according to step g) of claim 1 comprises air cooling.
13. The method according to any one of claims 1 to 12, wherein
- the cooling of the strip according to step g) of claim 1 is carried by means of a high-pressure bar so that cleaning and/or descaling of the strip takes place at the same
- 0 time.
14. The method according to any one of claims 1 to 13, wherein
- the heating of the strip according to step f) of claim 1 comprises inductive heating.
15. The method according to claim 14, wherein
- the inductive heating of the strip takes place in an inert gas atmosphere.
- 15 16. The method according to any one of claims 1 to 13, wherein

2008267505 24 Dec 2009 5

the heating of the strip according to step f) of claim 1 is effected by direct flame impingement of the strip.

17. The method according to claim 16, wherein

the direct flame impingement of the strip is effected by a gas jet comprising at least 75% oxygen in which a gaseous or liquid fuel is mixed.

18. The method according to claim 17, wherein

the direct flame impingement is effected by a gas jet comprising pure oxygen.

19. The method according to any one of claims 1 to 18, wherein

the removal of the strip according to step h) of claim 1 comprises coiling the strip.

20. The method according to any one of claims 1 to 18, wherein

the removal of the strip according to step h) of claim 1 comprises pushing off plate-like cut portions of the strip.

21. The method according to any one of claims 1 to 20, wherein

24 Dec 2009
2008267505

before the cooling according to step c) of claim 1 the strip has a temperature of at least 750°C.

22. The method according to any one of claims 1 to 21, wherein

after the cooling according to step c) of claim 1 and before coiling according to step d) of claim 1, the strip has a temperature of at least 25°C and at most 400°C, preferably between 100°C and 300°C.

23. The method according to any one of claims 1 to 22, wherein

after the heating according to step f) of claim 1, the strip has a temperature of at least 400°C, preferably between 400°C and 700°C.

- 0 24. The method according to any one of claims 1 to 23, wherein

the heating of the strip according to step f) of claim 1 is effected so that the strip has different temperatures over its width.

25. The method according to any one of claims 1 to 24, wherein

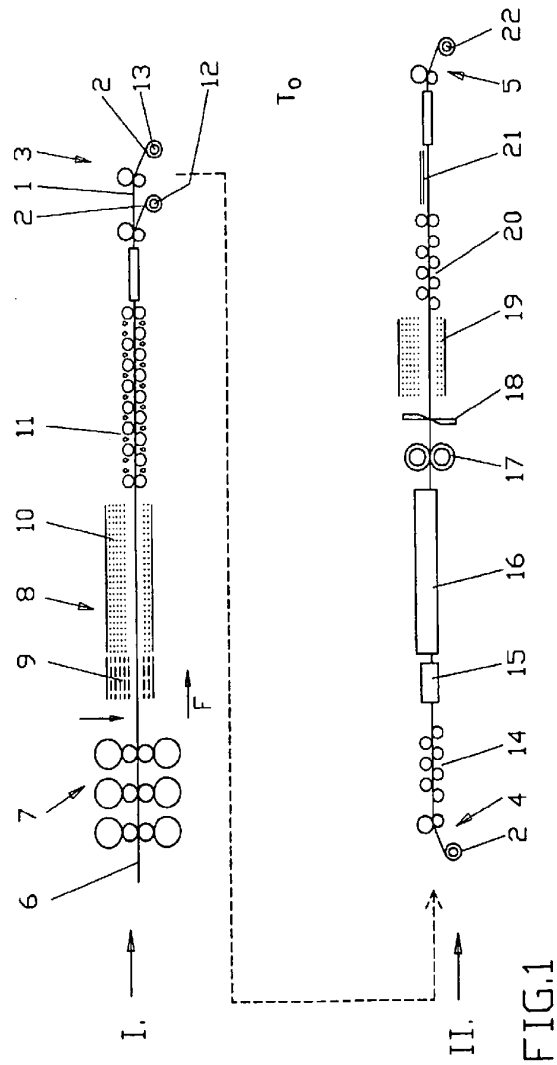
after the cooling according to step g) of claim 1 and before removal according to step h) of claim 1, the strip has a temperature of at most 200°C, preferably between 25°C and 200°C.

2008267505 24 Dec 2009

26. The method according to any one of claims 1 to 25, wherein
the steps e) to g) of claim 1 are carried out in reversing mode for which a coiling station located after the cooling according to step g) of claim 1 is used.
27. The method according to any one of claims 1 to 26, wherein
the flatness of the strip and/or the temperature of the strip is measured at least at two locations in the strip treatment installation for monitoring the quality of the strip.
28. The method according to any one of claims 1 to 27, wherein
the running speed of the strip through the strip treatment installation, the in particular zone-related strip heating, the adjustment of the straightening rolls and/or the in particular zone-related cooling are controlled or regulated by a process model.
29. The method according to any one of claims 1 to 28, wherein
during passage through the strip treatment installation, the strip is held under a defined strip tension at least in sections by means of drivers.

2008267505 24 Dec 2009

30. The method according to any one of claims 1 to 29, wherein
a strip tension is built up by means of drivers before and after the cooling of the strip.
31. The method according to any one of claims 1 to 30, wherein
the strip is guided transversely to its longitudinal axis by means of a lateral guidance.
32. The method according to claim 31, wherein
the lateral guidance takes place in the area of the cooling of the strip.
33. The method according to claim 32, wherein
the lateral guidance takes place in the area of the laminar cooling of the strip.
34. The method according to claim 30 and one of claims 31 to 33, wherein
the lateral guidance of the strip takes place before the driver and opens after passing the strip head and closes at the strip end.
35. The method according to any one of claims 1 to 34, wherein
a measurement of the strip temperature is made by means of a low-temperature radiation pyrometer.
36. The method according to any one of claims 1 to 35, wherein
a measurement of the strip temperature is made before, inside and/or after the cooling and/or heating devices.



ERSATZBLATT (REGEL 26)

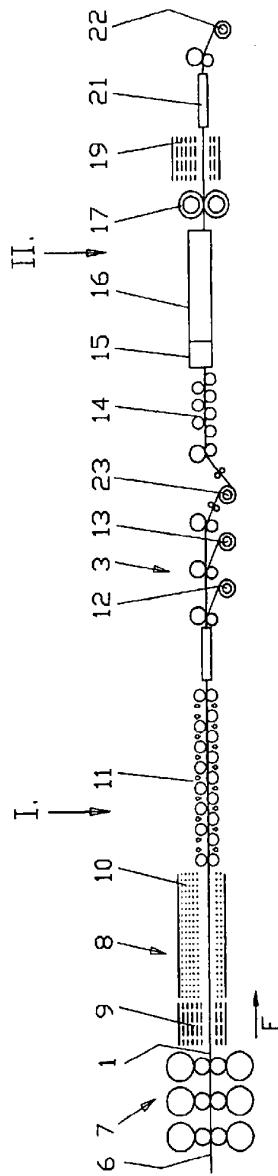


FIG. 2

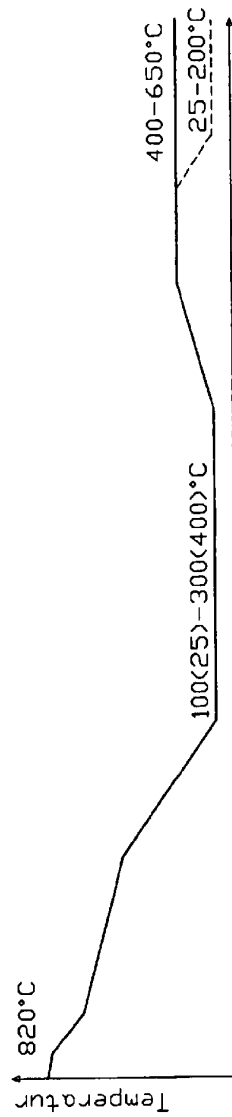
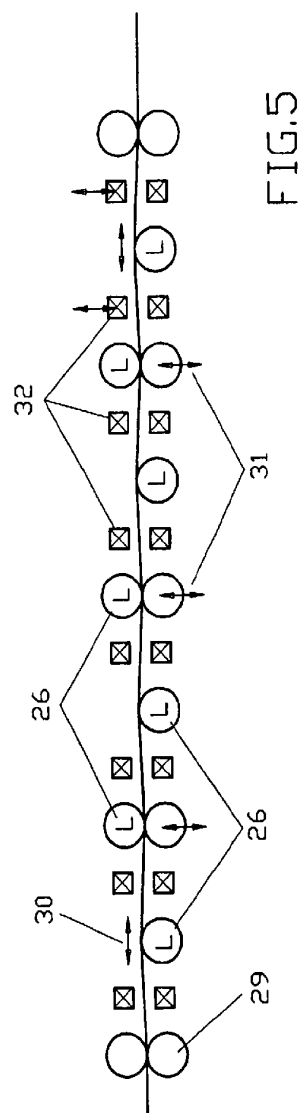
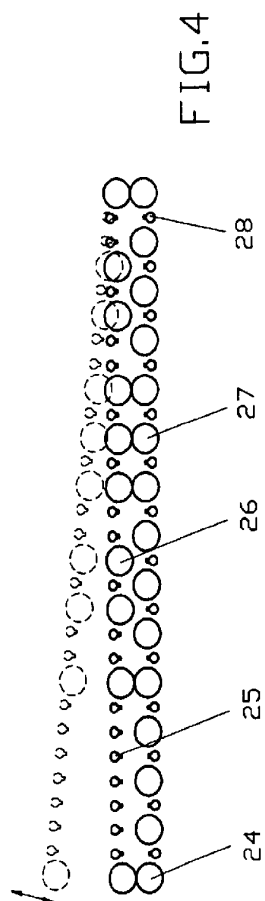


FIG. 3

ERSATZBLATT (REGEL 26)



ERSATZBLATT (REGEL 26)

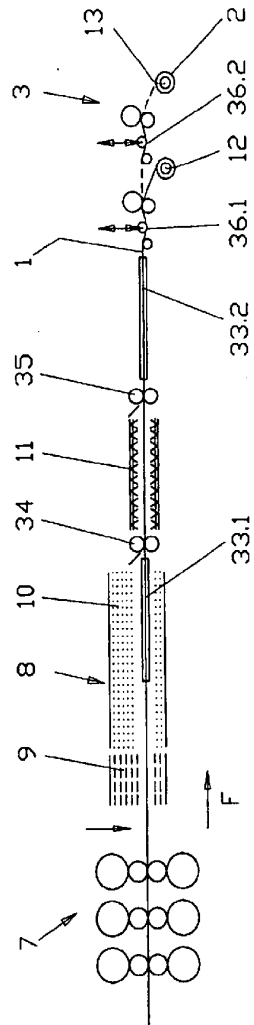


FIG. 6

ERSATZBLATT (REGEL 26)