

Description

The present invention relates to a process and relevant plant according to the precharacterising part of claim 1 and 3 respectively for producing coils of steel strips, having characteristics of a cold-rolled product and directly obtained in a hot-rolling line from a continuous casting with arc-shaped path and horizontal outlet.

It is known that for obtaining hot-rolled steel strip coils, the following operations are provided, successively:

- producing by casting a steel slab having a thickness of between 160 and 250 mm, and possibly storing the same;
- heating such a slab, if coming from the store, or in any case bringing it again to a rolling temperature of at least 1050°C;
- hot-rolling the slab for a first cogging and thereafter for obtaining hot-rolled strips having a minimum thickness of 2 mm;
- taking again the hot-rolled strip and subjecting the same to annealing for a reconstruction of the grain which has been deformed and become dishomogeneous during the preceding operations, in particular hot-rolling step;
- subjecting the product to pickling in order to eliminate from its surface the oxides previously formed, especially during annealing; and
- causing the actual cold-rolling step to be performed, which comprises mounting the coil onto an unwinding reel to bring again the strip onto a plane, causing the strip to pass through at least one cold-rolling stand until obtaining thicknesses of less than 1 mm, down to 0.5-0.2 mm and finally winding the strip on a reel to obtain the final coil.

It will be noted that the number of passes in the stands for cold-rolling depends on the desired final thickness and the reduction percentage which is to be obtained, in other words the ratio between thickness of the hot-rolled strip and thickness of the final product. For high values of such a percentage reduction it is not enough to increase the number of said passes, but it will be necessary to subject the strip to another annealing operation and the consequent pickling, otherwise the material hardens and the final product results to be of low quality.

Although it is possible to obtain by hot-rolling strips having a thickness of less than 2 mm, it is usually avoided to reach these values, as this type of processing is considered anti-economical, above all due to the reduced productivity that would be obtained in this case with a conventional rolling mill. The costs relating to the reduction of strip thickness are however extremely high in any case. Assuming 100 the cost of hot-rolling, starting from liquid steel, the cost of cold-rolling step alone is of at least 80.

Attempts have been described as to making plants for obtaining thin strips by means of more compact operating cycles with respect to the above-mentioned conventional cycle, in order to reduce complexity and duration of the latter. For example EP-A-226446 describes a number of hot-rolling examples, all in line and at a very high speed (not less than 1500 mm/min) but the final product not only has a thickness of 2-6 mm, falling thereby in the range of hot-rolling, but also certainly does not show the structural features of a cold-rolled product. The main purpose of this published application is in fact restricted to a high productivity while obtaining at the same time a product of good processability, but not of high quality.

In EP-370 575 there is described a method for the manufacture of a steel strip having a final thickness of between 0.5 and 1.5 mm, comprising the steps of hot-rolling a steel slab of less than 100 mm thickness, at a temperature of between 300°C and a temperature at which at least 75% of the material is converted into ferrite, with a thickness reduction of over 30% in at least one reduction stage, and an exit speed after hot-rolling of less than 1000 m/min, with final coiling of the strip after recrystallization. This was an attempt to avoid the two successive cycles of hot- and cold-rolling, with intermediate stages of annealing and pickling, but also this attempt has been unsuccessful, and it could not find success indeed, apart from the proposed solution, as in any case the inner structure of the material, when subjected to cold-rolling, is unsuitable to undergo this treatment for obtaining a final product of acceptable quality. This occurs owing to the fact that the inner structure, if not recrystallized before cold-rolling, results to be dishomogeneous under a dimensional aspect and with insufficiently fine grains, in comparison with the grain size which would be required by the conventional cold-rolling technology according to the above-described cycle.

It is known on the other hand that an excessive reduction of thickness with successive rolling stands on the same hot-rolling line gives rise to such a temperature decrease to go below the recrystallization point A_{r3} , at which the steel is no longer austenitic, whereby a subsequent annealing above A_{r3} restores the pre-existing structural situation without the benefits of grain reduction.

An attempt in improving the results obtained is disclosed in EP-A-0 306 076 representing the closest prior art according to which a first rolling step of the product in the austenitic region is followed by a subsequent rolling step in the ferritic region, with the two steps being separated by means of an intermediate cooling step. However, in order to produce high quality steel, recrystallization annealing and possibly pickling steps are required.

Instead it has been surprisingly found that if a

preliminary reduction of the thickness is carried out in a liquid core situation of the casting product immediately under the mould, followed by a further reduction of thickness at temperatures higher than 1100°C, the product entering the second rolling step shows an inner structure with fine grains, so uniformly distributed to have the characteristics of a material suitable to be cold-rolled. Therefore it has been thought that rolling up to thicknesses of less than 1 mm can be obtained with no need of annealing and pickling, as it can be in practice performed in line with the hot-rolling carried out upstream.

In this way a technical prejudice can be overcome, which is extremely common and deep-rooted both among those skilled in hot-rolling, and those, normally distinct therefrom, who are skilled in cold-rolling, since the material obtained in the hot-rolling line results to be suitable to cold-rolling, even if its temperature is caused to be lower than recrystallization point A_{r3} .

It was found to be important to reach such results, that during the first stage of hot-rolling in the austenitic region the temperature is kept as homogeneous as possible at about 1100°C by induction reheating, as disclosed in WO 89/11363.

Therefore it is an object of the present invention to provide a process and relevant plant for obtaining a cold-rolled product, of extremely thin thickness, directly starting from the hot-rolled product, being coupled thereto as to the speed and with no need of further treatment (such as annealing and pickling) on the material, thereby without any discontinuity in the manufacturing line.

This is obtained by means of a process according to the features of present claim 1 and a plant having the features of claim 3.

It should be appreciated that the expected temperature at the outlet from the controlled cooling device is always less than that of recrystallization point A_{r3} , which varies according to the carbon content in the steel, with a minimum of 690°C for 0.6% of carbon, up to a maximum of 900°C for lower or higher carbon contents. Therefore it is certain that the subsequent processing is actually a cold-rolling step, which is carried out on a material the inner structure of which has all the required characteristics in order that the cold-rolling operation is accomplished in the best way and the final product is provided, from a metallurgical point of view, with all the properties which are required to a cold-rolled product.

These and further objects, advantages and features of the process according to the present invention, as well as of the relevant plant, will be clear to those skilled in the art from the following detailed description of a preferred embodiment, given by way of a non-limiting example with reference to the annexed drawing showing a diagrammatic view of a plant according to the invention, useful to describe also the

process of the invention.

From a continuous casting mould 10, the steel flat product 1, driven and guided by a known-type roller path being arc-shaped, from an initially vertical direction, passes through the arc-shaped path formed by the rollers 11, to a horizontal direction. According to the present invention the thickness of the casting product 1 is firstly reduced in a condition of liquid core, for example in two distinct sections of rollers 13 and thereafter, upon solidification, but still at a temperature of about 1100°C, in a first stage of rolling 15 at the end of the bent path 11 and at the beginning of the horizontal path. Subsequently, in an induction oven 21 the flat product 1 is re-heated to bring it again to hot-rolling temperature, and then rolled in one or more rolling stands 27, between which there may be possibly provided additional induction ovens (not shown in the drawing) for maintaining the rolling temperature of at least 865°C at the outlet from the stand.

According to an embodiment of this first portion of the plant, immediately after the first rolling stage 15 there may be provided a shear 17 and before said stage 15 a discaling device 19 for eliminating scale from the surface of the product to be treated. Furthermore, between the induction oven 21 and the hot-rolling stands 27 there may be provided a winding and unwinding device 23 comprising a reel 22 for coiling the strip from oven 21, being coupled to a reel 24 for uncoiling the strip itself to be fed to stands 27, possibly after an additional discaling step in a suitable device 25 provided at the inlet of the first rolling stand.

The hot-rolled strip 1, at the outlet of the last rolling stand 27 at a temperature certainly higher than the recrystallization point A_{r3} , is caused to enter, still in the same production line, a cooling and temperature controlling apparatus 29, at the exit of which the strip has a temperature, controllable at each time, comprised in a range of between 250 and 600°C. It substantially consists of a water-based cooling device, for example of the so-called "laminar rain" type, being provided with a temperature detector with a feed-back controlling the valves for feeding water into the device. The value of temperature to be fixed for strip 1 at the inlet of the subsequent cold-rolling stage, with deviations of not more than 20°C, will depend on the type of steel (carbon content, etc.), the feeding speed of the strip and its thickness, but in any case it will be less than the temperature at the recrystallization point A_{r3} , which varies between 900°C and a minimum of 690°C for a carbon content of 0.6%. As the maximum temperature provided at the outlet of apparatus 29, thereby at the inlet of subsequent cold-rolling stage 31, is of 600°C, the strip is surely under the point A_{r3} , and thus at the best conditions to undergo the cold-rolling step, due to the fine grain structure of the material from the upstream treatment, absolutely suitable to be subjected to cold-rolling.

Such a rolling occurs in at least one stand, for ex-

ample of "six high" type, i.e. with six rolls mounted in vertical. The passes of cold-rolling may however be more than one, but all in series when providing a multiplicity of stands side by side, contrary to the method of providing for a multiplicity of subsequent passes in the same stands, as according to the conventional technology of cold-rolling.

Finally the cold-rolled strip, with a thickness of less than 1 mm, ready for use as it shows the typical microcrystalline features of a cold-rolled product, such as a homogeneous distribution of grains, is wound on a final coiler 33. The lower limit of the thickness that can be obtained in this way will be only dictated by the nip of the cold-rolling stands 31, as well as their precision, not certainly by problems of material hardening or anyhow deriving from its metallurgical structure.

Claims

1. A process for obtaining steel strip coils, having characteristics of cold-rolled product, being directly obtained in hot-rolling line, comprising the steps of:

- a) continuous casting at a thickness of less than 100 mm;
- b) induction re-heating up to a temperature as homogeneous as possible of about 1100°C;
- c) subjecting the flat product to a further stage of hot-rolling in the austenitic region;
- d) bringing the temperature of the product from the hot-rolling stage, still above point A_{r3} , to prefixable values lower than said point A_{r3} , preferably in the range between 600 and 250°C; and
- e) one or more cold-rolling steps in series, with final coiling of the strip-shaped product obtained, characterized by the fact that between said steps a) and b) said process comprises:
- f) a preliminary reduction of the thickness in a situation of liquid core of the casting product immediately under the mould; and
- g) a further reduction of thickness upon solidification of casting in a first stage of rolling at temperatures higher than 1100°C until values of 10-30 mm.

2. A process according to claim 1, further comprising one or more of the following steps:

- i) coiling and subsequent uncoiling of the strip immediately after the induction heating, upon cutting the strip immediately after the first rolling stage;
- ii) at least one discaling step;
- iii) additional heating between two further stages of hot-rolling.

3. A plant for obtaining steel strip coils, having characteristics of cold-rolled product, directly obtained in a hot-rolling line, comprising:

- a) a mould (10) for continuous casting of flat products (1) with a subsequent arc-shaped guide roller path (11);
- b) a device (21) for induction heating and homogenization of temperature along the cross-section of the flat product (1);
- c) at least one additional rolling stand (27);
- d) an apparatus (29) for cooling and controlling the temperature of product (1) until under point A_{r3} immediately downstream of the last hot-rolling stand (27);
- e) one or more cold-rolling (31); and
- f) a final coiler (33) for winding the strip in a coil (1'),

characterized by a first reduction device (13, 15) for reducing thickness of the flat product in the curved path in a condition of liquid core and/or immediately thereafter upon solidification of the product (1).

4. A plant according to claim 3, characterized in that said cooling apparatus (29) is a water cooling device provided with a temperature detector with feed-back for automatic controlling of the cooling water feeding valves.

5. A plant according to claim 3 or 4, characterized in that the range of variation of the temperatures at the exit of said cooling apparatus (29) is between 250 and 600°C, with a deviation of more or less 10°C from the prefixed value at the inside of said range according to the quality of steel, the feeding speed and the product (1) thickness.

6. A plant according to any of claims 3-5 further comprising a device (23) for winding and subsequently unwinding the strip immediately downstream of the induction oven (21), upstream of the latter there being provided a shear cutting device (17).

7. A plant according to any of claims 3-6, further comprising at least a discaling device (19, 25), respectively upstream of the first rolling stage (15) and downstream of said induction oven (21).

8. A plant according to any of claims 3-7, further comprising at least an additional induction oven intermediate between two subsequent rolling stands (27).

Patentansprüche

1. Verfahren zur Herstellung von Stahlbandcoils mit



ample of "six high" type, i.e. with six rolls mounted in vertical. The passes of cold-rolling may however be more than one, but all in series when providing a multiplicity of stands side by side, contrary to the method of providing for a multiplicity of subsequent passes in the same stands, as according to the conventional technology of cold-rolling.

Finally the cold-rolled strip, with a thickness of less than 1 mm, ready for use as it shows the typical microcrystalline features of a cold-rolled product, such as a homogeneous distribution of grains, is wound on a final coiler 33. The lower limit of the thickness that can be obtained in this way will be only dictated by the nip of the cold-rolling stands 31, as well as their precision, not certainly by problems of material hardening or anyhow deriving from its metallurgical structure.

Claims

1. A process for obtaining steel strip coils, having characteristics of cold-rolled product, being directly obtained in hot-rolling line, comprising the steps of:

- a) continuous casting at a thickness of less than 100 mm;
- b) induction re-heating up to a temperature as homogeneous as possible of about 1100°C;
- c) subjecting the flat product to a further stage of hot-rolling in the austenitic region;
- d) bringing the temperature of the product from the hot-rolling stage, still above point A_{r3} , to prefixable values lower than said point A_{r3} , preferably in the range between 600 and 250°C; and
- e) one or more cold-rolling steps in series, with final coiling of the strip-shaped product obtained, characterized by the fact that between said steps a) and b) said process comprises:
- f) a preliminary reduction of the thickness in a situation of liquid core of the casting product immediately under the mould; and
- g) a further reduction of thickness upon solidification of casting in a first stage of rolling at temperatures higher than 1100°C until values of 10-30 mm.

2. A process according to claim 1, further comprising one or more of the following steps:
 - i) coiling and subsequent uncoiling of the strip immediately after the induction heating, upon cutting the strip immediately after the first rolling stage;
 - ii) at least one discaling step;
 - iii) additional heating between two further stages of hot-rolling.

3. A plant for obtaining steel strip coils, having characteristics of cold-rolled product, directly obtained in a hot-rolling line, comprising:

- a) a mould (10) for continuous casting of flat products (1) with a subsequent arc-shaped guide roller path (11);
- b) a device (21) for induction heating and homogenization of temperature along the cross-section of the flat product (1);
- c) at least one additional rolling stand (27);
- d) an apparatus (29) for cooling and controlling the temperature of product (1) until under point A_{r3} immediately downstream of the last hot-rolling stand (27);
- e) one or more cold-rolling (31); and
- f) a final coiler (33) for winding the strip in a coil (1'),

characterized by a first reduction device (13, 15) for reducing thickness of the flat product in the curved path in a condition of liquid core and/or immediately thereafter upon solidification of the product (1).

4. A plant according to claim 3, characterized in that said cooling apparatus (29) is a water cooling device provided with a temperature detector with feed-back for automatic controlling of the cooling water feeding valves.

5. A plant according to claim 3 or 4, characterized in that the range of variation of the temperatures at the exit of said cooling apparatus (29) is between 250 and 600°C, with a deviation of more or less 10°C from the prefixed value at the inside of said range according to the quality of steel, the feeding speed and the product (1) thickness.

6. A plant according to any of claims 3-5 further comprising a device (23) for winding and subsequently unwinding the strip immediately downstream of the induction oven (21), upstream of the latter there being provided a shear cutting device (17).

7. A plant according to any of claims 3-6, further comprising at least a discaling device (19, 25), respectively upstream of the first rolling stage (15) and downstream of said induction oven (21).

8. A plant according to any of claims 3-7, further comprising at least an additional induction oven intermediate between two subsequent rolling stands (27).

Patentansprüche

1. Verfahren zur Herstellung von Stahlbandcoils mit



Kaltwalzeigenschaften direkt in einer Warmwalzstraße, mit den Verfahrensschritten:

- a) kontinuierliches Gießen mit einer Dicke von weniger als 100 mm
- b) Wiedererwärmen durch Induktion so homogen wie möglich bis auf etwa 1100°C,
- c) erneutes Warmwalzen des flachen Produktes im austenitischen Bereich;
- d) Abkühlen des Produktes aus der Warmwalzstufe mit einer Temperatur überhalb des Punktes Ar_3 auf voreinstellbare Werte unterhalb des Punktes Ar_3 , vorzugsweise im Bereich zwischen 600 und 250° C; und
- e) einmaliges oder mehrmaliges Kaltwalzen in Reihe mit abschließendem Aufwickeln des bandförmigen Produktes,

gekennzeichnet dadurch, daß die Verfahrensschritte a) und b) darüber hinaus beinhalten:

- f) eine vorläufige Reduzierung der Dicke in einer Situation, in der ein flüssiger Kern des Gußstückes vorliegt, direkt unter der Gußform, und
- g) eine weitere Reduzierung der Dicke nach Verfestigung des Gußstückes in einer ersten Walzstufe bei Temperaturen höher als 1100° C bis auf Werte von 10-30 mm.

2. Verfahren nach Anspruch 1, mit weiterhin einem oder mehreren folgenden Verfahrensschritten:

- i) Aufwickeln und nachfolgendes Abwickeln des Bandes direkt nach der Induktionserwärmung nach dem Schneiden des Bandes direkt nach der ersten Walzstufe,
- ii) wenigstens einmaliges Entfernen von Zunder,
- iii) zusätzliches Erwärmen zwischen zwei Warmwalzstufen.

3. Anlage zur Herstellung von Stahlbandcoils mit Kaltwalzeigenschaften direkt in einer Warmwalzstraße mit:

- a) einer Gußform (10) zum kontinuierlichen Gießen eines flachen Produktes (1) mit einer nachfolgenden bogenförmigen Führungswalzbahn (11),
- b) einer Vorrichtung (21) zur Induktionserwärmung und Vergleichmäßigung der Temperatur entlang des Querschnitts des flachen Produktes (1),
- c) wenigstens einem zusätzlichen Walzgerüst,
- d) einem Gerät (29) zum Abkühlen und Regeln der Temperatur des Produktes (1) bis unterhalb des Punktes Ar_3 unmittelbar hinter dem letzten Warmwalzgerüstes (27),
- e) einer oder mehreren Kaltwalzen (31), und
- f) einer abschließenden Wickelmaschine (33) zum Aufwickeln des Bandes zu einer Rolle (1),

gekennzeichnet durch, eine erste Reduziervorrichtung (13, 15) zum Reduzieren der Dicke des flachen Produktes in einer Kurvenbahn im Zustand mit einem flüssigen Kern und/oder unmittelbar danach nach Verfestigung des Produktes (1).

4. Anlage nach Anspruch 3, dadurch gekennzeichnet, daß das Kühlgerät (29) eine Wasserkühlvorrichtung ist, die mit einem Temperaturdetektor mit einer Rückkoppelung zur automatischen Regelung der Kühlwasser-Einlaßventile ausgerüstet ist.
5. Anlage nach Anspruch 3 oder 4, dadurch gekennzeichnet, daß der Temperaturschwankungsbereich am Ausgang des Kühlgerätes zwischen 250° und 600° mit einer Abweichung von mehr oder weniger 10° C von dem festgelegten Wert innerhalb dieses Bereiches liegt, entsprechend der Qualität des Stahls, der Zuführgeschwindigkeit und der Produktdicke.
6. Anlage nach einem der Ansprüche 3 bis 5, mit einer Vorrichtung (23) zum Aufwickeln und nachfolgendem Abwickeln des Bandes unmittelbar nach dem Induktionsofen (21), vor dem eine Scherschneidvorrichtung (17) angeordnet ist.
7. Vorrichtung nach einem der Ansprüche 3 bis 6, mit wenigstens einer Vorrichtung (19, 25) zum Entfernen von Zunder vor dem ersten Walzgerüst (15) bzw. hinter dem Induktionsofen (21).
8. Vorrichtung nach einem der Ansprüche 3 bis 7, mit wenigstens einem Induktionsofen zwischen zwei aufeinanderfolgenden Walzgerüsten.

Revendications

1. Procédé de production de bobines de feuilles d'acier possédant les caractéristiques d'un produit laminé à froid, et directement obtenues d'un train de laminage à chaud, comprenant les étapes suivantes :
 - a) une coulée continue avec une épaisseur inférieure à 100 mm ;
 - b) un réchauffage par induction jusqu'à une température aussi homogène que possible d'environ 1100 °C ;
 - c) soumettre ensuite le produit plat à une opération de laminage à chaud dans la phase austénitique ;
 - d) porter la température du produit de la phase de laminage à chaud, encore au-dessus du point Ar_3 , à des valeurs pouvant être fixées au préalable, inférieures audit point Ar_3 , de préfé-



rence dans la plage de 600 à 250 °C ; et
e) une ou plusieurs étapes successives de laminage à froid, avec bobinage final du produit en feuille ainsi obtenu,

caractérisé en ce que, entre lesdites étapes a) et b), ledit procédé comprend :

f) une première réduction d'épaisseur lorsque le coeur du produit de coulée est encore fluide, immédiatement sous le creuset de coulée ; et

g) une seconde réduction d'épaisseur, lors de la solidification du produit de coulée dans une première phase de laminage à des températures supérieures à 1100 °C, jusqu'à des valeurs de 10 à 30 mm.

2. Procédé selon la revendication 1, comportant en outre une ou plusieurs des étapes suivantes :

- i) un enroulage suivi d'un déroulage de la feuille immédiatement après le chauffage par induction, en coupant la feuille immédiatement après la première étape de laminage ;
- ii) au moins une étape de décalaminage ;
- iii) un chauffage complémentaire entre deux autres étapes de laminage à chaud.

3. Installation de production de bobines de feuilles d'acier possédant les caractéristiques d'un produit laminé à froid, et directement obtenues sur un train de laminage à chaud, comprenant :

- a) une lingotière (10) pour la coulée en continu de produits plats (1) avec une sortie en arc de cercle (11) avec rouleaux de guidage ;
- b) un équipement (21) pour le chauffage à induction et l'homogénéisation de la température dans la section transversale du produit plat (1) ;
- c) au moins une cage de laminoir supplémentaire (27) ;
- d) un dispositif (29) pour le refroidissement et le contrôle de la température du produit (1) jusqu'en dessous du point Ar_3 immédiatement en aval de la dernière cage du laminoir à chaud (27) ;
- e) au moins un laminage à froid (31) ; et
- f) une bobineuse finale (33) pour enrouler la feuille en bobine (1'),

caractérisée par un premier équipement de réduction (13, 15) pour réduire l'épaisseur du produit plat dans la section curviligne, lorsque le coeur est encore fluide et/ou immédiatement après, à la solidification du produit (1).

4. Installation selon la revendication 3, caractérisée en ce que ledit dispositif de refroidissement (29) est un dispositif de refroidissement par eau doté d'un détecteur de température avec rétroaction pour la commande automatique des vannes d'alimentation en eau de refroidissement.

mentation en eau de refroidissement.

5. Installation selon la revendication 3 ou la revendication 4, caractérisée en ce que la plage de variation de température en sortie dudit dispositif de refroidissement (29) se situe entre 250 et 600 °C, avec un écart de plus ou moins 10 °C par rapport à la valeur de consigne dans ladite plage, en fonction de la nuance d'acier, de la vitesse du train et de l'épaisseur du produit (1).

6. Installation selon l'une quelconque des revendications 3 à 5, comportant en outre un dispositif (23) d'enroulage puis de déroulage de la feuille immédiatement en aval du four à induction (21), un équipement de cisaille (17) étant prévu en amont de ce dernier.

7. Installation selon l'une quelconque des revendications 3 à 6, comportant en outre au moins un équipement de décalaminage (19, 25), respectivement en amont de la première phase de laminage (15) et en aval dudit four à induction (21).

8. Installation selon l'une quelconque des revendications 3 à 7, comportant en outre au moins un four à induction supplémentaire intercalé entre deux cages de laminoir successives (27).