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(54) **A METHOD AND A DEVICE FOR CONTROLLING TAIL DIMENSIONS IN A ROLLING MILL**

VERFAHREN UND VORRICHTUNG ZUR REGLUNG DER ABMESSUNGEN EINES
WALZGUTENDES IN EINEM WALZWERK

PROCEDE ET DISPOSITIF DE REGULATION DES DIMENSIONS DE FIN D'EBAUCHE DANS UN
LAMINOIR

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Description

TECHNICAL FIELD

[0001] The present invention is related to method for controlling the dimensions of an elongated material rolled in a rolling mill comprising at least three mill stands arranged after each other, wherein a first stand is arranged upstream of a second stand, which is arranged upstream of a third stand, each of said stands comprising two spaced rolls, said elongated material being fed between the rolls of each stand by rotating the rolls, wherein an interstand tension is controlled between at least two of said stands. The invention is a control method for continuous and semi-continuous rolling mills for the production of profiles other than sheet or strip, that is, for hot rolling rod or bar profile of various types. More particularly the invention relates to dimensional control over the tail portion of the rolled material.

[0002] The present invention is further related to a device for controlling the dimensions of an elongated material rolled in a rolling mill.

BACKGROUND ART

[0003] In the rolling of metals to produce rod, bar and similar profiles other than strip or sheet, an alternating series of rolls are typically arranged in a train of mill stands grouped in rolling pairs. A rolling mill is usually arranged in three sections, with a roughing, intermediate and finishing section. Each pair of mill stands in a section usually consists of a first mill stand with rolls set, for example for horizontal rolling thus changing the vertical dimension, and the rolls of a second stand arranged perpendicular to the first stand, vertical in this example. Thus, the vertical dimension is reduced in the first stand and the horizontal dimension reduced in the second stand.

[0004] The rolls of each mill stand have a groove shaped in a specific profile. The depth of the groove and the gap between the rolls determines the resultant height of the rolled material. As the rolled material is deformed in the height dimension it also spreads out in a direction perpendicular to the height, the width dimension. The material spreads out in width, preferably to a specified degree. If the material spreads out beyond the contours of the groove, it is called overfill, and if it spreads less than groove contour it is called underfill. The term width is used hereafter to describe a diameter dimension of the rolled material that is parallel to the axis of the rolls of a mill stand.

[0005] The separation of the rolls in each mill stand and the relative speeds in each mill stand necessary to produce the right dimensions on the finished product are specified in a schedule before rolling starts. The dimensions of the rolled material may be changed in two ways, by changing the separation of the rolls, the roll gap, so deforming the rolled material to a greater or lesser ex-

tent. The other principal method is by adjusting the tension in the rolled material.

[0006] As the material passes between the mill stands, there exists a tension or compression in the length of material passing between any two mill stands. A tension in the rolled material between any two stands is described hereafter as an interstand tension. The physical dimensions of the rolled material, in particular the width, may be affected by changing the interstand tension. The interstand tension is changed by adjusting the speed of the rolls of a one mill stand relative to the rolls of a second mill stand.

[0007] The interstand tension in rolled material moving downstream towards a point of reference is known as back tension. Interstand tension in rolled material moving downstream away from a point of reference is called front tension. Methods are known for manipulating rolled material which use front tension and methods which use back tension. Adjustments to back tension are more commonly used as a control method because it is up to three times more effective in affecting the width dimension of rolled material than front tension. It is known for example from GB 2,009,974 to measure back tension and use that measurement to control roll speeds.

[0008] However improvement in rolling mill control systems is necessary to reduce the amount of rolled material produced with substandard dimensions. In the practice of semi-continuous hot rolling billets are rolled one at a time. The first part of the billet entering the rolling mill is known as the head end. Dimensional control is in need of improvement, and in particular over the final part of the rolled material, known as the tail end. As soon as the tail of the rolled material travelling between a first and a second mill stand leaves the first mill stand, the ability to provide dimensional control over the rolled material by using back tension between that pair of stands is lost. This makes it difficult to maintain dimensional accuracy for the tail of the material, which, depending on the distance between mill stands, may consist of many metres of material in every billet rolled. A method of controlling the dimensions of the tail of the rolled material is required.

SUMMARY OF THE INVENTION

[0009] The object of the invention is to control the width of the tail of the rolled material. A further object of the invention is to improve control over width of the tail of the rolled material in any section of the rolling mill.

[0010] These objects are achieved in that a tail of the rolled material is detected leaving the first stand, that after said detection, a back tension control between the first and the second stand is switched off for the period while the tail travels between the first stand and the second stand, and that a front tension control between the second and the third stand is switched on for the period while the tail travels between the first stand and the sec-

ond stand. Further developments of the control method according to the invention are characterised by the features of the additional claims 2 to 5.

[0011] The present invention is a method for controlling the width of a tail of the rolled material between any pair of mill stands in any part of a rolling mill. Control is switched to front tension for each successive pair of mill stands as the tail travels through a rolling mill. The present invention extends control over the width of the rolled material to the tail. Adjustments to increase or decrease interstand tension for the purpose of adjusting width of the tail of the rolled material by means of front tension may be made between any pair of mill stands using this method.

[0012] The advantage of this control method is that it reduces the amount of substandard rolled material in each rolled billet. A further advantage is that it may be applied to any pair of mill stands with the sole exception of the final pair of stands of a finishing section. A still further advantage is that this control method may be applied in any section of the mill, the roughing section, intermediate section or the finishing section. A yet still further advantage is that this method may be easily refitted to existing rolling mills because it requires measurement and control equipment only, and new mill stands with automatic roll gap separation for example are not required. A yet still further advantage of this method is that control throughout all sections of the mill means that smaller, fewer corrections required in the finishing section. It also means reduced wear of the rolls and guide rails due to rolled material that is more consistent in its dimensions.

[0013] The inventive device for controlling the rolling mill is more closely defined in the claims and the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] With reference to the enclosed drawings a more close description of embodiment examples of the invention follows hereunder:

[0015] In the drawings;

Fig 1 shows schematically a tail of a rolled material before passing through a first mill stand according to the invention.

Fig 2 shows schematically the tail of the rolled material after it has left a first mill stand according to the invention.

Fig 3 is a block diagram of the device for controlling the dimensions of an elongated material rolled in a rolling mill.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0016] The term width is used hereafter to describe a

diameter of a rolled material that is parallel to the axis of the rolls of a mill stand.

[0017] Figure 1 and 2 illustrates a part of the rolling mill comprising three mill stands 1, 2, 3. Each stand comprises two spaced, parallel rolls 4, 5. An elongated material 6 is fed between the rolls. A tail of the material has the reference numeral 7. The arrow 14 indicates the feeding direction.

[0018] Figure 3 illustrates a block diagram of a device according to the invention for controlling the dimensions of the elongated material. Means 8, 9, 10 are arranged for controlling the rotational speed of the rolls in each stand. These rotation means 8, 9, 10 are preferably formed by electric motors. A means 11 is arranged for controlling interstand tension between at least two of said stands. A means 12 is arranged for detecting a tail of the rolled material leaving said first stand. Said detection means 12 is connected to said interstand control means 11. Said control means 11 is arranged to, after having received a detection signal from the detection means, switch off a back tension control between the first 1 and the second stand 2 for the period while the tail 7 travels between the first stand and the second stand, and to switch on a front tension control between the second 2 and the third stand 3, arranged downstream of said second stand, for the period while the tail travels between the first stand and the second stand. Means 13 is arranged for measuring the width of the material between said second stand 2 and said third stand 3. The measuring means is connected to said interstand tension control means 11 in order to adjust the interstand tension based on the measured width. The measuring means 13 are arranged for substantially continuously determining the width of the rolled material after one or more mill stands. The means 8, 9, 10 are arranged for independently controlling the speed of the rolls of each mill stand. The means 12 are arranged for detecting tail position in any mill stand.

[0019] A control method according to the invention is carried out in a rolling mill that is equipped with measuring means for substantially continuously measuring and storing the width after a first mill stand and after a second mill stand of any pair of mill stands. The speed of each mill stand is independently controlled via a cascade system. The mill stand motors are also arranged with means for measuring the motor current in each mill stand, which is used to detect when a tail of rolled material leaves the roll gap of a mill stand. This is possible because motor current changes as the load in the mill stand changes due to the exit of the tail of the rolled material. Also other means are of course applicable for performing said detection, such as optical means and sensors.

[0020] The steps of a control method for the tail of the rolled material are as follows:

- the width of said rolled material is continuously measured after at least the second mill stand

- the tail of the rolled material is detected leaving the roll gap of the first mill stand,
- a signal is sent to the second mill stand, switching off back tension control for the period while the tail travels between the first mill stand and the second mill stand
- a signal is sent to the second mill stand switching on front tension control for the period that the tail travels between the first mill stand and the second mill stand.
- a measured change in width of said rolled material after the second mill stand that is out of tolerance results in a front tension adjustment to the speed of the second mill stand relative to the speed of a next mill stand downstream, to correct the measured difference in the width of the rolled material leaving the second mill stand while the tail travels between the first and second mill stand.
- the tail of the rolled material is detected leaving the roll gap of the second mill stand,
- a signal is sent resetting control to back tension between the first mill stand and the second mill stand in readiness for the head end of the next billet of rolled material.

[0021] Measurements of the height and width of the rolled material is preferably carried out using U-gauges manufactured by ABB Industrial Systems AB. Within the scope of the invention it is also possible to use optical equipment such as lasers or cameras to measure the diameters of the rolled material, or a combination of optical methods and mechanical sensors.

[0022] It should be noted that the description presented here above only should be considered as exemplifying for the inventive idea, on which the invention is built. Thus, it is obvious for a man skilled in the art that detailed modifications may be made without leaving the scope of the invention as defined by the claims.

Claims

1. A method for controlling the dimensions of an elongated material (6) rolled in a rolling mill comprising at least three mill stands (1, 2, 3) arranged after each other, wherein a first stand (1) is arranged upstream of a second stand (2), which is arranged upstream of a third stand (3), each of said stands comprising two spaced rolls (4, 5), said elongated material being fed between the rolls of each stand by rotating the rolls, wherein an interstand tension is controlled between at least two of said stands, **characterised in that** a tail (7) of the rolled material (6) is detected leaving the first stand, that after said detection, a back tension control between the first (1) and the second stand (2) is switched off for the period while the tail (7) travels between the first stand and the second stand, and that a front tension

control between the second (2) and the third stand (3) is switched on for the period while the tail travels between the first stand and the second stand.

2. A method according to claim 1, **characterised in that** the width of the material (6) is measured between said second (2) and the third stand (3), and that said interstand tension control is adjusted based on such measurements during both back tension control and front tension control.

3. A method according to claim 2, **characterised in that**:

- a measured difference in width of said rolled material (6) after the second stand (2) that is out of tolerance results in a front tension adjustment to the rotational speed of the rolls (4, 5) of said second stand relative to the rotational speed of the rolls (4,5) of said third stand (3), to correct the measured difference in the width of the rolled material leaving the second stand while the tail (7) travels between the first (1) and second stand (2).

4. A method according to claim 2 or 3, **characterised in that** changes are made to the rotational speed of the rolls (4, 5) of the second stand (2) using front tension control to correct any measured dimensional deviation of the rolled material (6) while the tail (7) of the rolled material travels between the first and second stand.

5. A method according to any of the preceding claims, **characterised in that**

- the tail of the rolled material (6) is detected leaving the roll gap of the second stand (2),
- a signal is sent resetting control to back tension between the first stand (1) and the second stand (2) in readiness for the head end of the next billet of rolled material.

6. A device for controlling the dimensions of an elongated material (6) rolled in a rolling mill comprising at least three mill stands (1, 2, 3) arranged after each other, wherein a first stand (1) is arranged upstream of a second stand (2), which is arranged upstream of a third stand (3), each of said stands comprising two spaced rolls (4, 5), wherein the device comprises means (8, 9, 10) for controlling the rotational speed of the rolls (4, 5) in order to feed the material between the rolls of each stand, means (11) for controlling interstand tension between at least two of said stands, **characterised in that** the device comprises means (12) for detecting a tail (7) of the rolled material leaving said first stand (1), that said detection means is connected to said inter-

stand control means (11), and that said control means (11) is arranged to, after having received a detection signal from the detection means (12), switch off a back tension control between the first (1) and the second stand (2) for the period while the tail (7) travels between the first stand and the second stand, and to switch on a front tension control between the second stand (2) and the third stand (3) for the period while the tail travels between the first stand and the second stand.

7. A device according to claim 6, **characterised in that** the device comprises means (13) for measuring the width of the material between said second stand (2) and said third stand (3), that the measuring means (13) is connected to said interstand tension control means (11) in order to adjust the interstand tension based on the measured width.

Patentansprüche

1. Verfahren zur Regelung oder Steuerung der Abmessungen von langgestrecktem Material (6), welches in einem Walzwerk gewalzt wird, welches mindestens drei Walzgerüste (1,2,3) enthält, die hintereinander angeordnet sind, wobei ein erstes Gerüst (1) stromaufwärts (in Walzrichtung vor) einem zweiten Gerüst (2) angeordnet ist, welches stromaufwärts eines dritten Gerüsts (3) angeordnet ist, wobei jedes der genannten Gerüste zwei voneinander beabstandete Walzen (4,5) enthält, und das langgestreckte Material durch die Walzen eines jeden Gerüsts durch Drehung der Walzen befördert wird, wobei die Zwischengerüst-Spannung zwischen mindestens zwei der genannten Gerüste geregelt oder gesteuert wird, **dadurch gekennzeichnet, daß** festgestellt wird, wann das hintere Ende (7) des Walzmaterials (6) das erste Gerüst verläßt, daß nach der genannten Feststellung eine Hinterspannungsregelung zwischen dem ersten (1) und zweiten Gerüst (2) für die Zeitdauer, während der das hintere Ende (7) zwischen dem ersten Gerüst und dem zweiten Gerüst wandert, abgeschaltet wird und daß eine Frontspannungsregelung zwischen dem zweiten (2) und dem dritten Gerüst (3) eingeschaltet wird für die Zeitdauer, während der das hintere Ende zwischen dem ersten und dem zweiten Gerüst wandert.
2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, daß** die Breite des Materials (6) zwischen dem genannten zweiten (2) und dritten Gerüst (3) gemessen wird und daß die genannte Zwischengerüst-Spannung in Abhängigkeit dieser Messung sowohl während der Hinterspannungsregelung als auch während der Frontspannungsregelung verstellt wird.

3. Verfahren nach Anspruch 2, **dadurch gekennzeichnet, daß** eine gemessene Breitendifferenz des genannten Walzmaterials (6) hinter dem zweiten Gerüst (2), welche Breitendifferenz außerhalb des Toleranzbereiches liegt, zu einer Frontspannungsanpassung der Rotationsgeschwindigkeit der Walzen (4,5) des genannten zweiten Gerüsts relativ zu der Rotationsgeschwindigkeit der Walzen (4,5) des genannten dritten Gerüsts führt, um die gemessene Breitendifferenz des Walzmaterials, welches das zweite Gerüst verläßt, zu korrigieren, während das hintere Ende (7) zwischen dem ersten (1) und dem zweiten Gerüst (2) wandert.

4. Verfahren nach einem der Ansprüche 2 oder 3, **dadurch gekennzeichnet, daß** Änderungen der Rotationsgeschwindigkeit der Walzen (4,5) des zweiten Gerüsts (2) vorgenommen werden unter Anwendung der Frontspannungsregelung, um eine gemessene Abmessungsabweichung des Walzmaterials (6), während das hintere Ende (7) des Walzmaterials zwischen dem ersten und dem zweiten Gerüst wandert, zu korrigieren.

5. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet,**

- **daß** festgestellt wird, wann das hintere Ende des Walzmaterials (6) den Walzenspalt des zweiten Gerüsts (2) verläßt,
- und **daß** ein Signal erzeugt wird zur Zurückstellung auf Hinterspannungsregelung zwischen dem ersten Gerüst (1) und dem zweiten Gerüst (2), um für das Kopfende des nächsten Blocks aus Walzmaterial gerüstet zu sein.

6. Anordnung zur Regelung oder Steuerung der Abmessungen von langgestrecktem Material (6), welches in einem Walzwerk gewalzt wird, welches mindestens drei Walzgerüste (1,2,3) enthält, die hintereinander angeordnet sind, wobei ein erstes Gerüst (1) stromaufwärts (in Walzrichtung vor) einem zweiten Gerüst (2) angeordnet ist, welches stromaufwärts eines dritten Gerüsts (3) angeordnet ist, wobei jedes der genannten Gerüste zwei voneinander beabstandete Walzen (4,5) enthält, wobei die Anordnung Glieder (8,9,10) zur Regelung oder Steuerung der Rotationsgeschwindigkeit der Walzen (4,5) enthält, um das Material zwischen den Walzen eines jeden Gerüsts hindurch zu befördern, sowie ein Glied (11) zur Regelung oder Steuerung der Zwischengerüst-Spannung zwischen mindestens zwei der genannten Gerüste enthält, **dadurch gekennzeichnet, daß** die Anordnung ein Glied (12) enthält zur Feststellung, wann das hintere Ende 7 des Walzmaterials das erste Gerüst (1) verläßt, daß das genannte Feststellungsglied an das Zwischen-

gerüst-Spannungsregelglied (11) angeschlossen ist und daß das genannte Regelglied (11) so beschaffen ist, daß es, nachdem es das Feststellungssignal von dem Feststellungsglied (12) erhalten hat, die Hinterspannungsregelung zwischen dem ersten (1) und dem zweiten Gerüst (2) abschaltet für die Zeitdauer, während der das hintere Ende (7) zwischen dem ersten Gerüst und dem zweiten Gerüst wandert, und eine Frontspannungsregelung zwischen dem zweiten Gerüst (2) und dem dritten Gerüst (3) für die Zeitdauer einschaltet, während der das hintere Ende zwischen dem ersten Gerüst und dem zweiten Gerüst wandert.

7. Anordnung nach Anspruch 6, **dadurch gekennzeichnet, daß** die Anordnung ein Glied (13) zur Messung der Breite des Materials zwischen dem genannten zweiten Gerüst und dem genannten dritten Gerüst enthält, daß das Meßglied an das Zwischengerüst-Spannungsregelglied (11) angeschlossen ist, um die Zwischengerüst-Spannung in Abhängigkeit der gemessenen Breite anzupassen.

Revendications

1. Procédé pour se rendre maître des dimensions d'un matériau (6) oblong laminé dans un laminoir comprenant au moins trois cages (1, 2, 3) de laminoir disposées l'une après l'autre, une première cage (1) étant disposée en amont d'une deuxième cage (2) qui est disposée en amont d'une troisième cage (3), chacune des cages comprenant deux cylindres (4, 5) à distance, le matériau oblong étant chargé entre les cylindres de chaque cage en faisant tourner les cylindres, une tension entre cages étant commandée entre au moins deux des cages, **caractérisé en ce que** l'on détecte une fin du matériau (6) laminé quittant la première cage, **en ce qu'**après cette détection, on débranche une commande de tension arrière entre la première cage (1) et la deuxième cage (2) pendant le laps de temps pendant lequel la fin (7) passe entre la première cage et la deuxième cage, et **en ce que** l'on branche une commande de tension avant entre la deuxième cage (2) et la troisième cage (3) pendant le laps de temps pendant lequel la fin passe entre la première cage et la deuxième cage.
2. Procédé suivant la revendication 1, **caractérisé en ce que** l'on mesure la largeur du matériau (6) entre la deuxième cage (2) et la troisième cage (3), et **en ce que** l'on ajuste la commande de tension entre cages sur la base de mesures de ce genre, à la fois pendant la commande de tension arrière et pendant la commande de tension avant.
3. Procédé suivant la revendication 2, **caractérisé en**

ce que une différence mesurée de la largeur du matériau (6) laminé après la deuxième cage (2), qui est en dehors des tolérances, entraîne un ajustement de la tension avant sur la vitesse de rotation des cylindres (4, 5) de la deuxième cage par rapport à la vitesse de rotation des cylindres (4, 5) de la troisième cage (3) pour corriger la différence mesurée de largeur du matériau laminé quittant la deuxième cage alors que la fin (7) passe entre la première cage (1) et la deuxième cage (2).

4. Procédé suivant la revendication 2 ou 3, **caractérisé en ce que** l'on effectue des changements de la vitesse de rotation des cylindres (4, 5) de la deuxième cage (2) en utilisant la commande de tension avant pour corriger toute déviation de dimension mesurée du matériau (6) laminé alors que la fin (7) du matériau laminé passe entre la première cage et la deuxième cage.

5. Procédé suivant l'une quelconque des revendications précédentes, **caractérisé en ce que** :

- on détecte la fin du matériau (6) laminé quittant l'emprise de la deuxième cage (2),
- on envoie un signal de remise à l'état initial de la commande à la tension arrière entre la première cage (1) et la deuxième cage (2) afin de se préparer à l'extrémité de tête de la billette suivante du matériau laminé.

6. Dispositif pour se rendre maître des dimensions d'un matériau (6) oblong laminé dans un laminoir comprenant au moins trois cages (1, 2, 3) de laminoir disposées l'une après l'autre, une première cage (1) étant disposée en amont d'une deuxième cage (2) qui est disposée en amont d'une troisième cage (3), chacune des cages comprenant deux cylindres (4, 5) à distance, le dispositif comprenant des moyens (8, 9, 10) de commande de la vitesse de rotation des cylindres (4, 5) afin de charger le matériau entre les cylindres de chaque cage, des moyens (11) de commande de la tension entre cages entre au moins deux des cages, **caractérisé en ce que** le dispositif comprend des moyens (12) de détection d'une fin (7) du matériau laminé quittant la première cage (1), **en ce que** les moyens de détection sont reliés aux moyens (11) de commande de la tension entre cages, et **en ce que** les moyens (11) de commande sont disposés de façon à ce que, après avoir reçu un signal de détection des moyens (12) de détection, il débranche une commande de tension arrière entre la première cage (1) et la deuxième cage (2) pendant le laps de temps pendant lequel la fin (7) passe entre la première cage et la deuxième cage, et il branche une commande de tension avant entre la deuxième cage (2) et la troisième cage (3) pendant un laps de

temps pendant lequel la fin passe entre la première cage et la deuxième cage.

7. Dispositif selon la revendication 6, **caractérisé en ce** dispositif comprend des moyens (13) de mesure de la largeur du matériau entre la deuxième cage (2) et la troisième cage (3), en ce que les moyens (13) de mesure sont reliés aux moyens (11) de commande de la tension entre cages afin d'ajuster la tension entre cages sur la base de la largeur mesurée.

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