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(54) **LOOPER-LESS SMART ROLLING IN LONG PRODUCT MILLS**

LOOPERLOSES INTELLIGENTES WALZEN IN WALZWERKEN FÜR LANGERZEUGNISSE

LAMINAGE INTELLIGENT SANS BOUCLEUR DANS DES LAMINOIRS À PRODUITS LONGS

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(73) Proprietor: **Primetals Technologies USA LLC**
Alpharetta, GA 30005 (US)

(72) Inventors:
- **MORGAN, Steven**
  Port Talbot SA13 1ES (GB)
- **PALFREMAN, Matthew D.**
  Charlton
  MA 01507 (US)
- **RICHES, Paul Barry**
  Paxton
  MA 01612 (US)

(74) Representative: **Metals@Linz**
Primetals Technologies Austria GmbH
Intellectual Property Upstream IP UP
Turmstraße 44
4031 Linz (AT)

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Description

[0001] The invention is related to the field of long product mills, and in particular to long product mills utilizing tensionless or loop-less smart rolling or a method thereof according to the preamble of claims 1 and 9.

[0002] Inter-stand tension is inherent in all long rolling mills. The physical manifestation of tension is the difference in speed from one rolling mill stand to the other, in theory the speed of each rolling mill stand is derived from the work being carried out, however due to differences in material spread, roll wear and stock control, the speed between two rolling mill stands in a long products mill is never 100% matched. This mismatch is called tension or compression as the material can be pushed and or pulled dependent on the error in speed between the two rolling mill stands.

[0003] In the early part of a rolling mill, tension control is managed using a minimum control tension system (MTC). The MTC calculates the speed and torque for each rolling mill stand allowing for speed adjustments. Such a control arrangement is described by JPS59118212A.

[0004] In the later part of the rolling mill, loopers are utilized that are natural breaks in the mill rolling process. A loop is formed to give an area of float or a buffer in the continuous process between two rolling stands. This loop can be pushed or pulled as the mill speed changes. If the loop grows or shrinks out of a preset position the rolling mill stands can adjust their speeds accordingly in an attempt to maintain equilibrium.

[0005] The theory being that with the looper in the ideal or dead band position, an error in speed between the rolling mill stands is compensated for and the process remains stable. A looper, however, never removes all tension or compression in the mill as by nature the true material speed is never known and the force of the push or pull is inherent in the material. Loopers include mechanical and electrics/automation (EA) equipment that has an added cost and they add length to the overall rolling mill further adding to the overall cost of a rolling mill line.

[0006] According to one aspect of the invention as claimed in claim 1, there is provided a rolling mill for producing rolling mill product. The rolling mill includes a rolling mill line that moves the rolling mill product. A plurality of rolling mill stands are coupled to the rolling mill line that receives the rolling mill product and rolls the rolling mill product. A plurality of speed measuring devices that are positioned in close proximity to each rolling mill stand, where each speed measuring device measures the speed of the rolling mill product as it passes the speed measuring devices. A control device receives information associated with the speed measuring devices and adjusts the speed of the rolling mill product for any speed differential that might exist between any of the rolling mill stands, wherein the speed differential is the difference between the actual speed of the rolling mill product with a calculated speed at a point on the rolling mill line.

[0007] According to another aspect of the invention, as claimed in claim 9, there is provided a method for producing rolling mill product in a rolling mill. The method includes providing a rolling mill line that moves the rolling mill product. Also, the method includes providing a plurality of rolling mill stands that are coupled to the rolling line that receives the rolling mill product and rolls the rolling mill product. A plurality of speed measuring devices are positioned in close proximity to each rolling mill stand, where each speed measuring device measures the speed of the rolling mill product as it passes the speed measuring devices. Furthermore, the method includes adjusting the speed of the rolling mill product for any speed differential that might exist between any of the rolling mill stands using a control device that receives information associated with the speed measuring devices, wherein the speed differential is the difference between the actual speed of the rolling mill product with a calculated speed at a point on the rolling mill line.

[0008] These and further advantageous aspects of the claimed invention will now be described in further detail with reference to the accompanying drawings..

FIG. 1 is a schematic diagram illustrating the looper-less rolling mill arrangement used in accordance with the invention; and

FIG. 2 is a schematic diagram illustrating another embodiment of the looper-less rolling mill arrangement used in accordance with the invention.

[0009] The invention describes a systematic approach that eliminates the need for a mechanical looper in a rolling mill and its associated control. The looper is replaced with a simple laser velocimetry system and/or camera arrangement where one laser is positioned in-between each individual rolling mill stand. This can include machines of multiple rolls but with one drive motor.

[0010] In the prior art, the tension and loop control systems work from a theoretical speed calculated from a theoretical working diameter. This diameter change is dependent on the process section being rolled. Furthermore, as the material is rolled in the rolling mill, its area is reduced and passes through each subsequent rolling mill stand at higher velocities. This complicates a looper design and control as enough buffer "storage" must be accounted for each looper to effectively support and control smaller product or sections sizes.

[0011] As an example, if a section in question is travelling at 15 m/s and the rolling stands in question have the ability to adjust at 2.5 m/s/s. Then the required loop storage for a speed differential of 3% would be 0.18m of material, from the initial start position or pass line to reach equilibrium.

[0012] The invention eliminates the need for the complications and limitations referenced above, as the actual product speed between rolling mill stands is measured with non-contact velocimetry. In the early part of the rolling mill line, speed measurements can be utilized as the rolling mill stands are positioned close to one another as the metallurgical process in the mill does not require water-quenching and/or equalization.

[0013] FIG. 1 shows an illustrative example of the looper-less rolling mill arrangement 2 used in accordance with the invention. The looper-less roll mill arrangement 2 includes a rolling mill line 4, rolling mill stands STD13 and STD14, cameras C12o, C13o and C14o, and output lasers L12o, L13o and L140. The rolling mill product is moved thru various points in the mill 2 using a rolling mill line 4 that passes thru a number of rolling mill stands. Each rolling mill stand STD13, STD14 includes a respective camera C12o, C13o, C14o and output laser L12o, L13o, L14o.

[0014] Each camera C12o, C13o, C14o is used as a visual tool to assess the quality of the rolling mill product, such as the height of a stock section for accurate control. Each laser L12o, L13o, L14o measures the true product speed of the rolling mill line 4 and compares this with the calculated speed at this point and makes the necessary speed adjustments to the rolling mill stand in question and the subsequent rolling mill stands if needed to balance the rolling process. The rolling mill stands are connected to a control system that allows for the speed adjustment at each rolling mill stand. Both the laser and the camera can share a common mount or enclosure.

[0015] In most rolling mills, the individual rolling mill stands are controlled from a master speed reference. This speed reference takes into consideration the calculated reduction in area achieved in each rolling mill stand, the roll diameter of each rolling mill stand, and the associated gear ratio.

[0016] The error can manifest itself due to slightly incorrect roll profiles or diameters, poor section control in the mill, or slight differences in the theoretical and actual gearbox ratios in the rolling mill stands. In the slower part of the rolling mill, a MTC (minimum tension control) system is utilized that leverages an iterative self-learning system to match the rolling mill stand speeds. Further upstream in the rolling mill, this iterative approach is not possible as the speed error grows and the risk of a rolling mill cobble increases.

[0017] The means for controlling this error in speed in most rolling mills in the prior art is the looper. The looper is effectively a mechanical piece of equipment that is controlled by a loop. The looper allows for a mismatch in equipment speed by giving the rolling mill product a buffer space to either grow a loop or collapse a loop to a setpoint with limits for loop growth or decay dependent upon process changes. The looper effectively balances any error in the rolling mill speed reference. A new speed reference is then sent to a control device in the mill to control the rolling speeds so as to ensure the speed of each rolling mill stand is correct relative to the one before it and/or after it. As one can theorize, the speed reference is a calculated value and is subject to error.

[0018] The invention eliminates the need for the mechanical looper and its associated control. The looper is replaced with a simple laser velocimetry system described herein. One laser is positioned in-between each individual rolling mill stand. This can include machines of multiple rolls but with one drive motor.

[0019] FIG. 2 shows an illustrative example of another embodiment of the looper-less rolling mill arrangement 20 used in accordance with the invention. The looper-less rolling mill arrangement 20 includes a rolling mill having a line 4, roll milling stands STD13 and STD14, input lasers L13i and L14i, and output lasers L13o and L140. Note the looper-less arrangement 20 is similar to the looper-less rolling mill arrangement 2 of FIG. 1. Each rolling mill stand STD13, STD14 includes a respective input laser L13i, L14i and output laser L13o, L14o. The input lasers L13i, L14i measure the incoming speed of the rolling mill product to its respective rolling stand STD13, STD14. The output lasers L13o, L14o measure the outgoing speed of the rolling mill product from its respective rolling stand STD13, STD14.

[0020] The incoming speeds and outgoing speeds of the rolling mill product at each rolling mill stand is compared to its theoretically controlled rolling speed as well as comparing the incoming speed and outgoing speed form a previous rolling mill stand.

[0021] Using the invention and tying the actual rolling mill product speed into the control device of a rolling mill, one could further improve the control of ancillary machines, such as head and tail crop shears, or achieve shorter crop lengths thus reducing metallic yield loss.

[0022] Moreover, the invention can allow the ring spacing at the laying head area of a rolling mill to be maintained perfectly from head to tail of a rolling mill product. Any change in product speed could be instantly adjusted using the lasers and cameras discussed herein. Moreover, the information provided by the cameras and lasers can be used to devise an intelligent mill system that requires less mechanical equipment. This can reduce the building length and any associated costs as well as the cost of maintaining less equipment, and the product quality is improved due to the overall increase in accurate seed control of the rolling mill.

[0023] Where metallurgical processes dictate larger inter-stand distance due to the necessity to quenching and equalization, then two non-contact gauges can be utilized, one at the exit of the first rolling mill stand and one at the entry to the subsequent rolling mill stand. This ensures any effects from quenching and resistance to forward motion is accounted by the control device.

[0024] Although the present invention has been shown and described with respect to several preferred embodiments thereof, various changes, omissions and additions to the form and detail thereof, may be made therein, without departing from the scope of the invention as defined by the appended claims.

Claims

1. A rolling mill for producing rolling mill product, said rolling mill comprising:

   a rolling mill line (4) that moves the rolling mill product;
   a plurality of rolling mill stands (STD13, STD14) that are coupled to the rolling mill line that receives the rolling mill product and rolls the rolling mill product;
   a plurality of speed measuring devices that are positioned in close proximity to each rolling mill stand, each speed measuring device measures the speed of the rolling mill product as it passes the speed measuring devices; and
   a control device that receives information associated with the speed measuring devices **characterized in that** said control device adjusts the speed of the rolling mill product for any speed differential that might exist between any of the rolling mill stands, wherein the speed differential is the difference between the actual speed of the rolling mill product with a calculated speed at a point on the rolling mill line.

2. The rolling mill of claim 1, wherein the speed measuring devices comprise a laser (L12o, L13i, L13o, L14i, L14o) and a camera (C12o, C13o, C14o).

3. The rolling mill of claim 2, wherein the camera (C12o, C13o, C14o) assesses the quality of the rolling mill product.

4. The rolling mill of claim 3, wherein the laser (L12o, L13i, L13o, L14i, L14o) measures the actual speed of the rolling mill product.

5. The rolling mill of claim 1, wherein the speed measuring devices comprise a plurality of lasers (L12o, L13i, L13o, L14i, L14o).

6. The rolling mill of claim 5, wherein the lasers (L12o, L13i, L13o, L14i, L14o) are arranged such that a selective number of the lasers is associated with each rolling mill stand (STD13, STD14).

7. The rolling mill of claim 6, wherein the selective number of the lasers (L12o, L13i, L13o, L14i, L14o) measure the incoming and outgoing speeds of the rolling mill product for its respective rolling mill stand (STD13, STD14).

8. The rolling mill of claim 1, wherein the control device increases or decreases the rolling speed of one or more rolling mill stands (STD13, STD14) to ensure the mill speeds are equalized to stabilize the rolling mill.

9. A method for producing rolling mill product in a rolling mill, said method comprising:

   providing a rolling mill line (4) that moves the rolling mill product;
   providing a plurality of rolling mill stands (STD13, STD14) that are coupled to the rolling line that receives the rolling mill product and rolls the rolling mill product;
   positioning in close proximity to each rolling mill stand a plurality of speed measuring devices, each speed measuring device measures the speed of the rolling mill product as it passes the speed measuring devices; and **characterized by**
   adjusting the speed of the rolling mill product for any speed differential that might exist between any of the rolling mill stands using a control device that receives information associated with the speed measuring devices, wherein the speed differential is the difference between the actual speed of the rolling mill product with a calculated speed at a point on the rolling mill line.

10. The method of claim 9, wherein the speed measuring devices comprise a laser (L12o, L13i, L13o, L14i, L14o) and a camera (C12o, C13o, C14o).

11. The method of claim 10, wherein the camera (C12o, C13o, C14o) assesses the quality of the rolling mill product.

12. The method of claim 10 or 11, wherein the laser (L12o, L13i, L13o, L14i, L14o) measures the actual speed of the rolling mill product.

13. The method of claim 9, wherein the speed measuring devices comprises a plurality of lasers (L12o, L13i, L13o, L14i, L14o).

14. The method of claim 13, wherein the lasers (L12o, L13i, L13o, L14i, L14o) are arranged such that a selective number of the lasers is associated with each rolling mill stand (STD13, STD14).

15. The method of claim 14, wherein the selective number of the lasers (L13i, L13o, L14i, L14o) measure the incoming and outgoing speeds of the rolling mill product for its respective rolling mill stand (STD13, STD14).

16. The method of claim 9, wherein the control device increases or decreases the rolling speed of one or more rolling mill stands (STD13, STD14) to stabilize the rolling mill.

Patentansprüche

1. Walzwerk zur Produktion von Walzerzeugnissen, wobei das Walzwerk Folgendes umfasst:

eine Walzwerklinie (4), die das Walzerzeugnis bewegt;
mehrere Walzgerüste (STD13, STD14), die mit der Walzwerklinie gekoppelt sind, die das Walzerzeugnis aufnehmen und das Walzerzeugnis walzen;
mehrere Geschwindigkeitsmessvorrichtungen, die in unmittelbarer Nähe zu den einzelnen Walzgerüsten positioniert sind, wobei jede Geschwindigkeitsmessvorrichtung die Geschwindigkeit des Walzerzeugnisses misst, wenn dieses die Geschwindigkeitsmessvorrichtungen passiert; und
eine Steuervorrichtung, die Informationen in Verbindung mit den Geschwindigkeitsmessvorrichtungen empfängt, **dadurch gekennzeichnet, dass** die Steuervorrichtung die Geschwindigkeit des Walzerzeugnisses für ein beliebiges Geschwindigkeitsdifferenzial anpasst, das zwischen beliebigen der Walzgerüste vorhanden sein kann, wobei das Geschwindigkeitsdifferenzial die Differenz zwischen der tatsächlichen Geschwindigkeit des Walzerzeugnisses und einer berechneten Geschwindigkeit an einem Punkt an der Walzwerklinie ist.

2. Walzwerk nach Anspruch 1, wobei die Geschwindigkeitsmessvorrichtungen einen Laser (L12o, L13i, L13o, L14i, L14o) und eine Kamera (C12o, C13o, C14o) umfassen.

3. Walzwerk nach Anspruch 2, wobei die Kamera (C12o, C13o, C14o) die Qualität des Walzerzeugnisses beurteilt.

4. Walzwerk nach Anspruch 3, wobei der Laser (L12o, L13i, L13o, L14i, L14o) die tatsächliche Geschwindigkeit des Walzerzeugnisses misst.

5. Walzwerk nach Anspruch 1, wobei die Geschwindigkeitsmessvorrichtungen mehrere Laser (L12o, L13i, L13o, L14i, L14o) umfassen.

6. Walzwerk nach Anspruch 5, wobei die Laser (L12o, L13i, L13o, L14i, L14o) so angeordnet sind, dass eine selektive Anzahl von Lasern mit den einzelnen Walzgerüsten (STD13, STD14) verknüpft ist.

7. Walzwerk nach Anspruch 6, wobei die selektive Anzahl der Laser (L12o, L13i, L13o, L14i, L14o) die eingehenden und ausgehenden Geschwindigkeiten des Walzerzeugnisses für ihr entsprechendes Walzgerüst (STD13, STD14) messen.

8. Walzwerk nach Anspruch 1, wobei die Steuervorrichtung die Walzgeschwindigkeit eines oder mehrerer Walzgerüste (STD13, STD14) erhöht oder verringert, um sicherzustellen, dass die Walzgeschwindigkeiten ausgeglichen werden, um das Walzwerk zu stabilisieren.

9. Verfahren zum Produzieren von Walzerzeugnissen in einem Walzwerk, wobei das Verfahren Folgendes umfasst:

Bereitstellen einer Walzwerklinie (4), die das Walzerzeugnis bewegt;
Bereitstellen von mehreren Walzgerüsten (STD13, STD14), die mit der Walzlinie gekoppelt sind, die das Walzerzeugnis aufnehmen und das Walzerzeugnis walzen;
Positionieren, in unmittelbarer Nähe zu jedem Walzgerüst, von mehreren Geschwindigkeitsmessvorrichtungen, wobei jede Geschwindigkeitsmessvorrichtung die Geschwindigkeit des Walzerzeugnisses misst, wenn dieses die Geschwindigkeitsmessvorrichtungen passiert; und
gekennzeichnet durch
Anpassen der Geschwindigkeit des Walzerzeugnisses für ein beliebiges Geschwindigkeitsdifferenzial, das zwischen beliebigen der Walzgerüste vorhanden sein kann, unter Verwendung einer Steuervorrichtung, die Informationen in Verbindung mit den Geschwindigkeitsmessvorrichtungen empfängt, wobei das Geschwindigkeitsdifferenzial die Differenz zwischen der tatsächlichen Geschwindigkeit des Walzerzeugnisses und einer berechneten Geschwindigkeit an einem Punkt an der Walzwerklinie ist.

10. Verfahren nach Anspruch 9, wobei die Geschwindigkeitsmessvorrichtungen einen Laser (L12o, L13i, L13o, L14i, L14o) und eine Kamera (C12o, C13o, C14o) umfassen.

11. Verfahren nach Anspruch 10, wobei die Kamera (C12o, C13o, C14o) die Qualität des Walzerzeugnisses beurteilt.

12. Verfahren nach Anspruch 10 oder 11, wobei der Laser (L12o, L13i, L13o, L14i, L14o) die tatsächliche Geschwindigkeit des Walzerzeugnisses misst.

13. Verfahren nach Anspruch 9, wobei die Geschwindigkeitsmessvorrichtungen mehrere Laser (L12o, L13i, L13o, L14i, L14o) umfassen.

14. Verfahren nach Anspruch 13, wobei die Laser (L12o, L13i, L13o, L14i, L14o) so angeordnet sind, dass eine selektive Anzahl von Lasern mit den einzelnen Walzgerüsten (STD13, STD14) verknüpft ist.

15. Verfahren nach Anspruch 14, wobei die selektive Anzahl der Laser (L13i, L13o, L14i, L14o) die eingehenden und ausgehenden Geschwindigkeiten des Walzerzeugnisses für ihr entsprechendes Walzgerüst (STD13, STD14) messen.

16. Verfahren nach Anspruch 9, wobei die Steuervorrichtung die Walzgeschwindigkeit eines oder mehrerer Walzgerüste (STD13, STD14) erhöht oder verringert, um das Walzwerk zu stabilisieren.

Revendications

1. Laminoir pour produire un produit de laminoir, ledit laminoir comprenant :

une ligne de laminoir (4) qui déplace le produit de laminoir ;
une pluralité de cages de laminoir (STD13, STD14) qui sont accouplées à la ligne de laminoir qui reçoit le produit de laminoir et lamine le produit de laminoir ;
une pluralité de dispositifs de mesure de vitesse qui sont positionnés à proximité immédiate de chaque cage de laminoir, chaque dispositif de mesure de vitesse mesurant la vitesse du produit de laminoir lorsqu'il passe par les dispositifs de mesure de vitesse ; et
un dispositif de commande qui reçoit des informations associées aux dispositifs de mesure de vitesse **caractérisé en ce que** ledit dispositif de commande ajuste la vitesse du produit de laminoir pour n'importe quel différentiel de vitesse qui pourrait exister entre des cages de laminoir quelconques, dans lequel le différentiel de vitesse est la différence entre la vitesse réelle du produit de laminoir et une vitesse calculée en un point sur la ligne de laminoir.

2. Laminoir selon la revendication 1, dans lequel les dispositifs de mesure de vitesse comprennent un laser (L12o, L13i, L13o, L14i, L14o) et une caméra (C12o, C13o, C14o).

3. Laminoir selon la revendication 2, dans lequel la caméra (C12o, C13o, C14o) évalue la qualité du produit de laminoir.

4. Laminoir selon la revendication 3, dans lequel le laser (L12o, L13i, L13o, L14i, L14o) mesure la vitesse réelle du produit de laminoir.

5. Laminoir selon la revendication 1, dans lequel les dispositifs de mesure de vitesse comprennent une pluralité de lasers (L12o, L13i, L13o, L14i, L14o).

6. Laminoir selon la revendication 5, dans lequel les lasers (L12o, L13i, L13o, L14i, L14o) sont agencés de telle sorte qu'un nombre sélectif des lasers soit associé à chaque cage de laminoir (STD13, STD14).

7. Laminoir selon la revendication 6, dans lequel le nombre sélectif des lasers (L12o, L13i, L13o, L14i, L14o) mesurent les vitesses d'entrée et de sortie du produit de laminoir pour sa cage de laminoir (STD13, STD14) respective.

8. Laminoir selon la revendication 1, dans lequel le dispositif de commande augmente ou diminue la vitesse de laminage d'une ou de plusieurs cages de laminoir (STD13, STD14) afin de garantir que les vitesses de laminoir soient égalisées afin de stabiliser le laminoir.

9. Procédé pour produire un produit de laminoir dans un laminoir, ledit procédé comprenant :

la fourniture d'une ligne de laminoir (4) qui déplace le produit de laminoir ;
la fourniture d'une pluralité de cages de laminoir (STD13, STD14) qui sont accouplées à la ligne de laminage qui reçoit le produit de laminoir et lamine le produit de laminoir ;
le positionnement à proximité immédiate de chaque cage de laminoir d'une pluralité de dispositifs de mesure de vitesse, chaque dispositif de mesure de vitesse mesurant la vitesse du produit de laminoir lorsqu'il passe par les dispositifs de mesure de vitesse ; et **caractérisé par** l'ajustement de la vitesse du produit de laminoir pour n'importe quel différentiel de vitesse qui pourrait exister entre des cages de laminoir quelconques à l'aide d'un dispositif de commande qui reçoit des informations associées aux dispositifs de mesure de vitesse, dans lequel le différentiel de vitesse est la différence entre la vitesse réelle du produit de laminoir et une vitesse calculée en un point sur la ligne de laminoir.

10. Procédé selon la revendication 9, dans lequel les dispositifs de mesure de vitesse comprennent un laser (L12o, L13i, L13o, L14i, L14o) et une caméra (C12o, C13o, C14o).

11. Procédé selon la revendication 10, dans lequel la caméra (C12o, C13o, C14o) évalue la qualité du produit de laminoir.

12. Procédé selon la revendication 10 ou la revendication 11, dans lequel le laser (L12o, L13i, L13o, L14i, L14o) mesure la vitesse réelle du produit de laminoir.

13. Procédé selon la revendication 9, dans lequel les dispositifs de mesure de vitesse comprennent une pluralité de lasers (L12o, L13i, L13o, L14i, L14o).

14. Procédé selon la revendication 13, dans lequel les lasers (L12o, L13i, L13o, L14i, L14o) sont agencés de telle sorte qu'un nombre sélectif des lasers soit associé à chaque cage de laminoir (STD13, STD14).

15. Procédé selon la revendication 14, dans lequel le nombre sélectif des lasers (L13i, L13o, L14i, L14o) mesurent les vitesses d'entrée et de sortie du produit de laminoir pour sa cage de laminoir (STD13, STD14) respective.

16. Procédé selon la revendication 9, dans lequel le dispositif de commande augmente ou diminue la vitesse de laminage d'une ou de plusieurs cages de laminoir (STD13, STD14) afin de stabiliser le laminoir.

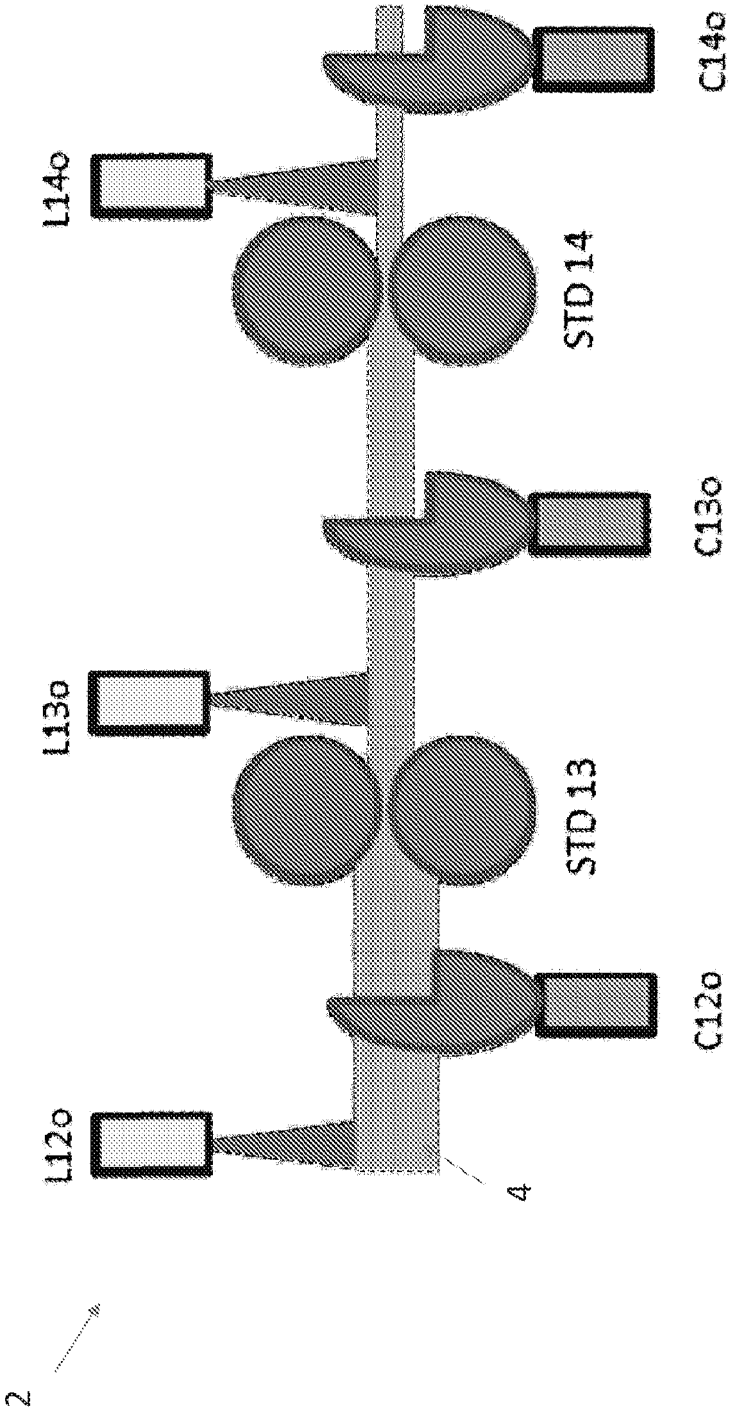

FIG. 1

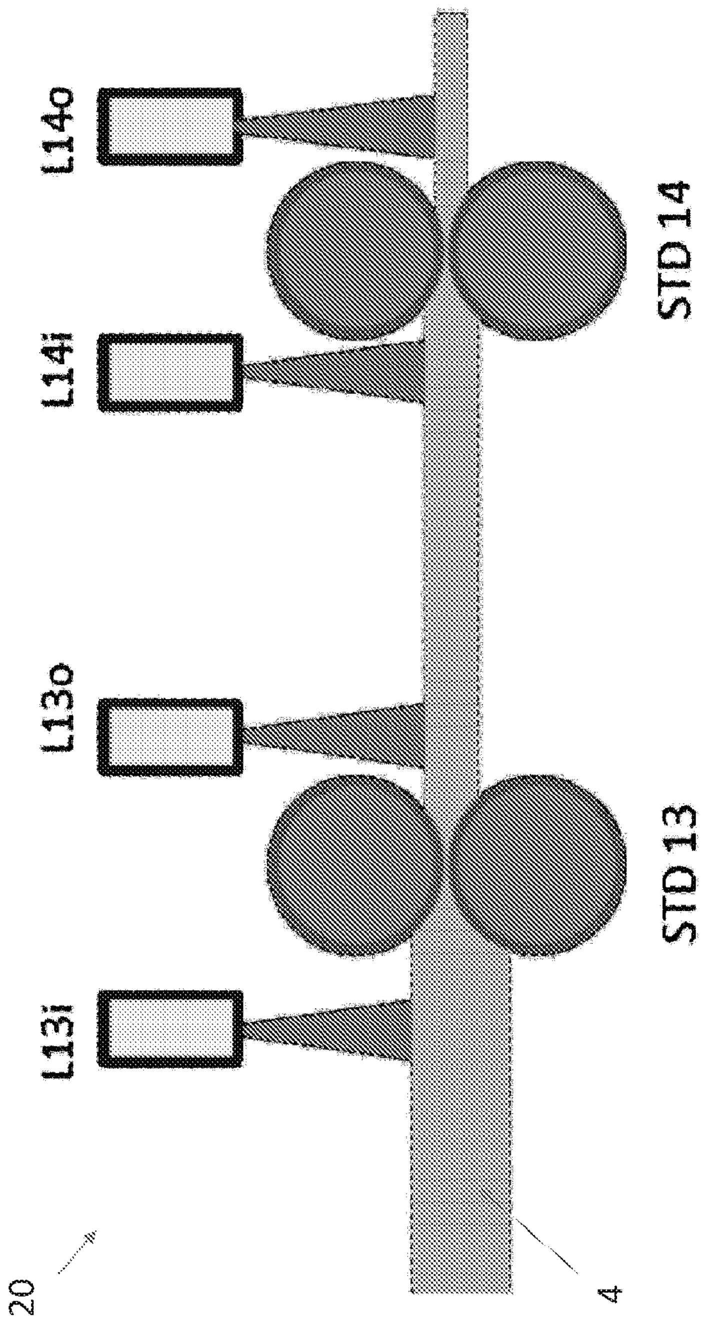

FIG. 2

REFERENCES CITED IN THE DESCRIPTION

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