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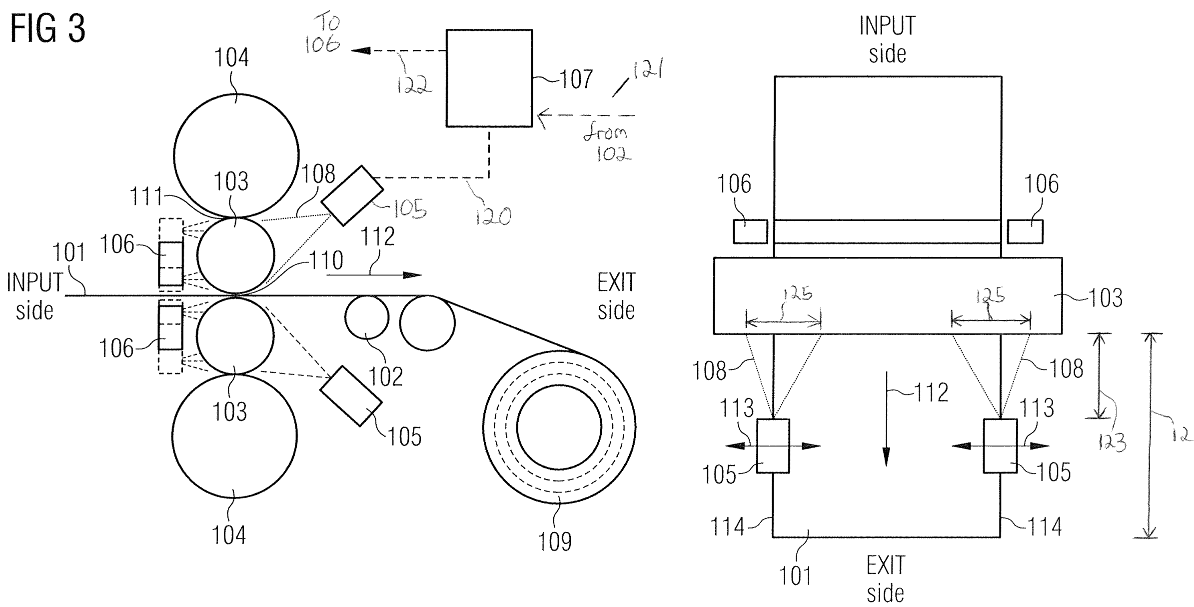
(54) Edge flatness monitoring

(57) A metallic strip edge flatness monitoring system for a rolling mill comprises one or more thermal imaging devices (105) arranged to monitor temperature or temperature variances across at least one region of interest (108, 115) in the rolling mill. The monitored temperature or temperature variances are input to a flatness control system (107) and a control signal (122) is generated in the flatness control system to modify actuation of actuators (106) in the rolling mill. The region of interest (108, 115) has a width (125) of less than half the width (126) of the metallic strip (101) and comprises a region on each side of the strip. The total width monitored is less than half the total width (126) of the metallic strip.

FIG 3



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Description

[0001] This invention relates to a metallic strip edge flatness monitoring system for a rolling mill, in particular for cold and foil ferrous and non-ferrous metal rolling mills.

[0002] On cold and foil aluminium rolling mills, strip edge flatness defects, in particular tight edges, or tight edges and loose pockets, caused by steep temperature gradients in the locale of the strip edge, reduce product quality, productivity and are the trigger to many strip breaks during rolling. In some cases fine tuning of the conventional actuators, like work roll bending and work roll cooling sprays, can be used to address the problem, but more often than not the effect of these actuators becomes limited with increased demand on productivity and quality.

[0003] There are actuators that exist, such as hot edge sprays and edge inductors that move the position of the temperature fall off on the work roll away from the strip edge by heating the rolls with hot sprays or electromagnetic induction in the periphery of the strip edges. However, these actuators are not operated to their full potential, as limitations in the accuracy and/or resolution of the flatness measurement devices at the strip edge restrict any high level automatic control.

[0004] Strip flatness for the whole width of the strip on aluminium rolling mills is most commonly measured with a flatness measurement roll. There are three dominant roll designs from three different manufacturers and although the measurement method differs, the concept is fundamentally the same. All three variations rely on being in contact with the strip on the entry, or exit side of the mill and they measure the strip pressure in defined zones across the strip width. The pressure in each zone is then converted to an equivalent strain to give an indication of strip 'shape', or flatness in that zone. The zones on the rolls are typically 50mm wide in the body of the strip and are reduced to 25 or 26mm wide in the locale of the strip edges for the desired strip width range. The shape signal is reported to a control system which then uses an appropriate actuator to correct the shape defect. The zoned regions on the flatness measurement roll are most useful when used in conjunction with cooling sprays. In this instance the control system regulates the amount of cooling applied to the work roll in the corresponding zones. To enable flatness control, the flatness measurement rolls average the signals from the sensors in each zone for that particular zone width and also take into account the signal from the adjacent zones.

[0005] There are problems with measuring the edge flatness because, depending on the particular strip width range for a rolling mill, the edge of the strip may lie on the flatness measurement roll, such that not enough of the zone is covered to provide an accurate output. This results in the signal at the strip edges being ignored by the control system and, in the case of tight edge loose pocket, the tight edge and loose pocket may fall on the same zone, so the phenomenon is inadvertently ignored by the control system and it is then left to the operator to make online visual inspections and correct accordingly.

[0006] In accordance with a first aspect of the present invention, a metallic strip edge flatness monitoring system for a rolling mill comprises one or more thermal imaging devices arranged to monitor temperature or temperature variances across at least one region of interest in the rolling mill; wherein the monitored temperature or temperature variances are input to a flatness control system; wherein a control signal is generated in the flatness control system to modify actuation of actuators in the rolling mill; wherein the region of interest has a width of less than half the width of the metallic strip; and wherein the region of interest comprises a region on each side of the strip and the total width monitored is less than half the total width of the metallic strip.

[0007] The present invention provides enhanced edge shape control and allows for faster production speeds

[0008] In one embodiment, the region of interest is on a periphery of one or more work rolls.

[0009] In this embodiment, the outer cylindrical surface of the work roll is monitored.

[0010] Preferably, the region of interest is on an input or exit side of the rolling mill.

[0011] When monitoring the periphery of the work roll, this can be done at either the input or exit side.

[0012] Preferably, the region of interest extends between a nip of the work rolls and a nip of a work roll and an adjacent support roll.

[0013] The length of the region of interest on either side may be up to half the circumference of the work roll.

[0014] In another embodiment, the region of interest is at an edge of the metallic strip exiting the work rolls.

[0015] In this embodiment, a region of the metallic strip exiting the work rolls is monitored.

[0016] Preferably, the region of interest has a length less than the length of the metallic strip between a nip of the work rolls and a strip re-coiler.

[0017] When the metallic strip is being monitored, the length of the region of interest does not extend beyond the strip recoiler.

[0018] Preferably, the system further comprises a fixed mount thermal imaging device with a field of view capable of measuring the temperature, or temperature variances, for all product width combinations in a particular application.

[0019] This is a particularly cost effective option.

[0020] Preferably, the system further comprises a mount for each thermal imaging device, each mount being adapted to allow transverse movement of the device across the width of the region of interest on the metallic strip.

[0021] Preferably, the device adjusts its transverse position in response from up to date information in the control system on the product being rolled.

[0022] This allows for better resolution and system response.

[0023] Preferably, the device adjusts its transverse position in response to edge position detected by the thermal imaging device.

[0024] This allows for fully automatic online edge control and also feedback position to other mill actuators.

[0025] Preferably, the system further comprises a flatness measurement device on the exit side of the rolling mill.

[0026] Preferably, the actuators comprise at least one of hot edge spray controllers and inductor controllers.

[0027] Preferably, both temperature and temperature variance are monitored.

[0028] In accordance with a second aspect of the present invention, a method of monitoring strip edge flatness of a metallic strip in a rolling mill comprises measuring a temperature, or temperature variance across a region of interest using a thermal imaging device, wherein the region of interest has a width of less than half of the width of the strip; and wherein the region of interest comprises a region on each side of the strip and the total width monitored is less than half the total width of the metallic strip, the method further comprising deriving a control signal based on the measured temperature or temperature variance; and controlling operation of actuators in the rolling mill using the derived control signal to provide enhanced edge shape control.

[0029] In one embodiment, the temperature, or temperature variance, is measured on a periphery of one or more work rolls.

[0030] Preferably, the region of interest is on an input or exit side of the rolling mill.

[0031] Preferably, the region of interest extends between a nip of the work rolls and a nip of a work roll and an adjacent support roll.

[0032] In an alternative embodiment, the region of interest is at an edge of the metallic strip on an exit side the rolling mill.

[0033] Preferably, the temperature, or temperature variance, is measured over a section of length less than or equal to the length of the metallic strip between a nip of the work rolls and a strip re-coiler.

[0034] Preferably, the method further comprises a fixed mount thermal imaging device with a field of view capable of measuring the temperature or temperature variances for all product width combinations in a particular application.

[0035] Preferably, the method further comprises a mount for each thermal imaging device, each mount being adapted to allow transverse movement of the device across the width of the region of interest on the metallic strip.

[0036] Preferably, the device adjusts its transverse position in response from up to date information in the control system on the product being rolled.

[0037] This allows for better resolution and system response.

[0038] Preferably, the device adjusts its transverse position in response to edge position detected by the thermal imaging device.

[0039] This allows for fully automatic online edge control and also feedback position to other mill actuators.

[0040] Preferably, the method further comprises measuring flatness of the strip using a flatness measurement device on the exit side of the rolling mill.

[0041] Preferably, the method further comprises inputting signals from the flatness measurement device to the flatness control system to further modify the control signal to the actuators.

[0042] Preferably, both temperature and temperature variance are monitored.

[0043] An example of a metallic strip edge flatness monitoring system according to the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 illustrates a first known device for measuring entire strip flatness with temperature using infra-red sensors;

Figure 2 illustrates a second known device for measuring entire strip flatness with temperature using infra-red sensors;

Figure 3 illustrates a first example of a metallic strip edge flatness monitoring system for a rolling mill; and,

Figure 4 illustrates a second example of a metallic strip edge flatness monitoring system for a rolling mill.

[0044] In modem automation of rolling mills, certain control levels are defined. Level 1 covers basic automation, for example using programmable logic controllers. Level 2 covers process automation systems for process control, for example process models and diagnostics. Level 3 covers production automation, for production planning and control systems, for example shop floor and quality management. In a normal rolling mill environment flatness control sits in the level 1 category. However this is not exclusively where flatness control takes place.

[0045] The present invention makes use of thermal imaging devices in a particular way, in order to monitor strip edge flatness. Two examples of prior art systems that use thermal radiation to measure strip flatness, rather than using a flatness measurement roll as referred to above, are described below. DE2747729A1 describes, as shown in Fig. 1, a simple infra-red line scanning system with a scanning arrangement 11 which receives infra-red radiation representing the exit temperature of a strip 5, the radiation being reflected via a rotating mirror 12 to an infra-red sensor 13 mounted away from the strip to provide a signal for flatness control purposes. EP0376887B1, shown in Fig. 2, illustrates monitoring the exit strip temperature using an infra-red detector 32 to receive infra-red radiation 36 from a highly emissive blackened contact roll 30 that is in contact with the ribbon 28 downstream of a nip 11 between work rolls 10, 12. These methods are somewhat incomplete because to accurately measure and quantify real strip flatness from its worked temperature one requires, in addition to the temperature monitoring, an indication of the material thickness and temperature across the whole width on the entry, or input, side of the mill, the heat input from the mill and the output from the sprays and also knowledge of the varying roll geometry around its circumference for the length of the roll.

[0046] The prior art examples mentioned above are both concerned with determining temperature across the strip, acting as alternatives to the conventional contact roll pressure method. Neither of them focuses on the detection of strip edge flatness defects in order to reduce strip breaks and improve production rate and product quality. Furthermore, the methods in both prior art examples do not lend themselves for use on modem high speed rolling mills, particularly in the modem high speed aluminium strip rolling environment.

[0047] The present invention, applied in a high speed rolling mill, enables strip edge flatness defects to be determined by monitoring temperature gradient over a limited area of interest at the periphery of the path which is taken by the metallic strip. There are two methods of carrying out the monitoring. In a first method, a thermal imaging device is targeted at top or bottom, or both, surfaces of a work roll in the locale of the strip edges on the input or exit side of the mill. By continuously monitoring the cylindrical surface of the roll, the roll periphery, for any temperature variation between inboard and outboard sections of the strip passing through, feedback can be provided to a central processor to control the heat input and position of edge shape improvement actuators. Alternatively, imaging devices are targeted to map the temperature at the edges and inboard of the edges of the exiting strip in order to continuously monitor under worked and cool tight edges and over worked and hot loose pockets that fall inboard of the strip edge. The information obtained is then used to position and control the correct heat input with the edge improvement enhancement actuators, so that edge flatness improvement is provided by reducing the shape error.

[0048] In addition to the flatness control, the thermal imaging device can be used to accurately detect the strip edge position which to date is an ongoing concern. There are other strip edge sensing devices available ranging from fixed inductance detectors (the most expensive solution, but also the most accurate with an accuracy in the region of +/- 1mm), backlighting the strip and using a traversing, or fixed line scan cameras and light sources under the body, or strip, with motorised traversing photo electric cells above. When the photo electric cell has 50% shadow, or coverage, the cell is aligned with the strip edge. An encoder, or displacement guide, on the traversing mechanism reports the position to the mill control system.

[0049] To detect the strip edge the thermal imaging device senses the difference in temperature between the ambient surroundings outside of the strip and the edge of the worked strip. The image is then processed to report the position of the strip edge in relation to the device field of view and if a traversing type, by taking into account the traversed position from an encoder, or linear displacement sensor.

[0050] Specific examples of the system of the present invention are described in more detail in Fig.3. A rolling mill comprises a pair of work rolls 103, with corresponding adjacent support rolls 104 and edge shape enhancement actuators 106 at an input side of the work rolls. A metallic strip 101 which is being rolled passes in a direction of movement indicated by arrow 112 through the work rolls 103, over a flatness measurement roll 102 on an exit side of the mill and onto a strip re-coiler 109. One or more thermal imaging devices 105, capable of interpreting radiated heat from a body and converting that to electrical signals 120, e.g. an infra-red (IR) camera, are targeted at a region 108 on the periphery of one or both of the work rolls 103. The width 125 of the targeted region of the work rolls is less than half the width of the metallic strip passing through the work rolls. Addressing the problems of strip edge flatness can be done by monitoring a region of width equivalent to less than half the total width 126 of the metallic strip. In the example shown in Fig. 3, the sensors are positioned on the exit side of the mill, targeting the work roll 103 on that side, but they are not limited to this location and they could equally well be positioned to target the entry side of the mill, either instead of, or as well as the exit side ones. Furthermore, the length of the region being monitored may be limited to a length equivalent to or less than the length from the work roll nip 110 to a strip recoiler 109 on the exit side. The thermal imaging devices are typically mounted so that they can be moved in a transverse direction in order to adapt to the width of the strip being rolled.

[0051] The region of the work roll that can be used for temperature measurement is anywhere on the radial periphery of the work roll between the roll nip 110 and an interface 111 between the work roll 103 and any adjacent supporting roll 104. To compensate for all strip width variations the cameras 105 are able to automatically adjust their transverse position 113 by either sensing the strip edge 114 through temperature information received in the signals 120 from the thermal imaging devices 105, or recipe driven from strip width data from the mill control system. An alternative to sensors having variable positions is to have fixed sensors, but to use sensors 105 with a wide angle field of view, so that the edge of the strip for the particular strip width range is accommodated in the wider viewing angle and so the corresponding region of the work roll at which the camera is targeted.

[0052] The information received in the signals 120 from the thermal sensors is reported to the flatness control system 107 which then interprets the signals and if necessary, combines, or compares the thermal information signals with signals 121 received from the flatness measurement roll 102 and outputs a signal 122 to control the edge shape enhancement actuators 106. The actuators may be, for example, but not limited to, coolant sprays, shift, bend, hot edge spray, or edge inductors. The actuators are controlled in a manner to correct any edge flatness defects. The process is in the form of a substantially real-time feedback control loop, so during rolling the edge shape is continually monitored by the sensors and the actuators modified by the flatness control system to correct the shape of the strip edge.

[0053] Fig. 4 shows an example of an alternative system and method for monitoring strip edge flatness. Equivalent features have the same reference numbers as those in Fig. 3. As before, the metallic strip 101 which is being rolled passes in the direction of movement indicated by arrow 112 through the work rolls 103, over the flatness measurement roll 102 on an exit side of the mill and onto the strip re-coiler 109. However, in this example the one or more thermal imaging devices, or sensors, 105 are targeted to monitor the thermal profile of the metallic strip 101 in a defined region 115 about the strip edge 114 on the exit side of the mill, instead of targeting the radial periphery of the work roll 103. The invention is concerned with strip edge flatness, so the area of interest 115 has a width 125 which is less than half the width 126 of the metallic strip 101 and the total width of the strip whose edge is monitored in this area covers less than half the overall width 126 of the strip 101. For practical reasons, the length over which the strip edge is monitored is limited to being less than or equal to the length between the length between the work roll nip the strip re-coiler. The sensors 105 can be located to monitor the profile of the top or bottom of the edge of the strip 101, i.e. from above or below, at any point along the strip edge, between the work roll nip 110 and the strip re-coiler 109 and send signals 120 to the flatness control system 107. As the strip on the incoming side of the mill has had time to stabilise thermally and has not been immediately cold worked this method is not suitable for monitoring thermal radiation of the strip edge on the upstream, input, side of the roll nip.

[0054] The present invention provides automation of edge flatness control by using signals 120 fed from thermal imaging sensors 105 and optionally from the flatness measurement roll, to the level 1 mill control centre 107, where the sensors are directed at either the work rolls, or the metallic strip. The mill control centre is then able to generate signals 122 which are output to modify actuators 106 at the input to correct errors in the edge flatness. With an automated feedback system, improved edge flatness is achieved in combination with high speed operation.

Claims

1. A metallic strip edge flatness monitoring system for a rolling mill, the system comprising one or more thermal imaging devices (105) arranged to monitor temperature or temperature variances across at least one region of interest (108, 115) in the rolling mill; wherein the monitored temperature or temperature variances (120) are input to a flatness control system (107); wherein a control signal (122) is generated in the flatness control system to modify actuation of actuators (106) in the rolling mill; wherein the region of interest (108, 115) has a width of less than half the width of the metallic strip; and wherein the region of interest comprises a region on each side (114) of the strip (101) and the total width monitored is less than half the total width of the metallic strip.

2. A system according to claim 1, wherein the region of interest (108, 115) is on a periphery of one or more work rolls (103).

3. A system according to claim 1 or claim 2, wherein the region of interest (108, 115) is on an input or exit side of the rolling mill.

4. A system according to any preceding claim, wherein the region of interest (108, 115) extends between a nip (110) of the work rolls (103) and a nip (111) of a work roll and an adjacent support roll (104).

5. A system according to claim 1, wherein the region of interest (108, 115) is at an edge (114) of the metallic strip (101) exiting the work rolls.

6. A system according to claim 5, wherein the region of interest (108, 115) has a length (123) less than the length (124) of the metallic strip between a nip (110) of the work rolls (103) and a strip re-coiler (109).

7. A system according to any preceding claim, wherein the system further comprises a fixed mount thermal imaging device (105) with a field of view capable of measuring the temperature or temperature variances for all product width combinations in a particular application.

8. A system according to any preceding claim, wherein the system further comprises a mount for each thermal imaging device, each mount being adapted to allow transverse movement of the device across the width of the region of interest on the metallic strip.

9. A system according to claim 8, wherein the device (105) adjusts its transverse position (113) in response to up to date information in the control system (107) on the product being rolled.

10. A system according to claim 8 or claim 9, wherein the device (105) adjusts its transverse (113) position in response to edge position detected by the thermal imaging device (105).

11. A system according to any preceding claim, wherein the system further comprises a flatness measurement device (102) on the exit side of the rolling mill.

12. A system according to any preceding claim, wherein the actuators (106) comprise at least one of hot edge spray controllers and inductor controllers.

13. A system according to any preceding claim, wherein both temperature and temperature variance are monitored.

14. A method of monitoring strip edge flatness of a metallic strip in a rolling mill; the method comprising measuring a temperature, or temperature variance across a region of interest using a thermal imaging device (105), wherein the region of interest (108, 115) has a width (125) of less than half of the width of the strip; and wherein the region of interest comprises a region on each side of the strip and the total width monitored is less than half the total width (126) of the metallic strip (101), the method further comprising deriving a control signal (122) based on the measured temperature or temperature variance; and controlling operation of actuators (106) in the rolling mill using the derived control signal to provide enhanced edge shape control.

15. A method according to claim 14, wherein the temperature, or temperature variance, is measured on a periphery of one or more work rolls (103).

16. A method according to claim 15, wherein the region of interest (108, 115) is on an exit side of the rolling mill.

17. A method according to any of claims 14 to 16, wherein the region of interest (108, 115) extends between a nip (110) of the work rolls (103) and a nip (111) of a work roll (103) and an adjacent support roll (104).

18. A method according to claim 14, wherein the region of interest (108, 115) is at an edge of the metallic strip (101) on an exit side the rolling mill.

19. A method according to claim 18, wherein the temperature, or temperature variance, is measured over a section of length (123) less than or equal to the length (124) of the metallic strip (101) between a nip (110) of the work rolls (103) and a strip re-coiler (109).

20. A method according to any of claims 14 to 19, wherein the method further comprises a fixed mount thermal imaging device (105) with a field of view capable of measuring the temperature or temperature variances for all product width combinations in a particular application.

21. A method according to any of claims 14 to 20, wherein the method further comprises a mount for each thermal imaging device (105), each mount being adapted to allow transverse movement (113) of the device across the width (25) of the region of interest on the metallic strip (101).

22. A method according to claim 21, wherein the device (105) adjusts its transverse position (113) in response to up to date information in the control system (107) on the product being rolled.

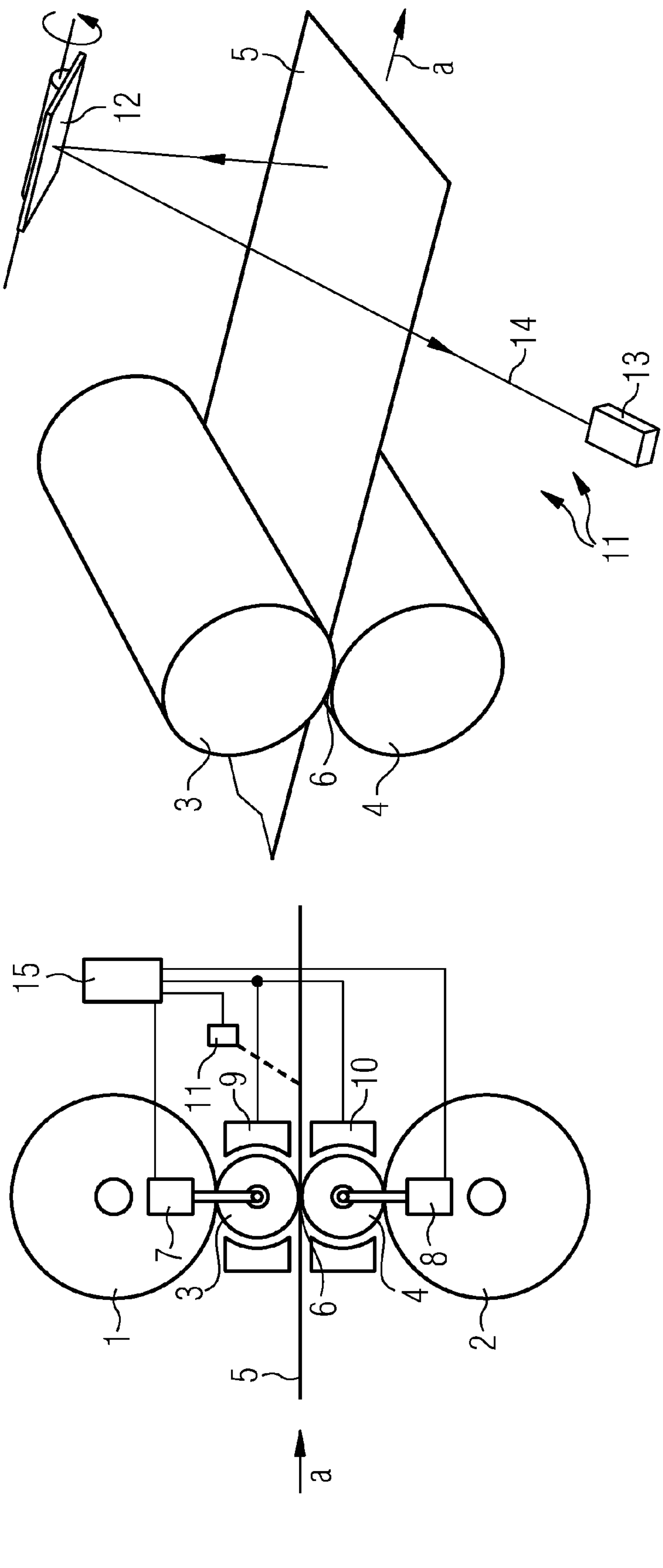
23. A method according to claim 21 or 22, wherein the device (105) adjusts its transverse position (113) in response to edge position detected by the thermal imaging device.

24. A method according to any of claims 14 to 23, wherein the method further comprises measuring flatness of the strip (101) using a flatness measurement device (102) on the exit side of the rolling mill.

25. A method according to claim 24, further comprising inputting signals (121) from the flatness measurement device (102) to the flatness control system (107) to further modify the control signal (122) to the actuators (106).

26. A method according to any of claims 14 to 25, wherein both temperature and temperature variance are monitored.

FIG 1



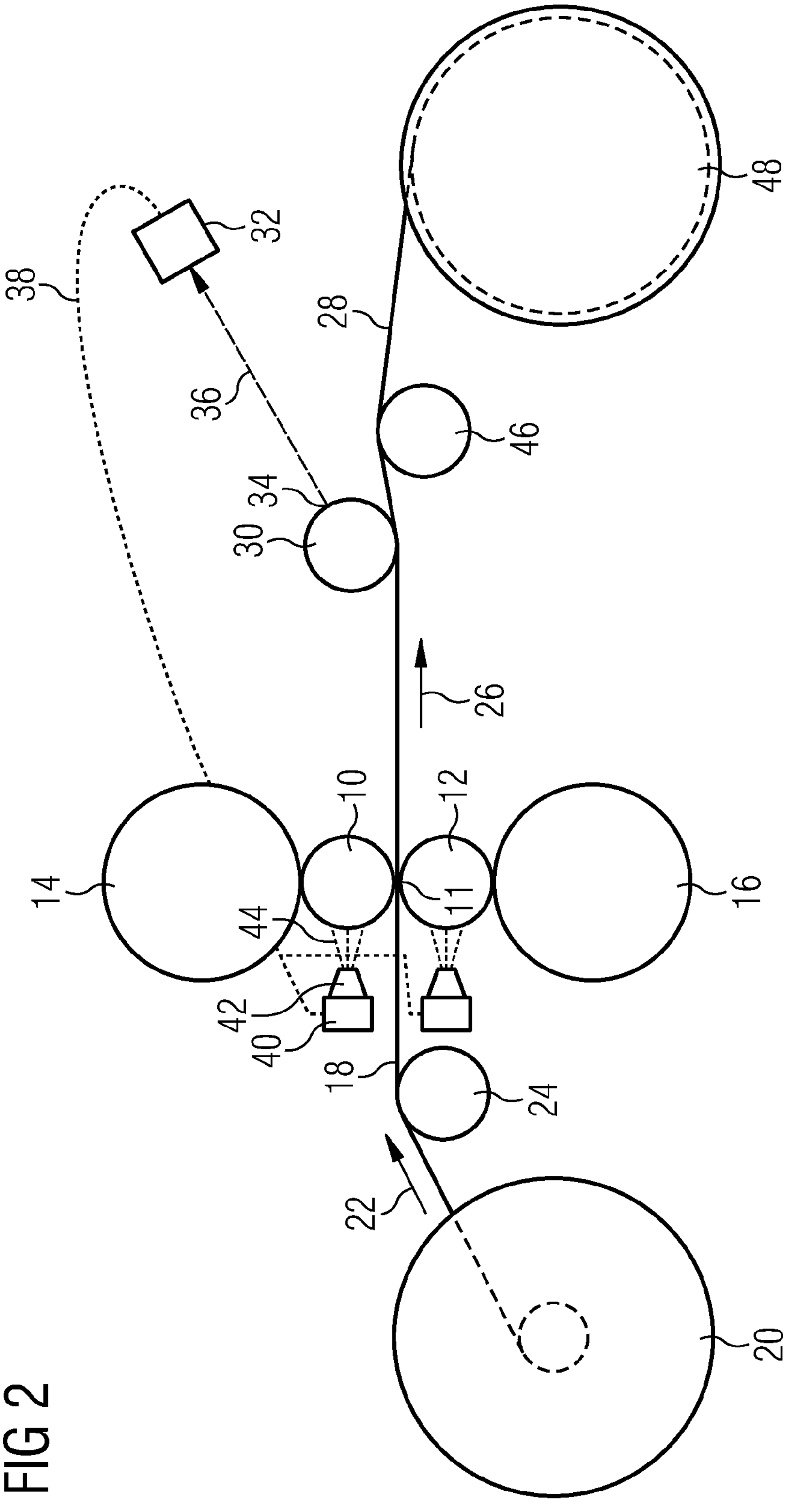
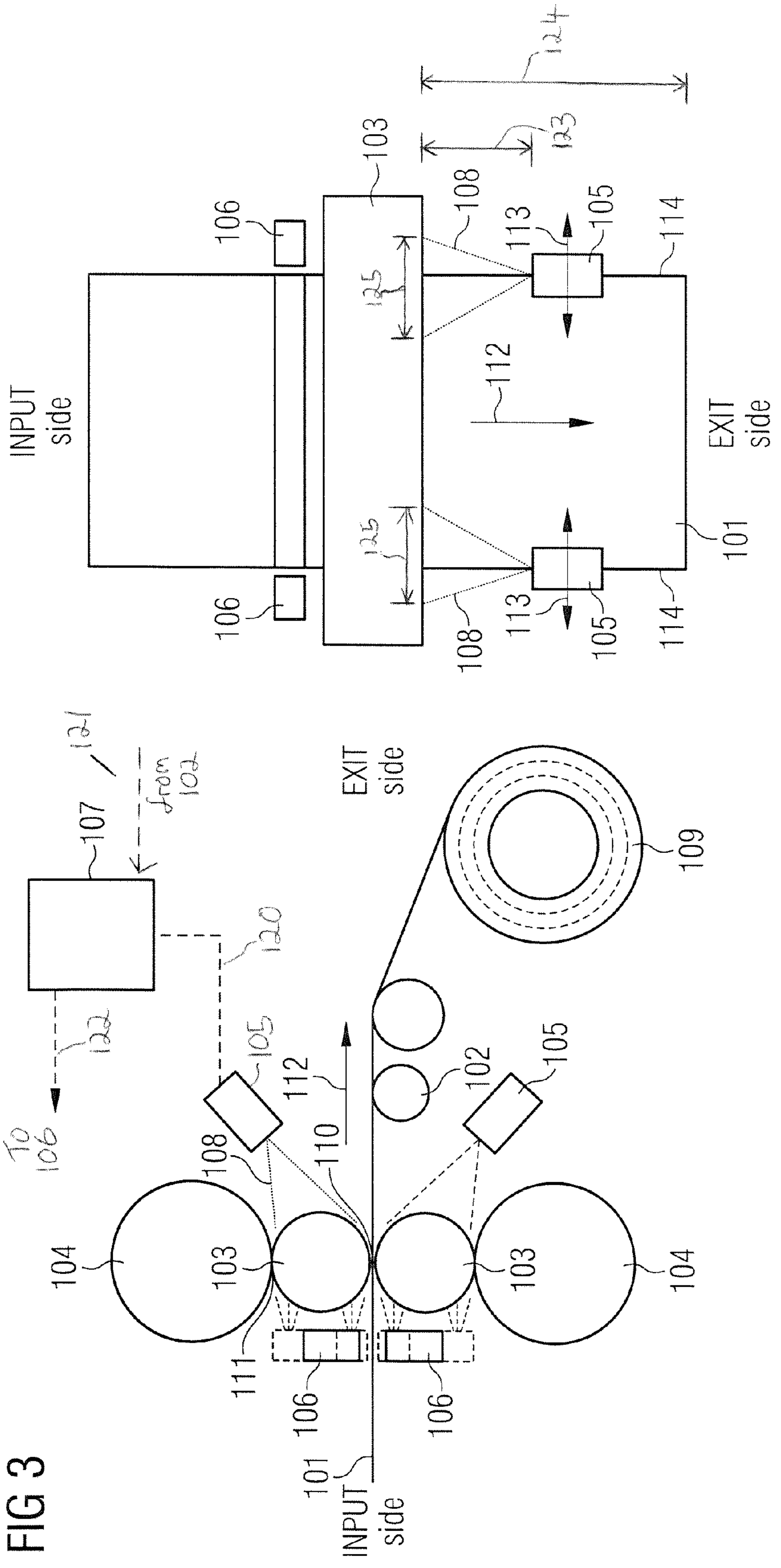
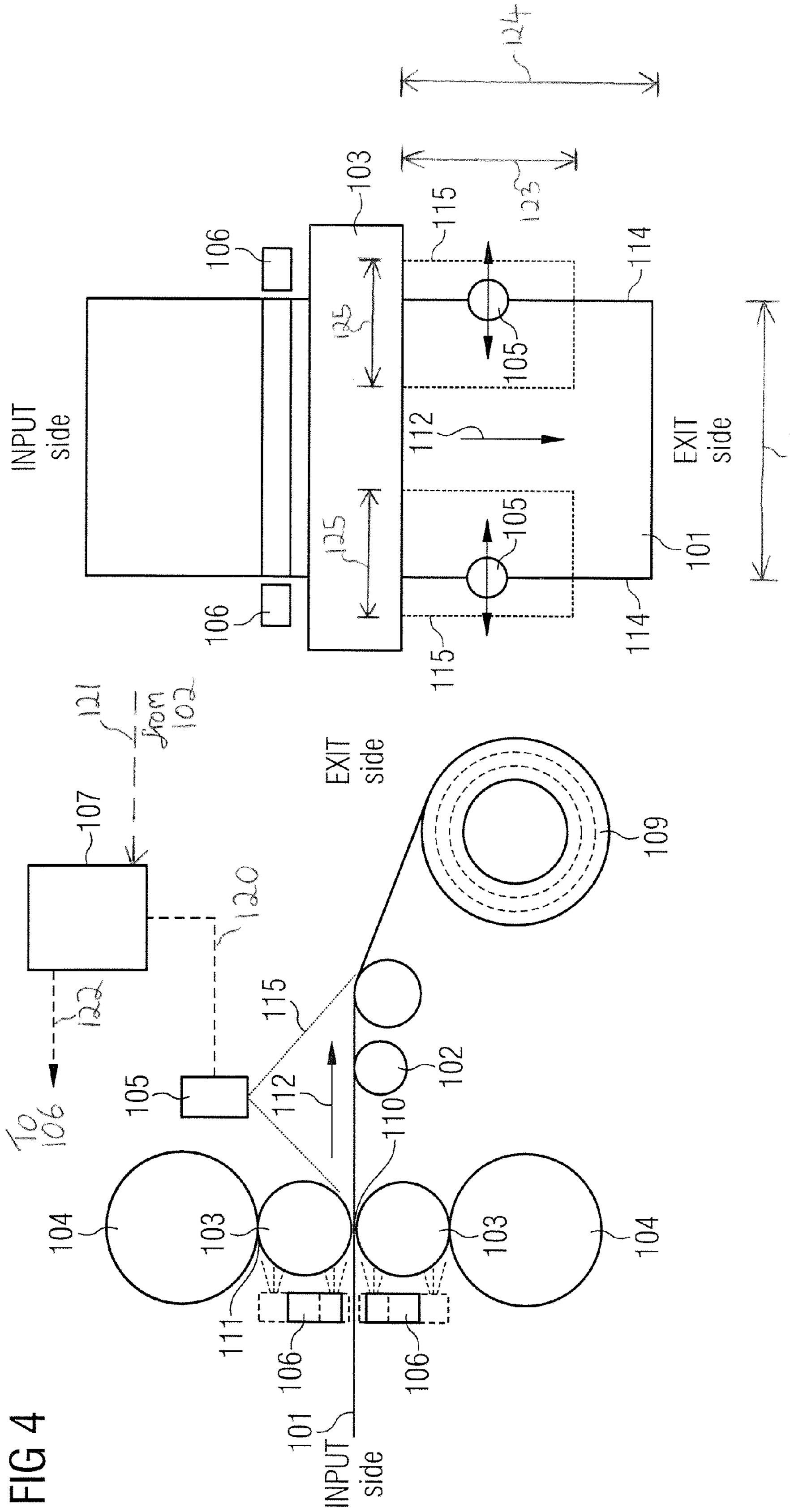


FIG 2

FIG 3



INPUT side
EXIT side
101
102
103
104
105
106
107
108
109
110
111
112
113
114
120
121
122
123
124
125
TO 106
from 102


INPUT side
EXIT side
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102
103
104
105
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107
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110
111
112
114
115
120
121
from 102
122
To 106
123
124
125
126

FIG 4

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EUROPEAN SEARCH REPORT

Application Number
EP 10 15 3818

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D A	DE 27 47 729 A1 (ACHENBACH BUSCHHUETTEN GMBH) 26 April 1979 (1979-04-26) * page 3, line 27 - page 4, paragraph 1; figures 1-2 *	1-13 14-26	INV. B21B37/32 G01J5/00
X,D A	EP 0 376 887 B1 (ALUSUISSE LONZA SERVICES AG [CH]) 14 July 1993 (1993-07-14) * claims 1,4,5; figure 1 *	1-13 14-26	
X A	US 3 990 284 A (BARTEN ERNST H) 9 November 1976 (1976-11-09) * claims 7-12; figures 1-4 *	1-13 14-26	
X A	GB 1 542 916 A (ACHENBACH BUSCHHUETTEN GMBH) 28 March 1979 (1979-03-28) * page 1, line 77 - page 2, line 88; figures 1-2 *	1-13 14-26	
			TECHNICAL FIELDS SEARCHED (IPC)
			B21B G01J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 July 2010	Forciniti, Marco

CATEGORY OF CITED DOCUMENTS

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Patent document cited in search report		Publication date	Patent family member(s)			Publication date
DE 2747729	A1	26-04-1979	DE	2349611	A1	10-04-1975
EP 0376887	B1	14-07-1993	DE	58904914	D1	19-08-1993
			EP	0376887	A1	04-07-1990
			US	4964289	A	23-10-1990
US 3990284	A	09-11-1976	FR	2246319	A1	02-05-1975
			GB	1465792	A	02-03-1977
GB 1542916	A	28-03-1979	DE	2554246	A1	16-06-1977
			FR	2333588	A2	01-07-1977

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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Patent documents cited in the description

- DE 2747729 A1 **[0045]**
- EP 0376887 B1 **[0045]**