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(54) IMPROVING THE FLATNESS OF A ROLLED STRIP

ERHÖHUNG DER FLACHHEIT EINES WALZBANDES

AMÉLIORATION DE LA PLANÉITÉ D'UNE BANDE LAMINÉE

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(73) Proprietor: **Novelis Inc.**
Atlanta, GA 30326 (US)

(72) Inventors:
- **NELSON, Paul David**
  North Bloomfield, OH 44450 (US)
- **GAENSBAUER, David Anthony**
  Atlanta, GA 30305 (US)
- **HOBBIS, Andrew James**
  Kennesaw, GA 30152 (US)

(74) Representative: **Weickmann & Weickmann PartmbB**
Postfach 860 820
81635 München (DE)

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Description

Cross Reference to Related Applications

[0001] The present application claims the benefit of U.S. Provisional Patent Application Ser. No. 61/776,241 filed March 11, 2013.

Technical Field

[0002] The present disclosure relates to systems and methods for improving the flatness of a metal strip. The present invention relates to the use of a system according to the preamble of claim 1 and a method according to the preamble of claim 9.

Background

[0003] Hot and cold rolling are metal forming processes in which stock sheets or strips are passed through a pair of rolls to reduce the thickness of the stock sheet or strip. In some cases, the rolled strips are processed or otherwise treated after rolling. For example, rolled strips may pass through a coating line to apply a coating of polymeric materials or other suitable coating to the rolled strips. After the coating is applied, the coated strip may be cured in an oven. In many cases, rolled strips emerge from the oven with center waves or other distortion along the strip that reduce the overall flatness of the strip. It is thus desirable to improve the flatness of the metal strip.

Summary

[0004] The term embodiment and like terms are intended to refer broadly to all of the subject matter of this disclosure and the claims below. Statements containing these terms should be understood not to limit the subject matter described herein or to limit the meaning or scope of the claims below. Embodiments of the present disclosure covered herein are defined by the claims below, not this summary. This summary is a high-level overview of various aspects of the disclosure and introduces some of the concepts that are further described in the Detailed Description section below. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used in isolation to determine the scope of the claimed subject matter. The subject matter should be understood by reference to appropriate portions of the entire specification of this disclosure, any or all drawings and each claim.

[0005] The present disclosure recites methods and systems for improving the flatness of a metal strip, including applying differential cooling across the width of a hot strip to improve the flatness of the strip. In some embodiments, a feedback control loop can be implemented including a flatness measurement device and a control system that controls the differential cooling. If used, the control system can make automatic, dynamic adjustments based on the flatness measurement of the differentially cooled strip.

[0006] The object of the present invention is therefore to provide a use of a system and a method improving the flatness of a metal strip.

[0007] This object is solved according to the invention by the use of a system according to claim 1 and the method according to claim 9. Preferred embodiments of the invention are described in the dependent claims.

[0008] Document WO2009/024644A1 discloses a system suitable for applying differential cooling across the width of a hot strip. The subject matter of the preamble of claim 1 and the preamble of claim 9 is disclosed in DE102007053523A.

Brief Description of the Drawings

[0009] The specification makes reference to the following appended figures, in which use of like reference numerals in different figures is intended to illustrate like or analogous components.

FIG. 1 is a schematic representation of a system for improving the flatness of rolled strips used in the present invention.
FIG. 2 is a schematic representation of a portion of a cooling unit.
FIG. 3 is a schematic representation of a nozzle having a continuous slot.
FIG. 4 is an isometric view of a sleeve.
FIG. 5 is an isometric view of a continuous slot nozzle having a sleeve.
FIG. 6 is a flow chart of a portion of a metalworking process including a feedback control loop for calculating and applying differential cooling.

Detailed Description

[0010] In the following embodiments of the invention are disclosed making references to the appended figures.

[0011] Disclosed herein are systems and processes for improving the flatness of a piece of rolled metal, hereinafter referred to as a "rolled strip" or a "strip." In some embodiments, a flatness measurement device is used to measure the flatness of a rolled strip. A control system can receive the flatness measurements and control a cooling unit that differentially cools the metal strip to create a desired non-homogenous temperature gradient across the width of the metal strip. The temperature gradient generates differential tensions in the strip, which are imparted while the metal strip is sufficiently hot and can improve the flatness of the metal strip.

[0012] FIG. 1 is a schematic representation of a system 100 for improving the flatness of rolled strips according to one embodiment. Metal can be rolled into a strip 102. The strip 102 can optionally be coated. As shown in FIG. 1, the strip 102, moving in a direction 104, passes through an oven 106. After passing through the oven 106, the strip 102 will be hot. The strip 102 then passes through a cooling unit 108. In the embodiment illustrated in FIG. 1, cooling unit 108 includes a plurality of nozzles 110 that distribute any suitable cooling agent 112 (also referred to as a cooling medium) onto the strip 102. After passing through the cooling unit 108, the strip 102 passes through a flatness measuring device 114. The flatness measuring device 114 determines the flatness of the strip 102 and provides a flatness signal 116 to a control system 118. The control system 118 then determines the desired cooling profile and provides a cooling signal 120 to the cooling unit 108. Based on the cooling signal 120, the cooling unit 108 can control, and adjust if needed, the application of cooling agent 112, as described in further detail below.

[0013] FIG. 2 is a schematic representation of a portion of a cooling unit 108. The cooling unit 108 is configured to provide differential cooling across the width 202 of the strip 102 to reduce center waves of the strip 102. The cooling unit 108 can be part of the cooling section of a continuous process line, although the differential cooling may be applied at any other suitable point during the metalworking process for rolled metals. In some embodiments, the cooling unit 108 is positioned at a point in the process line so that differential cooling is applied as the strip 102 exits the oven 106 of the coating line, although the cooling unit 108 can be otherwise positioned so differential cooling is applied to the strip 102 at other points in the process line.

[0014] As mentioned above, cooling unit 108 can distribute a cooling agent 112 to the strip 102. The cooling agent 112 can be distributed from above, below, or to the sides of the strip 102, or any combination thereof. In some embodiments, the cooling agent 112 is air, gas, water, oil, or any other cooling agent capable of sufficiently removing heat from the strip 102 to generate the desired differential cooling. The amount and application of cooling to particular locations along the width of the strip 102 can be adjusted based on the desired flatness.

[0015] Differential cooling can be achieved by cooling selected portions 204 of strip 102 along the width 202 of strip 102. In some embodiments, the selected portions 204 are portions where the strip tension is highest. Strip tension can be highest at the edges 208 of the strip 102. The more localized the stress, the less differential cooling may be required to achieve the desired improved flatness. In some cases, a relatively small amount of cooling (for example, but not limited to, cooling at or around 250° Celsius) can be applied to the edges 208 of the strip 102, which can remove or reduce significant center buckles from the strip 102. Portions along the width 202 of the strip 102 that receive less cooling than the selected portions 204 are referred to as unselected portions 206. Unselected portions 206 can be portions where the strip tension is lower. Differential cooling includes any difference in temperature applied across the width 202 of the strip 102. In some embodiments, a selected portion 204 (the edges 208) along the width 202 of the strip 102 can be subjected to cooling while an unselected portion 206 (the middle of the strip 102) along the width 202 of the strip 102 is not subjected to any cooling. In other embodiments, selected portions 204 (the edges 208) along the width 202 of the strip 102 can be subjected to greater cooling than the cooling provided to the unselected portion 206 (the middle of the strip 102) along the width 202 of the strip 102.

[0016] Application of differential (also referred to as non-uniform, preferential, or selective) cooling to selected portion 204 of the width 202 of a strip 102 can cause the selected portions 204 to thermally contract, increasing the tension along the selected portions 204. Differential cooling can cause a temporary temperature gradient along the strip 102 where the selected portions 204 of the width 202 of the strip 102 (the edges 208) are cooler than the unselected portion(s) 206 (the middle).

[0017] According to the invention, cooling is applied to the edges 208 of the strip 102 to generate the temperature gradient, so that the tension at the edges 208 of the strip 102 can be temporarily increased, compared to the warmer, unselected portion 206 (middle) of the strip 102. Because the temperature along the width 202 of the strip 102 is not uniform, differential tension exists along the width 202 of the strip 102. If this imposed tension distribution is not equalized soon after being applied (e.g., by intervening support rolls, or otherwise), and the strip 102 is sufficiently hot to yield slightly under the differential tension, the differential temperature imparted by the differential cooling can cause the strip 102 to lengthen slightly along the colder portion of the width 202 (e.g., the selected portions 204) of the strip 102. Yield, as used herein, can be considered a permanent strain or elongation of the strip 102, which partially relieves the applied stress (e.g., from the imposed tension distribution). The stress required to cause permanent strain decreases as the strip 102 temperature increases. As used herein with reference to strip 102, yield includes permanent strain at conventionally accepted yield stress levels, as well as at stress levels below the conventionally accepted yield stress levels, such as the permanent strain that can occur from rapid creep. Therefore, for a strip 102 to yield, as the term is used herein, it is not necessary to induce differential tension that provides stress levels at or above the conventionally accepted yield stress of the strip 102.

[0018] Regardless of whether or not the actual temperature gradient imposed on the strip 102 is known, the temperature gradient is based on the differential cooling, which can be based on various factors, such as models, flatness measurements, or other, as disclosed herein.

[0019] Differential cooling of the edges 208 of a strip 102 causes a local concentration of tensile stress sufficient to put the strip 102 into yield and stretch the edges 208, correcting any center waves present in the strip 102. In this way, the flatness of the strip 102 can be adjusted and/or improved using differential cooling. When active differential cooling of the strip 102 is discontinued, the temperature profile of the strip 102 across its width 202 will eventually equalize, but any changes due to yield will remain, and therefore the improved flatness will be maintained.

[0020] Cooling agent 112 can be delivered by cooling unit 108 in any suitable way. In one embodiment, as shown in FIGS. 1-2, cooling agent 112 is delivered through nozzles 110 of cooling unit 108. In one embodiment, such nozzles 110 are arranged in an array 212 of discrete nozzles 110. Referring to FIG. 2, cooling agent 112 can be delivered, through supply lines 214, to the nozzles 110. A valve 210 associated with each nozzle 110 moves between a closed position, in which cooling agent 112 is blocked, and an open position, in which cooling agent 112 is allowed to pass. In such embodiments, valves 210 can be controlled to determine which nozzles 110 distribute cooling agent 112 and which nozzles 110 do not. Additionally, partial closing of some valves 210 can enable some nozzles 110 to distribute less cooling agent 112 than other nearby nozzles 110 with fully opened valves 210. Valves 210 can be manually adjustable or automatically adjustable. In some embodiments, valves 210 are dynamically controlled by a control system 118.

[0021] FIG. 3 is a schematic representation of a nozzle 110 that is a continuous slot nozzle 302 having a continuous slot 304. Instead of arrays 212 of discrete nozzles 110 as shown in FIGS. 1-2, continuous slot nozzle 302 of FIG. 3 includes at least one continuous slot 304. In other embodiments, other suitable structure for distributing cooling agent 112 is utilized instead of at least one continuous slot 304. As shown in FIG. 3, continuous slot nozzle 302 includes a sleeve 306 that partially blocks cooling agent 112 from being applied to the strip 102. In this way, cooling agent 112 can be directed to selected portions 204 (e.g., the edges 208) of the strip 102 to cool the strip 102 at the selected portion 204 (e.g., those edges 208). As also described above, application of cooling agent 112 can be controlled across the width 202 of the strip 102 so that the cooling is uneven transversely across the width 202 of the strip 102. Application of cooling agent 112 can be entirely or partially suppressed across unselected portions 206 of the strip.

[0022] FIG. 4 is an isometric view of a sleeve 306 (sometimes referred to as a cover) according to one embodiment. Sleeve 306 includes one or more openings 402 through which cooling agent 112 can be allowed to flow. The openings 402 can be of various shapes and sizes. The portion of sleeve 306 between the openings 402 is an occlusion portion 404, which blocks cooling agent 112 from being applied to the strip 102.

[0023] FIG. 5 is an isometric view of a continuous slot nozzle 302 with a sleeve 306 according to another embodiment. Sleeve 306 includes at least one occlusion portion 404. As described above, continuous slot 304 is configured to apply cooling agent 112 to strip 102. The sleeve 306 depicted in FIG. 5 includes one occlusion portion 404, which occludes at least some of the width of the continuous slot 304, thereby blocking cooling agent 112 from being applied to the strip 102 where the sleeve 306 occludes the continuous slot 304. The occlusion portion 404 of the sleeve approximately corresponds to the unselected portion 206 of the strip 102. In some embodiments, the occlusion portion(s) 404 can be designed to partially limit, as opposed to completely block, the amount of cooling agent 112 delivered to the unselected portion 206 of the strip 102. The occlusion portion(s) 404 can be designed to at least partially limit delivery of cooling agent 112 in various ways, including, for example, having holes or being made of a mesh material.

[0024] In some embodiments, the sleeve 306 can be movable and/or adjustable to adjust the size and/or position of the occlusion portion 404 with respect to the continuous slot 304. The sleeve 306 can incorporate two overlapping sleeves 306 that slidably move with respect to one another, wherein each of their occlusion portions 404 can overlap to varying extents in order to adjust the size of the actual occlusion portion 404 with respect to the continuous slot 304. The sleeve 306 can be manually adjustable or automatically adjustable. In some embodiments, the sleeve 306 may be dynamically adjusted by a control system 118. The sleeve 306 can be adjusted depending on the desired distribution path of the cooling agent 112 and the desired flatness of the strip 102. In some embodiments, each sleeve 306 may be adjusted differently along the strip 102 (e.g., over each edge 208 of the strip 102) to provide independent control so that the strip 102 can be asymmetrically cooled relative to a midpoint of the width 202 of the strip 102.

[0025] In some embodiments, the differential cooling described above can be applied and adjusted using information obtained from a feedback control loop. FIG. 6 is a flow chart of a portion of a metalworking process 600 including an exemplary feedback control loop for calculating and applying differential cooling. With reference to FIG. 6, a metal strip 102 is rolled at block 602. The strip 102 is optionally coated at block 604. The strip 102 is optionally heated at block 606. Differential cooling is applied to the strip 102 by a cooling unit 108 at block 608, according to cooling parameters at block 610. Cooling parameters can be stored in the control system 118. After the strip 102 is differentially cooled at block 608, the strip 102 is allowed to yield at block 612. At block 612, the strip 102 can be kept away from portions of the metalworking process (e.g., intervening support rolls, or otherwise) that can equalize the temperature gradient across the width 202 of the strip 102 or mechanically equalize the imposed tension distribution across the width 202 of the strip 102 (e.g., by the strip 102 wrapping around an intervening roller) before the strip 102 has been allowed to yield. The flatness of the strip 102 is measured at block 614. Results from the flatness measurement of block 614 are used to calculate the differential cooling necessary for the desired flatness at block 616. The cooling parameters are adjusted at block 610 based on the calculated differential cooling from block 616. In some embodiments, updated cooling parameters are sent to the cooling unit 108 to make adjustments to the distribution of cooling agent 112. In alternate embodiments, cooling parameters are stored in a storage device and updated as needed. In these embodiments, the cooling unit 108 accesses (e.g., routinely accesses or otherwise is prompted to access) the storage device to determine how to distribute the cooling agent 112.

[0026] As described above, the system 100 shown in FIG. 1 may optionally include a closed feedback loop control system 118 that enables automatic control and/or adjustment of the differential cooling based on measurements of the strip's 102 flatness. In some embodiments, feedback loop control system 118 proceeds as illustrated in FIG. 6. Measurement of the strip's 102 flatness can be taken upstream or downstream of the cooling unit 108. The order of blocks in FIG. 6 can be adjusted accordingly.

[0027] The flatness measuring device 114 of FIG. 1 may be a segmented stress roll (e.g., a stressometer roll produced by ABB Ltd), an optical device (e.g., a VIP optical flatness measurement device produced by Volmer America, Inc. or a non-contact laser system such as produced by Shapeline in Linköping, Sweden), or a different suitable measuring technique capable of measuring the flatness of the sheet in order to provide a flatness signal 116 to the control system 118.

[0028] In some embodiments, the flatness measuring device 114 is positioned so it is higher than the strip 102. In other embodiments, the flatness measuring device 114 is positioned at any suitable height and in any suitable location. In some embodiments, the actual flatness of the strip 102 is measured downstream of the cooling unit 108 or at another location where the strip 102 temperature is approximately uniform (e.g., the temperature profile of the strip has substantially equalized so the temperature gradient is substantially no longer present) to obtain an accurate reading of flatness.

[0029] The control system 118 can use the flatness signal 116 to determine any necessary adjustments that are to be made to the cooling unit 108 in order to achieve the desired flatness. The control system 118 can compare the measured flatness from the flatness measuring device 114 with a desired flatness that has been previously selected and/or stored in the memory of the control system 118. The control system 118 can then send a cooling signal 120 to the cooling unit 108. The cooling signal 120 can direct the cooling unit 108 to adjust the dispersion of cooling agent 112 as described herein. Adjustments can be made to the volume and/or temperature of the cooling agent 112 and/or the locations to which the cooling agent 112 will be applied relative to the strip 102 (e.g., the size and position of the selected portions 204).

[0030] In one embodiment, delivery of the cooling agent 112 is adjusted by adjusting the one or more moveable sleeves 306, as described herein. In other embodiments, the delivery of cooling agent 112 is adjusted by adjusting valves 210 in the supply lines 214 to discrete cooling nozzles 110. In this way, the flatness measurement of a strip 102 can be used to automatically and dynamically adjust and control the differential cooling to improve the flatness of the strip 102. The feedback control system enables the differential cooling of the strip 102 to serve as an adjustable actuator to adjust and correct any buckling and/or curvature of the strip 102, so its flatness reaches a desired level. The flatness then can be optimized by automatic feed-forward or feedback control, depending on the actual flatness measurement.

[0031] In some embodiments, the control system 118 can use information from a model-based approach (e.g., a coil stress model) instead of flatness measurements to determine the necessary differential cooling to be applied to the strip 102. A flatness measuring device 114 can be omitted in some embodiments. In some embodiments, using a model-based approach eliminates or reduces the need for actual measurements of the flatness of the strip 102, such that the determination of what differential cooling is to be applied could be made based on the model.

[0032] It can be desirable to differentially cool strips 102, as described herein, after rolling, at least because distortions can appear in the strip 102 after rolling, although the differential cooling described herein is not so limited. It can be desirable to differentially cool strips 102, as described herein, after the strip 102 has been coated and passed through an oven 106, at least because the coating and heating stages can induce distortions in the strip 102. However, differential cooling is not limited to use in cooling sections after the strip 102 passes through a coating line. Instead, differential cooling can be applied in any other suitable process line or at any other stage in the process. For example, differential cooling can be applied at the cooling section of a continuous annealing line, or at any other suitable line or stage of the process. In addition, the differential cooling described above can also be used to control the camber (sometimes referred to as the lateral bow) of the strip by applying differential cooling resulting in an asymmetric temperature gradient. Various embodiments can apply differential cooling, as described above, in various desired fashions along any suitable thermal line, including cold rolling mills.

[0033] It can be desirable to differentially cool strips 102, as described herein, rather than use other flattening devices in an effort to improve the flatness of the strip 102, at least because other flattening devices can add in some degree of unflatness, harm coatings and/or finishes of the strip 102, and/or can have negative effects (e.g., reduced formability of the strip 102 due to leveling) on certain mechanical properties of the strip 102. It can be desirable to differentially cool strips 102, as described herein, rather than use other methods, at least because the differential cooling described herein can produce strips 102 with increased uniformity across the width 202 of the strip 102. It can be desirable to differentially cool strips 102, as described herein, over other methods, as it can reduce the amount of leveling that may be necessary downstream.

[0034] Various embodiments have been described. It should be recognized that these embodiments are merely illustrative of the principles of the present disclosure. Numerous modifications and adaptations thereof will be readily apparent to those skilled in the art without departing from the scope of the present disclosure as defined in the following claims.

Claims

1. Use of a system for improving flatness of rolled metal, the system comprising:

   a cooling unit (108) comprising at least one nozzle (110) for distributing cooling agent to a strip (102), wherein
   the cooling unit (108) is adapted to cool-a selected portions (204) of a width (202) of the strip more than an unselected portion (206) of the width of the strip; a control system (118) adapted to receive flatness measurements from a flatness measurement device (114) of the system and to control the cooling unit (108), wherein the system is used to create a desired non-homogenous temperature gradient across the width of the strip (102),
   characterized in that the selected portions (204) are the edges (208) of the strip (102) and the unselected portion (206) is a middle of the strip (102) and **in that** the system is used to create the desired non-homogenous temperature gradient across the width of the strip (102) in such a manner that center waves present in the strip (102) before entering the cooling unit (108) are reduced or removed.

2. The use of the system according to claim 1, wherein the at least one nozzle (302) comprises a continuous slot (304) for distributing the cooling agent (112) and a sleeve (306) comprising an occlusion portion (404) positioned to block distribution of the cooling agent onto the unselected portion of the strip.

3. The use of the system according to claim 1, wherein:

   the at least one nozzle (110) comprises a plurality of nozzles for applying the cooling agent to the strip;
   one or more valves (210) fluidly connecting respective ones of the plurality of nozzles (110) to a supply of the cooling agent (112), each of the one or more valves (210) being actuatable to restrict flow of the cooling agent (112) from the respective ones of the nozzles (110); and
   the cooling unit (108) is adapted to actuate the one or more valves (210) of the plurality of nozzles (110) to block distribution of the cooling agent (112) on the unselected portion (206) of the width (202) of the strip.

4. The use of the system according to claim 3, wherein:

   the cooling unit (108) is further adapted to cool a first portion of the cooling agent (112) distributable through a first set of the plurality of nozzles to a temperature below a second portion of the cooling agent (112) distributable through a second set of the plurality of nozzles;
   the first set of the plurality of nozzles is positioned to distribute the first portion of the cooling agent to the selected portions of the width of the strip; and
   the second set of the plurality of nozzles is positioned to distribute the second portion of the cooling agent to the unselected portion of the width of the strip.

5. The use of the system according to claim 1, wherein the cooling agent is air blown through the at least one nozzle.

6. The use of the system of claim 1, wherein:

   the flatness measuring device (114) outputs a flatness signal (116) indicative of the flatness of the strip along the width of the strip (102); and
   the cooling unit (108) is adapted to cool the selected portions of the width of the strip more than the unselected portion of the width of the strip based on the flatness signal (116).

7. The use of the system according to claim 6, wherein:

   the control system is adapted to compare the flatness signal (116) to the desired flatness and output a cooling signal to the cooling unit; and
   the cooling unit (108) is coupled to the control system (118) to cool the selected portions of the width of the strip more than the unselected portion of the width of the strip based on the cooling signal.

8. The use of the system according to claim 1, additionally comprising means for coating the strip arranged upstream of the cooling unit.

9. A method of improving flatness in rolled metal, including:

   heating a strip;
   providing a cooling unit (108);
   selectively cooling the strip using the cooling unit (108) to induce a temperature distribution in the

strip (102) across a width of the strip (102);
maintaining the temperature distribution in the strip (102) for a desired amount of time,
providing a flatness measurement device (114) and a control unit (118) adapted to receive flatness measurements from the flatness measurement device (114) and to control the cooling unit (108),
wherein the temperature distribution is a non-homogenous temperature gradient across the width of the strip, **characterized in that** the selective cooling results in each edge of the width of the strip (102) having a first temperature colder than a second temperature of a middle of the strip (102) so that centre waves present in the strip (102) before entering the cooling unit (108) are reduced or removed.

10. The method according to claim 9, wherein the selective cooling includes:
applying a cooling agent to selected portions of the width of the strip (102), wherein the applying the cooling agent preferably includes:

actuating at least one valve (210) of an array of valves on an array of nozzles (110) to selectively block distribution of the cooling agent from each of the array of nozzles (110) positioned adjacent an unselected portion of the width of the strip (102),
or
applying the cooling agent from a continuous slot (304) of a nozzle (302); and
positioning an occlusion portion (404) of a sleeve (306) over the continuous slot (304) to block distribution of the cooling agent from the continuous slot (304) to an unselected portion of the width of the strip (102).

11. The method according to claim 9, additionally comprising:
measuring a flatness of the strip (102), wherein the temperature gradient is based on a flatness measurement of the strip.

12. The method according to claim 11, additionally comprising:
comparing the flatness measurement of the strip (102) to a desired flatness to generate a cooling signal, wherein the temperature gradient is based on the cooling signal.

13. The method according to claim 11, wherein:

the temperature gradient is induced so a first portion of the width of the strip (102) is cooled to a temperature below a second portion of the width of the strip (102); and
the first portion of the width of the strip (102) has a first magnitude of tensile stress greater than a second magnitude of tensile stress of the second portion of the width of the strip (102).

14. The method according to claim 9, additionally comprising applying a coating to the strip (102) prior to selectively cooling the strip (102).

15. The use of the system according to claim 1,

wherein the cooling unit (108) is adapted for accepting the strip (102), which is a coated and heated strip;
and wherein the system further comprises:

a plurality of nozzles (110) fluidly connected to a supply of cooling agent and positioned in the cooling unit (108);
wherein the control system (118) is coupled to the cooling unit (108) to control the plurality of nozzles (110) to distribute cooling agent to the selected portions of the coated and heated strip to induce the temperature gradient along a width of the coated and heated strip; and wherein the flatness measuring device (114) is positioned to measure a flatness of the coated and heated strip and coupled to the control system (118) to transmit a flatness signal to the control system (118); wherein the temperature gradient is based on a comparison of the flatness signal and a desired flatness of the coated and heated strip.

16. The use of the system according to claim 15, wherein:

the cooling agent is air;
the selected portions of the coated and heated strip are edges of the coated and heated strip;
the temperature gradient includes a middle of the coated and heated strip having a first temperature at or above a yield temperature of the coated and heated strip; and
the temperature gradient includes the selected portions of the coated and heated strip each having a second temperature below the first temperature.

Patentansprüche

1. Verwendung eines Systems zum Verbessern einer Ebenheit eines gewalzten Metalls, wobei das System umfasst:

eine Kühleinheit (108), welche mindestens eine

Düse (110) zum Verteilen eines Kühlmittels auf einen Streifen (102) umfasst, wobei
die Kühleinheit (108) dafür eingerichtet ist, ausgewählte Teile (204) einer Breite (202) des Streifens stärker als einen nicht-ausgewählten Teil (206) der Breite des Streifens zu kühlen;
ein Regelungs-/Steuerungssystem (118), welches dafür eingerichtet ist,
Ebenheitsmessungen von einer Ebenheitsmessvorrichtung (114) des Systems zu empfangen und die Kühleinheit (108) zu regeln/steuern, wobei das System verwendet wird, um einen gewünschten nicht-homogenen Temperaturgradienten über die Breite des Streifens (102) zu erzeugen,
dadurch gekennzeichnet, dass die ausgewählten Teile (204) die Ränder (208) des Streifens (102) sind, und der nicht-ausgewählte Teil (206) eine Mitte des Streifens (102) ist, und dass das System verwendet wird, um den gewünschten nicht-homogenen Temperaturgradienten über die Breite des Streifens (102) so zu erzeugen, dass in dem Streifen (102) vor dem Eintritt in die Kühleinheit (108) vorliegende Mittenwellen reduziert oder entfernt werden.

2. Verwendung des Systems nach Anspruch 1, wobei die mindestens eine Düse (302) einen kontinuierlichen Schlitz (304) zum Verteilen des Kühlmittels (112) und eine Manschette (306) umfasst, welche einen Verdeckungsteil (404) umfasst, der positioniert ist, um ein Verteilen des Kühlmittels auf den nicht-ausgewählten Teil des Streifens zu blockieren.

3. Verwendung des Systems nach Anspruch 1, wobei:

die mindestens eine Düse (110) eine Mehrzahl von Düsen zum Applizieren des Kühlmittels auf den Streifen umfasst;
ein oder mehrere Ventile (210) jeweilige aus der Mehrzahl von Düsen (110) fluidmäßig mit einer Zufuhr des Kühlmittels (112) verbinden, wobei jedes aus dem einen oder den mehreren Ventilen (210) betätigbar ist, um eine Strömung des Kühlmittels (112) aus den jeweiligen der Düsen (110) zu beschränken; und
die Kühleinheit (108) dafür eingerichtet ist, das eine oder die mehreren Ventile (210) der Mehrzahl von Düsen (110) zu betätigen, um ein Verteilen des Kühlmittels (112) auf den nicht-ausgewählten Teil (206) der Breite (202) des Streifens zu blockieren.

4. Verwendung des Systems nach Anspruch 3, wobei:

die Kühleinheit (108) ferner dafür eingerichtet ist, einen ersten Teil des Kühlmittels (112), welcher durch einen ersten Satz aus der Mehrzahl von Düsen verteilbar ist, auf eine Temperatur unterhalb eines zweiten Teils des Kühlmittels (112), welcher durch einen zweiten Satz aus der Mehrzahl von Düsen verteilbar ist, zu kühlen;
der erste Satz aus der Mehrzahl von Düsen positioniert ist, um den ersten Teil des Kühlmittels zu den ausgewählten Teilen der Breite des Streifens zu verteilen; und
der zweite Satz aus der Mehrzahl von Düsen positioniert ist, um den zweiten Teil des Kühlmittels zu dem nicht-ausgewählten Teil der Breite des Streifens zu verteilen.

5. Verwendung des Systems nach Anspruch 1, wobei das Kühlmittel durch die mindestens eine Düse geblasene Luft ist.

6. Verwendung des Systems nach Anspruch 1, wobei:

die Ebenheitsmessvorrichtung (114) ein Ebenheitssignal (116) ausgibt, welches die Ebenheit des Streifens entlang der Breite des Streifens (102) angibt; und
die Kühleinheit (108) dafür eingerichtet ist, die ausgewählten Teile der Breite des Streifens stärker als den nicht-ausgewählten Teil der Breite des Streifens basierend auf dem Ebenheitssignal (116) zu kühlen.

7. Verwendung des Systems nach Anspruch 6, wobei:

das Regelungs-/Steuerungssystem dafür eingerichtet ist, das Ebenheitssignal (116) mit der gewünschten Ebenheit zu vergleichen und ein Kühlsignal zu der Kühleinheit auszugeben; und
die Kühleinheit (108) mit dem Regelungs-/Steuerungssystem (118) gekoppelt ist, um, basierend auf dem Kühlsignal, die ausgewählten Teile der Breite des Streifens stärker als den nicht-ausgewählten Teil der Breite des Streifens zu kühlen.

8. Verwendung des Systems nach Anspruch 1, welches zusätzlich ein stromaufwärts von der Kühleinheit angeordnetes Mittel zum Beschichten des Streifens umfasst.

9. Verfahren zum Verbessern einer Ebenheit in gewalztem Metall, umfassend:

Heizen eines Streifens;
Bereitstellen einer Kühleinheit (108);
selektives Kühlen des Streifens unter Verwendung der Kühleinheit (108), um eine Temperaturverteilung in dem Streifen (102) über eine Breite des Streifens (102) zu induzieren;
Aufrechterhalten der Temperaturverteilung in

dem Streifen (102) für eine gewünschte Zeitdauer,
Bereitstellen einer Ebenheitsmessvorrichtung (114) und einer Regelungs-/Steuerungseinheit (118), welche dafür eingerichtet ist, Ebenheitsmessungen von der Ebenheitsmessvorrichtung (114) zu empfangen und die Kühleinheit (108) zu regeln/steuern,
wobei die Temperaturverteilung ein nicht-homogener Temperaturgradient über die Breite des Streifens ist,
dadurch gekennzeichnet, dasss das selektive Kühlen darin resultiert, dass jeder Rand der Breite des Streifens (102) eine erste Temperatur aufweist, welche kühler als eine zweite Temperatur einer Mitte des Streifens (102) ist, so dass in dem Streifen (102) vor dem Eintritt in die Kühleinheit (108) vorliegende Mittenwellen reduziert oder entfernt werden

10. Verfahren nach Anspruch 9, wobei das selektive Kühlen umfasst:

Applizieren eines Kühlmittels auf ausgewählte Teile der Breite des Streifens (102),
wobei das Applizieren des Kühlmittels vorzugsweise umfasst:

Betätigen mindestens eines Ventils (210) einer Anordnung von Ventilen an einer Anordnung von Düsen (110), um selektiv ein Verteilen des Kühlmittels von jeder aus der Anordnung von Düsen (110) zu blockieren, welche benachbart einem nicht-ausgewählten Teil der Breite des Streifens (102) positioniert ist, oder
Applizieren des Kühlmittels aus einem kontinuierlichen Schlitz (304) einer Düse (302); und
Positionieren eines Verdeckungsteils (404) einer Manschette (306) über dem kontinuierlichen Schlitz (304), um ein Verteilen des Kühlmittels aus dem kontinuierlichen Schlitz (304) zu einem nicht-ausgewählten Teil der Breite des Streifens (102) zu blockieren.

11. Verfahren nach Anspruch 9, zusätzlich umfassend: Messen einer Ebenheit des Streifens (102), wobei der Temperaturgradient auf einer Ebenheitsmessung des Streifens basiert.

12. Verfahren nach Anspruch 11, zusätzlich umfassend: Vergleichen der Ebenheitsmessung des Streifens (102) mit einer gewünschten Ebenheit, um ein Kühlsignal zu generieren, wobei der Temperaturgradient auf dem Kühlsignal basiert.

13. Verfahren nach Anspruch 11, wobei:

der Temperaturgradient so induziert wird, dass ein erster Teil der Breite des Streifens (102) auf eine Temperatur unterhalb eines zweiten Teils der Breite des Streifens (102) gekühlt wird; und der erste Teil der Breite des Streifens (102) eine erste Größe an Zugspannung aufweist, welche größer ist als eine zweite Größe an Zugspannung des zweiten Teils der Breite des Streifens (102).

14. Verfahren nach Anspruch 9, welches zusätzlich ein Applizieren einer Beschichtung auf den Streifen (102) vor dem selektiven Kühlen des Streifens (102) umfasst.

15. Verwendung des Systems nach Anspruch 1,

wobei die Kühleinheit (108) dafür eingerichtet ist, den Streifen (102) aufzunehmen, welcher ein beschichteter und geheizter Streifen ist;
und wobei das System ferner umfasst:

eine Mehrzahl von Düsen (110), welche fluidmäßig mit einer Zufuhr eines Kühlmittels verbunden und in der Kühleinheit (108) positioniert sind;
wobei das Regelungs-/Steuerungssystem (118) mit der Kühleinheit (108) gekoppelt ist, um die Mehrzahl an Düsen (110) zu regeln/steuern, um Kühlmittel zu den ausgewählten Teilen des beschichteten und geheizten Streifens zu verteilen, um den Temperaturgradienten entlang einer Breite des beschichteten und geheizten Streifens zu induzieren; und wobei die Ebenheitsmessvorrichtung (114) positioniert ist, um eine Ebenheit des beschichteten und geheizten Streifens zu messen, und mit dem Regelungs-/Steuerungssystem (118) gekoppelt ist, um ein Ebenheitssignal zu dem Regelungs-/Steuerungssystem (118) zu übertragen;
wobei der Temperaturgradient auf einem Vergleich des Ebenheitssignals und einer gewünschten Ebenheit des beschichteten und geheizten Streifens basiert.

16. Verwendung des Systems nach Anspruch 15, wobei:

das Kühlmittel Luft ist;
die ausgewählten Teile des beschichteten und geheizten Streifens Ränder des beschichteten und geheizten Streifens sind;
der Temperaturgradient umfasst, dass eine Mitte des beschichteten und geheizten Streifens

eine erste Temperatur bei oder oberhalb einer Fließgrenzentemperatur/Nachgabetemperatur des beschichteten und geheizten Streifens aufweist; und

der Temperaturgradient umfasst, dass die ausgewählten Teile des beschichteten und geheizten Streifens jeweils eine zweite Temperatur unterhalb der ersten Temperatur aufweisen.

Revendications

1. Utilisation d'un système pour améliorer la planéité d'un métal laminé, le système comprenant :

   une unité de refroidissement (108) comprenant au moins une buse (110) pour distribuer un agent de refroidissement à une bande (102), dans laquelle l'unité de refroidissement (108) est adaptée pour refroidir des parties sélectionnées (204) d'une largeur (202) de la bande plus qu'une partie non sélectionnée (206) de la largeur de la bande ;

   un système de commande (118) adapté pour recevoir des mesures de planéité depuis un dispositif de mesure de planéité (114) du système et pour commander l'unité de refroidissement (108),

   caractérisée en ce que les parties sélectionnées (204) sont les bords (208) de la bande (102) et la partie non sélectionnée (206) est un milieu de la bande (102), et **en ce que** le système est utilisé pour créer un gradient de température non homogène souhaité sur la largeur de la bande (102) de sorte que des ondes centrales présentes dans la bande (102) avant l'entrée dans l'unité de refroidissement (108) sont réduites ou supprimées.

2. Utilisation du système selon la revendication 1, dans laquelle l'au moins une buse (302) comprend une fente continue (304) pour distribuer l'agent de refroidissement (112) et un manchon (306) comprenant une partie d'occlusion (404) positionnée pour bloquer la distribution de l'agent de refroidissement sur la partie non sélectionnée de la bande.

3. Utilisation du système selon la revendication 1, dans laquelle :

   l'au moins une buse (110) comprend une pluralité de buses pour appliquer l'agent de refroidissement sur la bande ;

   un ou plusieurs clapets (210) connectant fluidiquement des buses respectives de la pluralité de buses (110) à une charge de l'agent de refroidissement (112), chacun des un ou plusieurs clapets (210) étant actionnable pour limiter l'écoulement de l'agent de refroidissement (112) provenant de celles respectives des buses (110) ; et

   l'unité de refroidissement (108) est adaptée pour actionner les un ou plusieurs clapets (210) de la pluralité de buses (110) afin de bloquer la distribution de l'agent de refroidissement (112) sur la partie non sélectionnée (206) de la largeur (202) de la bande.

4. Utilisation du système selon la revendication 3, dans laquelle :

   l'unité de refroidissement (108) est en outre adaptée pour refroidir une première partie de l'agent de refroidissement (112) pouvant être distribuée par le biais d'un premier jeu de la pluralité de buses à une température sous une deuxième partie de l'agent de refroidissement (112) pouvant être distribuée par le biais d'un deuxième jeu de la pluralité de buses ;

   le premier jeu de la pluralité de buses est positionné pour distribuer la première partie de l'agent de refroidissement aux parties sélectionnées de la largeur de la bande ; et

   le deuxième jeu de la pluralité de buses est positionné pour distribuer la deuxième partie de l'agent de refroidissement à la partie non sélectionnée de la largeur de la bande.

5. Utilisation du système selon la revendication 1, dans laquelle l'agent de refroidissement est de l'air soufflé à travers l'au moins une buse.

6. Utilisation du système selon la revendication 1, dans laquelle :

   le dispositif de mesure de planéité (114) sort un signal de planéité (116) indicatif de la planéité de la bande le long de la largeur de la bande (102) ; et

   l'unité de refroidissement (108) est adaptée pour refroidir les parties sélectionnées de la largeur de la bande plus que la partie non sélectionnée de la largeur de la bande sur la base du signal de planéité (116).

7. Utilisation du système selon la revendication 6, dans laquelle :

   le système de commande est adapté pour comparer le signal de planéité (116) à la planéité souhaitée et sortir un signal de refroidissement sur l'unité de refroidissement ; et

   l'unité de refroidissement (108) est couplée au système de commande (118) afin de refroidir les parties sélectionnées de la largeur de la bande plus que la partie non sélectionnée de la largeur de la bande sur la base du signal de refroidissement.

8. Utilisation du système selon la revendication 1, comprenant de plus un moyen pour revêtir la bande agencée en amont de l'unité de refroidissement.

9. Procédé d'amélioration de la planéité d'un métal laminé, incluant :

le chauffage d'une bande ;
la fourniture d'une unité de refroidissement (108) ;
le refroidissement sélectif de la bande en utilisant l'unité de refroidissement (108) afin de provoquer une distribution de température dans la bande (102) sur une largeur de la bande (102) ;
le maintien de la distribution de température dans la bande (102) pendant une période de temps souhaitée ;
la fourniture d'un dispositif de mesure de planéité (114) et d'une unité de commande (118) adaptée pour recevoir des mesures de planéité provenant du dispositif de mesure de planéité (114) et pour commander l'unité de refroidissement (108),
dans lequel la distribution de température est un gradient de température non homogène sur la largeur de la bande, **caractérisé en ce que** le refroidissement sélectif résulte **en ce que** chaque bord de la bande (102) a une première température inférieure à une seconde température d'un milieu de la bande (102), de sorte que des ondes centrales présentes dans la bande (102) avant l'entrée dans l'unité de refroidissement (108) sont réduites ou supprimées.

10. Procédé selon la revendication 9, dans lequel le refroidissement sélectif inclut :
l'application d'un agent de refroidissement à des parties sélectionnées de la largeur de la bande (102), dans lequel l'application de l'agent de refroidissement inclut de préférence :

l'actionnement d'au moins un clapet (210) d'un réseau de clapets sur un réseau de buses (110) pour bloquer sélectivement la distribution de l'agent de refroidissement depuis chacune du réseau de buses (110) positionnées de manière adjacente à une partie non sélectionnée de la largeur de la bande (102),
ou
l'application de l'agent de refroidissement depuis une fente continue (304) d'une buse (302) ; et
le positionnement d'une partie d'occlusion (404) d'un manchon (306) sur la fente continue (304) pour bloquer la distribution de l'agent de refroidissement depuis la fente continue (304) vers une partie non sélectionnée de la largeur de la bande (102).

11. Procédé selon la revendication 9, comprenant de plus :
la mesure d'une planéité de la bande (102), dans lequel le gradient de température est basé sur une mesure de planéité de la bande.

12. Procédé selon la revendication 11, comprenant de plus :
la comparaison de la mesure de planéité de la bande (102) à une planéité souhaitée pour générer un signal de refroidissement, dans lequel le gradient de température est basé sur le signal de refroidissement.

13. Procédé selon la revendication 11, dans lequel :

le gradient de température est induit pour qu'une première partie de la largeur de la bande (102) soit refroidie à une température sous une deuxième partie de la largeur de la bande (102) ; et
la première partie de la largeur de la bande (102) a une première amplitude de tension de traction supérieure à une deuxième amplitude de tension de traction de la deuxième partie de la largeur de la bande (102).

14. Procédé selon la revendication 9, comprenant de plus l'application d'un revêtement à la bande (102) avant le refroidissement sélectif de la bande (102).

15. Utilisation du système selon la revendication 1,

dans laquelle l'unité de refroidissement (108) est adaptée pour accepter la bande (102), qui est une bande revêtue et chauffée ;
et dans laquelle le système comprend en outre :

une pluralité de buses (110) connectées fluidiquement à une charge d'agent de refroidissement et positionnées dans l'unité de refroidissement (108) ;
dans laquelle le système de commande (118) est couplé à l'unité de refroidissement (108) pour commander la pluralité de buses (110) afin de distribuer l'agent de refroidissement aux parties sélectionnées de la bande revêtue et chauffée afin d'induire un gradient de température le long d'une largeur de la bande revêtue et chauffée ; et
dans laquelle le dispositif de mesure de planéité (114) est positionné pour mesurer une planéité de la bande revêtue et chauffée et couplé au système de commande

(118) afin de transmettre un signal de planéité au système de commande (118) ;
dans laquelle le gradient de température est basé sur une comparaison du signal de planéité et d'une planéité souhaitée de la bande revêtue et chauffée.

16. Utilisation du système selon la revendication 15, dans laquelle :

l'agent de refroidissement est de l'air ;
les parties sélectionnées de la bande revêtue et chauffée sont des bords de la bande revêtue et chauffée ;
le gradient de température inclut un milieu de la bande revêtue et chauffée ayant une première température à ou au-dessus d'une température d'écoulement de la bande revêtue et chauffée ; et
le gradient de température inclut les parties sélectionnées de la bande revêtue et chauffée ayant chacune une deuxième température sous la première température.

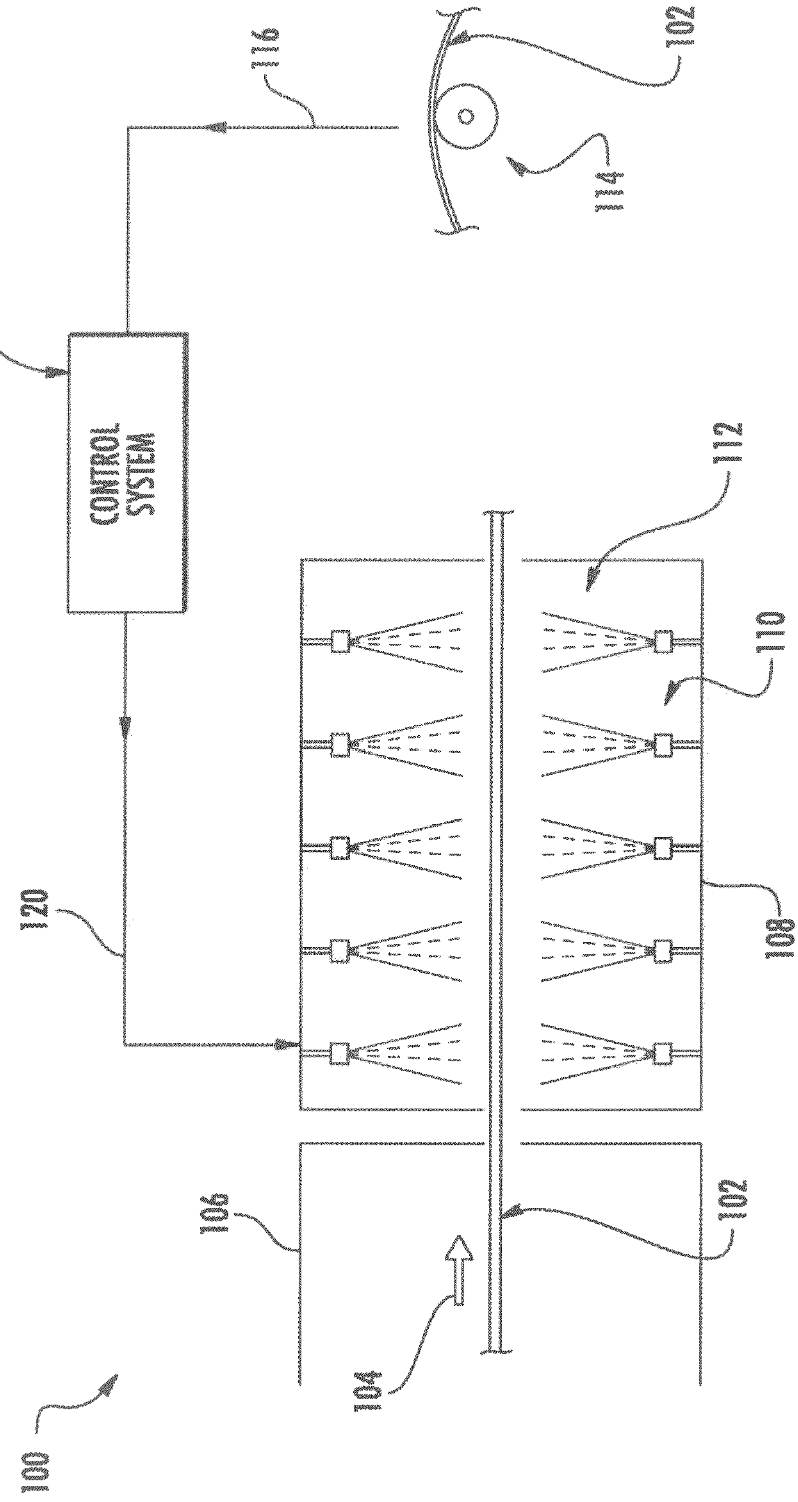

FIG. 1

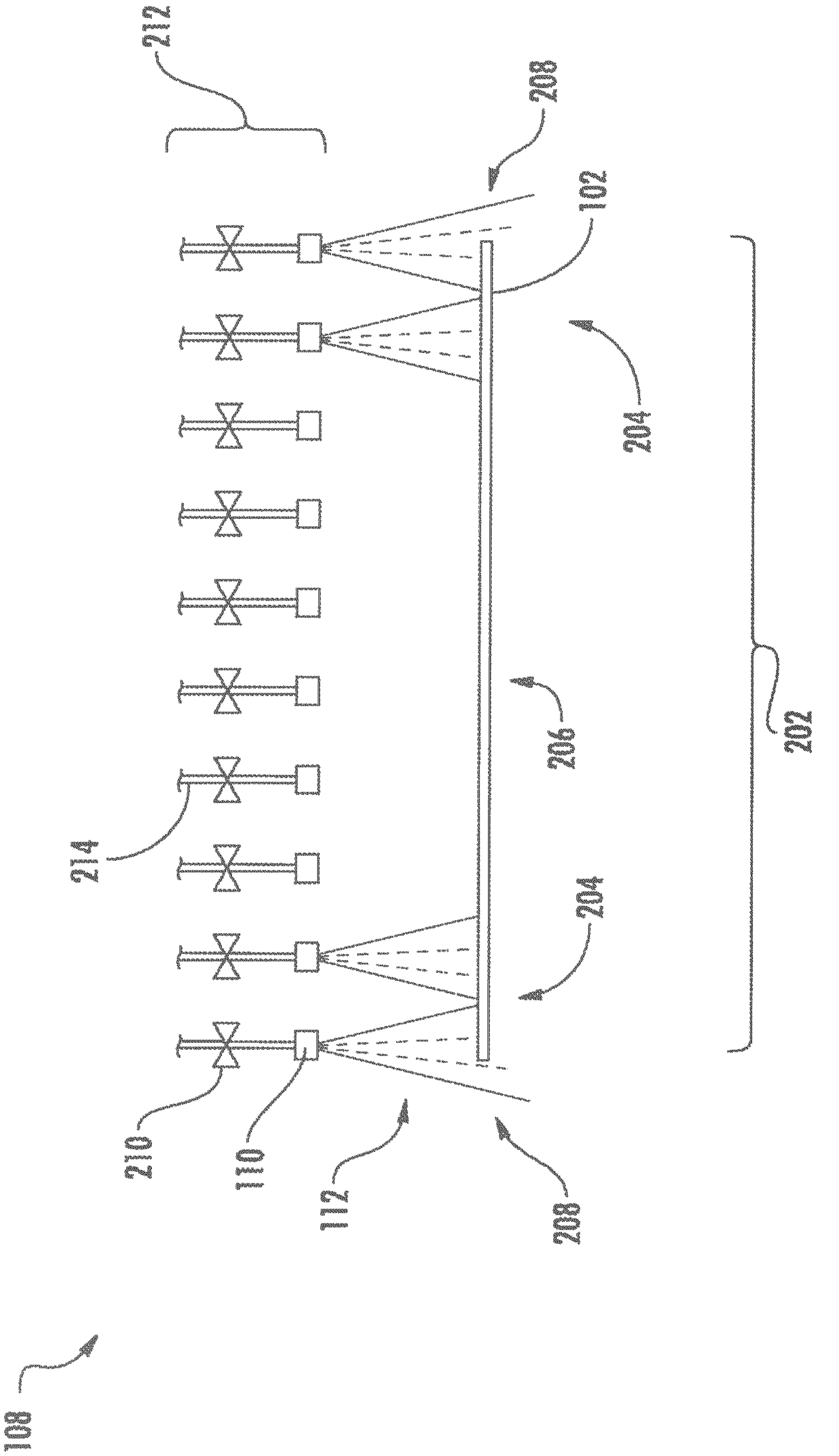

FIG. 2

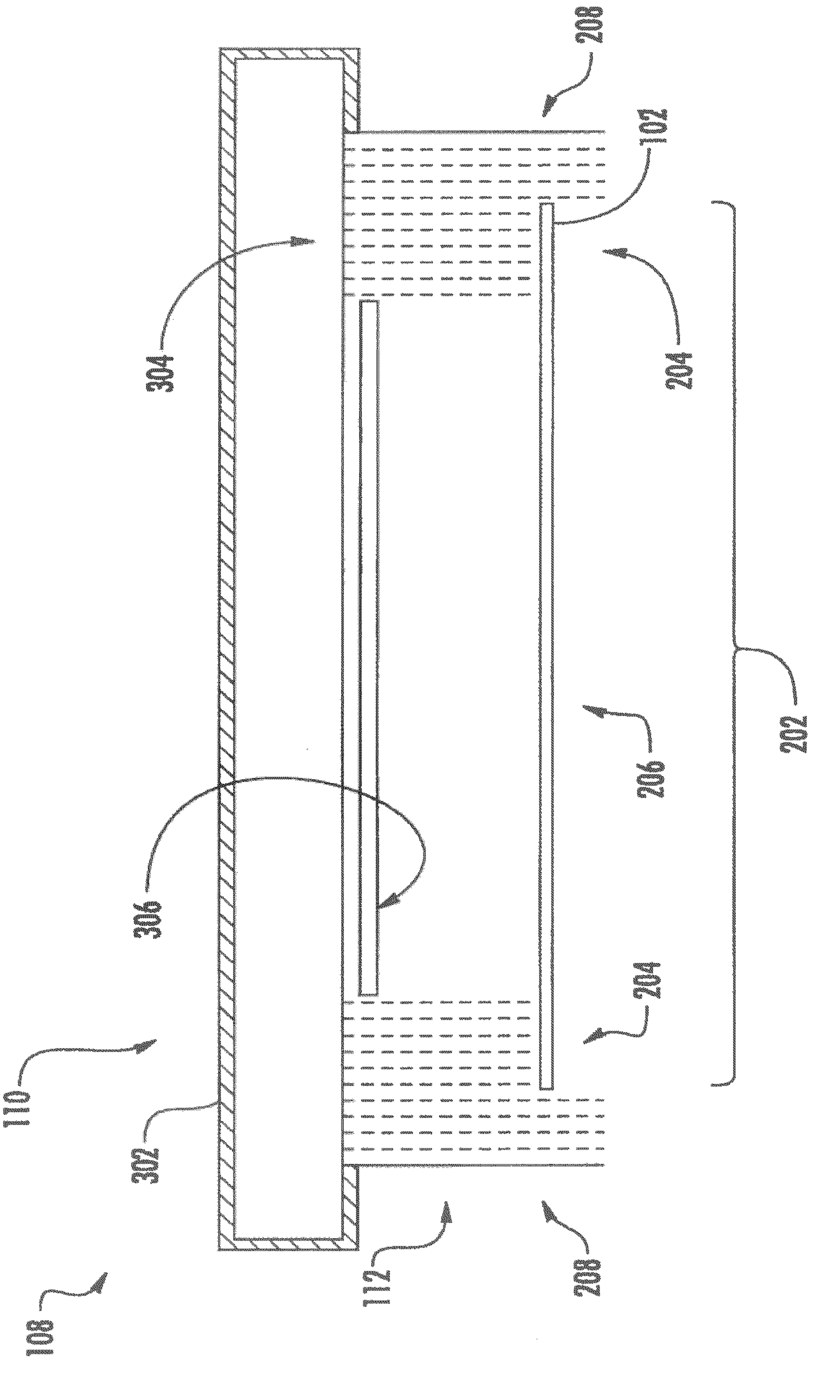

FIG. 3

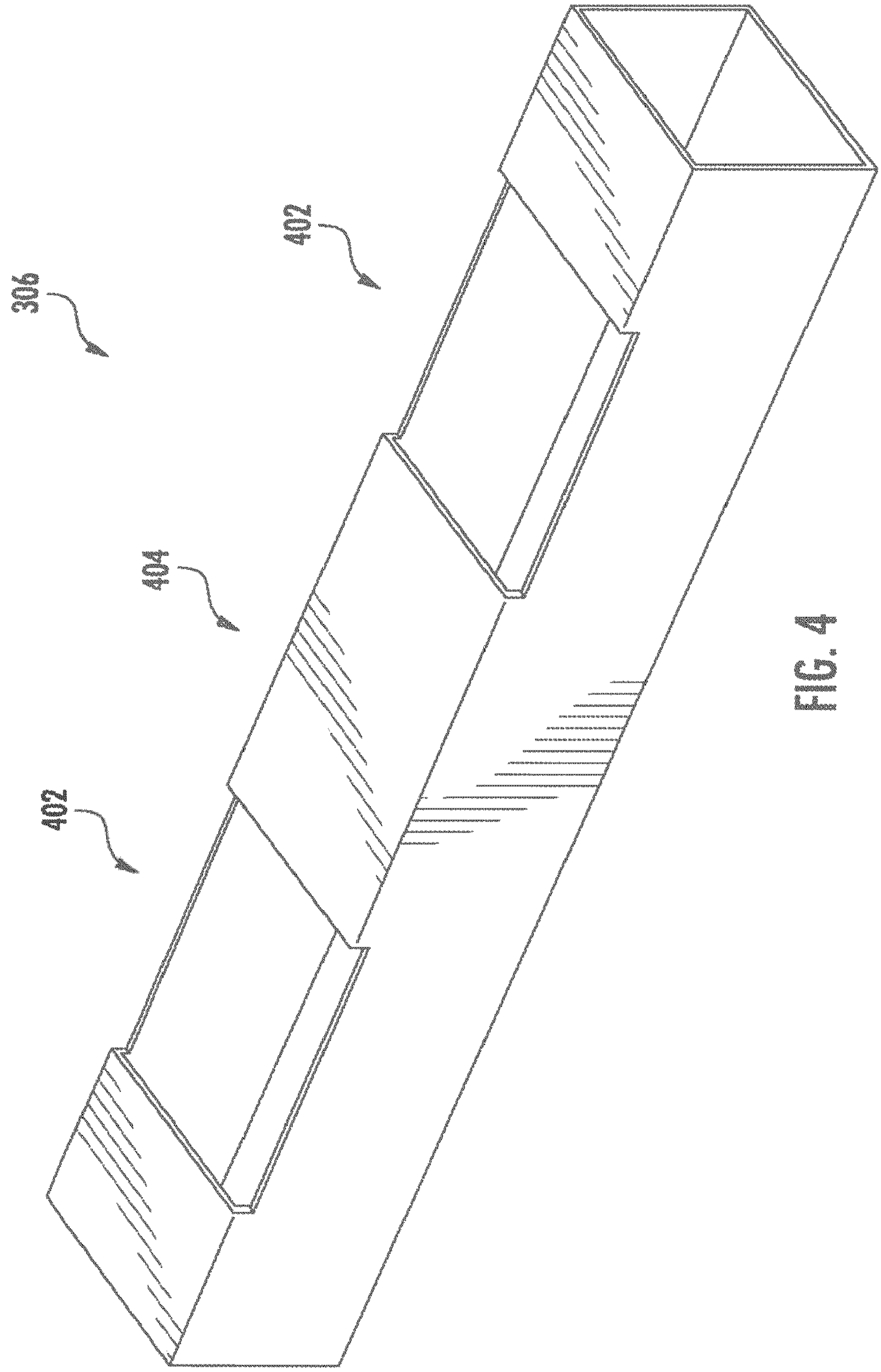

FIG. 4

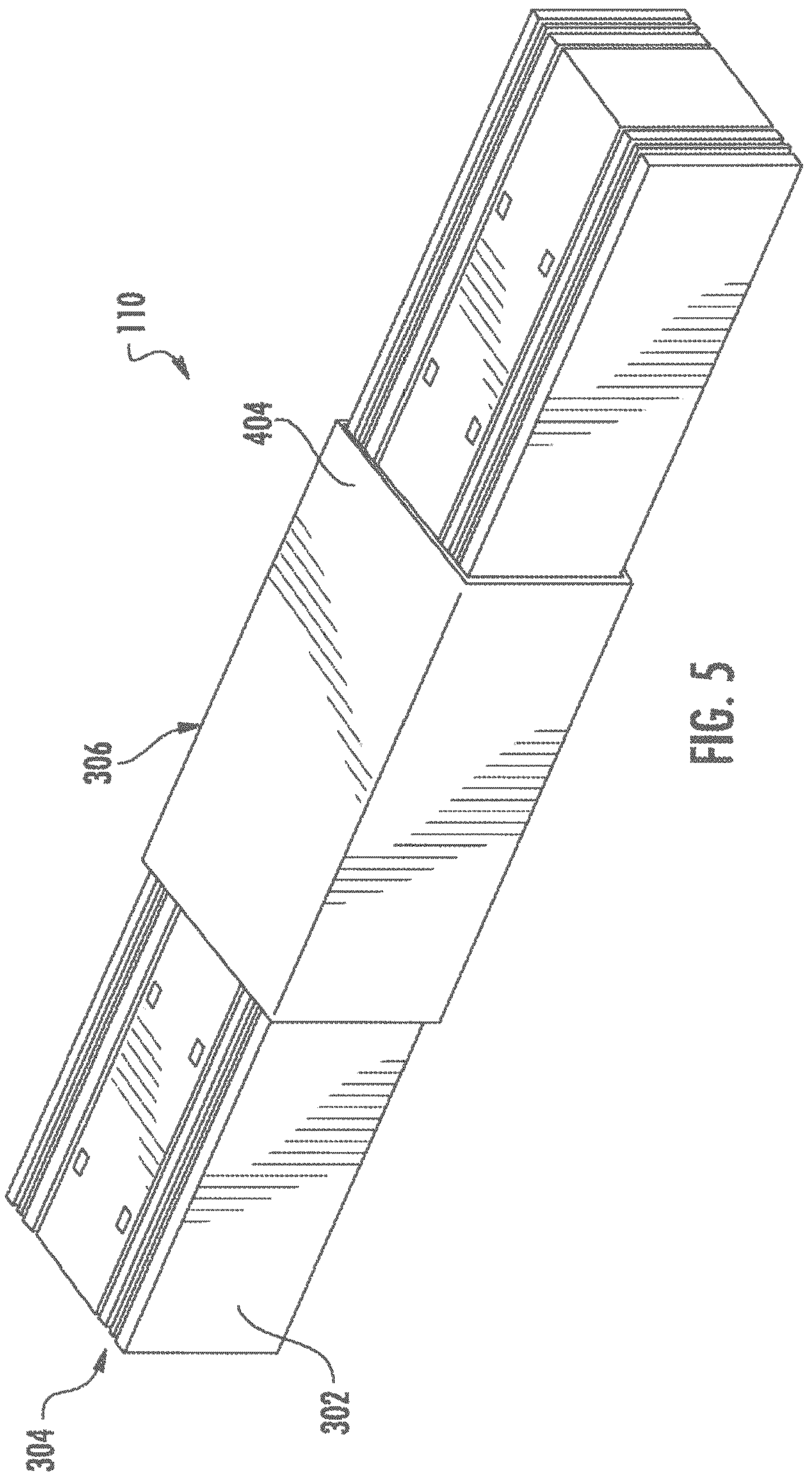

FIG. 5

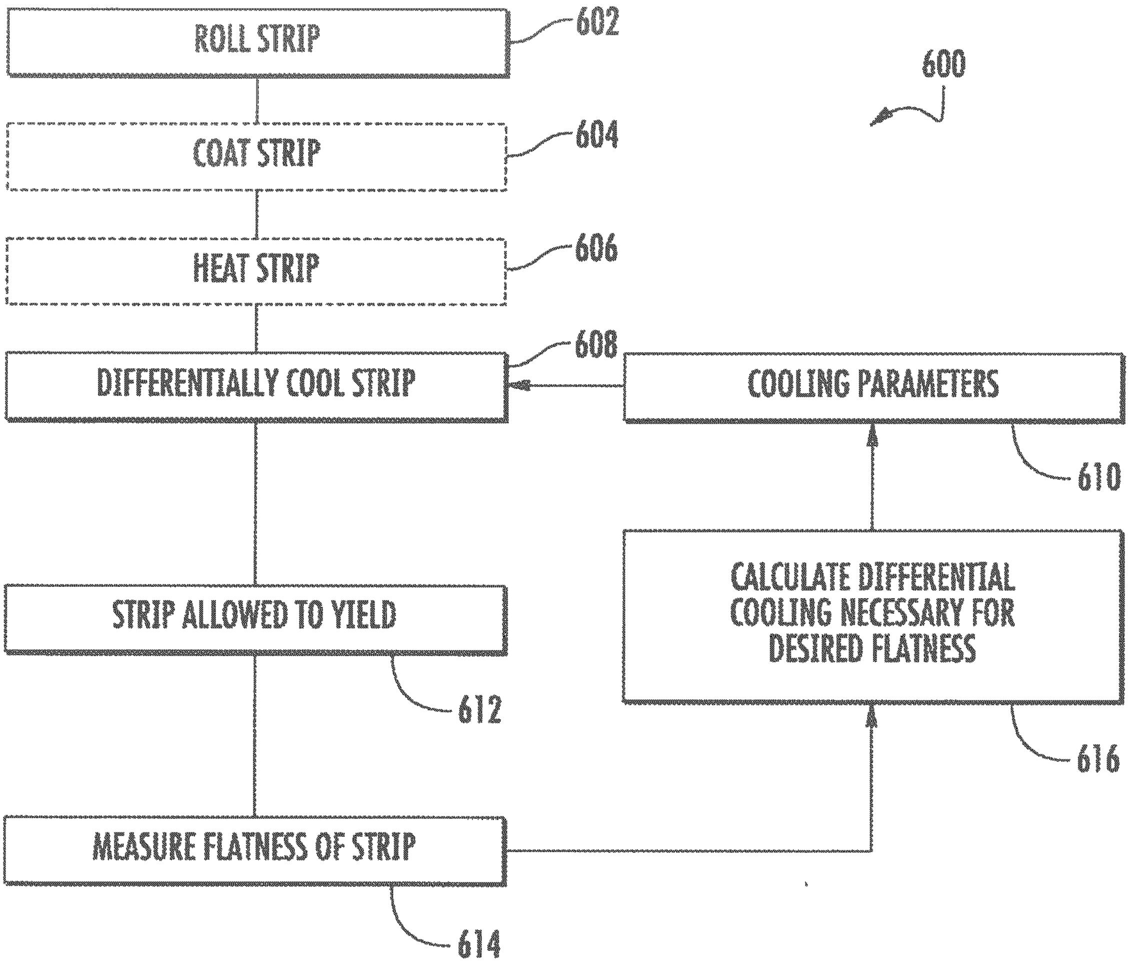
ROLL STRIP
602
600
COAT STRIP
604
HEAT STRIP
606
608
DIFFERENTIALLY COOL STRIP
COOLING PARAMETERS
610
STRIP ALLOWED TO YIELD
612
CALCULATE DIFFERENTIAL COOLING NECESSARY FOR DESIRED FLATNESS
616
MEASURE FLATNESS OF STRIP
614

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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