A system includes a roll formed from a conductive material, where the roll is configured to rotate about an axis. The system also includes an induction heating workcoil configured to generate currents within the roll. The induction heating workcoil is unbalanced and is oriented so that minimal currents flow in a direction substantially parallel to the axis of the roll. The induction heating workcoil could include one or more substantially U-shaped or C-shaped cores and at least one coil each wound around at least one of the one or more cores. Also, the roll may further include a shaft and bearings, and the induction heating workcoil can be positioned so that the currents do not flow substantially through the bearings.
FIGURE 3

FIGURE 4

START

402
PLACE INDUCTION HEATING WORKCOILS IN PROXIMITY WITH ROLL

404
ORIENT INDUCTION HEATING WORKCOILS

406
ROTATE ROLL DURING PRODUCTION OF PAPER SHEET OR OTHER WEB PRODUCT

408
GENERATE CURRENTS THROUGH ROLL THAT DO NOT FLOW SUBSTANTIALLY THROUGH BEARINGS OF ROLL

END
SYSTEM AND METHOD FOR REDUCING CURRENT EXITING A ROLL THROUGH ITS BEARINGS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This disclosure is related to the following U.S. patent applications, which are incorporated by reference:
[0002] Ser. No. _______entitled “SYSTEM AND METHOD FOR REDUCING CURRENT EXITING A ROLL THROUGH ITS BEARINGS USING BALANCED MAGNETIC FLUX VECTORS IN INDUCTION HEATING APPLICATIONS” filed on _______ [DOCKET NO. H0019204-0108]; and

TECHNICAL FIELD

[0004] This disclosure relates generally to paper production systems and other systems using rolls. More specifically, this disclosure relates to a system and method for reducing current exiting a roll through its bearings.

BACKGROUND

[0005] Paper production systems and other types of systems often include a number of large rotating rolls. For example, sets of counter-rotating rolls can be used in a paper production system to compress a paper sheet being formed. The amount of compression provided by the counter-rotating rolls is often controlled through the use of induction heating devices. The induction heating devices create currents in a roll, which heats the surface of the roll. The heat or lack thereof causes the roll to expand and contract, which controls the amount of compression applied to the paper sheet being formed.

SUMMARY

[0006] This disclosure provides a system and method for reducing current exiting a roll through its bearings.
[0007] In a first embodiment, a system includes a roll formed from a conductive material, where the roll is configured to rotate about an axis. The system also includes an induction heating workcoil configured to generate currents within the roll. The induction heating workcoil is unbalanced and is oriented so that minimal currents flow in a direction substantially parallel to the axis of the roll.
[0008] In particular embodiments, the induction heating workcoil includes one or more U-shaped or C-shaped cores and at least one coil each wound around at least one of the one or more cores.
[0009] In other particular embodiments, the roll further includes a shaft and bearings. Also, the induction heating workcoil is oriented so that the currents do not flow substantially through the bearings.
[0010] In yet other particular embodiments, the roll represents one of a set of counter-rotating rolls. The counter-rotating rolls are configured to compress a web of material. Also, an induction heating actuator includes the induction heating workcoil and a power source coupled to at least one coil of the induction heating actuator. In addition, the system further includes a controller configured to control the power source to control an amount of compression provided by at least a portion of the counter-rotating rolls.
[0011] In still other particular embodiments, multiple induction heating workcoils are located adjacent to each other in a row proximate to the roll. Also, multiple rows of induction heating workcoils are located adjacent to each other proximate to the roll.
[0012] In a second embodiment, a system includes a roll formed from a conductive material, where the roll is configured to rotate about an axis. The system also includes an induction heating workcoil configured to generate a magnetic flux for producing currents within the roll. The induction heating workcoil is unbalanced and is oriented so that a path of the magnetic flux through the roll is substantially parallel to the axis of the roll.
[0013] In a third embodiment, a method includes placing an induction heating workcoil in proximity with a roll. The roll is configured to rotate about an axis, and the induction heating workcoil represents an unbalanced induction heating workcoil. The method also includes orienting the induction heating workcoil so that a magnetic flux path within the roll produced by the induction heating workcoil is axially aligned with the axis of the roll. In addition, the method includes producing currents within the roll.
[0014] Other technical features may be readily apparent to one skilled in the art from the following figures, descriptions, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] For a more complete understanding of this disclosure, reference is now made to the following description, taken in conjunction with the accompanying drawings, in which:
[0016] FIG. 1 illustrates an example paper production system according to this disclosure;
[0017] FIGS. 2A and 2B illustrate example orientations of an induction heating workcoil with respect to a roll according to this disclosure;
[0018] FIG. 3 illustrates an example configuration of induction heating workcoils with respect to a roll according to this disclosure; and
[0019] FIG. 4 illustrates an example method for reducing current exiting a roll through its bearings according to this disclosure.

DETAILED DESCRIPTION

[0020] FIGS. 1 through 4, discussed below, and the various embodiments used to describe the principles of the present invention in this patent document are by way of illustration only and should not be construed in any way to limit the scope of the invention. Those skilled in the art will understand that the principles of the invention may be implemented in any type of suitably arranged device or system.
[0021] FIG. 1 illustrates an example paper production system 100 according to this disclosure. The embodiment of the paper production system 100 shown in FIG. 1 is for illustration only. Other embodiments of the paper production system 100 may be used without departing from the scope of this disclosure.
[0022] As shown in FIG. 1, the paper production system 100 includes a paper machine 102, a controller 104, and a network 106. The paper machine 102 includes various components used to produce a paper product. In this example, the
of constant to a surface of the paper to improve the smoothness and printability of the paper sheet). Similarly, additional flow actuators may be used to control the proportions of different types of pulp and filler material in the thick stock and to control the amounts of various additives (such as retention aid or dyes) that are mixed into the stock.

[0027] This represents a brief description of one type of paper machine 102 that may be used to produce a paper product. Additional details regarding this type of paper machine 102 are well-known in the art and are not needed for an understanding of this disclosure. Also, this represents one specific type of paper machine 102 that may be used in the system 100. Other machines or devices could be used that include any other or additional components for producing a paper product. In addition, this disclosure is not limited to use with systems for producing paper sheets and could be used with systems that process the paper sheets or with systems that produce or process other products or materials in continuous webs (such as plastic sheets or thin metal films like aluminum foils).

[0028] In order to control the paper-making process, one or more properties of the paper sheet 108 may be continuously or repeatedly measured. The sheet properties can be measured at one or various stages in the manufacturing process. This information may then be used to adjust the paper machine 102, such as by adjusting various actuators within the paper machine 102. This may help to compensate for any variations of the sheet properties from desired targets, which may help to ensure the quality of the sheet 108.

[0029] As shown in FIG. 1, the paper machine 102 includes a scanner 126, which may include one or more sensors. The scanner 126 is capable of scanning the paper sheet 108 and measuring one or more characteristics of the paper sheet 108. For example, the scanner 126 could include sensors for measuring the weight, moisture, caliper (thickness), gloss, color, smoothness, or any other or additional characteristics of the paper sheet 108. The scanner 126 includes any suitable structure or structures for measuring or detecting one or more characteristics of the paper sheet 108, such as sets or arrays of sensors.

[0030] The controller 104 receives measurement data from the scanner 126 and uses the data to control the system 100. For example, the controller 104 may use the measurement data to adjust the various actuators in the paper machine 102 so that the paper sheet 108 has properties at or near desired properties. The controller 104 includes any hardware, software, firmware, or combination thereof for controlling the operation of at least part of the system 100. Also, while one controller is shown here, multiple controllers could be used to control the paper machine 102.

[0031] The network 106 is coupled to the controller 104 and various components of the system 100 (such as actuators and scanners). The network 106 facilitates communication between components of system 100. The network 106 represents any suitable network or combination of networks facilitating communication between components in the system 100. The network 106 could, for example, represent an Ethernet network, an electrical signal network (such as a HART or FOUNDATION FIELDBUS network), a pneumatic control signal network, or any other or additional network(s).

[0032] In one aspect of operation, the induction heating windcoils 120 may operate by generating currents in the surface of one or more of the rolls 119. In some conventional systems, the currents created in a roll can exit the roll through
its bearings. These so-called “bearing currents” (also called “shaft currents”) can lead to premature wear and damage to the bearings supporting the roll. For example, the bearings can sometimes separate by small distances, and the currents flowing through the bearings can create sparks that pit or otherwise damage the bearings. Because of this, the bearings need to be replaced sooner or more often than desired. This leads to down time of the system 100 and monetary losses. While insulated bearings are available and could be used, the insulated bearings are often quite expensive compared to conventional bearings. In accordance with this disclosure, the induction heating workcoils 120 are configured so that little or no current flows out of the rolls 119 through their bearings. This leads to reduced wear on and damage to the bearings, resulting in increased usage and fewer replacements. Additional details are provided below.

[0033] Although FIG. 1 illustrates one example of a paper production system 100, various changes may be made to FIG. 1. For example, other systems could be used to produce paper sheets or other products. Also, while shown as including a single paper machine 102 with various components and a single controller 104, the production system 100 could include any number of paper machines or other production machinery having any suitable structure, and the system 100 could include any number of controllers. In addition, FIG. 1 illustrates one operational environment in which induction heating workcoils 120 or other workcoils can be used and oriented to reduce currents flowing through bearings of one or more rolls. This functionality could be used in any other suitable system.

[0034] FIGS. 2A and 2B illustrate example orientations 200a-200b of an induction heating workcoil with respect to a roll according to this disclosure. In the example shown in FIG. 2A, an induction heating workcoil 202 includes at least one coil 204 and a core 206. The coil 204 generally represents any suitable conductive material(s) wound in a coil or otherwise wrapped around at least a portion of the core 206. The coil 204 could, for example, represent Litz wire or other conductive wire wrapped around the core 206. The core 206 generally represents a structure that can direct or focus a magnetic field created by current flowing through the coil 204. The core 206 could, for example, represent ferrite. Terminal wires 208 couple the coil 204 to a power source 210, forming an induction heating actuator. The power source 210 generally represents a source of electrical energy flowing through the coil 204. The power source 210 could, for example, represent an alternating current (AC) source that operates at a specified frequency (such as 16 kHz or other frequency). The AC signal flows through the coil 204 and produces a magnetic flux 212.

[0035] In this example, the induction heating workcoil 202 is placed in proximity to a roll 214. The magnetic flux 212 produces currents 216 that flow through the surface of the roll 214, heating the surface of the roll 214. The production of the currents 216 can be adjusted to control the amount of heating of the roll’s surface, which also controls the amount of compression applied by the roll 214 to a paper sheet or other product.

[0036] In this embodiment, the induction heating workcoil 202 represents an unbalanced workcoil, meaning the workcoil 202 produces magnetic fluxes that have an appreciably non-null sum spatial vector. In other words, for an individual workcoil 202 or collection of workcoils 202, the workcoil(s) 202 can produce enough current to damage the bearings of the roll 214.

[0037] As shown in FIG. 2A, the currents 216 produced by the induction heating workcoil 202 flow generally perpendicular to the path of the induced magnetic flux 212. However, in this orientation 200a, the path of the magnetic flux 212 is substantially orthogonal (perpendicular) to an axis 218 about which the roll 214 rotates. Because of this, the currents 216 flow in a direction that is generally parallel to the axis 218 of the roll 214. As a result, in this orientation 200a, the currents 216 would therefore exit the roll 214 through bearings supporting the roll 214 at the ends of the roll 214.

[0038] As shown in FIG. 2B, the induction heating workcoil 202 has been repositioned so that the path of the induced magnetic flux 212 within the roll 214 is generally parallel to or axially aligned with the axis 218 about which the roll 214 rotates. Again, the currents 216 produced by the induction heating workcoil 202 flow generally perpendicular to the path of the induced magnetic flux 212. Here, though, the currents 216 flow in a direction that is generally orthogonal to the roll axis 218. More specifically, the currents 216 produced by the induction heating workcoil 202 flow in a direction normal to the roll axis 218 (rather than towards the ends of the roll 214). In this way, little or none of the currents 216 may flow through the bearings at the ends of the roll 214. It may be noted that the induction heating workcoil 202 could initially be installed (and possibly even used for a period of time) as shown in FIG. 2A and then reoriented as shown in FIG. 2B. The ability to reorient the induction heating workcoil 202 may be associated with the workcoil alone, mounting hardware used to mount the workcoil, a support beam on which the workcoil is mounted, a combination of these structures, or any other suitable structure(s).

[0039] Although FIGS. 2A and 2B illustrate examples of orientations 200a-200b of an induction heating workcoil with respect to a roll, various changes may be made to FIGS. 2A and 2B. For example, any suitable number of induction heating workcoils 202 could be used with the roll 214. Also, in the example shown in FIGS. 2A and 2B, the induction heating workcoil 202 includes an open substantially U-shaped core 206 having opposed legs and a central portion, and the coil 204 is formed around the central portion of the core 206. Here, the U-shape is defined by a cross-section of the core 206 lengthwise along the legs and through the central portion of the core 206. The core 206 could have any other suitable shape or cross-section (such as a substantially C-shaped core), and one or multiple coils 204 could be placed in any suitable location(s) on the core 206. As a particular example, one or more coils 204 could be placed on each opposed leg of the U-shaped core 206. In general, any induction heating workcoil 202 that can create an induced magnetic flux that is substantially axially aligned with or parallel to the axis 218 of the roll 214 could be used here.

[0040] FIG. 3 illustrates an example configuration 300 of an induction heating workcoils with respect to a roll according to this disclosure. As shown in FIG. 3, the configuration 300 includes multiple induction heating workcoils 302 placed adjacent to each other in an end-to-end fashion across the surface of a roll 304. The induction heating workcoils 302 could have any suitable spacing, such as one induction heating workcoil every fifty millimeters. The configuration 300 also includes multiple rows of induction heating workcoils.
The induction heating workcoils 302 in the different rows may or may not be offset, and the rows could have any suitable spacing.

The induction heating workcoils 302 operate to produce currents in different areas or zones of a conductive shell 306 of the roll 304. The conductive shell 306 generally represents the portion of the roll 304 that contacts a paper sheet or other product being formed. The conductive shell 306 or the roll 304 could be formed from any suitable material(s), such as a metallic ferromagnetic material. The currents could also be produced in different areas or zones of the roll 304 itself, such as when the roll 304 is solid. The amount of current flowing through the zones could be controlled by adjusting the amount of energy flowing into the coils of the induction heating workcoils 302 (via control of the power sources 210). This control could, for example, be provided by the controller 104 in the paper production system 100 of FIG. 1.

In order to reduce or minimize currents flowing through the shaft 308 and through bearings in a bearing house 310 of the roll 304, the induction heating workcoils 302 are oriented so that the currents flow within the roll 304. The currents 304 are not directed parallel to the axis of the roll 304, so a reduced or minimized amount of current flows through the bearings of the roll 304.

Although FIG. 3 illustrates one example of a configuration 300 of induction heating workcoils with respect to a roll, various changes may be made to FIG. 3. For example, the configuration 300 could include any number of rows of induction heating workcoils 302 at any uniform or non-uniform spacing. Also, each row could include any number of induction heating workcoils 302 at any uniform or non-uniform spacing.

FIG. 4 illustrates an example method 400 for reducing current exiting a roll through its bearings according to this disclosure. As shown in FIG. 4, one or more induction heating workcoils are placed in proximity to a roll at step 402. This could include, for example, placing multiple induction heating workcoils 120 near a roll 119 in a paper calender. Any suitable number of induction heating workcoils could be placed near the roll, and the induction heating workcoils could have any suitable arrangement or configuration.

The induction heating workcoils are oriented at step 404. This could include, for example, orienting the induction heating workcoils so that their cores 206 are substantially parallel to the roll's axis. In general, the orientation involves positioning the induction heating workcoils so that the paths of their induced magnetic fluxes are substantially parallel to the roll's axis.

Once oriented, the roll can be rotated during the production of a paper sheet or other continuous web product at step 406, and currents are produced through the roll at step 408. The currents can be generated by providing AC signals to the coils 204 of the induction heating workcoils. Moreover, the currents produced by the induction heating workcoils do not flow substantially axially within the roll, so the amount of current exiting the roll through its bearings can be reduced or minimized.

Although FIG. 4 illustrates one example of a method 400 for reducing current exiting a roll through its bearings, various changes may be made to FIG. 4. For example, while shown as a series of steps, various steps shown in FIG. 4 could overlap, occur in parallel, occur in a different order, or occur multiple times.

It may be advantageous to set forth definitions of certain words and phrases used throughout this patent document. The term “couple” and its derivatives refer to any direct or indirect communication between two or more elements, whether or not those elements are in physical contact with one another. The terms “include” and “comprise,” as well as derivatives thereof, mean inclusion without limitation. The term “or” is inclusive, meaning and/or. The phrases “associated with” and “associated therewith,” as well as derivatives thereof, may mean to include, be included within, interconnect with, contain, be contained within, connect to or with, couple to or with, be communicable with, cooperate with, interleave, juxtapose, be proximate to, be bound to or with, have, have a property of, or the like. The term “controller” means any device, system, or part thereof that controls at least one operation. A controller may be implemented in hardware, firmware, software, or some combination of at least two of the same. The functionality associated with any particular controller may be centralized or distributed, whether locally or remotely.

While this disclosure has described certain embodiments and generally associated methods, alterations and permutations of these embodiments and methods will be apparent to those skilled in the art. Accordingly, the above description of example embodiments does not define or constrain this disclosure. Other changes, substitutions, and alterations are also possible without departing from the spirit and scope of this disclosure, as defined by the following claims.

What is claimed is:

1. A system comprising: a roll comprising a conductive material, the roll configured to rotate about an axis; and an induction heating workcoil configured to generate currents within the roll, wherein the induction heating workcoil is unbalanced and is oriented so that minimal currents flow in a direction substantially parallel to the axis of the roll.

2. The system of claim 1, wherein the induction heating workcoil comprises: one or more substantially U-shaped or C-shaped cores; and at least one coil, each coil wound around at least one of the one or more cores.

3. The system of claim 1, wherein: the roll further comprises a shaft and bearings; and the induction heating workcoil is oriented so that the currents do not flow substantially through the bearings.

4. The system of claim 1, wherein the roll comprises one of a set of counter-rotating rolls, the counter-rotating rolls configured to compress a web of material.

5. The system of claim 4, wherein: an induction heating actuator comprises the induction heating workcoil and a power source coupled to at least one coil of the induction heating workcoil; and the system further comprises a controller configured to control the power source to control an amount of compression provided by at least a portion of the counter-rotating rolls.

6. The system of claim 1, wherein multiple induction heating workcoils are located adjacent to each other in a row proximate to the roll.

7. The system of claim 6, wherein multiple rows of induction heating workcoils are located adjacent to each other proximate to the roll.
8. A system comprising:
a roll comprising a conductive material, the roll configured
to rotate about an axis; and
an induction heating workcoil configured to generate a
magnetic flux for producing currents within the roll,
wherein the induction heating workcoil is unbalanced
and is oriented so that a path of the magnetic flux through
the roll is substantially parallel to the axis of the roll.
9. The system of claim 8, wherein the currents within the
roll do not flow substantially parallel to the axis of the roll.
10. The system of claim 8, wherein the induction heating
workcoil comprises:
one or more substantially U-shaped or C-shaped cores; and
at least one coil, each coil wound around at least one of the
one or more cores.
11. The system of claim 8, wherein:
the roll further comprises a shaft and bearings; and
the induction heating workcoil is oriented so that the cur-
rents do not flow substantially through the bearings.
12. The system of claim 8, wherein the roll comprises one
of a set of counter-rotating rolls, the counter-rotating rolls
configured to compress a web of material.
13. The system of claim 12, wherein:
an induction heating actuator comprises the induction heat-
ing workcoil and a power source coupled to at least one
coil of the induction heating workcoil; and
the system further comprises a controller configured to
control the power source to control an amount of comp-
pression provided by at least a portion of the counter-
rotating rolls.
14. The system of claim 8, wherein multiple induction
heating workcoils are located adjacent to each other in a row
proximate to the roll.

15. The system of claim 14, wherein multiple rows of
induction heating workcoils are located adjacent to each other
proximate to the roll.
16. A method comprising:
placing an induction heating workcoil in proximity with a
roll, the roll configured to rotate about an axis, the induc-
tion heating workcoil comprising an unbalanced induc-
tion heating workcoil;
orienting the induction heating workcoil so that a magnetic
flux path within the roll produced by the unbalanced
induction heating workcoil is axially aligned with the
axis of the roll; and
producing currents within the roll.
17. The method of claim 16, further comprising:
initially orienting the induction heating workcoil so that
the magnetic flux path is not axially aligned with the axis
of the roll, before orienting the induction heating work-
coil so that the magnetic flux path is axially aligned with
the axis of the roll.
18. The method of claim 16, wherein:
the roll comprises a shaft and bearings; and
orienting the induction heating workcoil comprises orient-
ing the induction heating workcoil so that the currents do
not flow substantially through the bearings.
19. The method of claim 16, wherein the roll comprises one
of a set of counter-rotating rolls, the counter-rotating rolls
configured to compress a web of material.
20. The method of claim 19, wherein:
an induction heating actuator comprises the induction heat-
ing workcoil and a power source coupled to at least one
coil of the induction heating workcoil; and
further comprising controlling the power source to control
an amount of compression provided by at least a portion
of the counter-rotating rolls.

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