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Wrap stretch sensing for a baler implement

Abstract

A baler implement includes a baler controller configured to determine an unstretched length of wrap material dispensed by a wrap system during a wrap cycle, and determine a circumference of a bale in a baling chamber. The baler controller may then determine a stretched length of the wrap material as applied onto the bale during the wrap cycle from the circumference of the bale and a number of wrap layers of the wrap material wrapped around the circumference of the bale. The baler controller may then compare the stretched length of the wrap material as applied onto the bale to the unstretched length of the wrap material dispensed by the wrap system during the wrap cycle to determine an applied wrap stretch factor. The applied wrap stretch factor may be communicated to an operator, or used to control the wrap system to achieve a desired wrap stretch.

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Background/Summary

TECHNICAL FIELD
(1) The disclosure generally relates to a baler implement, and more particularly to a method of controlling a wrap system of the baler implement.
BACKGROUND
(2) There are a wide variety of different types of baler implements that generate bales of material. Such baler implements can bale material like hay, straw, silage, cotton, recycled paper products, etc. One type of machine produces a bale having a cylindrical shape. Such a machine is often referred to as a round baler. A round baler gathers crop material and feeds the crop material into a baling chamber. The baler implement rolls the crop material in a spiral fashion into the bale having a cylindrical shape. Once formed, the baler implement wraps the bale with a wrap material to secure the cylindrical shape of the bale and hold the baled crop material together.
(3) The wrap material may include, for example, a net wrap or a solid wrap. The wrap material must be tightly tensioned about the exterior circumferential surface of the completed bale to secure the shape of the bale and hold the baled crop material together. If the wrap material is not sufficiently tensioned, the bale will be loose, allowing the crop material to sag and/or deform from the desired cylindrical shape. When properly tensioned, the wrap material maintains the generally cylindrical shape of the bale without excessive sag and/or deformation of the desired cylindrical shape. When properly tensioned, the wrap material exhibits a desired amount of stretch, particularly in the circumferential direction, relative to an unstretched condition of the wrap

material.

(4) It is known to include markings on the wrap material for indicating an amount of stretch in the wrap material. For example, the wrap material may include a pair of lines spaced apart from each other a defined distance when in an upstretched condition. The spacing between the pair of lines may be measured on the completed bale in the as applied condition, and the amount of stretch estimated based on the change in the distance between the unstretched condition and the as-applied condition. This procedure requires the operator to stop the baling operation, exit the tractor, and examine the completed and ejected bale to determine the amount of stretch in the wrap material.

SUMMARY

(5) A baler implement is provided. The baler implement includes a baling system having a baling chamber configured to form crop material into a bale having a cylindrical shape. A wrap system is configured to feed a wrap material into the baling chamber to wrap a circumference of the bale with a number of wrap layers of the wrap material during a wrap cycle. A wrap sensor is configured to detect data related to an unstretched length of the wrap material dispensed by the wrap system during the wrap cycle. A bale size sensor is configured to detect data related to a diameter of the bale within the baling chamber. The baler implement further includes a baler controller including a processor and a memory having a wrap stretch algorithm stored thereon. The processor is operable to execute the wrap stretch algorithm to determine the unstretched length of the wrap material dispensed by the wrap system during the wrap cycle from the data sensed by the wrap sensor related to the unstretched length of the wrap material. The baler controller further determines a circumference of the bale in the baling chamber from the data sensed by the bale size sensor related to the diameter of the bale. The baler controller may then determine a stretched length of the wrap material as applied onto the bale during the wrap cycle from the circumference of the bale in the baling chamber and the number of wrap layers of the wrap material, and then compare the stretched length of the wrap material as applied onto the bale to the unstretched length of the wrap material dispensed by the wrap system during the wrap cycle to determine an applied wrap stretch factor.

(6) In one aspect of the disclosure, the applied wrap stretch factor may be defined in terms of a percentage of stretch of the wrap material. For example, the applied wrap stretch factor may be expressed as a percentage increase in the length of the wrap material when compared to the unstretched length of the wrap material, e.g., an applied wrap stretch factor of twenty five percent (25%) would indicate that the as applied stretched length of the wrap material is twenty five percent longer than the un-stretched length of the wrap material. It should be appreciated that the applied wrap stretch factor may be expressed in some other manner, ratio, number, visual representation, etc.

(7) In one aspect of the disclosure, the baler implement may include a communicator configured to communicate a message. The communicator may be located with the baler implement or remote from the baler implement. For example, the communicator may include, but is not limited to, a visual display located in the operator's station of an associated tractor linked to the baler implement. The processor may be operable to execute the wrap stretch algorithm to generate and transmit a communication signal to the communicator for communicating the applied wrap stretch factor. The communication signal may be configured to generate the applied wrap stretch factor as a visual representation and/or as text on the visual display.

(8) In one aspect of the disclosure, the processor may be operable to execute the wrap stretch algorithm to determine if the applied wrap stretch factor is less than a minimum threshold or greater than a maximum threshold. The baler controller may then control a torque controlling device of the wrap system to increase tension in the wrap material during the wrap cycle when the applied wrap stretch factor is less than the minimum threshold. In contrast, the baler controller may control the torque controlling device of the wrap system to decrease tension in the wrap material during the wrap cycle when the applied wrap stretch factor is greater than the maximum threshold.

(9) In one aspect of the disclosure, the wrap system includes a supply roll of the wrap material. In

one implementation, the torque controlling device may include, but is not limited to, a brake coupled to the supply roll and configured to resist rotation of the supply roll during the wrap cycle. The brake may be controlled to apply a braking force to resist rotation of the supply roll during the wrap cycle. The brake force may be increased to increase tension in the wrap material during the wrap cycle and increase the wrap stretch. In contrast, the braking force may be decreased to decrease tension in the wrap material during the wrap cycle and reduce the wrap stretch.
(10) In one implementation of the disclosure, the wrap sensor may include, but is not limited to, a position sensor coupled to the supply roll of the wrap material. The position sensor may be configured for sensing data related to a diameter of the supply roll of the wrap material. For example, the position sensor may be coupled to a linkage, bar, bracket or other structure supporting the supply roll of the wrap material and that moves with the supply roll of the wrap material as the amount of wrap material on the supply roll changes. Alternatively, the position sensor may be placed in direct contact with an exterior surface of the wrap material on the supply roll, such that a change in the amount of the wrap material on the supply roll changes a position of the position sensor.
(11) In one aspect of the disclosure, the processor may be operable to execute the wrap stretch algorithm to correlate a change in the diameter of the supply roll during a wrap cycle to a length of the wrap material dispensed during the wrap cycle. In other words, as the wrap material is dispensed during the wrap cycle, the diameter of the supply roll of the wrap material also changes. The change in diameter of the supply roll during a wrap cycle is directly related to the amount of the wrap material dispensed during the wrap cycle. As such, the baler controller may determine and/or calculate the length of the wrap material dispensed during the wrap cycle based on the change in diameter of the supply roll of the wrap material during the wrap cycle. The baler controller may then define the length of the wrap material dispensed during the wrap cycle as the unstretched length of the wrap material dispensed by the wrap system during the wrap cycle.
(12) In one implementation of the disclosure, the wrap sensor may include, but is not limited to, a rotational speed sensor configured for sensing data related to a rotational speed of the supply roll of the wrap material during the wrap cycle. The baler controller may calculate the unstretched length of the wrap material dispensed during the wrap cycle from the data related to the diameter of the supply roll of the wrap material and the data related to the rotational speed of the supply roll of the wrap material during the wrap cycle.
(13) In one implementation, the wrap sensor may include a linear measuring device that is configured for measuring a length of the wrap material dispensed during the wrap cycle. For example, the linear measuring device may include a measuring wheel disposed in contact with an exterior circumferential surface of the supply roll of the wrap material.
(14) In one aspect of the disclosure, the processor may be operable to execute the wrap stretch algorithm to receive a user input setting the number of wrap layers of the wrap material during the wrap cycle. For example, an operator may select **4** complete wraps around the circumference of the bale. The baler controller may then rotate the bale within the baling chamber to apply the desired number of wrap layers of the wrap material during the wrap cycle.
(15) A method of controlling the wrap system of the baler implement is also provided. The method includes the baler controller determining the unstretched length of the wrap material dispensed by the wrap system during the wrap cycle from data sensed by the wrap sensor related to the unstretched length of the wrap material. The baler controller further determines a circumference of the bale in the baling chamber of the baler implement from data sensed by the bale size sensor related to the diameter of the bale. The baler controller may then determine a stretched length of the wrap material as applied onto the bale during the wrap cycle from the circumference of the bale in the baling chamber and the number of wrap layers of the wrap material around the bale. The stretched length of the wrap material as applied onto the bale may be compared by the baler controller to the unstretched length of the wrap material dispensed by the wrap system during the

wrap cycle to determine the applied wrap stretch factor. The baler controller may then transmit a communication signal to a communicator. The communication signal is configured to generate an output from the communicator indicating the applied wrap stretch factor.
(16) In one aspect of the method described herein, the baler controller may control a torque controlling device of the wrap system to increase tension in the wrap material during the wrap cycle when the applied wrap stretch factor is less than a minimum threshold. The baler controller may control the torque controlling device of the wrap system to decrease tension in the wrap material during the wrap cycle when the applied wrap stretch factor is greater than a maximum threshold.
(17) In one aspect of the method described herein, the wrap sensor includes the position sensor coupled to the supply roll of the wrap material. The position sensor is configured for sensing data related to a diameter of the supply roll of the wrap material. The method may further include determining the unstretched length of the wrap material dispensed by the wrap system during a wrap cycle by correlating a change in the diameter of the supply roll during a wrap cycle to a length of the wrap material dispensed during the wrap cycle. The baler controller may then define the length of the wrap material dispensed during the wrap cycle as the unstretched length of the wrap material dispensed by the wrap system during the wrap cycle.
(18) Accordingly, the baler implement and the process described herein provide real time on the go feedback to the operator of the applied wrap stretch factor of the wrap material, i.e., the wrap stretch. As such, the operator does not have to stop baling operations and exit the operator's station of the tractor to visually inspect the wrap material to determine the stretch factor. The operator may use the stretch factor to make changes to the wrap system, or in other implementations, the baler controller may automatically adjust the wrap system to achieve the desired stretch factor.
(19) The above features and advantages and other features and advantages of the present teachings are readily apparent from the following detailed description of the best modes for carrying out the teachings when taken in connection with the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a schematic side view of a baler implement.
(2) FIG. **2** is a schematic cross-sectional view of a bale showing a number of wrap layers of a wrap material on the bale.
(3) FIG. **3** is a schematic cross-sectional view of a wrap system of the baler implement, viewed from a first side of the baler implement.
(4) FIG. **4** is a schematic cross-sectional view of the wrap system, viewed from a second side of the baler implement.
DETAILED DESCRIPTION
(5) Those having ordinary skill in the art will recognize that terms such as “above,” “below,” “upward,” “downward,” “top,” “bottom,” etc., are used descriptively for the figures, and do not represent limitations on the scope of the disclosure, as defined by the appended claims. Furthermore, the teachings may be described herein in terms of functional and/or logical block components and/or various processing steps. It should be realized that such block components may be comprised of any number of hardware, software, and/or firmware components configured to perform the specified functions.
(6) The terms “forward”, “rearward”, “left”, and “right”, when used in connection with a moveable implement and/or components thereof are usually determined with reference to the direction of travel during operation, but should not be construed as limiting. The terms “longitudinal” and “transverse” are usually determined with reference to the fore-and-aft direction of the implement

relative to the direction of travel during operation, and should also not be construed as limiting.
(7) Terms of degree, such as "generally", "substantially" or "approximately" are understood by those of ordinary skill to refer to reasonable ranges outside of a given value or orientation, for example, general tolerances or positional relationships associated with manufacturing, assembly, and use of the described embodiments.
(8) As used herein, "e.g." is utilized to non-exhaustively list examples, and carries the same meaning as alternative illustrative phrases such as "including," "including, but not limited to," and "including without limitation." As used herein, unless otherwise limited or modified, lists with elements that are separated by conjunctive terms (e.g., "and") and that are also preceded by the phrase "one or more of," "at least one of," "at least," or a like phrase, indicate configurations or arrangements that potentially include individual elements of the list, or any combination thereof. For example, "at least one of A, B, and C" and "one or more of A, B, and C" each indicate the possibility of only A, only B, only C, or any combination of two or more of A, B, and C (A and B; A and C; B and C; or A, B, and C). As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. Further, "comprises," "includes," and like phrases are intended to specify the presence of stated features, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, steps, operations, elements, components, and/or groups thereof.
(9) Referring to the Figures, wherein like numerals indicate like parts throughout the several views, an example implementation of a baler implement is generally shown at **20**. The example implementation of the baler implement **20** is shown and described herein as a round baler. It should be appreciated that the features and operation of the baler implement **20** may differ from the example implementation shown in the Figures and described herein.
(10) Referring to FIG. **1**, the baler implement **20** includes a frame **22**. One or more ground engaging elements **24**, such as but not limited to one or more wheels and/or tracks, are attached to and rotatably supported by the frame **22**. A tongue **26** may be coupled to the frame **22** at a forward end of the frame **22**. A hitch arrangement **28** may be included with the tongue **26**. The hitch arrangement **28** may be used to attach the baler implement **20** to a traction unit, such as but not limited to an agricultural tractor. In other embodiments, the baler implement **20** may be self-propelled, in which case the traction unit and the baler implement **20** are configured as a single, self-propelled vehicle.
(11) The baler implement **20** includes a baling system **30** having a baling chamber **32** that is configured to form crop material into a bale **34**. The baler implement **20** includes a housing **36** partially forming the baling chamber **32**. The housing **36** is attached to and supported by the frame **22**. The housing **36** may include one or more walls or panels that at least partially enclose and/or define the baling chamber **32**. The baler implement **20** further includes a gate **38**. The gate **38** is attached to and rotatably supported by the housing **36**. The gate **38** is positioned adjacent a rearward end of the frame **22** and is pivotably moveable about a gate axis **40**. The gate axis **40** is generally horizontal and perpendicular to a central longitudinal axis **42** of the frame **22**. The gate **38** is moveable between a closed position for forming the bale **34** within the baling chamber **32**, and an open position for discharging the bale **34** from the baling chamber **32**.
(12) The baler implement **20** includes a pick-up **44** disposed proximate the forward end of the frame **22**. The pickup gathers crop material from a ground surface and directs the gathered crop material toward and into an inlet **46** of the baling chamber **32**. The pickup may include, but is not limited to tines, forks, augers, conveyors, baffles, etc., for gathering and moving the crop material.
(13) The baler implement **20** may be configured as a variable chamber baler, or as a fixed chamber baler. As understood by those skilled in the art, the fixed chamber baler includes a plurality of transversely extending rollers **50** that are fixed in position relative to the frame **22** and the housing **36**. The rollers **50** rotatably support the crop material therein and form the circumferential limits of the baling chamber **32**. The baler implement **20** shown in the Figures and described herein is

depicted and described as a variable chamber baler. As is understood by those skilled in the art, the variable chamber baler includes a plurality of longitudinally extending side-by-side forming belts **48** that are supported by a plurality of rollers **50**. The bale **34** is formed by the forming belts **48** and one or more side walls of the housing **36**. The forming belts **48** therefore form the circumferential surface of the baling chamber **32**.

(14) The crop material is directed through the inlet **46** and into the baling chamber **32**, whereby the forming belts **48** roll the crop material in a spiral fashion into the bale **34** having a cylindrical shape. The forming belts **48** apply a constant pressure to the crop material as the crop material is formed into the bale **34**. A belt tensioner **52** continuously moves the forming belts **48** radially outward relative to a center of the cylindrical bale **34** as a diameter **54** of the bale **34** increases. The belt tensioner **52** maintains the appropriate tension in the forming belts **48** to obtain the desired density of the crop material forming the bale **34**.

(15) The baler implement **20** includes a wrap system **56**. The wrap system **56** is operable to wrap the formed bale **34** within the baling chamber **32** with a wrap material **58**. The wrap system **56** is configured to wrap a circumference **60** of the bale **34** with a number of wrap layers **62**A, **62**B, **62**CA, of the wrap material **58** during a wrap cycle. The wrap material **58** may include, but is not limited to, a net mesh wrap or a solid plastic wrap as is understood by those skilled in the art. Once the bale **34** is formed to a desired size within the baling chamber **32**, the wrap system **56** is initiated to begin the wrap cycle. Upon initiation of the wrap cycle, the wrap system **56** feeds or inserts the wrap material **58** through an access **80** and into the baling chamber **32**, whereby the wrap material **58** is wrapped around the exterior circumference **60** of the cylindrical shape of the bale **34** with the defined number of wrap layers **62**A, **62**B, **62**C to secure the crop material in a tight package and maintain the desired generally cylindrical shape of the bale **34**, at the desired density, such as shown in FIG. **2**. In one implementation, the access **80** may include the inlet **46**, through which the crop material moves into the baling chamber **32**. In another implementation, the access **80** may include an opening into the baling chamber **32** that is separate from the inlet **46**. When the wrap cycle is complete, the gate **38** is moved into the open position, which simultaneously moves the forming belts **48** clear of the formed bale **34**, and allows the formed and wrapped bale **34** to be discharged through the rear of the baling chamber **32**.

(16) Referring to FIGS. **3**, an example implementation of the wrap system **56** is generally shown. It should be appreciated that the wrap system **56** may differ from the example implementation shown in the Figures and described herein. As shown, the wrap system **56** includes a pair of spool rollers **64**, **66**. The pair of spool rollers **64**, **66** includes a first roller **64** and a second roller **66**. The first roller **64** and the second roller **66** are arranged in a parallel relationship, and extend transversely across a width of the frame **22** in a horizontal orientation, generally perpendicular to the central longitudinal axis **42** of the frame **22**. The first roller **64** includes a cylindrical shape having a respective centerline **68**, about which the first roller **64** rotates. As such, the respective centerline **68** of the first roller **64** is an axis of rotation of the first roller **64**. The second roller **66** includes a cylindrical shape having a respective centerline **70**, about which the second roller **66** rotates. As such, the respective centerline **70** of the second roller **66** is an axis of rotation of the second roller **66**. The first roller **64** and the second roller **66** are arranged such that a circumferential surface of the first roller **64** and a circumferential surface of the second roller **66** are disposed in contacting or abutting engagement, and form a nip **72** therebetween where their respective circumferential surfaces come together and meet. As used herein, the term “nip **72**” may be defined as, but is not limited to, the region where the first roller **64** and the second roller **66** come together and contact each other.

(17) As described above, the pair of spool rollers **64**, **66** are configured to rotate about their respective axes of rotation. The first roller **64** and the second roller **66** rotate in opposite rotational directions relative to each other and receive the wrap material **58** from a supply roll **74** of the wrap material **58**. The first roller **64** and the second roller **66** receive the wrap material **58** through the

nip **72**. As shown in the example implementation of the Figures, the first roller **64** is rotatable about its' respective axis of rotation in a counter-clockwise direction as viewed on the page of the drawing, and the second roller **66** is rotatable about its' respective axis of rotation in a clockwise direction as viewed on the page of the drawing. As such, the first roller **64** and the second roller **66** cooperate to feed the wrap material **58** through the nip **72**, from left to right as viewed on the page of the drawing.

(18) The first roller **64** includes an elastomer defining a cylindrical outer elastomer surface of the first roller **64**. The elastomer exhibits static adhesion or "sticky" properties which limits movement of the wrap material **58** relative to the cylindrical outer elastomer surface of the first roller **64**. The elastomer may include for example, but is not limited to, a natural or synthetic rubber material, or some other material having similar static adhesion properties.

(19) The baler implement **20** further includes a support structure **76**. The support structure **76** is configured to support the supply roll **74** of the wrap material **58** relative to the pair of spool rollers **64**, **66**. The support structure **76** supports the supply roll **74** such that the supply roll **74** of the wrap material **58** rests against the cylindrical outer elastomer surface of the first roller **64** along a contact region **78**. Because the supply roll **74** of the wrap material **58** rests against the cylindrical outer elastomer surface of the first roller **64**, it should be appreciated that the support structure **76** must allow the supply roll **74** of the wrap material **58** to move relative to the frame **22** of the baler implement **20** as the wrap material **58** is dispensed to maintain contact between the wrap material **58** on the supply roll **74** and the cylindrical outer elastomer surface of the first roller **64**. The support structure **76** may include, but is not limited to, wall portions of the housing **36** of the baler implement **20**, various guides, pins, grooves, brackets, etc. The specific construction of the support structure **76** in which the supply roll **74** of the wrap material **58** is supported is understood by those skilled in the art, is not pertinent to the teachings of this disclosure, and is therefore not described in greater detail herein.

(20) As described above, the supply roll **74** of the wrap material **58** rests against the cylindrical outer elastomer surface of the first roller **64** along the contact region **78** and is continuously pressed against the cylindrical outer elastomer surface of the first roller **64** as a radial or diametric size of the supply roll **74** of the wrap material **58** decreases. The contact region **78** is the common contact surface area between the supply roll **74** of the wrap material **58** and the first roller **64**. It should be appreciated that the contact region **78** extends generally parallel with a centerline **114** of the supply roll **74** and the centerline **68** of the first roller **64**, across a width of the supply roll **74** of the wrap material **58**.

(21) The wrap material **58** follows a routing path that partially encircles the first roller **64**, between the contact region **78** and the nip **72** and about the axis of rotation of the first roller **64**. The routing path follows a counter-clockwise path around the cylindrical outer elastomer surface of the first roller **64** as viewed on the page of the drawing. The wrap material **58** enters the nip **72** moving from left to right as viewed on the page of the drawing, whereby the wrap material **58** is grasped between the first roller **64** and the second roller **66** at the nip **72**. During a wrap cycle, the first roller **64** and the second roller **66** are counter rotated bout their respective axes of rotation to eject the wrap material **58** from the nip **72** toward and through the access **80** and into the baling chamber **32**.

(22) Referring to FIG. **4**, the wrap system **56** includes a driver **82** that is coupled to the pair of spool rollers **64**, **66**. The driver **82** is operable to transmit torque to the pair of spool rollers **64**, **66** to rotate the pair of spool rollers **64**, **66** about their respective axes of rotation. The driver **82** may be configured in any suitable manner, and include a device, system, or mechanism capable rotating the pair of spool rollers **64**, **66** about their respective axes of rotation. In one implementation, the driver **82** includes a belt **84** coupled to at least one of the pair of spool rollers **64**, **66** and a tensioner **86** operable to tension the belt **84**. The belt **84** may be coupled to a rotating element **88**, such as but not limited to a driven roller of the baling system **30**, to receive torque therefrom. When the belt **84**

is sufficiently tensioned by the tensioner **86**, the belt **84** transmits torque from the rotating element **88** to the pair of spool rollers **64**, **66**, thereby rotating the pair of spool rollers **64**, **66** about their respective axes of rotation. When tension in the belt **84** is reduced by the tensioner **86**, the belt **84** slips relative to the rotating element **88** and/or at least one of the pair of spool rollers **64**, **66**, such that the pair of spool rollers **64**, **66** do not rotate. Accordingly, it should be appreciated that the amount of torque applied to the pair of spool rollers **64**, **66** is proportional to and/or controlled by the tension in the belt **84**. It should be appreciated the torque transfer to the pair of spool rollers **64**, **66** may be controlled via other systems and/or components of the baler implement **20**, other than the example implementation described herein.

(23) Referring to FIG. **4**, the baler implement **20** may further include a torque controlling device **90** operable to control tension in the wrap material **58** during the wrap cycle. Once the wrap material **58** is introduced into the baling chamber **32** during a wrap cycle, the wrap material **58** is trapped between the bale **34** and the baling system **30**, e.g., the forming belts **48**. The bale **34** is rotated within the baling chamber **32**, thereby rotating the wrap material **58** with the bale **34** and wrapping the wrap material **58** around the outer circumference **60** of the bale **34**. In order to maintain the compression of the crop material forming the bale **34** after ejection from the baler implement **20**, the wrap material **58** is tensioned as it is wrapped around the bale **34** within the baling chamber **32**. Tensioning the wrap material **58** applies a compressive force to the bale **34**, securing the shape and density of the bale **34** once ejected from the baling chamber **32**.

(24) In order to tension the wrap material **58** during the wrap cycle, the baler implement **20** may include the torque controlling device **90**. The torque controlling device **90** may include a system that is configured to resist or pull against the wrap material **58** as the wrap material **58** is being drawn into the baling chamber **32** to wrap the bale **34**, thereby generating tension in the wrap material **58**. For example, the torque controlling device **90** may include, but is not limited to, a brake **92** that is coupled to the supply roll **74** and configured to resist rotation of the supply roll **74** during the wrap cycle. It should be appreciated that the brake **92** may be coupled to and/or incorporated into the driver **82**. After initial insertion of the wrap material **58** into the baling chamber **32** during the wrap cycle, the brake **92** may be engaged to resist rotation of the supply roll **74** of the wrap material **58** and thereby introduce tension into the wrap material **58** during the wrap cycle. It should be appreciated that the torque controlling device **90** may be implemented using some other system couped to some other component of the wrap system **56**, such as but not limited to the first roller **64** and/or the second roller **66**. The features and operation of the torque controlling device **90**, such as the brake **92** for example, are understood by those skilled in the art, are not pertinent to the teachings of this disclosure, and are therefore not described in greater detail herein.

(25) Referring to FIG. **3**, The baler implement **20** includes a wrap sensor **94** that is configured to detect data related to an unstretched length of the wrap material **58** dispensed by the wrap system **56** during the wrap cycle. As noted above, the wrap material **58** is tensioned during the wrap cycle. Tension in the wrap material **58** during the wrap cycle introduces a degree or an amount of stretch into the wrap material **58**. The unstretched length of the wrap material **58** dispensed during the wrap cycle is the length that the wrap material **58** used to wrap the bale **34** would exhibit if the wrap material **58** were in an unstretched or non-tensioned condition.

(26) The wrap sensor **94** may include a device that is capable of collecting data related to and/or that may be used to determine/calculate the unstretched length of the wrap material **58**. For example, in one implementation, the wrap sensor **94** may include a position sensor that is coupled to the supply roll **74** of the wrap material **58**, for example, the support structure **76** supporting the supply roll **74**. The position sensor may be configured for sensing data related to a diameter **96** of the supply roll **74** of the wrap material **58**. For example, the position sensor may be configured for sensing data related to a position of the supply roll **74** relative to the support structure **76**, or relative to the first roller **64**. As described above, an outer surface of the supply roll **74** of the wrap material **58** rides on the first roller **64**. As the wrap material **58** is dispensed, the diameter **96** of the

supply roll **74** decreases. As such, as the diameter **96** of the supply roll **74** changes, the position of a center of the supply roll **74** changes relative to the first roller **64**. As the supply roll **74** is supported by the support structure **76**, as the diameter **96** of the supply roll **74** changes, the position of the supply roll **74** may also change relative to the support structure **76**. The position sensor may detect data related to the position of the supply roll **74**, which may be correlated to a diameter **96** of the supply roll **74**. The position sensor may include, but is not limited to, an axial or linear position sensor, a rotary position sensor, an optical sensor, etc.

(27) The position sensor may be configured to detect a position of a component of the wrap system **56** that moves as the wrap material **58** is dispensed during the wrap cycle. By detecting the position of the component at the beginning of the wrap cycle and at the end of the wrap cycle, a change in position during the wrap cycle may be determined. This change in position during the wrap cycle may be correlated to a change in diameter **96** of the supply roll **74** of the wrap cycle, which may in turn be correlated to a length of the wrap material **58** dispensed during the wrap cycle. This length of the wrap material **58** dispensed during the wrap cycle may be defined as the unstretched length of the wrap material **58**.

(28) In another implementation, the wrap sensor **94** may include a rotational speed sensor configured for sensing data related to a rotational speed of the supply roll **74** of the wrap material **58** during the wrap cycle. The unstretched length of the wrap material **58** may be calculated from the rotational speed and a diameter **96** of the supply roll **74** of the wrap material **58**. The diameter **96** of the supply roll **74** of the wrap material **58** may be determined for example, via the position sensor described above, or via some other sensor capable of detecting data related to the diameter **96** of the supply roll **74** of the wrap material **58** during the wrap cycle.

(29) In another implementation, the wrap sensor **94** may include a linear measuring device configured for measuring a length of the wrap material **58** dispensed during the wrap cycle. For example, the linear measuring device may include a measuring wheel disposed in contact with the supply roll **74** of the wrap material **58**. The linear measuring device may directly measure the length of the wrap material **58** dispensed from the supply roll **74**.

(30) Referring to FIG. **1**, the baler implement **20** may further include a bale size sensor **98** that is configured to detect data related to a diameter **54** of the bale **34** within the baling chamber **32**. The bale size sensor **98** may include a device that is capable of collecting data related to and/or that may be used to determine/calculate the diameter **54** of the bale **34**. For example, the bale size sensor **98** may include, but is not limited to a position sensor, e.g., a rotary position sensor coupled to the belt tensioner **52** of the baling system **30**. In other implementations, the bale size sensor **98** may include an optical sensor positioned to capture an image from which the diameter **54** of the bale **34** may be determined. It should be appreciated that the bale size sensor **98** may include some other type of sensor capable of detecting some other type of data from some other component of the baler implement **20** not specifically described herein, which may be used to calculate and/or determine the diameter **54** of the bale **34**.

(31) Referring to FIG. **1**, the baler implement **20** may further include a baler controller **100**. The baler controller **100** may be disposed in communication with the various components of the baler implement **20** for receiving and/or communicating information and/or instructions to achieve the operations described below. The baler controller **100** is operable to receive data signals from the various sensors and/or communicate control signals to the components of the baler implement **20**. While the baler controller **100** is generally described herein as a singular device, it should be appreciated that the baler controller **100** may include multiple devices linked together to share and/or communicate information therebetween. Furthermore, it should be appreciated that the baler controller **100** may be located on the baler implement **20** or located remotely from the baler implement **20**.

(32) The baler controller **100** may alternatively be referred to as a computing device, a computer, a controller, a control unit, a control module, a module, etc. The baler controller **100** includes a

processor **102**, a memory **104**, and all software, hardware, algorithms, connections, sensors, etc., necessary to manage and control the operation of the baler implement **20** as described herein. As such, a method may be embodied as a program or algorithm operable on the baler controller **100**. It should be appreciated that the baler controller **100** may include any device capable of analyzing data from various sensors, comparing data, making decisions, and executing the required tasks.

(33) As used herein, "controller" is intended to be used consistent with how the term is used by a person of skill in the art, and refers to a computing component with processing, memory, and communication capabilities, which is utilized to execute instructions (i.e., stored on the memory **104** or received via the communication capabilities) to control or communicate with one or more other components. In certain embodiments, the baler controller **100** may be configured to receive input signals in various formats (e.g., hydraulic signals, voltage signals, current signals, CAN messages, optical signals, radio signals), and to output command or communication signals in various formats (e.g., hydraulic signals, voltage signals, current signals, CAN messages, optical signals, radio signals).

(34) The baler controller **100** may be in communication with other components on the baler implement **20**, such as hydraulic components, electrical components, and operator inputs within an operator station of an associated work vehicle. The baler controller **100** may be electrically connected to these other components wirelessly or via a wiring harness such that messages, commands, and electrical power may be transmitted between the baler controller **100** and the other components. Although the baler controller **100** is referenced in the singular, in alternative embodiments the configuration and functionality described herein can be split across multiple devices using techniques known to a person of ordinary skill in the art.

(35) The baler controller **100** may be embodied as one or multiple digital computers or host machines each having one or more processors, read only memory (ROM), random access memory (RAM), electrically-programmable read only memory (EPROM), optical drives, magnetic drives, etc., a high-speed clock, analog-to-digital (A/D) circuitry, digital-to-analog (D/A) circuitry, and any required input/output (I/O) circuitry, I/O devices, and communication interfaces, as well as signal conditioning and buffer electronics.

(36) The computer-readable memory **104** may include any non-transitory/tangible medium which participates in providing data or computer-readable instructions. The memory **104** may be non-volatile or volatile. Non-volatile media may include, for example, optical or magnetic disks and other persistent memory. Example volatile media may include dynamic random access memory (DRAM), which may constitute a main memory. Other examples of embodiments for memory **104** include a floppy, flexible disk, or hard disk, magnetic tape or other magnetic medium, a CD-ROM, DVD, and/or any other optical medium, as well as other possible memory devices such as flash memory.

(37) As noted above, with reference to FIG. **1**, the baler controller **100** may be disposed in communication with a communicator **106**. The communicator **106** may be located on the baler implement **20**, or remotely from the baler implement **20**, such as in an operator's station of an associated traction unit. The communicator **106** is configured for communicating a message to an operator of the baler implement **20**. The communicator **106** may include, for example, a visual display, such as but not limited to a touch screen display of the operator's station, a speaker, an indicator light, etc. The baler controller **100** may generate and transmit a communication signal **112** to the communicator **106** operable to cause the communicator **106** to generate a message indicating an applied wrap stretch factor **110**. The applied wrap stretch factor **110** may be represented in terms of a percentage of stretch of the wrap material **58** in an as-applied condition on the bale **34**. In other implementations, the message indicating the applied wrap stretch factor **110** may visually represent the applied wrap stretch factor **110**, either textually or symbolically. In yet other implementations, the communicator **106** may generate an audio signal indicating the applied wrap stretch factor **110**.

(38) As described above, the baler controller **100** includes the tangible, non-transitory memory **104**

on which are recorded computer-executable instructions, including a wrap stretch algorithm **108**. The processor **102** of the baler controller **100** is configured for executing the wrap stretch algorithm **108**. The wrap stretch algorithm **108** implements a method of controlling the wrap system **56** of the baler implement **20**, described in detail below.

(39) The method of controlling the wrap system **56** may include the baler controller **100** receiving a user input setting and/or defining the number of wrap layers **62**A, **62**B, **62**C of the wrap material **58** to be applied around the bale **34** during the wrap cycle. An operator may enter the user input via the communicator **106**, or some other data input device, such as but not limited to a keypad, microphone, touchscreen, keyboard, etc. The desired number of wrap layers **62**A, **62**B, **62**C may be selected and/or defined based on the crop type, type of wrap material **58**, e.g., net material or solid material, a physical property of the wrap material **58**, e.g., stretchability, an intended use of the bale **34**, e.g., hay or silage, or some other factor not specifically noted herein. The number of wrap layers **62**A, **62**B, **62**C of the wrap material **58** may be defined to include a partial or fractional number, e.g., three point seven wraps (3.7 wraps), or four and one quarter wraps (4.25 wraps), etc. For example, FIG. **2** shows three (3) wrap layers **62**A, **62**B, **62**C, with layers **62**A and **62**B as complete wrap layers, and layer **62**C as one quarter (¼) of a complete wrap layer. In other implementations, the baler controller **100** may automatically select the desired number of wrap layers **62**A, **62**B, **62**C of the wrap material **58** to apply to the bale **34**, based on pre-defined factors and/or settings.

(40) Once the baler implement **20** has formed the bale **34** to the desired size in the bailing chamber, the baler controller **100** or the operator may initiate the wrap cycle. Upon initiation of the wrap cycle, the wrap system **56** is engaged to initiate the wrap material **58** into the baling chamber **32** as described above. As a leading edge of the wrap material **58** enters the baling chamber **32**, the leading edge engages the crop forming the bale **34** in the baling chamber **32** and is drawn into the baling chamber **32**, between the bale **34** and baling system **30**. Friction between the wrap material **58**, the crop forming the bale **34**, and the components of the baling system **30** keep the wrap material **58** secured relative to the bale **34**. Once the wrap material **58** is introduced into the baling chamber **32** and engaged with the bale **34**, the baler controller **100** may then rotate the bale **34** within the baling chamber **32** the requisite number of revolutions to apply the number of wrap layers **62**A, **62**B, **62**C of the wrap material **58** during the wrap cycle, around the exterior circumference **60** of the bale **34**. As described above, as the bale **34** is rotated within the baling chamber **32** to wind the wrap material **58** around the bale **34**, the torque controlling device **90** is engaged to apply tension to the wrap material **58**, which in turn stretches the wrap material **58** as the wrap material **58** is applied onto the bale **34**.

(41) Upon the completion of the wrap cycle, at which time the bale **34** is wrapped with the number of wrap layers **62**A, **62**B, **62**C and the wrap material **58** disposed around the bale **34** has been severed from the supply roll **74** of the wrap material **58**, the baler controller **100** may then determine and/or calculate the unstretched length of the wrap material **58** that was dispensed by the wrap system **56** during the wrap cycle. The baler controller **100** may determine the unstretched length of the wrap material **58** from the data sensed by the wrap sensor **94** related to the unstretched length of the wrap material **58**.

(42) For example, as described above, the wrap sensor **94** may be configured to detect a position of a component of the wrap system **56** that moves as the wrap material **58** is dispensed during the wrap cycle. By detecting the position of the component at the beginning of the wrap cycle and at the end of the wrap cycle, a change in position during the wrap cycle may be determined. This change in position during the wrap cycle may be correlated to a change in diameter **96** of the supply roll **74** of the wrap cycle, which may in turn be correlated to a length of the wrap material **58** dispensed during the wrap cycle. This length of the wrap material **58** dispensed during the wrap cycle may be defined as the unstretched length of the wrap material **58** dispensed by the wrap system **56** during the wrap cycle.

(43) In another implementation, the wrap sensor **94** may include a rotational speed sensor configured for sensing data related to a rotational speed of the supply roll **74** of the wrap material **58** during the wrap cycle. The unstretched length of the wrap material **58** may be calculated from the rotational speed and a diameter **96** of the supply roll **74** of the wrap material **58**. The diameter **96** of the supply roll **74** of the wrap material **58** may be determined for example, via the position sensor described above, or via some other sensor capable of detecting data related to the diameter **96** of the supply roll **74** of the wrap material **58** during the wrap cycle. In yet another implementation, the upstretched length of the wrap material **58** may be directly measured using a linear measuring device, such as a measuring wheel disposed in contact with an exterior surface of the supply roll **74** of the wrap material **58**. It should be appreciated that the unstretched length of the wrap material **58** may be determined and/or calculated in some other manner not described herein.
(44) The baler controller **100** may further determine a length of the circumference **60** of the bale **34** in the baling chamber **32**. The baler controller **100** may use the data sensed by the bale size sensor **98** related to the diameter **54** of the bale **34** to determine/calculate the diameter **54** of the bale **34**. For example, the bale size sensor **98** may include, but is not limited to a position sensor, e.g., a rotary position sensor coupled to the belt tensioner **52** of the baling system **30**. The bale size sensor **98** may detect a position of the belt tensioner **52** and communicate the position of the belt tensioner **52** to the baler controller **100**. The baler controller **100** may use this data, i.e., the position of the belt tensioner **52** sensed by the bale size sensor **98**, to determine the diameter **54** of the bale **34**. It should be appreciated that the baler controller **100** may determine the diameter **54** of the bale **34** using some other form of data in some other manner not described herein. The diameter **54** of the bale **34** may then be used to determine the length of the circumference **60** of the bale **34**.
(45) The baler controller **100** may then determine a stretched length of the wrap material **58** as applied onto the bale **34** during the wrap cycle. The baler controller **100** may determine the stretched length of the wrap material **58** as applied onto the bale **34** from the length of the circumference **60** of the bale **34** in the baling chamber **32** and the number of wrap layers **62**A, **62**B, **62**C of the wrap material **58** applied onto the bale **34**. The baler controller **100** may determine the circumference **60** of the bale **34** from the diameter **54** of the bale **34** determined above. As noted above, the number of wrap layers **62**A, **62**B, **62**C of the wrap material **58** is defined and/or selected by the operator, or automatically selected by the baler controller **100**. It should be appreciated that the circumference **60** of the bale **34** multiplied by the number of wrap layers **62**A, **62**B, **62**C of the wrap material **58** is equal to the stretched length of the wrap material **58** as applied onto the bale **34** during the wrap cycle.
(46) Once the baler controller **100** has determined the unstretched length of the wrap material **58** dispensed during the wrap cycle, and the stretched length of the wrap material **58** as applied onto the bale **34** during the wrap cycle, the baler controller **100** may then compare the stretched length of the wrap material **58** as applied onto the bale **34** to the unstretched length of the wrap material **58** dispensed by the wrap system **56** during the wrap cycle to determine an applied wrap stretch factor **110**. In one implementation, the applied wrap stretch factor **110** may be expressed as a ratio comparing the upstretched length of the wrap material **58** to the stretched length of the wrap material **58**. In other implementations, the applied wrap stretch factor **110** may include and be expressed as a percentage of stretch of the wrap material **58**, e.g., the percentage of the stretched length of the wrap material **58** relative to the unstretched length of the wrap material **58**. It should be appreciated that the applied wrap stretch factor **110** may be calculated and expressed in some other manner not described herein.
(47) The baler controller **100** may then generate and transmit the communication signal **112** to the communicator **106** for communicating the applied wrap stretch factor **110**. As described above, the communication signal **112** is configured and operable to generate an output from/on the communicator **106** indicating the applied wrap stretch factor **110**. For example, the communication

signal **112** may cause the communicator **106** to display the applied wrap stretch factor **110** as text on a visual display, graphically as a symbol on the visual display, graphically via a sliding scale on the visual display, audibly via a speaker, etc. It should be appreciated that the communicator **106** and the communication signal **112** thereto may cause the communicator **106** to generate the message in some other way capable of communicating the applied wrap stretch factor **110** to the operator not described herein.

(48) The baler controller **100** may further compare the applied wrap stretch factor **110** to a minimum threshold and/or a maximum threshold. The minimum threshold may define a lower acceptable or desirable limit of the amount of stretch and/or tension in the wrap material **58** as applied onto the bale **34**, whereas the maximum threshold may define an upper acceptable or desirable limit of the amount of stretch and/or tension in the wrap material **58** as applied onto the bale **34**. The baler controller **100** may compare the applied wrap stretch factor **110** to the minimum threshold and/or the maximum threshold to determine if the applied wrap stretch factor **110** is less than the minimum threshold, or greater than the maximum threshold.

(49) If the baler controller **100** determines that the applied wrap stretch factor **110** is less than the minimum threshold, then the stretch of the wrap material **58** and the associated tension thereof may be insufficient to maintain the desired shape and density of the bale **34**. As such, if the baler controller **100** determines that the applied wrap stretch factor **110** is less than the minimum threshold, the baler controller **100** may control or adjust the torque controlling device **90** of the wrap system **56** to increase tension in the wrap material **58** during the wrap cycle, and thereby increase the amount of stretch in the wrap material **58** as applied onto the bale **34** during the wrap cycle. In contrast, if the baler controller **100** determines that the applied wrap stretch factor **110** is greater than the maximum threshold, then the baler controller **100** may control or adjust the torque controlling device **90** of the wrap system **56** to decrease tension in the wrap material **58** during the wrap cycle, and thereby reduce the amount of stretch in the wrap material **58** as applied onto the bale **34** during the wrap cycle.

(50) The detailed description and the drawings or figures are supportive and descriptive of the disclosure, but the scope of the disclosure is defined solely by the claims. While some of the best modes and other embodiments for carrying out the claimed teachings have been described in detail, various alternative designs and embodiments exist for practicing the disclosure defined in the appended claims.

Claims

1. A baler implement comprising: a baling system having a baling chamber configured to form crop material into a bale having a cylindrical shape; a wrap system configured to feed a wrap material into the baling chamber to wrap a circumference of the bale with a number of wrap layers of the wrap material during a wrap cycle; a wrap sensor configured to detect data related to an unstretched length of the wrap material dispensed by the wrap system during the wrap cycle; a bale size sensor configured to detect data related to a diameter of the bale within the baling chamber; a baler controller including a processor and a memory having a wrap stretch algorithm stored thereon, wherein the processor is operable to execute the wrap stretch algorithm to: determine the unstretched length of the wrap material dispensed by the wrap system during the wrap cycle from the data sensed by the wrap sensor related to the unstretched length of the wrap material; determine a circumference of the bale in the baling chamber from the data sensed by the bale size sensor related to the diameter of the bale; determine a stretched length of the wrap material as applied onto the bale during the wrap cycle from the circumference of the bale in the baling chamber and the number of wrap layers of the wrap material; and compare the stretched length of the wrap material as applied onto the bale to the unstretched length of the wrap material dispensed by the wrap system during the wrap cycle to determine an applied wrap stretch factor.

2. The baler implement set forth in claim 1, further comprising a communicator configured to communicate a message, wherein the processor is operable to execute the wrap stretch algorithm to generate and transmit a communication signal to the communicator for communicating the applied wrap stretch factor.
3. The baler implement set forth in claim 1, wherein the processor is operable to execute the wrap stretch algorithm to determine if the applied wrap stretch factor is less than a minimum threshold or greater than a maximum threshold.
4. The baler implement set forth in claim 3 wherein the processor is operable to control a torque controlling device of the wrap system to increase tension in the wrap material during the wrap cycle when the applied wrap stretch factor is less than the minimum threshold, and wherein the processor is operable to control the torque controlling device of the wrap system to decrease tension in the wrap material during the wrap cycle when the applied wrap stretch factor is greater than the maximum threshold.
5. The baler implement set forth in claim 4, wherein the wrap system includes a supply roll of the wrap material, and wherein the torque controlling device includes a brake coupled to the supply roll and configured to resist rotation of the supply roll during the wrap cycle.
6. The baler implement set forth in claim 1, wherein the wrap system includes a supply roll of the wrap material.
7. The baler implement set forth in claim 6, wherein the wrap sensor includes a position sensor coupled to the supply roll of the wrap material, wherein the position sensor is configured for sensing data related to a diameter of the supply roll of the wrap material.
8. The baler implement set forth in claim 7, wherein the processor is operable to execute the wrap stretch algorithm to correlate a change in the diameter of the supply roll during a wrap cycle to a length of the wrap material dispensed during the wrap cycle.
9. The baler implement set forth in claim 8, wherein the processor is operable to execute the wrap stretch algorithm to define the length of the wrap material dispensed during the wrap cycle as the unstretched length of the wrap material dispensed by the wrap system during the wrap cycle.
10. The baler implement set forth in claim 7, wherein the wrap sensor includes a rotational speed sensor configured for sensing data related to a rotational speed of the supply roll of the wrap material during the wrap cycle.
11. The baler implement set forth in claim 10, wherein the processor is operable to execute the wrap stretch algorithm to calculate the unstretched length of the wrap material dispensed during the wrap cycle from the data related to the diameter of the supply roll of the wrap material and the data related to the rotational speed of the supply roll of the wrap material during the wrap cycle.
12. The baler implement set forth in claim 1, wherein the processor is operable to execute the wrap stretch algorithm to receive a user input setting the number of wrap layers of the wrap material during the wrap cycle.
13. The baler implement set forth in claim 10, wherein the processor is operable to rotate the bale within the baling chamber to apply the number of wrap layers of the wrap material during the wrap cycle.
14. The baler implement set forth in claim 1, wherein the applied wrap stretch factor includes a percentage of stretch of the wrap material.
15. The baler implement set forth in claim 1, wherein the wrap sensor includes a linear measuring device configured for measuring a length of the wrap material dispensed during the wrap cycle.
16. The baler implement set forth in claim 13, wherein the linear measuring device includes a measuring wheel disposed in contact with a supply roll of the wrap material.