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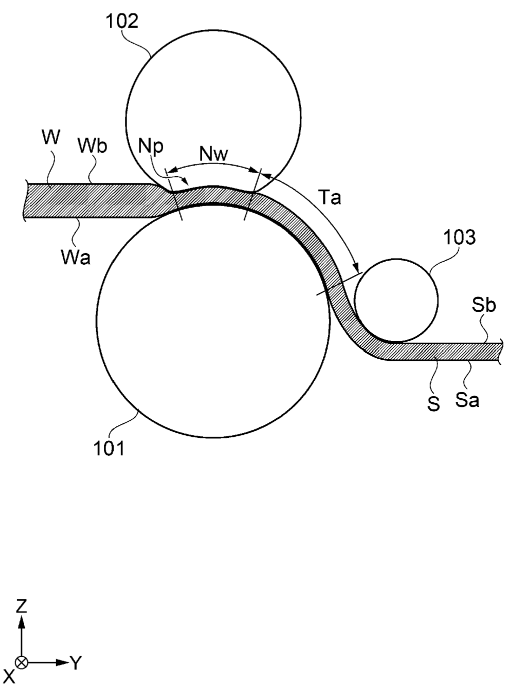
(54) SHEET MANUFACTURING APPARATUS

(57) There is provided a sheet manufacturing apparatus including: an accumulation section that accumulates a material containing fibers by an air flow to form a web; a humidification section that applies moisture from one surface side of the web; and a pressurization section that pressurizes the humidified web to form a sheet, in which the pressurization section includes a first roller that comes into contact with one surface of the web and a second roller that comes into contact with the other surface of the web, and a surface of the first roller is harder than a surface of the second roller.

FIG. 3



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Description

[0001] The present application is based on, and claims priority from JP Application Serial Number 2022-146829, filed September 15, 2022, the disclosure of which is hereby incorporated by reference herein in its entirety.

BACKGROUND

1. Technical Field

[0002] The present disclosure relates to a sheet manufacturing apparatus.

2. Related Art

[0003] In the related art, as described in JP-A-2015-137437, a sheet manufacturing apparatus including a defibration section that defibrates a product to be defibrated in the atmosphere; a mixing section that mixes an additive containing a resin with the defibrated product which was defibrated, in the atmosphere; a humidity control section that humidity-controls a mixture in which the defibrated product is mixed with the additive; a pressurization section that pressurizes the humidity-controlled mixture; and a heating section that heats the pressurized mixture, is known.

[0004] However, in the above-described apparatus, a resin is required as a binder to manufacture a sheet having sufficient strength. In recent years, there is a demand for a method for manufacturing a sheet having sufficient strength without using a resin.

SUMMARY

[0005] There is provided a sheet manufacturing apparatus including: an accumulation section that accumulates a material containing fibers by an air flow to form a web; a humidification section that applies moisture from one surface side of the web; and a pressurization section that pressurizes the humidified web to form a sheet, in which the pressurization section includes a first roller that comes into contact with one surface of the web and a second roller that comes into contact with the other surface of the web, and a surface of the first roller is harder than a surface of the second roller.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

FIG. 1 is a schematic view illustrating a configuration of a sheet manufacturing apparatus.
FIG. 2 is a schematic view illustrating a configuration of a pressurization section and the surroundings thereof.
FIG. 3 is a schematic view illustrating a nip state and the like of a web in the pressurization section.

DESCRIPTION OF EMBODIMENTS

[0007] First, a configuration of a sheet manufacturing apparatus 1 will be described. The sheet manufacturing apparatus 1 is an apparatus for forming a sheet S.

[0008] As illustrated in FIG. 1, the sheet manufacturing apparatus 1 includes, for example, a supply section 10, a crushing section 11, a defibration section 20, a sorting section 40, a first web forming section 45, a rotating body 49, a mixing section 50, an accumulation section 60, a web transport section 80, a humidification section 90, a pressurization section 100, and a cutting section 120. Furthermore, the sheet manufacturing apparatus 1 includes a control section (processor) that controls a drive mechanism of each of the above sections.

[0009] The supply section 10 supplies the raw material to the crushing section 11. The supply section 10 is, for example, an automatic charging section for continuously charging the raw material into the crushing section 11. The raw material supplied by the supply section 10 is a material containing various fibers.

[0010] The fiber is not particularly limited, and a wide range of fiber materials can be used. Examples of the fiber include natural fiber (animal fiber, plant fiber) and chemical fiber (organic fiber, inorganic fiber, and organic-inorganic composite fiber). More specifically, the fiber includes fibers made of cellulose, silk, wool, cotton, cannabis, kenaf, flax, ramie, jute, Manila hemp, sisal, coniferous tree, broadleaf tree, and the like, and these may be used alone, may be appropriately mixed and used, or may be used as a purified regenerated fiber.

[0011] Examples of the raw material of the fiber include pulp, used paper, and used cloth. Further, the fiber may be subjected to various surface treatments. Further, the material of the fiber may be a pure substance or a material containing a plurality of components such as impurities and other components. Further, as the fiber, a defibrated product obtained by defibrating used paper, pulp sheet, or the like by a dry method may be used.

[0012] The length of the fiber is not particularly limited, but in a case of one independent fiber, the length of the fiber in the longitudinal direction is 1 μm or more and 5 mm or less, preferably 2 μm or more and 3 mm or less, and more preferably 3 μm or more and 2 mm or less.

[0013] In the sheet manufacturing apparatus 1, moisture is applied in the humidification section 90, and thus the mechanical strength of the formed sheet S can be increased by using a fiber having the ability to form hydrogen bonds. Examples of such fibers include cellulose.

[0014] The fiber content in the sheet S is, for example, 50% by mass or more and 99.9% by mass or less, preferably 60% by mass or more and 99% by mass or less, and more preferably 70% by mass or more and 99% by mass or less. Such a content can be obtained by performing blending when forming the mixture.

[0015] The crushing section 11 cuts the raw material supplied by the supply section 10 into strips in the air such as the atmosphere. The shape and size of the strips are, for example, several centimeter square. The crushing section 11 has a crushing blade 12, and the charged raw material can be cut by the crushing blade 12. As the crushing section 11, for example, a shredder is used. The raw material cut by the crushing section 11 is received by a hopper 14 and then transferred to the defibration section 20 through a pipe 15.

[0016] The defibration section 20 defibrates the raw material cut by the crushing section 11. Here, "defibrating" means unraveling a raw material obtained by binding a plurality of fibers into each fiber. The defibration section 20 also has a function of separating substances (such as resin particles, ink, toner, and a blot inhibitor) adhering to the raw material from the fibers.

[0017] A product that passed through the defibration section 20 is referred to as "defibrated product". In addition to the unraveled fiber, the "defibrated product" may include resin particles separated from the fiber when the fiber is unraveled, coloring agents such as ink and toner, or additives such as blot inhibitors and paper strength enhancers. The shape of the unraveled defibrated product is a shape of a string. The unraveled defibrated product may exist in a state of not being entangled with other unraveled fibers, that is, in an independent state, or may exist in a state of being entangled with other unraveled defibrated products to form a mass shape, that is, in a state where a lump is formed.

[0018] The defibration section 20 performs defibration by a dry method. Here, the treatment of defibrating or the like in the air such as the atmosphere, not in the liquid, is referred to as a dry method. As the defibration section 20, for example, an impeller mill is used. The defibration section 20 has a function of suctioning the raw material and generating an air flow that discharges the defibrated product. Accordingly, the defibration section 20 can suction the raw material together with the air flow from an introduction port 22 by the self-generated air flow, perform the defibration treatment, and transport the defibrated product to a discharge port 24. The defibrated product that passed through the defibration section 20 is transferred to the sorting section 40 through the pipe 16. As the air flow for transporting the defibrated product from the defibration section 20 to the sorting section 40, the air flow generated by the defibration section 20 may be used, or an air flow generation device such as a blower may be provided to use the air flow thereof.

[0019] The sorting section 40 introduces the defibrated product defibrated by the defibration section 20 from the introduction port 42 and sorts the defibrated products according to the length of the fibers. The sorting section 40 has, for example, a drum section 41 and a housing section 43 that accommodates the drum section 41 therein. As the drum section 41, for example, a sieve is used. The drum section 41 has a net, and can sort out fibers or particles smaller than the size of the mesh opening of the net, that is, a first sorted product passing through the net, and fibers, undefibrated pieces, and lumps larger than the size of the mesh opening of the net, that is, a second sorted product that does not pass through the net. For example, the first sorted product is transferred to the accumulation section 60 through a pipe 17. The second sorted product is returned from the discharge port 44 to the defibration section 20 through a pipe 18. Specifically, the drum section 41 is a cylindrical sieve that is rotationally driven by a motor. As the net of the drum section 41, for example, a wire net, an expanded metal obtained by stretching a metal plate having a cut, or a punching metal in which a hole is formed in the metal plate by a press machine or the like is used.

[0020] The first web forming section 45 transports the first sorted product that passed through the sorting section 40 to the pipe 17. The first web forming section 45 includes, for example, a mesh belt 46, a stretching roller 47, and a suction mechanism 48.

[0021] The suction mechanism 48 can suction the first sorted product, which is dispersed in the air through the opening of the sorting section 40, onto the mesh belt 46. As a result, the first sorted product is accumulated on the moving mesh belt 46.

[0022] The first sorted product that passed through the opening of the sorting section 40 is accumulated on the mesh belt 46. The mesh belt 46 is stretched by the stretching roller 47, and is configured such that the first sorted product is unlikely to pass therethrough and air is allowed to pass therethrough. The mesh belt 46 moves as the stretching roller 47 revolves. While the mesh belt 46 moves continuously, the first sorted product that passed through the sorting section 40 is continuously piled up, and accordingly, a web V is formed on the mesh belt 46.

[0023] The suction mechanism 48 is provided below the mesh belt 46. The suction mechanism 48 can generate a downward air flow. By the suction mechanism 48, the first sorted product dispersed in the air from the sorting section 40 can be suctioned onto the mesh belt 46. Accordingly, the discharge speed from the sorting section 40 can be increased.

[0024] The web V is formed in a soft and swollen state containing a large amount of air by passing through the sorting section 40 and the first web forming section 45. The web V accumulated on the mesh belt 46 is charged into the pipe 17 and transported to the accumulation section 60.

[0025] The rotating body 49 cuts the web V. In the illustrated example, the rotating body 49 has a base portion 49a and a protrusion portion 49b protruding from the base portion 49a. The protrusion portion 49b has, for example, a plate-like shape. In the illustrated example, four protrusion portions 49b are provided, and four protrusion portions 49b are provided at equal intervals. By rotating the base portion 49a in a direction R, the protrusion portion 49b can rotate around the base portion 49a as an axis. By cutting the web V by the rotating body 49, for example, the fluctuation of the fiber amount per unit time supplied to the accumulation section 60 can be reduced.

[0026] The rotating body 49 is provided in the vicinity of the first web forming section 45. In the illustrated example, the rotating body 49 is provided in the vicinity of a stretching roller 47a positioned downstream in the path of the web V. The rotating body 49 is provided at a position where the protrusion portion 49b can come into contact with the web V and that does not come into contact with the mesh belt 46 on which the web V is accumulated. Accordingly, it is possible to suppress abrasion of the mesh belt 46 by the protrusion portion 49b. The shortest distance between the protrusion portion 49b and the mesh belt 46 is, for example, 0.05 mm or more and 0.5 mm or less. This is the distance at which the mesh belt 46 can cut the web V without being damaged.

[0027] The mixing section 50 mixes the first sorted product (fiber) that passed through the sorting section 40 and starch as a binder. The mixing section 50 includes a starch supply section 52 that supplies starch, a pipe 54 that transports the first sorted product and starch, and a blower 56. In the illustrated example, the starch is supplied from the starch supply section 52 to the pipe 54 through a hopper 19. The pipe 54 is coupled to the pipe 17.

[0028] In the mixing section 50, an air flow is generated by the blower 56, and the first sorted product and the starch can be transported while being mixed in the pipe 54. The mechanism for mixing the first sorted product and the starch is not particularly limited, and may be stirred by a blade that rotates at high speed, or may use rotation of a container such as a V-type mixer.

[0029] As the starch supply section 52, a screw feeder, a disc feeder, or the like is used.

[0030] Starch supplied from the starch supply section 52 is a polymer in which a plurality of α-glucose molecules are polymerized by glycosidic bonds. The starch may be linear or may contain branches.

[0031] As the starch, those derived from various plants can be used. Raw materials for starch include grains such as corn, wheat, and rice, beans such as broad beans, mung beans, and red beans, tubers such as potatoes, sweet potatoes, and tapioca, wild grasses such as Erythronium japonicum, bracken, and kudzu, and palms such as sago palm.

[0032] Further, processed starch or modified starch may be used as the starch. Examples of the processed starch include acetylated adipic acid cross-linked starch, acetylated starch, oxidized starch, octenyl succinate starch sodium, hydroxypropyl starch, hydroxypropylated phosphoric acid cross-linked starch, phosphorylated starch, phosphoric acid esterified phosphoric acid cross-linked starch, urea phosphorylated esterified starch, sodium starch glycolate, and high amylose corn starch. Further, as the dextrin that serves as the modified starch, those obtained by processing or modifying the starch can be preferably used.

[0033] By using starch as the binder in the sheet manufacturing apparatus 1, the environmental load can be reduced as compared with the case where a synthetic resin is used. In addition, moisture is applied to the fibers containing starch (first sorted product) and then the fibers are pressurized and heated. Accordingly, at least one of the fiber-to-fiber bond and the fiber-to-fiber hydrogen bond is generated by gelatinization of starch, and the sheet S can have sufficient strength. Meanwhile, when the sheet S can be given sufficient strength only by the fiber-to-fiber hydrogen bonds, the sheet S can be manufactured without using a starch. When the sheet S is manufactured without using the starch, the sheet manufacturing apparatus 1 may not include the starch supply section 52.

[0034] The starch content in the sheet S is, for example, 0.1% by mass or more and 50% by mass or less, preferably 1% by mass or more and 40% by mass or less, and more preferably 1% by mass or more and 30% by mass or less. Such a content can be obtained by performing blending when forming the mixture.

[0035] In addition, in the starch supply section 52, in addition to the starch, in accordance with the type of the sheet S to be manufactured, a colorant for coloring the fibers, an aggregation inhibitor for suppressing coagulation of fibers or coagulation of starch, a flame retardant for making fibers and the like unlikely to burn, and the like, may be included. The mixture that passed through the mixing section 50 is transferred to the accumulation section 60 through the pipe 54.

[0036] The accumulation section 60 introduces the mixture that passed through the mixing section 50 from an introduction port 62, unravels the entangled fibers, and disperses the unraveled fibers in the air to make the product fall. Accordingly, the accumulation section 60 can uniformly accumulate the mixture on the second web forming section 70.

[0037] The accumulation section 60 has, for example, a drum section 61 and a housing section 63 that accommodates the drum section 61 therein. As the drum section 61, a rotating cylindrical sieve is used. The drum section 61 has a net and makes fibers or particles smaller than the size of the mesh opening of the net, which are contained in the mixture that passed through the mixing section 50, fall. The configuration of the drum section 61 is, for example, the same as the configuration of the drum section 41.

[0038] The "sieve" of the drum section 61 may not have a function of sorting a specific object. In other words, the "sieve" used as the drum section 61 means a sieve provided with a net, and the drum section 61 may make all of the mixture introduced into the drum section 61 fall.

[0039] The accumulation section 60 includes a second web forming section 70. The second web forming section 70 accumulates the mixture that passed through the drum section 61 to form a web W. The second web forming section 70 includes, for example, a first mesh belt 72, a stretching roller 74, and a suction mechanism 76.

[0040] The mixture that passed through the opening of the accumulation section 60 is accumulated on the first mesh belt 72. The first mesh belt 72 is stretched by the stretching roller 74, and is configured such that the mixture is unlikely to pass therethrough and air is allowed to pass therethrough. The first mesh belt 72 moves as the stretching roller 74 revolves. While the first mesh belt 72 moves continuously, the mixture that passed through the accumulation section 60 is continuously piled up, and accordingly, the web W is formed on the first mesh belt 72.

[0041] The suction mechanism 76 is provided below the first mesh belt 72. The suction mechanism 76 can generate a downward air flow. By the suction mechanism 76, the mixture dispersed in the air from the drum section 61 can be suctioned onto the first mesh belt 72. Accordingly, the discharge speed from the accumulation section 60 can be increased. Furthermore, the suction mechanism 76 can form a downflow in the falling path of the mixture, and can prevent the fibers and the starch from being entangled during the fall.

[0042] As described above, the web W in a soft and swollen state containing a large amount of air is formed by passing through the accumulation section 60.

[0043] The web transport section 80 is disposed downstream of the web W in the transport direction on the first mesh belt 72. The web transport section 80 peels off the web W on the first mesh belt 72 from the first mesh belt 72 and transports the web W toward the pressurization section 100.

[0044] As illustrated in FIG. 2, the web transport section 80 includes a second mesh belt 81 as a transport belt, a plurality of rollers 82, and a suction mechanism 83 as a suction section. The second mesh belt 81 is stretched by the plurality of rollers 82, and is configured such that the air passes therethrough. The second mesh belt 81 is configured to be rotationally driven by the revolution of the rollers 82. The suction mechanism 83 is disposed at a position facing the web W with the second mesh belt 81 interposed therebetween. The suction mechanism 83 includes an intake fan (not illustrated), and generates an upward (+Z direction) air flow on the second mesh belt 81 by the suction force of the intake fan. The web W is suctioned by this air flow.

[0045] Accordingly, the web W can be peeled off from the first mesh belt 72, and the other surface Wb, which is the upper surface of the web W peeled off from the first mesh belt 72, can be brought into contact with the second mesh belt 81. Then, the other surface Wb of the web W comes into contact with the second mesh belt 81 and is transported in a state where the web W is held.

[0046] The humidification section 90 is disposed below the web transport section 80. The humidification section 90 is disposed to face the second mesh belt 81. The humidification section 90 applies moisture from one surface Wa, which is the lower surface of the web W that is in contact with the second mesh belt 81. In the humidification section 90, humidified air (for example, water vapor or mist) is applied to the web W as moisture.

[0047] As illustrated in FIG. 2, the humidification section 90 includes a container 91 capable of storing water and a piezoelectric vibrator 92 disposed at the bottom portion of the container 91. A discharge port 93 for discharging humidified air is formed at the upper portion of the container 91. The container 91 is disposed such that the discharge port 93 faces the one surface Wa of the web W. By driving the piezoelectric vibrator 92, ultrasonic waves are generated in water, and mist (humidified air) is generated in the container 91. The generated mist is applied to the one surface Wa of the web W through the discharge port 93 of the container 91. By applying moisture to the web W from below, water droplets do not fall on the web W even when dew condensation is generated in the humidification section 90 or in the vicinity thereof. In other words, for example, when moisture is applied to the web W from above, there is a concern that the moisture adheres to the humidification section 90 or the vicinity thereof and falls as water droplets, and the water droplets adhere to the web W. In this case, the application of moisture to the web W becomes non-uniform. However, in the present embodiment, the falling of water droplets and the like is suppressed, and affecting the quality of the sheet S can be avoided.

[0048] The suction mechanism 83 is disposed at a position facing the humidification section 90 with the second mesh belt 81 interposed therebetween. The suction mechanism 83 suctions the mist discharged from the humidification section 90. The mist discharged from the discharge port 93 is suctioned by the suction mechanism 83 disposed facing the discharge port 93. As a result, the mist is suctioned into the suction mechanism 83 via the web W, and thus moisture can be applied in the thickness direction of the web W.

[0049] The water content of the web W to which moisture is applied in the humidification section 90 is, for example, 12% by mass or more and 40% by mass or less. With the web water content, the fiber-to-fiber hydrogen bonds can be effectively formed and the strength of the sheet S can be increased.

[0050] The pressurization section 100 is disposed downstream of the web transport section 80 and the humidification section 90. The web W to which the moisture is applied is transported to the pressurization section 100.

[0051] The pressurization section 100 pressurizes the humidified web W to form the sheet S. The pressurization section 100 includes a first roller 101 that comes into contact with the one surface Wa of the web W and a second roller 102 that comes into contact with the other surface Wb of the web W. The web W is pinched between the first roller 101 and the second roller 102 and pressurized to form the sheet S. The detailed configuration of the pressurization section 100 will be described later.

[0052] The cutting section 120 is disposed downstream of the pressurization section 100. The sheet S formed by the pressurization section 100 is transported to the cutting section 120.

[0053] The cutting section 120 cuts the sheet S formed by the pressurization section 100. In the illustrated example, the cutting section 120 includes a first cutting section 122 that cuts the sheet S in the direction intersecting the transport direction of the sheet S, and a second cutting section 124 that cuts the sheet S in the direction parallel to the transport direction. For example, the second cutting section 124 cuts the sheet S that passed through the first cutting section 122.

[0054] As a result, a cut-form sheet S having a predetermined size is formed. The cut cut-form sheet S is discharged to a reception section 130.

[0055] Next, a detailed configuration of the pressurization section 100 will be described. First, the form of a nip section Np (pressurization location) in the pressurization section 100 will be described.

[0056] As described above, in the present embodiment, the sheet manufacturing apparatus 1 that forms the sheet S by using starch as a binder is realized. Here, in the sheet manufacturing process using starch, it is necessary to apply moisture to the web W containing the starch, and the moisture content in the web W is relatively large. Therefore, for example, wrinkles or the like are likely to occur when the web W is pressurized, and it becomes difficult to maintain the smoothness of the sheet S.

[0057] Therefore, the pressurization section 100 of the present embodiment is capable of forming the smooth sheet S. Hereinafter, a specific description will be given.

[0058] As illustrated in FIGS. 2 and 3, the pressurization section 100 includes the first roller 101 and the second roller 102. Each of the rotation axes of the first roller 101 and the second roller 102 is disposed along the direction along the X axis. The dimensional lengths of the first roller 101 and the second roller 102 along the X axis are longer than the dimensional length of the transported web W along the X axis. As a result, the first roller 101 and the second roller 102 can nip the entire region along the X axis of the web W.

[0059] In the present embodiment, the surface of the first roller 101 is configured to be harder than the surface of the second roller 102. Specifically, the first roller 101 is made of metal, and the second roller 102 is made of metal and rubber covering the surface thereof.

[0060] More specifically, the first roller 101 includes a hollow cored bar 111 made of, for example, aluminum, iron, or stainless steel. On the surface of the first roller 101, a surface layer 112 made of a fluororesin, such as polytetrafluoroethylene (PTFE), tetrafluoroethylene-perfluoroalkyl vinyl ether copolymer (PFA), tetrafluoroethylene-hexafluoropropylene copolymer (FEP), and tetrafluoroethylene-ethylene copolymer (ETFE), a silicone resin, or the like is provided. By providing the surface layer 112, the releasability with respect to the web W (sheet S) can be improved. In addition, abrasion or damage of the cored bar 111 can be suppressed.

[0061] The second roller 102 includes, for example, a hollow cored bar 114 made of aluminum, iron, stainless steel, or the like. The surface of the cored bar 114 is covered with an elastic layer 115 made of silicon rubber, urethane rubber, or the like as rubber. The hardness of the elastic body is preferably ASKER C30 or more and C70 or less, and more preferably ASKER C40 or more and C60 or less. The thickness of the elastic layer is preferably 1 mm or more and 10 mm or less, and more preferably 1 mm or more and 5 mm or less. Furthermore, the surface of the elastic layer 115 is covered with a surface layer 116 composed of a fluororesin layer, such as polytetrafluoroethylene (PTFE), tetrafluoroethylene-perfluoroalkyl vinyl ether copolymer (PFA), tetrafluoroethylene-hexafluoropropylene copolymer (FEP), and tetrafluoroethylene-ethylene copolymer (ETFE), or a tube containing fluororesin. By providing the surface layer 116, the releasability with respect to the web W (sheet S) can be improved. In addition, abrasion or damage of the elastic layer 115 can be suppressed.

[0062] By pressurizing the web W with the first roller 101 and the second roller 102, the web W is thinned and the fiber density in the web W is increased. The pressure applied to the web W by the first roller 101 and the second roller 102 is preferably 0.1 Mpa or more and 15 Mpa or less, more preferably 0.2 Mpa or more and 10 Mpa or less, and further preferably 0.4 Mpa or more and 8 Mpa or less. Within such a pressure range, deterioration of fibers can be suppressed, and the sheet S having good strength can be manufactured again using a defibrated product obtained by defibrating the manufactured sheet S as a raw material.

[0063] In addition, the first roller 101 and the second roller 102 of the present embodiment have built-in heaters 113 and 117 (for example, halogen heaters) for heating, respectively, as heating mechanisms. Each temperature of the first roller 101, the second roller 102, and each of the heaters 113 and 117 is acquired by a temperature detection section, and the driving of each of the heaters 113 and 117 is controlled based on the acquired temperature. As a result, it is possible to maintain the surface temperatures of the first roller 101 and the second roller 102 at predetermined temperatures. For example, the surface temperature of the first roller 101 is preferably 100°C or higher and 130°C or lower, and the surface temperature of the second roller 102 is preferably 80°C or higher and 100°C or lower.

[0064] Since the pressurization section 100 of the present embodiment simultaneously pressurizes and heats the web W, the productivity of the sheet S can be improved. Further, the configuration of the sheet manufacturing apparatus 1 can be simplified. Accordingly, the moisture contained in the web W evaporates after the temperature rises, and the thickness of the web W becomes thin to increase the fiber density. The temperature of the moisture and the starch rises due to heat, the fiber density increases due to the pressure, the starch is gelatinized, and then the moisture evaporates to bind the plurality of fibers to each other through the gelatinized starch. Furthermore, the moisture evaporates due to heat and the fiber density increases due to the pressure, and accordingly, the plurality of fibers are bound to each other by hydrogen bonds.

[0065] Here, when moisture is applied to the web W containing the starch and the fibers, it is necessary for the pressurization section 100 to surely bind the fibers in the web W to form the sheet S. This is because when moisture remains in the web W, the binding of the fibers is insufficient, and wrinkles or the like are likely to occur on the sheet S.

[0066] Therefore, it is necessary to sufficiently ensure a nip width Nw at the nip section Np in which the web W is pinched between the first roller 101 and the second roller 102. The nip section Np refers to a pressurization location where the web W is pressurized by the first roller 101 and the second roller 102, and the nip width Nw is a dimension of the nip section Np in the transport direction of the web W. That is, the nip width Nw is a length dimension from the nip start position to the nip end position of the web W by the first roller 101 and the second roller 102. The nip width Nw is formed with substantially constant dimensions along the X axis of the nip section Np.

[0067] By ensuring a sufficient nip width Nw, the heating and pressurizing time of the web W is ensured. Therefore, the fibers contained in the sheet S are reliably bound, and the sheet S having better mechanical strength can be formed. In order to ensure the nip width Nw, for example, a configuration using a soft roller of which the surface is made of rubber can be considered for both the first roller 101 and the second roller 102. As a result, the nip width Nw is ensured by the elastic deformation of each soft roller. However, since each of the soft rollers is elastically deformed, the variation in pressure at the nip section Np becomes large, and wrinkles are likely to occur. Therefore, a smooth sheet S cannot be formed. On the other hand, when a metal roller (hard roller) is used for both the first roller 101 and the second roller 102, elastic deformation does not occur, and thus, the nip width Nw cannot be sufficiently ensured and the pressurization heating time of the web W cannot be ensured. Therefore, the binding of the fibers is insufficient.

[0068] According to the present embodiment, when the web W is nipped by the first roller 101 and the second roller 102 having different hardnesses from each other, the surface of the second roller 102 is in a state of being stably recessed by the pressure of the first roller 101. As a result, a constant nip width Nw is maintained, and the pressure at the nip section Np is stabilized. Since the web W can be heated and pressurized in this state, the fibers in the web W can be reliably bound, and a smooth sheet S can be formed.

[0069] Further, since moisture is applied from the one surface Wa side of the web W, the moisture content of the one surface Wa side is larger than that of the other surface Wb side in the thickness direction of the web W. Therefore, when the web W is nipped, moisture can be moved from the one surface Wa side to the other surface Wb side by heating the hard first roller 101 made of metal having good thermal conductivity. As a result, the web W is pressurized and heated in a state where the moisture is distributed over the entire thickness direction of the web W, and thus the uniformity of the strength in the surface of the sheet S can be improved.

[0070] Further, since the first roller 101 side of the web W is heated at a high temperature, the steam in the web W is likely to spread to the other surface Wb that comes into contact with the second roller 102 side on the low temperature side. Further, by heating the one surface Wa side, which has a large moisture content in the web W, at a higher temperature, diffusion of the moisture into the other surface Wb is promoted, and the heating efficiency is improved.

[0071] When the soft rollers are used for both the first roller 101 and the second roller 102, the thickness unevenness of the sheet S occurs due to the expansion and contraction of the surface of each soft roller at the nip section Np. According to the present embodiment, the one surface Wa of the web W containing a large amount of moisture is likely to stick to the harder first roller 101 side, and nipping is possible in a state where the web W follows the first roller 101 side. At this time, since the one surface Wa of the web W is pinned to the first roller 101 side and the other surface Wb is nipped in a slipped state on the second roller 102 side, a smooth sheet S can be formed.

[0072] In addition, the surface of the first roller 101 of the present embodiment has irregularities. In this case, the surface roughness measured by a surface roughness meter is preferably 2 μm or more and 8 μm or less in arithmetic average roughness (Ra), and more preferably 3 μm or more and 6 μm or less. The maximum height (Rz) is preferably 15 μm or more and 70 μm or less, and more preferably 25 μm or more and 50 μm or less. The irregularities of the surface of the first roller 101 are formed by, for example, blasting or spraying.

[0073] Since the surface of the first roller 101 is formed with extremely minute irregularities, after ensuring the smoothness of the sheet S, the surface quality difference between a first surface Sa of the sheet S (the surface corresponding to the one surface Wa of the web W) and a second surface Sb (the surface corresponding to the other surface Wb of the web W) can be reduced. Specifically, when the web W is pressurized between the first roller 101 and the second roller 102, a part of the web W having a high fiber density has a large thickness, and a part having a low fiber density has a small thickness. Here, when both the first roller 101 and the second roller 102 are soft rollers, both rollers are elastically deformed, and thus irregularities in the web W are generated substantially evenly on the one surface Wa and the other surface Wb. As a result, the surface quality difference between the first surface Sa and the second surface Sb in the sheet S is reduced. However, in the present embodiment, since the first roller 101 on one side is made of metal, the first roller 101 is not elastically deformed, and when the web W is nipped, the irregularities in the web W are biased toward the second roller 102 having a soft surface. Therefore, the second surface Sb on the second roller 102 side of the sheet S becomes a relatively rough surface, the first surface Sa on the first roller 101 side becomes a smooth surface, and the surface quality difference between the first surface Sa and the second surface Sb of the sheet S occurs. Therefore, by forming minute irregularities on the surface of the first roller 101, the first surface Sa on the first roller 101 side also becomes a relatively rough surface. Therefore, the surface quality difference between the first surface Sa and the second surface Sb of the sheet S can be reduced. Further, when the first surface Sa and the second surface Sb of the sheet S are touched with a finger, the textures of the first surface Sa and the second surface Sb of the sheet S are the same, and a feeling of discomfort is reduced. Further, for example, when an image is formed on the sheet S by a printer or the like, the same image quality can be maintained on the first surface Sa and the second surface Sb.

[0074] Next, the winding form of the web W in the pressurization section 100 will be described.

[0075] As described above, in the present embodiment, a sheet manufacturing process using starch is adopted. Here, since moisture is applied to the web W by the humidification section 90, deformation, breakage, and the like are likely to occur, and it is difficult to handle the web W.

[0076] Therefore, the pressurization section 100 of the present embodiment is capable of handling the web W in a stable state. Hereinafter, a specific description will be given.

[0077] The pressurization section 100 includes the first roller 101 that comes into contact with the one surface Wa of the web W at the nip section Np (pressurization location) and the second roller 102 that comes into contact with the other surface Wb of the web W at the nip section Np.

[0078] As illustrated in FIG. 3, the web W is transported such that the one surface Wa of the web W comes into contact with the surface of the first roller 101 over a predetermined length starting from the nip section Np. Then, while the one surface Wa of the web W is in contact with the surface of the first roller 101, the first roller 101 heats the web W. That is, the web W is heated in a winding region Ta wound around the nip section Np and the first roller 101 over a predetermined length from the nip section Np. The sheet S is formed by passing through the winding region Ta.

[0079] In the present embodiment, since moisture is applied from the one surface Wa side of the web W, the moisture content is larger than that of the other surface Wb. Therefore, the one surface Wa of the web W is more likely to stick. By utilizing this characteristic and transporting the web W in a state where the one surface Wa of the web W is sticked to the first roller 101 (wound state), the web W can be stably handled. In addition, since the one surface Wa side, which has a large moisture content in the web W, is wound around the first roller 101, the web W can be efficiently heated.

[0080] Further, moisture still remains inside the web W discharged from the nip section Np, and the web W is in a state of being easily deformed or broken. In the present embodiment, by providing the winding region Ta on the first roller 101 downstream in the transport direction of the nip section Np, the transportability of the web W can be improved and the web W can be reliably dried.

[0081] Further, by winding around the first roller 101 disposed below the web W to be transported by the weight of the web W, the transport posture of the web W after the nip section Np can be stabilized, and the occurrence of deformation or the like can be suppressed.

[0082] A third roller 103 is provided at a position facing the first roller 101 and downstream of the nip section Np in the transport direction of the web W. Further, a transport roller pair 118 is disposed downstream of the third roller 103. The web W (sheet S) is transported downstream by driving the transport roller pair 118. Then, the web W that passed through the winding region Ta from the nip section Np is peeled off from the first roller 101 at a predetermined position, comes into contact with the lower portion of the third roller 103, and is transported downstream.

[0083] Since the web W is transported via the third roller 103, a predetermined length (winding region Ta) of being wound around the first roller 101 of the web W can be held constant.

[0084] Further, since the surface of the first roller 101 has irregularities, due to the pinning effect (anchor effect) caused by the irregularities, while suppressing deformation or breakage of the web W after the nip section Np, it is possible to suppress the occurrence of waviness of the web W due to shrinkage during heating of the winding region Ta.

[0085] Here, the first roller 101 is a driving roller, and the second roller 102 is a driven roller. Since the first roller 101 on the side around which the web W is wound is the driving roller, the transport speed of the web W and the tension with respect to the web W are stable, and a smooth sheet S can be formed.

[0086] Further, in the present embodiment, the diameter of the first roller 101 is larger than the diameter of the second roller 102. The diameter of the first roller 101 is, for example, 110 mm or more and 150 mm or less, and the diameter of the second roller 102 is, for example, 80 mm or more and less than 110 mm.

[0087] By increasing the diameter of the first roller 101, the winding region Ta can be ensured. That is, the heating time of the web W can be ensured. The winding dimension of the web W in the winding region Ta is, for example, approximately 1/8 to 1/2, and preferably approximately 1/8 to 1/4 of the outer peripheral dimension of the first roller 101. The winding region Ta can be appropriately set and changed depending on the heating conditions of the heater 113 and the like.

[0088] Since the web W is transported following a larger roller peripheral surface, the winding curl of the sheet S at the completion of drying is reduced.

[0089] Further, by making the second roller 102 smaller, the configuration of the pressurization section 100 can be made smaller.

Claims

1. A sheet manufacturing apparatus comprising:

    an accumulation section that accumulates a material containing fibers by an air flow to form a web;
    a humidification section that applies moisture from one surface side of the web; and
    a pressurization section that pressurizes the humidified web to form a sheet, wherein
    the pressurization section includes a first roller that comes into contact with one surface of the web and a second roller that comes into contact with the other surface of the web, and
    a surface of the first roller is harder than a surface of the second roller.

2. The sheet manufacturing apparatus according to claim 1, wherein
the first roller is made of metal and the second roller is made of metal and rubber covering the surface thereof.

3. The sheet manufacturing apparatus according to claim 2, wherein
the surface of the first roller has irregularities.

4. The sheet manufacturing apparatus according to claim 1, wherein
the first roller is a driving roller and the second roller is a driven roller.

5. The sheet manufacturing apparatus according to claim 1, wherein
each of the first roller and the second roller has a built-in heater for heating.

6. The sheet manufacturing apparatus according to claim 1, further comprising:

    a starch supply section that supplies starch for bonding the fibers; and
    a mixing section that mixes the starch and the fiber.

FIG. 1

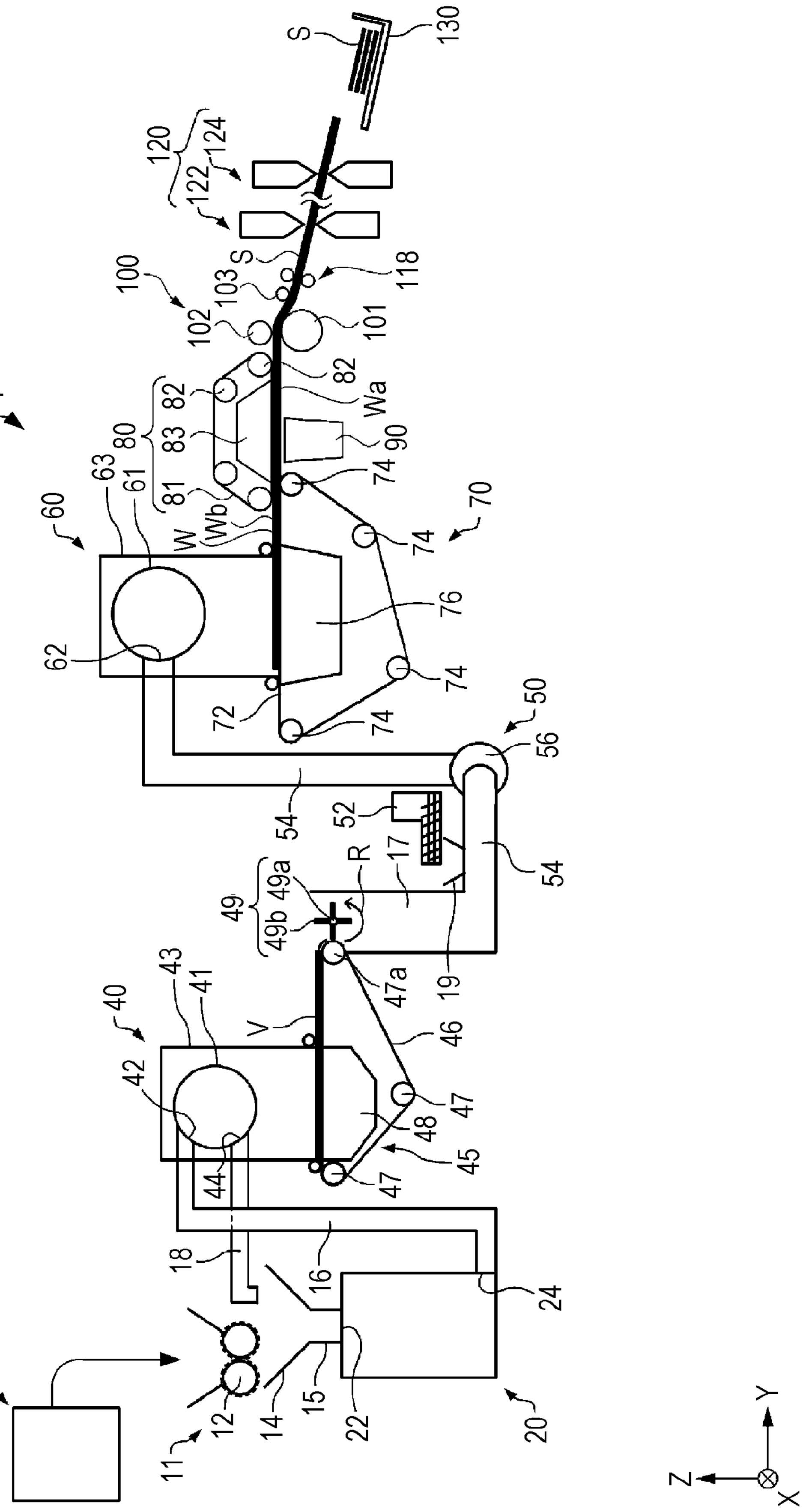
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FIG. 2

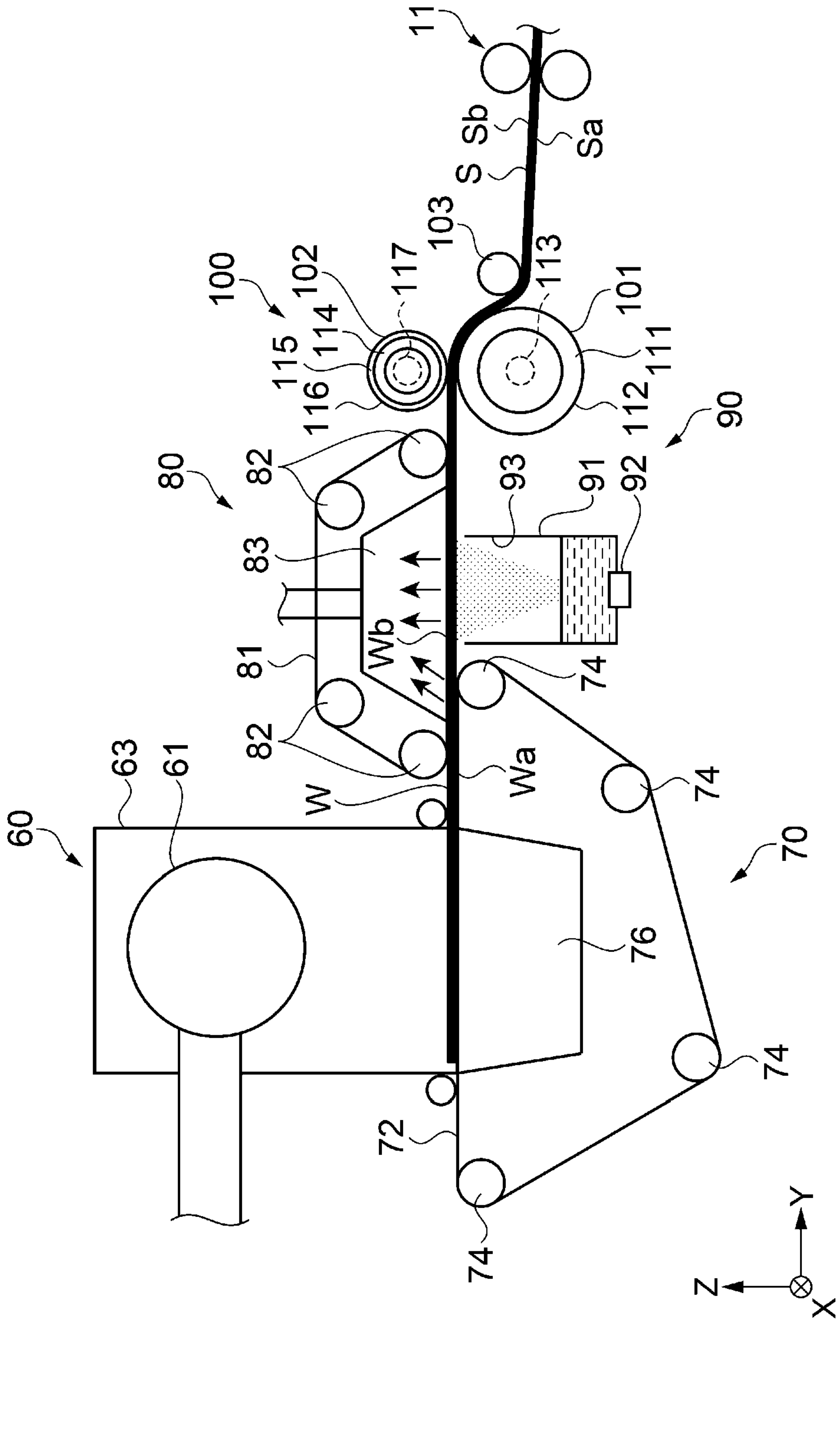
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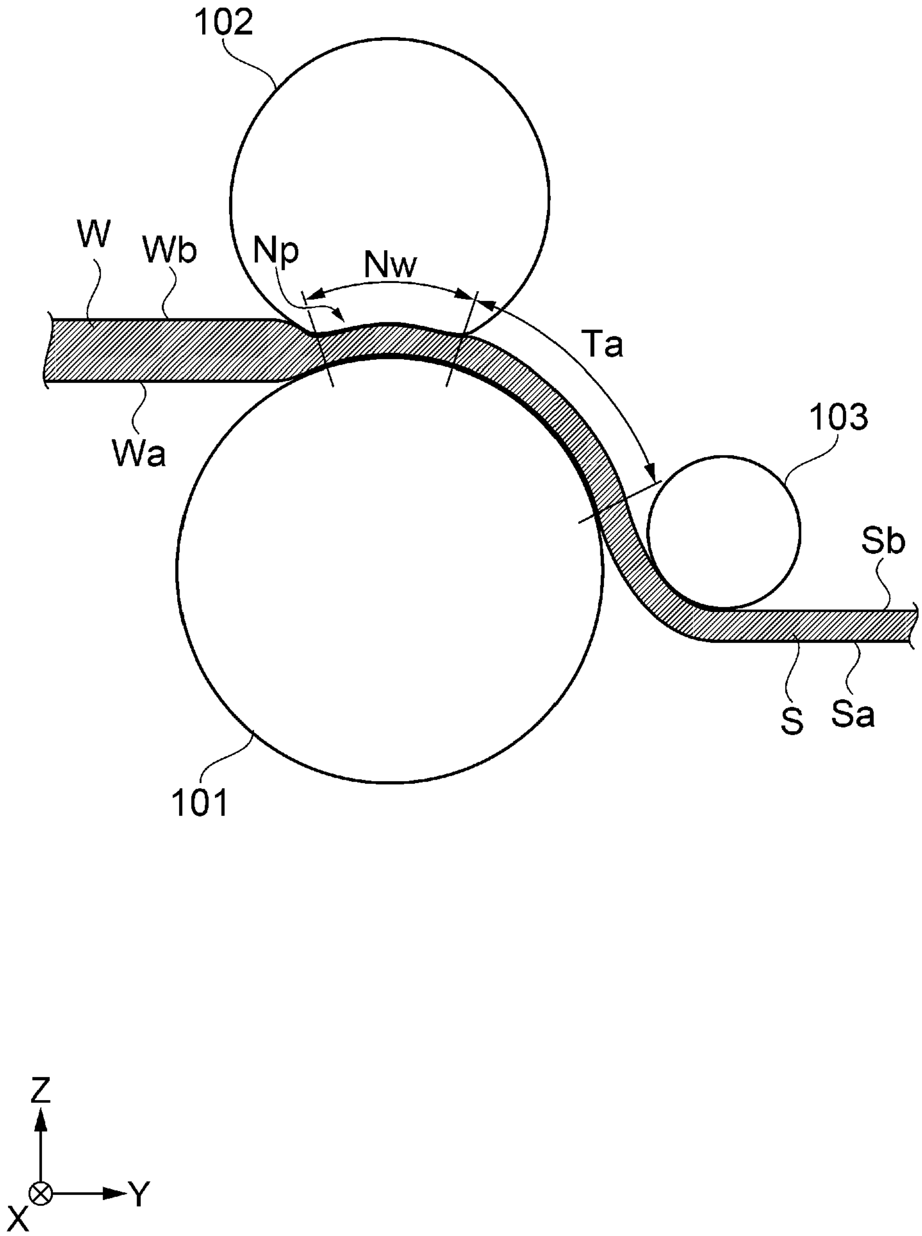
FIG. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 23 19 7722

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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	30 January 2024	Saunders, Thomas

CATEGORY OF CITED DOCUMENTS

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