



(11)

EP 4 382 668 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:

12.06.2024 Bulletin 2024/24

(51) International Patent Classification (IPC):

D21J 3/00 ^(2006.01) **B65D 1/00** ^(2006.01)
B65D 1/34 ^(2006.01)

(21) Application number: **22853060.6**

(52) Cooperative Patent Classification (CPC):

B65D 1/00; B65D 1/34; D21J 3/00

(22) Date of filing: **02.08.2022**

(86) International application number:

PCT/JP2022/029666

(87) International publication number:

WO 2023/013641 (09.02.2023 Gazette 2023/06)

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

Designated Extension States:

BA ME

Designated Validation States:

KH MA MD TN

(71) Applicant: **TOPPAN INC.**

Tokyo 110-0016 (JP)

(72) Inventors:

- **ISHII, Megumi**
Tokyo 110-0016 (JP)
- **SAKAIRI, Koji**
Tokyo 110-0016 (JP)

(30) Priority: **02.08.2021 JP 2021126691**

22.06.2022 JP 2022100643

(74) Representative: **TBK**

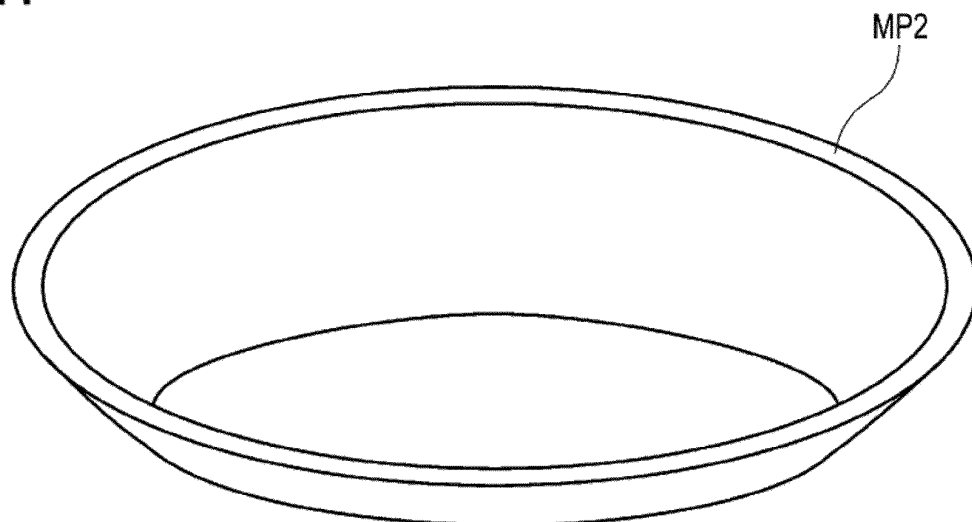
Bavariaring 4-6
80336 München (DE)

(54) **MOLDED PULP PRODUCT AND METHOD FOR MANUFACTURING SAME**

(57) There can be achieved a molded pulp article that has a small thickness and high strength and is excellent in release properties at the time of production. In a molded pulp article (MP2), a percentage of fibers having a fiber length of 1 mm or less to pulp is in the range of 35%

to 50%, the pulp has an average fiber length in the range of 1.2 mm to 1.5 mm, the molded pulp article has a density is in the range of 0.65 g/cm³ to 1.3 g/cm³, and the molded pulp article has a nitrogen content is in the range of 400 μg/g to 2000 μg/g.

FIG.1



EP 4 382 668 A1

Description

[Technical Field]

5 **[0001]** The present invention relates to a molded pulp article.

[Background Art]

10 **[0002]** In recent years, environmental problems related to, for example, an increase in waste have been occurring frequently. In view of this, paper containers are being used instead of plastic containers and metal containers for storing toiletries, drinks, food, and the like. For example, as paper containers for liquids such as milk containers, there are so-called gable top paper containers which are containers made of a paper board coated with polyethylene resin on both surfaces and that have a gable roof-like shape. Such paper containers not only contribute to resource and energy conservation, but also contribute to environmental conservation by being easy to recycle or incinerate when disposed of. Therefore, paper containers have become widespread in various fields.

15 **[0003]** However, since the above-described paper container is formed by folding and bonding a paper board, the production process is complicated, and the production cost is increased. Further, since the above-described paper containers have a low degree of freedom in shape, there has been a problem in that, for example, the appeal of commercial products based on the container shape cannot be sufficiently exerted.

20 **[0004]** One of the ways to increase the degree of freedom in the shape of paper containers is pulp molding, which produces molded articles from a slurry containing pulp and water. In pulp molding, pulp in a slurry is generally deposited on a paper-making mold to form a pulp layer, and this pulp layer is dehydrated and thereafter dried in a furnace. Molded articles obtained by this technique, that is, molded pulp articles, have excellent heat resistance, cold resistance, moisture absorption and desorption properties, and the like, which are characteristics in terms of physical properties of paper-based packaging materials, and are becoming widely used as paper tray containers for food, fixed cushioning materials for fruits, and the like (PTL 1).

[Citation List]

30 [Patent Literature]

[0005] PTL 1: JP 2008-285188 A

[Summary of the Invention]

35 **[0006]** The present invention has as its object to achieve a molded pulp article that has a small thickness and high strength and is excellent in release properties at the time of production.

40 **[0007]** According to an aspect of the present invention, there is provided a molded pulp article, wherein a percentage of fibers having a fiber length of 1 mm or less in the pulp is in the range of 35% to 50%, the pulp has an average fiber length in the range of 1.2 mm to 1.5 mm, the molded pulp article has a density in the range of 0.65 g/cm³ to 1.3 g/cm³, and the molded pulp article has a nitrogen content in the range of 400 μg/g to 2,000 μg/g.

[0008] According to another aspect of the present invention, there is provided a molded pulp article according to the above-described aspect, wherein the molded pulp article has a thickness in the range of 0.5 mm to 1 mm.

45 **[0009]** According to still another aspect of the present invention, there is provided a molded pulp article according to any of the above-described aspects, wherein the molded pulp article has a density in the range of 0.65 g/cm³ to 0.80 g/cm³, and the molded pulp article has a nitrogen content is in the range of 500 μg/g to 1,000 μg/g.

[0010] According to still another aspect of the present invention, there is provided a molded pulp article according to any of the above-described aspects, wherein the molded pulp article has a tensile strength in the range of 30 kN/m to 55 kN/m.

50 **[0011]** According to still another aspect of the present invention, there is provided a molded pulp article according to any of the above-described aspects, wherein the molded pulp article has a peeling strength in the range of 0.3 N/mm² to 0.9 N/mm².

[0012] According to still another aspect of the present invention, there is provided a molded pulp article according to any of the above-described aspects, wherein the molded pulp article has a standard deviation of basis weight in the range of 2 g/m² to 30 g/m².

[0013] According to still another aspect of the present invention, there is provided a molded pulp article according to any of the above-described aspects, wherein the molded pulp article is a container.

[0014] According to still another aspect of the present invention, there is provided a method for producing a molded

pulp article, including: preparing a slurry that contains pulp and water in which a percentage of fibers having a fiber length of 1 mm or less in pulp is in the range of 35% to 50%; depositing the pulp on a paper-making mold having a three-dimensional shape to form a pulp layer; dehydrating the pulp layer to obtain an intermediate molded article; and holding the undried intermediate molded article between male and female molds, and heating the intermediate molded article to a temperature in the range of 150°C to 220°C while applying pressure in the range of 0.4 MPa to 4.5 MPa.

[0015] According to still another aspect of the present invention, there is provided a method for producing a molded pulp article according to the above-described aspect, wherein depositing the pulp on a paper-making mold includes: preparing a cover body as a hollow body having an opening; fixing the paper-making mold to the opening; immersing the paper-making mold fixed to the opening in the slurry; and depressurizing a space surrounded by the cover body and the paper-making mold immersed in the slurry.

[0016] According to still another aspect of the present invention, there is provided a method for producing a molded pulp article according to any of the above-described aspects, wherein the paper-making mold is immersed in the slurry such that the paper-making mold is positioned above the cover body.

[0017] According to still another aspect of the present invention, there is provided a method for producing a molded pulp article according to any of the above-described aspects, wherein pressurization and heating of the undried intermediate molded article held between the male and female molds is performed at a pressure in the range of 0.4 MPa to 2.0 MPa and at a temperature in the range of 150°C to 200°C, respectively.

[0018] According to the present invention, there can be achieved a molded pulp article that has a small thickness and high strength and is excellent in release properties at the time of production.

[Brief Description of the Drawings]

[0019]

Fig. 1 is a perspective view showing a molded pulp article according to an embodiment of the present invention.

Fig. 2 is a view schematically showing an example of a production apparatus that can be used in producing the molded pulp article of Fig. 1.

Fig. 3 is a view showing a pulp layer formation step in pulp molding using the apparatus of Fig. 2.

Fig. 4 is a cross-sectional view schematically showing an example of a pulp layer formed on a paper-making mold.

Fig. 5 is a view showing a dehydration step in pulp molding using the apparatus of Fig. 2.

Fig. 6 is a view showing a pulp layer transport step in pulp molding using the apparatus of Fig. 2.

Fig. 7 is a view showing a hot press-forming step in pulp molding using the apparatus of Fig. 2.

Fig. 8 is a cross-sectional view schematically showing an example of a molded pulp article obtained by a hot pressing step.

Fig. 9 is a view showing a molded pulp article transport step in pulp molding using the apparatus of Fig. 2.

Fig. 10 is a view showing a state after completing the transport step of Fig. 9.

[Description of the Embodiments]

[0020] Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings. Components having identical or similar functions are denoted by the same reference signs throughout the drawings, and redundant description is omitted.

<1> Molded pulp article

[0021] Fig. 1 is a perspective view showing a molded pulp article according to an embodiment of the present invention.

[0022] A molded pulp article MP2 shown in Fig. 1 is a container. This molded pulp article MP2 includes a bottom and a sidewall and is open at the top.

[0023] The bottom has a disk shape. The orthogonal projection of the bottom on a plane perpendicular to the depth direction of the container may have a shape other than a circle, for example, a polygonal shape such as a rectangular shape.

[0024] The sidewall has a tubular shape which extends upward from the edge of the bottom. The sidewall expands from the bottom toward the opening. The inner surface and the outer surface of the sidewall may be perpendicular to the upper surface of the bottom. However, a molded pulp article MP2 of which the sidewall expands from the bottom toward the opening is advantageous in achieving high release properties and is easy to stack.

[0025] The molded pulp article MP2 can have various shapes such as a cup shape, a bowl shape, a tray shape, and a box shape. The molded pulp article MP2 may not be a container as long as it is a three-dimensional molded article, i.e., a molded article that does not have a two-dimensional shape such as a sheet but has a three-dimensional shape.

[0026] The molded pulp article MP2 has a thickness of 1 mm or less. That is, in the molded pulp article MP2, the thickness of the walls (here, the thickness of each of the bottom and the sidewall) is 1 mm or less. The thickness of the molded pulp article MP2 is preferably 0.8 mm or less. When the molded pulp article MP2 is thicker, it is bulky particularly when stacked. Moreover, making the walls of the molded pulp article MP2 thinner is advantageous in that drying during

production can be completed in a shorter time.

[0027] The thickness of the molded pulp article MP2 is preferably 0.5 mm or more, more preferably 0.6 mm or more, and further more preferably 0.7 mm or more. When the wall of the molded pulp article MP2 is thin, the wall is likely to vary in thickness.

[0028] Here, the thickness of the molded pulp article MP2 is a value obtained by the following method. That is, five samples are cut out from arbitrary positions in the molded pulp article MP2. Next, the thickness of each sample is measured. The thickness is measured using, for example, a thickness gauge manufactured by Mitutoyo Corporation. The thickness of the molded pulp article MP2 is the average value of the measurement results obtained for the five samples.

[0029] In the molded pulp article MP2, the percentage of fibers having a fiber length of 1 mm or less in the pulp is in the range of 35% to 50%. This percentage is preferably in the range of 40% to 50%, and more preferably in the range of 40% to 48%. When this ratio is increased, the density of the molded pulp article MP2 is easily increased, and its strength becomes high. Furthermore, when this percentage is increased, a molded pulp article MP2 having excellent decorative properties can be easily obtained. However, when this ratio is excessively increased, drying during production is unlikely to be completed in a short time, or reduction in release properties and cracking caused by drying failure are likely to occur.

[0030] The percentage of fibers having a fiber length of 1 mm or less in the pulp is the ratio of the number of fibers having a fiber length of 1 mm or less to the total number of fibers in the pulp. This percentage is obtained by the following method.

[0031] First, a 5 g sample is acquired from the molded pulp article MP2. Next, the sample is cut into fine strips and added with water to have a total mass of 500 g, and the mixture is immersed overnight. Next, the resultant is stirred with a stirrer to defibrate the pulp. In this manner, a dispersion liquid that contains pulp is obtained. Next, an appropriate amount of sample is taken from this dispersion liquid and further diluted with water to prepare an aqueous dispersion liquid having a pulp solid content of 0.05 mass%.

[0032] The fiber length of the thus-obtained sample is measured in accordance with JIS P 8226-2:2011 "Pulps - Determination of fibre length by automated optical analysis - Part 2: Unpolarized light method". The fiber length measurement is terminated when 20,000 or more fibers with a fiber length of 0.2 mm or more are detected. The percentage of fibers with a fiber length of 1 mm or less in the pulp is determined from the frequency distribution of fiber length obtained by this fiber length measurement.

[0033] In the molded pulp article MP2, the percentage of fibers having a fiber length of 0.2 mm or less in the pulp is preferably in the range of 20% to 35% and more preferably in the range of 25% to 33%. When this ratio is increased, a dense layer is formed with a small amount of pulp, and improvement in strength and smoothness of the surface are expected. However, when the percentage is excessively increased, water filterability decreases leading to a nonuniform pulp layer being obtained, time is taken in the dehydration step leading to a drop in production efficiency, or dehydration to a prescribed moisture percentage is not achieved leading to a failure to retain the shape.

[0034] Here, the percentage of fibers having a fiber length of 0.2 mm or less in the pulp is the ratio of the number of fibers having a fiber length of 0.2 mm or less to the total number of fibers in the pulp. This percentage is obtained by the following method.

[0035] First, a 5 g sample is acquired from the molded pulp article MP2. Next, the sample is cut into fine strips and added with water to have a total mass of 500 g, and the mixture is immersed overnight. Next, the resultant is stirred with a stirrer to defibrate the pulp. In this manner, a dispersion liquid that contains pulp is obtained. Next, an appropriate amount of sample is taken from this dispersion liquid and further diluted with water to prepare an aqueous dispersion liquid having a pulp solid content of 0.05 mass%.

[0036] The fiber length of the thus-obtained sample is measured in accordance with JIS P 8226-2:2011 "Pulps - Determination of fibre length by automated optical analysis - Part 2: Unpolarized light method". The fiber length measurement is terminated when 20,000 or more fibers with a fiber length of 0.2 mm or more are detected. From the frequency distribution of the fiber length obtained through this measurement of the fiber length, the percentage of fibers having a fiber length of 0.2 mm or less in the pulp is obtained.

[0037] In the molded pulp article MP2, the average fiber length of pulp is preferably in the range of 1.2 mm to 1.5 mm, and more preferably in the range of 1.3 mm to 1.5 mm. Increasing the average fiber length decreases the strength of the molded pulp article MP2. Decreasing the average fiber length requires longer drying times during production. The average fiber length is a length-weighted average fiber length LL obtained by measuring a fiber length in accordance with the above-described method for a percentage of fibers having a fiber length of 1 mm or less in the pulp.

[0038] In a pulp suspension obtained by dispersing, in water, pulp contained in the molded pulp article MP2, the

Canadian Standard Freeness (CSF) is preferably 640 mL or less, more preferably 620 mL or less, and further more preferably 610 mL or less. When this Canadian Standard Freeness is higher than this, the molded pulp article MP2 tends to have insufficient strength.

[0039] The above-described Canadian Standard Freeness is preferably 500 mL or more, more preferably 530 mL or more, and further more preferably 550 mL or more. When this Canadian Standard Freeness is higher than this, it tends to take an excessive time to dry the molded pulp article MP2 at the time of its production.

[0040] Here, the above-described Canadian Standard Freeness is a value obtained by the following method. First, a sample is acquired from the molded pulp article MP2, and a dispersion liquid that contains pulp is prepared by the same method as described above. Next, this dispersion liquid is diluted with water to a solid content concentration of 0.3 mass% to obtain an aqueous suspension of pulp. Next, 1 L of the suspension is used to perform measurement defined in JIS P 8121-2:2012 "Pulps - Determination of drainability - Part 2: Canadian Standard Freeness method". For this measurement, a Canadian free tester manufactured by Kumagai Riki Kogyo Co., Ltd. is used, for example. Further, the measurement value is corrected by referring to the previously measured temperature of the suspension in the correction table. In this manner, a Canadian Standard Freeness is obtained.

[0041] It is assumed that the molded pulp article MP2 or an item placed in a container including the molded pulp article MP2 as the main body of the container will be stacked, for example, during transportation and display. The container body of the stacked container-containing article is sometimes damaged by, for example, impact associated with dropping. The molded pulp article MP2 is required to have sufficient strength, particularly sufficient impact resistance, under such a situation.

[0042] The tensile strength of the molded pulp article MP2 is preferably in the range of 30 kN/m to 55 kN/m, more preferably in the range of 35 kN/m to 55 kN/m, and further more preferably in the range of 40 kN/m to 55 kN/m. When inter-fiber bonding in the in-plane direction is strengthened, tensile strength tends to increase. Therefore, when tensile strength is increased, impact resistance can be improved. However, when tensile strength is excessively increased, damage is likely to occur, for example, under a situation in which large impact such as dropping occurs. That is, the molded pulp article MP2 becomes brittle.

[0043] The tensile elongation at break of the molded pulp article MP2 is preferably in the range of 5% to 25%, more preferably in the range of 10% to 25%, and further more preferably in the range of 15% to 25%. When the tensile elongation at break of the molded pulp article MP2 is increased, the molded pulp article MP2 can endure being deformed and can absorb impact without causing cracking or the like in response to the large impact.

[0044] Here, the above-described tensile strength and tensile elongation at break are values obtained by the following method. Firstly, a sample having a strip shape with a width of 15 mm and a length of 40 mm is cut out from a non-curved surface of the molded pulp article MP2. Next, the thickness and mass of this sample are measured. Next, this sample is used to perform measurement defined in JIS P 8113:2006 "Paper and board - Determination of tensile properties - Part 2: Constant rate of elongation method". Here, the strip is held such that an interval between grips is 20 mm. Further, the moving speed of the grips, i.e., the elongation rate of the sample, is set to 20 mm/min. Each of the tensile strength and tensile elongation at break is the average value of the values obtained from three measurements.

[0045] The peeling strength of the molded pulp article MP2 is preferably in the range of 0.3 N/mm² to 0.9 N/mm², more preferably in the range of 0.5 N/mm² to 0.9 N/mm², and more preferably in the range of 0.6 N/mm² to 0.9 N/mm². When the inter-fiber bonding in the thickness direction, i.e., in a direction perpendicular to the surface, of the molded pulp article MP2 is strengthened, peeling strength tends to increase. When the peeling strength is lower, bonding among fibers in the thickness direction is weak, and cracking may occur from the inside in response to a large impact on the molded pulp article 2. Further, when the peeling strength is lower, surface peeling or the like is likely to occur in response to a force in a direction parallel to the surface, such as rubbing. Thus, from the viewpoint of strength, the peel strength is preferably high. However, for achieving peeling strength exceeding the upper limit value, excessive densification is required, which can lead to a decrease in productivity.

[0046] Here, the above-described peeling strength is a value obtained by "Internal bond strength test method - Part 1: Z-axis direction tensile test method" described in JAPAN TAPPI 18-1. Firstly, a sample having a square shape with a side of 25 mm is cut out from the molded pulp article MP2. Next, two-sided adhesive tapes are attached to opposing surfaces of the sample to fix the sample to upper and lower jigs via these tapes. An example of the two-sided adhesive tapes to be used is a Scotch tape (registered trademark) #400 manufactured by 3M Co. These jigs are pressed against each other at a load of 150 kgf, and this state is retained for 20 seconds. This causes the sample to be pressure-bonded to the jigs. Thereafter, the upper jig is raised at a speed of 20 mm/min while the lower jig is fixed in position, which causes interlayer peeling of the sample. The maximum load at peeling is obtained. The peeling strength is the average value of the values calculated through two measurements.

[0047] The density of the molded pulp article MP2 is in the range of 0.65 g to 1.3/cm³. The density of the molded pulp article MP2 is preferably in the range of 0.7 g to 1.3/cm³ and more preferably in the range of 0.8 g to 1.3/cm³. The density of the molded pulp article MP2 may be in the range of 0.65 g/cm³ to 0.80 g/cm³.

[0048] Here, the above-described density is a value obtained by the following method. That is, a square or rectangular

sample is cut out from a non-curved surface of the molded pulp article MP2, and the size, mass, and thickness are measured. Density is calculated from the obtained values.

[0049] The molded pulp article MP2 preferably further contains a paper strength enhancer such as polyacrylamide. The use of a paper strength enhancer can enhance the strength of the molded pulp article MP2. Among paper strength

enhancers, polyacrylamide is particularly convenient in the production of the molded pulp article MP2.
[0050] The nitrogen content of the molded pulp article MP2 produced with a paper strength enhancer is higher than that of the molded pulp article MP2 produced without a paper strength enhancer. The nitrogen content of the molded pulp article MP2 produced with a paper strength enhancer is in the range of 400 $\mu\text{g/g}$ to 2,000 $\mu\text{g/g}$, preferably in the range of 500 $\mu\text{g/g}$ to 1,500 $\mu\text{g/g}$, and more preferably in the range of 600 $\mu\text{g/g}$ to 1,500 $\mu\text{g/g}$. The nitrogen content of the molded pulp article MP2 may be in the range of 500 $\mu\text{g/g}$ to 1,000 $\mu\text{g/g}$.

[0051] When the nitrogen content of the molded pulp article MP2 is decreased, the molded pulp article MP2 decreases in strength and is easily subject to damage or the like in response to a large applied impact. When the nitrogen content is decreased, the property of retaining the container shape can decrease in use as a container-containing article. When the nitrogen content is excessively increased, fiber aggregates increase in size, and the strength improvement effect accompanying the increase in nitrogen content reaches a plateau.

[0052] The nitrogen content of the molded pulp article MP2 is obtained by the following method. Firstly, two samples are taken from arbitrary positions in the molded pulp article MP2. The mass of each sample is 10 mg. Next, each sample is subjected to measurement by a chemiluminescence method defined in JIS K 2609:1998 "Crude petroleum and petroleum products - Nitrogen analysis test method". This measurement may be performed using, for example, a TN-2100H manufactured by Nittoseiko Analytech Co., Ltd. The nitrogen content is the average value of the measurement results obtained for two samples.

<2> Production apparatus of molded pulp article

[0053] Next, a production apparatus that can be used in the production of the molded pulp article MP2 will be described. Fig. 2 is a view schematically showing an example of a production apparatus that can be used for the production of the molded pulp article of Fig. 1.

[0054] A production apparatus 1 shown in Fig. 2 includes a support 10, a first station 20, a second station 30, and a third station 40.

[0055] The support 10 includes a frame body and a rail disposed thereon.

[0056] The first station includes a container 210, a lifting device 220, a cover body 230, a paper-making mold 240, a conveying device 250, a lifting device 260, and an upper mold 270.

[0057] The container 210 is disposed in the frame body of the support 10. The container 210 is open at the top. The container 210 accommodates a slurry S that contains pulp and water.

[0058] The lifting device 220 is attached to the frame body of the support 10 above the container 210. The lifting device 220 may include, for example, a hydraulic cylinder. The lifting device 220 supports the cover body 230. The lifting device 220 can raise and lower the cover body 230 in the position of the opening of the container 210.

[0059] The cover body 230 is a hollow body that has an opening on the top. The cover body 230 is connected with an unillustrated pump.

[0060] The paper-making mold 240 is fixed to the opening of the cover body 230. Specifically, the paper-making mold 240 is fixed to the opening of the cover body 230 such that a space adjacent to one surface of the paper-making mold 240 is surrounded by the paper-making mold 240 and the cover body 230.

[0061] The paper-making mold 240 is a liquid-permeable mold. The paper-making mold 240 has a three-dimensional shape. That is, the paper-making mold 240 has one or more raised portions and/or one or more recessed portions on a surface on which pulp is to be deposited. Specifically, the outer surface of the paper-making mold 240, i.e., the back surface of a surface adjacent to the above-described space, has a shape corresponding to a molded pulp article. Here, the paper-making mold 240 is a male mold that has a protruding upper surface.

[0062] The paper-making mold 240 may include, for example, a paper-making mold main body that has multiple through holes and has an outer surface having a shape corresponding to a molded pulp article, and a net body that is disposed on and along the outer surface of the paper-making mold main body.

[0063] The conveying device 250 is movable along the rail of the support 10 between the first station 20 and the second station 30. The conveying device 250 may include, for example, a motor, as a power source. The lifting device 260 is attached to the conveying device 250, and can be transported between the first station 20 and the second station 30.

[0064] The lifting device 260 is attached to the conveying device 250, as described above. The lifting device 260 may include, for example, a hydraulic cylinder. The lifting device 260 supports the upper mold 270. The lifting device 260 can raise and lower the upper mold 270.

[0065] The upper mold 270 is a holder to allow a later-described pulp layer to be sandwiched between the upper mold 270 and the paper-making mold 240 and hold the pulp layer by a vacuum suction. The lower surface of the upper mold

270 has a shape corresponding to the above-described outer surface of the paper-making mold 240. Here, the upper mold 270 is a female mold having a recessed lower surface. The upper mold 270 may have, for example, multiple through holes each opening on the lower surface at one end and being connected to the pump at the other end.

[0066] The second station 30 is disposed near the first station 20. The second station 30 includes a stand 310, a lower mold 320, a conveying device 330, a press device 340, and an upper mold 350.

[0067] The stand 310 is disposed in the frame body of the support 10. The lower mold 320 is disposed on the stand 310.

[0068] The lower mold 320 is a mold that has gas and/or liquid permeability. The upper surface of the lower mold 320 has a shape corresponding to the above-described outer surface of the paper-making mold 240. Here, the lower mold 320 is a male mold having a protruding upper surface. The lower mold 320 may have, for example, many through holes and a smooth face with a shape corresponding to the outer surface of the paper-making mold 240.

[0069] The conveying device 330 is movable along the rail of the support 10 between the second station 30 and an unillustrated fourth station. The conveying device 330 may include, for example, a motor, as a power source. When the conveying device 330 is located in the second station 30, movement in the vertical, horizontal, and forward/backward directions may be restricted by a locking mechanism. Further, the press device 340 is attached to the conveying device 330, and can be transported between the second station 30 and the fourth station.

[0070] The press device 340 is attached to the conveying device 330, as described above. The press device 340 may include, for example, a hydraulic cylinder. The press device 340 supports the upper mold 350. The press device 340 can raise and lower the upper mold 350.

[0071] The upper mold 350 is a mold without gas permeability or liquid permeability. The lower surface of the upper mold 350 has a shape corresponding to the above-described outer surface of the paper-making mold 240. Here, the upper mold 350 is a female mold having a recessed lower surface. In the upper mold 350, the surface having a shape corresponding to the above-described outer surface of the paper-making mold 240 is smooth.

[0072] The second station 30 further includes a heater and a pump (both are not shown). The heater heats both the lower mold 320 and the upper mold 350. The pump is connected to the bottom space of the lower mold 320.

[0073] The third station 40 is disposed near the second station 30. The third station 40 includes a stand 410, a conveying device 420, a lifting device 430, and a holder 440.

[0074] The stand 410 is disposed in the frame body of the support 10. A molded pulp article is placed on the stand 410.

[0075] The conveying device 420 is movable along the rail of the support 10 between the second station 30 and the third station 40. The conveying device 420 may include, for example, a motor, as a power source. The lifting device 430 is attached to the conveying device 420, and this can be transported between the second station 30 and the third station 40.

[0076] The lifting device 430 is attached to the conveying device 420, as described above. The lifting device 430 may include, for example, a hydraulic cylinder. The lifting device 430 supports the holder 440. The lifting device 430 can raise and lower the holder 440.

[0077] The holder 440 is a holder that holds a later-described molded pulp article by a vacuum suction. The lower surface of the holder 440 has a shape corresponding to the above-described outer surface of the paper-making mold 240. Here, the lower surface of the holder 440 has a recessed shape. The holder 440 may have, for example, multiple through holes each opening on the lower surface at one end and being connected to the pump at the other end.

<3> Method for producing molded pulp article

[0078] In a production method according to an embodiment of the present invention, a molded pulp article MP2 is produced, for example, using the above-described production apparatus 1. This will be described with reference to Fig. 1 to Fig. 10.

[0079] Fig. 3 is a view showing a pulp layer formation step in pulp molding using the apparatus of Fig. 2. Fig. 4 is a cross-sectional view schematically showing an example of a pulp layer formed on a paper-making mold. Fig. 5 is a view showing a dehydration step in pulp molding using the apparatus of Fig. 2. Fig. 6 is a view showing a pulp layer transport step in pulp molding using the apparatus of Fig. 2. Fig. 7 is a view showing a hot press-molding step in pulp molding using the apparatus of Fig. 2. Fig. 8 is a cross-sectional view schematically showing an example of a molded pulp article obtained by a hot pressing step. Fig. 9 is a view showing a molded pulp article transport step in pulp molding using the apparatus of Fig. 2. Fig. 10 is a view showing a state after completing the transport step of Fig. 9.

[0080] In this method, a slurry S is firstly prepared.

[0081] As described above, the slurry S contains pulp and water. The slurry S is a suspension that contains pulp dispersed in water and has high viscosity.

[0082] The pulp contained in the slurry S has substantially the same characteristics as those described above for the pulp contained in the molded pulp article MP2.

[0083] The type of pulp used in the slurry S is not particularly limited. Examples of the pulp include wood pulp, non-wood pulp, and waste paper, and wood pulp and non-wood pulp are preferable. From the viewpoint of forest preservation and utilization of unused resources, non-wood pulp is preferably used.

[0084] Pulp is classified according to differences in its preparation method. Examples of wood pulp include chemical pulps such as kraft pulp (KP), sulfite pulp (SP), and soda pulp (AP); semi-chemical pulps such as semi-chemical pulp (SCP) and chemi-ground wood pulp (CGP); ground pulp (GP); and thermomechanical pulp (TMP). Among these, chemical pulps are preferably used.

[0085] Wood pulps can be classified according to the raw materials. Examples of wood pulps include softwood pulp and hardwood pulp. Examples of softwood pulp include pulp obtained from the genus *Abies*, *Pinus*, or the like. Further, examples of hardwood pulp include pulp obtained from the genus *Acacia*, *Eucalyptus*, *Beech*, *Populus* (e.g., poplar), or the like.

[0086] Non-wood pulp is obtained from fibers taken from the bark, stem, leaf, and leaf sheath of a plant. Specific examples include pulp obtained from cotton linter, cotton, linen, hemp, ramie, straw, esparto, Manila hemp, sisal hemp, jute, flax, kenaf, bamboo, sugarcane, ganpi, *Edgeworthia chrysantha*, *paper mulberry*, or mulberry. Especially, pulp of bamboo or sugarcane is preferable.

[0087] These pulps can be used singly or as a mixture of two or more at a preferred ratio.

[0088] Pulps have different fiber lengths depending on their raw materials and production methods. For example, in general, pulp made from sugarcane has a shorter average fiber length than pulp made from bamboo. Further, the average fiber length of pulp can be adjusted by an arbitrary method, for example, by a mechanical treatment such as beating or crushing. Therefore, pulp having certain characteristics can be obtained by, for example, selecting an appropriate pulp from a plurality of pulps or by appropriately combining two or more pulps. The pulp to be used is preferably non-wood pulp and preferably pulp including sugarcane as a material, pulp including bamboo as a material, or a combination thereof.

[0089] The pulp content of the slurry S is preferably in the range of 0.01 mass% to 3.0 mass% and more preferably in the range of 0.01 mass% to 0.5 mass%. When the pulp content is small, high productivity is unlikely to be achieved. When the pulp content is large, there is the possibility that the variance in thickness of the pulp layer may become large.

[0090] The slurry S preferably further contains a paper strength enhancer. The ratio (based on solid content) of the paper strength enhancer to the total of pulp and the paper strength enhancer is preferably in the range of 0.3 mass% to 3 mass%, more preferably in the range of 0.5 mass% to 2 mass%, and further more preferably in the range of 0.7 mass% to 2 mass%.

[0091] The slurry S may further contain other additives. Organic low-molecular-weight materials, organic high-molecular-weight materials, inorganic materials or combinations thereof can be used as additives, such as agents that impart water resistance and oil resistance, and the agent should be selected according to the required performance as a molded pulp container.

[0092] The ratio of the additive to the total of pulp and the additive is preferably 10 mass% or less and more preferably 5 mass% or less. That is, the percentage of pulp in the total solid content of the slurry S is preferably 90 mass% or more and more preferably 95 mass% or more.

[0093] Next, the slurry S is supplied into the container 210. Subsequently, as shown in Fig. 3, the cover body 230 is lowered by the lifting device 220, such that the upper surface of the paper-making mold 240 is positioned sufficiently below the liquid surface of the slurry S. In this state, the pump is driven to depressurize the space surrounded by the cover body 230 and the paper mold 240. In this manner, a flow of the slurry S is produced across the paper mold 240, and the pulp is deposited on the paper mold 240. In the above-described manner, a pulp layer MP1 is formed on the paper-making mold 240, as shown in Fig. 4.

[0094] Next, as shown in Fig. 5, while the pump is driven, the cover body 230 is raised by the lifting device 220, such that the bottom of the paper-making mold 240 is positioned sufficiently above the liquid surface of the slurry S. In this manner, the pulp layer MP1 is dehydrated under reduced pressure. Next, the lifting device 260 is driven to lower the upper mold 270 until the lower surface thereof is brought into contact with the pulp layer MP 1. The pulp layer MP 1 is not shown in Fig. 5. The dehydration step is performed without heating either of the upper mold 270 or the paper-making mold 240.

[0095] The depressurization time in the dehydration step is preferably in the range of 1 to 60 seconds and more preferably in the range of 1 to 10 seconds.

[0096] The water content of the pulp layer MP1 immediately after dehydration is preferably in the range of 40 mass% to 90 mass%, more preferably in the range of 50 mass% to 70 mass%, and further more preferably in the range of 60 mass% to 70 mass%. When the water content is small, in the hot pressing step, movement of fibers in the in-plane direction in the pulp layer may be insufficient. When the water content is large, there is the possibility that in the hot pressing step, movement of fibers in the in-plane direction in the pulp layer may be excessive, or the shape retention properties of the pulp layer MP1 may be insufficient in a period from the end of the dehydration step to the start of the hot pressing step.

[0097] After terminating the above-described depressurization and pressurization of the space, the pump is driven to allow the upper mold 270 to adsorb and hold the pulp layer MP1. Suction by the pump and the upper mold 270 does not cause further dehydration of the pulp layer MP1.

[0098] Then, while allowing the upper mold 270 to adsorb and hold the pulp layer MP1, the lifting device 260 is driven

to raise the upper mold 270, as shown in Fig. 2. This causes the pulp layer MP1 to be removed from the paper-making mold 240.

[0099] Next, the conveying devices 250 and 330 are driven to move the press device 340 and the upper mold 350 from the second station 30 to the fourth station as well as the lifting device 260 and the upper mold 270 from the first station 20 to the second station 30, as shown in Fig. 6. Subsequently, the lifting device 260 is driven to lower the upper mold 270 until the pulp layer MP1 is brought into contact with the lower mold 320. Thereafter, the suction by the pump and the upper mold 270 is terminated to free the pulp layer MP1 from the upper mold 270. Subsequently, the lifting device 260 is driven to raise the upper mold 270. In this manner, the pulp layer MP1 is transferred from the first station 20 to the second station 30, and the pulp layer MP1 is placed on the lower mold 320.

[0100] Next, the conveying devices 250 and 330 are driven to move the lifting device 260 and the upper mold 270 from the second station 30 to the first station 20 as well as the press device 340 and the upper mold 350 from the fourth station to the second station 30, as shown in Fig. 2. Subsequently, the press device 340 is driven to lower the upper mold 350, as shown in Fig. 7. Then, the upper mold 350 and the lower mold 320 pressurize the pulp layer MP1 held between them. At the same time, the heater is driven to heat the pulp layer MP1. At the same time, the pump is driven to suction and remove water and/or water vapor from a space sandwiched between the upper mold 350 and the lower mold 320. Accordingly, the surface shape of the pulp layer MP1 is adjusted, and the pulp layer MP1 is densified and dried. In the above-described manner, a molded pulp article MP2 shown in Fig. 8 is obtained.

[0101] It is noted that the water content of the pulp layer MP1 immediately before the start of this hot pressing step is substantially equal to the water content of the pulp layer MP1 immediately after the end of the dehydration step.

[0102] In this hot pressing step, the press pressure is preferably in the range of 0.4 MPa to 4.5 MPa and more preferably in the range of 0.8 MPa to 2.5 MPa. When the press pressure is lower, there is the possibility that the molded pulp article MP2 having high density may not be obtained. The pulp layer MP1 contains a large amount of pulp having a short fiber length. Such pulp is likely to move in the pulp layer MP1, particularly when the press pressure is excessively high. Therefore, when the press pressure is excessively high, the molded pulp article MP2 is likely to have variation in thickness.

The press pressure may be in the range of 0.4 MPa to 2.0 MPa.

[0103] In this hot pressing step, the heating temperature of the pulp layer MP1, i.e., the temperature of the upper mold 350 or the lower mold 320 for heating by the heater, is preferably in the range of 150°C to 220°C, more preferably in the range of 150°C to 200°C, and further more preferably in the range of 165°C to 190°C. Since the pulp layer MP1 contains a large amount of pulp having a short fiber length, water vapor is unlikely to escape to the outside. Therefore, when the heating temperature is low, a long time is required for drying the pulp layer MP1. When the heating temperature is increased, there is a possibility that shrinkage of the pulp layer MP1 associated with drying may increase, with the result that the distortion in the molded pulp article MP2 may increase.

[0104] The press time in the hot pressing step is preferably in the range of 10 to 300 seconds and more preferably in the range of 20 to 200 seconds, depending on the heating temperature, the shape of a molded article, and others.

[0105] When the press device 340 is driven to raise the upper mold 350 in terminating the above-described hot pressing step, the molded pulp article MP2 is removed from the upper mold 350.

[0106] Next, the conveying devices 330 and 420 are driven to move the press device 340 and the upper mold 350 from the second station 30 to the fourth station as well as the lifting device 430 and the holder 440 from the third station 40 to the second station 30, as illustrated in Fig. 9. Subsequently, the lifting device 430 is driven to lower the holder 440 until the holder 440 is brought into contact with the molded pulp article MP2. The molded pulp article MP2 is released from the lower mold by blowing air from the inside of the lower mold. Thereafter, the pump is driven to allow the holder 440 to suction and hold the molded pulp article MP2.

[0107] Subsequently, the lifting device 430 is driven, in a state in which the holder 440 is allowed to suction and hold the molded pulp article MP2, to raise the holder 440. Subsequently, the conveying devices 330 and 420 are driven to move the lifting device 430 and the holder 440 from the second station 30 to the third station 40 as well as the press device 340 and the upper mold 350 from the fourth station to the second station 30, as illustrated in Fig. 10. Subsequently, suction by the pump and the holder 440 is terminated to free the molded pulp article MP2 from the holder 440. In this manner, the molded pulp article MP2 is transferred from the second station 30 to the third station 40, and the molded pulp article MP2 is placed on the stand 410.

[0108] In the above-described manner, the molded pulp article MP2 is produced.

[0109] Thereafter, the molded pulp article MP2 is subjected to post-treatment, for example, printing such as picture printing or plain printing, coating, or a combination thereof, as necessary. The coating layer formed by post-treatment may be, for example, a layer containing a chemical agent that imparts water resistance or oil resistance, a layer filled with a material that imparts heat insulation properties, a layer foamed with a foaming agent, or a combination thereof. Performing the post treatment can, for example, further enhance the decorative properties of the molded pulp article MP2 or impart new functions to the molded pulp article MP2.

[0110] According to the above-described method, excellent release properties can be achieved at the time of production, and the molded pulp article MP2 having a small thickness and high strength can be produced. It is noted that being

excellent in release properties denotes that releasing the molded pulp article MP2 from the lower mold by blowing air is possible, and releasing does not cause peeling or cracking on the surface.

[0111] Since the molded pulp article MP2 has a small wall thickness, the weight is light, and additionally the height when stacked is small. Therefore, the molded pulp article MP2 can achieve high transportation efficiency.

[0112] Furthermore, according to the above-described method, drying can be completed in a short time. Therefore, improvement in production efficiency and reduction in energy can be expected.

[0113] Further, the molded pulp article MP2 obtained by the above-described method has excellent surface properties. Reasons therefor will be described below.

[0114] When drying with an oven is performed in place of the hot pressing step, the surface of the pulp layer becomes uneven with large height differences due to its contraction. Further, in such a method, the pulp layer is not sufficiently densified, and thus the molded pulp article has high porosity. Therefore, in this case, the molded pulp article having excellent surface properties cannot be produced.

[0115] Further, when the dehydration step is followed by drying the product with an oven, humidifying the dried product as necessary, and performing a hot pressing treatment on this product, height differences due to unevenness formed on the surface due to drying can be reduced by the subsequent humidification and hot pressing treatment. The porosity can also be decreased by the humidification and hot pressing treatment. However, the height differences of the unevenness formed on the surface due to drying using an oven are very large, and thus cannot be sufficiently reduced by the subsequent humidification and hot pressing treatment. Further, even when drying is followed by humidification and hot pressing treatment, it is difficult to sufficiently decrease the porosity.

[0116] In the method described with reference to Fig. 2 to Fig. 10, the pulp layer MP1 is dried in the hot pressing step. That is, in the above-described method, the hot pressing step is performed after the dehydration step without a drying step. Further, as pulp, pulp having an average fiber length in the above-described range is used.

[0117] Since the drying step is not performed before the hot pressing step, unevenness with a large height difference does not occur on the surface of the pulp layer MP1. In the hot pressing step, deformation of the pulp layer MP1 associated with drying is prevented by the upper mold 350 and the lower mold 320. Further, since the hot pressing step is performed on the pulp layer MP1, which has a high water content and whose pulp has an average fiber length within the above-described range, only moderate movement of fibers in the in-plane direction can occur within the pulp layer MP1. The pulp layer MP1 can be densified without causing variation in thickness.

[0118] Therefore, according to the method described with reference to Fig. 2 to Fig. 10, the molded pulp article MP2 having excellent surface properties can be produced. Specifically, a molded pulp article MP2 can be obtained having, on the surface, a region in which one or more of arithmetic mean roughness Ra, maximum height roughness Rz, and average length of roughness curve elements RSm are small. Such a molded pulp article MP2 is excellent in decorative properties as well as facilitates the formation of a print layer and a coating layer.

[0119] The arithmetic mean roughness Ra is preferably in the range of 2 μm to 10 μm and more preferably in the range of 2.5 μm to 4.5 μm . The maximum height roughness Rz is preferably in the range of 10 μm to 60 μm and more preferably in the range of 15 μm to 30 μm . The average length of roughness curve elements RSm is preferably in the range of 90 μm to 300 μm , more preferably in the range of 90 μm to 150 μm , and further more preferably in the range of 90 μm to 130 μm .

[0120] Here, the "arithmetic mean roughness Ra", "maximum height roughness Rz", and "average length of roughness curve elements RSm" are surface properties parameters defined in JIS B 0601:2001. The surface properties parameters are measured using, for example, a Surface Roughness Meter SJ-210 (tip radius: 2 μm , measuring force: 0.75 mN) produced by Mitutoyo Corporation, under the following conditions.

Filter: Gasussian

Cutoff λc : 0.25 mm

Cutoff λs : 8 μm

Measurement speed: 0.25 mm/s

Number of sections: 5

[0121] A plate-shaped piece is taken from the molded pulp article MP2, measurements are performed at five arbitrary locations, and the average value is calculated.

[0122] In the molded pulp article MP2, the entire surface may have the above-described surface properties, or only some areas of the surface may have the above-described surface properties. For example, only areas including the part to undergo post-treatment, such as printing, may have the above surface properties, and the other areas may not have the above surface properties. Alternatively, one surface of the molded pulp article MP2 may have the above-described surface properties, and the back surface thereof may not have the above-described surface properties. Such a structure can be achieved by, for example, allowing the surface properties to differ between a partial area and the other areas of the surface of each of the upper mold 350 and the lower mold 320 which are in contact with the pulp layer MP1.

[0123] Further, according to the method described with reference to Fig. 2 to Fig. 10, there can be produced the molded pulp article MP2 having a small standard deviation of basis weight. The standard deviation of basis weight of the molded pulp article MP2 is preferably 30 g/m² or less and more preferably 15 g/m² or less. The lower limit value of this standard deviation is zero and, according to an example, 2 g/m².

[0124] Here, the standard deviation of basis weight of the molded pulp article MP2 is a value obtained by the following method.

[0125] First, nine strip-shaped samples with a width of 15 mm and a length of 40 mm are cut out from multiple regions located within a certain plane of the molded pulp article MP2. Next, the masses of these samples are measured. Thereafter, the basis weight of each of the samples is calculated from its mass and area (600 mm²). The standard deviation is calculated from the thus-obtained basis weight.

[0126] Next, nine samples are cut out from multiple regions located within a different plane of the molded pulp article MP2 in the same manner as described above. For these samples, measurement of mass and calculation of basis weight and its standard deviation are similarly performed.

[0127] If the molded pulp article MP2 further has other surfaces, for each of the other surfaces, samples are cut out, and the mass measurement and the calculation of basis weight and its standard deviation are performed in the same manner as described above.

[0128] Then, the maximum value of these standard deviations is the standard deviation of basis weight of the molded pulp article MP2.

[0129] The present inventors consider that the reason why the molded pulp article MP2 with a low standard deviation of basis weight can be produced by the method explained with reference to Fig. 2 to Fig. 10 (hereinafter referred to as the first method) is as follows.

[0130] A molded pulp article can also be produced by, for example, the method described below (hereinafter, referred to as a second method).

[0131] In the second method, a female mold is firstly prepared as a paper-making mold. This paper-making mold includes: a paper-making mold main body that is disposed with multiple through holes and includes an upper surface having a recessed shape corresponding to a molded pulp article; and a net body provided on and across the inner surface of the paper-making mold main body.

[0132] Next, this paper-making mold is disposed with its opening facing upward. Subsequently, a slurry that contains pulp and water is supplied into the cavity of the paper-making mold and fills the inside of the paper-making mold. Furthermore, the supply of the slurry into the paper-making mold is continued to deposit pulp on the net body. The slurry is supplied into the paper mold so that the slurry inside the paper mold is under pressure.

[0133] After a sufficient amount of pulp has been deposited on the net body, the supply of the slurry into the paper-making mold is terminated. Subsequently, water remaining in the paper-making mold is discharged from the paper-making mold. For example, air is pressed into the paper-making mold to allow water remaining in the paper-making mold to be discharged from the paper-making mold.

[0134] Next, the pulp layer is pressed by the paper-making mold and an upper mold as a male mold to dehydrate the pulp layer. This dehydration step is performed without heating either of the upper mold or the paper-making mold. The water content of the pulp layer immediately after dehydration is similar to the water content of the pulp layer MP1 immediately after dehydration in the first method.

[0135] Next, the upper mold is allowed to suction and hold the pulp layer, and the upper mold is raised in this state. Accordingly, the pulp layer is removed from the paper-making mold.

[0136] Next, the upper mold, which suctions and holds the pulp layer, is moved to the position of a lower mold as a female mold. Subsequently, the upper mold is lowered until the pulp layer is brought into contact with the lower mold. Thereafter, the suction is terminated to release the pulp layer from the upper mold. In this manner, the pulp layer is placed on the lower mold.

[0137] Next, the pulp layer is held between upper and lower molds for hot pressing, and the pulp layer between them is pressurized. At the same time, a heater is driven to heat the pulp layer. At the same time, a pump is driven to suction and remove water and/or water vapor from the space sandwiched between the upper mold and the lower mold. In the second method, a molded pulp article is obtained in the above-described manner.

[0138] In the second method, the flow of the slurry circulating in the paper-making mold can occur in a period from the start of the supply of the slurry into the paper-making mold until the inside of the paper-making mold is completely filled with the slurry. This circulating flow can prevent the pulp from settling. However, in the second method, the inside of the paper-making mold needs to be filled with the slurry, and therefore a structure allowing water to be quickly discharged cannot be adopted for the paper-making mold. Therefore, after the inside of the paper-making mold is completely filled with the slurry, even if the pressure of the slurry is increased, a circulating flow of the slurry sufficient to prevent the pulp from settling is not generated, and the pulp settles in the slurry inside the paper-making mold.

[0139] As a result, the amount of pulp deposited on the side wall of the paper-making mold is greater in the lower part than in the upper part. When the slurry is supplied until a sufficient amount of pulp is deposited in the upper part on the

side wall of the paper-making mold, an excessive amount of pulp comes to be deposited on the bottom of the paper-making mold. When an excessive amount of pulp is deposited, the variation in the amount of pulp deposited will increase. For example, a large difference in the deposited amount of pulp can occur between vicinities of the through holes disposed to the paper-making mold main body and at positions further from them.

[0140] Thus, in the second method, a large variation occurs in the amount of pulp deposited. During hot pressing treatment, fibers can move in the in-plane direction in the pulp layer, but the movement of each fiber is restricted to a narrow range. That is, variation in the amount of pulp deposited cannot be eliminated by the movement of fibers during hot pressing treatment. Therefore, the second method cannot produce a molded pulp article with a low standard deviation of basis weight.

[0141] On the other hand, in the first method, the paper-making mold 240 is disposed on the top of the cover body 230, and the combination thereof is immersed in the slurry S. The depth of the slurry S is much greater than the height of the paper-making mold 240. Therefore, even if the pulp settles in the slurry S, the pulp concentration does not differ greatly between upper positions in the paper mold 240 and lower position in the paper mold 240. Therefore, according to the first method, pulp can be substantially uniformly deposited on the paper-making mold 240, and thus a molded pulp article MP2 having only a small standard deviation of basis weight can be produced.

[0142] The molded pulp article MP2 has an opening, the diameter of which does not expand in a direction away from this opening. Here, the molded pulp article MP2 has an opening which tapers in a direction away from the opening. This shape makes it possible to reduce the volume of a stack of a plurality of molded pulp articles MP2.

[0143] In the first method, when the pulp layer MP1 held between one of the upper mold 350 and the lower mold 320 and an elastic body is pressurized, instead of pressurizing the pulp layer MP1 by the upper mold 350 and the lower mold 320, the elastic body is deformed. Therefore, a sufficient pressure is not applied on the pulp layer MP1, and thus a molded pulp article having excellent surface properties cannot be obtained.

[0144] In the second method as well, when one of the upper and lower molds used for the hot pressing treatment is changed to an elastic body, a molded pulp article with excellent surface properties cannot be obtained. Further, in this case, the standard deviation of basis weight increases as described above.

[0145] The molded pulp article MP2 may be, for example, a container. The molded pulp article MP2 may be an article other than a container. The molded pulp article MP2 is not particularly limited as long as it is a three-dimensional molded article, i.e., a molded article that does not have a two-dimensional shape such as a sheet but has a three-dimensional shape.

[0146] Fig. 2 to Fig. 10 are intended to facilitate the understanding of the method for producing a molded pulp article according to an embodiment of the present invention. The methods described above can also be performed using production apparatuses having other structures. For example, in the production apparatus 1, the upper mold 270 and the upper mold 350 are female molds, and the paper-making mold 240 and the lower mold 320 are male molds. The upper mold 270 and the upper mold 350 may be male molds, and the paper-making mold 240 and the lower mold 320 may be female molds. In this manner, the above-described production apparatus 1 and production method can be modified in various ways.

Examples

[0147] Specific examples of the present invention will be described below. The present invention is not limited to any of these specific examples.

<1> Production of molded pulp article

(Example 1)

[0148] A pulper was used to prepare a slurry that contains pulp, a paper strength enhancer, and water. The pulp content of the slurry was 0.3 mass%. As the pulp, pulp A having an average fiber length of 1.6 mm and pulp B having an average fiber length of 0.94 mm were used. The amount of pulp A to the total amount (100 parts by mass) of pulp was 80 parts by mass. As the paper strength enhancer, Polyston (registered trademark) 1280 manufactured by Arakawa Chemical Industries, Ltd. was used. The percentage of the paper strength enhancer in the solid content of the slurry was 1 mass%.

[0149] This slurry was used to produce a molded pulp article by the method described with reference to Fig. 2 to Fig. 10. Here, the dehydration step was performed such that the water content of the pulp layer immediately after dehydration became 65 mass%. In the hot pressing step, the heating temperature was 160°C, the press pressure was 1.2 MPa, and the press time was 140 seconds. In the dehydration step and the hot pressing step, the clearance between the upper mold and the lower mold was 1.0 mm such that a molded pulp article having a wall thickness of 1.0 mm was obtained.

[0150] In the above-described manner, a container was produced as a molded pulp article.

(Example 2)

[0151] A molded pulp article was produced by the same method as in Example 1, except that pulp C having an average fiber length of 0.86 mm was used instead of pulp B.

(Example 3)

[0152] A molded pulp article was produced by the same method as in Example 1, except that the amount of pulp A to the total amount (100 parts by mass) of pulp was 70 parts by mass, and the percentage of the paper strength enhancer in the solid content of the slurry was 3 mass%.

(Example 4)

[0153] A molded pulp article was produced by the same method as in Example 1, except that the amount of pulp A to the total amount (100 parts by mass) of pulp was 70 parts by mass.

(Example 5)

[0154] A molded pulp article was produced by the same method as in Example 1, except that the amount of pulp A to the total amount (100 parts by mass) of pulp was 70 parts by mass, and the percentage of the paper strength enhancer in the solid content of the slurry was 0.5 mass%.

(Example 6)

[0155] A molded pulp article was produced by the same method as in Example 1, except that the amount of pulp A to the total amount (100 parts by mass) of pulp was 50 parts by mass.

(Example 7)

[0156] A molded pulp article was produced by the same method as in Example 1, except that the amount of pulp A to the total amount (100 parts by mass) of pulp was 50 parts by mass, and the percentage of the paper strength enhancer in the solid content of the slurry was 0.5 mass%.

(Example 8)

[0157] A molded pulp article was produced by the same method as in Example 1, except that the amount of pulp A to the total amount (100 parts by mass) of pulp was 70 parts by mass, and the clearance between the upper mold and the lower mold was 0.7 mm in the dehydration step and the hot pressing step such that a molded pulp article having a wall thickness of 0.7 mm was obtained.

(Example 9)

[0158] A molded pulp article was produced by the same method as in Example 1, except that the amount of pulp A to the total amount (100 parts by mass) of pulp was 70 parts by mass, and the clearance between the upper mold and the lower mold was 0.7 mm in the dehydration step and the hot pressing step such that a molded pulp article having a wall thickness of 0.7 mm was obtained. It is noted that in this Example, the density of the molded pulp article was lower than that in Example 8.

(Example 10)

[0159] A molded pulp article was produced by the same method as in Example 1, except that the amount of pulp A to the total amount (100 parts by mass) of pulp was 50 parts by mass, and the percentage of the paper strength enhancer in the solid content of the slurry was 2 mass%.

(Comparative Example 1)

[0160] A molded pulp article was produced by the same method as in Example 1, except that the total amount of pulp was pulp A.

EP 4 382 668 A1

(Comparative Example 2)

[0161] A molded pulp article was produced by the same method as in Example 1, except that the amount of pulp A to the total amount (100 parts by mass) of pulp was 30 parts by mass.

(Comparative Example 3)

[0162] A molded pulp article was produced by the same method as in Example 1, except that the total amount of pulp was pulp B.

(Comparative Example 4)

[0163] A molded pulp article was produced by the same method as in Example 1, except that the amount of pulp A to the total amount (100 parts by mass) of pulp was 70 parts by mass, and the paper strength enhancer was not used.

(Comparative Example 5)

[0164] A molded pulp article was produced by the same method as in Example 1, except that the amount of pulp A to the total amount (100 parts by mass) of pulp was 70 parts by mass, and the percentage of the paper strength enhancer in the solid content of the slurry was 0.3 mass%.

(Comparative Example 6)

[0165] A molded pulp article was produced by the same method as in Example 1, except that the amount of pulp A to the total amount (100 parts by mass) of pulp was 70 parts by mass. It is noted that in this Example, the density of the molded pulp article was low.

(Comparative Example 7)

[0166] A molded pulp article was produced by the same method as in Example 1, except that the amount of pulp A to the total amount (100 parts by mass) of pulp was 70 parts by mass, and the clearance between the upper mold and the lower mold was 0.7 mm in the dehydration step and the hot pressing step such that a molded pulp article having a wall thickness of 0.7 mm was obtained. It is noted that in this Example, the density of the molded pulp article was low.

<2> Evaluation

[0167] For each of the molded pulp articles produced in Examples 1 to 10 and Comparative Examples 1 to 7, various measurements were performed by the above-described methods. The results are described in Table 1 to Table 3 below.

[Table 1]

	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6
Pulp A (parts by mass)	80	80	70	70	70	50
Pulp B (parts by mass)	20	0	30	30	30	50
Pulp C (parts by mass)	0	20	0	0	0	0
Paper strength enhancer (solid content; mass%)	1	1	3	1	0.5	1
Nitrogen content (μg/g)	750	770	1910	780	560	850
Average fiber length (mm)	1.5	1.4	1.4	1.4	1.4	1.3
Percentage of short fibers (%)	37	40	41	41	41	49
Canadian Standard Freeness (mL)	635	600	590	590	610	530
Thickness (mm)	1.0	1.0	1.0	1.0	1.0	1.0
Tensile strength (kN/m)	35	48	48	44	46	38

EP 4 382 668 A1

(continued)

	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6
Peeling strength (N/m ²)	0.69	0.85	0.82	0.74	0.44	0.71
Density (g/cm ³)	0.70	0.95	0.92	0.92	0.88	0.74
Release properties	A	A	A	A	A	A

[Table 2]

	Example 7	Example 8	Example 9	Example 10	Comparative Example 1	Comparative Example 2
Pulp A (parts by mass)	50	70	70	50	100	30
Pulp B (parts by mass)	50	30	30	50	0	70
Pulp C (parts by mass)	0	0	0	0	0	0
Paper strength enhancer (solid content; mass%)	0.5	1	1	2	1	1
Nitrogen content (μg/g)	560	780	780	1465	700	900
Average fiber length (mm)	1.3	1.4	1.4	1.3	1.6	1.1
Percentage of short fibers (%)	49	41	41	49	30	56
Canadian Standard Freeness (mL)	530	590	590	530	678	484
Thickness (mm)	1.0	0.7	0.7	1.0	1.0	1.0
Tensile strength (kN/m)	32	44	39	53	28	35
Peeling strength (N/m ²)	0.53	0.68	0.65	0.80	0.20	>1.0
Density (g/cm ³)	0.70	0.90	0.77	1.24	0.71	1.35
Release properties	A	A	A	A	A	B

[Table 3]

	Comparative Example 3	Comparative Example 4	Comparative Example 5	Comparative Example 6	Comparative Example 7
Pulp A (parts by mass)	0	70	70	70	70
Pulp B (parts by mass)	100	30	30	30	30
Pulp C (parts by mass)	0	0	0	0	0
Paper strength enhancer (solid content; mass%)	1	0	0.3	1	1
Nitrogen content (μg/g)	980	256	395	780	780
Average fiber length (mm)	0.94	1.4	1.4	1.4	1.4
Percentage of short fibers (%)	67	41	41	41	41

(continued)

	Comparative Example 3	Comparative Example 4	Comparative Example 5	Comparative Example 6	Comparative Example 7
Canadian Standard Freeness (mL)	401	610	610	610	610
Thickness (mm)	1.0	1.0	1.0	1.0	0.7
Tensile strength (kN/m)	N.D.	27	28	28	20
Peeling strength (N/m ²)	N.D.	0.18	0.21	0.08	0.06
Density (g/cm ³)	N.D.	0.82	0.70	0.64	0.58
Release properties	C	A	A	A	A

[0168] In Table 1 to Table 3, evaluation of the release properties is as follows. When drying failure occurs in the molded pulp article MP2, cracking or peeling occurs on the surface of the molded pulp article MP2, or release failure occurs in which the molded pulp article MP2 is not released from the mold, and an intended molded article is not obtained.

A: Releasable by blowing air, good surface state

B: Releasable by blowing air, occurrence of peeling or cracking on the surface

C: Not releasable by blowing air

[0169] It is noted that in Table 1 to Table 3, "Percentage of short fibers" denotes the percentage of fibers having a fiber length of 1 mm or less in the pulp. It is noted that for Comparative Example 3, the molded pulp article was not releasable, and therefore values of tensile strength, peeling strength, and density are not shown.

[0170] As apparent from comparison between Examples 1 to 10 and Comparative Examples 1 to 7, a molded pulp article having a percentage of fibers having a fiber length of 1 mm or less in the pulp, average fiber length, density, and nitrogen content in prescribed ranges had high strength in spite of having a small wall thickness and was also excellent in release properties. It is noted that in all the molded pulp articles of Examples 1 to 10, the arithmetic mean roughness Ra was in the range of 2 μm to 10 μm , the maximum height roughness Rz was in the range of 10 μm to 60 μm , and the average length of roughness curve elements RSm was in the range of 90 μm to 300 μm . Further, all the molded pulp articles of Examples 1 to 10 had a standard deviation of basis weight in the range of 2 g/m² to 30 g/m².

[Reference Signs List]

[0171]

- 1 Production apparatus
- 10 Support
- 20 First station
- 30 Second station
- 40 Third station
- 210 Container
- 220 Lifting device
- 230 Cover body
- 240 Paper-making mold
- 250 Conveying device
- 260 Lifting device
- 270 Upper mold
- 310 Stand
- 320 Lower mold
- 330 Conveying device
- 340 Press device
- 350 Upper mold

410	Stand
420	Conveying device
430	Lifting device
440	Holder
5	MP1 Pulp layer
	MP2 Molded pulp article
	S Slurry

Claims

1. A molded pulp article, wherein

a percentage of fibers having a fiber length of 1 mm or less in pulp is in the range of 35% to 50%,
the pulp has an average fiber length in the range of 1.2 mm to 1.5 mm,
the molded pulp article has a density in the range of 0.65 g/cm³ to 1.3 g/cm³, and
the molded pulp article has a nitrogen content in the range of 400 µg/g to 2,000 µg/g.

2. The molded pulp article according to claim 1, wherein
the molded pulp article has a thickness in the range of 0.5 mm to 1 mm.

3. The molded pulp article according to claim 1 or 2, wherein

the molded pulp article has a density in the range of 0.65 g/cm³ to 0.80 g/cm³, and
the molded pulp article has a nitrogen content in the range of 500 µg/g to 1,000 µg/g.

4. The molded pulp article according to any one of claims 1 to 3, wherein
the molded pulp article has a tensile strength in the range of 30 kN/m to 55 kN/m.

5. The molded pulp article according to any one of claims 1 to 4, wherein
the molded pulp article has a peeling strength in the range of 0.3 N/mm² to 0.9 N/mm².

6. The molded pulp article according to any one of claims 1 to 5, wherein
the molded pulp article has a standard deviation of basis weight in the range of 2 g/m² to 30 g/m².

7. The molded pulp article according to any one of claims 1 to 6, wherein
the molded pulp article is a container.

8. A method for producing a molded pulp article, the method comprising:

preparing a slurry that contains pulp and water in which a percentage of fibers having a fiber length of 1 mm or less in pulp is in the range of 35% to 50%;
depositing the pulp on a paper-making mold having a three-dimensional shape to form a pulp layer;
dehydrating the pulp layer to obtain an intermediate molded article; and
holding the undried intermediate molded article between male and female molds, and heating the intermediate molded article to a temperature in the range of 150°C to 220°C while applying pressure in the range of 0.4 MPa to 4.5 MPa.

9. The method for producing a molded pulp article according to claim 8, wherein depositing the pulp on a paper-making mold comprises:

preparing a cover body as a hollow body having an opening;
fixing the paper-making mold to the opening;
immersing the paper-making mold fixed to the opening in the slurry; and
depressurizing a space surrounded by the cover body and the paper-making mold immersed in the slurry.

10. The method for producing a molded pulp article according to claim 9, wherein
the paper-making mold is immersed in the slurry such that the paper-making mold is positioned above the cover body.

11. The method for producing a molded pulp article according to any one of claims 8 to 10, wherein the pressurization and heating of the undried intermediate molded article held between the male and female molds is performed under a pressure in the range of 0.4 MPa to 2.0 MPa and at a temperature in the range of 150°C to 200°C, respectively.

5

10

15

20

25

30

35

40

45

50

55

FIG.1

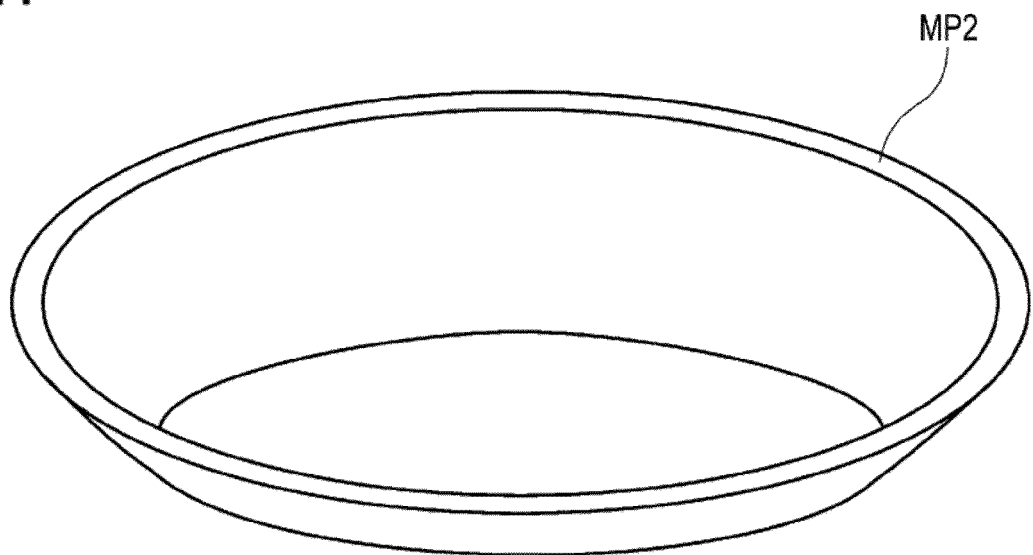


FIG.2

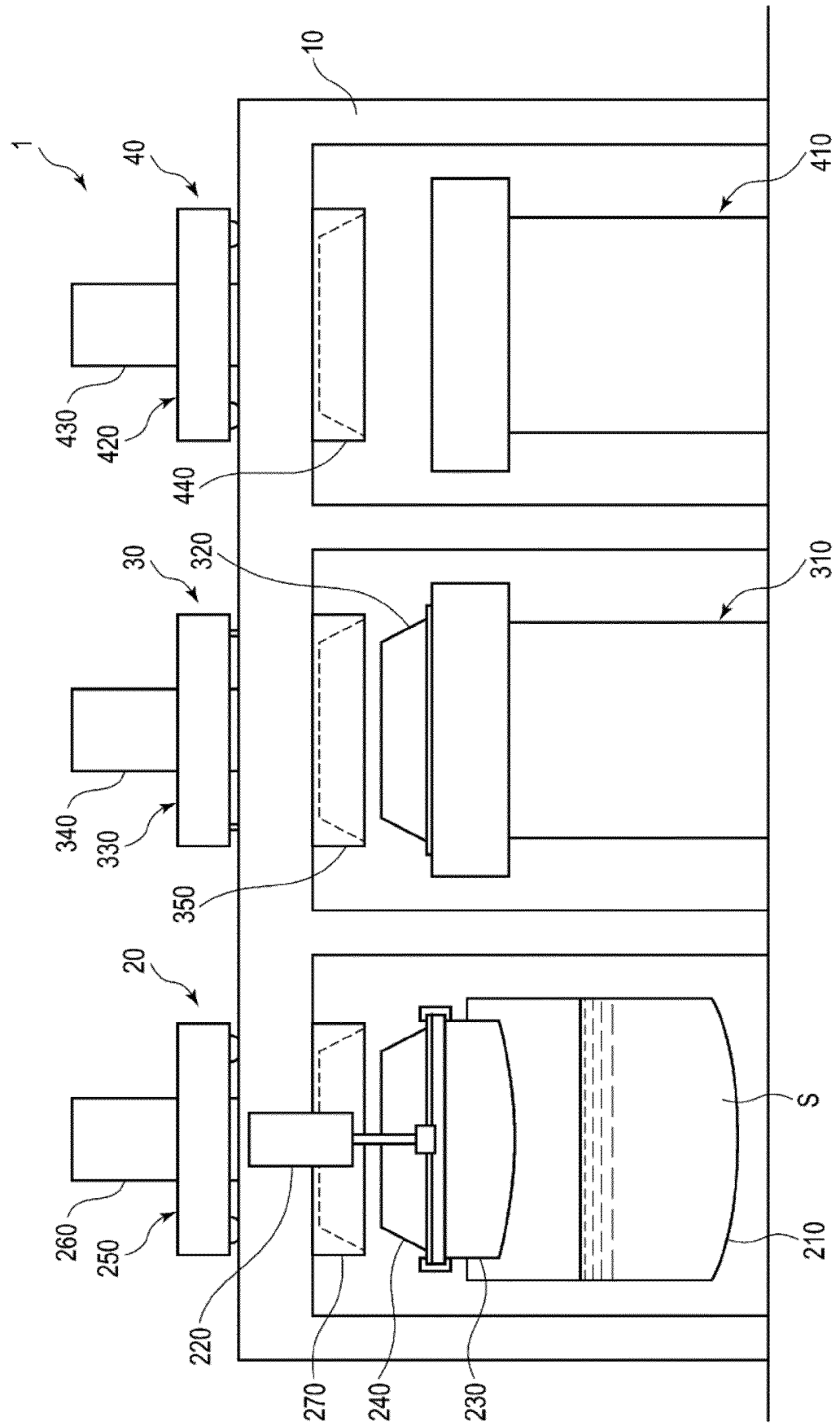


FIG. 3

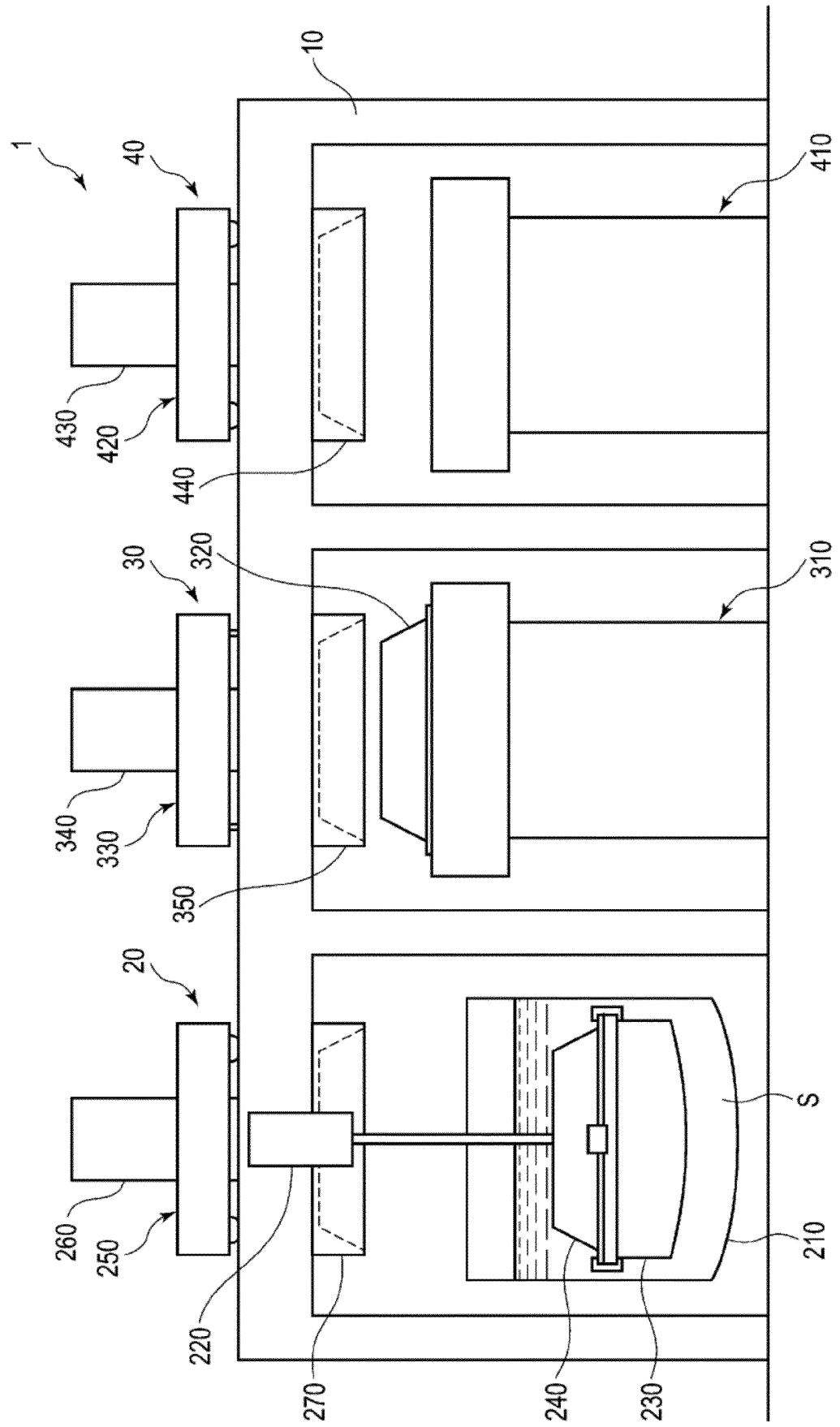


FIG.4

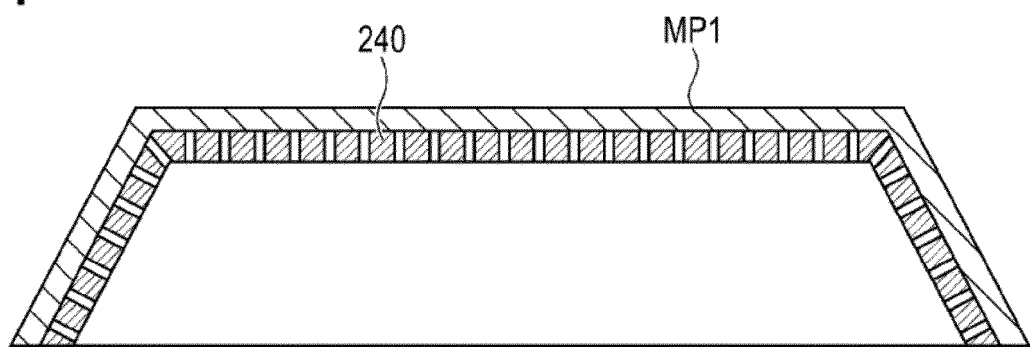


FIG.5

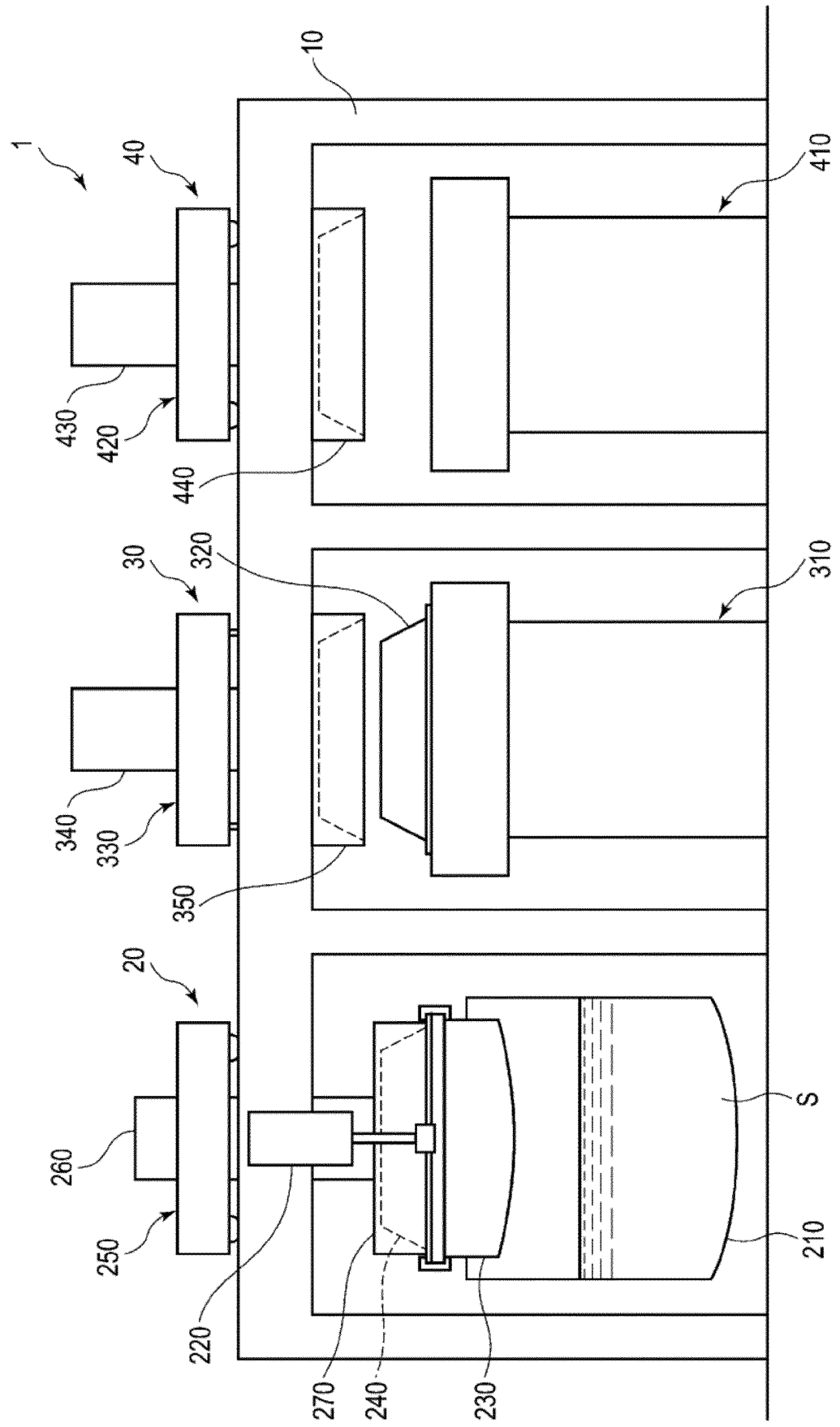


FIG.6

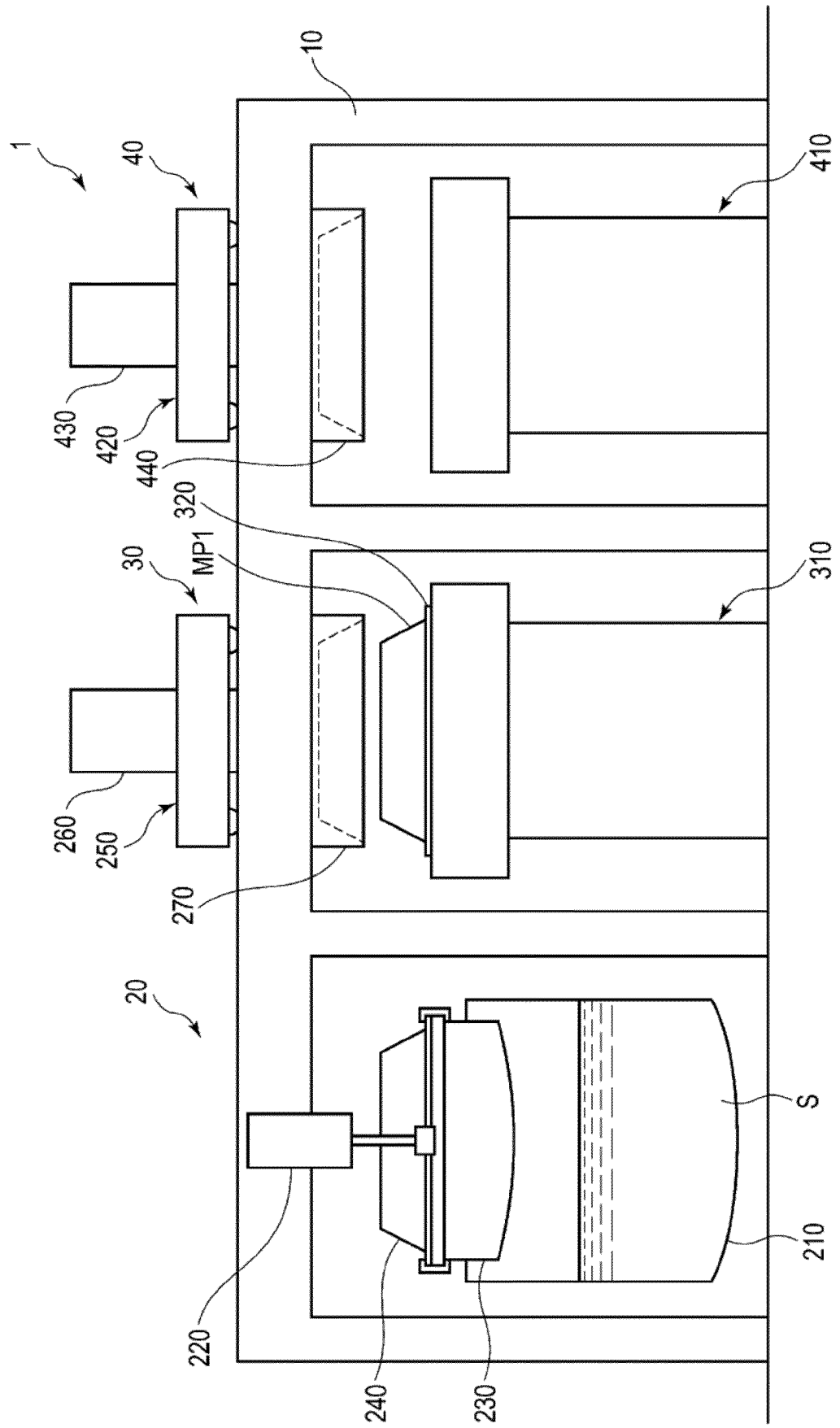


FIG.7

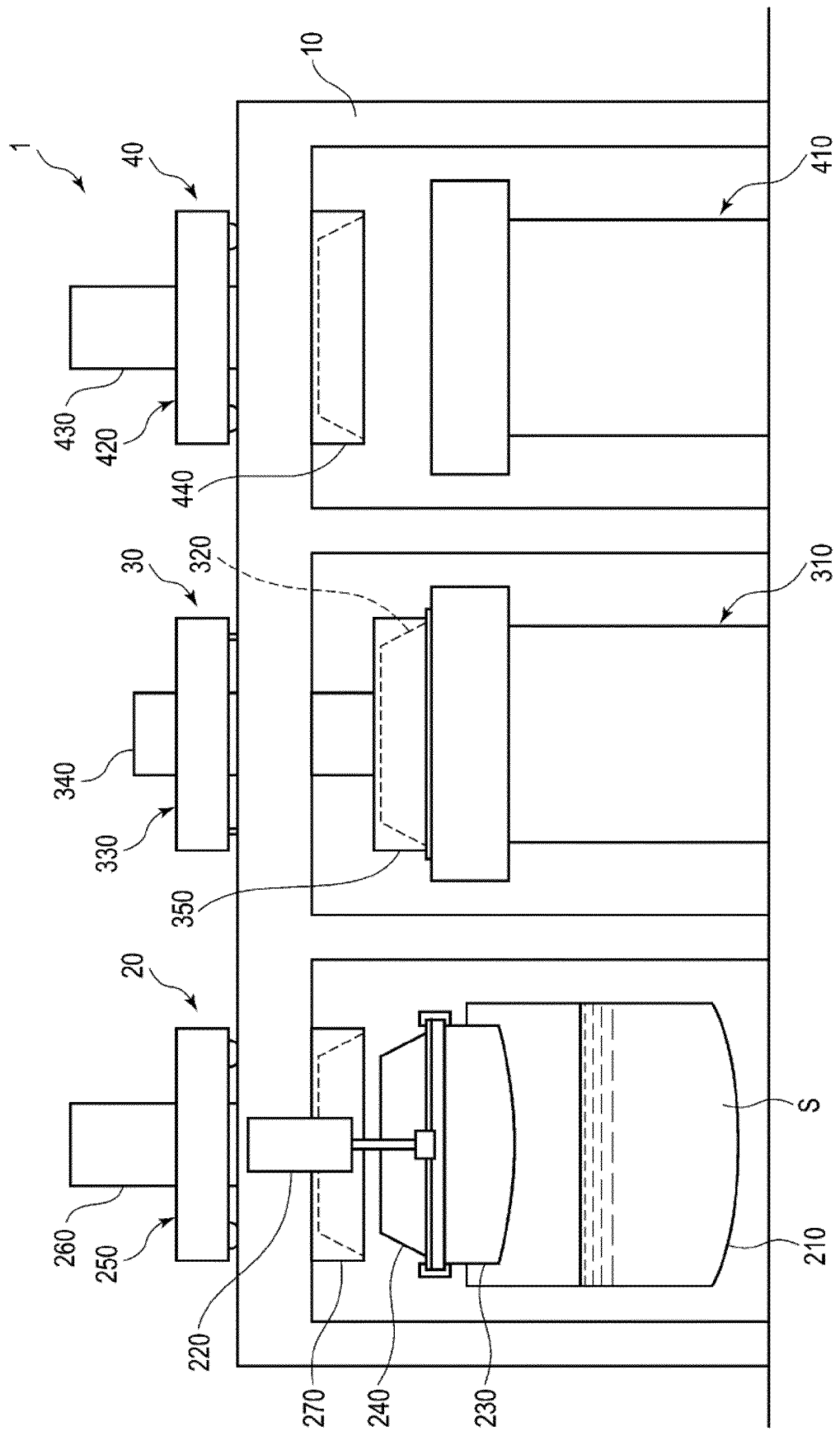


FIG.8

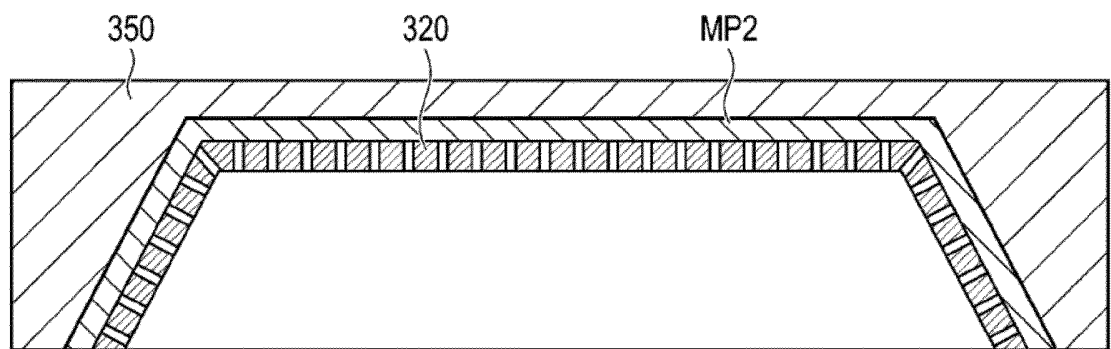


FIG.9

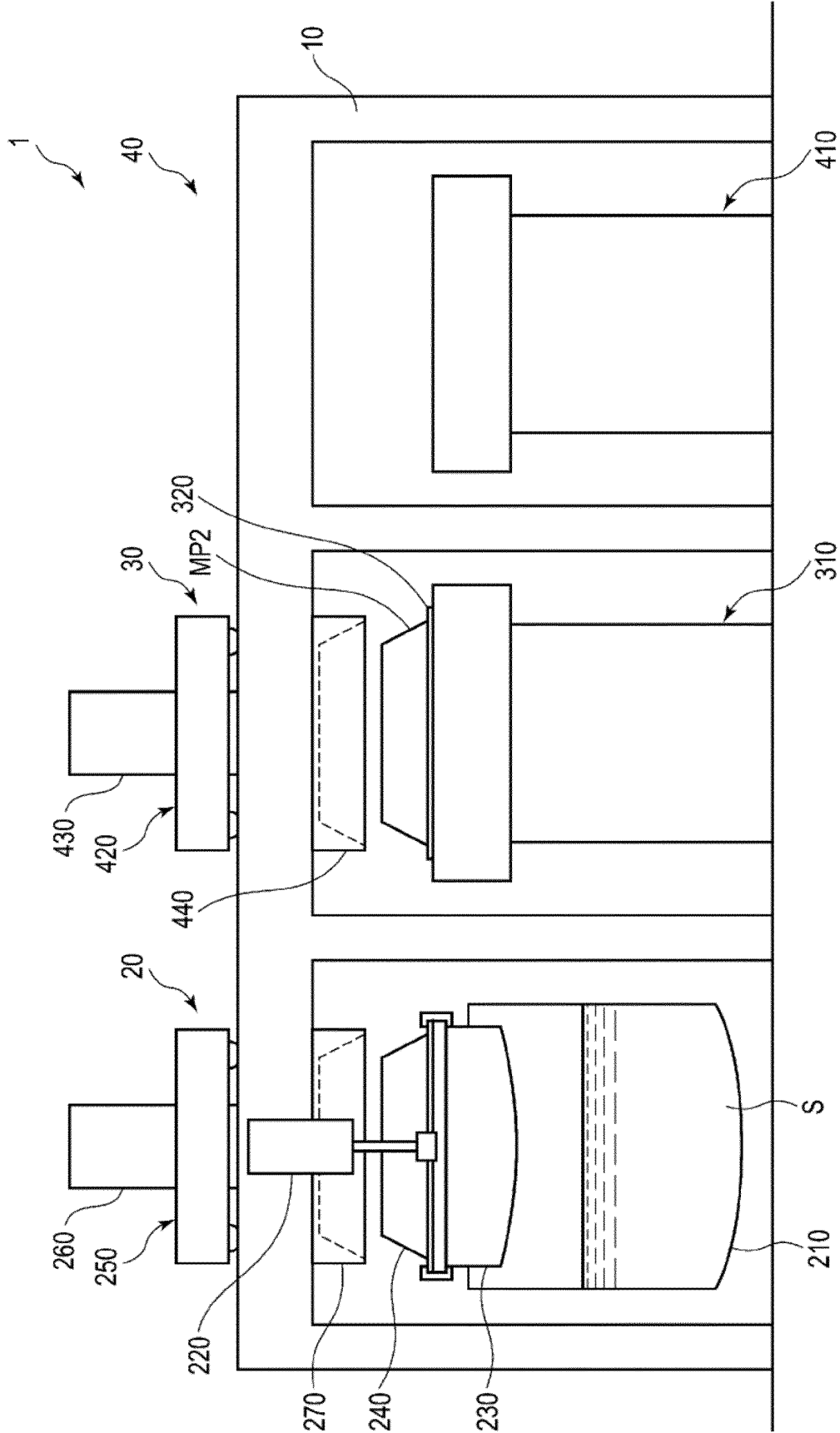
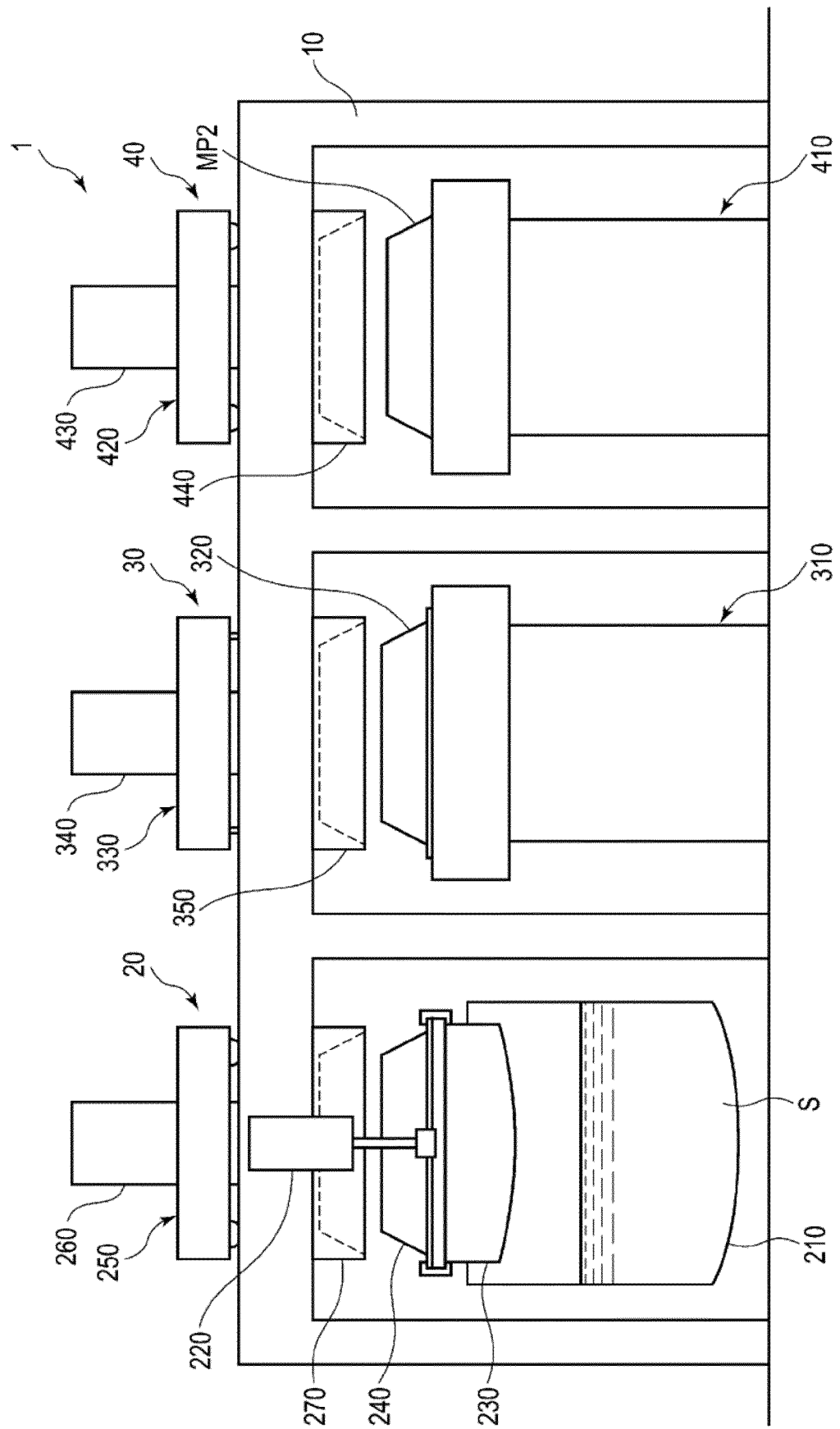


FIG.10



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/029666

A. CLASSIFICATION OF SUBJECT MATTER

D21J 3/00(2006.01)i; **B65D 1/00**(2006.01)i; **B65D 1/34**(2006.01)i

FI: D21J3/00; B65D1/00 110; B65D1/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B65D1/00-1/48, D21B1/00-1/38, D21C1/00-11/14, D21D1/00-99/00, D21F1/00-13/12, D21G1/00-9/00, D21H11/00-27/42, D21J1/00-7/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
 Published unexamined utility model applications of Japan 1971-2022
 Registered utility model specifications of Japan 1996-2022
 Published registered utility model applications of Japan 1994-2022

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

JSTPlus/JMEDPlus/JST7580 (JDreamIII)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2007/0227680 A1 (INDUSTRY-ACADEMIC COOPERATION FOUNDATION GYEONGSANG NATIONAL UNIVERSITY) 04 October 2007 (2007-10-04)	1-11
A	JP 2000-303399 A (KAO CORPORATION) 31 October 2000 (2000-10-31)	1-11
A	JP 11-061700 A (OJI PAPER COMPANY, LIMITED) 05 March 1999 (1999-03-05)	1-11
A	JP 2002-088698 A (KAO CORPORATION) 27 March 2002 (2002-03-27)	1-11
A	JP 2003-129400 A (KAO CORPORATION) 08 May 2003 (2003-05-08)	1-11
A	JP 2004-183162 A (KAO CORPORATION) 02 July 2004 (2004-07-02)	1-11

☐ Further documents are listed in the continuation of Box C.
 ☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

30 September 2022

Date of mailing of the international search report

18 October 2022

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)
 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915
 Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/029666

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

(Invention 1) Claims 1-7

Claims 1-7 have the special technical feature of a "molded pulp article having a proportion of fibers having a length of 1 mm or less in the pulp in the range of 35-50%, wherein the pulp has an average fiber length in the range of 1.2-1.5 mm and a density in the range of 0.65-1.3 g/cm³, and the molded pulp article has a nitrogen content in the range of 400-2,000 µg/g", and thus are classified as invention 1.

(Invention 2) Claims 8-11

Claims 8-11 and claim 1 classified as invention 1 share the technical feature of a "proportion of fibers having a length of 1 mm or less in the pulp in the range of 35-50%". However, this technical feature does not make a contribution over the prior art in light of the content disclosed in document 1, and thus cannot be said to be a special technical feature. Moreover, there are no other same or corresponding special technical features among these inventions.

Furthermore, claims 8-11 are not dependent on claim 1. In addition, claims 8-11 are not substantially identical to or similarly closely related to any of the claims classified as invention 1.

Accordingly, claims 8-11 cannot be classified as invention 1.

Claims 8-11 have the special technical feature of a "method for producing a molded pulp article, comprising preparing a slurry that contains pulp and water and has a proportion of fibers having a length of 1 mm or less in the pulp in the range of 35-50%, depositing the pulp on a papermaking mold having a three-dimensional shape to form a pulp layer, dehydrating the pulp layer to obtain an intermediate article, and heating the intermediate article before drying to a temperature in the range of 150-220°C while sandwiching the intermediate article between a male mold and a female mold and applying pressure in the range of 0.4-4.5 MPa", and thus are classified as invention 2.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/029666

5

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
US	2007/0227680	A1	04 October 2007	KR 10-0710876 B1	
JP	2000-303399	A	31 October 2000	(Family: none)	
JP	11-061700	A	05 March 1999	(Family: none)	
JP	2002-088698	A	27 March 2002	(Family: none)	
JP	2003-129400	A	08 May 2003	(Family: none)	
JP	2004-183162	A	02 July 2004	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2008285188 A [0005]