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Clarahan et al.(10) **Pub. No.: US 2010/0206505 A1**(43) **Pub. Date: Aug. 19, 2010**(54) **METHOD AND APPARATUS FOR DRYING OF
FIBROUS WEBS****Publication Classification**(76) Inventors: **Dan Clarahan**, Greenleaf, WI
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Paul Arnold, Liverdun (FR)(51) **Int. Cl.**
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D21F 5/18 (2006.01)
(52) **U.S. Cl.** **162/207; 162/290**(57) **ABSTRACT**

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A machine and process for production of wet formed fibrous webs, in which the web is formed from a suspension on a fabric and subjected to a final drying process such as a Yankee dryer roll, while further subjecting the Web to an intermediate drying on a high-heat-transfer roll, with or without hood, before the final drying process. The intermediate dryer roll has a solid, gas-impermeable surface, and a localized heat source directly heats the dryer to a higher temperature than in the final drying process.

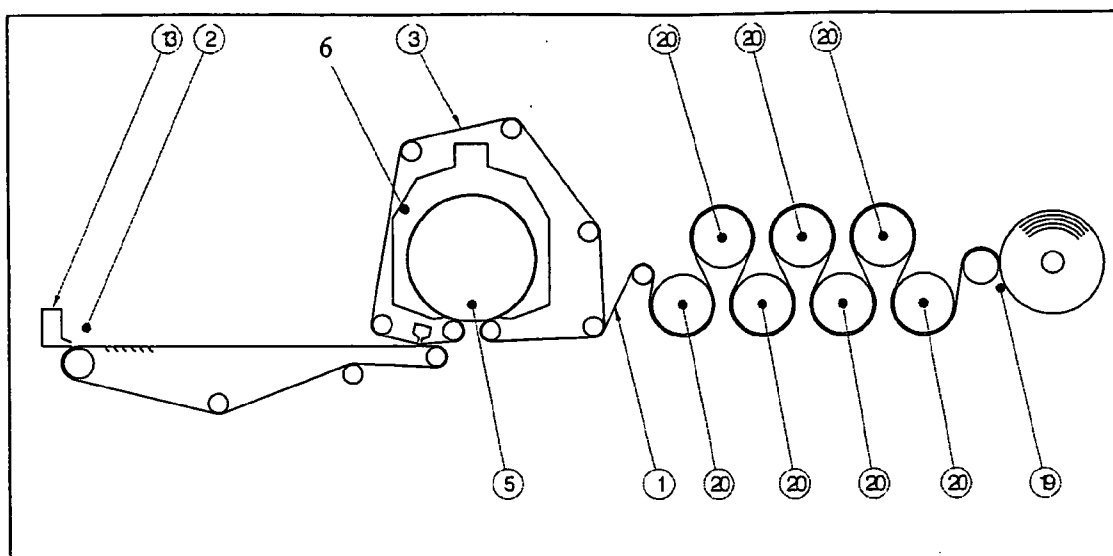
(21) Appl. No.: **12/378,297**(22) Filed: **Feb. 13, 2009**

Fig. 1
Prior Art

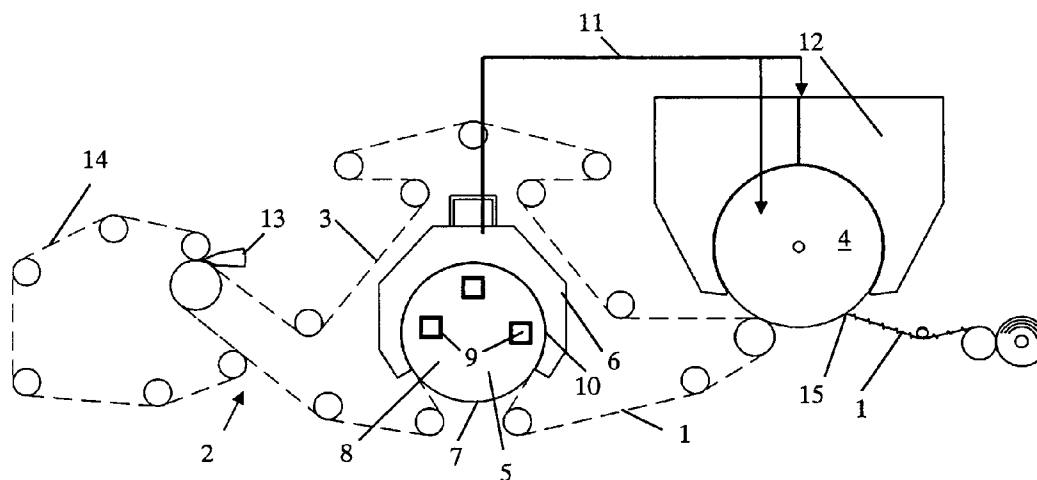
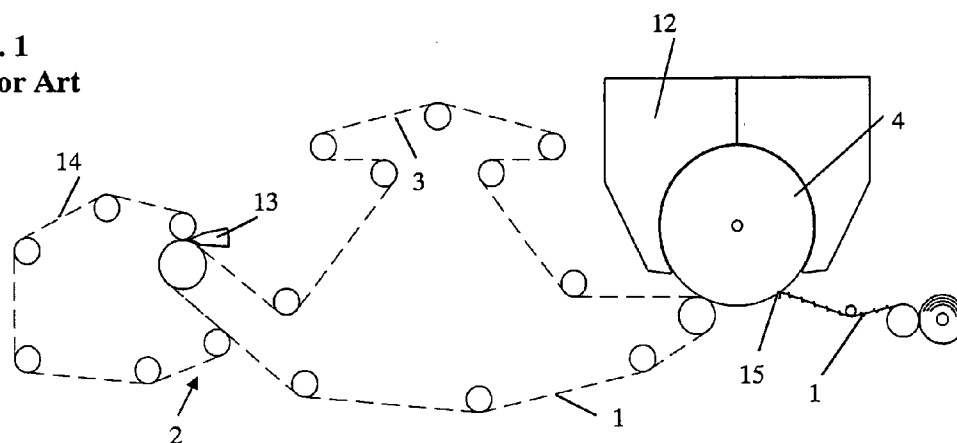


Fig. 2

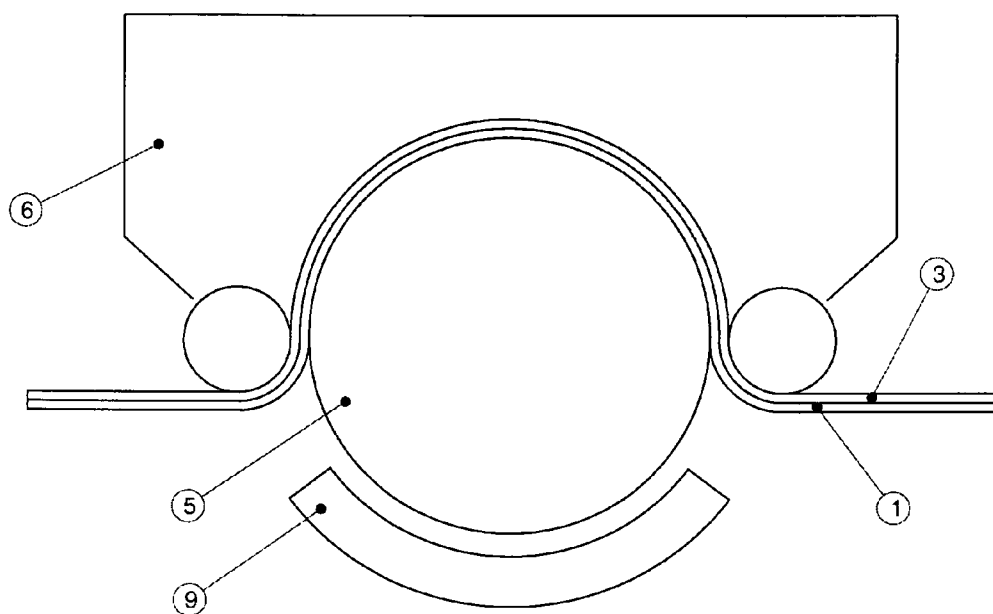


Fig. 3

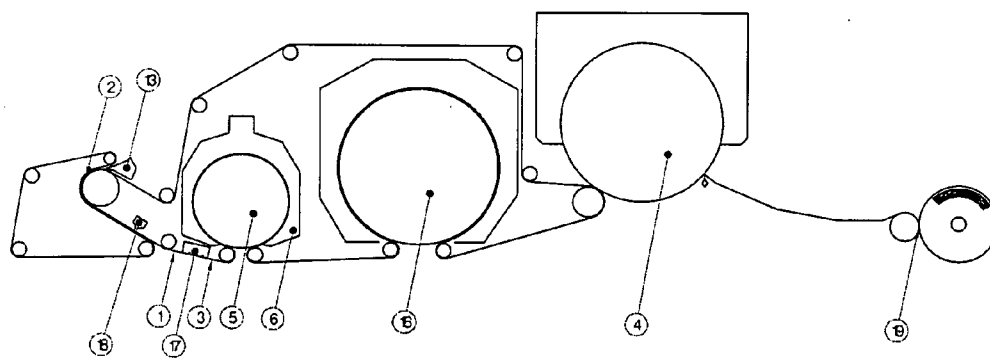


Fig. 4

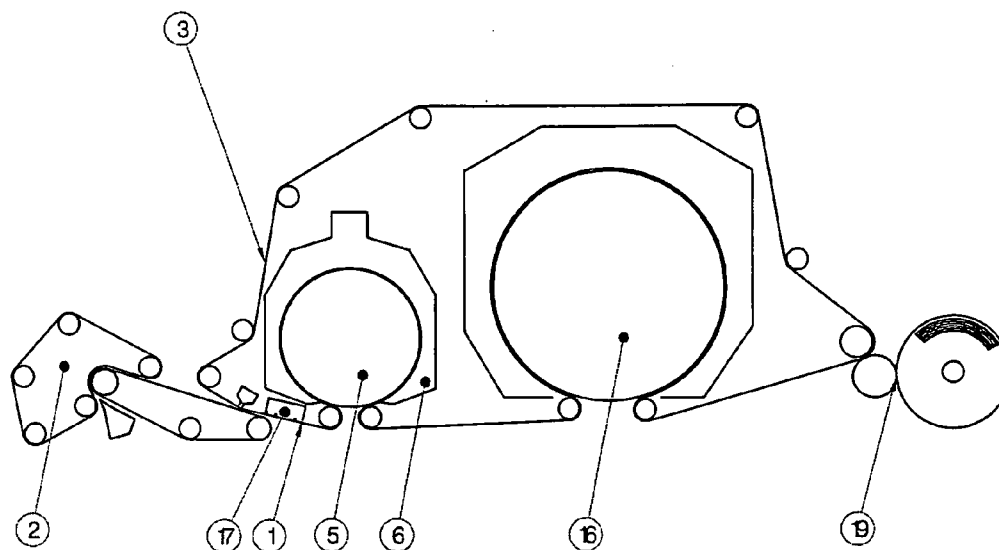


Fig. 5

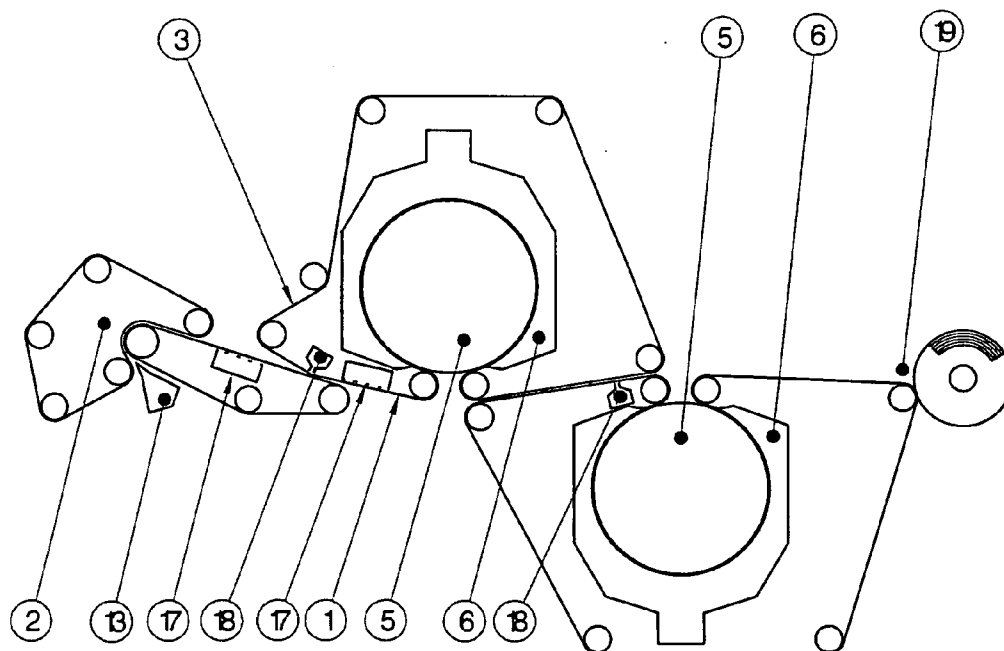


Fig. 6

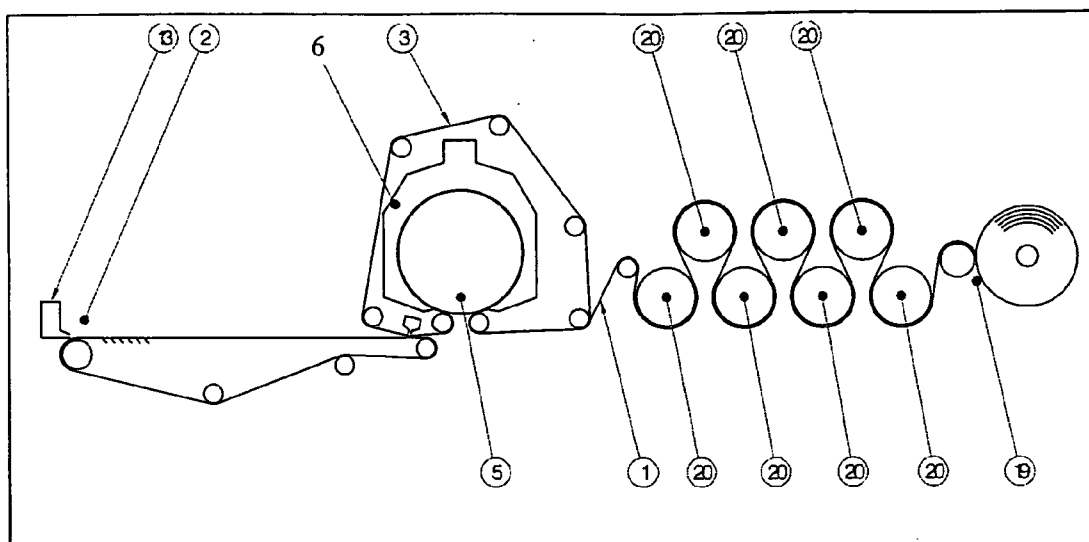


Fig. 7

METHOD AND APPARATUS FOR DRYING OF FIBROUS WEBS

BACKGROUND

[0001] The present invention relates to a method and apparatus for drying of fibrous webs, typically comprised of cellulosic and/or synthetic fibres.

[0002] Fibrous webs form the basis for many products such as paper, tissue paper, filters, covers and wraps. After forming a fibrous web, many methods of drying the web to a final moisture level exist and are well known within the industry. Commonly these drying methods consume large amounts of energy and some embodiments result in compromises in the desired properties in the final web.

[0003] Many methods and apparatus for creating and drying fibrous webs are well known in the industry and have been described in previous patents. Paper products are an example of fibrous webs created by these means. Typically the process begins with forming the fibrous web by placing an aqueous suspension of fibres on an initial forming and dewatering section. Common concentrations of fibres in the suspension range from 0.06% solids to 0.3% solids when entering the section. The forming section typically comprises an apparatus such as a nozzle, orifice or head box to place the suspension on one or more carrier belts, foraminous elements or fabrics, such as described in U.S. Pat. Pub. US20080245498; U.S. Pat. No. 7,118,647; U.S. Pat. No. 7,455,752; U.S. Pat. No. 4,425,394 or U.S. Pat. No. 7,452,446 (hereafter collectively called "fabrics") which pass over or through various rolls, boxes and dewatering elements.

[0004] After the initial forming and dewatering, the fibrous web typically has a concentration of 15% to 40% solids, after which it enters other sections for drying to a final concentration of 92% to 99% solids. The process for final drying may or may not begin with a transfer of the web from fabric to another; the speeds of the fabrics may or may not be matched or run at different speeds and the transfer from one fabric to another may or may not be assisted by vacuum. The combinations of fabrics, speeds and the presence or absence of a transfer assisted or not by vacuum all affect the desired properties in the final fibrous web. One such process for drying paper is described in U.S. Pat. No. 7,459,062 another in U.S. Pat. No. 4,799,318.

[0005] There are several methods for drying the fibrous web which are well known in the industry. These methods include all of the following (either alone or in various combinations; with or without transfer from one fabric to another; with or without means to provide differential densification of the sheet; with or without a vacuum assistance into the drying section, with or without means to use pressure to remove water from the web and with or without means for separating the fibrous web from one or more of the drying elements, such as a creping blade for softening or chemical spray or release agent): a) passing hot air through the fibrous web while running over one or more rotating rolls (known as through-air drying in the industry); b) passing hot air through the fibrous web while it travels in a relatively linear fashion through one or more hood and bed systems (known in the industry as flat-bed drying); c) impinging hot air on one side of the web, with the air typically reflected from the web by a solid surface or steam heated drum on the other side (known in the industry as impingement drying); d) passing the fibrous web beside or between infrared or micro-wave heating devices; e) passing the fibrous web beside or between ultrasonic means of drying;

f) passing the fibrous web over rotating rolls heated by various means such as steam (known in the industry as can drying or roll drying), with or without fabrics; and g) with or without pressurized or vacuum plenums over the web and rotating rolls (known as hoods in the industry). The final dryness of the web typically varies from 92% solids to 99% solids depending on the process and the desired properties of the web.

[0006] After drying the fibrous web is typically wound into large rolls for use in subsequent processing and in some cases the web is directly processed into a final product. As an example, a process of this type and a corresponding device with a sheet formation zone, a press zone, and a drying roll is described in DE 10 2005 054 510 A1. A process of this kind, however, cannot produce a fibrous sheet that has high bulk, high permeability or a structure allowing this.

[0007] A similar process is disclosed in U.S. Pat. Pub. 2005166418A. Here, a further dryer, a "booster dryer", is included before the final drying roll. The fibrous web, a permeable conveying belt, a condensation fabric, and an impermeable pressing belt run round this steam-heated, additional dryer. The water from the fibrous web condenses in the condensation fabric and can be removed from it as soon as the condensation fabric has separated again from the fibrous web, i.e. after the "boost dryer". The disadvantage of this drying arrangement is its very complex design due to the large number of belts. Another difficulty is in cleaning the fabrics. Further there is a limit as to the final sheet moisture that is achieved as the sheet leaves the dryer.

[0008] EP1749934 A1 also discloses an additional drying unit before the final drying roll. Here, the fibrous web undergoes pre-drying by means of a TAD drum operating according to the through-air drying principle. This type of through-air dryer has very high energy consumption. The large diameter of the drum and the room required for the auxiliary ducts, fans, and burners usually precludes the use of a TAD system in an existing fibrous machine to retrofit the process.

SUMMARY

[0009] The present invention is an improved apparatus and method for the production of fibrous webs that is less complex and has a simple, compact design and can produce very high quality products with advantages in permeability, absorption capacity, bulk density and softness. In the case of producing paper or fibrous tissue, the elimination of the mechanical pressing step is particularly advantageous.

[0010] These advances and advantages are achieved with a rotating high-heat-transfer dryer cylinder roll which may or not be used in combination with various process configurations, fabrics, hoods and other drying elements as described above. A heating element, such as a combustion unit or burner to directly heat the roll, is also provided. Heating the dryer with an internal heat source such as a burner holds the advantage that higher surface temperatures can be achieved than when using conventional steam-heated dryers. The surface temperature here can be virtually unlimited; however 400° C. is likely a practical limit for a number of operational considerations. With this manufacturing process fibrous webs can be efficiently dried at basis weights down to 7 g/m² while maintaining desirable physical characteristics of the web. Conventional pressing and drying results in very highly compacted sheets with low bulk-density, and through air drying is extremely inefficient in energy usage at low basis weights.

[0011] To achieve the greatest benefit, the sheet is held down against the dryer surface with a fabric (fabric, felt,

foraminous belt, etc.). One of the phenomena of the invention is that as the fibrous web is dried very quickly, the partial pressure of the water vapor escaping from the web is sufficient to lift the web off of the dryer, interrupting the drying process and creating other operational problems. To overcome that problem a fabric wraps around the dryer overlaying the web, i.e., with the web sandwiched between the fabric and the dryer. The fabric exerts a normal force on the web, holding it against the dryer and is porous to allow water vapor to pass through. The fabric can have a differential topography such that parts of the fabric hold the web against the dryer (pressure areas) and the rest of the web area is in relief (relief areas).

[0012] The highest rate of drying occurs at the pressure area (contact points), with the water in the relief area migrating toward the pressure area (high heat transfer contact points). In one preferred embodiment the distance between the pressure areas is between 0.5 and 1.5 times the depth of the relief area to maximize the rate of water transport through the web to the pressure Area.

[0013] The fabric needs to be either permeable to allow the water vapor through the fabric, or in another embodiment the fabric has a backing layer with sufficient water vapor retention capacity to hold the water and water vapor until the web is separated from the fabric at which time, or in a separate stage, the water and water vapor can be released.

[0014] The efficient and compact design of the invention compared to existing technology also enables subsequent use of the waste energy, making the total fibrous web production process more energy efficient.

[0015] The present invention may be used to dry the web to its final dryness level or it may be used to dry the web to an intermediate level of dryness with the final drying accomplished by one of the methods described above.

[0016] Five commonly used measures to differentiate between various fibrous webs are the strength (X, Y, Z direction or multidimensional measures of tensile strength, corrected or not for fibre mass), the basis weight (mass per unit area), the bulk density (apparent volume displaced per unit mass) of the product, permeability (ability to pass fluids through the web) and differences in apparent density throughout the sheet. For each of these measures there are many standard laboratory methods known and used in the industry. The present invention enables improved drying and manipulation of the bulk density and porosity independent of the other four measures.

[0017] The flexibility of fabric design accommodated with the present Invention also allows for the manipulation of other properties of the web (such as bulk-density, porosity, etc.) to be modified as described in some of the fabric-related patents identified above. In some embodiments the dryer or a plurality of dryers are used to take the web to final dryness. In other embodiments the dryer or a plurality of dryers are incorporated between the web forming process and the final drying process. In all embodiments significant energy reductions is possible relative to existing technologies for drying.

[0018] The total drying surface area required is lower than conventional processes such as steam heated dryers, through-air-dryers and the like because of the advantaged (high) drying rate. A benefit of the smaller drying surface areas is that the equipment involved (rolls, hoods and the like) can be smaller, reduce the capital and operating expenditures and are more likely to accommodate retrofitting of existing machines and processes. A preferred embodiment is a dryer with a diameter between 2 and 3.5 meters.

[0019] Because the invention provides a more energy efficient method of drying fibrous webs, greater control of the bulk density and porosity of the web over a wide range of strengths and basis weights can be achieved. Controlling bulk-density is important for many grades of fibrous webs. Examples include webs used for wiping surfaces or skin; the bulk density relates directly to how much water can be absorbed and the relative softness and flexibility of the web. Another example of webs that will benefit from this invention are grades where web permeability attributes are important, such as dry and wet filter papers, and grades where saturation of various additives is important.

[0020] To maintain the highest possible drying rate the dryer is constructed and operated in a fashion to maintain a uniform and elevated surface temperature. A preferred embodiment is a drum typed dryer of 3 meters diameter for the cylindrical shell, with a shell (wall) thickness of 10-15 mm that is not pressurized with steam but is directly heated by a heating element such as a combustion unit or an electrical element or magnet.

[0021] An extensive laboratory study was completed to evaluate this invention. The goal of the study was the demonstration of the drying capability and to compare different dryer surface temperatures, different web basis weights and moisture levels, different fabric designs and fabric tensions holding the web against the dryer installed in a machine operating at 2,000 meters per minute.

[0022] The testing equipment included a heated platen, a web and a fabric support with an accurate lifting mechanism. The lifting mechanism brought the web and fabric against the heated platen, controlling to a low normal force, which represents the fabric tension holding the web against the dryer. The duration of the contact was established to simulate a 3 meter diameter dryer. For all the tests performed with a surface temperature above 180° C., the TAPPI drying rate was superior to 200 kg/h/m² and many results were above 300 kg/h/m². Extracted from the results, the figure below illustrates the particularly high drying effectiveness of the present solution for very low basis weight such as 10 gsm.

	Test Condition Parameter		
	A	B	C
Basis weight [gsm]	10.6	1.,8	21.4
Dryer surface temperature [° C.]	230	230	231
Contact time [sec]	0.3	0.4	0.4
Start dryness [%]	23.4	25.3	25.6
Finish dryness [%]	64.0	69.7	52.6
TAPPI drying rate [kg/h/m ²]	283	300	322

[0023] For the drying process it is an advantage if the cylinder shell is made of a material with thermal conductivity greater than 25 W/(K*m). Example of such materials are steel, cast iron, copper, aluminium, or alloys containing at least one of these metals or carbon fiber.

[0024] In an advantageous embodiment the burner is a gas burner, particularly a natural gas burner. It is also conceivable,

however, that the burner is an oil burner. The heat can be transferred to the wall by radiation, by convection, by direct contact with combustion products, or by a combination of these methods. Other methods of heating the wall are electrical induction or conduction using a fluid.

[0025] In order to achieve the maximum heat transfer and drying effect, it is expedient to maximize the wrap of the web around the dryer. One preferred embodiment is to have a wrap angle of at least 270° around the dryer shell and most preferably 330° , when in operation. In less preferred embodiments, it is possible to utilize the roll with a wrap as low as 130° , but this does not take full advantage of the improvements.

[0026] A preferred embodiment is to include a hood over the dryer. The hood could be a simple, stationary extractor (canopy) hood, but this dryer presents a unique opportunity. The temperature of the water vapor is elevated sufficiently such that the evaporated water can be collected as steam under a slight hood pressure. Tightly fitting seals and special in running and out running seals will allow the water evaporated from the web (steam) to be collected with very little air entrainment, and in-turn will allow for additional heating by use of the waste heat from the internal burner. This waste energy can be utilized by other steam heated devices, making the entire process more efficient than is typical today.

[0027] The invention can be adapted to virtually any web making process. An example of one preferred embodiment is incorporating the invention into the production of a cellulose tissue web. One common process for the production of tissue is the crescent former in which a tissue web is formed from a pulp suspension on a fabric in a forming section and this tissue web is then finally dried on a Yankee. One embodiment is the incorporation of the dryer before the web reaches the Yankee. The drying process can be incorporated into other types of tissue machines such as suction breast roll formers, Fourdrinier, through dryers and twin wire formers.

[0028] In a preferred embodiment the water vapor generated during drying is collected in a hood as steam. The steam collected in the hood is preferably utilized by other processes, such as heating a dryer hood. The thermal energy contained in the steam from the steam collecting hood can thus be used in further process steps, resulting in an energy saving for the entire process.

[0029] Similarly, the exhaust gas from the burner can be used to pre-heat fresh air for the burner or can be used in a hood or in other processes as vacuum dewatering improvement.

[0030] In a preferred embodiment the entire dewatering process for the fibrous web can be conducted without utilizing mechanical pressure on the web, commonly known as a press section in the industry. Pressures of up to 160 KN/m are common, which create undesirably high web densities for many fibrous Web grades. Omitting the mechanical pressing offers the opportunity of making particularly soft, absorbent and permeable webs with less fiber.

[0031] In a further advantageous embodiment the surface of the dryer can have a non-stick coating. This non-stick coating prevents the fibrous web from sticking to the surface of the dryer. This non-stick effect can be achieved by permanent anti-adhesive coating or by spraying on chemicals, and the dryer will have a doctor to ensure that there is no build up that would impede heat transfer or other operational impediment.

[0032] Some embodiments anticipate using two or more of the high-heat-transfer dryers.

BRIEF DESCRIPTION OF THE DRAWING

[0033] Various embodiments of the invention are described below with reference to the drawing, in which:

[0034] FIG. 1 is a schematic view of a conventional machine for fibrous production;

[0035] FIG. 2 shows a machine for fibrous production according to one embodiment of the invention; and

[0036] FIGS. 3 to 7 show further embodiments of the invention.

DETAILED DESCRIPTION

[0037] FIG. 1 shows as an example a machine for fibrous web production in one embodiment that is state of the art. In the wire section 2, a suitably prepared pulp suspension is fed through a headbox 13 onto a fabric 3 to form a fibrous web 1. The dewatering and forming processes are assisted by a wire 14. The fibrous web 1 is transferred from the fabric 3 to a steam-heated drying roll 4 and dried. Here, the drying process is assisted by hot air that is blown through the drying roll hood 12 onto the fibrous web 1. When it leaves the drying roll the fibrous web is scraped off the drying roll surface 4 using a doctor blade 15 and wound onto a reel.

[0038] The numeric identifiers used in FIGS. 2 to 7 refer to the same machine components as in FIG. 1. FIG. 2 shows a machine for fibrous production according to an aspect of the invention, where an intermediate rotating drum or roll dryer 5 with a hood 6 is arranged before the final drying roll 4. This intermediate dryer 5 has a gas impermeable (gas-tight) cylindrical outer surface 7 and is heated on the inside 8 by the heat source 9. The heat source 9 comprises gas burners, however these can also be substituted by oil burners or other heating systems.

[0039] The cylinder shell 10 of the dryer 5 is made of a material with high thermal conductivity and is surrounded by a hood 6 that can be designed as a steam collecting hood and used to remove the steam generated. This steam is then fed through a steam duct 11 processed to the drying roll 4 heating system or to the drying roll hood 12. The fabric 3 runs round the dryer 5 in such a way that the fibrous web 1 to be dried comes into direct contact with the gas-tight surface 7 of the cylinder shell 10. The fabric 3 is permeable at least for steam.

[0040] During operation, a pulp suspension is fed through a headbox 13 and sprayed over the entire machine width between the wire 14 and the fabric 3. A fibrous web 1 then forms on the fabric 3 and is guided directly over the rotating dryer 5 for drying purposes. The surface temperature of the dryer 5 is between 150°C . and 400°C . Here, the gas-tight surface 7 of the dryer 5 is preferably provided with a non-stick coating that prevents the fibrous web 1 from sticking and a doctor that assures that the heat transfer is not impeded. The steam generated at the dryer 5 by the drying process escapes through the fabric 3 and the sheet into the steam collecting hood 6, from where it can be fed through a steam duct 11 to the drying roll 4 and/or the drying roll hood in order to make use of the waste heat. The exhaust air from the burner can be used to pre-heat the fresh air for the burner.

[0041] After the dryer 5, the fibrous web 1 is transferred to the drying roll 4 and the drying process continues. A doctor blade 15 then scrapes the dried fibrous Web 1 off the drying roll 4. A subsequent winder reels the finished fibrous Web.

[0042] FIG. 3 shows the dryer 5 with an external heat source 9 and a relatively small fabric wrap angle. It can be appreciated that in FIGS. 2 and 3 the heat source is located at the dryer 5 and does not rely on heat transfer from the origin of the heat (e.g., combustion or IR emitter) to an intervening medium such as steam or forced air.

[0043] FIG. 4 shows an embodiment of the invention where a TAD drum 16 is used in addition to the inventive dryer 5. A dewatering vacuum box 17 is illustrated after a pick-up transfer box 18. A reel section 19 is also illustrated.

[0044] FIG. 5 shows another embodiment of the invention where the inventive dryer 5 is used in conjunction with a TAD drum 16 without the uses of another dryer.

[0045] FIG. 6 shows yet another embodiment of the invention where two inventive dryer rolls 5 are used on different fabrics in such a way that the web will be dried consecutively from one side and then from the other side. Some dewatering vacuum boxes 17 are also illustrated before and after the pick-up transfer box 18.

[0046] FIG. 7 shows an embodiment of the invention applied to a flat paper grade process including a Fourdrinier forming unit and several can dryers 20.

[0047] The figures show only some embodiments of the invention. The invention also comprises other embodiments in which, for example, two inventive dryers 5 are used prior to a TAD drum or two inventive dryers 5 are used on the same fabric without any transfers.

[0048] A further embodiment is to utilize the high-heat-transfer dryer to provide thermal curing and treatment for other webs that are not formed with a wet fibrous web process. Examples of this include chemically impregnated non-woven fabrics and drapes.

1. Machine for production of fibrous webs with a forming section in which the web is formed on a fabric, and with at least one rotatable dryer which is located after the forming section, wherein the improvement comprises that the dryer has a solid surface and at least one heat source to heat the dryer, provided on the inside and or outside of the dryer.

2. Machine according to claim 1, wherein the dryer is wrapped by a fabric, felt, foraminous member or other belt which produces pressure on the web to overcome vapor pressure of escaping water vapor and hold the web in continuous contact with the dryer.

3. Machine according to claim 1, wherein the dryer is wrapped by a fabric, felt, foraminous member or other belt which produces 700 to 14,000 Pa pressure on the Web to overcome vapor pressure of escaping water vapor.

4. Machine according to claim 1, wherein the dryer has a steam collecting hood that extracts steam generated by the dryer, while minimizing mixing with ambient air in order to make the steam available for other uses with or without further processing.

5. Machine according to claim 1, wherein the dryer comprises a cylinder having a diameter of 1 to 5 m.

6. Machine according to claim 1 wherein the dryer comprises a solid cylinder shell with a shell wall thickness of 2 to 80 mm.

7. Machine according to claim 6, wherein the cylinder shell is made of a material with thermal conductivity greater than 25 W/(K*m).

8. Machine according to claim 6, wherein the cylinder shell is made of carbon fiber, or a steel, cast iron, copper, or aluminium metal, or alloys containing at least one of said metals.

9. Machine according to claim 1 wherein the heat source is a gas fuel burner.

10. Machine according to claim 1, wherein the heat source is an oil burner.

11. Machine according to claim 1, wherein the surface of the dryer has non-stick coating.

12. Machine according to claim 1, wherein the web has a wrap angle of at least 180 degrees around the dryer.

13. Machine according to claim 1, wherein the web has a wrap angle of at least 270 degrees around the dryer.

14. Machine according to claim 1, wherein the web has a wrap angle in the range of 300 to 330 degrees around the dryer.

15. Process for production of a wet formed web, in which the web is formed from a suspension on a fabric and subjected to a final drying process such as a Yankee dryer roll, wherein the improvement comprises subjecting the web to an intermediate drying on a high-heat-transfer roll, with or without hood, before the final drying process.

16. Process according to claim 15, wherein steam generated during intermediate drying is removed by a steam collecting hood that reduces air contamination.

17. Process according to claim 16, wherein the steam in the steam collecting hood is fed to further processes for energy savings or external energy recovery equipment.

18. Process according to claim 16, wherein the steam generated in the steam hood is used to heat a hood in a downstream dryer.

19. Process according to claim 17, wherein the steam is delivered to a sectionalized profile controlling vacuum box or other vacuum box to improve effectiveness of the box.

20. Process according to claim 16, wherein steam generated in the steam hood is used to heat a dryer cylinder of the final drying process.

21. Process according to claim 15, wherein the exhaust gas of the burner is fed a drying hood of a dryer cylinder of the final drying process.

22. Process according to claim 15, wherein the exhaust gas of the burner is fed to a through air dryer of the final drying process.

23. Process according to claim 15, wherein the exhaust gas from the burner pre-heats fresh air for the burner.

24. Process according to claim 15, wherein after forming, the web is dewatered and dried without mechanical pressing.

25. Process according to claim 15, wherein the intermediate dryer has a surface temperature between 101° C. and 450° C.

26. Process according to claim 15, wherein the intermediate dryer has a surface temperature between about 200 and 220° C.

27. Process according to claim 15, wherein the intermediate drying is carried out with several intermediate dryers, each intermediate dryer having the web held against the respective heated surface by either the forming fabric or another fabric.

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