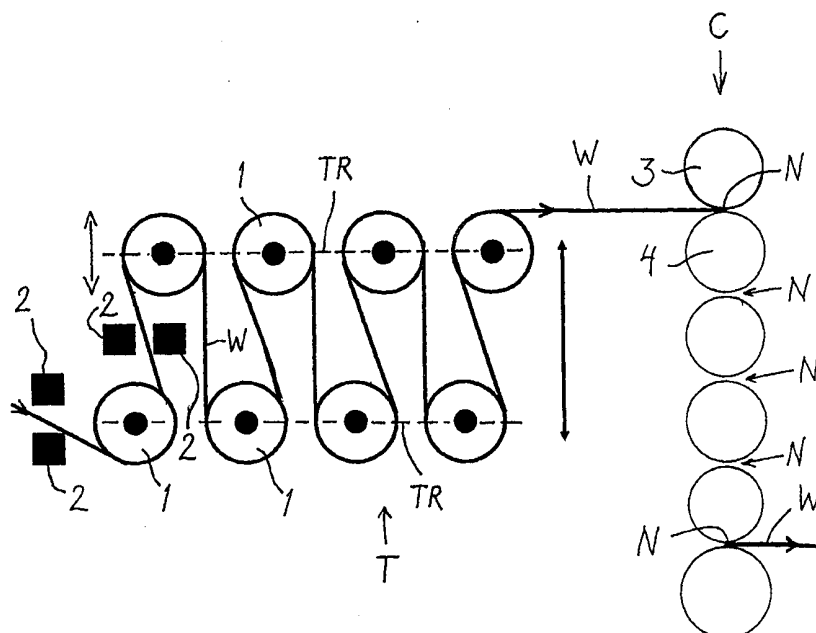




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(54) Title: METHOD AND APPARATUS IN MOISTENING OF A WEB



(57) Abstract

In the method in moistening of a web, water is applied with a wetting device (2) in a predetermined point on the surface of a paper web (W) or the like passing by the point, and the web is thereafter passed to a calender (C). The liquid is applied at such an early stage that before the surface treatment, the fibres exposed to wetting in the paper web (W) or the like have the time to absorb it at least 80 % of the amount of liquid they are capable of absorbing. The distance travelled by the web between the drying section and the calender is increased with rolls (1) which guide the web (W) along a winding path.

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Method and apparatus in moistening of a web

The invention relates to a method in moistening of a web, in which liquid is applied in a predetermined point on the surface of a paper web or the like moving past the point, whereafter the web is guided to surface treatment. In particular, the invention relates to a method in which the surface of a paper web is wetted in a wetting unit in the paper machine before the web is calendered. The invention also relates to an apparatus for implementing the aforementioned method. Hereinbelow, the term paper web refers to all materials in the form of a flexible web made of fibrous material and capable of absorbing liquid.

After the paper has been dried, the surface structure of the web is made suitable by means of a mechanical treatment, calendering. There are several calendering methods, but it is common to all of them that the web is passed through one or several nips which are formed between two surfaces, typically between rotating roll surfaces. The purpose of the calendering is to improve the paper quality by pressing the paper into a fixed final thickness, and especially by smoothing its surface. As is well known, the mouldability of the fibres contained in the paper or paperboard, the "plasticization" of the web in connection with the calendering, can be improved by increasing the temperature and/or moisture. The mouldability of the polymers contained in the paper can be increased by raising the treatment temperature to or above their glass transition temperature. By increasing the moisture content it is, in turn, possible to lower the glass transition temperature. It is often advantageous to restrict the impact of the temperature and moisture only on either surface layer or on both surface layers of the web, wherein the mouldability of their fibres can be improved without excessively affecting the central layer of the web. As a result of this, a known procedure is the wetting of the surfaces of the web before the calendering of the web. Another known procedure is the adding of steam before the nip between the calender rolls, wherein a preheating of the surface is also attained. Calendering processes are presented for example in the European patent 617165.

At present, the manufacture of SC paper requires so-called overdrying of the paper. This means that the paper is dried before calendering into a moisture which is smaller than its moisture of use. Maximally this means that the paper is dried very dry down into a moisture range of
5 1.5 to 2.5.

Overdrying is well founded, because the moisture expansion potential of the paper is reduced when the smallest moisture content which it experiences during the papermaking is reduced. Small moisture
10 expansion potential improves the printability of the product. Furthermore, at present, overdrying and re-wetting produce better profiles in view of calendering when compared to drying of the paper directly to the target inlet moisture of the calendering.

15 Particularly in the manufacturing processes of SC paper the paper has to be wetted to attain the correct target moisture. In Off-line processes the wetting and the location in which it is conducted are not very crucial, because the moisture profiles, tensions and other corresponding variables of the paper have the time to be sufficiently equalized in the
20 reel field before supercalendering. In on-line processes, in turn, it is important to reach the correct moisture of the paper before calendering.

The problem in the wetting of a web in the form of a continuous strip is that it is difficult to set the water content absolutely accurately to attain
25 the desired moisture gradient in the thickness direction of the web. There is a risk that the moisture gradient is set too low, and the flattening effect of the calendering is unnecessarily directed to the central layer of the web instead of being directed in a most appropriate manner to the surface fibres of the web. However, in view of the final
30 quality of the paper or paperboard, it is important that the calendering is successful. Thus, a correct dosage of water is the basic condition for a successful surface treatment.

To attain a sufficiently steep moisture gradient, it is possible to use
35 arrangements known as such which relate to the structure and/or placement of wetting devices, but despite these arrangements the moisture gradient can be disadvantageous when the web enters the

calender. Thus, the problems relate to the build-up of a correct moisture gradient as a result of the absorption of water taking place after the wetting devices. It is possible that after the wetting the absorption of water in the web before the calender is insufficient, or too much water is absorbed in the web. Similarly, it is a problem that with water the desired effect is not attained in the calendaring. This may result in that the web remains unevenly wetted, the central layer of the web is unnecessarily wetted, or the fibres will be insufficiently moulded in the nip.

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A known manner is to arrange the wetting devices in connection with the calender very close to the calender nip, as is presented e.g. in the European patent 617165 and in the US patent 4,945,654.

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It is a purpose of the invention to reduce the aforementioned problems and to introduce a method by means of which the intended wetting can be achieved. To attain this purpose, the method according to the invention is primarily characterized in that liquid is applied at such an early stage that the fibres exposed to wetting in the paper web or the like have time to absorb the liquid at least 80% of the total amount of liquid they are capable of absorbing before the surface is treated. The web is guided to surface treatment in the moisture content obtained by adding the liquid.

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The period of time during which the wetting is effective after the wetting can be influenced especially by adjusting the distance travelled by the web from the wetting point, which can be implemented e.g. by changing the respective location of the rolls in the roll system guiding the web in such a way that the overall length of the path of the web in the roll system is changed.

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The invention is based on the observation that in the end, only an optimal influence time of the wetting on the web when it travels from the wetting devices to the calender, is capable of ensuring the intended moisture effect. The web is wetted into the target moisture, and it is guided in this moisture into the calender nip.

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Other features characteristic to the method according to the invention appear in the appended dependent claims, which present additional adjustment manners and possibilities to influence the uniformity of the wetting.

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The apparatus according to the invention comprises a device for adding liquid, which is placed at such a distance from the device conducting surface treatment, taking into account the speed of the web, that the liquid added to the web will have time to be absorbed in the fibres exposed to wetting in the web at least 80% of the total amount of liquid which the fibres are capable of absorbing.

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In the following, the invention will be described in more detail with reference to the appended drawings, in which

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Fig. 1 shows the principle of the method according to the invention, and at the same time the apparatus according to the invention in a side view,

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Figs. 2 to 5 illustrate the absorption of water and the effect of the water amount,

Fig. 6 illustrates the dosage of water and its adjustment principle to attain an even two-dimensional application, and

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Fig. 7 shows an advantageous manner to attain an even application two-dimensionally with respect to the plane of the web.

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Fig. 1 shows schematically a paper or paperboard web W coming from a drying section in a paper or paperboard machine, which web W is passed via a wetting unit to a calender C. The wetting unit comprises at least one wetting device 2, by means of which one surface of the web W is moistened in a way known as such, and which wetting device 2 can function in any one of the following principles:

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- spray wetting,

of water to the fibre, as well as of a transfer induced by osmotic pressure, in other words the swelling of the fibres should be at least 80%.

5 In practice, the sufficient absorption of water into the fibres takes approximately 0.3 s, at the shortest. Fig. 2 shows the water sorption times of single fibres measured in laboratory conditions. For single fibres the relevant water amount in view of calendering would be approximately 80% of the maximum, i.e. the corresponding absorption
10 time would thus be approximately 200 ms. In practice, the fibres are not disposed individually, but they are tightly connected together in the network structure of the paper, and the network structure of the paper as well as the application conditions of the water decelerate the absorption of water in such a way that the presumable minimum time is
15 the aforementioned 0.3 s. In some advantageous conditions, the minimum time can be 0.2 s, including a small safety margin.

The optimal application time naturally depends on the fibrous material and the surface chemistry of the paper, as well as on the network
20 structure. As a result of the transition from chemical pulps towards mechanical pulp the necessary absorption time is increased. Therefore it is advantageous to apply the water 0.2 to 2 s, advantageously 0.3 to 2 s before the nip, depending on the paper grade. The most advantageous absorption time of most processes is 0.5 to 1.0 s. For
25 example in the manufacturing process of paperboard, the running speeds can be 600 m/min. Thus, it is advantageous to place the wetting device in a distance of 2 to 10 m from the first calender nip (corresponding the time of 0.2 to 1.0 s). In a typical manufacturing process of SC paper the running speed can be 1500 m/min. Thus, it is
30 advantageous to place the wetting device 5 to 25 m before the first calender nip (corresponding the time of 0.2 to 1.0 s).

On the other hand, water breaks the bonds between the fibres in the paper, relaxes the tensions developed during the drying in the paper,
35 and generates hydroexpansion of paper, which reduces the effect of streaks (variable moisture cross profile) resulting from the drying section and equalizes the cross profile of the paper. For example in SC

papers, to implement the aforementioned processes the optimum result of the wetting is to be expected within the period of 500 to 1500 ms, advantageously 600 to 1300 ms, which at the running speed of 1500m/min corresponds to the distance of 12.5 to 37.5 m and 15 to 5 32.5 m, respectively.

In machines utilizing high running speeds it is thus basically advantageous to place the wetting device as far as possible before the calender. The upper limit of the placement distance of the wetting 10 device is determined on the basis of the structure of the paper machine and/or the moisture retention. If the wetting device is placed too far before the first calender nip, it is possible that re-drying takes place in the web. This takes place especially if the wetting device is inside the drying section e.g. before the last dryer group. An advantageous 15 location point in all paper or paperboard machines and especially in SC paper machines, is at the most 40 m, advantageously at the most 35 m before the first calender nip of the calender, and advantageously after the drying section. In high-speed machines the long placement distance required by the speed and measured along the travel path of the web 20 can be implemented, irrespective of the straight fixed distance of the drying section and the calender in the machine direction, with an arrangement which will be described hereinbelow.

Sufficient absorption time ensures that the polymers contained in the 25 fibrous material of the paper are plasticized by the effect of water. This, in turn, improves the calendering result considerably. Figs. 3 and 4 show the development of PPS as a function of the absorption time with different added quantities, wherein Fig. 3 shows the results on the upper side of unsprayed SC paper and Fig. 4 the results on the lower 30 side of sprayed SC paper. In the drawings, the water amount "-1" denotes an increase of 1 g/m², "0" an increase of 1.8 g/m² and "1" an increase of 2.8 g/m². Fig. 5 shows the development of density as a function of the absorption time, and it also describes the experiment conditions of Figs. 3 and 4.

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In conventional solutions there is not enough time for the water to be sufficiently absorbed. Thus, the effect of the water is primarily based on

its bond-breaking effect between the fibres, wherein the surface layer of the paper is slackened and its mouldability is improved as a result of this. The method according to the invention utilizes both positive effects of the water, thus enhancing the calendering considerably. Thus, the
5 applied water amount is larger than the amount which would be necessary for wetting the fibres with the actual adsorption, i.e. there is also free water between the fibres in the surface layer of the web.

Long influence time is advantageous also in view of the result of
10 applying the liquid. If the liquid is applied on the surface of the web W by spraying in droplets, the film in question is discontinuous even in best spraying processes. To avoid drop marks, the liquid is given time to spread in the direction of the plane of the web. Thus, it is possible to avoid small-scale gloss variations of the paper resulting from the
15 uneven liquid film.

In the following, an advantageous manner of passing the web on the portion between the drying section and the calender will be described.

20 Since the distance travelled by the web from the wetting point to the calender is relatively long in high-speed machines to ensure a sufficient absorption time, it is advantageous to arrange the web W to travel along a winding or meandering path by guiding it between upper rolls 1 and lower rolls 1 in a roll system T arranged between the drying section
25 and the calender. Thus, the distance can be increased irrespective of the horizontal distances available in the paper machine. The rolls 2 are located after the wetting device 2. As shown in Fig.1, between two successive wetting devices 2 which wet the same side of the web there is a roll 1 by means of which the distance of the devices from each
30 other can be increased.

The distance between the wetting device 2 and the nip N can also be affected by changing the mutual location of the rolls 1 in the roll system T in such a way that the overall length of the path of the web W in the
35 portion of the roll system T is changed. To implement this, the location of at least one roll 1 in the roll system T is changed, i.e. the distance between two successive rolls 1 is changed, wherein the overall length

of the path between the first and the last roll 1 of the roll system T is changed. To change the distance, the roll 1 can be moved in the longitudinal direction of the wetting unit and/or in its height direction, but it is obvious that in view of the space economy required by the paper machine, the transfer of the roll 1 substantially in the height direction is the most advantageous embodiment.

Similarly, by moving the roll 1 between the wetting devices 2, it is possible to change the distance between the wetting devices 2 without moving them.

With regard to implementing the purpose of the invention, it is advantageous that instead of the possibility of moving one roll 1, several rolls 1 are arranged movable in the roll system T simultaneously or at different times. Thus, it is typical for the wetting unit that the rolls 1 are arranged to form special roll rows TR (preferably two on top of each other, as shown in the drawing), which is advantageous in view of the space economy of the paper or paperboard machine. Thus, an advantageous embodiment of the invention is such where an entire roll row TR is arranged to be moved especially substantially in the height direction in relation to the second roll line TR or other roll row TR.

To move the rolls 1 and/or roll rows TR it is possible to use force device arrangements, power transmission arrangements, control automation arrangements or corresponding arrangements known as such in connection with the papermachine technology. Especially for the transfer of an entire roll row TR, necessary support structure, coupling and other corresponding arrangements for simultaneous motion of the rolls are provided, which arrangements are based on prior art. It is obvious that by means of said arrangements it is possible to implement an embodiment in which either one or more rolls 1 can be moved separately in addition to moving the entire roll row TR.

The aforementioned facts also apply in the special case where the wetting unit is provided with only one roll 1, wherein the shortest overall length of the path of the web W is substantially formed of the straight

line between the wetting device 2 and the calender C, and the total length can be increased by turning the path of the web W with the roll 1. When the aforementioned distances of several metres are taken into account, a more advantageous solution entails at least two rolls 1 or the like which increase the travel path of the web. A multiple-roll structure with at least three rolls 1 or the like between the wetting device 2 and the calender C, is the most advantageous one.

It is possible to think that the rolls 1 are replaced with any other means which guide the travel of the web, and which can be moved to alter the length of the travel path of the web.

After the wetting unit the web W travels to a calender C whose two first rolls are illustrated in the drawing by rolls 3 and 4, forming a calender nip N therebetween through which the web W is passed. The nip in question can be the only nip of the calender C, or as shown in Fig. 1, it is the first nip in a multi-roll calender in which there are several successive calender nips N in the travel direction of the web W. In the nip N the heated roll is naturally on that side on which the web has been subjected to wetting. If the wetting has been conducted on both sides, both roll surfaces can be heated.

The method and the apparatus are used especially in connection with a machine calender functioning as a direct extension for the papermaking process, but it is also possible to use them when a paper web from an intermediate storage is calendered at a separate working stage, wherein the unwound paper is subjected to wetting before it is passed to the first calender nip.

By means of a sufficiently long residence time after adding liquid it is possible to improve the uniform absorption of water in the direction of the plane of the paper web as well. In the following, some ways of improving the adding of liquid with the wetting devices 2 especially in the direction of the plane of the web W will be described.

As was stated above, it has proved to be considerably difficult to apply a sufficiently even water film for the purpose of calendering on the

surface of the paper by means of a spray jet. In present configurations, the uneven quality of the film manifests itself in an uneven calendering result and surface damages, such as drop markings. With a sufficiently long absorption time these problems can be reduced. In the following, another way of improving the applying result especially when using spraying in droplets, will be described.

The basic requirement for producing an even water film includes well-functioning spray nozzles with a known function. It is difficult to find such nozzles because in present applications the accuracy requirements are insignificant, the manufacturing tolerances of the nozzles are too high in most cases, and it is very difficult to estimate and measure the function of the nozzles (droplet size distributions, coverage in the paper, the moisture transferred to the paper as well as the uniformity of the moisture).

By using the present basic nozzles as wetting devices 2, it is possible to attain an even water film in the wetting. The method is based on the knowledge of the water sorption capacity of the paper. Certain paper grade is capable of bonding and absorbing a particular water amount on a fixed surface area in a given time unit. Fig. 6 shows schematically the principle in the spray wetting effected from underneath the web W.

If the water amount is statistically sufficiently larger than the aforementioned water sorption capacity, it is possible to adjust the water amount by regulating the length of the jet in the machine direction of the web, and thus an even water film is attained despite the small irregularities of the jet. The water amount denotes the amount of liquid per surface area unit applied from the wetting device during one time unit. The amount must be considerably larger so that the loss of water bouncing from the surface would be taken into account.

Fig. 6 shows a spray beam 2a issued from a spray nozzle functioning as a wetting device. In the drawing, the designations in the longitudinal direction of the web can also be treated as surface areas, since the phenomena prevail on the entire width of a standard width web W.

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The contact time t_c is d/V_w , in which d is the length of the spray beam 2a on the surface of the web and V_w is the speed of the web W . The water amount V_{app} , the unit e.g. $g/(m^2 \times s)$, sprayed on the surface area A_1 covered by the jet, is dependent on the length d of the beam, and on the spraying velocity of the nozzle. On the other hand, the web W has a paper-grade-specific water sorption capacity V_{sorp} , which indicates the capability of the surface to absorb the water amount per surface area and time unit, the unit also $g/(m^2 \times s)$. A water amount larger than the water sorption capacity is sprayed, i.e. $V_{app} > V_{sorp}$. In practice this also means that the absorption or imbibition time t_i is longer than the contact time t_c , i.e. after the beam 2a, there is an even liquid film on the surface of the web W . When this is combined with a long influence time before the calender, a very uniform wetting is attained.

By arranging the distance of the nozzle from the web W adjustable, it is possible to alter the length d (surface area) of the beam 2a e.g. into a surface area A_2 , wherein V_{app} is also changed while the flow rate (g/s) of the nozzles remains constant.

V_{sorp} is dependent on several factors, such as the composition of the paper and the application conditions (air flows, linear velocity of the jet, spraying angle). This can be determined for paper grades in accordance with the conditions.

It is advantageous to add an amount of liquid which effects the swelling of fibres into the web W at least in two successive points, wherein it is possible to apply smaller quantities at a time. Thanks to this, the water can be directed to the surface layer that is important in view of the calendering result, which is significant e.g. when producing SC paper grades. Even though a good effect is obtained with one addition, addition in portions in two or more successive points is advantageous especially with increasing smoothness and/or hydrophobicity of the paper or if the form of the moisture gradient is important.

The absorption of water in successive portions into the web can be arranged in such a way that in the first adding point most of the added

water has been absorbed in the web, while part of it remains as a surface water in the roughness volume of the paper or paperboard when the next portion is added. Thereafter it is possible to add a third portion at a stage where most of the surface water + the water added at
5 the preceding stage has again been absorbed in the web.

The act of applying a water film or other liquid applied by spraying evenly on the surface of a moving web may thus require the use of several successive water jets. When the web is moving at a high speed,
10 the water jets must have a considerably high speed so that they can be brought in contact with the web. Spraying experiments have revealed turbulence phenomena on the surface of the web, which are due to uncontrolled flows of air. In Fig. 7a these turbulence zones are marked with the letter Z.

15 In the turbulence zone the mixture of air and water bouncing from the surface of the web migrates against the surface of the web and causes so-called "wind" marks on the surface of the web, i.e. quantitative fluctuation occurring at intervals of 5 to 10 cm, which impairs e.g. the
20 calendering result.

In Fig. 7b, control elements 5 are arranged between the jets 2a or on both or on one side of a single jet, depending on the spraying angle. By means of the elements the mixture of air and water bouncing from the
25 surface of the web is directed in such a way that it does not interfere with the preceding water jet and end up on the surface of the web again, wherein the extremely harmful wind marks are eliminated. Thus, the elements also improve the controllability of the entire system. The control elements 5 can be for example walls directed towards the
30 surface of the web W, which walls come sufficiently close to the surface of the web so that the mixture of air and water which is located close to the surface of the web collides with them. Fig. 7b illustrates spray-wetting underneath the web, in which water can run downwards along the surfaces of the elements 5. The method can also be applied from
35 other directions, e.g. for wetting effected from above, in which the elements can have such a structure that they do not spill water back to the web, i.e. they can be for example water absorbent.

The invention is not restricted solely to the above-presented description and drawings, but it can vary according to the appended drawings. Even though the preceding description is focused on the spray-wetting, the advantageous effects of the invention in the finishing of paper or paperboard web can also be attained with other wetting methods.

In particular, the invention can be applied for on-line papermaking in which the paper is dried after the formation down to a final moisture area of 2 to 6%, and the target moisture in re-wetting is 8 to 11%.

The liquid to be applied is typically water, wherein it can be water as such or contain other substances as solutes.

The treatment of the surface of the web conducted after the wetting is, in turn, of such a type that the wetting of the surface is useful. It is for example mechanical moulding, possibly with a thermal treatment connected thereto. Calendering provides a practical example of such a treatment.

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Claims:

1. Method in moistening of a web, in which liquid is applied at a predetermined point on the surface of a paper web (W) or the like passing by the point, and the web is passed thereafter to surface treatment, **characterized** in that the liquid is applied at such an early stage that before the surface treatment the fibres exposed to wetting in the paper web (W) or the like have the time to absorb it at least 80% of the liquid amount they are capable of absorbing.
2. Method according to claim 1, **characterized** in that the liquid is applied at least 0.2 s, advantageously at least 0.3 s before the surface treatment.
3. Method according to claim 2, **characterized** in that the liquid is applied 0.2 to 2 s, advantageously 0.3 to 2 s before the surface treatment.
4. Method according to claim 3, **characterized** in that the liquid is applied 0.5 to 1.5 s before the surface treatment.
5. Method according to any of the foregoing claims, **characterized** in that the liquid is applied in a spray wetting.
6. Method according to any of the foregoing claims, **characterized** in that the web (W) is passed between the point of adding liquid and the surface treatment via members (1) guiding the web along a winding path.
7. Method according to any of the foregoing claims, **characterized** in that the absorption time of the liquid into the web (W) is adjusted by changing the overall length of the path of the web (W) between the point of adding liquid and the surface treatment by changing the location of at least one member (1) guiding the web in a web guiding system (T).

8. Method according to claim 7, **characterized** in that the absorption time of the liquid into the web (W) is adjusted by changing the location of at least one member (1) in the height direction.

5 9. Method according to claim 7 or 8, **characterized** in that the absorption time of the liquid into the web (W) is adjusted by changing the location of at least one member row (TR) in the system (T), wherein the member row (TR) contains two or more successive members (1) between which the web is guided via a member excluded from the
10 member row (TR).

10. Method according to claim 9, **characterized** in that the absorption of water into the web (W) is adjusted by changing the location of the member row (TR) in the system (T) in the height direction.

15 11. Method according to any of the foregoing claims, **characterized** in that in the adding point, a liquid amount (V_{app}) which is larger than the sorption capacity (V_{sorp}) of the paper web (W) is applied.

20 12. Method according to claim 11, **characterized** in that the liquid is applied in spray wetting and the amount (V_{app}) is adjusted by adjusting the length (d) of the jet in the travel direction of the paper web (W).

25 13. Method according to claim 12, **characterized** in that the length (d) of the jet is adjusted by adjusting the distance of the corresponding nozzle from the paper web (W).

30 14. Method according to any of the foregoing claims, **characterized** in that the liquid absorbed by the fibres is applied on the same side of the web in two or more portions.

35 15. Method according to claim 14, **characterized** in that the liquid is applied in two or more successive spray wettings at least on one side of the web (W).

16. Method according to any of the foregoing claims, **characterized** in that liquid is applied in spray wetting and air flows are controlled with a

control element (5) arranged at least on one side of the jet (2a) in the travel direction of the web.

5 17. Method according to claim 15 or 16, **characterized** in that the air flows are controlled between two successive jets (2a) by means of the control element (5).

10 18. Method according to any of the claims 11 to 17, **characterized** in that the liquid is applied as a spray wetting underneath the web (W).

19. Method according to any of the foregoing claims, **characterized** in that the wetting is effected in the manufacture of SC paper, wherein the paper web (W) is wetted before calendering.

15 20. Method according to any of the foregoing claims, **characterized** in that in the manufacture of paper or paperboard the wetting is effected after the drying section.

20 21. Apparatus in moistening of a web (W), which comprises at least one device (2) for adding liquid, located in the travel direction of the paper web (W) or the like before a member (3, 4) effecting the treatment of the surface of the web (W) for wetting of the web (W), **characterized** in that the device (2) is arranged at such a distance from the member (3, 4) effecting the surface treatment, taking into account
25 the running speed of the paper web (W) or the like, that the liquid added with two or more devices (2) into the web (W) has the time to be absorbed in the fibres exposed to wetting in the web (W) at least 80% of the total amount of the liquid the fibres are capable of absorbing, before reaching the member (3, 4) effecting the surface treatment of
30 the web.

22. Apparatus according to claim 21, **characterized** in that the device (2) for adding liquid is located at the most 40, preferably at the most 35
35 m before the member (3, 4) effecting the surface treatment, when measured along the path travelled by the web (W).

23. Apparatus according to claim 22, **characterized** in that the device (2) for adding liquid is located 2 to 10 m before the member (3, 4) effecting the surface treatment of the web.
- 5 24. Apparatus according to claim 22, **characterized** in that the device (2) for adding liquid is located 5 to 25 m before the member (3, 4) effecting the surface treatment of the web.
- 10 25. Apparatus according to any of the foregoing claims 21 to 24, **characterized** in that there are members (1) such as rolls between the device (2) for adding liquid and the member (3, 4) effecting the surface treatment of the web, which members (1) are arranged to guide the web (W) along a winding path.
- 15 26. Apparatus according to claim 25, **characterized** in that it comprises:
- a roll system (T) for passing the web (W) between the device (2) for adding liquid and the member (3, 4) effecting the surface treatment, wherein the roll system (T) is advantageously composed of at least two rolls (1) preferably, however, of several rolls (1) arranged in one or more roll rows (TR) and
 - wherein the location of at least one roll (1) of the roll system (T) in the roll system (T) is arranged to be changeable in the height and/or longitudinal direction of the roll system (T) to change the overall length of the path of the web (W) within the portion of the roll system (T).
- 20
- 25
- 30 27. Apparatus according to claim 26, **characterized** in that the location of at least one roll row (TR) is arranged changeable in the height direction.
- 35 28. Apparatus according to any of the foregoing claims, **characterized** in that the device (2) for adding liquid is located after the drying section of a paper or paperboard machine.

29. Apparatus according to any of the foregoing claims, **characterized** in that the member (3, 4) effecting the surface treatment is a calender, advantageously a calender with over four nips.

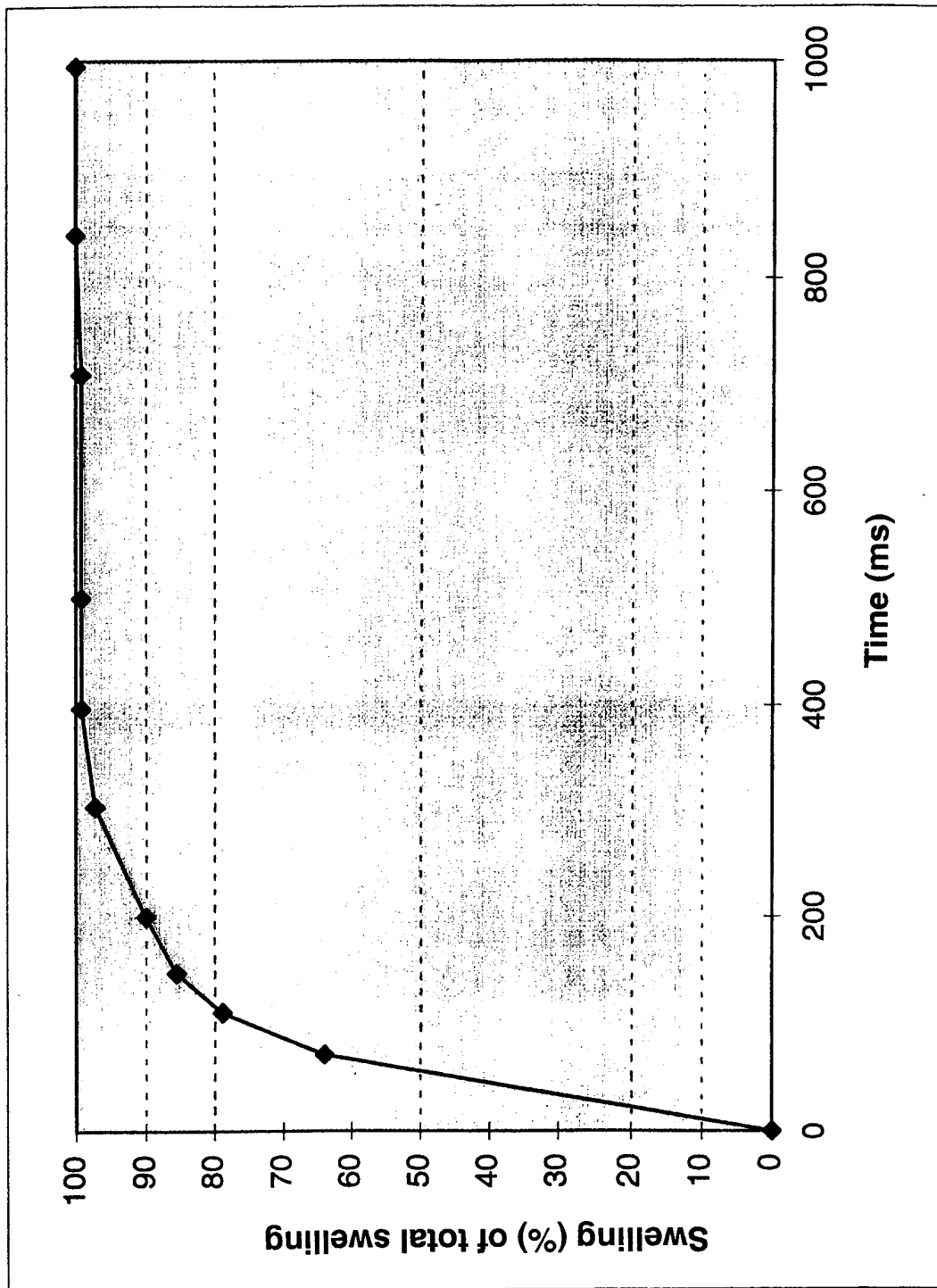
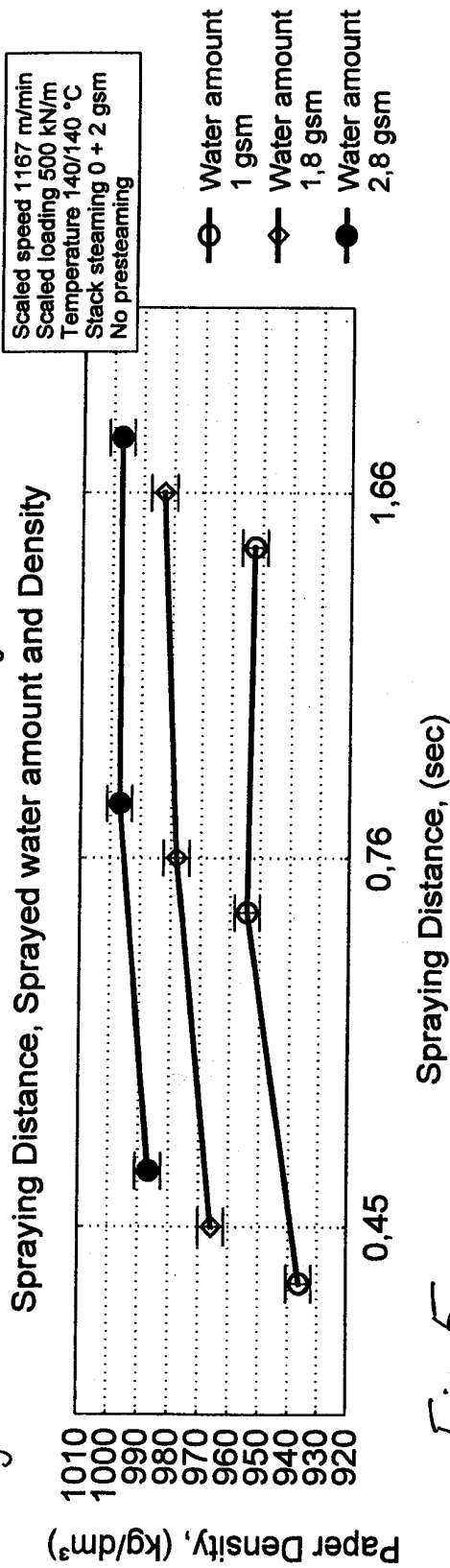
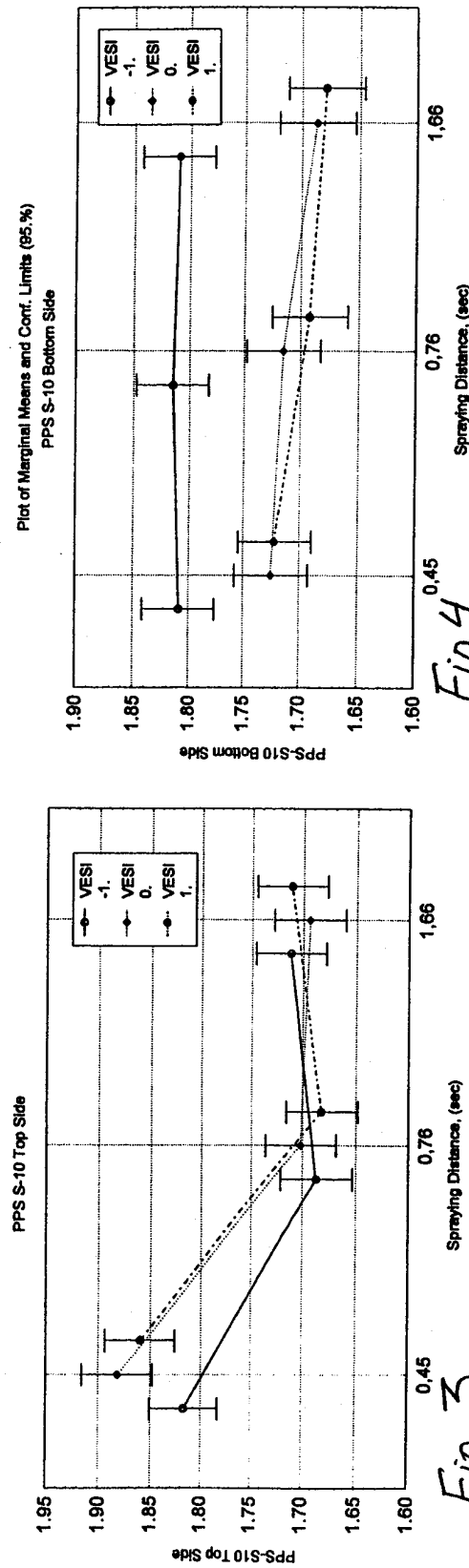
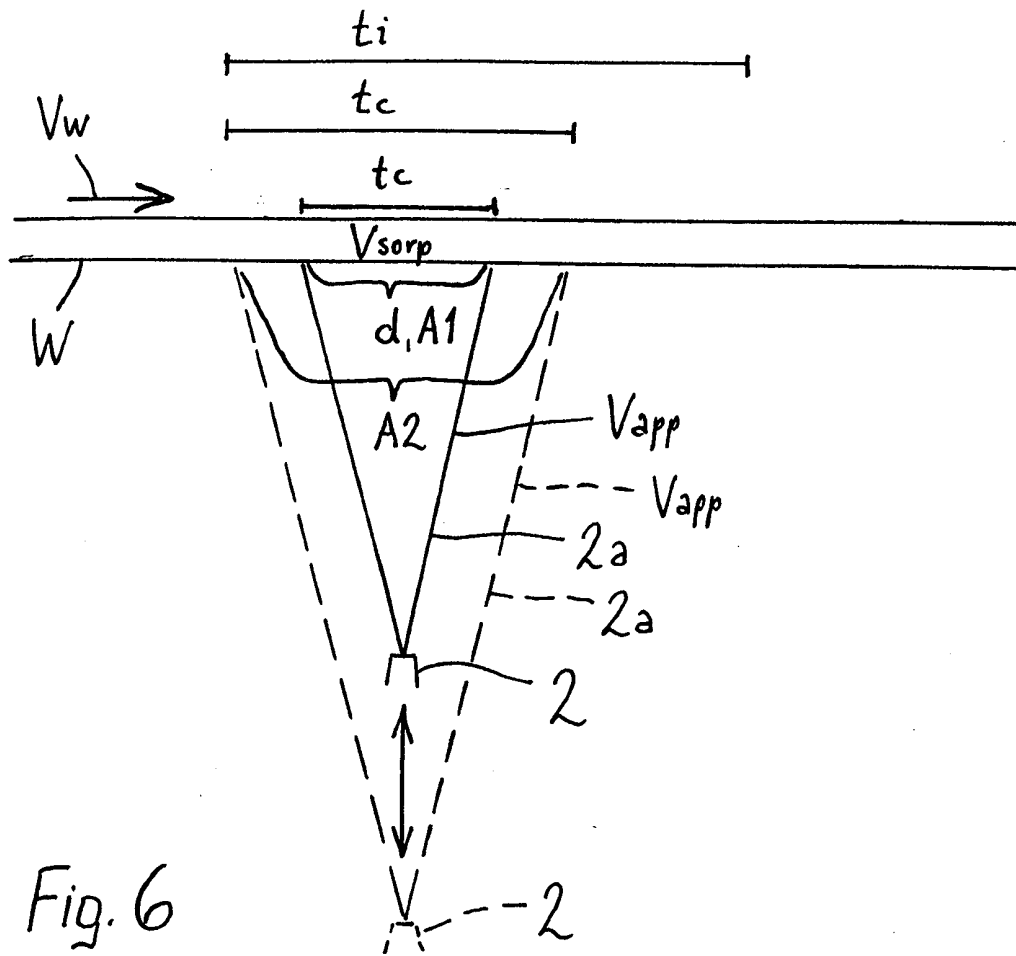


Fig. 2

Effect of imbibition time on calendering result
Plot of Marginal Means and Conf. Limits (95.%) Design: 2 3-level factors, 1 Blocks, 90 Runs





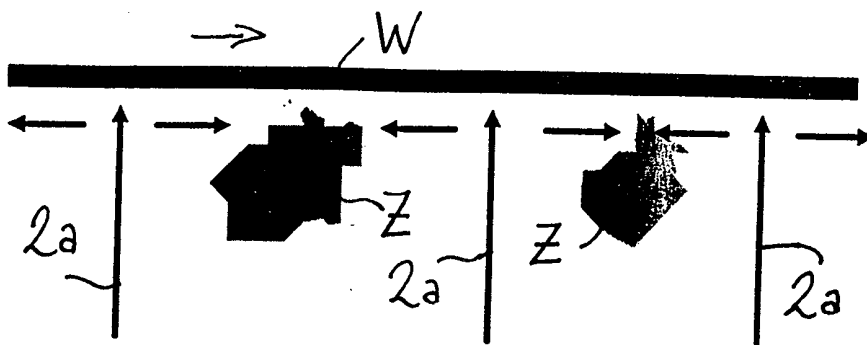


Fig. 7a -PRIOR ART-

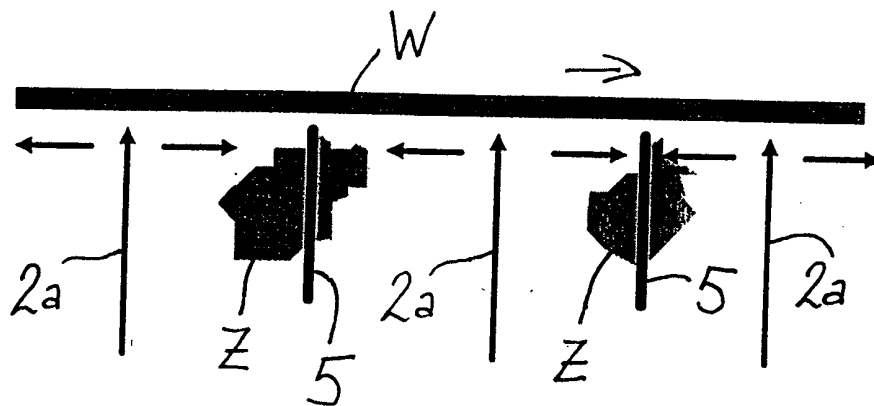


Fig. 7b

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 99/00608

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: D21G 7/00, D21F 5/00 // B65H 020/00
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)

IPC6: D21G, D21F, B65H

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

SE,DK,FI,NO classes as above

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

WPI,PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3948721 A (KARL H. WINHEIM), 6 April 1976 (06.04.76), column 2, line 18 - column 3, line 24; column 3, line 56 - column 5, line 16, figures 1,4, abstract --	1-6,11-25, 28-29
X	US 4474643 A (ROLF W. LINDBLAD), 2 October 1984 (02.10.84), column 3, line 12 - column 4, line 4, figure 1, claim 1, abstract --	1-6,11-25, 28-29
A	US 5286348 A (DIDIER J. PERIN), 15 February 1994 (15.02.94), figures 1,3,4, claim 1, abstract --	12-18

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 document 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	Date of mailing of the international search report
20 October 1999	25 -10- 1999

Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Ulf Nyström/MP Telephone No. +46 8 782 25 00
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 99/00608

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	DE 29815847 U1 (V.I.B.APPARATEBAU GMBH), 14 January 1999 (14.01.99), page 1 - page 4; page 9 - page 12, figure 1, claim 1 -- -----	1-6,11-25, 28-29

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

28/09/99

PCT/FI 99/00608

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 5286348 A	15/02/94	CA 2078841 A,C DE 4233992 A FI 98082 B,C FI 924667 A	17/04/93 22/04/93 31/12/96 17/04/93
DE 29815847 U1	14/01/99	NONE	