The invention relates to a paper machine fabric that consists of two layers, a paper-side layer and a wear-side layer. The paper-side layer consists of the top warps (1) and at least the binding top wefts (2), which have been adjusted to form a part of the paper-side surface, and the wear-side layer consists of the bottom warps (3) and bottom wefts (4). The binding top wefts (2) have been adjusted to bind the paper-side layer and the wear-side layer together. Each binding top well (2) is adjusted so that it forms a continuous independent yarn path.
Fig. 9a

Fig. 9b

Fig. 9c

Fig. 9d
Fig. 10
PAPER MACHINE FABRIC

[0001] The invention relates to a paper machine fabric consisting of two layers, a paper-side layer and a wear-side layer; the paper-side layer consists of the top warps and at least the binding top wefts, which have been adjusted to form a part of the paper-side surface, and the wear-side layer consists of the bottom warps and bottom wefts, where the binding top wefts have been adjusted to bind the paper-side layer and the wear-side layer together.

[0002] The formation of the paper web starts at the wire section, where most of the water is removed. When spread on the wet wire, the pulp consists of approximately 99% water, with the remainder consisting of fibres and possible fillers and additives. The quality of the paper is largely determined at the wire section of the paper machine. For example, the small-scale variations in the basis weight of the paper, i.e. the formation, the distribution of fines and fillers and the orientation of fibres, are mainly determined at the wire section.

[0003] Two-layer paper machine fabric structures, or double-layer wires, are widely known in the field. These structures have one warp system and two weft systems. The technology of a double-layer paper machine fabric has been described in the U.S. Pat. No. 4,041,989, for instance. Owing to the single warp system, the wires are thin, but also susceptible to breaking. As the dewatering elements of the paper machine wear down the fabric on the wear side, all yarns in the warp direction also wear down, and the risk of the fabric breaking increases. In addition, the wear on the yarns makes the fabric unstable, which degrades the paper profiles.

[0004] SSB structures are also known in the field. SSB is an acronym for sheet support binding. These structures have two warp systems and three weft systems. One of the weft systems consists of binding yarn pairs that bind the paper-side and wear-side layers together and also participate in forming the paper-side layer. The art of SSB structures is described in the U.S. Pat. Nos. 4,501,303, 5,967,195 and 5,826,627, for instance. Due to the two warp systems, SSB structures achieve greater wear resistance and improved stability, compared to double-layer structures.

[0005] In SSB structures, the top weft, on both sides of the intersection of the binding warps, presses down the top warp yarns at the intersection; at the same time, both yarns in the binding yarn pair descend inside the fabric and do not support the top warp yarns from below. As a result, the intersections remain under the surface of the wire, which may cause markings. This has been described in the U.S. Pat. No. 5,967,195, for instance.

[0006] Internal wear occurs in SSB structures. Internal wear occurs when the paper-side and the wear-side layers are not connected to each other closely enough, which results in the layers rubbing against each other. In SSB structures, internal wear especially occurs in the intersections of the binding yarns. The movement of the paper side and wear side against each other causes wear on the warp or weft yarns above and below the intersection of the binding yarns. The wear changes the overlap of the layers in the direction of the warp and the permeability of the paper machine fabric deteriorates considerably. The wear may be uneven, which means that the overlap of warp threads may vary over the width of the machine, causing profile issues in the paper.

[0007] In SSB structures, the layers are bound together with binding yarn pairs. This means that two binding weft threads are required to form one continuous weft path. For this reason, the weft density becomes quite high in denser structures. As a result, more material is needed to manufacture the product and it becomes more expensive to manufacture.

[0008] Passing between the top and bottom warps, the binding yarn pairs in SSB structures also increase the thickness of the wire. The thickness of the paper machine fabric becomes a problem for certain types of fast paper machines.

[0009] The purpose of the invention is to create a paper machine fabric that can eliminate the disadvantages of the prior art. This has been accomplished by the paper machine fabric of the invention. The paper machine fabric of the invention is known for each binding top weft being adjusted to form a continuous independent yarn path.

[0010] One of the advantages of the invention is that all yarns on the paper side are independent and form the paper side surface. In the prior SSB structures, two binding yarns form a continuous yarn path together. In order to achieve this, the weaving machine must beat two more wefts in between the warps or, in other words, two beats of the reed are needed when weaving. In the structure of the invention, each weft forms an independent weft path. Consequently, all yarns on the paper side are counted in the density. Therefore, only one beat of the reed per yarn path is needed in the weaving machine. This means that each beat of the reed advances the formation of the fabric, speeds up the weaving and improves the production efficiency at the weaving mill.

As a further advantage, the bottom warp, bound by the binding top weft, rises up inside the fabric to an extent, which creates a good binding. It is also advantageous that the bottom warp, bound by the binding top weft, does not quite reach the surface of the paper side, which means that the paper-side surface will not be blocked. In addition, the straighter the warps are in the final structure, the less the structure of the invention will stretch due to the tightness of the paper machine.

[0011] There is less internal wear in the structure of the invention than in prior art solutions. The benefit is due to the weft floats of the top wefts binding the structure being shorter than in normal SSB structures. The binding method of the invention also reduces internal wear and increases stability.

[0012] In one of the embodiments of the invention, the binding top weft binds to the bottom warp that rises between the top wefts, which makes the structure substantially thinner. In some embodiments with a warp ratio of 1:2, the warp density is lower than in conventional SSB paper machine fabrics, which means that the weft density may be increased, so that the long edge of the openings on the paper-side surface is in the cross-machine direction to the paper machine; that is, perpendicular to the direction in which the paper fibres mainly orient when the paper web is formed. This shape of the opening provides optimal fibre support and dewatering. In addition, the weft floats of the invention on the paper side facilitate the detachment of the web at the paper machine; the thin structure also results in a better formation compared to prior art solutions.

[0013] The structure of the invention creates a dense structure, whose thickness corresponds to the thickness of a double-layer wire, but whose stability corresponds to that of
SSB structures. The invention makes it possible to combine the benefits of a double-layer wire and the SSB structure, while eliminating their drawbacks.

[0014] The structure of the invention is thinner than the current SSB structures, which is a benefit, since a thin wire at the wet wire section improves the effect of low pressure and dewatering elements compared to SSB structures. Water removal can be accomplished more effectively at the paper machine, which reduces the load of the paper machine. Reducing the paper machine load makes it possible to increase its speed. This in turn increases productivity.

[0015] A thin structure is also an advantage when the aim is to improve the dry matter content of the paper web. The reason for a poor dry content in thick fabric structures is a large water space that increases the rewetting phenomenon. Rewetting refers to water drained from the paper web to the wire being absorbed back to the paper web in the wire section, after the dewatering elements. When the paper web is drier as it enters the press section, there are fewer breaks and the consumption of steam at the press section is reduced. This saves energy. The increase of dry content by one percent at the wet wire section may already make it possible to raise the speed of the paper machine to a new level.

[0016] Unlike in SSB structures, where the bottom warp is thicker than the top warp, the structures of the invention usually use warp yarns of the same thickness. This property directly affects the stiffness of the paper machine fabric in the direction of the warp. The stiffness of the structure of the invention is low in the warp direction, i.e. in the running direction of the paper machine fabric, which allows the structure to conform to the dewatering elements of the paper machine. This means that water is removed evenly over the fabric width at the different elements which results in a good formation.

[0017] It has been found, in the structure of the invention, that it is advantageous to use polyester in all binding top wefts and all top wefts, which improves stability and in turn reduces e.g. internal wear.

[0018] An essential factor affecting the mechanical life of the fabric on the paper machine is the structure of the bottom side of the fabric, such as the length of the wet float, the number of wet yarns and their thickness. In one of the structures of the invention, the floats on the bottom side form a 12-shaft structure. This embodiment of the invention enables the necessary longer mechanical life of the fabric on a paper machine.

[0019] In the following, the invention is described in greater detail by means of the application examples presented in the attached figures, where:

[0020] FIG. 1 presents the first embodiment of the invention, as a view from the paper side.

[0021] FIG. 2 presents the embodiment of the invention, according to FIG. 1, as a view from the wear side.

[0022] FIG. 3 presents the second embodiment of the invention as a view from the paper side.

[0023] FIG. 4 presents the embodiment of the invention, according to FIG. 3, as a view from the wear side.

[0024] FIG. 5 presents the third embodiment of the invention as a view from the paper side.

[0025] FIG. 6 presents the embodiment of the invention, according to FIG. 5, as a view from the wear side.

[0026] FIG. 7 presents the fourth embodiment of the invention as a view from the paper side.

[0027] FIG. 8 presents the embodiment of the invention, according to FIG. 7, as a view from the wear side.

[0028] FIGS. 9a-9d present the fifth embodiment of the invention as views in the direction of warp threads, and

[0029] FIG. 10 presents the sixth embodiment of the invention as a view from the paper side.

[0030] FIGS. 1 and 2 show the first embodiment of the invention. Each top weft forms an independent yarn path. The paper side of the structure consists of the top warps (1) and the binding top wefts (2). The binding top wefts (2) bind to the top warps (1) under two top warps (1) and over two top warps (1). Each of the binding top wefts (2) binds to a bottom warp (3), and every bottom warp (3) is bound. The wear side of the structure consists of the bottom warps (3) and the bottom wefts (4). The wear-side weave is an 8-shaft weave, meaning that the bottom wefts (4) pass over two bottom warps (3) and under six bottom warps (3). The ratio of top warps (2) to bottom warps (4) is 2:1.

[0031] FIGS. 3 and 4 show the second embodiment of the invention. The same reference numbers are used in FIGS. 3 and 4 as in FIGS. 1 and 2 to refer to the corresponding parts. In this embodiment, too, each top weft forms an independent yarn path. The paper side of the structure consists of the top warps (1) and the binding top wefts (2), in addition to the top wefts (2a). The top wefts (2a) are non-binding top wefts, meaning that the top wefts (2a) are not bound to the wear-side warps. The binding top wefts (2) bind to the top warps (1) under two top warps and over two top warps (1). Each of the binding top wefts (2) binds to a bottom warp (3), and every other bottom warp (3) is bound. Between each pair of adjacent binding top wefts (2) is one non-binding top weft (2a), which binds to the top warps (1) under one top warp (1) and over three top warps (1). The wear side of the structure consists of the bottom warps (3) and the bottom wefts (4). The wear-side weave is an 8-shaft weave, meaning that the bottom wefts (4) pass over two bottom warps (3) and under six bottom warps (3). The ratio of top warps to bottom wefts is 2:1.

[0032] FIGS. 5 and 6 show the third embodiment of the invention. The same reference numbers are used in FIGS. 5 and 6 as in FIGS. 4 and 5 to refer to the corresponding parts. In this embodiment, too, each top weft forms an independent yarn path. The paper side of the structure consists of the top warps (1) and the binding top wefts (2), as well as the top wefts (2a). The top wefts (2a) are non-binding top wefts, which are not bound to the wear-side warps. The binding top wefts (2) bind to the top warps (1) under two top warps (1) and over two top warps (1). Each of the binding top wefts (2) binds to a bottom warp (3), and every other bottom warp (3) is bound. Between each pair of adjacent binding top wefts (2) is one top weft (2a), which binds to the top warps (1) under one top warp (1) and over one top warp (1). The wear side of the structure consists of the bottom warps (3) and the bottom wefts (4). The wear-side weave is an 8-shaft weave, meaning that the bottom wefts (4) pass over two bottom warps (3) and under six bottom warps (3). In this embodiment, the ratio of top wefts to bottom warps is 2:1 and the ratio of top warps to bottom warps is 1:2.

[0033] FIGS. 7 and 8 show the fourth embodiment of the invention. The same reference numbers are used in FIGS. 7 and 8 as in e.g. FIGS. 5 and 6 to refer to the corresponding parts. In this embodiment, too, each top weft forms an independent yarn path. The paper side of the structure consists of the top warps (1) and the binding top wefts (2),
as well as the top wefts (2a). The top wefts (2a) are non-binding top wefts, which are not bound to the wear-side warps. The binding top wefts (2) bind to the top warps under one top warp (1) and over two top warps (1). Each of the binding top wefts (2) binds to a bottom warp (3), and every other bottom warp (3) is bound. Between each pair of adjacent binding top wefts (2), there is one non-binding top weft (2a), which binds to the top warps (1) under one top warp (1) and over two top warps (1). The wear side of the structure consists of the bottom warps (3) and the bottom wefts (4). The weave side is a 6-shaft weave, meaning that the bottom wefts (4) pass over two bottom warps (3) and under four bottom warps (3). The ratio of top wefts to bottom wefts is 2:1.

[0034] FIGS. 9a-9d show the fifth embodiment of the invention. The same reference numbers are used in FIGS. 9a-9d as in the previous embodiments to refer to the corresponding parts. In this embodiment, too, each top weft forms an independent yarn path. The paper side of the structure consists of the top warps (1) and the binding top wefts (2), as well as the top wefts (2a). The binding top wefts (2) bind to the top warps under three top warps (1) and over two top warps (1). Between each pair of adjacent binding top wefts (2) is one non-binding top weft (2a), which binds to the top warps (1) under two top warps (1) and over three top warps (1). The wear side of the structure consists of the bottom warps (3) and the bottom wefts (4). The weave side is a 6-shaft weave, meaning that the bottom wefts (4) pass over one bottom warp and under five bottom warps (3), in such a way that the adjacent bottom warps are also bound. The bottom weft could also be bound in a 3-shaft or a 12-shaft structure. In the embodiment shown in FIGS. 9a-9d, the warp ratio is 5:3.

[0035] FIG. 10 shows the fifth embodiment of the invention. The same reference numbers are used in FIG. 10 as in e.g. FIG. 5 to refer to the corresponding parts. In this embodiment, too, each top weft forms an independent yarn path. The paper side of the structure consists of the top warps (1) and the binding top wefts (2), as well as the top wefts (2a). The top wefts (2a) are non-binding top wefts, which are not bound to the wear-side warps. The binding top wefts (2) bind to the top warps under one top warp (1) and over three top warps (1). Each of the binding top wefts (2) binds to a bottom warp (3), and every other bottom warp (3) is bound. Between each pair of adjacent binding top wefts (2) is one non-binding top weft (2a), which is bound to the top warps (1) under one top warp (1) and over three top warps (1).

[0036] A common feature of all of the embodiments described above is that each top weft forms an independent yarn path. The paper side of the structure also consists of, at least, the top warps (1) and the binding top wefts (2). The weave of the binding top wefts (2) with the top warps (1) can vary, as shown in the figures, such as a 3-shaft or 4-shaft weave, twill, satin, etc. In the pattern repeat, the binding top weft (2) always binds to at least one bottom warp. The bottom binding top weft (2) can also bind to the bottom warps (3) in other ways, such as to every other bottom warp (3) or every third bottom warp (3). In some applications, there may be non-binding top wefts (2a) in between the binding top wefts (2). Their weave can vary, meaning that the weave can be a 2-shaft weave, twill, satin, etc. The ratio of the binding top wefts (2) to the non-binding top wefts (2a) may be 1, >1 or <1. Furthermore, in all embodiments of the invention, the wear side of the structure consists of the bottom warps (3) and the bottom wefts (4). The weave side can be twill or satin, for example, but other weaves are also possible. It is advantageous for the bottom weft (4) to bind to two adjacent bottom warps (3) and form a bottom weft loop after this, such as two over/3-14 under, but there are also other options from 2-shaft up to 16-shaft weaves. The ratio of top wefts to bottom wefts is 2:1 in many of the embodiments in the figures, but it can also be something else, such as 1:1, 1:2, 2:3, etc. The ratio of top warps to bottom warps is 1:2 in many of the embodiments in the figures, but it can also be 1 (=1), greater than one (>1) or smaller than one (<1). The top warps can be located either on top of the bottom warps or between them; for example, in 1:2 one bottom warp can be directly under a top warp, while the other bottom warp does not have a pair, or a top warp can be in the middle of the bottom warps.

[0037] The solutions described above use polyester and polyamide yarns. Other possible yarn materials include PEN (polyethylene naphthalate) or PPS (polyphenylene sulfide). The yarns or a part of the yarns may have a round cross-section or they may be, for example, profile yarns, where the cross-section is not round, but rather flat, oval, rectangle, or some other shape. The yarns may also be hollow, in which case they can flatten in the fabric and the structure can be made even thinner than before. One advantageous form of the invention is that all warps are 0.12 mm in diameter. The warp diameter may also be different; however, top warps 0.08 mm and bottom warps 0.11 mm. The diameter of the binding top wefts and the non-binding top wefts may be 0.08 mm. Similarly, bi-component yarns may also be used. The properties of the fabric can be influenced by the choice of yarn properties; for example, to achieve a thinner structure or an even paper-side surface, etc. The structure of the invention is intended for use as a wire in the wet section of a paper machine, but the structure can also be used with e.g. tissue, paperboard and non-woven machines. The structure of the invention can also be adjusted for use at the press or drying section of a paper machine.

[0038] The invention is described above by means of different embodiments. However, the invention is in no way restricted to the embodiments of the figures, but may naturally be freely modified, within the scope of the accompanying claims.

1. A paper machine fabric that consists of two layers, a paper-side layer and a wear-side layer, where the paper-side layer consists of the top warps (1) and at least the binding top wefts (2), which have been adjusted to form a part of the paper-side surface, and the wear-side layer consists of the bottom warps (3) and the bottom wefts (4), where the binding top wefts (2) have been adjusted to bind the paper-side layer and the wear-side layer together, characterised in that each binding top weft (2) has been adjusted to form a continuous independent yarn path.

2. A paper machine fabric according to claim 1, where at least one top weft (2a) has also been adjusted between two adjacent binding top wefts (2), and it has been adjusted to only bind to the top warps (1), characterised in that each top weft (2a) and each binding top weft (2) has been adjusted to form a continuous independent weft path.

3. A paper machine fabric according to claim 1, characterised in that the paper-side layer has been adjusted so that it consists of only the top warps (1) and the binding top wefts (2), where each binding top weft (2) has been adjusted to
bind to the top warps (1) under two top warps and over two top warps, and each binding top weft (2) has also been adjusted to bind to each bottom warp (3) in the pattern repeat.

4. A paper machine fabric according to claim 3, characterised in that the weave of the bottom wefts is an 8-shaft weave, meaning that the bottom wefts (4) pass over two bottom warps (3) and under six bottom warps (3).

5. A paper machine fabric according to claim 3, characterised in that the ratio of top warps to bottom warps is 2:1.

6. A paper machine fabric according to claim 2, characterised in that the paper-side layer has been adjusted so that it consists of the top warps (1), the binding top wefts (2) and the top wefts (2a), where each binding top weft (2) has been adjusted to bind to the top warps (1) under two top warps and under two top warps, and each binding top weft (2) has been adjusted so that it binds to every other bottom warp (3) in the pattern repeat, and where one top weft (2a) has been adjusted between two adjacent binding top wefts (2); it binds to the top warps (1) under one top warp and over three top warps.

7. A paper machine fabric according to claim 6, characterised in that the wear-side weave is an 8-shaft weave, meaning that the bottom wefts (4) pass over two bottom warps (3) and under six bottom warps (3).

8. A paper machine fabric according to claim 6, characterised in that the ratio of top warps to bottom warps is 2:1.

9. A paper machine fabric according to claim 2, characterised in that the paper-side layer has been adjusted so that it consists of the top warps (1), the binding top wefts (2) and the top wefts (2a), where each binding top weft (2) has been adjusted so that it binds to the top warps (1) under two top warps and over two top warps, and each binding top weft (2) has been adjusted so that it binds to every other bottom warp (3) in the pattern repeat, and where one top weft (2a) has been adjusted between two adjacent binding top wefts (2); it has been adjusted so that it binds to the top warps (1) under one top warp (1) and over one top warp (1).

10. A paper machine fabric according to claim 9, characterised in that the wear-side weave is an 8-shaft weave, meaning that the bottom wefts (4) pass over two bottom warps (3) and under six bottom warps (3).

11. A paper machine fabric according to claim 9, characterised in that the ratio of top warps to bottom warps is 2:1.

12. A paper machine fabric according to claim 2, characterised in that the paper-side layer has been adjusted so that it consists of the top warps (1), the binding top wefts (2) and the top wefts (2a), where each binding top weft (2) has been adjusted so that it binds to the top warps (1) under one top warp and over two top warps, and each binding top weft (2) has been adjusted so that it binds to every other bottom warp (3) in the pattern repeat, and where one top weft (2a) has been adjusted between two adjacent binding top wefts (2); it has been adjusted so that it binds to the top warps (1) under one top warp (1) and over two top warps (2).

13. A paper machine fabric according to claim 12, characterised in that the wear-side weave is a 6-shaft weave, meaning that the bottom wefts (4) pass over two bottom warps (3) and under four bottom warps (3).

14. A paper machine fabric according to claim 12, characterised in that the ratio of top warps to bottom warps is 2:1.

15. A paper machine fabric according to claim 2, characterised in that the paper-side layer has been adjusted so that it consists of the top warps (1), the binding top wefts (2) and the top wefts (2a), where each binding top weft (2) has been adjusted so that it binds to the top warps (1) under three top warps (1) and over three top warps (1) and where one top weft (2a) has been adjusted between two adjacent binding top wefts (2); it has been adjusted so that it binds to the top warps (1) under two top warps (1) and over three top warps (1).

16. A paper machine fabric according to claim 15, characterised in that the wear-side weave is a 6-shaft weave, meaning that the bottom wefts (4) pass over one bottom warp (3) and under five bottom warps (3).

17. A paper machine fabric according to claim 15, characterised in that the ratio of top warps to bottom warps is 5:3.

18. A paper machine fabric according to claim 2, characterised in that the paper-side layer has been adjusted so that it consists of the top warps (1), the binding top wefts (2) and the top wefts (2a), where each binding top weft (2) has been adjusted so that it binds to the top warps (1) under one top warp (1) and over three top warps (1), and each binding top weft (2) has been adjusted so that it binds to every other bottom warp (3) in the pattern repeat, and where one top weft (2a) has been adjusted between two adjacent binding top wefts (2); it has been adjusted so that it binds to the top warps under one top warp (1) and over three top warps (1).

19. A paper machine fabric according to claim 1, characterised in that the ratio of binding top wefts (2) to the top wefts (2a) is 1, >1 or <1.

20. A paper machine fabric according to claim 1, characterised in that the ratio of top warps to bottom warps is 1:1, 1:2 or 2:3.

21. A paper machine fabric according to claim 1, characterised in that the wear-side weave is between 2 and 16 shafts.

22. A paper machine fabric according to claim 1, characterised in that the paper machine fabric is a wire used in the wet section of a paper machine.

23. A paper machine fabric according to claim 1, characterised in that the paper-side layer consists of top warps (1) and binding top wefts (2a).

24. A paper machine fabric according to claim 1, characterised in that in a pattern repeat, the binding top wefts (2) have been adjusted so that they bind to each bottom warp (3).

25. A paper machine fabric according to claim 1, characterised in that the binding top wefts (2) have been adjusted so that they bind to every other bottom warp (3) in a pattern repeat.

26. A paper machine fabric according to claim 1, characterised in that the binding top wefts (2) have been adjusted so that they bind to every third bottom warp (3) in a pattern repeat.

27. A paper machine fabric according to claim 1, characterised in that the ratio of top warps (1) to bottom warps (3) is 1, <1 or >1.

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