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(54) **IMAGE FORMING METHOD AND PRINTER**

(57) A method of forming an image by applying radiation curable ink onto a recording medium (14) that is supported on a print surface (12); wherein the image comprises a first sub-image (22) and a second sub-image (24), and the method comprises the steps of:

(a) applying the first sub-image (22) onto the recording medium (14),

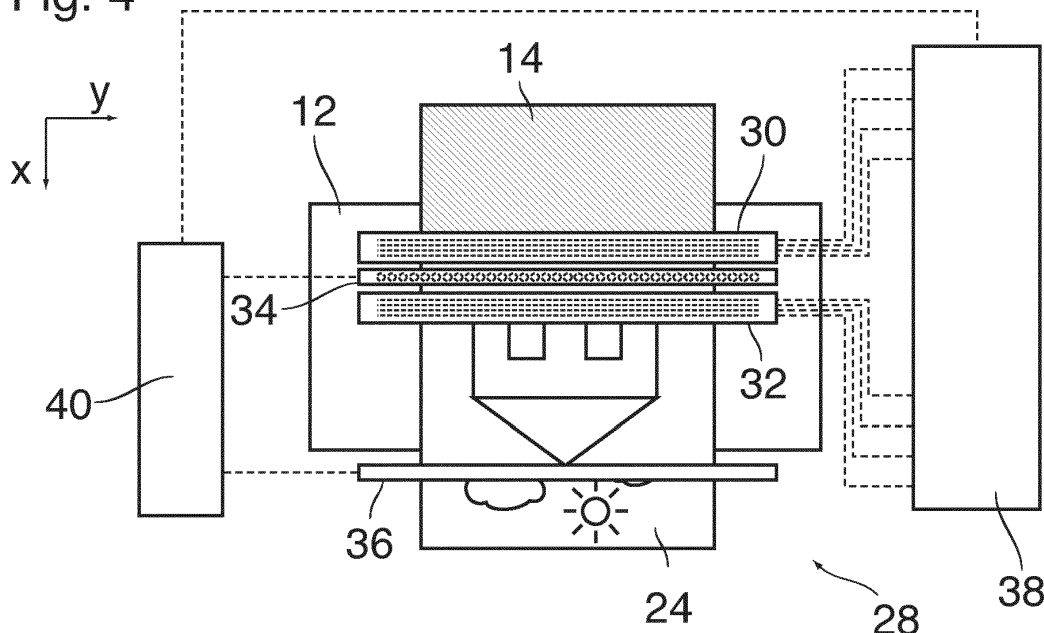
(b) curing the first sub-image by applying a first curing

strategy (34),

(c) applying the second sub-image (24) onto the recording medium (14), wherein the first sub-image is at least partly covered by the second sub-image, and

(d) curing the second sub-image by applying a second curing strategy (36) that is different from the first curing strategy.

Fig. 4



Description

[0001] The invention relates to a method of forming an image by applying radiation curable ink onto a recording medium that is supported on a print surface.

[0002] More particularly, the invention relates to an ink jet printing method using UV curable ink.

[0003] Radiation curable inks, such as UV curable inks are known in the art. A special class of UV curable inks are UV curable phase change inks. Phase change inks are inks that are fluid at elevated temperature and solid or semi-solid at room temperature. An example of a UV curable phase change ink is a UV curable gelling ink. Phase change inks are jetted at elevated temperature. When these inks are applied onto a recording medium, they may cool down, thereby increasing the viscosity of the ink. This increase in viscosity may prevent spread of a droplet and inter-droplet smearing.

The phase change property of the radiation curable ink may stabilize the droplets applied onto the receiving medium before they are cured. When a phase change radiation curable ink is used for applying an image onto a receiving medium, it may not be necessary to cure immediately after the droplet has landed onto the receiving medium; there may be a time interval in between application of the droplets onto the receiving medium and curing, without droplet smearing occurring. Moreover, it may be disadvantageous to cure the droplets of the UV curable phase change ink immediately after applying them onto the recording medium, as this may prevent the ink droplets to flow, thereby preventing the droplets of forming an even ink layer on the recording medium. Hence, a printing apparatus configured to print images by ejecting droplets of a UV curable phase change ink are typically configured to cure the ink only a certain time interval after the ink has been deposited onto the recording medium.

[0004] Generally, it is preferred to print images using a plurality of differently colored inks, as this allows printing multi-color images. For example, images may be applied by selectively applying droplets of a Cyan, a Magenta, a Yellow and a Black UV curable phase change ink composition, respectively. It may be desired to use additional types of ink, such as white ink, a metallic ink and/or a (colorless) overcoat. However, the different type of inks used to printing the image may have different rheologic behavior. For example, some of the ink compositions used may be non-phase change inks; i.e. these inks may be fluid at elevated temperature as well as at room temperature. Hence, non-phase change inks may spread when they are applied onto the recording medium. Therefore, it may be difficult to print images using different types of ink, while maintaining good print quality.

[0005] It is an object of the invention to provide an image forming method and a printer that offer a greater freedom of choice in the inks to be used for printing a single image in a single printing operation, while maintaining good print quality.

[0006] In order to achieve this object, the image forming method according to the invention is characterized in that the image comprises a first sub-image and a second sub-image, and the method comprises the steps of:

- (a) applying the first sub-image onto the recording medium,
- (b) curing the first sub-image by applying a first curing strategy,
- (c) applying the second sub-image onto the recording medium, wherein the first sub-image is at least partly covered by the second sub-image, and
- (d) curing the second sub-image by applying a second curing strategy that is different from the first curing strategy.

[0007] Thus, the invention proposes to switch between different curing strategies within the time period in which a single image is printed onto a single recording medium that is supported on the print surface. This has the advantage that different types of ink may be used for the first sub-image and for the second sub-image that is to cover at least a part of the first sub-image, and the curing strategy is always adapted to the type of ink being used. Preferably, the first sub-image is printed using a first ink composition and the second sub-image is printed using a second ink composition, wherein a first one of the first ink composition and the second ink composition is a radiation curable phase change ink composition and a second one of the first ink composition and the second ink composition is a radiation curable non-phase change ink composition. The radiation curable phase change ink composition may be cured a certain time interval after the radiation curable phase change ink composition is applied onto the recording medium. This curing strategy is also known as post curing.

[0008] The radiation curable non- phase change ink composition may be cured immediately after the radiation curable phase change ink composition is applied onto the recording medium. This curing strategy is also known as direct curing.

Preferably, the time lag between the time of printing and the time of curing differs between the first curing strategy and the second curing strategy. For example, if direct curing is applied, then the time lag between the time of printing and the time of curing is relatively small. If post curing is applied, then the time lag between the time of printing and the time of curing is relatively large.

[0009] In an embodiment, one of the first and second curing strategy comprises the step of curing using a first radiation source; the other of the first and second curing strategy comprises the step of curing using a second radiation source and does not comprise the step of curing using a first radiation source; and the first radiation source is positioned upstream in a direction of recording medium transport with regard to the second source of radiation.

When printing an image on a recording medium, the recording medium is moved in a recording medium transport direction. The recording medium may be moved continuously or alternatively, the recording medium may be moved step-wise.

The image applied onto the recording medium may comprise a first sub-image and a second sub-image. The image may be formed using a printing apparatus that comprises a first source of radiation and a second source of radiation. The first radiation source may be positioned upstream in a direction of recording medium transport with regard to the second source of radiation. The first and second sub-image may be cured using different curing strategies. The sub-images may be cured substantially completely by the curing strategy applied. For example, the sub-image cured by the first curing means may be essentially completely cured by irradiating the first sub-image with the first curing means. Optionally, the sub-image may be irradiated afterwards by the second radiation source, but -as the sub-image was already essentially completely cured-irradiating with the second radiation source may not result in (further) curing of the sub-image. The sub-image that is cured using the second radiation source may also be essentially completely cured, even though the sub-image was not irradiated with the first source of radiation.

For example, one of the first and the second sub-image may be formed using a radiation curable phase change ink. The sub-image formed using such ink may be cured by irradiating the sub-image using the second source of radiation but may not be irradiated using the first source of radiation. The other one of the first and the second sub-image may be formed using a radiation curable non-phase change ink. This sub-image may be cured using the first source of radiation. Optionally, this sub-image may also be irradiated using the second source of radiation.

[0010] In a further embodiment, the first sub-image may be printed by a first printing element and the second sub-image may be printed using a second printing element. The first curing means may irradiate a first irradiated area of the recording medium, whereas the second curing means may irradiate a second irradiated area of the recording medium. None of the first and second printing element may be positioned downstream with regard to the first irradiated area of the recording medium. Hence, depending on the selected print strategy, sub-images applied by the first and second element can be cured-depending on the curing strategy selected- using the first radiation source. However, only one of the first and second sub-images will be cured using the first source of radiation. Whether the first sub-image or the second sub-image is cured using the first source of radiation depends on the curing strategy selected.

For example, if a background layer is applied as the first sub-image, the first sub-image will be cured by the first source of radiation (direct-curing). The first sub-image may be irradiated by the second source of radiation, but

this will not result in further curing of the first sub-image. The second sub-image may be cured by the second source of radiation (post-curing). For example, the first sub-image is a background layer that is a white background layer. Preferably, the white background layer is applied onto the recording medium by ejecting droplets of a white UV curable non-phase change ink composition. In the embodiment, the white UV curable non-phase change ink composition may be cured using direct curing. The colour image may be applied by ejecting droplets of a coloured UV curable phase change ink e.g. CMYK ink. The coloured ink may be cured using post curing.

[0011] In an alternative embodiment, the method may be used for first printing a colour image directly onto the recording medium with using the first curing strategy and then printing a transparent overcoat ink layer on top of the colour image with using the second curing strategy. The overcoat ink layer may be e.g. a gloss-enhancing ink layer or a protective ink layer. In this embodiment, the overcoat ink layer may be printed by ejecting droplets of a colourless UV curable non-phase change ink composition. The colourless UV curable non-phase change ink composition may be cured using direct curing. The colour image may be applied onto the recording medium by ejecting droplets of a coloured UV curable phase change ink e.g. CMYK ink. The coloured ink may be cured using post curing. Hence, the curing strategy is adapted to the nature of the ink used for printing the first and second sub-image, respectively.

[0012] In an embodiment, the second sub-image may at least partially cover the first sub-image.

In an embodiment, the UV curable phase change ink composition comprises a crystalline gellant. The gellant is a thickener. When the ink cools down after being applied onto the recording medium, the ink thickens which may control or prevent spreading of the ink on the recording medium. Therefore, the gellant may prevent colour bleeding.

When the gellant is a crystalline component, the gellant can provide phase-change characteristic to the ink and can influence the gloss of the print. Alternatively, the crystalline component may be another component of the ink composition, e.g. a binder. The crystalline component may need some time to form crystals after an ink droplet has been applied onto the recording medium. The presence of crystals in the ink layer may influence the gloss level of the ink layer. Therefore, it is preferred that the crystals can form in the ink layer before the ink layer is cured. Hence, post-curing may be applied for curing UV curable phase-change inks comprising a crystalline gellant.

Non-limiting examples of crystalline gelling agents are ketones such as laurone, stearone, di-n-dodecylketone, pyristone, 15-nonacosanone, palmitone, di-n-hexadecylketone; long chain terminal alcohols, such as a C₁₀-C₄₀ long chain terminal alcohol, for example a C₁₅-C₃₀ long chain terminal alcohol, such as a C₂₀-C₂₅ long chain terminal alcohol; or urethane waxes or vinyl ether waxes,

such as the commercially available Vectomer ® monomers, obtainable from Sigma-Aldrich.

[0013] A printer that is capable of performing the image forming method described above with high efficiency comprises:

- a print surface,
- a first printing element disposed at the print surface for printing dots of a first radiation curable ink onto a recording medium on the print surface,
- a second printing element disposed at the print surface for printing dots of a second radiation curable ink onto the recording medium, and
- a curing system arranged to cure the dots by exposing them to radiation, the curing system comprising separate first and second radiation sources arranged to cure the dots with different time lags between the time of printing and the time of curing,

characterized in that a curing control system is arranged to disable the first radiation source, which has the smaller time lag, selectively for dots that have been printed with the second printing element.

[0014] With this printer, the switching between two different cure strategies can be performed in a very short time, simply by switching the first radiation source on and off. When it is switched on, the direct cure strategy is active in which each dot is cured immediately after it has been printed. When it is switched off, a dot that has just been printed will not be cured before it receives radiation from the second radiation source, so that a post cure strategy is applied. It is possible but not necessary to switch off the second radiation source when the direct cure strategy is to be applied.

[0015] Another printer that is also useful for carrying out the method described above with high efficiency comprises:

- a print surface,
- a first printing element disposed at the print surface for printing dots of a first radiation curable ink onto a recording medium on the print surface,
- a second printing element disposed at the print surface for printing dots of a second radiation curable ink onto the recording medium, and
- a curing system arranged to cure the dots by exposing them to radiation, the curing system comprising separate first and second radiation sources arranged to cure the dots with different time lags between the time of printing and the time of curing,

characterized in that the first printing element, the first radiation source, the second printing element, and the second radiation source are disposed in that order in a direction of movement of the recording medium relative to the printing elements and radiation sources.

[0016] More specific optional features of the invention are indicated in the dependent claims.

[0017] In the printers according to the invention, the at least one of the first and second printing elements may comprise page-wide print heads that are stationary relative to the print surface on which the recording medium is advanced. Then, the radiation sources may be configured as lamps that also extend over the entire width of the recording medium. Each of the first and second radiation sources may either be configured as a single lamp adapted to irradiate a complete line or a plurality of lines on the recording medium, or may be formed by plurality of lamps, e.g. UV-emitting LEDs, that are arranged for irradiating individual pixel positions. In the latter case, at least the lamps of the first radiation source may be controlled independently of one another.

[0018] In another embodiment, at least one of the first and second printing elements may comprise print heads that are disposed on a common carriage that travels in a main scanning direction across the print surface. Then, the radiation sources may be either stationary or arranged to travel together with the carriage.

[0019] A printer according to the invention in which the first radiation source is adapted to be switched on and off individually for each pixel position may also be used for performing a printing method in which the different cure strategies are not applied to different sub-images that are superposed one upon the other, but to different pixel positions, so that the printed image can be divided into areas which differ in their gloss. Then, for example, a printed image, e.g. a four colour image, may be defined not only by four bitmaps, one for each colour, but also by a fifth bitmap that specifies the cure strategy and hence the gloss for each pixel.

[0020] Embodiment examples will now be described in conjunction with the drawings, wherein:

- Fig. 1 is a schematic top plan view of an ink jet printer, illustrating an image forming method according to the invention;
- Figs. 2 and 3 are enlarged side views of the printer shown in Fig. 1, seen in the direction of arrows II-II in Fig. 1, for different passes of a print head carriage;
- Fig. 4 is a schematic top plan view of an example of a printer according to an embodiment of the invention;
- Fig. 5 is a top plan view of a print head carriage according to another embodiment of the invention;
- Figs. 6 and 7 are diagrams illustrating a method according to the invention to be performed with the print head carriage shown in Fig. 5;
- Fig. 8 is a diagram illustrating a method according to another embodiment of the invention;
- Fig. 9 is a schematic top plan view of a printer according to another embodiment of the invention;

- Fig. 10 is a front view of the printer shown in Fig. 9;
- Fig. 11 is a top plan view of a printer according to yet another embodiment of the invention;
- Fig. 12 shows the printer according to Fig. 11 during a return pass of a print head carriage; and
- Fig. 13 is a side view of the printer shown in Figs. 11 and 12, seen in the direction of arrows XIII-XIII in Fig. 11.

[0021] Fig. 1 shows an ink jet printer 10 having a print surface 12 that supports a sheet of a recording medium 14. By means of a transport system that is known per-se and has not been shown here, the recording medium 14 is advanced over the print surface 12 in a sub-scanning direction x. A print head carriage 16 is slidable along a rail 18 that extends across the entire width of the recording medium 14. The carriage 16 is driven to move back and forth in a main scanning direction y normal to the sub-scanning direction x and carries a number of print heads (symbolized by linear nozzle arrays in the drawing) with which inks of different colours may be expelled onto the recording medium 14 in order to print an image.

[0022] A curing system 20 for curing droplets of liquid ink that have been applied onto the recording medium 14 by means of the print heads is configured as a UV lamp that extends over the entire width of the recording medium 14 and is disposed downstream of the rail 18 in the sub-scanning direction x.

[0023] In the example shown, the recording medium 14 is a transparent sheet (symbolized by hatching in the area of the sheet in which no image has been formed as yet). One of the print heads on the carriage 16 is provided for printing with white ink in order to form a white background layer 22 on the recording medium. Other print heads on the carriage 16 are used for printing with coloured inks (e.g. UV-curable phase change inks in the colours cyan, magenta, yellow and black) so as to print a colour image 24 on top of the white background layer. The nozzle arrays of the print heads extend in the sub-scanning direction x, so that a swath of several pixel lines is printed during each pass of the carriage 16 across the recording medium. In the situation illustrated in Fig. 1, the carriage 16 travels in +y direction, and the "white" print head is used for printing a swath of the white background 22. The same situation has also been shown in Fig. 2, where the carriage 16 moves away from the viewer while printing the background layer 22. Swathes of the colour image 24, shown more to the right in Fig. 2, have been printed in earlier passes of the carriage 16.

[0024] In Fig. 2, the lamp constituting the curing system 20 is directed onto the swath of white background 22 that is just being printed, as has been indicated by a dashed line in Fig. 2. Although not shown in the drawing, the ultraviolet light is collimated such that it will irradiate the swath of the background 22 evenly over the entire width

of the recording medium 14 in the main scanning direction y and also evenly over the width of the swath in the sub-scanning direction x. Thus, when a dot of white ink has been expelled from the white print head onto the recording medium 14, it will only take a little time until the carriage 16 has travelled so far that the new dot is no longer in the shadow of the carriage and is cured by the ultraviolet light from the curing system 20. This curing strategy is called "direct cure".

[0025] When the carriage 16 has reached the right end of the recording medium 14 in Fig. 1, an entire swath of white background 22 will have been printed and cured. Then, the direction of movement of the carriage 16 is reversed without advancing the recording medium 14, and a second pass, from right to left in Fig. 1, is started. During this pass, the white print head is inactive and the print heads for coloured ink are active instead, so as to print another swath of the colour image 24 on top of the freshly printed swath of white background 22.

[0026] Fig. 3 illustrates the situation during this pass, with the carriage 16 moving towards the viewer. During the return pass shown in Fig. 3, the UV lamp forming the curing system 22 is shifted to another position, so that the light beam (dashed line) irradiates and cures another swath of the colour image 24 that had been printed a number of passes (five in this example) earlier. Thus, the coloured ink that is deposited on the white background 22 in the pass of the carriage shown in Fig. 3 will be cured only with a considerable time delay, which, in this example, corresponds to five passes of the carriage. This curing strategy is called "post cure".

[0027] Swathes of the colour image 24 that have been cured already have been indicated in Figs. 2 and 3 by a bold line 26 marking the top surface.

[0028] In this example, the white background layer 22 forms a first sub-image of the image to be printed, and the colour image 24 forms a second sub-image.

[0029] With the method described above, it is possible to use different curing strategies for the different sub-images. More particularly, direct cure is used for curing the white background image. This permits to use a white ink that tends to spread relatively fast, but spreading will be stopped in time because each dot is cured immediately after it has been printed. On the other hand, the inks used for the colour image 24 may be of a type that tends to spread more slowly, such as a radiation curable phase change ink, so that a post cure strategy is more appropriate.

[0030] Fig. 4 shows an example of a printer 28 according to the invention with which the method described above can be performed even more efficiently. Like or equivalent parts are designated by the same reference numerals as in Figs. 1 - 3.

[0031] In this example, a first printing element 30 is stationary relative to the print surface 12 and extends over the entire width of the recording medium 14. Thus, the only relative scan movement between the print head and the recording medium 14 is a movement in the di-

rection x. The first printing element 30 comprises a plurality of page-wide print heads suitable for printing in different colours. A second printing element 32 is disposed downstream of the first printing element 30 in the direction x and has essentially the same configuration as the first printing element 30.

[0032] In this embodiment, a curing system comprises a first radiation source 34 arranged between the first and second printing elements 30, 32, and a second radiation source 36 arranged downstream of the second printing element 32 and at a certain distance from the latter.

[0033] Further, a print head controller 38 and a curing control system 40 have been shown schematically in Fig. 4.

[0034] In order to perform the method according to the invention as described earlier, one of the print heads of the first printing element 30 is used for white ink, so as to print the first sub-image, in the form of the white background.

[0035] The radiation sources 34 and 36 extend over the entire width of the recording medium 14. In the example shown, the first radiation source 34 is constituted by a linear array of UV-emitting LEDs, arranged in positions (in the direction y) that correspond to the positions of the nozzles of the print heads in the first printing element 30. The second radiation source 36 may be formed by a single lamp that evenly irradiates a stripe-shaped area that extends across the entire width of the recording medium.

[0036] The recording medium 14 is advanced continuously, with a uniform speed, in the direction x. As soon as a white pixel line that has been printed by the first printing element 30 leaves the position underneath this printing element and reaches the position underneath the first radiation source 34, it will be cured with ultraviolet light. Thus, a direct cure strategy is applied to the first sub-image (white background).

[0037] As the recording medium 14 moves further, the print heads of the second printing element 32 are used for printing the colour image 24 (second sub-image) on top of the white background. This sub-image will then be cured with the second radiation source 36. However, due to the larger distance between the second printing element 32 and the second radiation source 36, there is a larger time lag between printing and curing, so that a post cure strategy is applied to the second sub-image.

[0038] The printer 28 shown in Fig. 4 is also versatile for a number of other applications. For example, when an entire image on the recording medium 14 is to be printed with inks for which direct cure is appropriate, this can be done with the first printing element 30 and the first radiation source 34 whereas the second printing element 32 and the second radiation source 36 are left idle. Conversely, when post cure is to be applied to the entire image, the first printing element 30 and the first radiation source 34 may be left idle.

[0039] In all these applications, the radiation sources 34, 36 will be switched on and off as required under the

control of the curing control system 40, so that it is also possible to apply different curing strategies to different parts of the recording medium.

[0040] Since the LEDs forming the first radiation source 34 may be controlled (switched on and off) individually by means of the curing system controller 40, the printer can also be used for another application, in which the print data supplied to the print head controller 38 do not just specify the colour in which each pixel is to be printed but also specify one of two different gloss values for each pixel, one of these gloss values being attainable by using the direct cure strategy and the other gloss value being attainable by using the post cure strategy. Then, the print head controller 38 will control the print heads of the first printing element 30 and, via the curing control system 40, the LEDs of the first radiation source 34 for printing each image area with the desired colour and the desired gloss. Optionally, the print heads of the second printing element 32 may also be used for printing pixels for which post cure is to be applied.

[0041] Optionally, the print heads of the second printing element 32 may be offset in the direction y by one half pixel position, and, when direct cure is not required for any part of the image, both printing elements 30, 32 may be used in combination for printing with increased resolution, at least in the direction y. Likewise, the print heads of the two printing elements 30, 32 may be timed such that an increased resolution in x direction is achieved for a given printing speed, or the printing speed can be doubled for a given resolution.

[0042] Fig. 5 is a schematic top plan view of a reciprocating print head carriage 42 of another example of a printer according to the invention. Five print heads 44, e.g. one for each of the colours W (white), C (cyan), M (magenta), Y (yellow) and K (black) are mounted side by side on the carriage 42 and form a row that extends in the main scanning direction y. A first radiation source 34' for direct cure, e.g. in the form of a UV lamp, is arranged at the left end of the row of print heads in Fig. 5. A second radiation source 36' for post cure is arranged at the opposite end of the row of print heads but is mounted on a cantilever 46 so as to offset from the print heads 44 in the direction x. Optionally, as has been shown in phantom lines in Fig. 5, additional radiation sources 34'' and 36'' may be arranged symmetrically with respect to the first and second radiation sources 34', 36'.

[0043] Although not shown in Fig. 5, the print heads 44 and all the radiation sources 34', 36', 34'' and 36'' will be controlled by the print head controller 38 and the curing control system 40 similarly as in Fig. 4.

[0044] When the printer according to the invention, having the carriage 42, is used for carrying out the method according to the invention, e.g. for printing a first sub-image in the form of a white background and a second sub-image in a form of a colour image superposed thereon, the printer is operated in a two pass mode. Fig. 6 illustrates a first pass in which the carriage 42 moves to the right. One of the print heads 44 is used for printing

with white ink, and the first radiation source 34' is switched on for direct cure. Fig. 7 illustrates the second pass, where the carriage 42 moves to the left and the other four print heads 44 are used for printing pixels of the colour image 24. In this pass, the first radiation source 34' may be switched off, but it may also be left active, because it will irradiate only the white background layer that has been cured already. The second radiation source 36' is active in the return pass shown in Fig. 7, but since it is offset in the direction x, it does not cure the pixels that have been printed in this pass, but it rather cures pixels that have been printed one or more passes earlier. Thus, post cure is applied to the pixels of the colour image.

[0045] In another variant of the method according to the invention, the white background (first sub-image) may cover only a part of the area of the recording medium 14 while inks for which post cure should be applied are printed directly onto the surface of the recording medium in other parts of the area (these parts belonging to the second sub-image). Then the first radiation source 34' will be switched on and off during the first pass (Fig. 6) depending upon the type of ink, and post cure will be applied continuously in the second pass.

[0046] Similarly as the printer described in conjunction with Fig. 4, the printer shown in Figs. 5 to 7 may also be used for other purposes. In particular, the lamps of the first radiation source 34' may be switched on and off individually for each pixel while the carriage 42 travels to the right in Fig. 6, so as to apply direct cure selectively only to certain parts of the swath that is printed in this pass. Of course, in such applications, direct cure may not only be applied to white ink but also to ink in any other colour.

[0047] The additional radiation sources 34" and 36" shown in Fig. 5 permit, for example, to apply either direct cure only or post cure only in a (more efficient) single pass mode.

[0048] Fig. 8 illustrates an example where the printer with the carriage 42 is used to perform a method according to the invention in which the first sub-image to be printed is a colour image 24' for which post cure is applied, and the second sub-image is a layer 22' of transparent clear ink that is printed on top of the colour image 24' for enhanced gloss. In two subsequent passes, in which the carriage 42 travels from left to right and back from right to left, the print heads 44 for coloured ink are used for printing the colour image 24'. In these passes, the radiation sources 34' and 34" are switched off, so that no direct cure is performed. In the next pass, from left to right, the radiation sources 34' and 34" (which are both in line with the print heads 44) are both switched on, and the print head for clear ink is used for printing the layer 22'. As soon as the radiation source 34" reaches a pixel of the colour image 24' that has been printed in one of the preceding two passes, it will post cure this pixel. Then, when the carriage moves on and the print head for clear ink reaches the position of the same pixel, a dot of clear

ink will be printed on top of the cured dot of the first sub-image (the surfaces of cured layers are again symbolized by bold lines). Then, the dot of clear ink will be cured immediately (direct cure) by means of the radiation source 34'. The clear layer 22' may also be applied in two passes and in the second pass (the fourth pass of the entire cycle), when the carriage 42 travels again from right to left, the radiation source 34' may be switched off and the radiation source 34" will be switched on for direct cure.

[0049] Fig. 9 shows a top plan view of another example of an ink jet printer 48 according to the invention. Similarly as in Fig. 1, the printer has a reciprocating print head carriage 16'. However, the first radiation source is formed by two UV lamps 50 which are disposed at opposite ends of the rail 18 and have respective optical systems for collimating and focussing the light to be emitted towards the end faces of the carriage 16'.

[0050] Fig. 10 is a front view and shows that the carriage 16' has inclined mirrors 52 for deflecting the light onto the surface of the recording medium 14.

[0051] In the example shown in Figs. 9 and 10, the carriage 16' moves to the right, and the left lamp 50 is active for performing direct cure. When the carriage moves in the opposite direction, the lamp 50 on the right side will be active for direct cure. When post cure is required rather than direct cure, both lamps 50 are switched off, and post cure is performed with the second radiation source 36 (Fig. 9) that may have the same constitution as in Fig. 4.

[0052] Optionally, the optical systems of the lamps 50 may be adjusted automatically to correct the focus when the focal length varies during the travel of the carriage 16'.

[0053] Figs. 11 to 13 show another embodiment of a printer 54 according to the invention. This printer has again the reciprocating print head carriage 16 movable along rail 18. However, a curing system 20' is formed by another carriage 56 that moves along another rail 58 in parallel with the rail 18. The carriage 56 carries first and second radiation sources 58 and 60 that may be switched on and off individually.

[0054] As is shown in Fig. 13, the carriage 56 has a light deflection system 62 that is constituted by prisms, mirrors and the like and is arranged to deflect the light from the first radiation source 58 to a position underneath the track of the print head carriage 16' and the light of the second radiation source 60 to a position further downstream in the sub-scanning direction x.

[0055] When the print head carriage 16 moves from left to right in Fig. 11, the carriage 56 of the curing system trails behind the print head carriage 16. When the print head carriage 16 moves from right to left, as in Fig. 12, the carriage 56 trails behind again. When direct cure is to be applied to the pixels being printed, the first radiation source 58 is switched on, and, via the light deflection system 62, will always irradiate the part of the recording medium 14 where pixels have just been printed. When post cure is to be applied to the pixels being printed, the

first radiation source 58 is switched off, so that no direct cure is performed. The second radiation source 60 will be switched on (or may be left active all the time), so that post cure will be performed several passes of the carriage 16 later, when the part of the recording medium 14 on which the pixels have been printed has reached the position where the light from the second radiation source 60 hits the recording medium.

Claims

1. A method of forming an image by applying radiation curable ink onto a recording medium (14) that is supported on a print surface (12); **characterized in that** the image comprises a first sub-image (22; 24') and a second sub-image (24; 22'), and the method comprises the steps of:
 - (a) applying the first sub-image (22; 24') onto the recording medium (14),
 - (b) curing the first sub-image by applying a first curing strategy,
 - (c) applying the second sub-image (24; 22') onto the recording medium (14), wherein the first sub-image is at least partly covered by the second sub-image, and
 - (d) curing the second sub-image by applying a second curing strategy that is different from the first curing strategy.
2. The method according to claim 1, wherein one of the first and second curing strategy comprises the step of curing using a first radiation source; wherein the other of the first and second curing strategy comprises the step of curing using a second radiation source and does not comprise the step of curing the first sub-image using a first radiation source; and wherein the first radiation source is positioned upstream in a direction of recording medium transport with regard to the second source of radiation.
3. The method according to claim 1 or 2, wherein the first sub-image is a background layer (22) and the second sub-image is a colour image (24) printed on the background layer.
4. The method according to any of the preceding claims, wherein the first sub-image is a colour image (24') and the second sub-image is a layer (22') of clear ink covering the colour image.
5. The method according to any of the preceding claims, wherein a part of the second sub-image is printed directly onto the recording medium.

6. The method according to any of the preceding claims, wherein the sub-images are applied by ink jet printing.

7. The method according to any of the preceding claims, wherein a UV-curable phase change ink is used for at least one of the sub-images.

8. A printer (28) comprising:

- a print surface (12),
- a first printing element (30) disposed at the print surface for printing dots of a first radiation curable ink onto a recording medium (14) on the print surface,
- a second printing element (32) disposed at the print surface for printing dots of a second radiation curable ink onto the recording medium, and
- a curing system arranged to cure the dots by exposing them to radiation, the curing system comprising separate first and second radiation sources (34, 36) arranged to cure the dots with different time lags between the time of printing and the time of curing,

characterized in that the first printing element (30), the first radiation source (34), the second printing element (32), and the second radiation source (36) are disposed **in that** order in a direction (x) of movement of the recording medium (14) relative to the printing elements and radiation sources.

9. A printer (28; 48; 54) comprising:

- a print surface (12),
- a first printing element (30) disposed at the print surface for printing dots of a first radiation curable ink onto a recording medium (14) on the print surface,
- a second printing element (32) disposed at the print surface for printing dots of a second radiation curable ink onto the recording medium, and
- a curing system (34, 36; 34', 36'; 50; 58, 60) arranged to cure the dots by exposing them to radiation, the curing system comprising separate first and second radiation sources (34, 36; 50; 58, 60) arranged to cure the dots with different time lags between the time of printing and the time of curing,

characterized in that a curing control system is arranged to disable the first radiation source (30; 50; 58), which has the smaller time lag, selectively for dots that have been printed with the second printing element.

10. The printer according to claim 8 or 9, wherein the first radiation source (34; 34') comprises a number of lamps controllable for selectively and independently irradiating single dots of ink that have been printed with the first printing element (30). 5
11. The printer according to any of the claims 8 to 10, wherein the first and second printing elements (30, 32) are stationary relative to the print surface (12) and extend over the entire width of the recording medium (14). 10
12. The printer according to any of the claims 8 to 10, wherein the first and second printing elements are mounted on a carriage (16; 16'; 42) that is movable relative to the print surface (12) for scanning the recording medium (14). 15
13. The printer according to claim 12, wherein the curing system (34', 36') or parts (52) thereof are mounted on the same carriage (42; 16') as the printing elements. 20
14. The printer according to claim 12, wherein the curing system (58, 60) is mounted on a separate carriage (56) driven to move in synchronism with the carriage (16) that carries the printing elements. 25
15. The printer according to any of the claims 8 to 14, wherein each of the first and second printing elements comprises at least one ink jet print head (44). 30

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Fig. 1

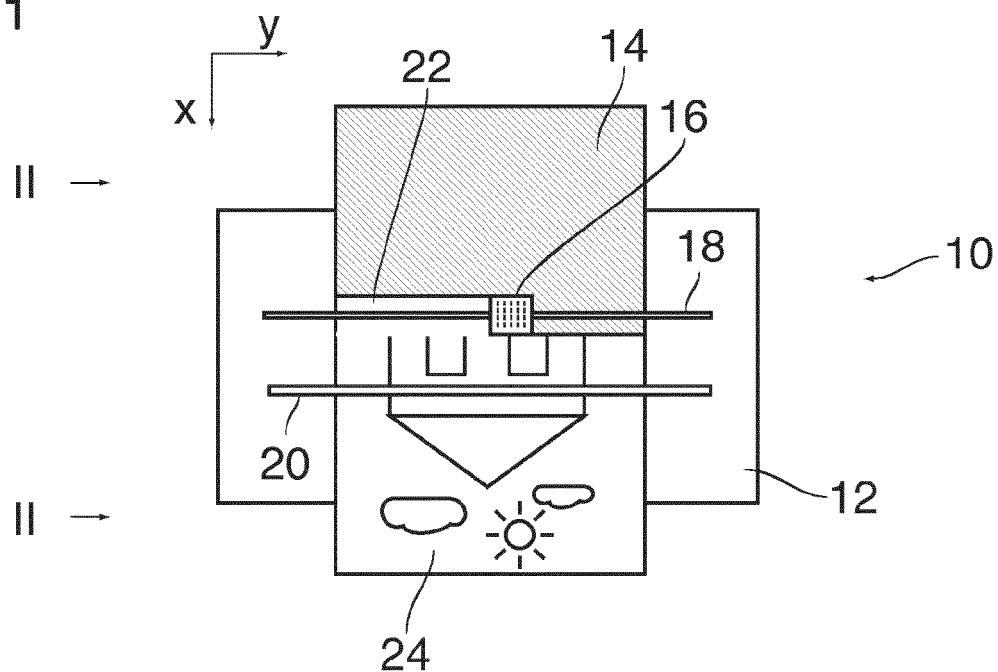


Fig. 2

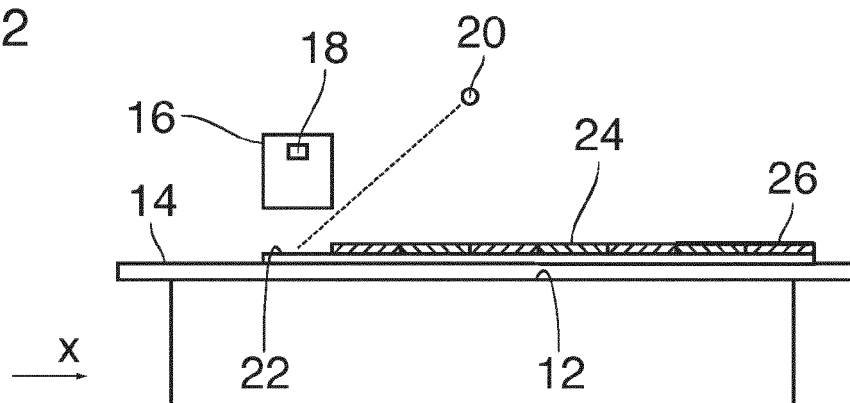


Fig. 3

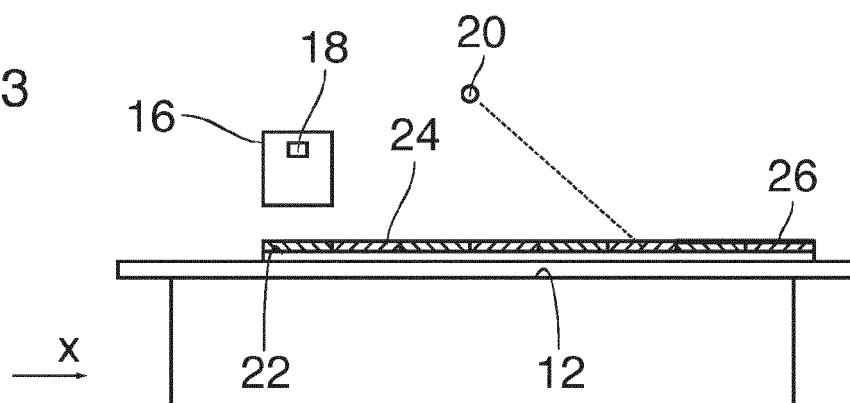


Fig. 4

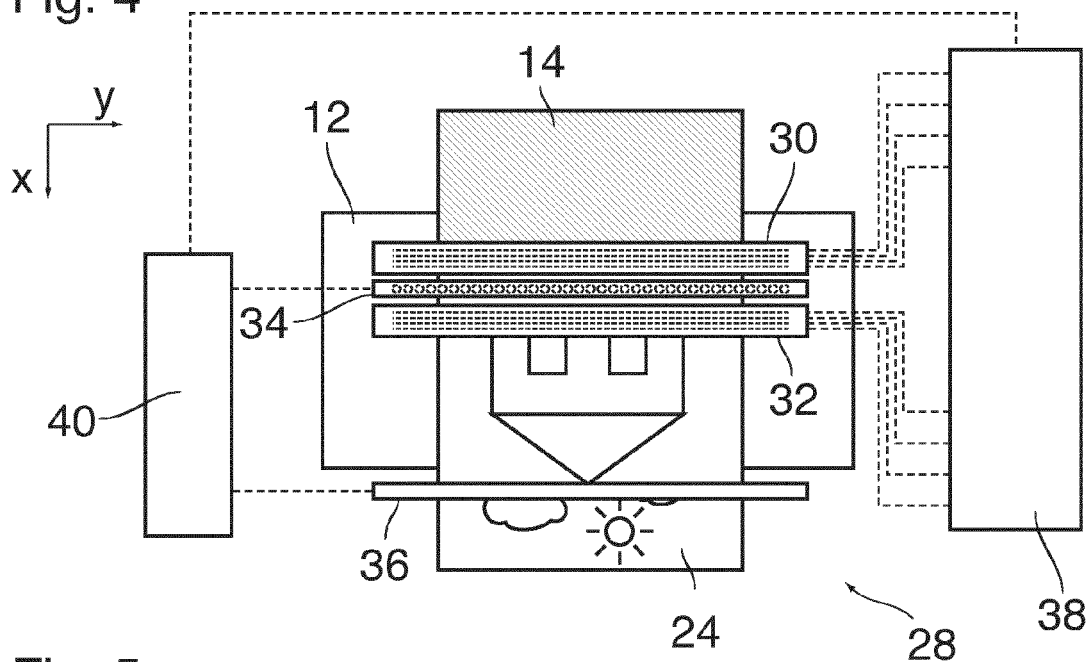


Fig. 5

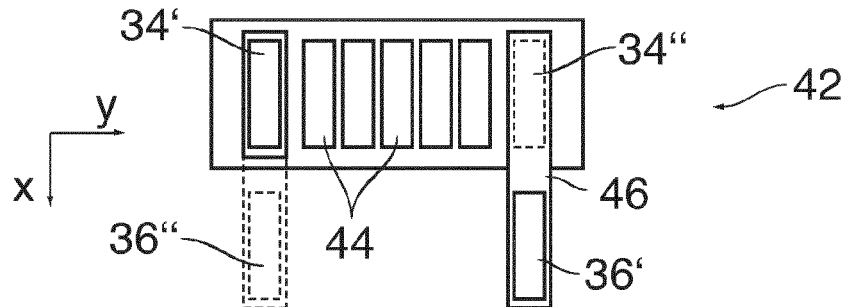


Fig. 6

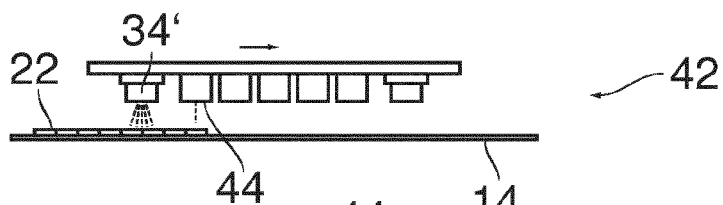


Fig. 7

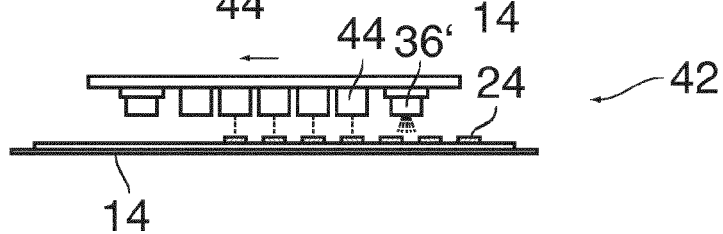


Fig. 8

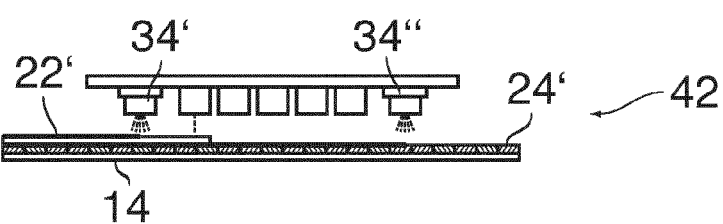


Fig. 9

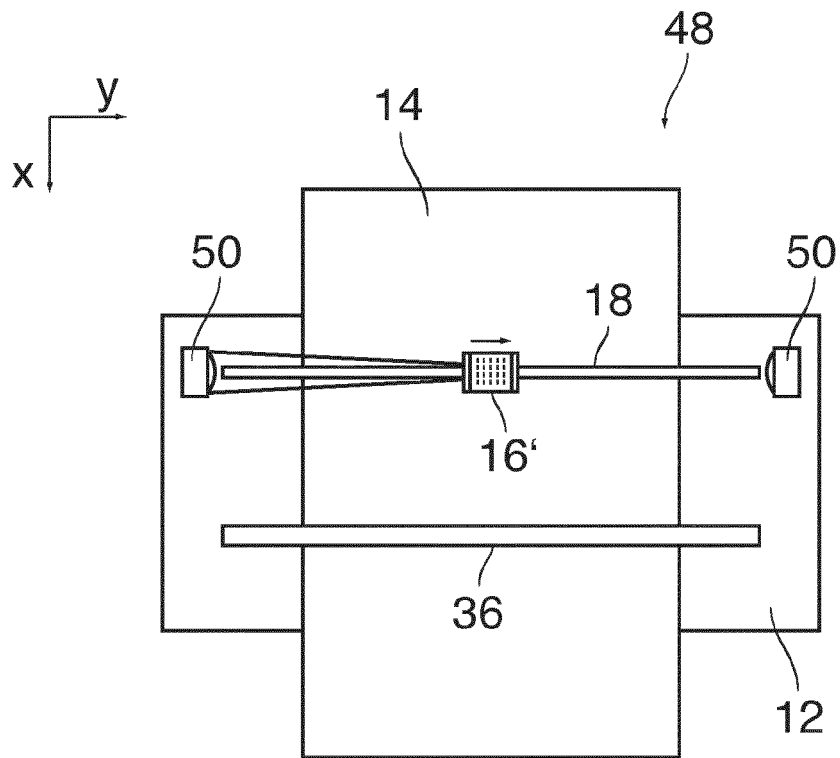


Fig. 10

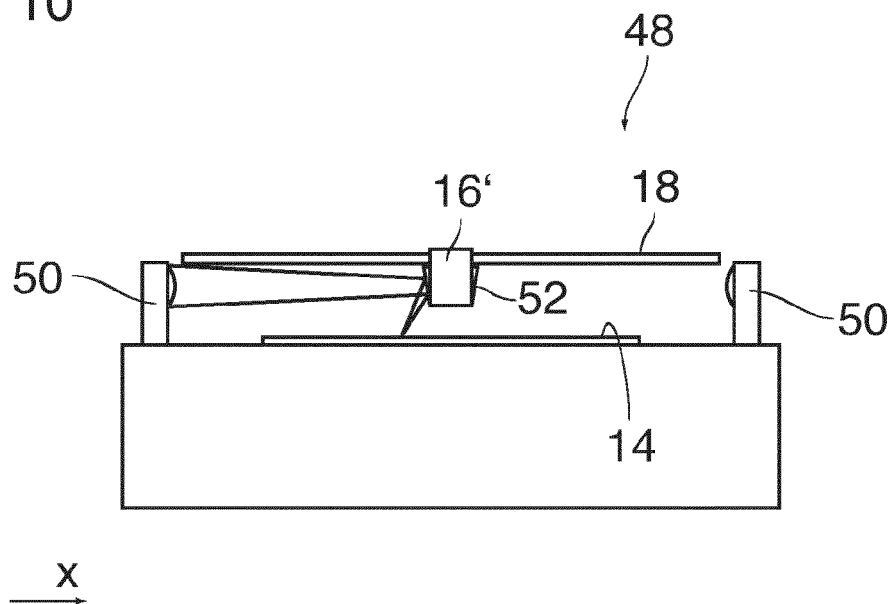


Fig. 11

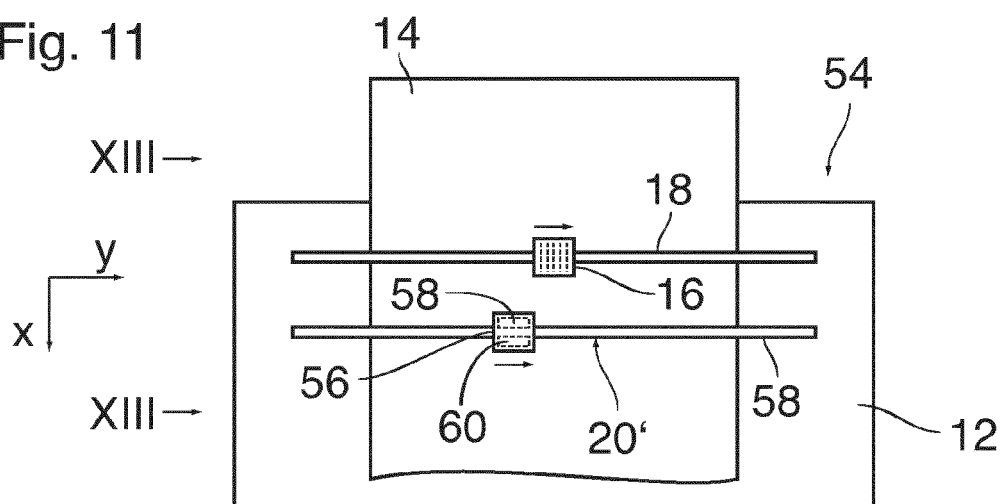


Fig. 12

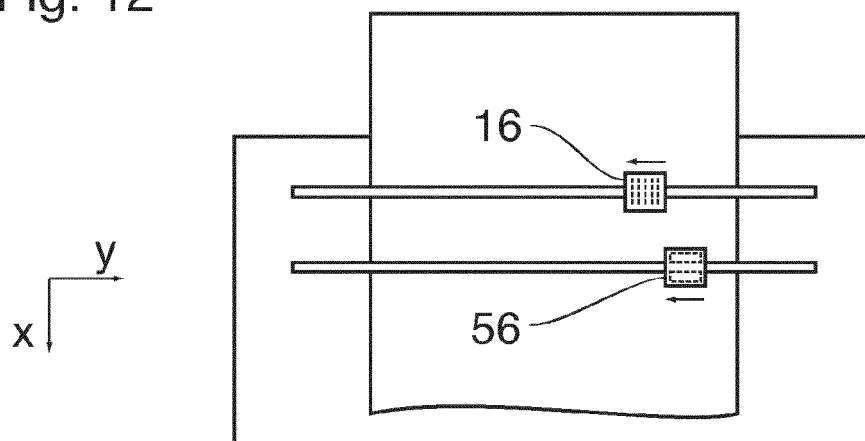


Fig. 13

