METHOD AND DEVICE FOR MONITORING AND/OR CORRECTING THE ALIGNMENT OF AN INK-JET PRINTER

To monitor the alignment of an ink-jet printer (1), a test pattern (40) can be printed on a substrate (3). According to the invention, the substrate (3) comprises a main substrate (30) and an auxiliary substrate (31), the normal patterns being printed on the main substrate (30) and test patterns being printed on the auxiliary substrate (31). In this case, the main substrate (30) and the auxiliary substrate (31) may be made from different materials. A printed test pattern (40) may, in digital form, be compared with an ideal test pattern (40'), and on the basis of this comparison a correction signal is transmitted in order to correct the alignment of the ink-jet printer (1). The correction is preferably carried out to some extent by varying the amplitudes of charging pulses (6) with which the droplets (2) are charged.
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Short title: Method and device for monitoring and/or correcting the alignment of an ink-jet printer

The invention relates to a method for monitoring the alignment of an ink-jet printer which, for the purpose of printing patterns on a substrate, comprises ink-jet means for producing ink droplets, charging means for charging the droplets, and deflection means for deflecting the charged droplets, which method comprises printing at least one pattern. A method of this type is known in practice.

The ink-jet means of an ink-jet printer in practice comprise one or more heads, each containing one or more ink-jets. These jets (or nozzles) may be arranged in an array. The jets produce ink droplets which are provided with an electrical charge and in an electrical field are deflected to the desired position on the substrate.

Generally, a plurality of droplets (for example 2 to 15 droplets) are used to form a pixel on the substrate. In the case of colour printing, droplets from different jets are used to form a pixel. It will be clear that the jets have to be very well aligned with respect to one another in order to obtain a good picture quality.

To monitor and, if necessary, correct the alignment of the jets, it is possible to print a test pattern on the substrate. However, this presents the problem that the substrate is not always suitable to have a test pattern printed on it. Firstly, it may be undesirable to disrupt, for example, a series of patterns which has been applied to the substrate. Also, material is lost if that part of the substrate to which the test pattern is applied is cut off. Secondly, the material of the substrate may be less suitable for accurate monitoring of the alignment on the basis of a test pattern. If the substrate has a relatively rough surface, as is generally the case with textiles for example, it will not be possible to notice slight
inaccuracies in the alignment.

In order to counteract these drawbacks, it has been proposed to employ a separate auxiliary substrate for test patterns to be printed on. By using an auxiliary substrate, it is possible to print a test pattern substantially independently of other, regular patterns and without disrupting these other patterns on the main substrate. Moreover, the print quality of the test pattern is made independent of the material of the (main) substrate on which the other patterns are printed. Smooth paper, for example, may be used for the auxiliary substrate. The drawback of this use of a separate auxiliary substrate is the fact that after the alignment has been monitored and, if appropriate, corrected the auxiliary substrate has to be replaced with the actual substrate. This involves additional time and operations.

It is an object of the invention to eliminate the drawbacks mentioned above, as well as other disadvantages of the prior art, and to provide a method for monitoring the alignment of an ink-jet printer, with which a test pattern can be printed which makes it possible to achieve accurate monitoring. It is a further object of the invention to provide a method of this nature which is efficient and involves minimum disruption to the printing process.

According to the invention, for this purpose a method of the type mentioned in the preamble is characterized in that the substrate comprises a main substrate and an auxiliary substrate, and in that a test pattern is printed on the auxiliary substrate in the presence of the main substrate. This ensures that test patterns and regular patterns can be printed without having to change the substrate. It will be clear that a considerable saving on time and cost can be achieved in this way.

The invention is based on the insight that in order for the alignment to be monitored easily and quickly, the auxiliary substrate has to be a substantially permanent presence in the ink-jet printer. By printing the test
pattern while the main substrate is also present in the
ink-jet printer, it is possible to print a test pattern
virtually at the same time as the actual printing process.
This makes it possible to monitor the print quality almost
continuously.

The main substrate and the auxiliary substrate are
preferably made from different materials, such as textile
and paper, respectively. In this way, it is possible to
print the test pattern or test patterns on relatively
smooth paper, even if the other patterns are printed on
textile or relatively rough paper.

The main substrate and the auxiliary substrate may
be fixedly connected to one another, for example in the
form of parallel strips which can be attached to one
another by adhesive bonding. Arranging the main substrate
and the auxiliary substrate next to one another has the
advantage that the ink-jet means and/or the substrate have
to be moved over only a relatively small distance in order
for a test pattern to be printed. However, since in general
a test pattern will not be printed continuously, a large
part of the auxiliary substrate remains unused in this
embodiment.

Advantageously, therefore, the main substrate and
the auxiliary substrate are arranged separately from one
another and are preferably transported at different speeds.
This makes it possible to make a considerable saving on the
amount of auxiliary substrate required. This method also
provides a greater level of flexibility, since in this way
the test patterns can be made independent of the patterns
which are printed on the auxiliary substrate.

Although the main substrate and the auxiliary
substrate, which is not attached to the main substrate, may
be arranged next to one another, they are advantageously
arranged crosswise. Crosswise directions of transport
provide a greater freedom in designing the ink-jet printer.
Moreover, the test patterns are available for monitoring at
an earlier time, since they are removed from the main
substrate more quickly.

Using the method according to the invention, the
alignment of an ink-jet printer can be corrected by recording the printed test pattern, comparing the said test pattern with an ideal test pattern, and providing at least one correction signal on the basis of the comparison. Preferably, the comparison takes place in digital form. The correction may be carried out by varying the times and/or amplitudes of charging pulses supplied to the charging means in dependence on a correction signal.

Preferably, according to the invention, in a first correction action, a correction is carried out by varying the amplitudes of the charging pulses, and then, in a second correction action, correction is carried out using the times of the charging pulses. Correction by means of varying the amplitudes of charging pulses supplied to the charging means may also take place irrespective of whether an auxiliary substrate is used.

The invention furthermore provides a device for monitoring the alignment of an ink-jet printer, comprising image recording means for recording a test pattern, and comparison means for comparing the recorded test pattern with an ideal test pattern and for supplying a correction signal to the ink-jet printer in dependence on the comparison.

The invention will be explained in more detail below with reference to the drawing, in which:

Fig. 1 diagrammatically shows part of an ink-jet printer in which the invention can be used;

Fig. 2 diagrammatically shows a substrate for use in the method according to the invention;

Fig. 3 diagrammatically shows a device according to the invention for monitoring the alignment of an ink-jet printer;

Fig. 4 diagrammatically shows a first test pattern which can be used in the method according to the invention;

Fig. 5 diagrammatically shows a second test pattern which can be used in the method according to the invention;

Fig. 6 diagrammatically shows a third test pattern which can be used in the method according to the invention.

The ink-jet head 10 of an ink-jet printer 1 which
is diagrammatically illustrated in Fig. 1 comprises an ink-jet nozzle 11 which produces a jet 20 directed at the substrate 3. At the charging electrode 12, the jet 20 breaks up into separate ink droplets 2. The break-up rhythm, and therefore the number of ink droplets 2 produced per second, can be influenced by arranging a vibrator (not shown) on the jet nozzle 11. Charging pulses 6 are supplied to the charging electrode 12 via an amplifier 15. This results in a voltage difference between the charging electrode 12 and the jet 20 which is electrically earthed via the jet nozzle 11. As a result, each of the droplets 2 formed will be electrically charged under the influence of the charging pulses 6. By supplying the charging pulses 6 to the amplifier 15 in the rhythm with which the droplets 2 are formed at the end of the jet 20, each droplet 2 may be given a separate charge.

A DC voltage is fed to the deflection electrodes 13, with the result that an electrical field prevails between these electrodes. Under the influence of the electrical field, the droplets 2 are deflected to a greater or lesser extent depending on their charge. In the case illustrated, charging pulses 6 with four different voltage levels are used, namely V0, V1, V2 and V3. Under the influence of a charging pulse with voltage V0, which may be equal to 0 volts, the droplets 2 are deflected towards the collection element ("blade") 16. These collected droplets do not reach the substrate, but rather are discharged, possibly for reuse. Charging pulses with voltages V1, V2 or V3 cause the dots to be moved into three different positions on the substrate, as shown in Fig. 1. In this way, three different pixels can be formed substantially at the same time. In this way, by moving the head 10 with respect to the substrate 3, three image lines are printed substantially at the same time.

Obviously, it is possible to generate charging pulses with only two different voltage levels (V0 and V1), with the result that the droplets are either guided to a (fixed) position on the substrate or are collected.

In practice, the ink-jet printer 1 may contain a
large number of components which, for the sake of clarity, are not shown in Fig. 1. The ink-jet printer 1 may also contain a plurality of ink-jet heads (print heads) 10, and each ink-jet head 10 may contain a plurality of jets 11.

Fig. 2 diagrammatically shows a plan view of a substrate 3 according to the invention. Patterns are printed on a main substrate 31. The main substrate may in this case be made from textile, paper or plastic. An auxiliary substrate 32, which is preferably made from relatively smooth paper, is arranged next to the main substrate. In this case, the ink-jet printer will preferably be controlled in such a manner that a test pattern 4 is always printed on the auxiliary substrate 32, while the image to be printed is printed on the main substrate 31. The main substrate 31 and the auxiliary substrate 32 may be transported at different speeds.

The fact that the paths of the substrate parts 31 and 32 intersect one another simplifies the design of the ink-jet printer and increases its user-friendliness.

The device 9 which is diagrammatically illustrated in Fig. 3 for monitoring the alignment of an ink-jet printer comprises a camera 91 and a comparison unit 92. The camera 91 is, for example, a CCD camera (CCD = Charge Coupled Device) which transmits a digital image. The auxiliary substrate 3 is moved in the direction indicated by means of rolls 30. In the case illustrated, the main substrate 31 is being transported perpendicular to the plane of the drawing.

The camera is directed at a part of the auxiliary substrate 32 which is situated downstream with respect to the deflection electrodes 13, charging electrode 12 and jet nozzle 11 (illustrated only diagrammatically) of the ink-jet printer. Preferably, the camera 91 is only directed at the auxiliary substrate 32 (cf. Fig. 2), on which a test pattern is printed periodically, or at the start of a new printing process (for example after a head has been changed), and not at the main substrate 31. The test pattern recorded is fed to the comparison unit 92 which may, for example, comprise a microprocessor. In the
comparison unit 92, the test pattern 4 which has been recorded by the camera 91 is compared with a stored ideal test pattern 4'. This comparison preferably takes place in digital form. A correction signal C is generated on the basis of the comparison and is supplied to a control unit 14 of the ink-jet printer 1. The comparison unit 92 may also transmit a quality signal Q which represents a measure of the quality of the signal.

Fig. 4 shows a first test pattern which can be used in the method according to the invention. The test pattern illustrated comprises a number of lines 41 which are printed using separate jets. In the case illustrated, sixteen jets are used, which are each able to print five pixels substantially at the same time and therefore to simultaneously print five lines during one strike (movement of the print head of the ink-jet printer with respect to the substrate). In each case only the first and fifth lines are printed in the test pattern 4.

The correction of the alignment of the ink-jet printer on the basis of a recorded test pattern is carried out as follows. Firstly, the reference lines 42 of the recorded test pattern 4 are matched to the corresponding reference lines of the ideal test pattern (4'). Then, the distances between the lines 41 of the test pattern 4 and the corresponding lines of the ideal test pattern (4') are determined. This is carried out, for example, by determining the distance from a printed line 41 to a line 42 and subtracting this measured distance from the distance in the ideal test pattern (4') from the corresponding line to the reference line. The difference is the deviation Δx. The distance between the first and last lines (in this example the first and fifth lines) of each jet is also determined. The number of volts per millimetre (dV/dx) required for correction can also be calculated from the difference between the charge voltages of the first and last lines and the distance between these lines. The difference Δx measured can be used to calculate the correction voltage ΔV required for each line.

Furthermore, it can be checked whether all the
lines have been printed and whether the quality of the
printed lines is adequate. If necessary, a fault message
can result from this check. Finally, the correction values
are determined on the basis of the previously determined
distances between the lines. Following correction, the test
pattern 4 can be printed again, and then the correction
process can be repeated using the same test pattern. If a
correct setting is obtained for this test pattern, the
correction may, if necessary, be continued with other test
patterns.

The test pattern shown in Figure 4 is preferably
used to align the jets within an array of jets with respect
to one another by means of amplitude correction. If an
array contains, for example, eight jets (for example for
eight different colours), the test pattern 4 of Figure 4 is
preferably printed eight times in succession. The test
pattern shown in Figure 5 can then be used to align the
arrays with respect to one another. In the test pattern
shown in Figure 5, each array of a jet head has a picture
line printed using in each case a different jet. All the
picture lines of this test pattern are the bottom (in this
elementary example fifth) picture line of the jet in question, and all
the other picture lines are deflected and collected.

While the test patterns shown in Figures 4 and 5
are used for correction in the vertical direction (y-
direction), the test pattern shown in Figure 6 is used for
correction in the horizontal direction (x-direction). All
the jets in a number of arrays (four in the example
illustrated) are used in each case to print a vertical
line. By then again determining the distances between these
vertical lines and reference lines, it is possible to carry
out suitable corrections.

The actual correction can be carried out by varying
the times at which the charging pulses 6 occur (cf. Fig.
1). According to the invention, the correction may also be
carried out by varying the amplitudes of the charging
pulses 6, for example on the basis of a correction voltage
AV. Preferably, in the first instance, for example for a
first test pattern, correction is only carried out on the
basis of the amplitudes of the charging pulses. Then, in a second instance, for example on the basis of a further test pattern, a further correction is carried out by varying the times of the charging pulses. In this way, it is possible to achieve a very accurate setting of the ink-jet printer.

It will be understood by the person skilled in the art that the invention is not limited to the exemplary embodiments illustrated and that numerous modifications and additions are possible without departing from the scope of the invention.
CLAIMS

1. Method for monitoring the alignment of an ink-jet printer (1) which, for the purpose of printing patterns on a substrate (3), comprises ink-jet means (11) for producing ink droplets (2), charging means (12) for charging the droplets (2), and deflection means (13) for deflecting the charged droplets, which method comprises printing at least one pattern, characterized in that the substrate (3) comprises a main substrate (31) and an auxiliary substrate (32), and in that a test pattern (4) is printed on the auxiliary substrate (32) in the presence of the main substrate (31).

2. Method according to claim 1, characterized in that the main substrate (31) and the auxiliary substrate (32) are made from different materials, such as textile and paper, respectively.

3. Method according to claim 1 or 2, characterized in that the main substrate (31) and the auxiliary substrate (32) are arranged separately from one another and are preferably transported at different speeds.

4. Method according to claim 3, characterized in that the main substrate (31) and the auxiliary substrate (32) are arranged crosswise.

5. Method according to any of the preceding claims, characterized in that a test pattern (4) is printed periodically.

6. Method according to one of the preceding claims, characterized by recording the printed test pattern (4), comparing the said test pattern (4) with an ideal test pattern (4'), and providing at least one correction signal (5) on the basis of the comparison.

7. Method according to claim 6, characterized by, for use in an ink-jet printer (1) which is designed to print a plurality of rows of pixels simultaneously using an ink-jet (11), comparing only some of the said rows and interpolating and/or extrapolating the other rows in order to generate respective correction signals (5).

8. Method according to claim 6 or 7, characterized by
varying the times of charging pulses (6) supplied to the charging means (32) in dependence on of a correction signal (5).

9. Method according to claim 6, 7 or 8, characterized by varying the amplitudes of charging pulses (6) supplied to the charging means (32) as a function of a correction signal (5).

10. Method for correcting the alignment of an ink-jet printer, which ink-jet printer (1), for the purpose of printing patterns on a substrate (3), comprises ink-jet means (11) for producing ink droplets (2), charging means (12) for charging the droplets (2), and deflection means (13) for deflecting the charged droplets, which method comprises printing at least one test pattern, characterized by recording the test pattern (4), comparing, in digital form, the test pattern (4) with an ideal test pattern (4'), and varying the amplitudes of charging pulses (6) supplied to the charging means (12) in dependence on the comparison.

11. Device (9) for monitoring the alignment of an ink-jet printer (1), characterized by:

- image recording means (91) for recording a test pattern (4), and

- comparison means (92) for comparing the recorded test pattern with an ideal test pattern (4') and for supplying a correction signal to the ink-jet printer (1) in dependence on the comparison.

12. Ink-jet printer (1) for printing patterns on a substrate (3), comprising ink-jet means (11) for producing ink droplets (2), charging means (12) for charging the droplets (2), and deflection means (13) for deflecting the charged droplets, characterized by a device (9) according to claim 11.

13. Ink-jet printer (1) for printing patterns on a substrate (3), comprising ink-jet means (11) for producing ink droplets (2), charging means (12) for charging the droplets (2), and deflection means (13) for deflecting the charged droplets, characterized by a main substrate (31) for an image to be printed on and an auxiliary substrate (32) for a test pattern (4) to be printed on.
(32) for a test pattern (4) to be printed on.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B41J29/393 B41J2/07

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)
IPC 6 B41J

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>EP 0 558 284 A (VIDEOJET SYSTEMS INT) 1 September 1993 see column 3, line 3 - line 53; figure 1</td>
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<td>US 4 551 731 A (LEWIS JOHN D ET AL) 5 November 1985 see column 3, line 12 - column 4, line 33; figures 1-3 see abstract</td>
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