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Amended claims in accordance with Rule 86 (2) EPC.

(54) A method for increasing the reliability of an inkjet printing system

(57) Based upon the analysis of print data for a printing element of an inkjet printhead, the printing element's actuating means are left inactive (not driven) if the print data does not require the printing element to eject an ink drop. Successive occurrences of such events provide a continuous period of inactivity for the printing element, i.e. a period of rest allowing the ink in the printing element and the printing element itself to recover from the excitations enforced by preceding drop ejection processes. Periods of inactivity of a printing element are interrupted at regular time intervals by driving the printing element's actuator with a precursor signal to prevent latency problems associated with inactive printing elements.

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a solution for increasing the reliability of ink jet printing processes and apparatus. More specifically the invention is related to a method for driving an ink jet print head and an ink jet printing apparatus embodying the method.

BACKGROUND OF THE INVENTION

[0002] Ink jet printing has become an established technology for conveying information generated by computing devices to the general public. One of the technologies frequently used in the industrial printing environment, is the drop on demand (DOD) ink jet technology wherein ink drops are ejected from a nozzle of a print head only upon request, depending on the image data. There are two main categories of drop on demand ink jet technologies: thermal DOD ink jet and piezo DOD ink jet. The difference between both technologies is related to the actuating means driving the drop ejection process, i.e. the way the ejection of a drop is initiated. In thermal DOD ink jet, a heater element within the ink chamber causes rapid thermal expansion of a small volume of ink within an ink chamber thereby creating a pressure pulse in the ink that causes a drop of ink to be squeezed out through a nozzle at an end of the ink chamber. In piezo DOD ink jet, piezoelectric material is used to construct part of the ink chamber walls. The piezoelectric material may cause rapid changes of the ink chamber volume, thereby creating a pressure pulse in the ink contained in the ink chamber and squeezing a drop of ink through a nozzle at an end of the ink chamber. In DOD ink jet printing there are several phenomena that may reduce the reliability of the drop ejection process. A first phenomenon is nozzle blockage, caused by deposits of external dust (e.g. paper dust) or precipitation of ink particles (e.g. pigments) in the nozzle.

[0003] Another problem may be causes by long periods of inactivity, leading to changes in the physico-chemical characteristics of the ink located in the nozzle and therefore also leading to a shift of the optimal operating conditions for the drop ejection process. This problem is often referred to as latency. Still another problem for the drop ejection process is heat dissipation by the thermal heating elements or the piezoelectric material into the ink contained in the ink chamber. Because the amount of heat dissipated varies with the printing activity, it contributes adversely to a well-defined and reliable operating window for the drop ejection process. A third phenomenon is the growth of gas bubbles in the ink chamber as a result of rectified mass diffusion caused by the large acoustic pressure field during the drop ejection process. Gas bubbles or seeds (nuclei) may be introduced in the ink chamber through an uncontrolled breakage of the meniscus during drop ejection or because of an improper dissolved gas level concentration of the ink resident in the ink chamber. Gas bubbles reduce the effectiveness of the actuating means in creating the pressure waves driving the drop ejection process. Gas bubbles absorb the acoustic energy. They often inhibit the ejection of drops from the nozzle.

[0004] Solutions for temperature control of the print head have been proposed in US 6 270 180 to Arakawa et al and US 6 827 428 to Silverbrook. These patents disclose methods and apparatuses having means for print head temperature measurement and operating with dedicated heating signals for driving the actuating means prior to the printing or between periods of printing. The heating signals cause heat dissipation in the ink without ejecting ink drops from the printing elements.

Latency control has been disclosed in US 6 431 674 to Suzuki et al, US 6 508 528 to Fujii et al and US 6 619 777 to Chang. These documents disclose dedicated drive signals with the intention to create minute vibrations of the nozzle meniscus of a printing element without ejecting a drop from that nozzle. In US 6 431 674 to Suzuki et al and US 6 508 528 to Fujii et al, these latency signals are applied to the printing element actuators during a preset period of time before or after a printing operation, i.e. in non-printing time. In US 6 619 777 to Chang a latency signal may be applied during the printing operation and replaces the drive signal corresponding with 'no drop ejection' at the specific pixel location.

A problem of gas bubbles in the ink chamber is in the prior frequently tackled with an active restoration operation, often referred to as a purging operation, wherein the ink chamber is purged (flushed) with ink, with the purpose to drain the gas bubble together with the ink. During this operation, a lot of ink is drained and a lot of operating printing time is wasted because the purging operation requires the print head to move and position itself relative a dedicated service station with appropriate nozzle capping, cleaning and purging means. In US 6 435 672 to Gröninger et al a solution has been proposed eliminating such an active restoration operation. According to the **'672** patent, when a gas bubble is detected, the ink chamber is left on its own for a predetermined period of time without driving the actuating means of the printing element. This time allows the printing elements to re-establish its normal operating conditions before resuming the printing operation. This approach could be referred to as self-restoration instead of active restoration of a failing printing element. Although this solution reduces the amount of active restoration operations that are required during a printing operation, it has a disadvantage that the method reduces overall printer throughput by interrupting the printing to allow self-restoration of the printing element, unless the printing is continued anyhow and the printing artefact from the non-operational printing element is accepted for the duration of the self-restoration time.

[0005] It would be an advantage for industrial and/or high-throughput ink jet printing devices to increase the

reliability of the printing device without losing valuable print production time that is to be allocated to print head maintenance or nozzle recovery.

SUMMARY OF THE INVENTION

[0006] The above-mentioned advantageous effects are realised by a method and an apparatus for executing the method, wherein, based upon the analysis of print data for a printing element of an inkjet printhead, the printing element's actuating means are left inactive (not driven) if the print data does not require the printing element to eject an ink drop. Successive occurrences of such events provide a continuous period of inactivity for the printing element, i.e. a period of rest allowing the ink in the printing element and the printing element itself to recover from the excitations enforced by the drop ejection process. Periods of inactivity of a printing element are interrupted at regular time intervals by driving the printing element's actuator with a precursor signal to prevent latency problems associated with inactive printing elements. Specific features for preferred embodiments of the invention are set out in the dependent claims.
Further advantages and embodiments of the present invention will become apparent from the following description.

DETAILED DESCRIPTION OF THE INVENTION

[0007] Before describing in detail preferred embodiments of the invention, some printing terms used hereinafter will be defined.
During a printing operation, a series of drops is ejected from a printing element and deposited onto the receiving medium as a pattern of dots. The deposited pattern is (at least partly) defined by the relative movement between the receiving medium and the printing element. The drop ejection process in the printing element is synchronized with the relative movement of the receiving medium versus the printing element (or vice versa) such that the dots are printed at predefined locations on the receiving medium i.e. a print raster. A print raster is used in the digital represent of an image. A print raster typically is a two-dimensional grid of individual points, referred to as pixels.
[0008] In single pass ink jet printers, that are characterized by having a fixed print head and a transport system that moves a receiving medium passed the print head while the print head is printing, the relative movement of the receiving medium versus the print head results in the printing of dots in a first direction on the receiving medium (further referred to as the scan direction) and the multiple printing elements of the print head, often arranged in a linear array, simultaneously print dots in a second direction (further referred to as the print direction). A series of printed dots along the print direction is referred to as a print line and a series of dots along the scan direction is referred to as a scan line.
Swath ink jet printers are characterized by having a limited width print head and require additional stepping of the print head relative to the receiving medium (or vice versa) in the print direction to cover the full print width. Typically a print head moves in a scan direction back and forth across a receiving medium while printing a swath of the digital image and the receiving medium moves stepwise between two print head scans along a print direction perpendicular to the scan direction. Successively printed swaths overlap or adjoin each other in the print direction to create a contiguous image.
[0009] In the description, reference is made to a piezo DOD ink jet print head, although the invention is also applicable to thermal and other types of drop on demand ink jet print heads. In general, the drop ejection process in ink jet print heads is controlled in the nozzle of a printing element. For a drop to be ejected from a nozzle, the ink surface tension at the nozzle meniscus must be overcome and the ink volume in the nozzle is accelerated to provide enough kinetic energy to the ink drop ejected from the nozzle. In piezo DOD ink jet print heads, the energy to eject a drop of ink from a nozzle is provided through piezoelectric actuators. These piezoelectric actuators are designed to quickly change the volume of the ink chamber by deformation of a wall (or part of a wall) of the ink chamber. The sudden volume changes impose pressure waves on the ink contained in the ink chamber, travelling towards the open nozzle of the ink chamber and causing ejection of a volume of ink out of the nozzle. Since the drop ejection process is linked to the action of pressure waves in the ink chamber, air bubbles resident in the ink chamber can be real show stoppers for the drop ejection process because they absorb the pressure and damp the pressure waves imposed by the actuators, thereby leaving insufficient energy to eject a drop of ink through the nozzle. Air bubbles may find their way into the ink chamber as a result of an uncontrolled drop ejection process, e.g. uncontrolled meniscus breakage and restoration due to accidental particles in or near the nozzle. Air bubbles may also get entrapped as a result of insufficient degassing of the ink supplied to the ink chamber or the phenomenon of bubble growth by rectified diffusion. They may also get entrapped during accidental mechanical impact on the print head, e.g. impact with the receiving medium during medium transport.
[0010] In US 6 435 672 it is disclosed that some of the disturbances caused by entrapped air bubbles may be resolved by interrupting the printing, i.e. not driving the printing element for a predetermined period of time. According to the **'672** patent, such a period of inactivity of a printing element is launched after detection of a drop ejection problem with the printing element (referred to in the **'672** patent as a disturbance in the ink chamber). We have found that regular periods of not driving a printing element may be beneficial towards the prevention of disturbances in the drop ejection process. It has been shown that the mean time between failure of a printing element increases when periods of inactivity are introduced regularly, irrespectively of drop ejection disturbances or fail-

ure. The introduction of regular periods of inactivity may therefore postpone or even cancel unexpected interruptions of the printing operation. Experiments have been conducted with arrays of 7440 printing element (24 printhead having 310 nozzle each) on a .Factory single pass printing press from Agfa-Gevaert NV (BE), allowing continuous printing. Solid areas where printed (i.e. a printing element duty cycle of 100%). The printing elements operated at a jetting frequency of 4.8 kHz. A UV-curable ink was used at an operating temperature of 45°C. In a reference experiment, the average failing nozzle rate without the use of inactivity periods was 1.1 failing nozzle per liter of ink jetted. The failing rate decreased to 0.28 failing nozzle per liter ink jetted when inactivity periods of 0.5 s were inserted every 19.85 s. The failing further decreased to 0.21 failing nozzle per liter ink jetted when inactivity periods of 0.125 s were used every 2.1 s. These results also show that the frequency at which the periods of inactivity are inserted is much more important than the duration of these periods. Different embodiments for realizing regular periods of inactivity for printing elements during normal printing operation, i.e. without interrupting the printing operation and losing valuable print production time, may be thought of and depend on printer configuration, printing mode, kind of print job, etc.

[0011] In swath printers, periods of inactivity are readily available between successive scans of the print head during which the receiving medium is transported and the print head is not printing. Therefore, print heads in swath printers may be regularly brought in an idle state without interrupting the normal printing operation or reducing print production throughput. In single pass printers, this is however not the case. A printing operation in single pass printers may be regarded as a single scan of a page wide print head across the receiving medium. In practice it is often the receiving medium that does the single scan passed a fixed page wide print head. The print head is continuously printing, ejecting drops in synchronism with the transport velocity of the receiving medium, during the whole of the printing operation. A solution for realizing periods of inactivity for print heads or printing elements in a single pass printer configuration, without interrupting the printing operation, is provided by analyzing the print data and searching for blanks in the print data during which no drops are to be ejected from the print head or printing element. This solution will be first described with a focus on a single printing element and will later on be broadened to cover a solution for a complete multi-color printing apparatus. It will be clear from the description hereinafter that, although the solution solves a specific problem of single pass printers, the solution is not limited thereto and is also applicable to swath printers.

[0012] Print data for a digital printing press may be delivered by a printstreamer or press server to the printing press at the printing press's nominal printing speed. The printing press passes the print data on to a print head controller driving the print head. Print data is often structured per print line, the print data for each print line comprising a series of pixel values, one pixel value for each pixel location of the print line to be printed with the printing elements of the print head. The print head controller translates the print data into driving signals (also referred to as waveforms) for the printing element actuators, e.g. a piezoelectric element. The print data may comprise binary pixel values for actuating binary print heads or grayscale pixel values for actuating grayscale print heads.

Next to the print data, the print head controller also receives a print timing signal. The print timing signal is provided in synchronism with the receiving medium transport. It triggers the driving signals for the printing element actuators and therefore controls the timing of the drop ejection process defining the moment a binary or grayscale drop is ejected or 'fired' from the printing element, such that the ejected drop is received on the receiving medium on its targeted pixel location. When the print head controller receives the print data, it examines each pixel value for each individual pixel location and checks whether a drop is to be ejected from a printing element at that pixel location. If the pixel value corresponds to 'no drop to be ejected', it is referred to as a 'zero pixel'. If the print data for a printing element comprises a series of consecutive zero pixels, it corresponds to a part in the image where the printing element is not supposed to print ink drops, i.e. a gap in the scan line. A gap in a scan line provides an opportunity to install a period of inactivity for the corresponding printing element. A period of inactivity for a printing element may be realized by disabling the print timing signal for the printing element, thereby preventing any drive signal from driving the printing element's actuator. It may also be realized by driving the actuator with a 'inactive signal' that is designed to minimize or disable energy input into the printing element. The first method may be required if the print head controller, by default, always inserts a latency signal when no drop is to be ejected from the printing element. Such a feature may be embedded in the print head controller firmware to prevent latency problems. Experiments show that the reliability of a printing element is significantly increased when periods of inactivity of minimum about one tenth of a second can be inserted regularly during normal printing operation In a preferred embodiment, periods of inactivity are chosen to be minimum about 0.3 s. Depending on the print timing signal frequency and the receiving medium transport velocity, this may already be feasible with gaps in the printed image of a few centimeters. Besides gaps in the printed image, also other events may provide an opportunity to install a period of inactivity or an idle time for a printing element. These events may be blanks between successive pages in a print job, a receiving medium standstill (e.g. web standstill or exchange of receiver roles), the preparation time for a print job, etc. During such events, idle periods may be installed without giving in print production time, which is an advantage compared to idle periods installed after detection of a disturbance in the printing element's operation and inter-

ruption of the printing operation as disclosed in the prior art.

[0013] Notwithstanding the beneficial effect of a period of inactivity onto the reliability of a printing element in that it may allow air bubbles to dissolve again the ink or evacuate from the ink chamber towards the ink manifold outside of the action radius of the pressure waves in the ink chamber, the adverse effect of total inactivity of a printing element - known as latency - should be avoided. Latency is the deterioration of ink in the ink chamber and in the nozzle area over time, with a potential negative impact on ink ejection or jetting reliability. Latency is very much depending on the ink composition and the printing environment, e.g. UV curable inks seem to be less susceptible to latency problems than water based inks. We have found that the reliability of a printing element is further increased with the application of a latency signal at regular intervals during a period of inactivity of the printing element. A latency signal, furhter referred to as a precursor signal, is designed to stir the ink in the ink chamber and create a short wobble of the meniscus without ejecting a drop from the printing element. It prevents settling of the ink in the ink chamber, local viscosity increases of the ink in the nozzle (as a result of evaporating of ink compounds), and other physicochemical processes that reduce the fit-to-fire condition of the ink. Different types of precursor signals have been disclosed in the prior art. Their specification strongly depends on the ink jet technology and the actuating means that are used, and configuration details of the printing element (ink chamber length and cross-section, nozzle diameter, etc.). A suitable precursor signal can readily be selected from the prior art. The frequency of application of a precursor signal during a period of inactivity of a printing element is a tradeoff between, on the one hand, avoiding energy input to the printing element to benefit maximally from the inactivity of the printing element and, on the other hand, applying enough stirring of the ink to keep the ink in a fit-to-fire condition. A frequency choice may also depend on the ink type used (e.g. a low frequency for UV curable ink versus a higher frequency for water based ink), the degassing level of the ink, the design of the print head and its susceptibility to the creation and retention of air bubbles in the ink chamber (e.g. through flow print heads are less susceptible to the retention of air bubbles in the ink chamber than end shooter print heads), the operating temperature, etc. Experiments showed , during a period of inactivity and for a UV curable ink having a viscosity between 3 and 15 mPa.s and operated at a temperature of about 40 °C, a precursor signal is preferably applied at a frequency of about 100 Hz. A solution for applying a precursor signal to a printing element during a period of inactivity may be to replace the 'inactive signal' with a 'precursor signal' for one or a number of consecutive zero pixels for the printing element, or enable the print timing signal for the printing element for one or a number of consecutive zero pixels and have the embedded precursor signal in the print head controller drive the printing element actuator.

[0014] The concept as discussed above for a single printing element, may now be extended to a full print head. Embodiments that may be thought of are very much depending on hard- and/or firmware features of the print heads themselves: ink jet print heads may comprise multiple printing elements arranged in one or more arrays, printing element actuators or drive parameters may be individually controllable or en bloc for the entire print head, multiple ink jet print heads may abut each other to create a single page wide print head configuration having a contiguous array of printing elements across the full width of a page, etc. Some embodiments of the invention are discussed hereinafter, without the intention to limit the list of possible embodiments to these examples.

- Assume an ink jet print head having a number of printing elements for which the timing of the drop ejection process is controlled with a common print timing signal. Assume further that a precursor signal is provided in the print head controller firmware that is automatically inserted when the pixel value for a given printing element corresponds with a 'zero pixel'. In this case, the inactivity of a printing element when drop ejection is not required from the printing element is overruled by the precursor signal that is automatically inserted. An embodiment of the invention may therefore include the use of the print timing signal to enforce a period of inactivity to all printing elements of the print head at the same time. The print head controller therefore needs to analyze the print data and detect the absence of a requirement for ejecting an ink drop from every printing element of the print head in a print line, a so called 'zero pixel line', before disabling the print timing signal for the print line to enforce a period of inactivity for all of the printing elements of the print head.

- Assume an ink jet print head having a number of printing elements for which the drop ejection process is synchronized using a single print timing signal for all the printing elements and for which drive signals or drive voltages for the printing element actuators are individually controllable. In this case the drive voltage for a printing element, for which the print head controller has detected a 'zero pixel', may be set to a non-energizing voltage (e.g. 0 Volt) putting the printing element de facto in a state of inactivity, independent of the activity of other printing elements in the print head that may still be ejecting drops when a print timing signal is applied. The embodiment has an additional advantage that a preconfigured firmware precursor signal in the print head controller may easily be blocked/overruled when a period of inactivity for the printing element is to be installed by setting a non-energizing drive voltage, and likewise may easily be passed when a precursor signal is to

interrupt the period of inactivity for the printing element by setting a normal drive voltage.

- A print head may have several banks or groups of printing elements, each bank or group being controlled with a separate driver circuitry, e.g. 64 printing elements per driver chip. Depending on the specific features of these driver chips and the way the print head controller accesses these driver chips, the level of controllability of the inactivity of printing elements of the print head may vary from the individual printing element to a group of printing elements associated with a driver chip or to all printing elements in the print head.

- In 'shared wall' piezo DOD print head actuators operating in 'shear mode', the piezoelectric actuators are designed as part of the walls separating neighboring ink chambers. Print head actuators of this type have been described extensively in the prior art, e.g. EP 0 364 136 to Temple. In this type of print head actuators, opposite side walls of an ink chamber can bend inward to reduce the volume of the ink chamber or outward to increase the volume of the ink chamber. The opposite side walls are shared with neighboring ink chambers, i.e. a left side wall shared with a left neighbor ink chamber and a right side wall shared with a right neighbor ink chamber. Driving the piezoelectric side walls of the ink chamber of a printing element not only affects the volume of the ink chamber of that printing element, it also affects the volume of the ink chamber of its neighboring printing elements (although limited to the effect of only one side wall of the neighboring ink chamber). That is one of the reasons why, with ink jet print heads based on a shared wall piezoelectric actuator, neighboring printing elements are preferably not driven simultaneously. Instead, printing elements may be driven every one out of three at the same time. Every first out of three printing elements in the linear array may be allocated to a first set A, every second to a second set B, and every third to a third set C. A print head as described above may be controlled with three individual print timing signals, one for each set of printing elements in the linear array. The print head may also be controlled with a single print timing signal for the complete print head, that is split and delayed internally in the print head controller to trigger the drop ejection process for each of the sets of printing elements in the linear array sequentially. Because of the mutual influence of neighboring printing elements, an embodiment for providing periods of inactivity for printing elements in a shared wall piezo DOD print head may be somewhat different from what has been described before. It may include the detection, in the print head controller, of groups of three neighboring zero pixels in a print line. The middle one of each group of three zero pixels reflects an opportunity for a state of inactivity of the corresponding printing element. In more general terms, the embodiment may include analyzing the print data, detecting a set consecutive zero pixels in a print line, and putting the corresponding printing elements of the set on inactive, except for the utmost printing elements from the set. If the printing elements can not be put inactive on an individual basis, the analysis of the print data may detect the presence of an entire print line of zero pixels and provide a period of inactivity for all the printing elements via disabling of the print timing signal if this situation occurs.

[0015] It is important to note the difference between print data and image data. To explain this difference, assume the printing of a continuous tone (contone) and single color image, e.g. a black & white photograph. This image is made available in digital format for preparing the image for printing during a number of prepress steps (e.g. color management, rendering, etc.). The digital representation of the image typically comprises a number of image pixels (e.g. 1024 x 768 pixels), each image pixel having a gray value (e.g. 0 to 255). The more image pixels used, the more image detail is preserved in the digital representation of the photograph; the more gray values used, the more shades can be represented. Ink jet print heads and printing devices typically have a number of limitations to print the digital representation of an image, e.g. the printing device may have a limited print resolution or the print head may have limited gray scale capability. Therefore a digital image is additionally processed before printing to map the digital representation to the capability of the printing device. This digital image processing is typically executed on a front end system. Some examples:

- The number of image pixels may have to be mapped to a number of print pixels to fit the print resolution of a printing device.
- The range of available gray values per image pixel (e.g. 0-255) may have to be mapped to a range of printable gray values per printed pixel (e.g. 0-15). This may for example result in all image pixels with a gray value between 0 and 15 being mapped into a 'zero pixel' value for the corresponding print pixels.
- Advanced digital image processing techniques such as rendering and error diffusion may be required to compensate for the image quality loss as a result of the above discussed print limitations.

[0016] Aside of prepress actions to preserve as much as possible the original image quality during printing, the preprocessed pixel data needs to be allocated to a print head and to printing elements within the print head for actually printing the pixel data on the receiving medium. It is not always possible to decide in advance which of the pixel data will be printed by a given printing element. This decision may for example depend on the specific

print head configuration of the printing device, on the composition of multiple images in a single print job or the imposition of multiple print jobs on a single printing device, on dedicated shingling techniques used in swath printers to reduce the visibility of a number of print artefact, etc. In view of the invention, it may therefore be preferable to analyze the print data at the print head controller level instead of analyzing image date at the front end system, that is after allocation of print data to printing elements.

[0017] The invention is also applicable to color printing devices after decomposition of a full color image into multiple monochrome image layers (e.g. a Cyan Magenta Yellow and BlacK image layer). At the printing device, each monochrome image layer is printed with dedicated pint head or print head setup allocated for printing the color of that specific monochrome image layer.

[0018] So far, periods of inactivity have been created to prevent the creation and retention of air bubbles in the ink chamber that may disturb the drop ejection process of the printing element. It has been described that periods of inactivity may be inserted without interrupting the printing process. Therefore the print data is analyzed and 'zero pixels' or sequences of 'zero pixels' in the print data for a given printing element are detected. The printing of 'zero pixels' may then be replaced with periods of inactivity of the printing element. Periods of inactivity may be interrupted with regular precursor signals to preserve a fit-to-fire condition of the ink in the ink chamber and in the nozzle.

[0019] Having described in detail preferred embodiments of the current invention, it will now be apparent to those skilled in the art that numerous modifications can be made therein without departing from the scope of the invention as defined in the appending claims.

Claims

1. A method for increasing the reliability of an ink jet printing system comprising at least one printing element having an ink chamber provided with an ink and a nozzle for ejecting ink drops therefrom and actuating means for controlling the drop ejection process, the method comprising the steps of:

    - analyzing print data for the printing element;
    - detecting the absence of a requirement for ejecting an ink drop from the printing element, based on the analyzed print data for the printing element;
    - leaving the actuating means of the printing element inactive if there is no requirement for ejecting an ink drop from the printing element;

    characterised in that the method further comprises the step of interrupting a period of inactivity of the printing element, after a period of time has elapsed, by driving the actuating means with a precursor signal.

2. The method according to claim 1, wherein the step of leaving the actuating means of the printing element inactive includes disabling a print timing signal for controlling the timing of the drop ejection process in the printing element or driving the actuating means of the printing element with an inactive signal for avoiding energy input into the ink chamber.

3. The method according to any one of the previous claims, wherein the period of time is determined by an ink parameter or a printing element operating parameter.

4. The method according to any one of the previous claims, wherein the step of interrupting a period of inactivity of the printing element by driving the actuating means with a precursor signal is repeated at an autoprecursor frequency.

5. An ink jet printing system comprising:

    - a print head having a printing element with an ink chamber provided with a nozzle for ejecting an ink drop therefrom and actuating means for controlling the ejection process;
    - a print head controller for receiving print data and driving the print head according to the print data;
    - the print head controller further comprising means for analyzing the print data and based thereupon detecting the absence of a requirement for ejecting an ink drop from the printing element, and control means for leaving the actuating means of the printing element inactive if there is no requirement for ejecting an ink drop from the printing element;

    characterised in that the system further comprises means for interrupting a period of inactivity of the printing element, after a period of time has elapsed, by driving the actuating means with a precursor signal.

6. The system according to claim 5, wherein the control means for leaving the actuating means of the printing element inactive includes means to disable a print timing signal used for controlling the timing of the drop ejection process in the printing element or to drive the actuating means of the printing element with an inactive signal for avoiding energy input into the ink chamber.

7. The system according to claim 5 or 6, wherein the period of time is adjustable as a function of an ink parameter or a printing element operating parame-

ter.

8. The system according to any one of the claims 5 to 7, wherein the means for interrupting a period of inactivity of the printing element by driving the actuating means with a precursor signal interrupt the period of inactivity of the printing element at an autoprecursor frequency.

Amended claims in accordance with Rule 86(2) EPC.

1. A method for increasing the reliability of an ink jet printing system comprising a print head having at least one printing element, the printing element having an ink chamber provided with an ink and a nozzle for ejecting ink drops therefrom and actuating means for controlling the drop ejection process, the method comprising the steps of:

- analyzing print data for the printing element;
- detecting zero-pixels for the printing element, corresponding with no drop ejection, based on the analyzed print data for the printing element;
- installing a period of inactivity of the printing element, wherein the printing element is not driven, for as long as zero-pixels are detected for the printing element;

characterised in that the method further comprises the step of interrupting a period of inactivity of the printing element, after a period of time has elapsed, by driving the actuating means with a precursor signal for stirring the ink in the ink chamber and wobbling an ink meniscus in the nozzle without ejecting a drop from the printing element.

2. The method according to claim 1, wherein the precursor signal is applied for one or a plurality of consecutive zero-pixels for the printing element.

3. The method according to any one of the previous claims, wherein the step of installing a period of inactivity of the printing element includes either disabling a print timing signal thereby preventing any drive signal from driving the actuating means of the printing element, or driving the actuating means of the printing element with an inactive-signal designed for avoiding energy input into the ink chamber.

4. The method according to any one of the previous claims, wherein the period of time is determined by an ink parameter or a printing element operating parameter.

5. The method according to any one of the previous claims, wherein the step of interrupting a period of inactivity of the printing element by driving the actuating means with a precursor signal is repeated at an autoprecursor frequency.

6. An ink jet printing system comprising:

- a print head having at least one printing element, the printing element having an ink chamber provided with a nozzle for ejecting an ink drop therefrom and actuating means for controlling the ejection process;
- a print head controller for receiving print data and driving the printing element according to the print data;
- the print head controller further comprising:
- means for analyzing the print data and based thereupon detecting zero-pixels for the printing element, corresponding with no drop ejection; and
- means for installing a period of inactivity of the printing element, wherein the printing element is not driven, for as long as zero-pixels are detected for the printing element;

characterised in that the system further comprises means for interrupting a period of inactivity of the printing element, after a period of time has elapsed, by driving the actuating means with a precursor signal for stirring the ink in the ink chamber and wobbling an ink meniscus in the nozzle without ejecting a drop from the printing element.

7. The system according to claim 6, wherein the control means for installing a period of inactivity of the printing element includes means for either disabling a print timing signal thereby preventing any drive signal from driving the actuating means of the printing element, or driving the actuating means of the printing element with an inactive-signal for avoiding energy input into the ink chamber.

8. The system according to claim 6 or 7, wherein the period of time is adjustable as a function of an ink parameter or a printing element operating parameter.

9. The system according to any one of the claims 6 to 8, wherein the means for interrupting a period of inactivity of the printing element by driving the actuating means with a precursor signal interrupt the period of inactivity of the printing element at an autoprecursor frequency.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 11 1567

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

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