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United States Patent 12391035
Kind Code B2
Date of Patent August 19, 2025
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Printing apparatus and printing method

Abstract

First, a correction area, which is a part of area where a second ink (typically, white ink) is to be ejected among the area on base material, is determined. Next, density data is corrected so that the second ink is ejected onto the correction area. Thereafter, actual printing on the base material is started. Then, the second ink is ejected onto the correction area, and a first ink (typically, color ink) is ejected onto the second ink that has been ejected onto the base material in the correction area.

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Appl. No.: **18/458351**

Filed: **August 30, 2023**

Prior Publication Data

Document Identifier	Publication Date
US 20240092078 A1	Mar. 21, 2024

Foreign Application Priority Data

JP	2022-150159	Sep. 21, 2022

Publication Classification

Int. Cl.: **B41J2/045** (20060101); **B41J2/21** (20060101)

U.S. Cl.:

CPC **B41J2/04508** (20130101); **B41J2/04586** (20130101); **B41J2/2114** (20130101);

Field of Classification Search

CPC: B41J (2/04508); B41J (2/04586); B41J (2/2114); B41J (2/2117); B41J (2/2146); B41J (11/00212); B41J (11/00214); B41J (2/2142); B41J (2/2139)

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2014-188785	12/2013	JP	N/A

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Background/Summary

BACKGROUND OF THE INVENTION
Field of the Invention
(1) The present invention relates to a printing apparatus including an ink ejection head (print head) provided with many nozzles for ejecting ink, and a printing method using the printing apparatus.
Description of Related Art
(2) Conventionally, an inkjet-type printing apparatus (hereinafter simply referred to as an “inkjet printing apparatus”) that performs printing by ejecting ink onto base material (printing paper, etc.) is known. In an inkjet printing apparatus, printing is generally performed using aqueous ink. However, in recent years, for example, for label printing, the development of an inkjet printing apparatus that performs printing using ultraviolet (UV) ink (ultraviolet curable ink) has been advanced. In the inkjet printing apparatus using UV ink, the UV ink is irradiated with ultraviolet rays (UV light) in order to fix the UV ink ejected from the ink ejection head to the base material.
(3) With respect to the inkjet printing apparatus, there are individual differences in the nozzles provided in the ink ejection head. For this reason, even when the ink is ejected from many nozzles provided in the ink ejection head based on the same drive signal, the amount of ink ejected from each of those many nozzles varies. When printing is performed in such a state, high-quality printed matter cannot be obtained. Therefore, density uniformity correction that corrects the density of the print data such that the ink is ejected from each of all the nozzles in the same manner is performed.
(4) In the inkjet printing apparatus, ink ejection failure may occur due to the solidification of the ink caused by non-use over a long period of time, or other reasons. When ink ejection failure occurs, the lacking of a dot corresponding to a nozzle in an ejection failure state (hereinafter referred to as a “defective nozzle”), that is, dot missing, occurs in the printed image. Therefore,

nozzle-defect correction that corrects the density of the print data such that the ink to be ejected from the defective nozzle is ejected from another nozzle (typically, a nozzle adjacent to the defective nozzle) is performed. Note that Japanese Laid-Open Patent Publication No. 2014-188785 discloses an example of nozzle-defect correction.

(5) With reference to FIG. **29**, density uniformity correction and nozzle-defect correction will be further described. Here, the focus is directed toward five pixel portions **9**(**1**) to **9**(**5**) corresponding to five nozzles. It is assumed that, in the five pixel portions **9**(**1**) to **9**(**5**), single-color printing is performed with the ink of the same color ejected from the five nozzles. It is assumed that, in print data generated by raster image processing (RIP processing), the densities (dot %) of the five pixel portions **9**(**1**) to **9**(**5**) are all 50 as indicated by the portion denoted by reference numeral **91**. By density uniformity correction, the densities of the five pixel portions **9**(**1**) to **9**(**5**) are corrected, for example, as indicated by the portion denoted by reference numeral **92**. In this example, the nozzle corresponding to the pixel portions **9**(**1**) ejects (5/4) times more ink than the nozzle corresponding to the pixel portion **9**(**2**) based on the same drive signal, and hence the density of the pixel portion **9**(**1**) has been corrected to 40, which is (4/5) times **50**. Also, the nozzle corresponding to the pixel portion **9**(**4**) ejects (5/6) times more ink than the nozzle corresponding to the pixel portion **9**(**2**) based on the same drive signal, and hence the density of the pixel portion **9**(**4**) has been corrected to 60, which is (6/5) times **50**. In this example, among the five nozzles, the nozzle corresponding to the pixel portion **9**(**3**) is a defective nozzle. Therefore, nozzle-defect correction is performed on data indicated by the portion denoted by reference numeral **92**. Thereby, the densities of the five pixel portions **9**(**1**) to **9**(**5**) are corrected as indicated by the portion denoted by reference numeral **93**. In this regard, since the density of the pixel portion **9**(**3**) before nozzle-defect correction is 40, 20 has been added to the density of the pixel portion **9**(**2**), and 20 has been added to the density of the pixel portion **9**(**4**). That is, the density of the pixel portion **9**(**2**) has been corrected to 70, and the density of the pixel portion **9**(**4**) has been corrected to 80.

(6) By the density uniformity correction and nozzle-defect correction as described above, the occurrence of unevenness in the printed image due to the individual difference among the nozzles and the presence of the defective nozzle is prevented.

(7) However, in the case of the occurrence of the defective nozzle, even when an amount of ink to be ejected from the defective nozzle is ejected from another nozzle by performing nozzle-defect correction, printed matter with a defect suitably eliminated may not be obtained. In particular, when a defect occurs in a nozzle corresponding to an area where single-color high-density printing is performed, the dot size of the ink ejected from another nozzle tends to be insufficient to eliminate the defect. Thus, depending on the image to be printed, printed matter of sufficient quality cannot be obtained by the conventional nozzle-defect correction.

(8) An ink ejection head generally includes a plurality of head modules, and color unevenness may occur in an area where there is overlap between an area where the ink is ejected by one head module and an area where the ink is ejected by its adjacent head nozzle. Moreover, there is a strong demand from a user to improve the print quality of a so-called solid image.

SUMMARY OF THE INVENTION

(9) In view of the above circumstances, an object of the present invention is to achieve an inkjet printing apparatus (a printing apparatus that performs printing by ejecting ink onto a printing medium) capable of improving the quality of printed matter.

(10) One aspect of the present invention is directed to a printing apparatus that performs printing by ejecting ink onto a printing medium, the printing apparatus including: a conveyor configured to convey the printing medium; a first ink ejection head including a plurality of ink ejection ports, the first ink ejection head being configured to eject a first ink onto the printing medium conveyed by the conveyor; a second ink ejection head including a plurality of ink ejection ports and disposed on an upstream side of the first ink ejection head regarding a direction in which the printing medium is conveyed by the conveyor, the second ink ejection head being configured to eject a second ink onto

the printing medium conveyed by the conveyor; a correction area determination unit configured to determine a correction area that is a part of area where the second ink is to be ejected among the area on the printing medium; and an ink ejection controller configured to control ejection of the second ink from the second ink ejection head to cause the second ink to be ejected onto the correction area before the first ink is ejected onto the correction area, wherein a wet spreading range of the first ink on the printing medium is larger when the first ink is ejected onto the second ink that is ejected onto the printing medium than when the first ink is directly ejected onto the printing medium.

(11) With such a configuration, the printing apparatus is provided with the first ink ejection head that ejects the first ink and the second ink ejection head that is disposed on the upstream side of the first ink ejection head regarding the conveyance direction of the printing medium and ejects the second ink. When printing is performed for the correction area determined by the correction area determination unit, the second ink is ejected before the first ink is ejected. Here, the wet spreading range of the first ink on the printing medium is larger when the first ink is ejected onto the second ink that is ejected onto the printing medium than when the first ink is directly ejected onto the printing medium. Therefore, in the correction area, the dot size of the first ink is larger than originally intended. Therefore, for example, by defining an area corresponding to a defective nozzle, an area where there is overlap between an area where the ink is ejected by one ink ejection head and an area where the ink is ejected by its adjacent ink ejection head, an area where a solid image is printed, or some other area as the correction area, it is possible to improve the print quality compared to the related art. Thus, a printing apparatus (a printing apparatus that performs printing by ejecting the ink onto a printing medium) capable of improving the quality of printed matter is achieved.

(12) Another aspect of the present invention is directed to a printing method using a printing apparatus that includes a conveyor configured to convey a printing medium, a first ink ejection head configured to eject a first ink onto the printing medium conveyed by the conveyor, and a second ink ejection head configured to eject a second ink onto the printing medium conveyed by the conveyor, the printing method including: a correction area determination step of determining a correction area that is a part of area where the second ink is to be ejected among the area on the printing medium; a second ink ejection step of ejecting the second ink from the second ink ejecting head; and a first ink ejection step of ejecting the first ink from the first ink ejecting head, wherein a wet spreading range of the first ink on the printing medium is larger when the first ink is ejected onto the second ink that is ejected onto the printing medium than when the first ink is directly ejected onto the printing medium, and before the first ink is ejected onto the correction area in the first ink ejection step, the second ink is ejected onto the correction area in the second ink ejection step.

(13) These and other objects, features, modes, and advantageous effects of the present invention will become more apparent from the following detailed description of the present invention with reference to the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** is an overall configuration diagram of a printing system according to a first embodiment of the present invention;

(2) FIG. **2** is a schematic diagram showing a configuration example of an inkjet printing apparatus in the first embodiment;

(3) FIG. **3** is a plan view schematically showing a configuration of a recording unit in the first embodiment;

(4) FIG. **4** is a plan view showing a configuration example of an ink ejection surface of one ink ejection head in the first embodiment;
(5) FIG. **5** is a view for explaining the arrangement of nozzles in a head module in the first embodiment;
(6) FIG. **6** is a block diagram showing a hardware configuration of a print controller in the first embodiment;
(7) FIG. **7** is a view for explaining an outline of white correction in the first embodiment;
(8) FIG. **8** is a view for explaining the ejection of ink in an area where white correction has been performed in the first embodiment;
(9) FIG. **9** is a view showing an example of a result of an experiment regarding the wet spreading of color inks on film base material;
(10) FIG. **10** is a block diagram showing a detailed functional configuration of a density correction processing unit in the first embodiment;
(11) FIG. **11** is a view showing an example of a template for white correction in the first embodiment;
(12) FIG. **12** is a view for explaining the creation of a correction pattern in the first embodiment;
(13) FIG. **13** is a view for explaining the creation of a correction pattern in the first embodiment;
(14) FIG. **14** is a view showing an example of a template for white correction in the first embodiment;
(15) FIG. **15** is a view showing an example of a template for white correction in the first embodiment;
(16) FIG. **16** is a view showing an example of a template for white correction in the first embodiment;
(17) FIG. **17** is a flowchart for explaining a procedure for density correction in the first embodiment;
(18) FIG. **18** is a view for explaining an outline of transparency correction in a first modification of the first embodiment;
(19) FIG. **19** is a view for explaining the ejection of ink in an area where transparency correction has been performed in the first modification of the first embodiment;
(20) FIG. **20** is a view for explaining an outline of yellow correction in a second modification of the first embodiment;
(21) FIG. **21** is a view for explaining the ejection of ink in an area where yellow correction has been performed in a second modification of the first embodiment;
(22) FIG. **22** is a view for explaining an outline of a second embodiment of the present invention;
(23) FIG. **23** is a block diagram showing a detailed functional configuration of a density correction processing unit in the second embodiment;
(24) FIG. **24** is a view showing an example of a template for white correction in the second embodiment;
(25) FIG. **25** is a flowchart for explaining a procedure for density correction in the second embodiment;
(26) FIG. **26** is a block diagram showing a detailed functional configuration of a density correction processing unit in a third embodiment of the present invention;
(27) FIG. **27** is a view for explaining the identification of a correction target nozzle in the third embodiment;
(28) FIG. **28** is a flowchart showing a schematic procedure in a concept encompassing the first to third embodiments; and
(29) FIG. **29** is a view for explaining density uniformity correction and nozzle-defect correction in a conventional example.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

(30) Preferred embodiments of the present invention will be described below with reference to the

drawings.

1. First Embodiment

(31) <1.1 Overall Configuration of Printing System>

(32) FIG. **1** is an overall configuration diagram of a printing system according to a first embodiment of the present invention; The printing system includes an inkjet printing apparatus **10** and a print data generation apparatus **30**. The inkjet printing apparatus **10** and the print data generation apparatus **30** are connected to each other through a communication line **4**. The print data generation apparatus generates print data by performing RIP processing or the like on submitted data such as a portable document format (PDF) file. The print data includes the density data of each of inks of a plurality of colors. The print data generated by the print data generation apparatus **30** is transmitted to the inkjet printing apparatus **10** via the communication line **4**. The inkjet printing apparatus **10** performs printing by ejecting ink onto base material as a printing medium such as a film or printing paper based on the print data transmitted from the print data generation apparatus **30** without using a printing plate. In the present embodiment, a UV ink (ultraviolet-curable ink) may be used as the printing ink. The inkjet printing apparatus **10** includes a printer body **100** and a print controller **200** that controls the operation of the printer body **100**.

(33) <1.2 Configuration of Inkjet Printing Apparatus>

(34) FIG. **2** is a schematic diagram showing a configuration example of the inkjet printing apparatus **10**. As described above, the inkjet printing apparatus **10** includes the printer body **100** and the print controller **200**. The printer body **100** includes: a base material feeding unit **11** that supplies base material **12**; a first drive roller **13** for conveying the base material **12** to the inside of a printing mechanism; a plurality of support rollers **14** for conveying the base material **12** in the inside of the printing mechanism; a recording unit **15** that records an image on the base material **12** by ejecting ink onto the base material **12** and curing the ink ejected onto the base material **12**; an imaging unit **16** that captures a printed image (the base material **12** after printing); a second drive roller **17** for outputting the base material **12** from the inside of the printing mechanism; and a base material winding unit **18** that winds the base material **12** after printing. As described later, the recording unit includes an ink ejection head that ejects ink and an ultraviolet light-emitting diode (UV-LED) (a light-emitting diode for emitting ultraviolet rays) that cures the ink. The print controller **200** controls the operation of the printer body **100** that is configured as described above. Note that the first drive roller **13**, the plurality of support rollers **14**, and the second drive roller **17** achieve a conveyor.

(35) Meanwhile, in the present embodiment, an inspection chart for inspecting the state of the nozzles in the ink ejection head is printed before printing for obtaining desired printed matter is performed. A printed image obtained by printing the inspection chart is captured by the imaging unit **16**, and the imaged data thereby obtained is sent to the print controller **200**. Then, in the print controller **200**, density correction to be described later is performed based on the imaged data.

(36) FIG. **3** is a plan view schematically showing the configuration of the recording unit **15** according to the present embodiment. The recording unit **15** includes a plurality of ink ejection head **150** each configured to eject ink and a plurality of UV-LEDs **159** each for curing the ink ejected onto the base material **12** by ultraviolet irradiation. More specifically, the recording unit **15** includes an ink ejection head **150**(W) that ejects white ink; a UV-LED **159**(*b*) for curing the white ink ejected onto the base material **12** by ultraviolet irradiation; an ink ejection head **150**(B) that ejects blue ink; an ink ejection head **150**(O) that ejects orange ink; an ink ejection head **150**(C) that ejects cyan ink; an ink ejection head **150**(M) that ejects magenta ink; an ink ejection head **150**(Y) that ejects yellow ink; an ink ejection head **150**(K) that ejects black ink; a UV-LED **159**(*c*) for curing the color ink (blue ink, orange ink, cyan ink, magenta ink, yellow ink, and black ink) ejected onto the base material **12** by ultraviolet irradiation, an ink ejection head **150**(E) that is provided preliminarily; and a UV-LED **159**(*a*) for curing the ink ejected from the ink ejection head **150**(E) onto the base material **12** by ultraviolet irradiation. The ink ejection head **150**(W) for white ink is

disposed on an upstream side of the ink ejection heads **150**(B), **150**(O), **150**(C), **150**(M), **150**(Y), and **150**(K) for color inks regarding the conveyance direction of the base material **12**. In the present embodiment, it is assumed that the ink ejection head **150**(E) and the UV-LED **159**(*a*) are not used.
(37) Since the base material **12** is conveyed from the lower side to the upper side in FIG. **3**, first, the white ink is ejected onto the base material **12**, and the UV-LED **159**(*b*) cures the white ink. Then, the blue ink, the orange ink, the cyan ink, the magenta ink, the yellow ink, and the black ink are sequentially ejected onto the base material **12**, and the UV-LED **159**(*c*) cures the blue ink, the orange ink, the cyan ink, the magenta ink, the yellow ink, and the black ink. However, the UV-LED **159**(*b*) does not cure the white ink in a case where the white ink is ejected onto the base material **12** by performing white correction to be described later. Therefore, in a case where white correction is performed, the color ink is ejected onto the uncured white ink.
(38) In the present embodiment, a first ink ejection head is achieved by each of the ink ejection head **150**(B), the ink ejection head **150**(O), the ink ejection head **150**(C), the ink ejection head **150**(M), the ink ejection head **150**(Y), and the ink ejection head **150**(K), a second ink ejection head is achieved by the ink ejection head **150**(W), a first ultraviolet irradiator is achieved by the UV-LED **159**(*c*), and a second ultraviolet irradiator is achieved by the UV-LED **159**(*b*).
(39) Note that the configuration of the recording unit **15** shown in FIG. **3** is an example, and the present invention is not limited thereto. For example, it is also possible to adopt the recording unit **15** with a configuration in which the ink ejection head **150**(B) that ejects the blue ink and the ink ejection head **150**(O) that ejects the orange ink are not provided.
(40) FIG. **4** is a plan view showing a configuration example of an ink ejection surface of one ink ejection head **150**. The ink ejection head **150** is made up of one rectangular head module **151**. The head module **151** has many nozzles **152** as ink ejection ports. Although the shape of the head module **151** is one rectangle in the example shown in FIG. **4**, the present invention is not limited thereto, and various configurations such as a plurality of parallelogram head modules and a plurality of trapezoidal head modules can be adopted. Note that the nozzle corresponds to an ink ejection port, and the defective nozzle described above corresponds to a defective ejection port.
(41) FIG. **5** is a view for explaining the arrangement of the nozzles **152** in the head module **151**. Typically, the head module **151** includes a plurality of rows of nozzle groups each including a plurality of nozzles arranged side by side in the main scanning direction. In the example shown in FIG. **5**, four rows of nozzle groups are included in the head module **151**. In FIG. **5**, the portion denoted by reference numeral **41** schematically shows a landing position of the ink ejected from each nozzle **152** on the base material **12**. The plurality of nozzles **152** in the head module **151** are arranged so that the landing positions of the ink ejected from the nozzles **152** included in the nozzle group in the first row, the landing positions of the ink ejected from the nozzles **152** included in the nozzle group in the second row, the landing positions of the ink ejected from the nozzles **152** included in the nozzle group in the third row, and the landing positions of the ink ejected from the nozzles **152** included in the nozzle group in the fourth row are different positions. For example, the landing position of the ink ejected from each nozzle **152** included in the nozzle group in the first row is a position between the landing position of the ink ejected from the nozzle **152** included in the nozzle group in the third row and the landing position of the ink ejected from the nozzle **152** included in the nozzle group in the fourth row.
(42) In the example shown in FIG. **5**, the landing position **42** of the ink ejected from the nozzle denoted by reference numeral **152**(*p*) and the landing position **43** of the ink ejected from the nozzle denoted by reference numeral **152**(*q*) are adjacent. In the present specification, two nozzles with such adjacent ink landing positions are treated as “nozzles adjacent to each other”. In the above example, the nozzle denoted by reference numeral **152**(*p*) and the nozzle denoted by reference numeral **152**(*q*) are treated as nozzles adjacent to each other.
(43) In the following description, when the name of one color is “Z”, a nozzle that ejects a Z ink (a nozzle included in the ink ejection head **150** for Z ink) may be referred to as a “Z ink ejection

nozzle". For example, a nozzle that ejects the cyan ink (a nozzle included in the ink ejection head **150**(C) for cyan ink) may be referred to as a "cyan ink ejection nozzle".

(44) <1.3 Hardware Configuration of Print Controller>

(45) FIG. **6** is a block diagram showing a hardware configuration of the print controller **200**. As shown in FIG. **6**, the print controller **200** includes a body **210**, an auxiliary storage device **221**, an optical disc drive **222**, a display unit **223**, a keyboard **224**, a mouse **225**, and the like. The body **210** includes a central processing unit (CPU) (processor) **211**, a memory **212**, a first disc interface unit **213**, a second disc interface unit **214**, a display control unit **215**, an input interface unit **216**, and a communication interface unit **217**. The CPU **211**, the memory **212**, the first disc interface unit **213**, the second disc interface unit **214**, the display control unit **215**, the input interface unit **216**, and the communication interface unit **217** are connected to each other via a system bus. The auxiliary storage device **221** is connected to the first disc interface unit **213**. An optical disc drive **222** is connected to the second disc interface unit **214**. A display unit (display device) **223** is connected to the display control unit **215**. A keyboard **224** and a mouse **225** are connected to the input interface unit **216**. The printer body **100** is connected to the communication interface unit **217** via a communication cable. The communication interface unit **217** is connected to the communication line **4**. The auxiliary storage device **221** is a magnetic disc device or the like. An optical disc **29** as a computer-readable recording medium such as a compact disc read-only memory (CD-ROM) or a digital versatile disc read-only memory (DVD-ROM) is inserted into the optical disc drive **222**. The display unit **223** is a liquid crystal display or the like. The display unit **223** is used to display information desired by an operator. The keyboard **224** and the mouse **225** are used by the operator to input instructions to the print controller **200**.

(46) The auxiliary storage device **221** stores a print control program (program for controlling the execution of print processing by the printer body **100**) P. The CPU **211** reads a print control program P stored in the auxiliary storage device **221** into the memory **212** and executes the program to achieve various functions of the print controller **200**. The memory **212** includes random-access memory (RAM) and read-only memory (ROM). The memory **212** functions as a work area for the CPU **211** to execute the print control program P stored in the auxiliary storage device **221**. Note that the print control program P is provided by being stored into the computer-readable recording medium (non-transitory recording medium). That is, for example, the user purchases the optical disc **29** as a recording medium of the print control program P, inserts the optical disc into the optical disc drive **222**, reads the print control program P from the optical disc **29**, and installs the print control program P in the auxiliary storage device **221**.

(47) <1.4 White Correction>

(48) In the present embodiment, when the nozzle-defect correction described above is performed, processing is performed to correct density data included in print data so that white ink is ejected from a white ink ejection nozzle corresponding to a nozzle adjacent to a defective nozzle (hereinafter, the nozzle adjacent to the defective nozzle is referred to as a "defect adjacent nozzle" for convenience). Hereinafter, this processing is referred to as "white correction".

(49) FIG. **7** is a view for explaining the outline of white correction. For convenience of description, in FIG. **7**, a plurality of nozzles are shown as being arranged in a line in each ink ejection head **150**. In FIG. **7**, the UV-LED **159** is omitted. Here, it is assumed that the nozzle denoted by reference numeral **51** among a plurality of nozzles included in the ink ejection head **150**(C) for cyan ink is a defective nozzle. In this case, by performing the nozzle-defect correction described above, a larger amount of cyan ink than originally intended is ejected from the defect adjacent nozzles (the nozzle denoted by reference numeral **52** and the nozzle denoted by reference numeral **53**). Further, by performing white correction, the white ink is ejected from the nozzles (the nozzle denoted by reference numeral **54** and the nozzle denoted by reference numeral **55**) corresponding to the defect adjacent nozzles. In this example, the cyan ink corresponds to the first ink, and the white ink corresponds to the second ink.

(50) In the present embodiment, white correction is performed only for an area where printing is performed with a single-color ink to be ejected from the defective nozzle, the single-color ink having a density equal to or higher than a predetermined value. Therefore, in a case where the defective nozzle is included in the ink ejection head **150**(C) for cyan ink as described above, white correction is performed, for example, only for an area where high-density cyan single-color printing is performed, for example, with a density of 80% or more. However, white correction may also be performed for an area where mixed-color printing is performed.
(51) When white correction is performed, in the above example, during printing, first, the white ink is ejected from the white ink ejection nozzle corresponding to the defect adjacent nozzle onto the base material **12**. Thereafter, the cyan ink is ejected from the defect adjacent nozzle. That is, in the area where white correction has been performed, as schematically shown in FIG. **8**, the cyan ink **6**(C) is ejected onto the white ink **6**(W) that has been ejected onto the base material **12**.
(52) The wet spreading range of the color ink (in the above example, cyan ink) on the base material **12** is larger when the color ink is ejected onto the white ink that has been ejected onto the base material **12** than when the color ink is directly ejected onto the base material **12**. An example of a result of an experiment related to this is shown in FIG. **9**. In FIG. **9**, the portion denoted by reference numeral **61** indicates (ink) dot sizes obtained when the color ink was directly ejected onto certain film base material, and the portion denoted by reference numeral **62** in FIG. **9** indicates (ink) dot sizes obtained when the color ink was ejected after the white ink was ejected onto the certain base material. For any color ink, it is understood that the wet spreading range increases (the dot size of the color ink increases in a pseudo manner) by ejecting the white ink onto the base material in advance. In view of the above, by ejecting the white ink in advance onto a position (a position on the base material **12**) where the color ink is ejected from the defect adjacent nozzle, the color ink ejected from the defect adjacent nozzle sufficiently spreads on the base material **12** to enhance the effect by nozzle-defect correction (the effect of eliminating the defect and preventing the occurrence of unevenness).
(53) Normally, the white ink is cured by ultraviolet irradiation after being ejected. However, in the present embodiment, the ultraviolet irradiation with the white ink by the UV-LED **159**(*b*) is stopped when the white ink is ejected onto the target area by white correction. By thus stopping the ultraviolet irradiation on the white ink, the wet spreading range of the white ink is increased, and the wet spreading range of the color ink ejected onto the white ink is also increased effectively.
(54) <1.5 Density Correction>
(55) In the inkjet printing apparatus **10** according to the present embodiment, the white correction described above is performed in addition to density uniformity correction and nozzle-defect correction that have been performed conventionally. In the present specification, a series of processing including density uniformity correction, nozzle-defect correction, and white correction is referred to as “density correction”. The print controller **200** executes the print control program P to achieve a density correction processing unit that is a functional component for performing density correction.
(56) <1.5.1 Functional Configuration>
(57) FIG. **10** is a block diagram showing a detailed functional configuration of a density correction processing unit **24** according to the present embodiment. As shown in FIG. **10**, the density correction processing unit **24** includes a correction factor calculation unit **241**, a defective nozzle detection unit **242**, a base material determination unit **243**, a print data holding unit (image memory) **244**, a white correction determination unit **245**, a correction target nozzle specification unit **246**, a correction pattern creation unit **247**, an ink ejection control unit **248**, and a UV-LED setting unit **249**. The ink ejection control unit **248** includes a first correction processing unit **2481** and a second correction processing unit **2482**.
(58) The correction factor calculation unit **241** calculates a correction factor **71** for performing density uniformity correction based on imaged data **70** obtained by the imaging unit **16** capturing

the printed image of the inspection chart. For example, focusing on a certain nozzle, in a case where the density obtained by ejecting the ink from the nozzle is (4/5) times the original density, the correction factor **71** corresponding to the nozzle is set to 1.25

(59) The defective nozzle detection unit **242** detects a defective nozzle, which is a nozzle in an ejection failure state, from among many nozzles included in the ink ejection head **150** for color ink based on the imaged data **70**. Defective nozzle information **72** for specifying a defective nozzle is outputted from the defective nozzle detection unit **242**. When no defective nozzle is detected, only density uniformity correction is performed in the first correction processing unit **2481** in the ink ejection control unit **248**.

(60) The base material determination unit **243** determines base material to be used for printing as a printing medium based on, for example, set print conditions. Then, base material information **73** for specifying the base material is outputted from the base material determination unit **243**.

(61) The print data holding unit **244** temporarily holds print data (data subjected to RIP processing) **74** transmitted from the print data generation apparatus **30**. Note that the print data holding unit **244** is achieved by the memory **212** (cf. FIG. **6**) as hardware.

(62) The white correction determination unit **245** determines whether to perform white correction based on the defective nozzle information **72**, the base material information **73**, and the print data **74**. Then, a determination result **75** thus obtained is outputted from white correction determination unit **245**. In this regard, in the present embodiment, it is determined that white correction is not to be performed when the base material used for printing is other than a white, base material based on the base material information **73**. Further, it is determined, based on the defective nozzle information **72** and the print data **74**, that white correction is to be performed when a defective nozzle is present, and an area where the ink is ejected from the defective nozzle and its neighboring nozzle includes an area where single-color high-density printing is performed using the color ink to be ejected from the defective nozzle. In other words, even when the defective nozzle is present, it is determined that white correction is not to be performed unless an area where the ink is ejected from the defective nozzle and its neighboring nozzle includes an area where single-color high-density printing is performed using the color ink to be ejected from the defective nozzle. In this way, white correction is performed only for an area where unevenness caused by the presence of a defective nozzle is noticeable, thereby reducing unnecessary consumption of white ink.

(63) When the determination result **75** outputted from the white correction determination unit **245** indicates that white correction is to be performed, the correction target nozzle specification unit **246** specifies a nozzle (hereinafter referred to as a “correction target nozzle”) that ejects white ink for white correction from among many nozzles included in the ink ejection head **150**(W) for white ink based on the defective nozzle information **72** and the print data **74**. Then, the correction target nozzle information **76** for specifying the correction target nozzle is outputted from the correction target nozzle specification unit **246**.

(64) Meanwhile, in the present embodiment, a template that defines a pattern with which the white ink is ejected onto the pixel portion in the print area by white correction is prepared, and the correction target nozzle specification unit **246** and the correction pattern creation unit **247** refer to the template. For example, a template as shown in FIG. **11** is prepared. In FIG. **11**, pixel portions in the column denoted by reference numeral **64** are pixel portions corresponding to a defective nozzle, and shaded pixel portions are pixel portions to be ejected with white ink. Each nozzle corresponds to one pixel portion regarding the main scanning direction. In the example shown in FIG. **11**, shaded pixel portions are included in the column denoted by reference numeral **64**L and the column denoted by reference numeral **64**R. Therefore, the nozzle that ejects the ink onto the pixel portions in the column denoted by reference numeral **64**L and the nozzle that ejects the ink onto the pixel portions in the column denoted by reference numeral **64**R among many nozzles included in the ink ejection head **150**(W) for white ink are specified as the correction target nozzles by the correction target nozzle specification unit **246**.

(65) The correction pattern creation unit **247** creates a correction pattern **77** representing a pattern in the entire print area as shown in the template, based on the correction target nozzle information **76** and the print data **74**. In the present embodiment, an area where the white ink is to be ejected based on the correction pattern **77** is treated as a correction area. Therefore, creating the correction pattern **77** corresponds to determining the correction area.
(66) As described above, in the present embodiment, white correction is performed only for the area where single-color high-density printing is performed. Here, it is assumed, for example, that a defect has occurred in a cyan ink ejection nozzle that ejects ink in the dotted line portion denoted by reference numeral **57** in FIG. **12**, and single-color high-density printing is performed with the cyan ink in the rectangular area denoted by reference numeral **58**. In this case, the correction pattern **77** created by the correction pattern creation unit **247** is a correction pattern as shown in FIG. **13** so that white correction is performed only for the area where single-color high-density printing is performed with the cyan ink.
(67) The ink ejection control unit **248** corrects the density data included in the print data **74** and controls the ejection of the ink from each ink ejection head **150** based on corrected density data **78**. As described above, the ink ejection control unit **248** includes the first correction processing unit **2481** and the second correction processing unit **2482**. When the determination result **75** outputted from the white correction determination unit **245** indicates that white correction is not to be performed, the processing of correcting the density data included in the print data **74** is performed by the first correction processing unit **2481**, and when the determination result **75** indicates that white correction is to be performed, the processing of correcting the density data included in the print data **74** is performed by the second correction processing unit **2482**.
(68) The first correction processing unit **2481** performs density uniformity correction and nozzle-defect correction based on the correction factor **71**, the defective nozzle information **72**, and the print data **74**. As a result, the density data included in the print data **74** is corrected, and the density data **78** for controlling the ejection of the ink from each ink ejection head **150** is generated.
(69) The second correction processing unit **2482** performs density uniformity correction, nozzle-defect correction, and white correction based on the correction factor **71**, the defective nozzle information **72**, the correction pattern **77**, and the print data **74**. As a result, the density data included in the print data **74** is corrected, and the density data **78** for controlling the ejection of the ink from each ink ejection head **150** is generated.
(70) Each of the ink ejection heads **150** including the ink ejection head **150**(W) for white ink is configured to be able to eject the ink with a plurality of sizes. Specifically, piezoelectric elements are provided corresponding to the respective nozzles in the ink ejection head **150**, and the size of the ink ejected from the nozzles can be changed by changing a voltage waveform of a drive signal applied to the piezoelectric elements. In the present embodiment, the density data is corrected by the second correction processing unit **2482** so that the white ink is ejected into the correction area with the smallest size among the plurality of sizes. That is, the ink ejection control unit **248** controls the ejection of the white ink from the ink ejection head **150**(W) so that the white ink is ejected into the correction area with the smallest size among the plurality of sizes. This prevents the white ink from being consumed more than necessary in order to widen the wet spreading range of the color ink. However, the white ink may be ejected into the correction area with a size other than the smallest size.
(71) Note that the time from when the color ink is ejected from the ink ejection head **150** onto the base material **12** to when the color ink is cured by ultraviolet irradiation from the UV-LED **159**(*c*) varies for each color of the color inks. Referring to FIG. **3**, for example, it can be grasped that the time from when the black ink is ejected from the ink ejection head **150**(K) onto the base material **12** until the black ink is cured is significantly shorter than the time from when the blue ink is ejected from the ink ejection head **150**(B) onto the base material **12** until the blue ink is cured. Thus, regarding white correction, when the size of the white ink ejected from the ink ejection head

150(W) is made constant, the wet spreading range of the black ink may be smaller than the wet spreading range of the blue ink. Therefore, the ejection of the white ink from the ink ejection head **150**(W) may be controlled so that the closer the distance from the ink ejection head **150** corresponding to the color ink ejected onto the white ink in the correction area to the UV-LED **159**(*c*), the larger the size of the white ink.

(72) The UV-LED setting unit **249** controls the ultraviolet irradiation performed by the UV-LED **159**(*b*) for white ink by giving an ultraviolet irradiation control signal **79** to the UV-LED **159**(*b*), based on the determination result **75** outputted from the white correction determination unit **245**. Specifically, when the determination result **75** indicates that white correction is to be performed, the UV-LED setting unit **249** stops the ultraviolet irradiation performed by the UV-LED **159**(*b*). Therefore, when white correction is performed, during printing, ultraviolet irradiation from the UV-LED **159**(*b*) is not performed on the white ink ejected from the ink ejection head **150**(W) onto the base material **12**. When the determination result **75** indicates that white correction is not to be performed, the UV-LED setting unit **249** maintains the ultraviolet irradiation performed by the UV-LED **159**(*b*). Regarding a case where the determination result **75** indicates that white correction is to be performed, the configuration may be such that the UV-LED setting unit **249** reduces the intensity of the ultraviolet irradiation performed by the UV-LED **159**(*b*). That is, if wet spreading range of the color ink becomes sufficiently wide when the color ink is ejected onto the white ink, it is not always necessary to stop the ultraviolet irradiation with the white ink performed by the UV-LED **159**(*b*).

(73) Although the calculation of the correction factor **71** by the correction factor calculation unit **241** and the identification of the defective nozzle by the defective nozzle detection unit **242** are performed based on the imaged data **70** in the present embodiment, the present invention is not limited thereto. In a case where an inkjet printing apparatus **10** that does not include the imaging unit **16** has been adopted, the calculation of the correction factor **71** and the identification of the defective nozzle may be performed by an operator visually checking the printed image of the inspection chart.

(74) In addition, a configuration may be adopted which includes a component to receive an input of the base material information **73** by an operator instead of the base material determination unit **243**, and the processing by the white correction determination unit **245** (the processing of determining whether to perform white correction) may be performed based on the base material information **73** received by the component.

(75) In the present embodiment, a correction area determination unit is achieved by the correction pattern creation unit **247**, and an ultraviolet irradiation controller is achieved by the UV-LED setting unit **249**.

(76) <1.5.2 Template of Correction Pattern>

(77) In the above description, it has been described that the template shown in FIG. **11** is prepared as the template that is the basis of the correction pattern **77** created by the correction pattern creation unit **247**. However, the template that can be adopted is not limited to the template shown in FIG. **11**. For example, a template illustrated in FIG. **14**, a template illustrated in FIG. **15**, a template illustrated in FIG. **16**, and the like can also be adopted. Templates other than the template shown in FIGS. **11** and **14** to **16** can also be adopted.

(78) In a case where the template shown in FIG. **11** or FIG. **15** is adopted, the nozzle that ejects the ink onto the pixel portions in the column denoted by reference numeral **64**L and the nozzle that ejects the ink onto the pixel portions in the column denoted by reference numeral **64**R among many nozzles included in the ink ejection head **150**(W) for white ink are specified as the correction target nozzles. In a case where the template shown in FIG. **14** or FIG. **16** is adopted, the nozzle that ejects the ink onto pixel portions in the column denoted by reference numeral **64**, the nozzle that ejects the ink onto pixel portions in the column denoted by reference numeral **64**L**1**, the nozzle that ejects the ink onto pixel portions in the column denoted by reference numeral **64**R**1**, the nozzle that ejects

the ink onto pixel portions in the column denoted by reference numeral **64**L**2**, and the nozzle that ejects the ink onto pixel portions in the column denoted by reference numeral **64**R**2** among many nozzles included in the ink ejection head **150**(W) for white ink are specified as the correction target nozzles.

(79) Focusing on the conveyance direction of the base material **12** with respect to the pixel portions onto which the white ink is ejected, in a case where the template shown in FIG. **11** or **14** is adopted, one pixel portion onto which the white ink is ejected and one pixel portion onto which the white ink is not ejected alternately appear, and in a case where the template shown in FIG. **15** or **16** is adopted, two pixel portions onto which the white ink is ejected and two pixel portions onto which the white ink is not ejected alternately appear.

(80) <1.5.3 Procedure>

(81) Hereinafter, a procedure for density correction in the present embodiment will be described with reference to FIG. **17**. It is assumed that the print data **74** to be processed has already been held in the print data holding unit **244** (cf. FIG. **10**).

(82) After the start of density correction, first, the recording unit **15** prints an inspection chart for inspecting the states of the nozzles in the ink ejection heads **150** for color inks (specifically, the ink ejection head **150**(B) for blue ink, the ink ejection head **150**(O) for orange ink, the ink ejection head **150**(C) for cyan ink, the ink ejection head **150**(M) for magenta ink, the ink ejection head **150**(Y) for yellow ink, and the ink ejection head **150**(K) for black ink) (step S**110**). Then, the imaging unit **16** captures the printed image obtained by printing the inspection chart (step S**112**). Thereby, the imaged data **70** is outputted from the imaging unit **16**.

(83) Thereafter, the correction factor calculation unit **241** calculates the correction factor **71** for performing density uniformity correction based on the imaged data **70** (step S**114**). Next, the defective nozzle detection unit **242** detects a defective nozzle among many nozzles included in the ink ejection heads **150** for color inks based on the imaged data **70** (step S**116**).

(84) After the detection of the defective nozzle, the base material determination unit **243** determines the base material (printing medium) to be used for printing (step S**118**). Then, the white correction determination unit **245** determines whether the base material used for printing is a white base material (step S**120**). As a result, when the base material used for printing is a white base material, the processing proceeds to step S**121**, and when the base material used for printing is not a white base material, the processing proceeds to step S**130**.

(85) In step S**121**, the white correction determination unit **245** further determines whether it is necessary to perform white correction based on the print data **74** and the information on the defective nozzle detected in step S**116** (the defective nozzle information **72** above). As a result, when it is necessary to perform white correction, the processing proceeds to step S**122**, and when it is not necessary to perform white correction, the processing proceeds to step S**130**.

(86) In step S**122**, the correction target nozzle specification unit **246** specifies the correction target nozzle described above based on the print data **74** and the information on the defective nozzle detected in step S**116** (the defective nozzle information **72** above).

(87) Next, the correction pattern creation unit **247** creates the correction pattern **77** described above based on the print data **74** and the information on the correction target nozzle specified in step S**122** (step S**124**) (the correction target nozzle information **76** above). In other words, the correction area, which is a part of area where the white ink is to be ejected for the purpose of widening the wet spreading range of the color ink among the area on the base material **12**, is determined.

(88) After the creation of the correction pattern **77**, the ultraviolet irradiation from the UV-LED **159**(*b*) for white ink is stopped based on the control by the UV-LED setting unit **249** (step S**126**). Thus, as described above, when white correction is performed, ultraviolet irradiation from the UV-LED **159**(*b*) is not performed on the white ink ejected from the ink ejection head **150**(W) onto the base material **12**.

(89) After the ultraviolet irradiation from the UV-LED **159**(*b*) is stopped, the second correction

processing unit **2482** performs density uniformity correction, nozzle-defect correction, and white correction based on the correction factor **71** calculated in step S**114**, the information on the defective nozzle detected in step S**116** (the defective nozzle information **72** above), the correction pattern **77** created in step S**124**, and the print data **74** (step S**128**).
(90) In step S**130**, the first correction processing unit **2481** performs density uniformity correction and nozzle-defect correction based on the correction factor **71** calculated in step S**114**, the information on the defective nozzle detected in step S**116** (the defective nozzle information **72** above), and the print data **74**.
(91) When the process of step S**128** or the process of step S**130** ends, density correction ends.
(92) After density correction is performed according to the above procedure, the ink ejection control unit **248** controls the ejection of the ink from each ink ejection head **150** based on the density data **78** obtained by density correction, whereby the actual printing on the base material **12** is performed. At this time, as can be grasped from FIG. **3**, the inks are ejected onto the base material **12** in the order of the white ink, blue ink, orange ink, cyan ink, magenta ink, yellow ink, and black ink. Here, for example, focusing on a case where a defect is detected in the cyan ink ejection nozzle, in the correction area, first, the white ink is ejected onto the base material **12**, and then, the cyan ink is ejected onto the white ink.
(93) <1.6 Effects>
(94) According to the present embodiment, when a defective nozzle is detected in the ink ejection head **150** for color ink, for a part of area where single-color high-density printing with the color ink to be ejected from the defective nozzle is performed among the area (an area on the base material **12**) where the ink is ejected from the defective nozzle and its neighboring nozzle, white correction that corrects the density data such that the white ink is ejected from the white ink ejection nozzle corresponding to the defect adjacent nozzle is performed. Here, the wet spreading range of the color ink on the base material **12** is larger when the color ink is ejected onto the white ink that has been ejected onto the base material **12** than when the color ink is directly ejected onto the base material **12**. Therefore, by ejecting the ink from each ink ejection head **150** based on the density data after white correction, the color ink sufficiently spreads on the base material **12** in the area to be subjected to white correction, and the effect by nozzle-defect correction (the effect of eliminating the defect and preventing the occurrence of unevenness) is enhanced compared to the related art. That is, even when a defect has occurred in the nozzle corresponding to the area where single-color high-density printing is performed, the occurrence of unevenness in the printed image due to the presence of the defective nozzle is prevented effectively. Note that the color of the ink (white ink) used to widen the wet spreading range of the color ink is the same as the color of the base material **12**. Therefore, the color of the ink ejected onto the base material **12** to widen the wet spreading range of the color ink is not noticeable on the printed image. As above, according to the present embodiment, the inkjet printing apparatus **10** capable of improving the quality of printed matter is achieved. Since the occurrence of unevenness due to the presence of the defective nozzle is effectively prevented, the necessity of reprinting is reduced compared to the related art, and the consumption of the base material and the ink can be reduced. In this way, it is possible to contribute to the achievement of the sustainable development goals (SDGs).
(95) <1.7. Modifications>
(96) In the first embodiment, in order to increase the wet spreading range of the color ink on the base material **12** by performing nozzle-defect correction, the white ink has been ejected onto the base material **12** before the ejection of the color ink onto the base material **12** in the target area. However, the present invention is not limited thereto. Therefore, examples of using inks other than the white ink to increase the wet spreading range of the color ink will be described below as modifications of the first embodiment. Note that a first modification and a second modification described here can also be applied to a second embodiment and a third embodiment to be described later.

(97) <1.7.1 First Modification>
(98) In the present modification, printing is performed on a transparent base material for a label. Then, a transparent ink is used instead of the white ink in the first embodiment. To achieve this, the ink ejection head **150**(E) provided in the recording unit **15** (FIG. **3**) is used as an ink ejection head that ejects the transparent ink. Further, instead of white correction in the first embodiment, processing is performed to correct the density data such that the transparent ink is ejected from the ink ejection head **150**(E) to make the wet spreading range of the color ink large (hereinafter, this processing is referred to as "transparency correction").
(99) Here, it is assumed that the nozzle denoted by reference numeral **511** in FIG. **18** among the plurality of nozzles included in the ink ejection head **150**(C) for cyan ink is a defective nozzle. In this case, by performing the nozzle-defect correction described above, a larger amount of cyan ink than originally intended is ejected from the defect adjacent nozzles (the nozzle denoted by reference numeral **512** and the nozzle denoted by reference numeral **513**). By performing transparency correction, the transparent ink is ejected from the transparent ink ejection nozzles (the nozzle denoted by reference numeral **514** and the nozzle denoted by reference numeral **515**) corresponding to the defect adjacent nozzles.
(100) When transparency correction is performed, in the above example, during printing, first, the transparent ink is ejected from the transparent ink ejection nozzles corresponding to the defect adjacent nozzles onto the base material (transparent base material) **12**. Thereafter, the cyan ink is ejected from the defect adjacent nozzles. That is, in the area where transparency correction has been performed, as schematically shown in FIG. **19**, the cyan ink **6**(C) is ejected onto the transparent ink **6**(T) that has been ejected onto the base material (transparent base material) **12**.
(101) <1.7.2 Second Modification>
(102) In the present modification, when a defect occurs in the black ink ejection nozzle, the yellow ink with a higher brightness value than the black ink is ejected onto the base material **12** before the black ink is ejected onto the base material **12** in the target area to enhance the effect of nozzle-defect correction. Further, instead of white correction in the first embodiment, processing is performed to correct the density data such that the yellow ink with a higher brightness value than the black ink is ejected from the ink ejection head **150**(Y) to make the wet spreading range of the black ink large (hereinafter, this processing is referred to as "yellow correction")
(103) Note that the area where the yellow ink is ejected for the purpose of enhancing the effect of nozzle-defect correction is limited to an area other than the area where the yellow ink is ejected to form the printed image. By limiting the area where the yellow ink is ejected in this way, it is possible to prevent the deterioration of the print quality due to the adoption of the yellow ink as the ink to increase the wet spreading range of the black ink.
(104) Here, it is assumed that the nozzle denoted by reference numeral **521** in FIG. **20** among a plurality of nozzles included in the ink ejection head **150**(K) for black ink is a defective nozzle. In this case, by performing the nozzle-defect correction described above, a larger amount of black ink than originally intended is ejected from the defect adjacent nozzles (the nozzle denoted by reference numeral **522** and the nozzle denoted by reference numeral **523**). By performing yellow correction, the yellow ink is ejected from the yellow ink ejection nozzles (the nozzle denoted by reference numeral **524** and the nozzle denoted by reference numeral **525**) corresponding to the defect adjacent nozzles.
(105) When the yellow correction is performed, during printing, first, the yellow ink is ejected from the yellow ink ejection nozzles corresponding to the defect adjacent nozzles onto the base material **12**. Thereafter, the black ink is ejected from the defect adjacent nozzles. That is, in the area where the yellow correction has been performed, as schematically shown in FIG. **21**, the black ink **6**(K) is ejected onto the yellow ink **6**(Y) that has been ejected onto the base material **12**.
(106) Moreover, as still another example, when a defect occurs in the black ink ejection nozzle, the blue ink with little color difference from the black ink may be ejected onto the base material **12**

before the black ink is ejected onto the base material **12** in the target area to enhance the effect of nozzle-defect correction. In such a case, instead of white correction in the first embodiment, processing may be performed to correct the density data such that the blue ink with little color difference from the black ink is ejected from the ink ejection head **150**(B) to make the wet spreading range of the black ink large (hereinafter, this processing is referred to as “blue correction”), and the same ejection control as in the case of yellow correction may be performed.
(107) In the present modification, the white ink and the transparent ink are not used. Therefore, even in the inkjet printing apparatus that performs printing using only the process color ink, the occurrence of unevenness in the printed image due to the presence of the defective nozzle for the black ink ejection nozzle can be effectively prevented by adopting the configuration of the present modification.
2. Second Embodiment
(108) <2.1 Overview>
(109) In general, each of the ink ejection head **150**(W) that ejects white ink, the ink ejection head **150**(B) that ejects blue ink, the ink ejection head **150**(O) that ejects orange ink, the ink ejection head **150**(C) that ejects cyan ink, the ink ejection head **150**(M) that ejects magenta ink, the ink ejection head **150**(Y) that ejects yellow ink, and the ink ejection head **150**(K) that ejects black ink constituting the recording unit **15** includes a plurality of ink ejection heads **150**. For example, the ink ejection head **150**(W), the ink ejection head **150**(B), the ink ejection head **150**(O), the ink ejection head **150**(C), the ink ejection head **150**(M), the ink ejection head **150**(Y), and the ink ejection head **150**(K) are each configured by arranging a plurality of ink ejection heads **150** in a staggered manner as shown in FIG. **22**. Therefore, color unevenness may occur in an area (hereinafter referred to as a “head connection area”) where there is overlap between an area where the ink is ejected by one ink ejection head **150** and an area where the ink is ejected by its adjacent ink ejection head **150**. For example, color unevenness may occur in an area where the ink is ejected from a nozzle included in the portion denoted by reference numeral **66** in FIG. **22** or an area where the ink is ejected from a nozzle included in the portion denoted by reference numeral **67** in FIG. **22**. Thus, in the present embodiment, unlike the first embodiment, white correction is performed to prevent such deterioration in print quality due to the ink being ejected from each of a plurality of ink ejection heads **150** onto the same area (an area on the base material **12**).
(110) The overall configuration of the printing system (cf. FIG. **1**), the configuration of the inkjet printing apparatus (cf. FIG. **2**), the configuration of the recording unit **15** (cf. FIG. **3**), the configuration of the ink ejection surface of the ink ejection head **150** (cf. FIG. **4**), the arrangement of the nozzles **152** in the head module **151** (cf. FIG. **5**), and the hardware configuration of the print controller **200** (cf. FIG. **6**) are similar to those in the first embodiment.
(111) <2.2 Density Correction>
(112) Hereinafter, density correction in the present embodiment will be described.
(113) <2.2.1 Functional Configuration>
(114) FIG. **23** is a block diagram showing a detailed functional configuration of the density correction processing unit **24** according to the present embodiment. As can be grasped from FIGS. **23** and **10**, the density correction processing unit **24** according to the present embodiment includes a white correction candidate area acquisition unit **251** in addition to the components according to the first embodiment. The correction factor calculation unit **241**, the defective nozzle detection unit **242**, the base material determination unit **243**, the print data holding unit **244**, the correction pattern creation unit **247**, the ink ejection control unit **248**, and the UV-LED setting unit **249** perform operations similar to those in the first embodiment.
(115) The white correction candidate area acquisition unit **251** obtains a white correction candidate area **81** as a candidate for an area to be subjected to white correction, based on head information **80** including information related to the position of the head module **151** in the ink ejection head **150**. In the present embodiment, for example, a head connection area such as an area where the ink is

ejected from each of the nozzles included in the portions denoted by reference numerals **66**, **67** in FIG. **22** is set as the white correction candidate area **81**.

(116) The white correction determination unit **245** determines whether to perform white correction based on the base material information **73**, the white correction candidate area **81**, and the print data **74**. Then, the determination result **75** is outputted from white correction determination unit **245**. In this regard, in the present embodiment, similarly to the first embodiment, it is determined that white correction is not to be performed when the base material used for printing is other than a white base material, based on the base material information **73**. It is determined that white correction is to be performed when an area where single-color printing is performed is included in the white correction candidate areas **81**, based on the white correction candidate area **81** and the print data **74**. In this way, white correction is performed only for an area where color unevenness is noticeable, thereby reducing unnecessary consumption of white ink. Although white correction is performed only for an area where the single-color printing is performed in the present embodiment, white correction may also be performed for an area where mixed-color printing is performed.

(117) The correction target nozzle specification unit **246** specifies a correction target nozzle from among many white ink ejection nozzles included in the ink ejection head **150**(W) for white ink based on the white correction candidate area **81** and the print data **74** when the determination result **75** outputted from the white correction determination unit **245** indicates that white correction is to be performed. Then, the correction target nozzle information **76** for specifying the correction target nozzle is outputted from the correction target nozzle specification unit **246**. Note that the head module portion corresponding to the white correction candidate area **81** includes many nozzles, and hence many white ink ejection nozzles are usually specified as correction target nozzles compared to the first embodiment. Therefore, the correction pattern creation unit **247** creates the correction pattern **77** so that the area to be the ejection target of the white ink (correction area) becomes wider than in the first embodiment.

(118) Meanwhile, in the present embodiment, a plurality of templates are prepared in advance each as a template that is a source of the correction pattern **77**, and a template to be adopted is determined based on a printing rate obtained from the print data **74**. For example, a template shown in FIG. **14** and a template shown in FIG. **24** are prepared in advance. When the printing rate is higher than a predetermined threshold, the template shown in FIG. **14** is adopted, and when the printing rate is equal to or lower than the predetermined threshold, the template shown in FIG. **24** is adopted. In a case where the template shown in FIG. **24** is adopted, similarly to the case where the template shown in FIG. **14** is adopted, a nozzle that ejects the ink to pixel portions in the column denoted by reference numeral **64**, a nozzle that ejects the ink to pixel portions in the column denoted by reference numeral **64**L**1**, a nozzle that ejects the ink to pixel portions in the column denoted by reference numeral **64**R**1**, a nozzle that ejects the ink to pixel portions in the column denoted by reference numeral **64**L**2**, and a nozzle that ejects the ink to pixel portions in the column denoted by reference numeral **64**R**2** among many nozzles included in the ink ejection head **150**(W) for white ink are specified as the correction target nozzles. Focusing on the conveyance direction of the base material **12** with respect to the pixel portions onto which the white ink is ejected, in a case where the template shown in FIG. **24** is adopted, one pixel portion onto which the white ink is ejected and three pixel portions onto which the white ink is not ejected alternately appear.

(119) <2.2.2 Procedure>

(120) Hereinafter, a procedure for density correction in the present embodiment will be described with reference to FIG. **25**. The processes of steps S**210** to S**216** are similar to the processes of steps S**110** to S**116** in the first embodiment (cf. FIG. **17**).

(121) In step S**217**, the white correction candidate area acquisition unit **251** obtains the white correction candidate area **81** described above. The processes of steps S**218** to S**220** are similar to the processes of steps S**118** to S**120** in the first embodiment.

(122) In step S**221**, the white correction determination unit **245** determines whether it is necessary

to perform white correction based on the print data **74** and the white correction candidate area **81** obtained in step S**217**. As a result, when it is necessary to perform white correction, the processing proceeds to step S**222**, and when it is not necessary to perform white correction, the processing proceeds to step S**230**. When an area where single-color printing is performed is included in the white correction candidate areas **81**, it is determined that it is necessary to perform white correction.
(123) In step S**222**, the correction target nozzle specification unit **246** specifies the correction target nozzle described above based on the print data **74** and the white correction candidate area **81** obtained in step S**217**.
(124) The processes of steps S**224** to S**230** are similar to the processes of steps S**124** to S**130** in the first embodiment.
(125) <2.3 Effects>
(126) According to the present embodiment, white correction for correcting the density data such that the white ink is ejected from the white ink ejection nozzle specified based on the predetermined pattern is performed for an area where single-color printing is performed among the head connection area described above. As described above, the wet spreading range of the color ink on the base material **12** is larger when the color ink is ejected onto the white ink that has been ejected onto the base material **12** than when the color ink is directly ejected onto the base material **12**. Therefore, by ejecting the ink from each ink ejection head **150** based on the density data after white correction, the color ink sufficiently spreads on the base material **12** in the area to be subjected to white correction, and the occurrence of color unevenness in the head connection area is prevented effectively. From the above, the inkjet printing apparatus capable of improving the quality of printed matter is achieved. Since the occurrence of color unevenness in the head connection area is effectively prevented, the necessity of reprinting is reduced compared to the related art, and the consumption of the base material and the ink can be reduced. In this way, it is possible to contribute to the achievement of the SDGs.
3. Third Embodiment
(127) <3.1 Overview>
(128) In a case where so-called solid image printing is performed using an inkjet printing apparatus, the dot size of ink ejected from a nozzle may become insufficient depending on printing conditions and base material used, and print quality satisfying a user may not be obtained. Therefore, in the present embodiment, white correction is performed to improve the print quality of the solid image.
(129) The overall configuration of the printing system (cf. FIG. **1**), the configuration of the inkjet printing apparatus (cf. FIG. **2**), the configuration of the recording unit **15** (cf. FIG. **3**), the configuration of the ink ejection surface of the ink ejection head **150** (cf. FIG. **4**), the arrangement of the nozzles **152** in the head module **151** (cf. FIG. **5**), and the hardware configuration of the print controller **200** (cf. FIG. **6**) are similar to those in the first embodiment.
(130) <3.2 Density Correction>
(131) Hereinafter, density correction in the present embodiment will be described.
(132) <3.2.1 Functional Configuration>
(133) FIG. **26** is a block diagram showing a detailed functional configuration of the density correction processing unit **24** according to the present embodiment. As can be grasped from FIGS. **26** and **10**, the density correction processing unit **24** according to the present embodiment includes components similar to those of the density correction processing unit **24** in the first embodiment. The correction factor calculation unit **241**, the defective nozzle detection unit **242**, the base material determination unit **243**, the print data holding unit **244**, the correction pattern creation unit **247**, the ink ejection control unit **248**, and the UV-LED setting unit **249** perform operations similar to those in the first embodiment, but the white correction determination unit **245** and the correction target nozzle specification unit **246** perform operations different from those in the first embodiment.

(134) The white correction determination unit **245** determines whether to perform white correction, based on the base material information **73** and the print data **74**. Then, the determination result **75** is outputted from white correction determination unit **245**. In this regard, in the present embodiment, similarly to the first embodiment, it is determined that white correction is not to be performed when the base material used for printing is other than a white base material, based on the base material information **73**. Based on the print data **74**, when there is an area where a solid image is to be formed (an area where the density of the color ink is 100%) in the print area, it is determined that white correction is to be performed. From the above, when the base material used for printing is a white base material and there is an area where a solid image is to be formed in the print area, it is determined that white correction is to be performed.
(135) The correction target nozzle specification unit **246** specifies a correction target nozzle from among many white ink ejection nozzles included in the ink ejection head **150**(W) for white ink based on the print data **74** when the determination result **75** outputted from the white correction determination unit **245** indicates that white correction is to be performed. Then, the correction target nozzle information **76** for specifying the correction target nozzle is outputted from the correction target nozzle specification unit **246**. In the present embodiment, the correction target nozzle is specified based on the color for forming the solid image and the area (range) for forming the solid image. For example, it is assumed that, according to the print data **74**, the shaded area denoted by reference numeral **85** in FIG. **27** is an area where a solid cyan image is to be formed, the shaded area denoted by reference numeral **86** in FIG. **27** is an area where a solid magenta image is to be formed, and the shaded area denoted by reference numeral **87** in FIG. **27** is an area where a solid yellow image is to be formed. In this case, for example, based on the template for white correction as shown in FIG. **14**, the correction target nozzle that ejects the white ink onto the shaded area **85** is specified from among the plurality of white ink ejection nozzles corresponding to the shaded area **85**, the correction target nozzle that ejects the white ink onto the shaded area **86** is specified from among the plurality of white ink ejection nozzles corresponding to the shaded area **86**, and the correction target nozzle that ejects the white ink onto the shaded area **87** is specified from among the plurality of white ink ejection nozzles corresponding to the shaded area **87**. In general, the area where the solid image is to be formed corresponds to many nozzles, and thus, similarly to the second embodiment, many white ink ejection nozzles are specified as the correction target nozzles compared to the first embodiment. Therefore, the correction pattern creation unit **247** creates the correction pattern **77** such that the area to be the ejection target of the white ink (correction area) becomes wider than in the first embodiment.
(136) <3.2.2 Procedure>
(137) A procedure for density correction in the present embodiment will be described with reference to the flowchart shown in FIG. **17**. The processes of steps S**110** to S**120** and the processes of steps S**124** to S**130** are similar to those in the first embodiment.
(138) In step S**121**, the white correction determination unit **245** determines whether it is necessary to perform white correction, based on the print data **74**. As a result, when it is necessary to perform white correction, the processing proceeds to step S**122**, and when it is not necessary to perform white correction, the processing proceeds to step S**130**. In the present embodiment, when there is an area where a solid image is to be formed in the print area, it is determined that it is necessary to perform white correction.
(139) In step S**122**, the correction target nozzle specification unit **246** specifies the correction target nozzle described above based on the print data **74**. At this time, the correction target nozzle is specified, based on the template for white correction, from among the plurality of white ink ejection nozzles corresponding to the area where the solid image is to be formed.
(140) <3.3 Effects>
(141) According to the present embodiment, white correction that corrects the density data such that the white ink is ejected from the white ink ejection nozzle specified based on the

predetermined pattern is performed for an area where a solid image is to be formed. As described above, the wet spreading range of the color ink on the base material **12** is larger when the color ink is ejected onto the white ink that has been ejected onto the base material **12** than when the color ink is directly ejected onto the base material **12**. Therefore, by ejecting the ink from each ink ejection head **150** based on the density data after white correction, the color ink sufficiently spreads on the base material **12** in the area where the solid image is printed, and the dot size of the color ink becomes larger than in the related art. This improves the print quality of the solid image. From the above, the inkjet printing apparatus **10** capable of improving the quality of printed matter is achieved.

4. Summary

(142) To summarize the first to third embodiments, the processing is performed schematically by the procedure shown in FIG. **28**. First, a correction area, which is a part of area where a second ink (typically, white ink) is to be ejected among the area on the base material **12**, is determined (step S**10**). Next, a process of correcting density data for controlling the ejection of the ink from the ink ejection head **150** for the second ink is performed so that the second ink is ejected onto the correction area determined in step S**10** (step S**20**). Thereafter, actual printing on the base material **12** is started (step S**30**). Then, the second ink is ejected onto the correction area (step S**40**). Next, a first ink (typically, color ink) is ejected onto the second ink that has been ejected onto the base material **12** in the correction area (step S**50**). Note that step S**10** corresponds to a correction area determination step, step S**40** corresponds to a second ink ejection step, and step S**50** corresponds to a first ink ejection step.

5. Others

(143) The present invention is not limited to the above embodiments (including the modification), and various modifications can be made without departing from the gist of the present invention. For example, although the inkjet printing apparatus **10** that performs printing using UV ink is exemplified in each of the above embodiments, the present invention can also be applied to a case where an inkjet printing apparatus that performs printing using ink cured by irradiation with radiation other than ultraviolet rays is adopted.

(144) This application is an application claiming priority based on Japanese Patent Application No. 2022-150159 entitled “Printing Apparatus and Printing Method” filed on Sep. 21, 2022, and the contents of which are herein incorporated by reference.

6. Appendix

(145) A printing apparatus with the configuration described below is also conceivable from the above disclosure.

(146) A printing apparatus that performs printing by ejecting ink onto a printing medium, the printing apparatus comprising: a conveyor configured to convey the printing medium; a first ink ejection head including a plurality of ink ejection ports, the first ink ejection head being configured to eject a first ink onto the printing medium conveyed by the conveyor; a second ink ejection head including a plurality of ink ejection ports and disposed on an upstream side of the first ink ejection head regarding a direction in which the printing medium is conveyed by the conveyor, the second ink ejection head being configured to eject a second ink onto the printing medium conveyed by the conveyor; a processor; and a memory configured to store a program; wherein a wet spreading range of the first ink on the printing medium is larger when the first ink is ejected onto the second ink that is ejected onto the printing medium than when the first ink is directly ejected onto the printing medium, and when the program stored in the memory is executed by the processor, the program causes the processor to: determine a correction area that is a part of area where the second ink is to be ejected among the area on the printing medium; and control ejection of the second ink from the second ink ejection head to cause the second ink to be ejected onto the correction area before the first ink is ejected onto the correction area.

Claims

1. A printing apparatus that performs printing by ejecting ink onto a printing medium, the printing apparatus comprising: a conveyor configured to convey the printing medium; a first ink ejection head including a plurality of ink ejection ports, the first ink ejection head being configured to eject a first ink onto the printing medium conveyed by the conveyor; a second ink ejection head including a plurality of ink ejection ports and disposed on an upstream side of the first ink ejection head regarding a direction in which the printing medium is conveyed by the conveyor, the second ink ejection head being configured to eject a second ink onto the printing medium conveyed by the conveyor; a correction area determination unit configured to determine a correction area that is a part of area where the second ink is to be ejected among the area on the printing medium; and an ink ejection controller configured to control ejection of the second ink from the second ink ejection head to cause the second ink to be ejected onto the correction area before the first ink is ejected onto the correction area, wherein a wet spreading range of the first ink on the printing medium is larger when the first ink is ejected onto the second ink that is ejected onto the printing medium than when the first ink is directly ejected onto the printing medium.
2. The printing apparatus according to claim 1, wherein the correction area determination unit determines the correction area based on a position of a defective ejection port that is an ink ejection port having an ejection defect among the plurality of ink ejection ports included in the first ink ejection head.
3. The printing apparatus according to claim 2, wherein the correction area determination unit determines the correction area to cause the second ink to be ejected from an ink ejection port that corresponds to an ink ejection port adjacent to the defective ejection port and is included in the second ink ejection head.
4. The printing apparatus according to claim 2, wherein the correction area determination unit determines the correction area based on print data including density data of each of a plurality of color inks in such a way that only an area where printing is performed with a single-color ink to be ejected from the defective ejection port is included in the correction area, the single-color ink having a density equal to or higher than a predetermined value.
5. The printing apparatus according to claim 2, wherein the correction area determination unit determines the correction area such that one pixel, onto which the second ink is ejected, and one pixel, onto which the second ink is not ejected, alternately appear regarding a direction in which the printing medium is conveyed by the conveyor.
6. The printing apparatus according to claim 2, wherein the correction area determination unit determines the correction area such that two pixels, onto which the second ink is ejected, and two pixels, onto which the second ink is not ejected, alternately appear regarding a direction in which the printing medium is conveyed by the conveyor.
7. The printing apparatus according to claim 1, wherein the first ink ejection head includes a plurality of ink ejection heads arranged in a staggered manner, and the correction area determination unit determines the correction area in such a way that an area where there is overlap between an area where ink is ejected by one ink ejection head and an area where ink is ejected by another ink ejection head is included in the correction area.
8. The printing apparatus according to claim 7, wherein the correction area determination unit determines the correction area based on print data including density data of each of a plurality of color inks in such a way that only an area where printing is performed with a single-color ink is included in the correction area.
9. The printing apparatus according to claim 7, wherein the correction area determination unit determines the correction area such that one pixel, onto which the second ink is ejected, and one pixel, onto which the second ink is not ejected, alternately appear regarding a direction in which the

printing medium is conveyed by the conveyor.

10. The printing apparatus according to claim 7, wherein the correction area determination unit determines the correction area such that one pixel, onto which the second ink is ejected, and three pixels, onto which the second ink is not ejected, alternately appear regarding a direction in which the printing medium is conveyed by the conveyor.

11. The printing apparatus according to claim 1, wherein the correction area determination unit determines the correction area in such a way that an area in which a density of the first ink is 100% is included in the correction area.

12. The printing apparatus according to claim 1, wherein the correction area determination unit determines the correction area in such a way that an area where the second ink is ejected in order to form a printed image is not included in the correction area.

13. The printing apparatus according to claim 1, wherein the first ink and the second ink are ultraviolet curable inks.

14. The printing apparatus according to claim 13, further comprising: a first ultraviolet irradiator configured to cure the first ink ejected from the first ink ejection head onto the printing medium by ultraviolet irradiation; a second ultraviolet irradiator configured to cure the second ink ejected from the second ink ejection head onto the printing medium by ultraviolet irradiation; and an ultraviolet irradiation controller configured to control the ultraviolet irradiation performed by the second ultraviolet irradiator, wherein when the second ink is ejected onto the correction area, the ultraviolet irradiation controller stops the ultraviolet irradiation performed by the second ultraviolet irradiator or reduces intensity of the ultraviolet irradiation performed by the second ultraviolet irradiator.

15. The printing apparatus according to claim 14, wherein the first ink ejection head includes a plurality of ink ejection heads corresponding to a plurality of colors, the plurality of ink ejection heads ejecting color inks of colors different from each other, and the ink ejection controller controls ejection of the second ink from the second ink ejection head such that a size of the second ink ejected from the second ink ejection head becomes larger as a distance from an ink ejection head corresponding to a color ink ejected as the first ink onto the second ink in the correction area among the plurality of ink ejection heads to the first ultraviolet irradiator becomes shorter.

16. The printing apparatus according to claim 1, wherein the second ink ejection head is configured to be able to eject the second ink in a plurality of sizes, and the ink ejection controller controls ejection of the second ink from the second ink ejection head such that the second ink is ejected onto the correction area with a smallest size among the plurality of sizes by the second ink ejection head.

17. The printing apparatus according to claim 1, wherein a color of the printing medium is white, the first ink is a color ink, and the second ink is a white ink.

18. The printing apparatus according to claim 1, wherein a color of the printing medium is transparent, the first ink is a color ink, and the second ink is a transparent ink.

19. The printing apparatus according to claim 1, wherein the first ink and the second ink are selected based on a brightness value or a color difference.

20. A printing method using a printing apparatus that includes a conveyor configured to convey a printing medium, a first ink ejection head configured to eject a first ink onto the printing medium conveyed by the conveyor, and a second ink ejection head configured to eject a second ink onto the printing medium conveyed by the conveyor, the printing method comprising: a correction area determination step of determining a correction area that is a part of area where the second ink is to be ejected among the area on the printing medium; a second ink ejection step of ejecting the second ink from the second ink ejecting head; and a first ink ejection step of ejecting the first ink from the first ink ejecting head, wherein a wet spreading range of the first ink on the printing medium is larger when the first ink is ejected onto the second ink that is ejected onto the printing medium than when the first ink is directly ejected onto the printing medium, and before the first ink is ejected

onto the correction area in the first ink ejection step, the second ink is ejected onto the correction area in the second ink ejection step.