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Image forming apparatus

Abstract

An image forming apparatus includes an image forming unit configured to form an image on a sheet through use of toner a reading unit configured to read the sheet on which a mark for correction is formed a display, and a controller configured to display a plurality of images included in a print job in a selectable manner, acquire user selection information indicating a selection result for an image selected from among the plurality of images, determine, based on the user selection information, an image for adjustment to be formed by the image forming unit, the image for adjustment including a pattern image, which is to have a toner adhesion amount corresponding to a density of the selected image, and the mark for correction, and control the image forming unit to form the image for adjustment on a sheet.

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Background/Summary

BACKGROUND OF THE INVENTION

Field of the Invention

(1) The present disclosure relates to an image forming apparatus capable of performing duplex printing.

Description of the Related Art

(2) For a printed matter to be printed by a commercial image forming apparatus, positions (printing positions) of an image to be printed on a front surface of a paper sheet and an image to be printed on a back surface of the paper sheet are required to be aligned with each other with high accuracy at a time of duplex printing. Thus, the image forming apparatus has a function (hereinafter referred to as “front-and-back position correction function”) of aligning the printing positions of the images on the front surface and the back surface of the paper sheet by adjusting the printing positions at the time of duplex printing. The front-and-back position correction function of the image forming apparatus enables images to be printed so as not to overlap with ruled lines in a case where the images are printed on preprinted paper on which the ruled lines and the like have been printed in advance.

(3) Front-and-back position correction that is performed by the front-and-back position correction function is required to be executed for each type of paper sheet on which images are to be printed. This is because an amount of expansion and contraction of a paper sheet varies depending on characteristics of the paper sheet, such as a size, a basis weight, and a material of the paper sheet. A

paper sheet has an optimum correction amount for the front-and-back position correction varying depending on a difference in the amount of expansion and contraction of the paper sheet. The front-and-back position correction is performed by causing a reading apparatus to read a sheet for adjustment on which a mark (image for adjustment) for position detection has been printed on a paper sheet to be corrected, and detecting a deviation of the printing position based on a reading result of the image for adjustment.

(4) The image forming apparatus detects the deviation of the printing position based on, for example, a length from a reference position to the mark which is obtained from a reading result of the sheet for adjustment. A correction amount for correcting the printing position is determined based on a detection result of the deviation of the printing position. In a case where printing processing is performed through use of a paper sheet having the same type as that of the paper sheet to be corrected, the image forming apparatus corrects the printing position based on the correction amount.

(5) Factors of the deviation of the printing position on each of the front surface and the back surface at a time of printing involve not only a paper sheet type but also a toner adhesion amount of a toner image printed on the paper sheet. A difference in the toner adhesion amount exerts an influence on a paper sheet conveying force at a time of transferring the toner image onto the paper sheet. In a case where the toner adhesion amount is large, slippage due to toner occurs, thereby lowering the paper sheet conveying force, and a deviation of the printing position occurs in a direction of contraction with respect to a conveyance direction of the paper sheet.

(6) In order to suppress the influence caused by the toner adhesion amount, an image forming apparatus as disclosed in United Status U.S. Pat. No. 11,178,290 determines the correction amount for the front-and-back position correction corresponding to the toner adhesion amount through use of the images for adjustment printed on a plurality of paper sheets having different toner adhesion amounts. Thus, even for printed matters having different toner adhesion amounts, the front-and-back position correction corresponding to the toner adhesion amounts is performed, to thereby improve correction accuracy.

(7) In general, an image forming apparatus provided with a front-and-back position correction function includes a front-and-back position correction function (hereinafter referred to as “initial front-and-back position correction”) of determining the correction amount corresponding to the type of paper sheet by performing, before execution of printing, the front-and-back position correction on a paper sheet to be used. However, even in a case where the printing position is corrected through use of the correction amount determined by the front-and-back position correction function, the correction accuracy of the printing position may deteriorate due to a temperature rise in the image forming apparatus caused by large-scale printing and a change in an image forming environment such as a change in a hygroscopic state of a paper sheet. For that reason, there is an image forming apparatus provided with a front-and-back position correction function (hereinafter referred to as “print front-and-back position correction”) of maintaining the correction amount in a proper state by again performing the front-and-back position correction at predetermined page intervals during printing.

(8) In the print front-and-back position correction that is performed during printing, in a case where an attempt is made to determine the correction amount corresponding to the toner adhesion amount, it is required to output the sheet for adjustment corresponding to the toner adhesion amount. FIG. **21** is an explanatory view of timings to output sheets for adjustment during printing. For example, in a case of performing the print front-and-back position correction on every 100 sheets in continuous printing of 300 sheets, the print front-and-back position correction is performed after the printing of the 100th sheet and the 200th sheet. At this time, in a case where five types of sheets for adjustment are required, the number of sheets to be paper to be discarded is 5×2=10. That is, as the number of sheets to be printed increases, the number of sheets of paper to be discarded by the print front-and-back position correction increases. In view of the above-mentioned problems, the

present disclosure has a main object to provide an image forming apparatus that updates a correction amount for front-and-back position correction corresponding to a toner adhesion amount while reducing the number of sheets of paper to be discarded.

SUMMARY OF THE INVENTION

(9) An image forming apparatus according to the present disclosure includes an image forming unit configured to form an image on a sheet through use of toner a reading unit configured to read the sheet on which a mark for correction is formed a display, and a controller configured to display a plurality of images included in a print job in a selectable manner on the display, acquire user selection information indicating a selection result for an image selected from among the plurality of images, determine, based on the user selection information, an image for adjustment to be formed by the image forming unit, the image for adjustment including a pattern image, which is to have a toner adhesion amount corresponding to a density of the selected image, and the mark for correction, control the image forming unit to form the image for adjustment on a sheet, control the reading unit to read the sheet on which the image for adjustment has been formed, and control a printing position of the selected image formed by the image forming unit based on a reading result of the sheet on which the image for adjustment read by the reading unit has been formed.

(10) Further features of the present invention will become apparent from the following description of exemplary embodiments (with reference to the attached drawings).

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** is an overall configuration diagram of a printing system.

(2) FIG. **2** is a configuration diagram of an image forming apparatus.

(3) FIG. **3** is an explanatory view of images for adjustment.

(4) FIG. **4** is an explanatory view of images for adjustment for reproducing contraction of a paper sheet.

(5) FIG. **5** is an exemplary view of an edit screen.

(6) FIG. **6** is an exemplary view of a paper sheet attribute edit screen.

(7) FIG. **7**A and FIG. **7**B are explanatory tables of a paper sheet library.

(8) FIG. **8** is an explanatory table of calculation methods for printing position deviation amounts.

(9) FIG. **9** is an exemplary view of a paper sheet type setting screen.

(10) FIG. **10**A, FIG. **10**B, and FIG. **10**C are exemplary views of a printing position adjustment screen.

(11) FIG. **11** is a flow chart for illustrating initial front-and-back position correction processing.

(12) FIG. **12** is a flow chart for illustrating image forming processing.

(13) FIG. **13** is a flow chart for illustrating execution interval setting processing for print front-and-back position correction.

(14) FIG. **14**A and FIG. **14**B are explanatory views of paper sheet selection screens.

(15) FIG. **15**A, FIG. **15**B, and FIG. **15**C are explanatory views of a method of storing print adjustment page settings.

(16) FIG. **16** is a flow chart for illustrating processing for setting pages on which the print front-and-back position correction is to be executed.

(17) FIG. **17** is a flow chart for illustrating the print front-and-back position correction processing.

(18) FIG. **18** is an exemplary view of a print adjustment page setting screen.

(19) FIG. **19**A and FIG. **19**B are exemplary views of a chart selection screen.

(20) FIG. **20**A and FIG. **20**B are explanatory views for a method of generating images for adjustment.

(21) FIG. **21** is an explanatory view of timings to output sheets for adjustment during printing.

DESCRIPTION OF THE EMBODIMENTS

(22) Now, referring to the accompanying drawings, description is given of at least one exemplary embodiment of the present disclosure.

(23) FIG. **1** is an overall configuration diagram of a printing system including an image forming apparatus according to the at least one embodiment. The printing system includes an image forming apparatus **100** and a host computer **101**. The image forming apparatus **100** and the host computer **101** are connected to each other so as to enable communication therebetween through a network **105**. The network **105** is, for example, a communication line such as a local area network (LAN) or a wide area network (WAN). A plurality of image forming apparatus **100** may be connected to the network **105**, and a plurality of host computers **101** may also be connected to the network **105**.

(24) The host computer **101** is, for example, a server, and transmits a print job to the image forming apparatus **100** through the network **105**. The print job includes various kinds of information required for printing, such as image data representing an image (output image) to be printed, a type of paper sheet used for printing, the number of sheets to be printed, and designation of duplex or simplex printing.

(25) The image forming apparatus **100** includes a controller **110**, an operation panel **120**, a sheet feeding apparatus **140**, a printer **150**, and a reading apparatus **160**. The image forming apparatus **100** prints an image on a paper sheet by the printer **150** based on the print job acquired from the host computer **101**. The controller **110**, the operation panel **120**, the sheet feeding apparatus **140**, the printer **150**, and the reading apparatus **160** are connected to each other through a system bus **116** so as to enable communication therebetween.

(26) The controller **110** controls each unit of the image forming apparatus **100**. The operation panel **120** is a user interface including an input interface and an output interface. The input interface includes operation buttons and a numeric keypad. The output interface includes a display, such as a liquid crystal display (LCD), and a speaker. An operator can input a print job, a command, a print setting, and the like to the image forming apparatus **100** through the operation panel **120**.

(27) The controller **110** acquires the print job, the command, the print setting, and the like input through the operation panel **120**. The operation panel **120** can display, under the control of the controller **110**, various setting screens and a state of the image forming apparatus **100** on the display.

(28) The sheet feeding apparatus **140** includes a plurality of sheet feeding stages that receive paper sheets. The sheet feeding apparatus **140** feeds one sheet at a time in order from the uppermost sheet of a paper sheet bundle that is a bundle of a plurality of paper sheets stacked on each sheet feeding stage. The sheet feeding apparatus **140** conveys, to the printer **150**, the paper sheet fed from the sheet feeding stage.

(29) The printer **150** generates a printed matter by printing an image (output image) on the paper sheet supplied from the sheet feeding apparatus **140** based on the image data. A specific configuration of the printer **150** is described later with reference to FIG. **2**. The reading apparatus **160** is a reader, and reads the printed matter generated by the printer **150** to transmit a reading result thereof to the controller **110**. A specific configuration of the reading apparatus **160** is described later with reference to FIG. **2**.

(30) The controller **110** is an information processing device including a read only memory (ROM) **112**, a random access memory (RAM) **113**, and a central processing unit (CPU) **114**. The controller **110** further includes an I/O controller **111** and a storage **115**. The storage **115** is a large capacity storage device such as a hard disk drive (HDD) or a solid state drive (SSD).

(31) The I/O controller **111** is a communication interface which controls communication to/from the host computer **101** and another apparatus through the network **105**. The ROM **112** is a storage device that stores various control programs. The storage **115** stores control programs and various kinds of data such as image data to be used for image forming processing (printing processing).

The RAM **113** functions as a system work memory into which the control programs stored in the ROM **112** and the storage **115** are to be loaded. The CPU **114** executes the control programs loaded into the RAM **113** to centrally control the image forming apparatus **100**. Modules included in the controller **110** are connected to each other through the system bus **116** so as to enable communication therebetween.

(32) FIG. **2** is a configuration diagram of the image forming apparatus **100**. The image forming apparatus **100** according to the at least one embodiment includes a finisher **190** in addition to the sheet feeding apparatus **140**, the printer **150**, and the reading apparatus **160**, which have been described with reference to FIG. **1**. The finisher **190** is a post-processing apparatus that performs predetermined post-processing on the printed matter generated by the printer **150**. As the post-processing, the finisher **190** performs, for example, stapling processing on a plurality of printed matters or sorting processing on the printed matters.

(33) The printer **150** includes a plurality of image forming units. In the at least one embodiment, four image forming units are provided in accordance with the number of colors of an image to be formed. The four image forming units are an image forming unit that forms a yellow image, an image forming unit that forms a magenta image, an image forming unit that forms a cyan image, and an image forming unit that forms a black image. The image forming units have substantially the same configurations.

(34) One image forming unit includes a photosensitive drum **153**, a charging device **220**, an exposure device **223**, and a developing device **152**. The photosensitive drum **153** is a drum-shaped photosensitive member including a photosensitive layer on a surface thereof, and is rotated in a direction indicated by an arrow R**1** by a motor (not shown). The charging device **220** charges the surface of the photosensitive drum **153**. The exposure device **223** irradiates (or exposes) the charged surface of the photosensitive drum **153** with (or to) laser light modulated based on the image data. Thus, an electrostatic latent image is formed on the surface of the photosensitive drum **153**. The developing device **152** develops the electrostatic latent image through use of a developer (toner). Thus, the electrostatic latent image on the surface of the photosensitive drum **153** is visualized, and an image (toner image) is formed on the photosensitive drum **153**.

(35) The printer **150** includes an intermediate transfer belt **154** onto which the toner images formed by the image forming units are to be transferred. The intermediate transfer belt **154** is rotated in a direction indicated by an arrow R**2**. The toner images of yellow, magenta, cyan, and black that have been formed by the respective image forming units are transferred onto the intermediate transfer belt **154** so as to overlap with each other at a timing corresponding to a rotation speed of the intermediate transfer belt **154**. Thus, a full-color toner image is formed on the intermediate transfer belt **154**. The toner image transferred onto the intermediate transfer belt **154** is conveyed in the direction indicated by an arrow R**2**, and is transferred onto the paper sheet fed from the sheet feeding apparatus **140** at a nip portion formed by the intermediate transfer belt **154** and a transfer roller **221**.

(36) The sheet feeding apparatus **140** includes a plurality of sheet feeding stages **140***a*, **140***b*, **140***c*, **140***d*, and **140***e* that receive paper sheets. Of the paper sheets, a paper sheet having a type designated by a print job is fed from any one of the sheet feeding stages **140***a*, **140***b*, **140***c*, **140***d*, and **140***e* in accordance with a timing at which each image forming unit starts forming an image. The fed paper sheet is conveyed to the nip portion formed by the intermediate transfer belt **154** and the transfer roller **221** with a timing being adjusted so that the toner image on the intermediate transfer belt **154** is transferred to a predetermined position.

(37) The printer **150** includes a first fixing device **155** and a second fixing device **156** that apply heat and pressure to the toner image transferred onto the paper sheet to fix the image to the paper sheet. The first fixing device **155** includes a fixing roller including a heater in an inside thereof and a pressure belt for bringing the paper sheet into press contact with the fixing roller. The fixing roller and the pressure belt are driven by motors (not shown) to nip and convey the paper sheet. The

second fixing device **156** is arranged downstream of the first fixing device **155** in a conveyance direction of the paper sheet. The second fixing device **156** is used for increasing a gloss of the image on the paper sheet that has passed through the first fixing device **155** and for ensuring fixability. The second fixing device **156** includes a fixing roller including a heater in an inside thereof and a pressure roller including a heater in an inside thereof. The fixing roller and the pressure roller are driven by motors (not shown) to nip and convey the paper sheet.

(38) The second fixing device **156** is not used depending on the type of image to be printed (type thereof such as photograph, characters, or the like) and the type of paper sheet to be used for printing. In this case, the paper sheet that has passed through the first fixing device **155** is conveyed to a conveyance path **130** without being conveyed to the second fixing device **156**. To that end, a flapper **131** that guides the paper sheet to any one of the conveyance path **130** and the second fixing device **156** is provided between the first fixing device **155** and the second fixing device **156**.

(39) The paper sheet that has passed through any one of the second fixing device **156** and the conveyance path **130** is conveyed to any one of a conveyance path **135** and a delivery path **139**. To that end, a flapper **132** is provided at a point at which the path branches off to the conveyance path **135** and the delivery path **139**. For example, in a duplex printing mode, the flapper **132** guides the paper sheet having an image printed on a first surface (front surface) thereof to the conveyance path **135**, and guides the paper sheet having an image printed on both surfaces thereof to the delivery path **139**. For example, in a face-up sheet delivery mode, the flapper **132** guides the paper sheet having an image printed on the front surface to the delivery path **139**. For example, in a face-down sheet delivery mode, the flapper **132** guides the paper sheet having an image printed on the front surface to the conveyance path **135**. Further, the flapper **132** guides the paper sheet having an image for adjustment, which is to be used for printing position adjustment, printed on the first surface (front surface) to the conveyance path **135** in order to print an image for adjustment, which is to be used for printing position adjustment, on a second surface (back surface) of the paper sheet.

(40) The paper sheet guided to the conveyance path **135** is conveyed to a reverser **136**. After a conveyance operation of the paper sheet conveyed to the reverser **136** has been temporarily stopped, the paper sheet is reversed in the conveyance direction. The paper sheet reversed in the conveyance direction is conveyed to any one of a conveyance path **138** and the conveyance path **135**. A flapper **133** is provided at a branch portion between the conveyance path **138** and the conveyance path **135**. The flapper **133** guides the paper sheet to any one of the conveyance path **138** and the conveyance path **135**. For example, the flapper **133** guides the paper sheet reversed in the conveyance direction to the conveyance path **138** in the duplex printing mode, and guides the paper sheet reversed in the conveyance direction to the conveyance path **135** in the face-down sheet delivery mode. The paper sheet conveyed to the conveyance path **135** by the flapper **133** is guided to the delivery path **139** by the flapper **134**. Further, in order to print the images for adjustment on the second surface (back surface) of the paper sheet, the flapper **133** guides the paper sheet reversed in the conveyance direction to the conveyance path **138**.

(41) The paper sheet conveyed to the conveyance path **138** by the flapper **133** is conveyed toward the nip portion between the intermediate transfer belt **154** and the transfer roller **221**. The front and back of the paper sheet have been reversed by the reverser **136**, and hence the paper sheet has a toner image transferred onto the second surface (back surface) while passing through the nip portion.

(42) The reading apparatus **160** that reads an image for adjustment printed on a paper sheet is connected on downstream of the printer **150** in the conveyance direction of the paper sheet. The paper sheet having an image printed thereon is sent to the reading apparatus **160** through the delivery path **139** as a printed matter. The paper sheet (printed matter) supplied from the printer **150** to the reading apparatus **160** is conveyed along a conveyance path **313**. The reading apparatus **160** includes a sheet detection sensor **311** and line sensors **312***a* and **312***b* along the conveyance path **313**. The reading apparatus **160** uses the line sensors **312***a* and **312***b* to read the paper sheet

having the image for adjustment printed thereon by the printer **150** while conveying the paper sheet along the conveyance path **313**.
(43) Details of the images for adjustment are described later. In the following description, a paper sheet having an image for adjustment printed thereon is referred to as "sheet for adjustment." In addition, a paper sheet having an image (output image designated by a print job) other than the image for adjustment printed thereon is also conveyed to the finisher **190** along the conveyance path **313**.
(44) The sheet detection sensor **311** is, for example, an optical sensor including a light-emitting element and a light-receiving element. The sheet detection sensor **311** detects a leading end of the sheet for adjustment in the conveyance direction, the sheet for adjustment being conveyed along the conveyance path **313**. The controller **110** can determine a skew feed amount of the paper sheet based on a timing at which the leading end of the paper sheet is detected by the sheet detection sensor **311**.
(45) The line sensor **312***a* and the line sensor **312***b* are arranged at positions opposed to each other across the conveyance path **313**. The line sensors **312***a* and **312***b* each read an image for adjustment on the sheet for adjustment. The images for adjustment are printed on, for example, both the front surface and the back surface of the paper sheet. While the paper sheet is being conveyed between the line sensor **312***a* and the line sensor **312***b*, the images for adjustment printed on both the surfaces are read at a time.
(46) In a case of performing the printing position adjustment, the image forming apparatus **100** detects a deviation amount of a printing position (image forming position) of the image for adjustment from an ideal position based on each of reading results of the images for adjustment obtained by the line sensors **312***a* and **312***b*. The controller **110** controls the image forming processing based on the detected deviation amount of the printing position (image forming position) so that the printing position (image forming position) with respect to the paper sheet becomes the ideal position. Front-and-back position adjustment for adjusting the printing positions on the front surface and the back surface of the paper sheet is also performed based on results of the printing position adjustment.
(47) The finisher **190** performs predetermined post-processing on the printed matter that has passed through the reading apparatus **160**, and delivers the printed matter. At this time, the printed matter on which the output image designated by the print job has been printed is delivered after the post-processing, but the sheet for adjustment on which the image for adjustment has been printed is delivered without being subjected to the post-processing. The sheet for adjustment is delivered onto, for example, a delivery tray that is different from a delivery tray onto which to deliver the printed matter on which the output image has been printed.
(48) <Image for Adjustment>
(49) FIG. **3** is an explanatory view of images for adjustment. The printer **150** prints an image **700** for adjustment on the front surface of the paper sheet, and prints an image **701** for adjustment on the back surface of the paper sheet. The images **700** and **701** for adjustment each include a plurality of marks **720** for correction. The marks **720** for correction are located in four corners (corner areas) of the paper sheet, and are each printed at a position spaced apart from a paper sheet end by a predetermined distance. The plurality of marks **720** for correction are formed through use of black toner at the same image density. Printing in black increases a difference between intensity of light reflected by the marks **720** for correction and intensity of light reflected by the paper sheet, and hence it is possible to detect contours of the marks **720** for correction with high accuracy from the reading result obtained by the reading apparatus **160**.
(50) In a case where the printing position is the ideal position, for each of the marks **720***a* for correction, a distance from the paper sheet end to the mark **720***a* is the predetermined distance. The controller **110** measures the positions of the marks **720** for correction on the paper sheet in order to detect the deviation amount of the printing position. The controller **110** measures a length (A) to a

length (V) of FIG. **3** based on the reading results of the images for adjustment, which have been obtained by the reading apparatus **160**.
(51) The length (A) to the length (V) are measured as follows. The controller **110** causes the line sensors **312***a* and **312***b* to read the images for adjustment. The controller **110** detects the paper sheet ends and edges of the marks **720** for correction (boundaries between the paper sheet and the marks **720** for correction) based on differences in read values such as brightness values between the read images of the images for adjustment, which have been obtained by the line sensors **312***a* and **312***b*, and the paper sheet. The controller **110** counts the numbers of read pixels from the detected paper sheet ends to the detected edges of the marks **720** for correction, and measures the lengths (A) to (V) based on the count values.
(52) The length (A) is a length of the sheet for adjustment in a short-side direction thereof, and the length (B) is a length of the sheet for adjustment in a long-side direction thereof. Ideal lengths of the length (A) and the length (B) are defined by a size of a paper sheet. The length (C) to the length (R) correspond to distances (lengths) from the paper sheet ends to the nearby marks **720** for correction.
(53) A printing position deviation amount is calculated based on the length (A) to the length (V). However, according to experiments conducted by the inventor(s), it was found that a deformation amount of the paper sheet generated by the images for adjustment exemplified in FIG. **3** was different from a deformation amount of the paper sheet on which an output image corresponding to an actual print job had been printed. This is because the deformation amount of the paper sheet varies depending on a toner adhesion amount. The toner adhesion amount of the paper sheet on which the output image has been printed varies depending on the type of image. For example, in a case where a photographic image is printed on an entire surface of the paper sheet, the toner adhesion amount of the paper sheet is larger than the toner adhesion amount of the sheet for adjustment. For that reason, there is a fear that it is not possible to correct the printing position of the output image to the ideal position by the correction amount obtained from the printing position deviation amount measured through use of the sheet for adjustment on which only the marks **720** for correction have been printed.
(54) In the at least one embodiment, another mark different from the marks **720** for correction is formed at a position that does not overlap with the marks **720** for correction, and the printing position adjustment is executed through use of an image for adjustment suitable for the toner adhesion amount of the paper sheet on which the output image has been printed in actuality. In the at least one embodiment, the toner adhesion amount of the paper sheet is classified into five classes, and images for adjustment corresponding to the respective toner adhesion amount classes are printed on sheets for adjustment. It is possible to calculate the printing position deviation amount even in a case where another mark is printed at the position that does not overlap with the marks **720** for correction.
(55) FIG. **4** is an explanatory view of images for adjustment for reproducing contraction of the paper sheet which occurs due to a difference in the toner adhesion amount. The image forming apparatus **100** performs the printing position adjustment through use of an image for adjustment suitable for the toner adhesion amount of the output image from among five types of images **70***a*, **70***b*, **70***c*, **70***d*, and **70***e* for adjustment having different image densities, which are illustrated in FIG. **4**. The toner adhesion amounts (image densities) of the images **70***a* to **70***e* for adjustment are the toner adhesion amounts corresponding to the toner adhesion amount classes **1** to **5**, respectively. Data on the image for adjustment for causing the printer **150** to print the images **70***a*, **70***b*, **70***c*, **70***d*, and **70***e* for adjustment is stored in advance in the storage **115**. The images for adjustment that correspond to each toner adhesion amount are not required to be limited to five types as long as the image densities are different.
(56) Only the marks **720** for correction are formed in the image **70***a* for adjustment. The image **70***b* for adjustment includes the marks **720** for correction and a rectangular mark **730**. The mark **730** is

formed at a position different from those of the mark **720** for correction so as not to overlap with the marks **720** for correction. The mark **730** is a toner image formed based on an image signal value of 25%. The image **70***c* for adjustment includes the marks **720** for correction and a rectangular mark **731**. The mark **731** is formed at a position different from those of the mark **720** for correction so as not to overlap with the marks **720** for correction. The mark **731** is a toner image formed based on an image signal value of 50%. The image **70***d* for adjustment includes the marks **720** for correction and a rectangular mark **732**. The mark **732** is formed at a position different from those of the mark **720** for correction so as not to overlap with the marks **720** for correction. The mark **732** is a toner image formed based on an image signal value of 75%. The image **70***e* for adjustment includes the marks **720** for correction and a rectangular mark **733**. The mark **733** is formed at a position different from those of the mark **720** for correction so as not to overlap with the marks **720** for correction. The mark **733** is a toner image formed based on an image signal value of 100%.

(57) The marks **730**, **731**, **732**, and **733** are images having the same area. The marks **730**, **731**, **732**, and **733** are formed based on mutually different image signal values, and therefore have mutually different image densities. The image densities of the respective marks **730**, **731**, **732**, and **733** become higher in an order of the mark **730** having the lowest image density, the mark **731**, the mark **732**, and the mark **733**. Thus, the image **70***e* for adjustment has the largest toner adhesion amount among the images **70***a*, **70***b*, **70***c*, **70***d*, and **70***e* for adjustment. The image **70***a* for adjustment has the smallest toner adhesion amount among the images **70***a*, **70***b*, **70***c*, **70***d*, and **70***e* for adjustment. The marks **730**, **731**, **732**, and **733** are each a pattern image supposed to have a toner adhesion amount determined in advance. The shape of the marks **730**, **731**, **732**, and **733** is not limited to a rectangular shape, and may be any shape.

(58) <Paper Sheet Library>

(59) Paper sheets usable by the image forming apparatus **100** are managed by a database. This database is referred to as “paper sheet library.” The paper sheet library is stored in, for example, the host computer **101** (server) connected to the image forming apparatus **100** or the storage **115**. Information on each paper sheet stored in the paper sheet library is read out therefrom or written thereto as required.

(60) FIG. **5** is an exemplary view of an edit screen for the operator to edit the information on the paper sheet stored in the paper sheet library. An edit screen **400** therefor is displayed on the operation panel **120** of the image forming apparatus **100**. The edit screen **400** includes a paper sheet list **410**, an add new button **420**, an edit button **421**, a delete button **422**, and a select button **423**.

(61) A list of paper sheets managed by a paper sheet library **600** is displayed in the paper sheet list **410**. Attribute information indicating characteristics of each paper sheet is displayed in columns **411** to **416**. A paper sheet name is displayed in the column **411**. The paper sheet name is information set by the operator so that the operator can identify the type of paper sheet. A paper sheet size is displayed in the columns **412** and **413**. A paper sheet length in the short-side direction is displayed in the column **412**, and a paper sheet length in the long-side direction is displayed in the column **413**. A basis weight of the paper sheet is displayed in the column **414**.

(62) Information for the operator to identify a surface property of the paper sheet is displayed in the column **415**. The information for the operator to identify the surface property of the paper sheet is information on a physical characteristic of a paper sheet surface. For example, the paper sheet displayed as “DOUBLE-SIDED COATED” in the column **415** refers to a paper sheet subjected to surface treatment for increasing glossiness. For example, the paper sheet displayed as “EMBOSSED” in the column **415** refers to a paper sheet subjected to unevenness processing. For example, the paper sheet displayed as “PLAIN PAPER” in the column **415** refers to a paper sheet that has not been subjected to special processing. A color of the paper sheet is displayed in the column **416**.

(63) To edit the information on the paper sheet, the operator selects a paper sheet (paper sheet

name) for which the information is to be edited from the paper sheet list **410** displayed on the operation panel **120**. A method of displaying the selected paper sheet is changed so that the selected paper sheet can be distinguished from unselected paper sheets. For example, the selected paper sheet is displayed brighter than the unselected paper sheets. In a case where "XYZ PAPER, COLOR 81" is selected, as exemplified in FIG. **5**, a row of "XYZ PAPER, COLOR 81" is displayed by a method different from a method of displaying rows of the other unselected paper sheets. In a case where the number of paper sheets managed in the paper sheet library is larger than the number of paper sheets that can be displayed in the paper sheet list **410** at a time, the operator can select another sheet by operating a scroll bar **417**.

(64) The add new button **420** is a button for newly adding information on the paper sheet to the paper sheet library **600**. The edit button **421** is a button for editing the information on the paper sheet selected by the operator from the paper sheet list **410**. The delete button **422** is a button for deleting the paper sheet selected by the operator in the paper sheet list **410** from the paper sheet library **600**. The select button **423** is a button for associating the paper sheet selected from the paper sheet list **410** with the sheet feeding stage.

(65) In a case where the add new button **420** or the edit button **421** on the edit screen **400** is pressed, a paper sheet attribute edit screen for inputting information on a paper sheet is displayed on the operation panel **120**. FIG. **6** is an exemplary view of the paper sheet attribute edit screen. A paper sheet attribute edit screen **500** includes text boxes **501** to **504**, combo boxes **505** and **506**, a checkbox **507**, an end edit button **520**, and a cancel button **521**.

(66) The text box **501** is an input area for the paper sheet name. The text box **502** is an input area for the paper sheet length in the short-side direction. The text box **503** is an input area for the paper sheet length in the long-side direction. The text box **504** is an input area for the basis weight of the paper sheet. The input to each of the text boxes **501** to **504** is performed by a software keyboard or the operation panel **120**.

(67) The combo box **505** is an area for designating the surface property of the paper sheet. The operator designates the surface property of the paper sheet from among a plurality of types of surface properties. Information on the plurality of types of surface properties is registered in advance, and is designated from a list displayed in a pull-down manner. The combo box **506** is an area for designating the color of the paper sheet. The operator designates the color of the paper sheet from among a plurality of colors. Information on the plurality of colors is registered in advance, and is designated from a list displayed in a pull-down manner. The checkbox **507** is a designation area for designating whether or not the paper sheet is preprinted paper. In a case where the paper sheet is preprinted paper, the operator checks the checkbox **507**.

(68) The end edit button **520** is a button for saving the information on the paper sheet, which has been input to the paper sheet attribute edit screen **500**, to the paper sheet library **600**. In a case where the end edit button **520** is pressed, the information on the paper sheet that has been input up to that time point is saved to the paper sheet library **600**. After the information on the paper sheet has been saved to the paper sheet library **600**, the paper sheet attribute edit screen **500** is switched to the edit screen **400** of FIG. **5**. The cancel button **521** is a button for transitioning to the edit screen **400** of FIG. **5** without saving the information on the paper sheet, which has been input to the paper sheet attribute edit screen **500**, to the paper sheet library **600**. In a case where the cancel button **521** is pressed, the editing of the information on the paper sheet is canceled.

(69) FIG. **7**A and FIG. **7**B are explanatory tables of the paper sheet library. The paper sheet library **600** is saved as digital information. The digital information as used herein refers to information described through use of, for example, extensible markup language (XML) or comma-separated values (CSV).

(70) Rows **601** to **605** indicate the information on paper sheets registered in the paper sheet library **600**. Columns **611** to **627** indicate sheet attributes. The column **611** indicates a name of each paper sheet. The columns **612** to **615** indicate the physical characteristic of the paper sheet. The column

612 indicates the paper sheet length in the short-side direction of the paper sheet, the column **613** indicates the paper sheet length in the long-side direction of the paper sheet, the column **614** indicates the basis weight of the paper sheet, and the column **615** indicates the surface property of the paper sheet. The column **616** indicates the color of the paper sheet. The column **617** indicates whether or not the paper sheet is preprinted paper.

(71) The columns **618** to **627** each indicate a printing position deviation amount on the front surface or the back surface of the paper sheet. The printing position deviation amount is a value that quantitatively represents a deviation between a predicted printing area, which has been predicted from the reading result of the image for adjustment, and an ideal printing area. In the at least one embodiment, the toner adhesion amount of the image to be printed on the paper sheet is divided into five toner adhesion amount classes, and printing position deviation amounts obtained at times of printing images belonging to the respective toner adhesion amount classes are stored.

(72) The columns **618** and **619** indicate the printing position deviation amounts on the front surface and the back surface that are obtained in a case where an adhesion amount of toner to be printed on the paper sheet belongs to a toner adhesion amount class 1. The columns **620** and **621** indicate the printing position deviation amounts on the front surface and the back surface that are obtained in a case where an adhesion amount of toner to be printed on the paper sheet belongs to a toner adhesion amount class 2. The columns **622** and **623** indicate the printing position deviation amounts on the front surface and the back surface that are obtained in a case where an adhesion amount of toner to be printed on the paper sheet belongs to a toner adhesion amount class 3. The columns **624** and **625** indicate the printing position deviation amounts on the front surface and the back surface that are obtained in a case where an adhesion amount of toner to be printed on the paper sheet belongs to a toner adhesion amount class 4. The columns **626** and **627** indicate the printing position deviation amounts on the front surface and the back surface that are obtained in a case where an adhesion amount of toner to be printed on the paper sheet belongs to a toner adhesion amount class 5.

(73) The ideal printing area is a rectangle with four sides having lengths determined in advance, one side of the printing area is parallel to a predetermined side of the paper sheet, and a distance between a predetermined side of the paper sheet and one side of the printing area parallel to the predetermined side is a predetermined distance.

(74) The printing position deviation amount is represented by parameters such as, for example, a right-angle correction amount, a trapezoidal correction amount, a lead position, a side position, a long-side-direction magnification, and a short-side-direction magnification. The right-angle correction amount represents an amount of deviation of any corner of the printing area from a right angle. For example, the right-angle correction amount is the amount of deviation between an ideal perpendicular and a straight line printed in the short-side direction of the printing area, the ideal perpendicular being calculated with respect to a straight line printed in the long-side direction of the printing area. The trapezoidal correction amount represents an amount of deviation due to expansion and contraction of the paper sheet. For example, the trapezoidal correction amount is the amount of deviation between a straight line printed from a printing start position on the paper sheet to a short-side-direction trailing end along the short-side direction and a straight line printed from a position in a long-side-direction trailing end of the paper sheet to the short-side-direction trailing end along the short-side direction.

(75) The lead position represents a printing position deviation amount in the short-side direction with respect to the paper sheet. The side position represents a printing position deviation amount in the long-side direction with respect to the paper sheet. The lead position is adjusted by changing a printing start position of the image with the leading end of the paper sheet being set as a starting point in the conveyance direction. The side position is adjusted by changing a printing start position of the image with an end portion of the paper sheet parallel to the conveyance direction being set as a starting point. Specifically, the lead position and the side position are adjusted by adjusting a laser

light irradiation start timing for the exposure device **223** to start to irradiate the photosensitive drum **153** with laser light. For example, the CPU **114** controls the exposure device **223** to adjust the laser light irradiation start timing.

(76) The short-side-direction magnification represents a deviation (magnification) of a length of an actual printing area in the short-side direction from an ideal length in the short-side direction. Specifically, the short-side-direction magnification is adjusted by controlling a rotation speed of the photosensitive drum **153** or the rotation speed of the intermediate transfer belt **154**. For example, the CPU **114** adjusts a magnification in the short-side direction by adjusting a rotation speed of a motor (not shown) that rotates the photosensitive drum **153** or a motor (not shown) that rotates the intermediate transfer belt **154**.

(77) The long-side-direction magnification represents a deviation (magnification) of a length of an actual printing area in the long-side direction from an ideal length in the long-side direction. Specifically, the long-side-direction magnification is adjusted by controlling a clock frequency of the laser light in a case where the exposure device **223** modulates the laser light based on the image data. For example, the CPU **114** controls the exposure device **223** to control the clock frequency. In another case, the CPU **114** may perform image processing on the image data so that the printing position of the output image becomes an ideal printing position. Image processing for causing the printing position of the output image to become an ideal printing position is image processing such as, for example, affine transformation.

(78) In a case where an output image is printed on a paper sheet based on a print job, the controller **110** adjusts the printing position based on the printing position deviation amount so that the image is to be printed at an ideal position on the paper sheet. The controller **110** refers to the printing position deviation amount in the paper sheet library **600** to perform the image processing on the image data so that the printing position becomes an ideal printing position. The controller **110** controls the printer **150** to print the image on the paper sheet based on the image data subjected to image processing.

(79) An initial value of each item of the printing position deviation amount is “0”. In a case where a paper sheet is newly registered in the paper sheet library **600** or in a case where the paper sheet has been registered but the printing position adjustment has not been performed, the initial value is used as the printing position deviation amount.

(80) FIG. **8** is an explanatory table of calculation methods for printing position deviation amounts. The printing position deviation amounts are obtained based on actually measured values of the length (A) to the length (V) (see FIG. **3**), the values having been measured from the reading result of the image for adjustment.

(81) The items **801** to **812** are items each of which indicates the printing position deviation amount. The parameters of the printing position deviation amounts obtained from the image **700** for adjustment include a lead position **801**, a side position **802**, a long-side-direction magnification **803**, a short-side-direction magnification **804**, a right-angle correction amount **805**, and a trapezoidal correction amount **806**. The parameters of the printing position deviation amounts obtained from the image **701** for adjustment include a lead position **807**, a side position **808**, a long-side-direction magnification **809**, a short-side-direction magnification **810**, a right-angle correction amount **811**, and a trapezoidal correction amount **812**.

(82) Measured values **820** of the image **700** for adjustment and the image **701** for adjustment are calculated based on the same calculation formula for each type of parameter, and printing position deviation amounts **822** of the image **700** for adjustment and the image **701** for adjustment are calculated based on the same calculation formula for each type of parameter. The same ideal value is set for the same type of parameter of the image **700** for adjustment and the image **701** for adjustment. The measured values **820** are calculated from the actually measured values of the lengths (A) to (V) illustrated in FIG. **3** based on the calculation formula set for each item.

(83) The measured value **820** of the lead position **801** (**807**) corresponds to an average value of

distances C and E (K and M) from a leading end portion of the paper sheet in the conveyance direction to the nearby marks **720** for correction **720**. The measured value **820** of the side position **802** (**808**) corresponds to an average value of distances F and J (N and R) from an end portion of the paper sheet on the left side when viewed along the conveyance direction of the paper sheet in FIG. **3** to the nearby marks **720** for correction.

(84) The measured value **820** of the long-side-direction magnification **803** (**809**) corresponds to an average value of distances between the marks **720** for correction aligned on the same line in the long-side direction. The measured value **820** of the short-side-direction magnification **804** (**810**) corresponds to an average value of distances between the marks **720** for correction aligned on the same line in the short-side direction.

(85) The measured value **820** of the right-angle correction amount **805** (**811**) corresponds, in a case where a perpendicular of a straight line connecting the marks **720** for correction on the leading end side of the paper sheet in the conveyance direction is used as a reference line, to an average value of deviation amounts S and T (U and V) of the mark for correction on the trailing end side of the paper sheet in the conveyance direction from the reference line in the long-side direction. The measured value **820** of the trapezoidal correction amount **806** (**812**) corresponds to a difference between a distance between the marks **720** for correction aligned on the leading end side of the paper sheet in the conveyance direction and a distance between the marks **720** for correction aligned on the trailing end side of the paper sheet in the conveyance direction.

(86) A column **821** indicates an ideal value of each corresponding item. The marks **720** for correction are each ideally printed at a position spaced apart from each corresponding paper sheet end by the ideal value. The ideal values of the lead position and the side position are, for example, 1 cm. The ideal value of the long-side-direction magnification is, for example, a length of 2 cm shorter than the paper sheet length in the long-side direction of the paper sheet registered in the paper sheet library **600**. The ideal value of the short-side-direction magnification is, for example, a length of 2 cm shorter than the paper sheet length in the short-side direction of the paper sheet registered in the paper sheet library **600**.

(87) A column **822** indicates a calculation formula for calculating a final printing position deviation amount of each item based on the measured value **820** and the ideal value **821**. The printing position deviation amount of each of the lead position and the side position is calculated (in mm) by subtracting the ideal value from the measured value. The printing position deviation amount of each of the long-side-direction magnification and the short-side-direction magnification is calculated (in %) by dividing a value obtained by subtracting an ideal value from a measured value by the ideal value. The measured value of each of the right-angle correction amount and the trapezoidal correction amount is directly used as the correction amount. The calculated printing position deviation amounts are each saved to the paper sheet library **600** (see FIG. **7**A and FIG. **7**B).

(88) <Paper Sheet Type Setting>

(89) FIG. **9** is an exemplary view of a paper sheet type setting screen **900** displayed on the operation panel **120**. The paper sheet type setting screen **900** includes a sheet setting status **901** of sheet feeding stages, a printing position adjustment button **902**, and a paper sheet registration button **903**. In the sheet setting status **901** of the sheet feeding stages, a paper sheet type registered for each of the sheet feeding stages (sheet feeding stages **140***a* to **140***e*) are displayed. In FIG. **9**, a sheet feeding stage **1** corresponds to the sheet feeding stage **140***a*, a sheet feeding stage **2** corresponds to the sheet feeding stage **140***b*, a sheet feeding stage **3** corresponds to the sheet feeding stage **140***c*, a sheet feeding stage **4** corresponds to the sheet feeding stage **140***d*, and a sheet feeding stage **5** corresponds to the sheet feeding stage **140***e*.

(90) In FIG. **9**, “ABC PAPER, RECYCLED 1” is registered for the sheet feeding stage **140***a*. “ABC PAPER, RECYCLED 2” is registered for the sheet feeding stage **140***b*. “DEF PAPER, EMBOSSED PAPER A-1” is registered for the sheet feeding stage **140***c*. “DEF PAPER, COATED

PAPER P-1” is registered for the sheet feeding stage **140***d*. “XYZ PAPER, COLOR 81” is registered for the sheet feeding stage **140***e*.

(91) The printing position adjustment button **902** is a button for transitioning to a printing position adjustment screen described later. The paper sheet registration button **903** is a button for registering the paper sheet type for the selected sheet feeding stage. In a case where the paper sheet registration button **903** is pressed, the edit screen **400** for the paper sheet library of FIG. **5** is displayed. In a case where the select button **423** on the edit screen **400** for the paper sheet library is pressed, the paper sheet selected on the edit screen **400** for the paper sheet library is registered for the sheet feeding stage selected by the operator. The printing position adjustment button **902** and the paper sheet registration button **903** cannot be pressed in a case where no sheet feeding stage is selected in the sheet setting status **901** of the sheet feeding stages.

(92) FIG. **10**A to FIG. **10**C are exemplary views of the printing position adjustment screen displayed on the operation panel **120**. FIG. **10**A is the printing position adjustment screen displayed in a case where the printing position adjustment button **902** on the paper sheet type setting screen **900** is pressed. A printing position adjustment screen **1000** includes an initial adjustment button **1001**, a print adjustment button **1002**, and a back button **1003**. The initial adjustment button **1001** is a button for transitioning to an initial adjustment screen **1010** of FIG. **10**B. The print adjustment button **1002** is a button for transitioning to a print adjustment screen **1020** of FIG. **10**C. The back button **1003** is a button for transitioning to the paper sheet type setting screen **900** of FIG. **9**.

(93) The initial adjustment screen **1010** of FIG. **10**B, which is displayed by pressing the initial adjustment button **1001**, includes a sheet feeding stage selection box **1011**, an execute button **1012**, and a cancel button **1013**. The sheet feeding stage selection box **1011** is a combo box for designating the sheet feeding stage. In the at least one embodiment, the sheet feeding stage selection box **1011** enables selection from among five sheet feeding stages from the sheet feeding stage **1** to the sheet feeding stage **5**, which are illustrated in FIG. **9**. The paper sheet type registered for the sheet feeding stage is also displayed in the sheet feeding stage selection box **1011**.

(94) The execute button **1012** is a button for performing initial front-and-back position correction described later on paper sheets on the sheet feeding stage selected by the sheet feeding stage selection box **1011** through use of the images **70***a* to **70***e* for adjustment of FIG. **4**. The controller **110** starts processing for the initial front-and-back position correction in a case where the execute button **1012** is pressed. The cancel button **1013** is a button for canceling the initial front-and-back position correction. In a case where the cancel button **1013** is pressed, the processing for the initial front-and-back position correction is canceled, and the display returns to the printing position adjustment screen **1000**.

(95) The print adjustment screen **1020** of FIG. **10**C, which is displayed by pressing the print adjustment button **1002**, includes a print adjustment enabling checkbox **1021**, a number-of-sheets setting box **1022**, an OK button **1023**, and a cancel button **1024**. The print adjustment enabling checkbox **1021** is a checkbox for switching between enabled and disabled states of print front-and-back position correction described later. The number-of-sheets setting box **1022** is a text box for inputting the number of sheets to be printed, which serves as an interval at which the print front-and-back position correction is to be performed.

(96) In a case where the print adjustment enabling checkbox **1021** is checked, the print front-and-back position correction is performed each time the number of sheets set in the number-of-sheets setting box **1022** has been printed. The print front-and-back position correction is a function of maintaining the correction amount in an appropriate state by again performing the front-and-back position correction at predetermined page intervals during printing. Each time the printer **150** has generated a predetermined number of printed matters, the correction amount for correcting the printing position is adjusted by the print front-and-back position correction. In a case where the print adjustment enabling checkbox **1021** is not checked, the print front-and-back position correction is not to be performed. In a case where the OK button **1023** is pressed, print adjustment

setting is saved to the RAM **113**, and the display returns to the printing position adjustment screen **1000**. In a case where the cancel button **1024** is pressed, the print adjustment setting is not saved, and the display returns to the printing position adjustment screen **1000**.

(97) <Initial Front-and-Back Position Correction>

(98) FIG. **11** is a flow chart for illustrating initial front-and-back position correction processing. Control in each step of this flow chart is implemented by the CPU **114** reading out and executing the program stored in the ROM **112**. In the initial front-and-back position correction, correction amounts of printing position deviation amounts for each toner adhesion amount are calculated through use of a plurality of sheets for adjustment that are generated by printing the five types of images **70***a* to **70***e* for adjustment illustrated in FIG. **4** on the paper sheets on the sheet feeding stage selected by the operator. Thus, an amount of printing position deviation generated on an actual printed matter can be obtained with high accuracy, and a correction amount of a printing position suitable for an output image to be actually printed by a print job can be obtained. This processing is performed prior to a start of a print job.

(99) In a case where the operator uses the operation panel **120** to make a request to display the paper sheet type setting screen **900** of FIG. **9**, the CPU **114** displays the paper sheet type setting screen **900** on the operation panel **120** (Step S**1201**). The CPU **114** stands by until the operator presses the printing position adjustment button **902** (N in Step S**1202**). In a case where the printing position adjustment button **902** is pressed (Y in Step S**1202**), the CPU **114** displays the printing position adjustment screen **1000** of FIG. **10**A on the operation panel **120** (Step S**1203**). The CPU **114** stands by until any one of the initial adjustment button **1001**, the print adjustment button **1002**, and the back button **1003** is pressed (N in Step S**1204**).

(100) In a case where a button other than the initial adjustment button **1001** is pressed (N in Step S**1205**), the CPU **114** determines whether or not the pressed button is the print adjustment button **1002** (Step S**1207**). In a case where the back button **1003** has been pressed (N in Step S**1207**), the CPU **114** returns the process to the processing step of Step S**1203**, and displays the printing position adjustment screen **1000** on the operation panel **120**. In a case where the print adjustment button **1002** has been pressed (Y in Step S**1207**), the CPU **114** performs print adjustment setting processing described later (Step S**1209**). In a case where the print adjustment setting processing is ended, the CPU **114** returns the process to the processing step of Step S**1203**, or ends the processing.

(101) In a case where the initial adjustment button **1001** has been pressed (Y in Step S**1205**), the CPU **114** displays the initial adjustment screen **1010** of FIG. **10**B on the operation panel **120** (Step S**1206**). The operator selects, through the initial adjustment screen **1010**, a sheet feeding stage in which paper sheets to be subjected to the initial front-and-back position correction are received. The CPU **114** stands by until the execute button **1012** or the cancel button **1013** on the initial adjustment screen **1010** is pressed (N in Step S**1208**).

(102) In a case where the cancel button **1013** is pressed (N in Step S**1210**), the CPU **114** returns the process to the processing step of Step S**1203**, and displays the printing position adjustment screen **1000** on the operation panel **120**. In a case where the execute button **1012** is pressed (Y in Step S**1210**), the CPU **114** controls the printer **150** to print the images for adjustment on the paper sheets received in the sheet feeding stage selected by the operator. To that end, the CPU **114** reads out the image data on each image for adjustment from the storage **115** (Step S**1211**), and causes the printer **150** to print the images for adjustment based on the image data (Step S**1212**).

(103) For example, in a case where the operator selects “DEF PAPER, EMBOSSED PAPER A-1” of the sheet feeding stage **3**, the CPU **114** reads out the image data on the image **70***a* for adjustment from the storage **115** (Step S**1211**). The CPU **114** causes the printer **150** to print the image **70***a* for adjustment on a paper sheet fed from the sheet feeding stage **140***c* based on the read-out image data (Step S**1212**). The printer **150** prints the image **70***a* for adjustment on the front surface of the paper sheet, and then conveys the paper sheet toward the reverser **136**. The printer **150** reverses the paper

sheet in the reverser **136**, and then conveys the paper sheet to the conveyance path **138**, and again prints the image **70***a* for adjustment on the back surface of the paper sheet. The image **70***a* for adjustment is printed on both the surfaces to create a sheet for adjustment. After that, the printer **150** conveys the created sheet for adjustment to the reading apparatus **160**.

(104) The CPU **114** controls the reading apparatus **160** to read the image **70***a* for adjustment printed on both the surfaces of the sheet for adjustment (Step S**1213**). The CPU **114** reads the image **70***a* for adjustment on both the surfaces by the line sensors **312***a* and **312***b* while conveying the sheet for adjustment to the conveyance path **313** of the reading apparatus **160**. The sheet for adjustment delivered from the reading apparatus **160** is delivered to the delivery tray of the finisher **190**.

(105) The CPU **114** acquires the reading results of the sheet for adjustment from the reading apparatus **160**, and calculates printing position deviation amounts from the reading results based on the calculation methods of FIG. **8** (Step S**1214**). The CPU **114** saves the calculated printing position deviation amounts in the paper sheet library **600** in association with the paper sheet of the sheet feeding stage selected by the operator (Step S**1215**). The initial front-and-back position correction based on one image for adjustment is ended by the processing steps of from Step S**1211** to Step S**1215**.

(106) The CPU **114** determines whether or not the initial front-and-back position correction has been ended for all the images **70***a* to **70***e* for adjustment (Step S**1216**). In a case where the initial front-and-back position correction has not been ended (N in Step S**1216**), the CPU **114** returns the process to the processing step of Step S**1211**, and reads out the image data on the next image for adjustment (in this case, the image **70***b* for adjustment) from the storage **115** to perform the initial front-and-back position correction.

(107) In a case where the initial front-and-back position correction has been ended for all the images for adjustment (Y in Step S**1216**), the CPU **114** ends the processing for the initial front-and-back position correction. Through the initial front-and-back position correction, the printing position deviation amounts of the respective toner adhesion amount classes of “DEF PAPER, EMBOSSED PAPER A-1” **603** are saved in the paper sheet library **600** of FIG. **7**A and FIG. **7**B. Specifically, the printing position deviation amounts calculated by reading the image **70***a* for adjustment are saved in the printing position deviation amount (front surface) **618** and the printing position deviation amount (back surface) **619**. The printing position deviation amounts calculated by reading the image **70***b* for adjustment are saved in the printing position deviation amount (front surface) **620** and the printing position deviation amount (back surface) **621**. The printing position deviation amounts calculated by reading the image **70***c* for adjustment are saved in the printing position deviation amount (front surface) **622** and the printing position deviation amount (back surface) **623**. The printing position deviation amounts calculated by reading the image **70***d* for adjustment are saved in the printing position deviation amount (front surface) **624** and the printing position deviation amount (back surface) **625**. The printing position deviation amounts calculated by reading the image **70***e* for adjustment are saved in the printing position deviation amount (front surface) **626** and the printing position deviation amount (back surface) **627**.

(108) <Image Forming Processing>

(109) FIG. **12** is a flow chart for illustrating image forming processing performed by the image forming apparatus **100**. Each step of this flow chart is implemented by the CPU **114** reading out and executing the program stored in the ROM **112**.

(110) In a case where a print job is input from the host computer **101** or the operation panel **120**, the CPU **114** acquires information on the type of sheet included in the print job (Step S**100**). The CPU **114** acquires density information on the output image, the density information being obtained from the image data in units of pages of the print job (Step S**101**). Specifically, the CPU **114** acquires, as the density information, an image signal value T from the image data in units of pages of the print job. The image signal value T is a value for designating an image density. The CPU **114** uses the image signal value T of the image data to determine the density information on a density

of the image included in the print job.
(111) The CPU **114** uses the pieces of information acquired in the processing steps of Step S**100** and Step S**101** to determine whether or not the printing position deviation amount of the paper sheet designated by the print job is saved (Step S**102**). For example, the CPU **114** refers to the paper sheet library **600** to determine whether or not the printing position deviation amount of the paper sheet designated by the print job has a value other than the initial value of 0.
(112) In a case where the printing position deviation amount is saved (the printing position deviation amount of the paper sheet has a value other than the initial value of 0) (Y in Step S**102**), the CPU **114** acquires the printing position deviation amount of the designated paper sheet (Step S**103**). The CPU **114** corrects the printing position by processing the image data included in the print job based on the acquired printing position deviation amount (Step S**104**). For example, the CPU **114** loads the image data included in the print job into a bitmap image, and performs affine transformation on the bitmap image based on the acquired printing position deviation amount, to thereby correct the printing position. The CPU **114** controls the printer **150** to feed the designated paper sheet from the sheet feeding apparatus **140** and print the image on the paper sheet based on the image data for which the printing position has been corrected (Step S**105**).
(113) In a case where the printing position deviation amount is not saved (the printing position deviation amount of the paper sheet has a value equal to the initial value of 0) (N in Step S**102**), the CPU **114** does not correct the printing position. In this case, the CPU **114** controls the printer **150** to feed the designated paper sheet from the sheet feeding apparatus **140** and print the image on the paper sheet based on the image data included in the print job (Step S**105**).
(114) After the above-mentioned steps, the image forming processing is ended. Through execution of the image forming processing in units of pages to be printed, it is possible to correct the printing position based on the printing position deviation amount corresponding to the toner adhesion amount for each page to be printed. This enables highly accurate correction of the printing position for each page.
(115) <Execution Interval Setting for Print Front-and-Back Position Correction>
(116) FIG. **13** is a flow chart for illustrating execution interval setting processing for the print front-and-back position correction. Control in each step of this flow chart is implemented by the CPU **114** reading out and executing the program stored in the ROM **112**. This processing is processing that is performed as the print adjustment setting processing in Step S**1209** of FIG. **11**.
(117) In a case where the print adjustment button **1002** is pressed in the processing step of Step S**1207** of FIG. **11**, the CPU **114** displays the print adjustment screen **1020** of FIG. **10**C on the operation panel **120** (Step S**1301**). The CPU **114** stands by until the OK button **1023** or the cancel button **1024** on the print adjustment screen **1020** is pressed (N in Step S**1302**). In a case where the button is pressed (Y in Step S**1302**), the CPU **114** determines which of the OK button **1023** and the cancel button **1024** has been pressed (Step S**1303**). In a case where the cancel button **1024** has been pressed (N in Step S**1303**), the CPU **114** ends the execution interval setting processing for the print front-and-back position correction, and returns the process to the processing step of Step S**1203** of FIG. **11**.
(118) In a case where the OK button **1023** has been pressed (Y in Step S**1303**), the CPU **114** saves input results (input values of the print adjustment enabling checkbox **1021** and the number-of-sheets setting box **1022**) obtained through the print adjustment screen **1020** (Step S**1304**). For example, in a case where the print adjustment enabling checkbox **1021** has been checked, the CPU **114** sets a print front-and-back position correction execution flag F saved in the RAM **113** to “1”. In a case where the print adjustment enabling checkbox **1021** has not been checked, the CPU **114** sets the print front-and-back position correction execution flag F to “0”. In addition, the CPU **114** saves a numerical value of the number of sheets input in the number-of-sheets setting box **1022** to the RAM **113** as the number N of sheets every which the print front-and-back position correction is to be executed. Each time the printing of the saved number N of sheets every which the print front-

and-back position correction is to be executed is performed, the front-and-back position correction is performed. After the input results have been saved, the CPU **114** ends the execution interval setting processing for the print front-and-back position correction.

(119) FIG. **14**A and FIG. **14**B are explanatory views of paper sheet selection screens that allow the operator to execute the print front-and-back position correction. FIG. **14**A and FIG. **14**B are application screens displayed on the operation panel **120**.

(120) On a job printing application screen **1400** exemplified in FIG. **14**A, a print job list **1410** and job actions **1420** are displayed. In the print job list **1410**, print jobs input from the host computer **101** are displayed in a list format. In the print job list **1410**, a job name, the number of sheets (number of pages) to be printed, the number of copies to be printed, and which of simplex printing and duplex printing is to be performed are displayed for each print job. Under the job actions **1420**, actions to be executed for each print job displayed in the print job list **1410** are displayed. The job actions **1420** include a print button **1421**, a RIP button **1422**, a print adjustment button **1423**, and a job property button **1424**.

(121) The print button **1421** is a button for causing the image forming apparatus **100** to print a print job selected by the operator from the print job list **1410**. The RIP button **1422** is a button for causing the image forming apparatus **100** to render the print job selected by the operator from the print job list **1410**. The print adjustment button **1423** is a button for setting the print front-and-back position correction of the paper sheet designated by the print job selected by the operator from the print job list **1410**. In a case where the print adjustment button **1423** is pressed, a print adjustment page setting screen **1450** exemplified in FIG. **14**B is displayed on the operation panel **120**. The job property button **1424** is a button for displaying the print settings of the print job selected by the operator from the print job list **1410**. In a case where the job property button **1424** is pressed, the operation panel **120** displays a job setting list (not shown). The job setting list includes the number of copies to be printed and information indicating which of the simplex printing and the duplex printing is to be performed.

(122) In a case where no print job has been selected from the print job list **1410**, the display on the operation panel **120** is not switched whichever one of the print button **1421**, the RIP button **1422**, the print adjustment button **1423**, and the job property button **1424** is pressed.

(123) The print adjustment page setting screen **1450** exemplified in FIG. **14**B includes a job display section **1460** being a screen for displaying the settings (such as the number of pages (the number of sheets), the number of copies, and which of the simplex printing and the duplex printing is to be performed) of the selected print job. The print adjustment page setting screen **1450** also includes a print front-and-back position correction page list **1461** being a page list of the selected print job in which items are displayed in unit of pairs of front and back pages. In a case where items of the page list displayed in the print front-and-back position correction page list **1461** are not displayed at a time, a scroll bar **1462** is displayed. The operator can view all the items of the page list by operating the scroll bar **1462**.

(124) In addition, the print adjustment page setting screen **1450** includes a print front-and-back position correction selection buttons **1463** (**1463***a* to **1463***e*), an all-page selection button **1464**, an all-page deselection button **1465**, a determine button **1470**, and a cancel button **1471**.

(125) The print front-and-back position correction selection buttons **1463** (**1463***a* to **1463***e*) are buttons for setting whether or not to perform the print front-and-back position correction in units of pages displayed in the print front-and-back position correction page list **1461**. The print front-and-back position correction selection buttons **1463** are each displayed in a so-called toggle manner. For that reason, each print front-and-back position correction selection button **1463** is switched to be displayed as “ON” by being pressed while being displayed as “OFF”, and is switched to be displayed as “OFF” by being pressed while being displayed as “ON”. Only five print front-and-back position correction selection buttons **1463** are displayed in FIG. **14**B, but there are as many print front-and-back position correction selection buttons **1463** as the number of pages (the number

of sheets) corresponding to the selected print job. In a case where the scroll bar **1462** is scrolled, buttons (not shown) including a print front-and-back position correction selection button **1463***f* and the subsequent print front-and-back position correction selection buttons are displayed together with items of the page list.

(126) The all-page selection button **1464** is a button for collectively setting the print front-and-back position correction to be performed for all the pages of the selected print job. In a case where the all-page selection button **1464** is pressed, the print front-and-back position correction selection buttons **1463** for all the pages are switched to be displayed as "ON". The all-page deselection button **1465** is a button for collectively setting the print front-and-back position correction not to be performed all the pages of the selected print job. In a case where the all-page deselection button **1465** is pressed, the print front-and-back position correction selection buttons **1463** for all the pages are switched to be displayed as "OFF".

(127) The print front-and-back position correction selection buttons **1463**, the all-page selection button **1464**, and the all-page deselection button **1465** can be pressed only at a time of a print job for duplex printing. For that reason, at a time of a print job for simplex printing, the display of the operation panel **120** is not switched whichever one of the print front-and-back position correction selection buttons **1463**, the all-page selection button **1464**, and the all-page deselection button **1465** is pressed.

(128) In a case where the determine button **1470** is pressed, print adjustment page settings are saved to the RAM **113**, and the display of the operation panel **120** returns to the job printing application screen **1400**. In a case where the cancel button **1471** is pressed, print adjustment page settings are not saved, and the display of the operation panel **120** returns to the job printing application screen **1400**.

(129) FIG. **15**A to FIG. **15**C are an explanatory view and explanatory tables of a method of storing the print adjustment page settings set for each print job through the print adjustment page setting screen **1450**. In this case, settings of a print job **1** of FIG. **14**B are described as an example. FIG. **15**A is an illustration of output images of the print job **1**. FIG. **15**B is a class table for determining the toner adhesion amount class from the image signal value T of the output image. FIG. **15**C shows a table of print front-and-back position correction execution information for each print job.

(130) As illustrated in FIG. **15**A, the print job **1** is a job for duplex printing, and the odd-numbered pages are front surface images, and the even-numbered pages are back surface images. The print job **1** is a job for 50 pages, but description is given of the first 10 pages for the sake of convenience. However, it goes without saying that the same applies to the subsequent pages.

(131) An output image **1500***a* is an output image on a first page of the print job **1**. There are margins in top, bottom, right, and left end portions. An output image **1500***b* is an output image on a second page of the print job **1**. An output image **1501***a* is an output image on a third page, and an output image **1501***b* is an output image on a fourth page. An output image **1502***a* is an output image on a fifth page, and an output image **1502***b* is an output image on a sixth page. Text is displayed in each of the output images **1501***a*, **1501***b*, **1502***a*, and **1502***b*. An output image **1503***a* is an output image on a seventh page, and an output image **1503***b* is an output image on an eighth page. An output image **1504***a* is an output image on a ninth page, and an output image **1504***b* is an output image on a tenth page. An image such as a photograph is displayed in each of the output images **1503***a*, **1503***b*, **1504***a*, and **1504***b*.

(132) A method of determining the toner adhesion amount class from the toner adhesion amount of each output image through use of a toner adhesion amount class table **1520** of FIG. **15**B is described. The toner adhesion amount class table **1520** is stored in advance in the ROM **112**. The CPU **114** determines the toner adhesion amount class of the page by comparing the image signal value T in units of pages of the print job acquired in the processing step of Step S**101** of FIG. **12** to threshold values determined in advance in the toner adhesion amount class table **1520**. For example, in a case where the image signal value of each page of the print job **1** is 50%, the toner

adhesion amount class of each page is determined to be “3”. The toner adhesion amount class table **1520** is stored in the ROM **112**, but may be stored in another nonvolatile memory such as the storage **115** or an EEPROM.

(133) The table of the print front-and-back position correction execution information of FIG. **15**C is stored in the RAM **113**, and is a setting table that stores the print front-and-back position correction execution information for each print job. A print front-and-back position correction setting table **1550** is a table including a page number **1560**, a print front-and-back position correction execution page flag Fp **1561**, and image data on images **1562** for adjustment (front surface **1562***a* and back surface **1562***b*). The print front-and-back position correction setting table **1550** is stored in the RAM **113** for each print job. The print front-and-back position correction setting table **1550** may be independently stored in the RAM **113**, or may be stored as one of job properties (not shown).

(134) The print job **1** of FIG. **14**B has the print front-and-back position correction selection buttons **1463** displayed as “OFF” for “PAGES 1 AND 2,” “PAGES 3 AND 4,” and “PAGES 5 AND 6,” that is, is set so that those pages are not to be subjected to the print front-and-back position correction. Therefore, “O” is set in the print front-and-back position correction execution page flag Fp. The print job **1** has the print front-and-back position correction selection buttons **1463** displayed as “ON” for “PAGES 7 AND 8” and “PAGES 9 AND 10,” that is, is set so that those pages are to be subjected to the print front-and-back position correction. Therefore, “1” is set in the print front-and-back position correction execution page flag Fp.

(135) Attention is given to a page for which the print front-and-back position correction execution page flag Fp is set to “1”. In a case where the image signal value T of the output image **1503***a* on the seventh page of FIG. **15**A is 30%, the toner adhesion amount class becomes “TONER ADHESION AMOUNT CLASS 2” from the toner adhesion amount class table **1520**. Therefore, the image for adjustment of “TONER ADHESION AMOUNT CLASS 2” is stored in the image **1562***a* for adjustment (front surface). At this time, a method of storing the image for adjustment involves storing the image data or storing reference information (so-called address information or pointer) on the image data of the image for adjustment of FIG. **4**. In the same manner, in a case where the image signal value T of the output image **1503***b* on the eighth page of FIG. **15**A is 90%, the image for adjustment of “TONER ADHESION AMOUNT CLASS 5” is stored in the image **1562***b* for adjustment (back surface). In a case where the image signal value T of the output image **1504***a* on the ninth page is 85%, the image for adjustment of “TONER ADHESION AMOUNT CLASS 4” is stored in the image **1562***a* for adjustment (front surface). In a case where the image signal value T of the output image **1504***b* on the tenth page is 55%, the image for adjustment of “TONER ADHESION AMOUNT CLASS 3” is stored in the image **1562***b* for adjustment (back surface).

(136) The table of the print front-and-back position correction execution information may be stored in the storage **115**. The table of the print front-and-back position correction execution information may be stored in both the RAM **113** and the storage **115** or in another memory such as an EEPROM. The threshold values of the toner adhesion amount class table **1520** are not limited to the example described herein, and may be changed as appropriate.

(137) FIG. **16** is a flow chart for illustrating processing for setting pages on which the print front-and-back position correction is to be executed, which is executed by the CPU **114** of the image forming apparatus **100**. Control in each step of this flow chart is implemented by the CPU **114** reading out and executing the program stored in the ROM **112**. This processing is performed prior to the start of the print job.

(138) In a case where the operator uses the operation panel **120** to make a request to display the job printing application screen **1400** of FIG. **14**A, the CPU **114** displays the job printing application screen **1400** on the operation panel **120** (Step S**1601**). The CPU **114** stands by until the operator selects a print job and presses the print adjustment button **1423** (N in Step S**1602**). Description of a

case in which each of the other buttons (print button **1421**, RIP button **1422**, and job property button **1424**) included in the job actions **1420** is pressed is omitted below. The print job selected by the operator is a job for instructing to print images of a plurality of pages.

(139) In a case where the print adjustment button **1423** is pressed (Y in Step S**1602**), the CPU **114** displays the print adjustment page setting screen **1450** of FIG. **14**B on the operation panel **120** (Step S**1603**). The CPU **114** stands by until the print front-and-back position correction selection button **1463** is appropriately set and the determine button **1470** or the cancel button **1471** on the print adjustment page setting screen **1450** is pressed (N in Step S**1604** and N in Step S**1605**). In a case where the cancel button **1471** is pressed (N in Step S**1604** and Y in Step S**1605**), the CPU **114** does not update a value of the print front-and-back position correction execution page flag Fp of FIG. **15**C, and returns the process to the processing step of Step S**1601** to display the job printing application screen **1400**.

(140) In a case where the determine button **1470** is pressed (Y in Step S**1604**), the CPU **114** updates the values of the print front-and-back position correction execution page flags Fp of the respective pages in accordance with the settings of the print front-and-back position correction selection buttons **1463**, and stores the updated values in the RAM **113** (Step S**1606**). That is, a page for which the print front-and-back position correction selection button **1463** is displayed as "OFF" has the print front-and-back position correction execution page flag Fp set to "0". A page for which the print front-and-back position correction selection button **1463** is displayed as "ON" has the print front-and-back position correction execution page flag Fp set to "1". A page for which the print front-and-back position correction selection button **1463** is displayed as "ON" indicates an image selected from a plurality of images included in the print job. The CPU **114** acquires information indicating that the print front-and-back position correction execution page flag Fp is "1" as user selection information indicating a selection result of the image selected from the plurality of images included in the print job.

(141) The CPU **114** determines whether or not the value of the print front-and-back position correction execution page flag Fp for each updated page is "1" (Step S**1607**). In a case where the value of the print front-and-back position correction execution page flag Fp is "1" (Y in Step S**1607**), the CPU **114** refers to the toner adhesion amount class table **1520** in the ROM **112** to determine the image for adjustment for the page (Step S**1608**).

(142) In a case where the value of the print front-and-back position correction execution page flag Fp is "0" (N in Step S**1607**), or in a case where the image for adjustment is determined, the CPU **114** determines whether or not the images for adjustment have been determined for all the pages of the selected print job (Step S**1609**). In a case where there is a page for which the image for adjustment has not been determined (N in Step S**1606**), the CPU **114** refers to the print front-and-back position correction execution page flag Fp for the subsequent page of the print front-and-back position correction setting table **1550** of FIG. **15**C, and returns the process to the processing step of Step S**1607**. In a case where the images for adjustment have been determined for all the pages (Y in Step S**1609**), the CPU **114** ends the processing for setting pages on which the print front-and-back position correction is to be executed. Thus, the CPU **114** determines images for adjustment to be formed.

(143) <Print Front-and-Back Position Correction>

(144) FIG. **17** is a flow chart for illustrating print front-and-back position correction processing executed by the CPU **114** of the image forming apparatus **100**. Control in each step of this flow chart is implemented by the CPU **114** reading out and executing the program stored in the ROM **112**.

(145) In a case where the operator presses the print button **1421** under the job actions **1420** on the job printing application screen **1400** of FIG. **14**A, the CPU **114** starts the print job (Step S**1701**). The CPU **114** determines whether or not the print job to be executed is a job for duplex printing (Step S**1702**). In a case of the duplex printing (Y in Step S**1702**), the CPU **114** determines whether

or not the print front-and-back position correction execution flag F in the RAM **113** is "1" (Step S**1703**).

(146) As described above, the print front-and-back position correction execution flag F is set by the print adjustment enabling checkbox **1021** on the print adjustment screen **1020** of FIG. **10**C. In a case where the print front-and-back position correction execution flag F is "1" (Y in Step S**1703**), the print front-and-back position correction is performed. In this case, the CPU **114** determines whether or not a counter "n" for the number of sheets on which the print front-and-back position correction has been executed is equal to or larger than the number N of sheets every which the print front-and-back position correction is to be executed, the counter "n" being stored in the RAM **113** (Step S**1704**). As described above, the number N of sheets every which the print front-and-back position correction is to be executed has a value set by the number-of-sheets setting box **1022** on the print adjustment screen **1020** of FIG. **10**C.

(147) In a case where the counter "n" for the number of sheets on which the print front-and-back position correction has been executed is smaller than the number N of sheets every which the print front-and-back position correction is to be executed (N in Step S**1704**), the CPU **114** adds 1 to, or increments by 1, the counter "n" for the number of sheets on which the print front-and-back position correction has been executed, and stores a resultant thereof in the RAM **113** (Step S**1714**). In a case where the counter "n" for the number of sheets on which the print front-and-back position correction has been executed is equal to or larger than the number N of sheets every which the print front-and-back position correction is to be executed (Y in Step S**1704**), the CPU **114** refers to the page numbers **1560** of the print front-and-back position correction setting table **1550** of FIG. **15**C in ascending order from the smallest number (Step S**1705**). The CPU **114** determines whether or not the images **1562** for adjustment are registered in the page numbers that have been referred to (Step S**1706**).

(148) In a case where the images **1562** for adjustment are registered (Y in Step S**1706**), the CPU **114** reads out the image data on the images **1562** for adjustment for the pages (Step S**1707**). The image data on the images **1562** for adjustment to be read out in this case has been determined in the processing of FIG. **16**. The CPU **114** prints, by duplex printing, the front surface image (image **1562***a* for adjustment) and the back surface image (image **1562***b* for adjustment) of the read-out images **1562** for adjustment on the pages (Step S**1708**). That is, the CPU **114** controls the printer **150** to feed a paper sheet having the same type as those of the pages from one of the sheet feeding stages **140***a*, **140***b*, **140***c*, **140***d*, and **140***e* to generate a sheet for adjustment.

(149) For example, in a case where the type of paper sheet of the pages is "DEF PAPER, EMBOSSED PAPER A-1," the printer **150** prints the read-out image **1562***a* for adjustment on the first surface (front surface) of the paper sheet fed from the sheet feeding stage **140***c*. Subsequently, the printer **150** reverses the paper sheet by the reverser **136**, and then prints the image **1562***b* for adjustment on the second surface (back surface) of the paper sheet. The printer **150** conveys the sheet for adjustment generated in this manner to the reading apparatus **160**.

(150) The CPU **114** controls the reading apparatus **160** to read the image **1562***a* for adjustment and the image **1562***b* for adjustment of the sheet for adjustment (Step S**1709**). The CPU **114** reads the images for adjustment by the line sensors **312***a* and **312***b* while conveying the sheet for adjustment by the reading apparatus **160**. The sheet for adjustment delivered from the reading apparatus **160** is delivered to the delivery tray of the finisher **190**.

(151) The CPU **114** acquires the reading results of the sheet for adjustment from the reading apparatus **160**, and calculates printing position deviation amounts from the reading results based on the calculation methods shown in FIG. **8** (Step S**1710**). The CPU **114** saves the calculated printing position deviation amounts in the paper sheet library **600** in association with the paper sheet of the sheet feeding stage for the page (Step S**1711**).

(152) For example, in a case where "DEF PAPER, EMBOSSED PAPER A-1" is used as the paper sheet for the pages, the calculated printing position deviation amounts are saved as the printing

position deviation amounts of “DEF PAPER, EMBOSSED PAPER A-1” **603** in the paper sheet library **600**. Specifically, in a case where the image **1562***a* for adjustment for the page has “TONER ADHESION AMOUNT CLASS 2,” the CPU **114** saves the calculated printing position deviation amounts in the printing position deviation amount (front surface) **620**. In a case where the image **1562***b* for adjustment for the page has “TONER ADHESION AMOUNT CLASS 5,” the CPU **114** saves the calculated printing position deviation amounts in the printing position deviation amount (back surface) **627**.

(153) The CPU **114** determines whether or not the print front-and-back position correction has been ended for all the images for adjustment stored in the print front-and-back position correction setting table **1550** (Step S**1712**). In a case where the print front-and-back position correction has not been ended (N in Step S**1712**), the CPU **114** returns the process to the processing step of Step S**1705**, and reads out the subsequent image for adjustment from the print front-and-back position correction setting table **1550** to perform print front-and-back position correction thereon.

(154) In a case where the print front-and-back position correction has been ended for all the images for adjustment (Y in Step S**1712**), the CPU **114** ends the print front-and-back position correction, and stores “O” as the value of the counter “n” for the number of sheets on which the print front-and-back position correction has been executed (Step S**1713**). After that, the CPU **114** causes the printer **150** to print an output image corresponding to the print job (Step S**1715**). In this case, the printing position is corrected based on the printing position deviation amounts acquired through the print front-and-back position correction. In a case where the printing of the image corresponding to one page has been finished, the CPU **114** determines whether or not the print job has been ended (Step S**1716**). In a case where the print job has not been ended (N in Step S**1716**), the CPU **114** returns the process to the processing step of Step S**1702**, and repeatedly performs Step S**1702** and the subsequent processing steps. In a case where the print job has been ended (Y in Step S**1716**), the CPU **114** ends the processing.

(155) In a case of the simplex printing (N in Step S**1702**), the CPU **114** causes the printer **150** to print an output image corresponding to the print job (Step S**1715**). In this case, the correction of the printing position based on the printing position deviation amounts acquired through the print front-and-back position correction is not performed. In a case where the printing of the image corresponding to one page has been finished, the CPU **114** determines whether or not the print job has been ended (Step S**1716**). In a case where the print job has not been ended (N in Step S**1716**), the CPU **114** returns the process to the processing step of Step S**1702**, and repeatedly performs Step S**1702** and the subsequent processing steps. In a case where the print job has been ended (Y in Step S**1716**), the CPU **114** ends the processing.

(156) In the same manner, in a case where the print front-and-back position correction execution flag F is “0” (N in Step S**1703**), the CPU **114** causes the printer **150** to print an output image corresponding to the print job (Step S**1715**). In this case, the correction of the printing position based on the printing position deviation amounts acquired through the print front-and-back position correction is not performed. In a case where the printing of the image corresponding to one page has been finished, the CPU **114** determines whether or not the print job has been ended (Step S**1716**). In a case where the print job has not been ended (N in Step S**1716**), the CPU **114** returns the process to the processing step of Step S**1702**, and repeatedly performs Step S**1702** and the subsequent processing steps. In a case where the print job has been ended (Y in Step S**1716**), the CPU **114** ends the processing.

(157) Further, after **1** is added in the processing step of Step S**1714** to the counter “n” for the number of sheets on which the print front-and-back position correction has been executed, the CPU **114** causes the printer **150** to print an output image corresponding to the print job (Step S**1715**). In this case, the printing position is corrected based on the printing position deviation amounts acquired through the initial front-and-back position correction or the print front-and-back position correction. In a case where the printing of the image corresponding to one page has been finished,

the CPU **114** determines whether or not the print job has been ended (Step S**1716**). In a case where the print job has not been ended (N in Step S**1716**), the CPU **114** returns the process to the processing step of Step S**1702**, and repeatedly performs Step S**1702** and the subsequent processing steps. In a case where the print job has been ended (Y in Step S**1716**), the CPU **114** ends the processing.

Modification Example

(158) The output image designated by a print job can also be used as the image for adjustment to perform the print front-and-back position correction.

(159) FIG. **18** is an exemplary view of the print adjustment page setting screen **1450**. This print adjustment page setting screen **1450** is obtained by adding a select chart button **1801**, which is indicated by being surrounded by the dotted line, to the screen of FIG. **14**B. The same screen components as those of the screen of FIG. **14**B are denoted by the same reference symbols. In the job display section **1460**, the print job selected through the print job list **1410** of FIG. **14**A by the operator from among the print jobs input from the host computer **101** is displayed.

(160) FIG. **19**A and FIG. **19**B are exemplary views of a chart selection screen displayed on the operation panel **120**. A chart selection screen **1900** is displayed on the operation panel **120** in a case where the select chart button **1801** is pressed with the pages being selected in the print front-and-back position correction page list **1461** on the print adjustment page setting screen **1450**. The chart selection screen **1900** includes a selected-chart display section **1910**, a correction chart selection button **1920**, an output image chart selection button **1921**, a determine button **1930**, and a cancel button **1931**.

(161) The selected-chart display section **1910** includes a correction chart display section **1910***a* and an output image chart display section **1910***b*. In the correction chart display section **1910***a*, the images for adjustment determined in the processing of FIG. **16** are displayed. In the output image chart display section **1910***b*, images obtained by adding the marks **720** for correction of FIG. **3** to the output images of the pages selected in the print front-and-back position correction page list **1461** are displayed.

(162) The correction chart selection button **1920** and the output image chart selection button **1921** are each displayed in a so-called toggle manner. For that reason, each of the correction chart selection button **1920** and the output image chart selection button **1921** is switched to be displayed as “ON” by being pressed while being displayed as “OFF”, and is switched to be displayed as “OFF” by being pressed while being displayed as “ON”.

(163) In addition, the correction chart display section **1910***a* and the output image chart display section **1910***b* are displayed exclusively of each other, and the correction chart selection button **1920** and the output image chart selection button **1921** are displayed exclusively of each other. Specifically, as illustrated in FIG. **19**A, in a case where the correction chart selection button **1920** is displayed as “ON”, the output image chart selection button **1921** is displayed as “OFF”. The correction chart display section **1910***a* is normally displayed, and the output image chart display section **1910***b* is grayed out. Conversely, as illustrated in FIG. **19**B, in a case where the correction chart selection button **1920** is displayed as “OFF”, the output image chart selection button **1921** is displayed as “ON”. The correction chart display section **1910***a* is grayed out, and the output image chart display section **1910***b* is normally displayed.

(164) In a case where the correction chart selection button **1920** is displayed as “ON”, the image forming apparatus **100** performs the above-mentioned processing for the print front-and-back position correction. In a case where the output image chart selection button **1921** is displayed as “ON”, the image forming apparatus **100** uses, as the images for adjustment, images obtained by adding the marks **720** for correction of FIG. **3** to the output images, and registers the images as the images **1562** for adjustment of FIG. **15**C. For that reason, the print front-and-back position correction can be performed through use of the images obtained by adding the marks **720** for correction to the output images.

(165) FIG. **20**A and FIG. **20**B are explanatory views for a method of generating images for adjustment by adding the marks **720** for correction to output images. FIG. **20**A is an illustration of a margin area for adding one of the marks **720** for correction to an output image. FIG. **20**B is an illustration of images for adjustment in which the marks **720** for correction are added to output images.

(166) The marks **720** for correction of FIG. **20**A are provided in the four corners (corner areas) of the paper sheet in the same manner as in FIG. **3**, but in this case, only the mark **720** for correction on the upper left and the lengths (C) and (D) are illustrated for simplicity of description. In Modification Example as well, the length (A) to the length (V) are measured from the marks **720** for correction provided in the four corners (corner areas).

(167) Margin lines **2001** for the marks for correction are boundary lines for generating margins for the reading apparatus **160** to read the marks **720** for correction. In a case where an output image overlaps with an area to which each mark **720** for correction is to be added, it becomes more difficult for the reading apparatus **160** to accurately read the marks **720** for correction. An output image area **2002** in which the output image is supposed to be formed is an area in which the original output image is masked with the margin lines **2001** for the marks for correction being used as boundaries. In this Modification Example, the margin lines **2001** for the marks for correction is included in the image for adjustment, but the margin lines **2001** for the marks for correction is not required to be included in the image for adjustment.

(168) FIG. **20**B is the illustration of the images for adjustment in each of which the original output image is masked through use of the margin lines **2001** for the marks for correction and the marks **720** for correction are added. The marks **720** for correction are added to an output image **2011**, to thereby generate an image **2012** for adjustment. In the output image **2011**, the original image is not to overlap with the areas of the marks **720** for correction. For that reason, the image **2012** for adjustment is an image in which the marks **720** for correction are added in four corners (corner areas) of the output image **2011**.

(169) The marks **720** for correction are added to an output image **2021**, to thereby generate an image **2022** for adjustment. In the output image **2021**, the original image is to overlap with the areas of the marks **720** for correction. For that reason, the image **2022** for adjustment is an image in which the marks **720** for correction are added in a margin area in which the original image is masked with the margin lines **2001** for the marks for correction being used as boundaries.

(170) In order to simplify the description, no reference is made to the front surface image of a paper sheet in a case of determining the printing position deviation amounts on the back surface of the paper sheet, but it has been found that the printing position deviation amounts on the back surface differs depending on the toner adhesion amount of the front surface image in actuality. For that reason, for example, in a case in which the toner adhesion amount class is “5”, the printing position deviation amounts on the back surface may be set to have a total of 25 types in combination of five toner adhesion amount classes for the front surface and five toner adhesion amount classes for the back surface.

(171) As described above, at a time of the print front-and-back position correction, the image forming apparatus **100** according to the at least one embodiment uses the images for adjustment corresponding to the pages selected by the operator to perform the print front-and-back position correction. Accordingly, it is possible to reduce the number of sheets for adjustment to be the paper to be discarded while updating the correction amount corresponding to the toner adhesion amount to a proper value.

(172) While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

(173) This application claims the benefit of Japanese Patent Application No. 2023-028425, filed Feb. 27, 2023, which is hereby incorporated by reference herein in its entirety.

Claims

1. An image forming apparatus comprising: an image former configured to form an image on a sheet through use of toner; a reader configured to read the sheet on which a mark for correction is formed; a display; and a processor configured to: display a plurality of images included in a print job in a selectable manner on the display; acquire user selection information indicating a selection result for an image selected from among the plurality of images; determine, based on the user selection information, an image for adjustment to be formed by the image former, the image for adjustment including a pattern image, which is to have a toner adhesion amount corresponding to a density of the selected image, and the mark for correction; control the image former to form the image for adjustment on a sheet; control the reader to read the sheet on which the image for adjustment has been formed; and control a printing position of the selected image formed by the image former based on a reading result of the sheet on which the image for adjustment read by the reader has been formed.
2. The image forming apparatus according to claim 1, wherein the image former is configured to form a plurality of images for adjustment, the plurality of images for adjustment including a plurality of pattern images having different toner adhesion amounts and the marks for correction, and wherein the processor is configured to determine the image for adjustment including a pattern image corresponding to the density of the selected image based on the user selection information from among the plurality of images for adjustment.
3. The image forming apparatus according to claim 1, wherein the mark for correction comprises marks to be formed in corner areas of the sheet.
4. The image forming apparatus according to claim 1, wherein the processor is configured to generate a right-angle correction amount based on the reading result of the sheet on which the image for adjustment read by the reader has been formed, and wherein the processor is configured to control the printing position of the selected image formed by image former based on the right-angle correction amount.
5. The image forming apparatus according to claim 1, wherein the processor is configured to generate a trapezoidal correction amount based on the reading result of the sheet on which the image for adjustment read by the reader has been formed, and wherein the processor is configured to control the printing position of the selected image formed by the image former based on the trapezoidal correction amount.
6. The image forming apparatus according to claim 1, wherein the processor is configured to generate respective parameters of a lead position, a side position, a long-side-direction magnification, and a short-side-direction magnification based on the reading result of the sheet on which the image for adjustment read by the reader has been formed, and wherein the processor is configured to control the printing position of the selected image formed by the image former based on the respective parameters.
7. The image forming apparatus according to claim 1, wherein the processor is configured to control the image former to form the image for adjustment each time the images have been formed on a predetermined number of sheets.
8. The image forming apparatus according to claim 7, wherein the processor is configured to display a screen for setting the predetermined numbers of sheets on the display.
9. The image forming apparatus according to claim 1, wherein the image former includes a conveyance roller configured to convey the sheet to a delivery tray for delivering the sheet, and wherein the reader is configured to read the sheet while the conveyance roller is conveying the sheet.

10. The image forming apparatus according to claim 9, wherein the reader includes a first sensor configured to read a first surface of the sheet and a second sensor configured to read a second surface of the sheet opposite the first surface.

11. The image forming apparatus according to claim 10, wherein the selected image includes an image to be formed on the first surface and an image to be formed on the second surface, wherein the processor is configured to control a printing position of the image for the first surface based on a reading result of the first surface of the sheet on which the image for adjustment read by the first sensor has been formed, and wherein the processor is configured to control a printing position of the image for the second surface based on a reading result of the second surface of the sheet on which the image for adjustment read by the second sensor has been formed.