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with a given pressure. The toner has a sunken rate of additives of 40% or more. The sunken rate of additives $X\% = \{ (A-B) / A \} \times 100$. "A (m²/g)" is a BET specific surface of toner matrix before sinking additives in toner, and "B (m²/g)" is a BET specific surface of the toner after sinking additives in toner. The pressing unit (18K) for the black image bearing member (20K) presses the transfer member (12K) with a pressure set smaller compared to other pressing units (18) for the other image bearing members (20).

Description

BACKGROUND OF THE INVENTION

5 Field of the Invention

[0001] The present disclosure generally relates to an image forming apparatus, and more particularly, to an image forming apparatus including a plurality of image bearing members and using two-component developer including toner and carrier.

10 Description of the Background Art

[0002] Image forming apparatuses (e.g., copiers, facsimiles, printers, etc.) include an image bearing member (e.g., photoconductor) for image formation. In addition, some image forming apparatuses have a plurality of image bearing members are fixed as a reproduced image on a sheet using either a direct transfer method or an indirect transfer method.

[0003] In the direct transfer method, toner images are directly transferred onto the sheet from the plurality of image bearing members, and then fixed on the sheet using heat energy. In the indirect transfer method (also referred to as the intermediate transfer method), toner images are firstly transferred onto an intermediate transfer medium from the plurality of image bearing members, after which the toner images are then transferred onto the sheet and then fixed on the sheet using heat energy.

[0004] To describe in greater detail, an image forming apparatus (e.g., color copier) using the intermediate transfer method, typically includes one or more image bearing members, an intermediate transfer medium, a primary transfer device, a secondary transfer device, a primary cleaning member, and a secondary cleaning member, for example.

[0005] In terms of function, the primary transfer device is used to transfer a toner image from the image bearing member to the intermediate transfer medium. The secondary, transfer device is used to transfer the toner image from the intermediate transfer medium to a sheet. The primary cleaning member is used to remove any toner remaining on the image bearing member after the toner image is transferred to the intermediate transfer medium. The secondary cleaning member is used to remove toner remaining on the intermediate transfer medium after the toner image is transferred to the sheet. Such cleaning members are typically a cleaning blade, which can scrape off toner remaining on the image bearing member or intermediate transfer medium.

[0006] Further, such image forming apparatus may use two-component developer including both toner and carrier for image formation, in which the toner included in the developer is transferred to the image bearing member to form a toner image, and then the toner image is transferred to a sheet and fixed on the sheet by applying heat energy.

[0007] Typically, in terms of composition, toner is a mass of colored particles including binder resin and other materials (e.g., colorant, charge control agent, additives), and can be categorized as pulverized toner or chemical toner.

[0008] With growing demand for high quality imaging, small-sized toner in which toner particle diameter has been reduced has been developed and commercialized. However, such small-sized toner is difficult to achieve as pulverized toner, insofar as the pulverized toner prepared by a pulverization method may have irregular particle shape, which may result in lower image quality, such as lower granularity and reduced sharpness of image.

[0009] Further, because of its irregular particle shape, the pulverized toner itself has a lower fluidity, and thus a large amount of external additives (used as fluidizing agents) may be required to improve the fluidity of the pulverized toner. Further, because of its irregular particle shape, the pulverized toner is not densely packed, and thus a larger toner bottle may be required, which hinders efforts at size reduction of the apparatus. In general, then, the pulverization method is not very suitable for the production of smaller-sized toner.

[0010] In addition, pulverized toner having irregular shape may not be used efficiently or effectively for forming full-color images because transfer process of toner images has become more complex when transferring the toner image from the image bearing member to the intermediate transfer medium and when transferring the toner image from the intermediate transfer medium to the sheet. For example, irregular shaped toner may have lower transfer performance, by which voids may occur in a transferred image, and thereby toner consumption amount may be increased to compensate or mitigate such drawbacks.

[0011] In view of such drawbacks of irregular-shaped toner, chemical toner having spherical shape (spherical toner) has been developed. Chemical toner can be prepared by a suspension polymerization method, for example, or by a condensation/emulsion polymerization method.

[0012] JP-H07-152202-A discloses a polymer solution suspension method, which is typically known as an ester elongation polymerization method, in which toner ingredients are dispersed and solved in a volatile solvent (e.g., low-boiling organic solvent), and then the solution is emulsified in an aqueous solvent having a dispersing agent to form emulsified product, and the volatile solvent is removed.

[0013] JP-H11-149179-A and JP-3762078-B also disclose a polymer solution suspension method, in which resin

having low-molecular weight is used to decrease viscosity of dispersed phase of the dispersed solution, by which dispensability of toner ingredients can be enhanced and emulsification can be conducted easily, and a polymerization reaction is further accelerated in toner particles to enhance fixability of toner.

[0014] Such polymer solution suspension methods may be preferable to the suspension polymerization method and condensation/emulsion polymerization method in several aspects. For example, the polymer solution suspension method has less limitation on types of resin that can be used. Specifically, polyester resin having good low-temperature fixability, translucency, and smoothness of fixed image can be used for the polymer solution suspension method.

[0015] In general, spherical toner having a smaller particle diameter may not be effectively removed by a cleaning blade (i.e., lower cleaning performance). The spherical toner may have a good level of transfer performance, but the smaller the particle diameter, the larger the attraction of toner to a photoconductor, by which transfer performance of spherical toner may be decreased as a result.

[0016] In light of drawback of spherical toner having a smaller particle diameter, JP-H03-100661-A discloses a method of using inorganic fine particles having a mid-sized particle diameter as external additives to enhance cleaning performance and transfer performance of the toner. Specifically, the inorganic fine particles may have an average particle diameter of from 20 nm to 40 nm (nanometers).

[0017] Further, JP-3328013-B, JP-H09-319134-A, and JP-3056122-B disclose a method of using inorganic fine particles having large-sized particle diameter (e.g., average particle diameter of 100 nm or more) as external additives to enhance cleaning performance. Such large-sized inorganic fine particles can also be used as a toner particle spacer, which can protect small-diameter external additives particles residing on surfaces of the toner particles from mechanical or other stress in a development unit, by which sinking phenomenon of small-diameter particle can be reduced.

[0018] Although such method can suppress sinking of external additives having small-diameter particles into toner particles and can enhance cleaning performance and transfer performance of the toner when toner particles are fresh, the external additives may still sink over time.

[0019] With growing demand for material saving and power saving, energy used for a fixing process is required to be decreased. For example, to decrease energy used for a fixing process, toner made from resin powders may have a lower softening point. Such toner can be prepared using a soft resin, for example polyester resin, as a binder resin of toner.

[0020] If soft resin (e.g., polyester resin or the like) is used as a binder resin for toner prepared by the above described method in JP-H03-100661-A, JP-3328013-B, JP-H09-319134-A, and JP-3056122-B, such toner may not exert a good level of cleaning performance and transfer performance over time because polyester resin is weaker than other resins that can be used as a binder resin. Accordingly, external additives may sink into toner particles easily over time, and as a result high quality imaging may not be obtained.

[0021] Further, when transferring a toner image from the image bearing member to the intermediate transfer medium, or from the intermediate transfer medium to the sheet, the toner image should be transferred to a transfer member in such a manner that the image is correctly and stably transferred. The transfer member is used as a member to receive an image, such as a toner image, from another member.

[0022] The image forming apparatus using the indirect transfer method may include a pressing device, which presses the intermediate transfer medium against the image bearing member at a transfer position. The pressing device applies pressure to the image bearing member and the intermediate transfer medium during a primary transfer process, in which the toner image is transferred from the image bearing member to the intermediate transfer medium. Such pressing device can enhance transfer performance of toner image, and prevent defective transfer such as a white patch on a printed sheet.

[0023] The pressing device can suppress surface waviness of the intermediate transfer medium at the transfer position so that the intermediate transfer medium can be evenly contacted against the surface of the image bearing member, by which abnormal transfer (e.g., uneven transfer phenomenon) can be reduced.

[0024] However, if the pressure is applied to the image bearing member and the intermediate transfer medium, a pressure imbalance may occur across the toner image formed on the intermediate transfer medium, by which a void image may occur on the intermediate transfer medium. For example, an image (e.g., solid image, line image, character image) may have a void area in its center.

[0025] In light of such void phenomenon, JP-2003-098770-A, JP-2000-162899-A, and JP-2000-155476-A disclose an image forming apparatus which sets a contact pressure of a primary transfer device to the image bearing member within a given range so that an excess pressure may not be applied to the toner image, by which void transfer phenomenon can be prevented.

[0026] However, optimal contact pressure may vary depending on image by image. For example, a single color image may not need a large amount of toner, but a multi-color image may need a large amount of toner. Accordingly, the optimal contact pressure may vary depending on images. If the contact pressure deviates from the optimal level, the toner image may not be transferred from the image bearing member to other transfer member effectively, and a defective transfer may occur.

[0027] In light of such contact pressure issue, JP-2002-014515-A and JP-2005-024936-A disclose a method of ad-

justing a contact pressure at a transfer position along a transfer direction. For example, a contact pressure at the downstream of the transfer direction is set lower than a contact pressure at the upstream of the transfer direction; a contact pressure at a black image transfer position may be set different from other transfer positions for other colors; and a contact pressure at the upstream of the transfer direction may be set different from other transfer positions.

[0028] Further, another related arts disclose methods for securing a stable contact between transfer members. For example, JP-2006-301673-A and JP-2004-264559-A disclose methods that an image bearing member can stably contact against an intermediate transfer medium using self-weight of a transfer unit encasing the image bearing member; JP-2978367-B discloses a method that a transfer sheet can stably contact against an intermediate transfer medium using self-weight of the transfer sheet.

SUMMARY

[0029] The advantages of the present invention are based on the subject-matter of independent claims 1, 11 and 14. Further advantageous embodiments are claimed by means of the features referred to in the sub-claims.

[0030] An image forming apparatus uses two-component developer including toner and carrier. The toner includes a binder resin and additives. The image forming apparatus includes a plurality of image bearing members, a transfer member, and a plurality of pressing units. The plurality of image bearing members form a toner image on each of the image bearing members. The plurality of image bearing members include a black image bearing member for forming black image and other image bearing members for forming other color images. The transfer member, facing the plurality of image bearing members, is transferred with the toner image from each of the plurality of image bearing members. The plurality of pressing units, disposed for each of the plurality of image bearing members, press the transfer member to corresponding each of the plurality of image bearing members with a given pressure. The toner has a sunken rate of additives 40% or more. The sunken rate of additives X% is defined: $\text{sunken rate of additives } X = \{(A-B)/A\} \times 100$, in which "A(m²/g)" is a BET specific surface of toner matrix before sinking additives in toner and "B(m²/g)" is a BET specific surface of the toner after sinking additives in toner. The pressing unit for the black image bearing member presses the transfer member with a pressure set smaller compared to other pressing units for the other image bearing members, which press the transfer member.

[0031] A method of forming an image using the image forming apparatus includes the steps of: forming a latent image on each of image bearing members; developing the latent image on the image bearing member as a toner image using by applying the toner having a sunken rate of additives 40% or more; and transferring the toner image onto a transfer member, wherein a toner image of black is transferred to the transfer member with a given pressure set smaller than a pressure for transferring toner images of other color.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] A more complete appreciation of the disclosure and many of the attendant advantages and features thereof can be readily obtained and understood from the following detailed description with reference to the accompanying drawings, wherein:

FIG. 1 illustrates a schematic configuration of an image forming apparatus according to a first exemplary embodiment; FIG. 2 illustrates a schematic configuration around an image bearing member of the image forming apparatus of FIG. 1; FIG. 3 shows evaluation results of image forming when primary transfer pressure is changed; FIG. 4 shows evaluation results of image forming when primary transfer pressure and sunken rate of additives to toner are changed; FIG. 5 shows evaluation results of image forming using two color images when an order of image forming of different colors is changed; FIG. 6 shows a correlation diagram for BET specific surface of toner matrix and unintended uneven image rank; and FIG. 7 illustrates a schematic configuration of an image forming apparatus according to a second exemplary embodiment.

[0033] The accompanying drawings are intended to depict example embodiments of the present invention and should not be interpreted to limit the scope thereof. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted, and identical or similar reference numerals designate identical or similar components throughout the several views.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

[0034] A description is now given of example embodiments of the present invention. It should be noted that although such terms as first, second, etc. may be used herein to describe various elements, components, regions, layers and/or sections, it should be understood that such elements, components, regions, layers and/or sections are not limited thereby because such terms are relative, that is, used only to distinguish one element, component, region, layer or section from another region, layer or section. Thus, for example, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the present invention.

[0035] In addition, it should be noted that the terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present invention. Thus, for example, as used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. Moreover, the terms "includes" and/or "including", when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0036] Furthermore, although in describing expanded views shown in the drawings, specific terminology is employed for the sake of clarity, the present disclosure is not limited to the specific terminology so selected and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner.

[0037] Referring now to the drawings, an image forming apparatus according to an example embodiment is described with reference to accompanying drawings. The image forming apparatus may employ electrophotography, for example, and may be used as copier, printer, facsimile, or a multi-functional apparatus, but not limited thereto.

[0038] FIG. 1 illustrates a schematic configuration of an image forming apparatus 100 according to a first exemplary embodiment. The image forming apparatus 100 may be a copier, a printer, a facsimile, and a multi-functional apparatus, for example. When the image forming apparatus 100 is used as a printer or a facsimile, the image forming apparatus 100 conducts an image forming process using image data received from an external device, such as a personal computer. The image forming apparatus 100 can produce full-color image, for example.

[0039] The image forming apparatus 100 can use a recording medium in sheet form, such as for example plain paper, OHP (overhead projector) sheet, heavy paper (e.g., card, postcard), envelope or the like. The image forming apparatus 100 can record images on both face of the recording medium.

[0040] The image forming apparatus 100 includes a printing unit 101, a sheet feed unit 23, a scanner 21, and an automatic document feeder (ADF) 22, for example. The printing unit 101 may be placed over the sheet feed unit 23, the scanner 300 may be placed on the printing unit 101, and the ADF 22 may be placed on the scanner 21, for example. The ADF 22 feeds document to the scanner 21. The sheet feed unit 23 stores sheets to be transported to the printing unit 101.

[0041] The printing unit 101 may include an image forming unit 60, which includes a plurality of photoconductor drums 20Y, 20M, 20C, and 20K for forming images of yellow(Y), magenta(M), cyan(C), and black(K), respectively. Hereinafter, Y, M, C, and K represent yellow, cyan, magenta, and black, respectively. The image forming apparatus 100 uses the photoconductor drums 20Y, 20M, 20C, and 20K as image bearing members arranged in a tandem manner. The photoconductor drums 20Y, 20M, 20C, and 20K, having a same diameter, are aligned along a face of an intermediate transfer belt 11 with a same interval. The intermediate transfer belt 11 is disposed under the image forming unit 60, for example, and has endless belt shape.

[0042] The intermediate transfer belt 11 may travel in a clockwise direction shown by an arrow A1 in FIG. 1. Toner images formed on each of the photoconductor drums 20Y, 20M, 20C, and 20K are superimposingly transferred to the intermediate transfer belt 11 moving in the direction shown by an arrow A1 as a full color image, and the full color image is transferred to a sheet. As such, in the image forming apparatus 100, the full color image is formed by way of indirect transfer method.

[0043] Toner images can be transferred and superimposed on the intermediate transfer belt 11 as follows: When the intermediate transfer belt 11 moves in the A1 direction, the toner images formed on the photoconductor drums 20Y, 20M, 20C, and 20K are superimposingly transferred on a same position on the intermediate transfer belt 11. Specifically, primary transfer rollers 12Y, 12M, 12C, and 12K, disposed against the photoconductor drums 20Y, 20M, 20C, and 20K via the intermediate transfer belt 11, apply given voltage to transfer the toner images from the photoconductor drums 20Y, 20M, 20C, and 20K to the intermediate transfer belt 11, in which the transfer process for each of the colors are conducted by setting a given time interval.

[0044] The intermediate transfer belt 11 can be manufactured with any methods and materials. For example, the intermediate transfer belt 11 can be made from polyimide resin having a good level of strength with following steps: Carbon black is dispersed in polyamic acid solution, and the dispersion solution is poured in a metal drum and dried; the dried material is separated from the metal drum and elongated under a higher temperature condition to form a polyimide resin film; the polyimide resin film is cut in a given size for preparing an endless belt of polyimide resin.

[0045] Such a typical film forming method may be conducted by dispersing carbon black in a polymer solution, pouring the solution in a cylindrical die, heating the materials under 100 to 200 degrees Celcius while the cylindrical die is rotated, and forming a film using centrifugal force.

[0046] The semi-hardened film is separated from the cylindrical die and set on an iron core, and hardened at 300 to 450 degrees Celcius to progress a reaction of obtaining polyimide resin, which becomes the intermediate transfer belt 11. Property of the intermediate transfer belt 11 can be adjusted by changing conditions, such as carbon amount, baking temperature, curing rate, by which volume resistivity and surface resistivity can be adjusted.

[0047] The volume resistivity and surface resistivity can be measured by using a highly precise resistivity meter of Hiresta UP (MCP-HT450) and URA probe (MCP-HTP14), both of products of Mitsubishi Chemical Corporation, for example.

[0048] Each of the photoconductor drums 20Y, 20M, 20C, and 20K are arranged in tandem in a direction shown by A1. The image forming unit 60 includes image forming engines 60Y, 60M, 60C, and 60K, in which each of the photoconductor drums 20Y, 20M, 20C, and 20K are included.

[0049] The image forming apparatus 100 further includes a transfer belt unit 10, which includes the intermediate transfer belt 11 disposed under the photoconductor drums 20Y, 20M, 20C, and 20K. The transfer belt unit 10 is used as an intermediate transfer unit.

[0050] The image forming apparatus 100 further includes a secondary transfer roller 17, a sheet transport unit 76, and a transfer belt cleaning unit 14.

[0051] The secondary transfer roller 17, contacted against the intermediate transfer belt 11, rotates in a same direction with the intermediate transfer belt 11 at the contact portion, at which a toner image is transferred from the intermediate transfer belt 11 to a sheet. The secondary transfer roller 17 is used as a second transfer device. The sheet transport unit 76 transports the sheet having the toner image transferred from the intermediate transfer belt 11. The transfer belt cleaning unit 14, facing the intermediate transfer belt 11, cleans the intermediate transfer belt 11 after the toner image is transferred to the sheet.

[0052] The image forming apparatus 100 further includes an optical writing unit 8, disposed over the image forming engines 60Y, 60M, 60C, and 60K.

[0053] The image forming apparatus 100 further includes registration roller(s) 13, which stops a sheet transported from the sheet feed unit 23 and feeds the sheet to a transfer nip between the intermediate transfer belt 11 and the secondary transfer roller 17 when toner images formed by the image forming engines 60Y, 60M, 60C, and 60K are transferred to the intermediate transfer belt 11. The image forming apparatus 100 further includes a sensor to detect that an edge of the sheet reaches the registration roller(s) 13.

[0054] The image forming apparatus 100 further includes a fixing unit 6, which fixes the toner image on the sheet transported by the sheet transport unit 76.

[0055] The image forming apparatus 100 further includes a sheet ejection unit 79, and a sheet reverse unit 96. The sheet ejection unit 79 includes a sheet ejection path and a sheet reverse path. The sheet is ejected from the printing unit 101 via the sheet ejection path, or transported to the sheet reverse unit 96 via the sheet reverse path. The sheet reverse unit 96 reverses the faces of sheet, supplied from the sheet reverse path of the sheet ejection unit 79 by using a switchback process, and then transports the sheet to the registration roller(s) 13 again.

[0056] The image forming apparatus 100 further includes an ejection tray 75, a manual sheet-feed unit 33, an operation panel, and a control unit. The ejection tray 75 stacks sheets ejected from the printing unit 101 after an image forming process. The manual sheet-feed unit 33 may be disposed on one side of the printing unit 101 as shown in FIG. 1. The operation panel is used to operate the image forming apparatus 100. The control unit controls the image forming apparatus 100 as a whole.

[0057] The transfer belt unit 10 includes the intermediate transfer belt 11, the primary transfer rollers 12Y, 12M, 12C, and 12K, the intermediate transfer belt 11, a drive roller 72, a transfer nip roller 73, and a tension roller 74, and a drive unit. The intermediate transfer belt 11 may be extended by the drive roller 72, the transfer nip roller 73, and the tension roller 74.

[0058] The drive unit can pivot the transfer belt unit 10 about the drive roller 72 in a counter-clockwise direction in FIG. 1, by which the photoconductor drums 20Y, 20M, and 20C can be separated from the intermediate transfer belt 11 while the photoconductor drum 20K is still contacted against the intermediate transfer belt 11. The drive unit can be controlled by the control unit.

[0059] FIG. 1 shows a state that a full color image forming is conducted. When a single black color image forming is conducted, the photoconductor drums 20Y, 20M, and 20C are separated from the intermediate transfer belt 11.

[0060] The image forming apparatus 100 includes the transfer belt cleaning unit 14. Accordingly, after the single black color image forming, black toner can be removed by the transfer belt cleaning unit 14, and thereby black toner may not contaminate the photoconductor drums 20Y, 20M, and 20C. Therefore, the photoconductor drums 20Y, 20M, and 20C may not need to be separated from the intermediate transfer belt 11. However, the photoconductor drums 20Y, 20M, and 20C may be separated from the intermediate transfer belt 11 just in case that the transfer belt cleaning unit 14

cannot remove black toner completely from the transfer belt cleaning unit 14 when the single black color image forming is conducted. Because black toner is so visible, if black toner adheres the photoconductor drums 20Y, 20M, and 20C, the image quality may degrade.

[0061] To decrease an effect of black toner contamination, the photoconductor drum 20K may be disposed at the most downstream of the A1 direction relative to the photoconductor drums 20Y, 20M, and 20C. When a full color image forming is conducted, the intermediate transfer belt 11 is contacted against the photoconductor drums 20Y, 20M, 20C, and 20K. In such a condition, the photoconductor drum 20K may be disposed at the most downstream of the A1 direction relative to the photoconductor drums 20Y, 20M, and 20C to decrease or prevent black toner contamination to the photoconductor drums 20Y, 20M, and 20C. In such a configuration, the black toner image is transferred to the intermediate transfer belt 11 after all other toner images are transferred to the intermediate transfer belt 11. With such a configuration, black toner may not contaminate the photoconductor drums 20Y, 20M, and 20C via the intermediate transfer belt 11.

[0062] The registration roller(s) 13 may be earthed. In general, the image forming apparatus 100 using an intermediate transfer method, paper powders may not be transported to the photoconductor drums 20Y, 20M, 20C, and 20K. Accordingly, paper powders transfer phenomenon may not be an issue, and thereby the registration roller(s) 13 may be earthed.

[0063] However, the registration roller(s) 13 may be applied with a bias voltage to remove paper powders of sheet. For example, the registration roller 13, having a diameter of 18 mm, includes a surface layer made of conductive rubber (e.g., nitrile butadiene rubber (NBR)) of 1 mm thickness, and volume resistance of rubber is about 10^9 Qcm. Using such registration roller 13, about -800 V is applied to a front face of the sheet that receives a toner image, and +200 V is applied to a back face of the sheet.

[0064] The registration roller 13 may be applied with DC (direct current) bias voltage, in general. However, the registration roller 13 may be applied with AC (alternative current) voltage including DC (direct current) off-set voltage to uniformly charge the sheet.

[0065] When the registration roller 13 may be applied with DC bias voltage, the sheet surface may be charged to a negative value in small scale. Accordingly, an image transfer from the intermediate transfer belt 11 to the sheet may need a change of image transfer condition compared to when no voltage is applied to the registration roller 13.

[0066] The sheet transport unit 76 includes a transport belt 5, which may be an endless belt for a transporting sheet, and a drive roller 15 and a driven roller 16 extending the transport belt 5.

[0067] The secondary transfer roller 17 faces the transfer nip roller 73 via the intermediate transfer belt 11. Accordingly, the secondary transfer roller 17 and the transfer nip roller 73 may contactingly press the intermediate transfer belt 11. The secondary transfer roller 17 may be a non-contact charger. In another configuration, the secondary transfer roller 17 may be included in a transfer/transport unit for transferring image and transporting a sheet to the fixing unit 6, in which the secondary transfer roller 17, other roller, and a belt may configure the transfer/transport unit (see 17a in FIG. 6).

[0068] The optical writing unit 8 includes a light source, a polygon mirror, a polygon motor, and optical devices, for example. The light source emits a laser beam based on image signal to scan a surface of the photoconductor drums 20Y, 20M, 20C, and 20K for writing an electrostatic latent image. The polygon mirror rotates to deflect the laser beam used for such scanning. The polygon motor drives the polygon mirror. The optical devices are used to guide the laser beam deflected by the polygon mirror to the photoconductor drums 20Y, 20M, 20C, and 20B.

[0069] The fixing unit 6 includes a heat roller 62, a pressure roller 63, a fixing belt 64, and a fixing roller 65. The heat roller 62 includes a heat source therein. The fixing belt 64 is extended by the heat roller 62 and the fixing roller 65. The pressure roller 63 applies pressure to the fixing belt 64 with the fixing roller 65. When a sheet having a toner image passes through a fixing nip set by the fixing belt 64 and the pressure roller 63, the toner image can be fixed on the sheet with an effect of heat and pressure.

[0070] The sheet ejection unit 79 includes an ejection roller 97, a transport roller 98, and a switch claw 94. The ejection roller 97 ejects sheet outside the printing unit 101. The transport roller 98 transports the sheet transported from the fixing unit 6 to the sheet reverse unit 96. The switch claw 94 switches the sheet to any one of the sheet ejection path and the sheet reverse path, in which the sheet is ejected outside the printing unit 101 via the sheet ejection path having the ejection roller 97; and the sheet is fed to the sheet reverse unit 96 via the sheet reverse path having the transport roller 98.

[0071] The sheet reverse unit 96 includes a tray 92, a reverse roller 93, a feed roller 95. The tray 92 temporarily stacks the sheet transported from the sheet ejection unit 79. The reverse roller 93 switchbacks the sheet stuck on the tray 92.

The feed roller 95 feeds the switch backed sheet to the registration roller 13.

[0072] The sheet feed unit 23 includes a sheet bank 26, a feed roller 24, a separation roller 27, a transport roller 28, and a feed route 29. The sheet bank 26 includes sheet cassette(s) 25 storing sheets. The feed roller 24 feeds the uppermost sheet of the sheets in the sheet cassette 25. The separation roller 27 separates the sheet picked by the feed roller 24 one by one. The transport roller 28 transports the sheet, fed by the feed roller 24 and the separation roller 27, to the registration roller 13 through the feed route 29. The feed route 29 having the transport roller 28 extends from the sheet feed unit 23 to the printing unit 101.

[0073] In the sheet feed unit 23, the feed roller 24 is rotated in a counter-clockwise direction in FIG. 1, and the separation roller 27 is activated to feed the sheet into the feed route 29, then the sheet is transported to the registration roller 13

by the rotating transport roller 28, and stopped by the registration roller 13.

[0074] The manual sheet-feed unit 33 includes a manual sheet tray 34, a feed roller 35, a separation roller 36, and a sheet sensor. The manual sheet tray 34 is used to stack sheets. The feed roller 35 feeds the uppermost sheet of the sheets on the manual sheet tray 34. The separation roller 36 separates the sheet picked by the feed roller 35 one by one. The sheet sensor detects existence of sheet on the manual sheet tray 34.

[0075] In the manual sheet-feed unit 33, the feed roller 35 is rotated in a clockwise direction in FIG. 1, and the separation roller 36 is activated to feed the sheet into the feed route 29, then the sheet is transported to the registration roller 13, and stopped by the registration roller 13.

[0076] The scanner 21 includes a contact glass 21a, a first carriage 21b, a second carriage 21c, a focus lens 21d, and an image sensor 21e. The first carriage 21b includes a light source for emitting light to the document placed on the contact glass 21a, and a first reflector for reflecting the light reflected on the document. The first carriage 21b moves in a horizontal direction in FIG. 1. The second carriage 21c includes a second reflector for reflecting the light reflected by the first reflector of the first carriage 21b. The focus lens 21d is used to focus the light coming from the second carriage 21c onto the image sensor 21e, at which image data of document is read.

[0077] The ADF 22 includes a document tray 22a for placing documents. The ADF 22 can be pivot about the scanner 21. When the ADF 22 is pivoted upward, the contact glass 21a can be seen. When a copying operation is performed by the image forming apparatus 100, a document is set on the document tray 22a of the ADF 22, or a document is set on the contact glass 21a by pivoting the ADF 22 upward and then closing the ADF 22 after setting the document on the contact glass 21a.

[0078] The operation panel includes a start button for starting operations (e.g., copying operation), keys for inputting information such as sheet number for copying operation, a mode key for selecting full color image forming or single black color image forming, for example. The control unit includes a CPU (central processing unit), a memory used for information storage, for example.

[0079] A description is now given to the image forming engines 60Y, 60C, 60M, and 60K. Because the image forming engines 60Y, 60C, 60M, and 60K have similar configuration one to another the image forming engine 60Y is used for describing the configuration of the image forming engines 60Y, 60C, 60M, and 60K.

[0080] As shown in FIG. 2, the image forming engine 60Y includes the photoconductor drum 20Y, a cleaning unit 40Y, a charge unit 30Y, a development unit 50Y, and a de-charge unit, wherein such units surround the photoconductor drum 20Y. The primary transfer roller 12Y contacts the intermediate transfer belt 11 and may rotate in one direction in FIG. 2. A pressing unit 18Y presses the primary transfer roller 12Y against the intermediate transfer belt 11 with a given pressure.

[0081] The photoconductor drum 20Y, the cleaning unit 40Y, the charge unit 30Y, the development unit 50Y, and the de-charge unit can be integrated as a process cartridge 95Y, which is detachably mountable to the printing unit 101. For example, the process cartridge 95Y can be withdrawn from the printing unit 101 along a guide rail, and can be pushed into the printing unit 101 along the guide rail.

[0082] The process cartridge 95Y can be positioned at a designed position in the printing unit 101 when pushed into the printing unit 101. Such a cartridge configuration can enhance maintenance performance because the process cartridge 95Y can be easily replaced from old one to new one.

[0083] The process cartridge 95Y detachably mountable to the printing unit 101 may include the photoconductor drum 20Y and the development unit 50Y at least. The process cartridge 95Y may further include any of the cleaning unit 40Y, the charge unit 30Y, the development unit 50Y, and the de-charge unit, as required.

[0084] The charge unit 30Y includes a charge roller 31Y, and a cleaning roller 32Y. The charge roller 31Y may contact the surface of the photoconductor drum 20Y, and can rotate when the photoconductor drum 20Y rotates. The cleaning roller 32Y may contact the charge roller 31Y and can rotate when the charge roller 31Y rotates. The charge roller 31Y may be connected to a voltage application unit, which supplies direct current superimposed with alternative current to the charge roller 31Y. The charge roller 31Y may charge the photoconductor drum 20Y to a given polarity and voltage at a charge area of the photoconductor drum 20Y. In such charging process, the charge roller 31Y may conduct de-charging and charging of the photoconductor drum 20Y at a substantially same time.

[0085] The cleaning roller 32Y can clean the charge roller 31Y by rotating with the charge roller 31Y. Although the charge unit 30Y may include a contact roller as such, other configuration can be used. For example, a proximity roller or scorotron (non-contact type) can be used.

[0086] The primary transfer roller 12Y contacts the intermediate transfer belt 11 and presses the intermediate transfer belt 11 to the photoconductor drum 20Y. The primary transfer roller 12Y includes a shaft 37Y and an elastic layer formed on the shaft 37Y. The primary transfer roller 12Y can rotate about the shaft 37Y, rotate-ably supported in the printing unit 101.

[0087] The primary transfer roller 12Y may include a metal core including the shaft 37Y and an elastic layer coated on the metal core. The elastic layer of the primary transfer roller 12Y may have Asker C hardness of 50 degrees or less, for example. The primary transfer roller 12Y may be supplied with a given primary transfer voltage by using a bias voltage

application unit having a power source and a bias control unit.

[0088] As shown in FIG. 2, the primary transfer roller 12Y and a pressure spring 19Y may be referred as a pressing unit 18Y as a whole.

[0089] The pressure spring 19Y, which is disposed between the shaft 37Y and the printing unit 101, is used to press the shaft 37Y of the primary transfer roller 12Y so as to press the primary transfer roller 12Y to the intermediate transfer belt 11. The shaft 37Y may be supported by a supporter disposed in the printing unit 101 so that the shaft 37Y can be moved in a given range by the pressure spring 19Y.

[0090] When the pressing unit 18Y presses the primary transfer roller 12Y toward the intermediate transfer belt 11 using the pressure spring 19Y, the intermediate transfer belt 11 can be contacted against the photoconductor drum 20Y. Accordingly, the pressing unit 18Y presses the intermediate transfer belt 11 against the photoconductor drum 20Y upward in a vertical direction. The pressure spring 19Y can press the intermediate transfer belt 11 to the photoconductor drum 20Y with a given pressure, which may be referred as primary transfer process pressure. FIGs. 3 and 4 show such pressure as a primary transfer process pressure, which are used in the experiment to be described later. The primary transfer process pressure may be referred as "primary transfer pressure," hereinafter.

[0091] The optical writing unit 8 shown in FIG. 1 irradiates a laser beam L, generated based on image information, onto the photoconductor drum 20Y to write an electrostatic latent image on the surface of the photoconductor drum 20Y charged by the charge roller 31Y. The development unit 50Y develops the electrostatic latent image as a yellow toner image.

[0092] The cleaning unit 40Y includes a casing 43Y, a brush roller 45Y, and a cleaning blade 41Y. The casing 43Y includes an opening facing the photoconductor drum 20Y. The brush roller 45Y contacts the photoconductor drum 20Y to remove residuals such as toner, carrier, and paper powders, from the photoconductor drum 20Y. The cleaning blade 41Y contacts the photoconductor drum 20Y at a downstream side of a rotation direction (see B1 in FIG. 2) of the photoconductor drum 20Y relative to the brush roller 45Y to remove the residuals from the photoconductor drum 20Y.

[0093] The brush roller 45Y is rotatably supported in the casing 43Y. The residuals scraped by the brush roller 45Y and the cleaning blade 41Y are transported to a waste toner tank using a screw 42Y or the like.

[0094] The development unit 50Y includes a casing 55Y, a development roller 51Y, and a doctor blade 52Y. The casing 55Y includes an opening facing the photoconductor drum 20Y. The development roller 51Y faces the photoconductor drum 20Y through the opening. The doctor blade 52Y regulates a thickness of developer on the developing roller 51Y at a preferable level for developing process.

[0095] The development unit 50Y further includes a first transport screw 53Y, a second transport screw 54Y, a separation wall 57Y, a first compartment 58Y, and a second compartment 59Y. The first transport screw 53Y and the second transport screw 54Y are disposed at a lower part of the casing 55Y side by side, and rotate in opposite directions each other. With such a configuration, developer can be agitated, transported, and supplied to the development roller 51Y. The first compartment 58Y including the first transport screw 53Y and the second compartment 59Y including the second transport screw 54Y are separated by the separation wall 57Y.

[0096] The development unit 50Y further includes a toner hopper 80Y, and a toner concentration sensor 56Y. The toner hopper 80Y stores yellow toner. The toner concentration sensor 56Y, disposed at the bottom of the second compartment 59Y, detects toner concentration in the developer. The toner concentration sensor 56Y may be attached on the second compartment 59Y using a double-face tape 86Y.

[0097] The development unit 50Y further includes a bias voltage supply unit for supplying a development bias voltage having direct current, a drive unit for driving the development roller 51Y, a transport drive unit for rotating the first transport screw 53Y and the second transport screw 54Y in opposite directions, and a toner supply unit for supplying toner from the toner hopper 80Y to the second compartment 59Y.

[0098] The development roller 51Y includes a magnet roller 81Y, and a development sleeve 82Y. The magnet roller 81Y generates a magnetic field. The development sleeve 82Y, made from non-magnetic material and encasing the magnet roller 81Y, can be rotated in a clockwise direction in FIG. 2 (see C1) by the drive unit.

[0099] The magnet roller 81Y includes a plastic casing fixed to the casing 55Y, and a plurality of magnet blocks embedded in the plastic casing to install a plurality of magnetic poles.

[0100] The development sleeve 82Y is rotatably supported by the casing 55Y and the magnet roller 81Y. The development sleeve 82Y is supplied with a development bias voltage by the bias voltage supply unit. A development gap set between the development sleeve 82Y and the photoconductor drum 20Y may be 0.3 ± 0.05 mm, for example.

[0101] The doctor blade 52Y may be made from a stainless steel (SUS). A doctor gap set between the development sleeve 82Y and doctor blade 52Y may be 0.5 ± 0.04 mm, for example.

[0102] The developer may be a two-component developer including toner and carrier. The carrier may be magnetic carrier, and includes a core material, and a resin layer formed on a surface of the core material. The resin layer includes a conductive layer having conductive particles. The detail of toner will be explained later.

[0103] The toner concentration in the developer can be controlled with a given concentration range, such as about 4 to 11 weight %, by the control unit based on a detection result of the toner concentration sensor 56Y so that toner/carrier

mixture ratio can be maintained at a preferable level, and thus higher quality images can be obtained. Specifically, when the toner concentration sensor 56Y detects that the toner concentration becomes lower than the given concentration range due to a consumption of toner by a developing process, toner is supplied to the second compartment 59Y from the toner hopper 80Y using the toner supply unit.

[0104] The first transport screw 53Y and the second transport screw 54Y extend in an axial direction of the development roller 51Y. The first transport screw 53Y transports the developer in the first compartment 58Y in one direction, and supplies the developer to the development roller 51Y during such transportation. Developer transported to a downstream end of the first compartment 58Y by the first transport screw 53Y is then guided into the second compartment 59Y through an opening of the separation wall 57Y.

[0105] In the second compartment 59Y, the second transport screw 54Y transports the developer in the opposite direction of the first transport screw 53Y. If the toner hopper 80Y supplies fresh toner, the fresh toner is mixed and transported with the developer by the second transport screw 54Y. Developer transported to a downstream end of the second compartment 59Y by the second transport screw 54Y is then guided into the first compartment 58Y through the other opening of the separation wall 57Y.

[0106] As such, the fresh toner can be agitated and transported with developer by the first transport screw 53Y and the second transport screw 54Y, by which the developer can be frictionally electrified and then supplied to the development roller 51Y.

[0107] After the doctor blade 52Y regulates the thickness or amount of the developer on the development roller 51Y, the development roller 51Y transports the developer to a developing area set between the development roller 51Y and the photoconductor drum 20Y. With an effect of the developing bias voltage, yellow toner in the developer can be electrostatically transferred to a latent image formed on the photoconductor drum 20Y, by which a yellow toner image can be developed on the development roller 51Y.

[0108] After such a development process, the developer consumed of yellow toner is returned to the development unit 50Y by a rotation of the development roller 51Y.

[0109] Although the bias voltage supply unit supplies a development bias voltage having direct current, the bias voltage supply unit can supply other development bias voltage, such as a bias voltage of alternative current or a bias voltage having superimposed alternative current to direct current.

[0110] As such, in the development unit 50Y, the developer can be agitated and transported by the first transport screw 53Y and the second transport screw 54Y, and can be attracted and carried on the development sleeve 82Y by magnet force. Then, the developer is transported to the developing area facing the photoconductor drum 20Y, and toner is supplied to the latent image on the photoconductor drum 20Y for developing the toner image. After such a development process, the toner-consumed developer is returned to the first compartment 58Y from the development sleeve 82Y by a rotation of the development roller 51Y, and then agitated and transported again by the first transport screw 53Y and the second transport screw 54Y in the first compartment 58Y and the second compartment 59Y, and again the developer can be attracted and carried on the development sleeve 82Y. Such a developer delivery cycle can be conducted by arranging the magnet blocks in a given order.

[0111] During the developer delivery cycle, toner in the developer may be consumed, by which toner concentration decreases. Such toner concentration decrease can be detected by the toner concentration sensor 56Y. The toner concentration sensor 56Y detects toner concentration by measuring magnetic permeability of the developer, wherein magnetic permeability of the developer can be detected as detection voltage "Vout" output from the toner concentration sensor 56Y. Specifically, the toner concentration sensor 56Y outputs a detection voltage "Vout" as a detected toner concentration signal to the control unit, and toner concentration is determined as "weight %" based on a value of the detection voltage Vout.

[0112] If two-component developer including toner and magnetic carrier is used, the lower the toner concentration TC, the higher the magnetic permeability because carrier ratio becomes higher; and the higher the toner concentration TC, the lower the magnetic permeability because carrier ratio becomes lower. Accordingly, the lower the toner concentration TC, the higher the detection voltage Vout (or the toner concentration TC and the detection voltage Vout is inversely related).

[0113] Accordingly, when the control unit recognizes a lower toner concentration based on the detection voltage Vout from the toner concentration sensor 56Y, the control unit activates the toner supply unit to supply toner to the second compartment 59Y from the toner hopper 80Y until the detection voltage Vout becomes a given level.

[0114] When a copying operation is performed by the image forming apparatus 100, a document is set on the document tray 22a of the ADF 22, or a document is set on the contact glass 21a by pivoting the ADF 22 upward and then closing the ADF 22 after setting the document on the contact glass 21a. Then a start button in the operation panel is pressed for starting a copying operation. When the image forming apparatus 100 is used as a printer the image forming apparatus 100 conducts an image forming process using image data received from an external device, such as a personal computer, which is used to select and input the image data for image forming operation.

[0115] When the document is set on the ADF 22, the document is fed to the contact glass 21a by pressing the start

button, and then the document is scanned by the scanner 21 to generate image data. When the document is set on the contact glass 21a, the document is scanned by pressing the start button to generate image data.

[0116] The scanner 21 includes the first carriage 21b and the second carriage 21c, which can move in a given direction when scanning a document. The light source of the first carriage 21b emits light to the document placed on the contact glass 21a, and then the first reflector reflects the light reflected on the document to the second reflector of the second carriage 21c. Then the light is reflected by the second reflector and guided to the focus lens 21d. The focus lens 21d focuses the light coming from the second carriage 21c onto the image sensor 21e, at which image data of the document is read.

[0117] Based on the generated image data or input image data, the image forming engines 60Y, 60M, 60C, and 60K can be activated.

[0118] In the image forming engine 60Y, the photoconductor drum 20Y rotating in the B1 direction is uniformly charged by the charge roller 31Y, and then irradiated by the laser beam L coming from the optical writing unit 8 to form an electrostatic latent image for yellow. The electrostatic latent image is then developed by the development unit 50Y as a yellow toner image. The yellow toner image is then transferred to the intermediate transfer belt 11 moving in the A1 direction using the primary transfer roller 12Y. After such transfer process, the cleaning unit 40Y removes residual materials, such as toner, remaining on the photoconductor drum 20Y, and the de-charge unit de-charges the photoconductor drum 20Y to prepare the photoconductor drum 20Y for an next image forming process.

[0119] Similarly, toner images are formed on the photoconductor drums 20C, 20M and 20K, and then the toner images are transferred onto the intermediate transfer belt 11 moving in the A1 direction using the primary transfer rollers 12C, 12M, and 12K to form a full color image. The full color image is then transported to a transfer nip set by the intermediate transfer belt 11 and the secondary transfer roller 17, and transferred to a sheet.

[0120] The sheet transported to the transfer nip set by the intermediate transfer belt 11 and the secondary transfer roller 17 may be fed from the sheet cassette 25, the manual sheet tray 34, or the sheet reverse unit 96, for example. The sheet is fed to the transfer nip by the registration roller 13 at a time that the toner images on the intermediate transfer belt 11 comes to the transfer nip facing the secondary transfer roller 17.

[0121] The sheet having the toner images is then transported to the fixing unit 6 by the sheet transport unit 76, at which the toner images are fixed on the sheet by applying heat and pressure to the sheet using the fixing belt 64 and the pressure roller 63, by which a color image is formed on the sheet. After passing the fixing unit 6, by adjusting a position of the switch claw 94, the sheet may be stacked on the ejection tray 75 using the ejection roller 97 or may be sent to the sheet reverse unit 96 by the transport roller 98 for double face printing. After a transfer process at the secondary transfer roller 17, the transfer belt cleaning unit removes residual materials, such as toner, remaining on the intermediate transfer belt 11 to prepare the intermediate transfer belt 11 for an next image forming process.

[0122] A description is now given to toner according to exemplary embodiments, which is used as two-component developer in the image forming apparatus 100. The toner can be manufactured with any methods, and any binder resin and colorant as long as such materials are within conditions set for exemplary embodiments.

[0123] Example of the binder resin include polyester resin, styrene resin, acrylic resin, styrene-acrylic resin, polyol resin, epoxy resin. Specifically, polyester resin is preferably used from a viewpoint of low-temperature fixability.

[0124] A glass-transition temperature "Tg" of the binder resin is preferably from 40 to 75 degrees Celcius, and more preferably from 45 to 65 degrees Celcius. If the glass-transition temperature is too low, thermostable preservability of toner may be degraded, and toner particles may be easily subjected to a blocking phenomenon at a higher temperature, which is not preferable. If the glass-transition temperature is too high, low-temperature fixability of the toner may deteriorate.

[0125] The glass-transition temperature Tg can be measured using a differential scanning calorimeter (DSC). The temperature Tg is measured from a DSC profile obtained by using DSC-60A (product of SHIMADZU CORPORATION) with a condition of temperature rising speed of 10 Degrees Celcius/min.

[0126] Further, conventional colorants such as pigment and dye can be used as a colorant for the toner. Examples of colorant include carbon black, nigrosin dye, naphthol yellow, Hansa yellow, ployazo yellow, oil yellow, pigment yellow, permanent yellow, brilliant carmine, permanent red, oil red, quinacridone red, pyrazolone red, ployazo red, phthalocyanine blue, anthraquinone blue, anthraquinone violet, naphthol green, and phthalocyanine green. These can be used alone or in combination.

[0127] The colorant may be included in toner matrix from 0.5 to 15 weight percent %, and preferably from 3 to 10 weight percent %, for example. The toner matrix is toner composition before adding additives (i.e., additives are not included). The colorant can be prepared as master batch by mixing resin and colorant. The resin used for master batch may be the resin used for the binder resin of toner, but not limited these.

[0128] Further, the toner particles may preferably include a release agent in addition to the binder resin and the colorant. Examples of the release agent include polyolefin wax (e.g., polyethylene wax, polypropylene wax); long-chain hydrocarbon (e.g., paraffin wax, southall wax); and carnauba wax, montan wax. The release agent may be included in toner matrix from 0 to 40 weight percent %, and preferably from 5 to 20 weight percent %.

[0129] Further, toner particles may include a charge control agent to enhance charge amount and charging speed of toner particles, as required. Examples of the charge control agent include nigrosine dye, triphenylmethane dye, chromium containing metal-complex compound dye, chelate molybdate pigment, quaternary ammonium salt, fluorine modified quaternary ammonium salt, salicylic acid metal salt, and metal salt of salicylic acid derivative.

[0130] The adding amount of the charge control agent is determined based on toner manufacturing condition such as types of binder resins, presence or absence of additives, and a dispersion method, or the like. The charge control agent may be included in toner matrix from 0.1 to 10 weight percent %, and preferably from 0.2 to 5 weight percent %. The charge control agent can be dispersed in toner, externally added to toner surface, or fixed on toner surface, for example.

[0131] Further, inorganic fine particles may be preferably used as external additives to facilitate fluidity, developing performance, charged performance of toner particles. Such inorganic fine particles preferably have a primary particle diameter of 5 nm (nanometer) to 2 μm . Such inorganic fine particles are preferably added to the toner particles with 0.01 wt%, to 5 wt%. Examples of the inorganic fine particles include silica, alumina, titanium oxide, barium titanate, magnesium titanate, calcium titanate, strontium titanate, zinc oxide, tin oxide, silica sand, clay, mica isinglass, sand-lime, diatomite, chrome oxide, cerium oxide, colcothar, antimony trioxide, magnesium oxide, zirconium oxide, barium sulfate, barium carbonate, calcium carbonate, silicon carbide, and silicon nitride. These can be used alone or in combination.

[0132] A description is now given to a binder resin used for toner having lower temperature fixability, in which polyester-based toner may be prepared. The toner used in the image forming apparatus 100 preferably includes polyester resin, prepared by an ester elongation polymerization method and having good level of low-temperature fixability, as the binder resin.

[0133] With growing demands on material saving and power saving, energy used for a fixing process is required to be decreased. For example, to decrease energy used for a fixing process, toner made from resin powders has been prepared by setting a lower softening point. Such toner can be prepared using a soft resin, for example polyester resin, as a binder resin of toner.

[0134] The ester elongation polymerization method is conducted as follows to prepare toner particles: An organic solvent containing polyester prepolymer is dispersed with compound having active hydrogen in an aqueous solvent; in the aqueous solvent, elongation reaction and/or cross-linking reaction is progressed; then remove the organic solvent; and wash and dry to obtain the resultant product as toner particles. Such method can easily control particle diameter, particle size distribution, and shape of toner. Hereinafter, the method and used materials are described.

[0135] The polyester prepolymer is reacted with compound having active hydrogen in the aqueous solvent (i.e., elongation reaction and/or cross-linking reaction) to form molecules having a larger molecular weight as binding resin of toner. The polyester prepolymer may have functional groups, such as for example isocyanate group, which can react with active hydrogen.

[0136] The polyester prepolymer having isocyanate group is preferably used as polyester prepolymer. Such polyester prepolymer can be prepared by reacting polyester having active hydrogen group and polyisocyanate (PIC), wherein the polyester is a polycondensation product of polyol (PO) and polycarboxylic acid (PC).

[0137] The polycondensation product having active hydrogen group, made from polyol (PO) and polycarboxylic acid (PC) may be prepared using bisphenol-A alkyleneoxide adduct and polycarboxylic acid, for example. Examples of the polycarboxylic acid include dicarboxylic acid (e.g., succinic acid, adipic acid, maleic acid, fumaric acid, phthalic acid, terephthalic acid), and trivalent or more polycarboxylic acid having trivalent or more (e.g., trimellitic acid, pyromellitic acid).

[0138] Examples of the polyisocyanate (PIC) include aliphatic polyisocyanate (e.g., tetramethylene diisocyanate, hexamethylene diisocyanate, 2,6-diisocyanate methyl caproate); alicyclic polyisocyanate (e.g., isophorone diisocyanate, cyclohexylmethane diisocyanate); aromatic diisocyanate (e.g., tolylene diisocyanate, diphenylmethane diisocyanate); aromatic aliphatic diisocyanate (e.g., $\alpha,\alpha,\alpha',\alpha'$ -tetramethylxylylene diisocyanate); isocyanates; and compounds formed by blocking the polyisocyanate with phenol derivative, oxime, or caprolactam. These can be used alone or in combination.

[0139] The number of isocyanate group contained in one molecule of the polyester prepolymer having isocyanate group is at least 1, preferably at an average of 1.5 to 3, and more preferably at an average of 1.8 to 2.5. If the number of isocyanate group per molecule is less than 1, the molecular weight of polyester after the elongation reaction becomes lower, by which hot offset resistance may be degraded. The polyester prepolymer is used by dissolving in organic solvent phase as above described. The polyester prepolymer may be included in toner matrix from 10 to 55 weight percent %, preferably 10 to 40 weight percent %, and more preferably from 15 to 30 weight percent %.

[0140] Further, non-reactive polyester can be used with the polyester prepolymer by dissolving in organic solvent phase. By adding the non-reactive polyester, low-temperature fixability of toner and glossiness of color image can be enhanced compared to using the polyester prepolymer alone.

[0141] The non-reactive polyester may be a polycondensation product of the polyol and the polycarboxylic acid as similar to the above described polyester prepolymer, to be reacted with the polyisocyanate (PIC), and the non-reactive polyester may be made from the above-mentioned polyol and polycarboxylic acid.

[0142] When the polyester prepolymer is mixed with the non-reactive polyester, a weight ratio of the polyester prepolymer and the non-reactive polyester is from 10/90 to 55/45, preferably from 10/90 to 40/60, more preferably from

15/85 to 30/70. If the weight ratio of polyester prepolymer is too small, hot offset resistance may be degraded, and a compatibility of thermostable preservability of the toner and low-temperature fixability of the toner may deteriorate.

[0143] Further, resin other than the non-reactive polyester can be used. For example, known toner binder resin, such as styrene resin, acrylic resin, epoxy resin, copolymer of styrene acrylic ester can be added.

[0144] Examples of compound having active hydrogen may be preferably amines. The amines react with the isocyanate group of the polyester prepolymer to obtain urea-modified polyester resin.

[0145] Examples of amines include diamine, trivalent or more polyamine, amino alcohol, amino mercaptan, amino acid, and these amine compound having blocked amino group. The compound having blocked amino group may be ketimine compound, in which amino group of amine compound is blocked by ketone: such amine compound may be 4,4'-diaminodiphenylmethane, isophorone diamine, hexamethylene diamine, ethanolamine, amino ethyl mercaptan, amino propionic acid; and ketone may be methyl ethyl ketone.

[0146] The colorant or colorant master batch may be preferably solved or dispersed in the organic solvent phase with the polyester prepolymer and the non-reactive polyester in advance. Further, the release agent and charge control agent may be also solved or dispersed in the organic solvent phase, as required.

[0147] The aqueous solvent may be composed water alone, but the aqueous solvent may be composed water and organic solvent. Specifically, such organic solvent added in aqueous solvent may preferably solve the resin composition in the organic solvent phase so that the viscosity of resin composition contained in the organic solvent can be decreased when the resin composition is dispersed in the aqueous solvent. Such organic solvent may be preferably volatile at less than 100 Degrees Celcius so that the organic solvent can be removed easily.

[0148] Examples of the organic solvent in the aqueous solvent include toluene, xylene, benzene, tetrachloride carbon, dichloromethane, 1,2-dichloroethane, 1,1,2-trichloroethane, trichloroethylene, chloroform, monochlorobenzene, dichloroethylidene, methyl acetate, acetic ether, methyl ethyl ketone, and methyl isobutyl ketone. These can be used alone or in combination.

[0149] Further, fine resin particles may be preferably dispersed in the aqueous solvent during a toner manufacturing process. Such fine resin particles may be used to control toner shape factors, such as for example sphericity, particle size distribution, and may be locally added on surfaces of the toner particles to be formed. Examples of the fine resin particles include vinyl resin, polyurethane resin, epoxy resin, polyester resin, polyamide resin, polyimide resin, silicone resin, phenol resin, melamine resin, urea resin, aniline resin, ionomer resin, and polycarbonate resin. These can be used alone or in combination. Among these, vinyl resin, polyurethane resin, epoxy resin, polyester resin or combination of these are preferably used to obtain spherical fine particles in an aqueous dispersion.

[0150] Examples of the vinyl resin include homopolymer or copolymer of vinyl monomers, and may be copolymer of styrene (meth)acrylic acid ester, copolymer of styrene/butadiene, copolymer of (meth)acrylic acid-acrylic acid ester, copolymer of styrene/acrylonitrile, copolymer of styrenemaleic anhydride, and copolymer of styrene (meth)acrylic acid.

[0151] The amount of such fine resin particles in the aqueous solvent is preferably from 0.5 to 10 weight %, and more preferably from 1 to 3 weight % with respect to the organic solvent phase. If the amount of fine resin particles is not within such range, emulsification may be failed, by which toner particles may not be formed. The fine resin particles may have an average particle diameter from 5 nm to 200 nm, and more preferably from 20 nm to 300 nm from a viewpoint of toner particles formation.

[0152] Further, a glass-transition temperature "Tg" of the fine resin particles is preferably from 40 to 90 degrees Celcius, and more preferably from 50 to 70 degrees Celcius from a viewpoint of low-temperature fixability and thermostable preservability of the toner.

[0153] A description is now given to measurement methods for toner particle diameter and toner sphericity.

[0154] The weight average particle diameter (D4), number average particle diameter (D1), and particle diameter distribution of a toner can be measured using an instrument COULTER COUNTER TA-II or COULETR MULTISIZER II from Coulter Electronics Inc. The typical measuring method is as follows:

(1) 0.1 to 5 ml of a surfactant (preferably alkylbenzene sulfonate) is included as a dispersant in 100 to 150 ml of an electrolyte (i.e., 1% NaCl aqueous solution including a first grade sodium chloride such as ISOTON-II from Coulter Electronics Inc.);

(2) 2 to 20 mg of toner is added to the electrolyte and dispersed using an ultrasonic dispersing machine for about 1 to 3 minutes to prepare a toner suspension liquid;

(3) the volume and the number of toner particles are measured by the above instrument using an aperture of 100 μm to determine volume and number distribution thereof; and

(4) the weight average particle diameter (D4) and the number average particle diameter (D1) are determined by counting 50,000 times.

[0155] The channels include 13 channels as follows: from 2.00 to less than 2.52 μm ; from 2.52 to less than 3.17 μm ; from 3.17 to less than 4.00 μm ; from 4.00 to less than 5.04 μm ; from 5.04 to less than 6.35 μm ; from 6.35 to less than

8.00 μm ; from 8.00 to less than 10.08 μm ; from 10.08 to less than 12.70 μm ; from 12.70 to less than 16.00 μm ; from 16.00 to less than 20.20 μm ; from 20.20 to less than 25.40 μm ; from 25.40 to less than 32.00 μm ; and from 32.00 to less than 40.30 μm . Namely, particles having a particle diameter of from not less than 2.00 μm to less than 40.30 μm can be measured.

[0156] A description is given to a method of measuring average sphericity of toner particles. The degree of sphericity SR of particles can be measured by using a flow-type particle image analyzing apparatus FPIA-2000 produced by Toa Medical Electronics Co., Ltd, and an analysis program (FPIA-2100 Data Processing Program for FPIA version 01-10) is used for analysis. Such measuring may be conducted as below.

[0157] First, 0.1-0.5 ml of 10 wt % surfactant, preferably alkyl benzene sulfonate (neogen SC-A, product of Daiichi Kogyo Seiyaku Co., Ltd.), used as a dispersing agent is placed in a 100 ml glass container, and about 0.1-0.5 g of measurement sample (i.e., toner) is further added thereto and mixed using a micro spatula. Then 80 ml of ion-exchange water is added. Then, an ultrasonic wave is applied to a suspension having a sample dispersed therein for 3 minute using an ultrasonic dispersing machine (product of Honda Electronics Co., Ltd.) to set a suspension dispersion density as 5,000-15,000 particles/ μl , and the shape of a toner particles and distribution of the degree of sphericity of toner particles are measured by using the above-mentioned flow-type particle image measuring apparatus FPIA-2100. The suspension dispersion density may be set to 5,000-15,000 particles/ μl so that the average sphericity of toner can be measured reliably.

[0158] Such suspension dispersion density can be determined based on the condition of dispersion liquid, which means the amount of surfactant and toner needs to be changed as required. The amount of surfactant may be adjusted depending on hydrophobicity of toner. If the amount of surfactant is too large, noise due to bubble may be counted, and if the amount of surfactant is too small, toner may not be wetted effectively, by which toner may not be dispersed effectively. The amount of toner may be changed based on particle diameter of toner. If the toner has small diameter particle, the amount of toner may be set small, and if the toner has large particle diameter, the amount of toner may be set large. If the toner has a particle diameter of 3 μm to 7 μm , 0.1 to 0.5 gram of toner may be added to set the suspension dispersion density from 5,000-15,000 particles/ μl .

[0159] As above mentioned, when relatively softer resin, such as for example polyester resin, is used as the binder resin of toner, additives may easily sink into toner particle. Such sinking phenomenon of additives may affect transfer performance of toner. In view of sinking phenomenon of additives, an index indicating sinking degree of additives into toner is devised as "sunken rate of additives." The sunken rate of additives is described hereinafter.

[0160] The sunken rate of additives indicates sunken degree of additives, added on toner surface and later sunk in toner particle, which is sunk due to agitation stress in a development unit over time.

[0161] The lower the physical strength of toner surface, the higher the sinking of additives in toner, by which the sunken rate of additives becomes larger. On one hand, the higher the physical strength of toner surface, the lower the sinking of additives in toner, by which the sunken rate of additives becomes smaller.

[0162] The sunken rate of additives X(%) can be defined as below:

$$\text{sunken rate of additives X(\%)} = [(A-B)/A] \times 100$$

in which A (m^2/g) is a BET specific surface of toner before sinking additives in toner, and B(m^2/g) is a BET specific surface of toner after a process of sinking additives in toner.

[0163] If the sunken rate of additives X(%) is set higher (e.g., 40% or more), such toner may be a softer toner having a lower melting point, by which toner can be fixed at a lower temperature, and the fixability of toner and energy saving can be compatibility balanced. However, if the sunken rate of additives X(%) is set too high, additives may sink in toner in greater degree, by which transferability of toner may be decreased and unintended uneven image may occur.

[0164] In general, the greater the sunken rate X(%), the better the fixability and the lower the transferability; and the smaller the sunken rate X(%), the better the transferability and the lower the fixability. Therefore, the sunken rate of additives X(%) needs to be set to a value which can compatibility balance the fixability and transferability of the toner image. The fixability and transferability of the toner image can be balanced by setting the sunken rate of additives X(%) at a given value and by setting the primary transfer pressure at a given value, which will be described later.

[0165] The sinking process of additives can be conducted as below.

1) toner of 10g and resin-coated ferrite carrier of 100g are put in a 300-500 ml polyethylene bottle, and mixed for 30 minutes using a mixer rotating at 100 rpm (revolution per minute). The resin-coated ferrite carrier may be available as silicone-resin coated ferrite carrier EF 963-60B (particle diameter 35 to 85 μm , product of POWDER TECH Co., Ltd.). The mixer may be a TURBULA® mixer T2F (a product of Willy A. Bachofen).

- 2) After mixing 30 minutes, 300 ml of water is added in the bottle, and agitated with an agitation bar slightly to separate toner from carrier in the water, and obtain supernatant of toner dispersion liquid.
- 3) The toner dispersion liquid is filtered to obtain toner, and the toner is dried under a reduced pressure and ambient temperature to obtain toner after a process sinking additives.

[0166] The BET specific surface of toner before additives sinking process and after additives sinking process is measured using automatic specific surface/pore distribution analyzer TriStar 3000 (product of SHIMADZU CORPORATION). Specifically, 1g of toner is placed in a measurement cell. A deaeration process is conducted to the measurement cell using a deaeration unit of Vacu-prep 061 (product of SHIMADZU CORPORATION) devised for the TriStar. The deaeration process is conducted under ambient temperature and reduced pressure of 100 mtorr for 20 hours. After the deaeration process, BET specific surface for sample in the measurement cell is measured automatically using TriStar 3000. The deaeration process uses nitrogen gas as absorption gas.

[0167] A description is given to a method of preparing toner having a given sunken rate of additives. The toner according to exemplary embodiments may have a sunken rate of additives of 42%, for examples. Such toner can be prepared as below.

[0168] First, 950 part of water, 20 part of water-dispersed vinyl resin (copolymer of sodium salt of sulfuric ester of styrene-methacrylic acid-butyl acrylate-methacrylic acid ethylene oxide adduct, product of Sanyo Chemical Industries, Ltd.), 16 part of 48.5% water solution of sodium dodecyl diphenyl ether disulfonate (Elemiol MON-7, product of Sanyo Chemical Industries, Ltd.), 12 part of 3.0% water solution of ploymer protective colloid carboxymethyl cellulose (cerogen BSH, product of Sanyo Chemical Industries, Ltd.), and 130 part of acetic ether were mixed and agitated to obtain an opaque white solution. This is called as water phase.

[0169] Then, 1200 part of water, 50 part of carbon black (REGAL® 400R, product of Cabot Corporation), 50 part of polyester resin (RS801, product of Sanyo Chemical Industries, Ltd.), and 30 part of water were mixed using a Henschel Mixer (product of MITSUI MINING COMPANY, LIMITED), and kneaded under 150 degrees Celcius for 30 minutes using two rolls. Then, the mixture was extended by applying pressure under a cooling condition, and pulverized by a pulverizer to obtain master batch of carbon black.

[0170] In a vessel set with an agitation bar and a temperature gauge, 500 part of polyester resin (RS801, product of Sanyo Chemical Industries, Ltd., weight-average molecular weight: 19,000, Tg: 64 degrees Celcius), 30 part of carnauba wax, and 850 part of acetic ether were put, and the mixture were agitated while increasing the temperature to 80 Degrees Celcius, and the mixture were set aside under 80 degrees Celcius for 5 hours. Then, the mixture was cooled to 30 Degrees Celcius for 1 hour. Then, by using a bead mill (ULTRA VISCO MILL, product of AIMEX CO., Ltd.), wax was dispersed under a condition of a liquid transfer rate of 1.2 kg/hr, a disk peripheral velocity of 8 m/sec, a loading of 0.5 mm zirconia beads of 80% by volume, and a pass number of 3. Then, 110 part of the master batch of carbon black and 500 of acetic ether were added in the vessel, and mixed for 1 hour to obtain a solution. Then, 240 part of acetic ether was added and by using a bead mill (ULTRA VISCO MILL, product of AIMEX CO., Ltd.), solution was dispersed under a condition of a liquid transfer rate of 1.2 kg/hr, a disk peripheral velocity of 8 m/sec, a loading of 0.5 mm zirconia beads of 80% by volume, and a pass number of 3 to obtain dispersion liquid. This is called as oil phase.

[0171] Then, 1780 part of the oil phase, 100 part of 50% polyester prepolymer acetic ether solution (product of Sanyo Chemical Industries, Ltd., number average molecular weight: 3800, weight-average molecular weight: 15000, Tg: 60 Degrees Celcius), 15 part of isobutyl alcohol, and 7.5 part of the isophorone diamine were put in a vessel and mixed for 1 minute under 6,000 rpm using a TK homomixer (product of Tokushu Kika Kogyo Co., Ltd.). Then, 1200 part of the water phase was added and mixed for 20 minutes under 7,500 rpm using the TK homomixer to obtain an aqueous solvent dispersion liquid.

[0172] Then, in a vessel set with an agitation bar and a temperature gauge, the aqueous solvent dispersion liquid was put and the solvent was removed under 30 degrees Celcius for 12 hours. Then, the liquid was heated to 45 degrees Celcius for 8 hours, by which a dispersion liquid removing organic solvent was obtained.

[0173] After filtering the dispersion liquid of 100 part under a reduced pressure, a resultant cake was added with 500 part of ion-exchange water, and mixed for 10 minutes using the TK homomixer (rotating at 12,000 rpm), and filtered again under a reduced pressure. The resultant cake was dried at 45 degrees Celcius for 48 hours using a circulating wind drier. The dried cake was filtered using a 75- μ m mesh to obtain toner matrix to be used for toner particles.

[0174] Then, the toner matrix of 100 weight part were mixed with external additives using Henschel Mixer: The used external additives were 1.2 weight part of hydrophobicity silica (product of Clariant(Japan)K.K.) having an average primary particle diameter of 12 nm, 0.5 weight part of hydrophobicity titanium oxide (product of Tayca Corporation) having an average primary particle diameter of 12 nm, and 0.8 weight part of hydrophobicity silica (Shin-Etsu Chemical Co., Ltd.) having an average primary particle diameter of 120 nm. Then, the mixture was filtered using a 38- μ m mesh to obtain toner particles.

[0175] The obtained toner had a weight-average particle diameter (D4) of 5.8 μ m, a number-average particle diameter (Dn) of 5.1 μ m, an average sphericity of 0.97, and a sunken rate of additives of 42%. The weight-average particle

diameter (D4) and the number-average particle diameter (Dn) were measured using the above-described procedure.

[0176] The sunken rate of additives can be adjusted by changing molecular weight of resin. For example, if polyester resin (RS801, product of Sanyo Chemical Industries, Ltd., weight-average molecular weight: 19000, Tg: 64 degrees Celcius) is changed to polyester resin (product of Sanyo Chemical Industries, Ltd., weight-average molecular weight: 12000, Tg: 56 degrees Celcius), toner having a weight average particle diameter (D4) of 5.7 μm , a number-average particle diameter (Dn) of 5.1 μm , an average sphericity of 0.98, and a sunken rate of additives of 56% was obtained. Further, when styrene-acrylic resin was used, toner having a sunken rate of additives of 30% was obtained.

[0177] As described as above, a demand for producing high quality image over a long period of time is growing even if an image forming apparatus uses a soft resin, to which external additives can sink easily.

[0178] Further, when transferring a toner image from the image bearing member to the intermediate transfer medium, or from the intermediate transfer medium to the sheet, the toner image should be transferred to a transfer member in a manner that the image is correctly and stably transferred at a primary transfer process. Such correct and stable transfer at the primary transfer process can be conducted by adjusting the primary transfer pressure, which is used to press the intermediate transfer medium to the image bearing member. However, the inventor found that the primary transfer pressure cause some effect to a secondary transfer performance.

[0179] In view of such pressure effect, an effect of primary transfer pressure to the secondary transfer performance in the image forming apparatus 100, using two-component developer having softer toner, needs to be considered for producing a good level of image. A description is now given to experiments conducted for obtaining favorable condition for image forming.

[0180] The primary transfer pressure can be adjusted by changing pressure of the pressure spring 19 (19Y, 19M, 19C, and 19K), which presses the intermediate transfer belt 11 to the photoconductor drum 20 (20Y, 20M, 20C, and 20K). As such, the pressure spring 19 is used as a pressing member or device.

[0181] In exemplary embodiments, the primary transfer pressure is a pressure that the primary transfer rollers 12Y, 12M, 12C, and 12K press the intermediate transfer belt 11.

[0182] Because the primary transfer rollers 12Y, 12M, 12C, and 12K contact the intermediate transfer belt 11 from a lower to an upper direction in a vertical direction, the primary transfer pressure can be computed by subtracting self-weight of the primary transfer rollers 12 (12Y, 12M, 12C, and 12K) from the pressure value of the pressure spring 19 (19Y, 19M, 19C, and 19K), for example.

[0183] Further, the primary transfer roller 12 including an elastic layer has an Asker C hardness of 50 degrees or less, by which the primary transfer roller 12 can be deformed easily when the primary transfer pressure is applied, and thereby the primary transfer roller 12 can contact the intermediate transfer belt 11 with a greater contact area.

[0184] Accordingly, even if imbalance of primary transfer pressure of the primary transfer roller 12 (12Y, 12M, 12C, and 12K) may occur along an axial direction of the primary transfer roller 12 due to some reasons (e.g., variation of tolerance value during assembly), and even if the primary transfer pressure may deviate from an intended pressure for some amount, the primary transfer roller 12 having such hardness can mitigate such effect of pressure variation or deviation. Accordingly, the secondary transfer performance can be conducted at a good level for producing images. Further, under such configuration, the primary transfer pressure can be set to a lower value.

[0185] FIGs. 3 to 5 show experiment results for image forming when the primary transfer pressure is changed. "Examples" in FIGs. 3 to 5 include favorable conditions for image forming. "Comparative Examples" in FIGs. 3 to 5 include not-favorable conditions for image forming. "Example" is abbreviated as "Ex." and "Comparative Example" is abbreviated as "Comp. Ex." in FIGs. 3 to 5.

[0186] In FIGs. 3 and 4, "void" means an image failure that some image in line edge of a formed image or some image in the center of letter image becomes void. In FIGs. 3 and 4, "unintended uneven image" means an image failure that a formed image has some uneven image due to a lower transfer performance, which may occur at some local portion on a transfer member (e.g., transfer belt, sheet). For example, "unintended uneven image" may occur as below: A sheet (e.g., paper) has irregularity (e.g., concavity and convexity) on its surface. If additives sink in toner, such toner may firmly adhere on a transfer member (e.g., intermediate transfer belt), by which toner images may be hard to transfer from the transfer member to a concavity portion of the surface of the sheet even if a given bias voltage is applied at a transfer nip. As a result, "unintended uneven image" may be formed on the sheet.

[0187] In FIGs. 3 and 4, Examples and Comparative Examples were evaluated in ranks 1 to 5, in which rank 1 is the worst and the rank 5 is the best. The rank 4 and rank 5 were evaluated as acceptable.

[0188] FIG. 3 shows evaluation results of "unintended uneven image" and "void" of image when the primary transfer pressure is changed. In "void" section in FIG. 3, "1C" means a case when single color image is formed (e.g., any one of Y, M, C, and K is formed), and "2C" means a case when two color images are superimposed (e.g., any two of Y, M, C, and K are superimposed).

[0189] In FIG. 3, Comparative Examples 1 to 3 use conditions that each of the color Y, M, C, K is formed under a same primary transfer pressure. The primary transfer pressure for Comparative Example 2 was set smaller than that of Comparative Example 1, and the primary transfer pressure for Comparative Example 3 was set smaller than that of

Comparative Example 2.

[0190] Although Comparative Example 1 had no problem on "void", "unintended uneven image" for magenta and cyan image was not in an allowable rank. This could be explained as below: If a greater primary transfer pressure is applied to softer toner, such toner is more likely to deform greater, by which a contact area of the toner on the intermediate transfer belt 11 becomes greater, and thereby toner may adhere on the intermediate transfer belt 11 firmly. Accordingly, "unintended uneven image" or "void" may be more likely to occur during a secondary transfer process.

[0191] In Comparative Examples 2 and 3, "unintended uneven image" rank was improved compared to Comparative Example 1, but "void" rank for 2C became a not-allowable rank. This could be explained as below: If a smaller primary transfer pressure is applied to softer toner, such toner is not likely to deform greater, by which a contact area of the toner on the intermediate transfer belt 11 becomes smaller, and thereby toner may adhere on the intermediate transfer belt 11 less firmly. Accordingly, a secondary transfer performance can be enhanced, by which "unintended uneven image" rank may be improved. However, when two color toner images are superimposed, such primary transfer pressure may not be enough for an effective transfer process, by which "void" may occur during a secondary transfer process.

[0192] Compared to Comparative Examples 1 to 3, Examples 1 and 2 used conditions that the primary transfer pressure for black(K) was set smaller than other colors Y/M/C, in which black image was transferred after all other Y/M/C color images were transferred. Examples 1 and 2 show that "unintended uneven image" rank and "void" rank were in allowable ranks.

[0193] This could be explained as below: If a smaller primary transfer pressure is applied to softer toner, such toner is not likely to deform greater, by which a contact area of the toner on the intermediate transfer belt 11 becomes smaller, and thereby toner may adhere on the intermediate transfer belt 11 less firmly. Accordingly, a secondary transfer performance can be enhanced, by which "unintended uneven image rank" is improved. Further, the results of Examples 1 and 2 show that if the primary transfer pressure for black alone is set lower than other colors, "void" may not occur even when two color toner images are superimposed.

[0194] Typically, a black image may be formed on a different position relative to positions of other color images on the intermediate transfer belt 11 or a sheet. Accordingly, when a black image and other color image(s) are formed on a same transfer member, two images (i.e., black and other color) may not overlap each other so much. Therefore, "void" may not occur even when two color toner images are superimposed.

[0195] In case of unintended uneven image, Comparative Example 2 had a slightly better results compared to Example 1, and Comparative Example 3 had a slightly better results compared to Example 2. As shown in FIG. 3, the primary transfer pressure was set smaller for all colors for Comparative Examples 2 and 3, and the primary transfer pressure was set smaller only for black in Examples 1 and 2. Accordingly, Comparative Example 2 and Example 1, and Comparative Example 3 and Example 2 can be compared in terms of whether a smaller primary transfer pressure is set for all colors or a smaller primary transfer pressure is set only for black.

[0196] The toner used for the experiment had a sunken rate of additives of 42%, and the intermediate transfer belt 11 used for the experiment was made from polyimide resin, and had a volume resistivity of $1 \times 10^9 \Omega \cdot \text{cm}$ and a surface resistivity of $1 \times 10^{11} \Omega/\square$.

[0197] FIG. 4 shows another evaluation results for "unintended uneven image" and "void" as similar to FIG. 3. Different from the experiment of FIG. 3, the sunken rate of additives of toner was changed for Examples and Comparative Examples, and toner fixability at low temperature/low humidity was also evaluated as shown in FIG. 4. The circle "O" indicates fixability was in an allowable level, and the cross "X" indicates fixability was not in an allowable level. Comparative Examples 4 to 9 used the primary transfer pressure of $100\text{g}/\text{cm}^2$ as similar to Comparative Example 1.

[0198] In Comparative Examples 4 to 6, the toner having the, sunken rate of additives of less than 40% was used. In Comparative Examples 4 to 6, "void" rank had a similar result as Comparative Example 1, which may be assumed acceptable for practical usage, but the toner fixability at the low temperature/low humidity (e.g., 10 degrees Celcius/15% humidity) was not in the allowable level.

[0199] In Comparative Examples 7 to 9, the toner having the sunken rate of additives of 40% or more was used. In Comparative Examples 7 to 9, "void" rank was in allowable rank, and toner fixability at the low temperature/low humidity (e.g., 10 degrees Celcius/15% humidity) was in the allowable level. However, compared to Comparative Examples 4 to 6, "unintended uneven image" rank became lower and in the not-allowable rank.

[0200] In Examples 3 to 5, the toner having the sunken rate of additives of 40% or more were used and the primary transfer pressure for black was set smaller than other colors. In Examples 3 to 5, "unintended uneven image" rank and "void" rank were in the allowable rank, and toner fixability at the low temperature/low humidity (e.g., 10 degrees Celcius/15% humidity) was also in an allowable level.

[0201] By using polyester resin as toner biding resin, toner having a lower physical strength, greater sunken rate of additives, and higher fixability at low temperature can be prepared easily.

[0202] The intermediate transfer belt 11 used for the experiment was made from polyimide resin, and had a volume resistivity of $1 \times 10^9 \Omega \cdot \text{cm}$ and a surface resistivity of $1 \times 10^{11} \Omega/\square$.

[0203] FIG. 5 shows results of "unintended uneven image" for an image composed of superimposing two colors

selected from Y, M, and C, in which the order of image forming of different colors (Y, M, C, K) is changed. In FIG. 5, "O" indicates that the level of "unintended uneven image" is allowable, and "X" indicates that the level of "unintended uneven image" is not allowable. Images composed of two colors of Y, M, and C were evaluated. Specifically, solid red image (=yellow+magenta), solid green image (=yellow+ cyan), and solid blue image (=magenta+cyan) formed by changing the order of image forming of different colors (Y, M, C, K) were evaluated for "unintended uneven image." For example, when the order of image forming of different colors (Y, M, C, K) is "YMCK", an image forming process is conducted in an order of "yellow (first), magenta (second), cyan (third), and black (last)" on the intermediate transfer belt 11 in its moving direction (A1 in FIG. 1) for a primary transfer process.

[0204] FIG. 5 shows that when the order of image forming of different colors (Y, M, C, K) is yellow, magenta, cyan, and black, red/green/blue images composed of two colors of Y, M, and C had allowable level for "unintended uneven image." This could be explained as below.

[0205] When the order of image forming of different colors (Y, M, C, K) is yellow, magenta, cyan, and black, red/green/blue images can be formed as below.

[0206] Red image is formed by forming yellow image at first then magenta image (Red image: yellow is formed first and then magenta is superimposed). Accordingly even if yellow is not formed effectively in some portion, magenta may suppress the effect of not-formed yellow.

[0207] Green image is formed by forming yellow image at first then cyan image (Green image: yellow is formed first and then cyan is superimposed). Accordingly even if yellow is not formed effectively in some portion, cyan may suppress the effect of not-formed yellow.

[0208] Blue image is formed by forming magenta image at first then cyan image (Blue image: magenta is formed first and then cyan is superimposed). Accordingly, even if magenta is not formed effectively in some portion, cyan may suppress the effect of not-formed magenta.

[0209] With such configuration, unintended uneven image may not be so visible, and thereby unintended uneven image may be within an allowable level.

[0210] When the order of image forming of different colors (Y, M, C, K) is set in other patterns, "unintended uneven image" may become visible, and thereby the level of "unintended uneven image" may not be within an allowable level. For example, when a blue image formed in the order of cyan image (at first) and then magenta image (at second), following phenomenon may occur; If cyan is not formed effectively, the formed blue image may not have an acceptable image quality because the later formed magenta may not suppress the effect of not-formed cyan (i.e., magenta is so visible).

[0211] As such, the image forming process may be preferably conducted by considering difference between colors of Y, M, C, and K. Specifically, the image forming process using a plurality of color images may be preferably conducted in the order of colors from light to dark (or lightest to darkest). Such image forming process conducted from light color to dark color may have other preferable aspects for producing higher quality images.

[0212] In general, disturbance on images caused by a transfer bias voltage may more likely occur for color images at an upstream side of the moving direction of the intermediate transfer belt 11. If the image forming process is conducted in the order from light color to dark color, such disturbance may not be so visible; Further, even if color toner at the upstream side of the moving direction of the intermediate transfer belt 11 may adhere on other image bearing member (s) disposed at the downstream side of the moving direction of the intermediate transfer belt 11, such adhered color toner may not be so visible on the other image bearing member(s). Accordingly, image failure may not become so visible, and thereby an image having higher quality can be preferably formed.

[0213] The toner used for the experiment shown in FIG. 5 had a sunken rate of additives of 42%, and the intermediate transfer belt 11 used for the experiment was made from polyimide resin, and had a volume resistivity of $1 \times 10^9 \Omega \cdot \text{cm}$ and a surface resistivity of $1 \times 10^{11} \Omega/\square$.

[0214] FIG. 6 shows a graph indicating a relationship of BET specific surface of toner matrix and rank of "unintended uneven image" for magenta image using toner of Example 3 in FIG. 4 without changing conditions of sunken rate of additives, toner resin, primary transfer pressure while changing the BET specific surface of toner matrix. As shown in FIG. 6, the unintended uneven image may be affected by BET specific surface of toner matrix.

[0215] Specifically, although the "unintended uneven image" for Example 3 (see FIG. 4) was in the allowable rank by adjusting the primary transfer pressure, the unintended uneven image may become lower than the rank 4 (allowable rank) if the BET specific surface of toner matrix becomes greater than $3 \text{ m}^2/\text{g}$ as shown in FIG. 6.

[0216] If the BET specific surface of toner matrix becomes greater than $3 \text{ m}^2/\text{g}$, a coating ratio of additives on toner particles when the additives are formed on the toner particles may become smaller. When toner-to-toner contact or toner-to-transfer member (e.g., intermediate transfer belt 11) contact occurs under such lower coating ratio of additives, adherence of toner-to-toner particle or adherence of toner-to-transfer member becomes weaker because additives may not exist on toner particles so much. Therefore, a transfer performance may not become a sufficient level.

[0217] Accordingly, by using toner having the sunken rate of additives of 40% or more, by setting the primary transfer pressure for black smaller than other colors, and by setting the BET specific surface of toner matrix to $3 \text{ m}^2/\text{g}$ or less,

unintended uneven image can be prevented more effectively.

[0218] The index for toner shape may include toner sphericity, toner shape factors (e.g., SF-1, SF-2). However, such indexes are two-dimensional index, which is computed by projecting toner on a two-dimensional plane, and thereby such indexes may indicate two-dimensional concavity and convexity. In contrast, the BET specific surface indicates a surface area of toner, by which three-dimensional concavity and convexity may be indicated. Accordingly, the BET specific surface can be correlated with the coating ratio of additives reliably. Further, the coating ratio of additives can be correlated with a transfer performance reliably, which influence unintended uneven image. Accordingly, the BET specific surface can be correlated with the level of unintended uneven image and transfer performance. As such, the BET specific surface is preferably used as an index of toner shape compared to conventional indexes such as sphericity, SF-1, and SF-2.

[0219] With the above described experiment results, a good level of image forming can be conducted by using toner having the sunken rate of additives of 40% or more, and by setting the primary transfer pressure for black smaller than other colors.

[0220] Further, the toner matrix may be preferably set to have the BET specific surface of 3 m²/g or less to prevent unintended uneven image effectively.

[0221] Further, as above described, the black toner may be a darkest color among Y/M/C/K colors, by which if the black toner adheres on the photoconductor drums 20Y, 20M, and 20C, the black toner may affect other color images significantly. In view of such effect, a black toner image is preferably transferred on the intermediate transfer belt 11 after other color toner images are transferred.

[0222] Further, because the primary transfer pressure for the black toner image is set smaller than other color toner images, the rank of "unintended uneven image" and "void" can be improved.

[0223] Further, a yellow toner image may be preferably transferred on the intermediate transfer belt 11 as the first toner image, by which unintended uneven image can be improved because yellow is a lightest color among Y/M/C/K colors.

[0224] Further, a magenta toner image and a cyan toner image may be preferably transferred on the intermediate transfer belt 11 as the second and third toner images respectively, by which the rank of unintended uneven image can be improved because yellow may be a lighter color than magenta and magenta may be a lighter color than cyan.

[0225] The toner may preferably include polyester resin as binder resin, by which the sunken rate of additives of toner can be set to 40% or more easily. With such toner, even if the primary transfer pressure is set smaller, "unintended uneven image" can be set in the allowable rank, and toner fixability at the low temperature/low humidity can be enhanced.

[0226] As such, a good level of image forming can be conducted if the above described preferable conditions are met.

[0227] FIG. 7 illustrates a schematic configuration of an image forming apparatus 100a according to a second exemplary embodiment.

[0228] The image forming apparatus 100a includes the transfer belt unit 10 over the image forming engines 60Y, 60M, 60C, and 60K, which is different from the first exemplary embodiment in FIG. 1.

[0229] The bias devices 18Y, 18M, 18C, and 18K in FIG. 7 includes the primary transfer rollers 12Y, 12M, 12C, and 12K. The primary transfer rollers 12Y, 12M, 12C, and 12K press the intermediate transfer belt 11 in a downward direction so that the intermediate transfer belt 11 can be pressed against the photoconductor drums 20Y, 20M, 20C, and 20K.

[0230] Each of the bias devices 18Y, 18M, 18C, and 18K include the primary transfer rollers 12Y, 12M, 12C, and 12K and a supporter for supporting each of the primary transfer rollers 12Y, 12M, 12C, and 12K. The bias devices 18Y, 18M, 18C, and 18K do not include a pressing member for pressing the primary transfer rollers 12Y, 12M, 12C, and 12K to the intermediate transfer belt 11, which is different from the first exemplary embodiment including the pressure spring 19Y (see FIG. 2). Accordingly, the primary transfer rollers 12Y, 12M, 12C, and 12K contact and press the intermediate transfer belt 11 by using self-weight of the primary transfer rollers 12Y, 12M, 12C, and 12K by moving from upper side to downside in a vertical direction along the supporter.

[0231] The primary transfer roller 12Y includes the shaft 37Y and an elastic layer formed on the shaft 37Y as similar to the first exemplary embodiment. The elastic layer of the primary transfer roller 12Y may have an Asker C hardness of 50 degrees or less, for example. A primary transfer pressure can be adjusted by setting a weight of the metal core.

[0232] In the image forming apparatus 100a, the bias devices 18Y, 18M, 18C, and 18K press the intermediate transfer belt 11 against the photoconductor drums 20Y, 20M, 20C, and 20K in a downward direction using the primary transfer roller 12 (12Y, 12M, 12C, and 12K) because of following reason.

[0233] In the first exemplary embodiment, the pressure springs 19 (19Y, 19M, 19C, and 19K) are disposed for the primary transfer roller 12 (12Y, 12M, 12C, and 12K) to press the primary transfer rollers 12 toward the intermediate transfer belt 11 in the image forming apparatus 100. However, each of the pressure springs 19 may have a variation on pressure strength in a main scanning direction, for example. If such variation may become greater than tolerance limits, a failed image may be produced. For example, uneven image concentration in the main scanning direction may occur or unintended uneven image in the main scanning direction may occur.

[0234] Further, if the primary transfer roller 12 is positioned under the photoconductor drum 20, the primary transfer

roller 12 is required to be pressed upward against the self-weight of the primary transfer roller 12. Accordingly, the primary transfer roller 12 is required to be pressed against the photoconductor drum 20 by increasing a pressure of the pressure spring 19Y.

[0235] However, if the pressure the pressure spring 19Y is increased, each of the pressure springs 19 disposed for the primary transfer rollers 12 may have a variation of pressure strength in the main scanning direction, for example. If such variation may become greater than tolerance limits, a failed image may be produced. For example, uneven image concentration in the main scanning direction may occur or unintended uneven image in the main scanning direction may occur.

[0236] Specifically, in case of Example 1 of FIG. 4, the primary transfer pressure for black was set to 70 g/cm². However, a primary transfer pressure at one end of the primary transfer roller 12 in a main scanning direction became greater than 70 g/cm², by which phenomenon of unintended uneven image was not prevented.

[0237] In case of Example 2 of FIG. 4, the primary transfer pressure for black was set to 50 g/cm². However, a primary transfer pressure at one end of the primary transfer roller 12 in a main scanning direction became smaller than 50 g/cm², by which transfer performance was degraded, and thereby defective transfer occurred.

[0238] In the second exemplary embodiment, the primary transfer rollers 12Y, 12M, 12C, and 12K are disposed over the photoconductor drums 20Y, 20M, 20C, and 20K in a vertical direction. Accordingly, it is not required to press the primary transfer roller 12 against its self-weight to the photoconductor drum 20. Accordingly, the primary transfer pressure for the primary transfer roller 12 in its main scanning direction can be balanced effectively in its entire length. Accordingly, uneven image concentration or unintended uneven image can be reduced compared to a configuration of the first exemplary embodiment.

[0239] In the second exemplary embodiment, the primary transfer pressure is generated using the self-weight of the primary transfer roller 12, but other pressing member (e.g., pressure spring 19) can be added. In such a configuration, the other pressing member may not need to exert its force against the self-weight of the primary transfer roller 12, by which the other pressing member may be set to have a smaller pressing force, which can assist the primary transfer pressure. Accordingly, the primary transfer pressure for the primary transfer roller 12 in a main scanning direction can be balanced effectively in its entire length. However, from a viewpoint of simpler configuration, size reduction, cost reduction, or the like, the primary transfer pressure may be preferably generated using only self-weight of the primary transfer roller 12 in the second exemplary embodiment.

[0240] Further, the primary transfer roller 12 has an Asker C hardness of 50 degrees or less, by which the primary transfer roller 12 can be deformed easily when the primary transfer pressure is applied, and thereby the primary transfer roller 12 can contact the intermediate transfer belt 11 with a greater contact area. Accordingly, even if imbalance of primary transfer pressure of the primary transfer roller 12 (12Y, 12M, 12C, and 12K) may occur along an axial direction of the primary transfer roller 12 due to some reasons (e.g., e.g., variation of tolerance value during assembly), and even if the primary transfer pressure may deviate from an intended pressure for some amount, the primary transfer roller 12 having such hardness can mitigate such effect of pressure variation or deviation. Accordingly, the secondary transfer performance can be conducted at a good level for producing images for the second exemplary embodiment. Further, under such configuration, the primary transfer pressure can be set to a lower value.

[0241] The image forming apparatus 100a includes transfer/transport unit 17a as a secondary transfer unit for transferring a toner image from the intermediate transfer belt 11 to a sheet and for transporting the sheet to the fixing unit 6. The image forming apparatus 100a may not include a double face printing function. The image forming apparatus 100a may be a multi-functional apparatus of printer and facsimile, for example, but not limited thereto.

[0242] In the above-described embodiments, an intermediate transfer medium is used for transferring a toner image to a sheet (indirect transfer method), but a direct transfer method can be used for transferring a toner image to a sheet, in which toner images are directly transferred to the sheet from a photoconductor.

[0243] In the above-described embodiments, an intermediate transfer medium may be a belt, or a drum. In the above-described embodiments, an image forming apparatus may be a copier, a printer, a facsimile, a multi-functional apparatus having several functions such as copier and printer, or the like.

[0244] As above described, toner having polyester resin, which is relatively easy to sink external additives in toner and which has a good level of low-temperature fixability, can be reliably used for producing a higher quality image over time.

[0245] As above described, an image forming apparatus, such as copier, facsimile, printer including a plurality of image bearing members and using two-component developer having carrier and relatively softer toner according to exemplary embodiments can conduct an image forming method, which can exert a good level of image transfer process.

[0246] Numerous additional modifications and variations are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the disclosure of the present invention may be practiced otherwise than as specifically described herein. For example, elements and/or features of different examples and illustrative embodiments may be combined each other and/or substituted for each other within the scope of this disclosure and appended claims.

Claims

1. An image forming apparatus using two-component developer including toner and carrier, the toner including a binder resin and additives, the image forming apparatus comprising:

a plurality of image bearing members to form toner images, the plurality of image bearing members including one image bearing member for forming a black toner image and other image bearing members for forming other color toner images;
 a transfer member disposed facing the plurality of image bearing members to be transferred with the toner image from each of the plurality of image bearing members; and
 a plurality of pressing units for each of the plurality of image bearing members to press the transfer member corresponding to each of the plurality of image bearing members with a given pressure,

wherein the toner has a sunken rate of additives of 40% or more, wherein the sunken rate of additives is defined as $\{(A-B)/A\} \times 100$, in which "A(m²/g)" is a BET specific surface of toner matrix before sinking additives in toner and "B(m²/g)" is a BET specific surface of the toner after sinking additives in toner, the pressing unit for the black image bearing member pressing the transfer member with a pressure set smaller compared to other pressing units for the other image bearing members, which press the transfer member.

2. The image forming apparatus according to claim 1, wherein the BET specific surface of the toner matrix is 3 m²/g or less.

3. The image forming apparatus according to claims 1 to 2, wherein each of the pressing units includes a pressing member that contacts the transfer member, the pressing member pressing the transfer member to each of the plurality of image bearing members from an upper to a lower direction in a vertical direction, each of the pressing units corresponding to each of the image bearing members.

4. The image forming apparatus according to claim 3, wherein the pressing unit presses the transfer member to each of the plurality of image bearing members using self-weight of the pressing member, each of the pressing units corresponding to each of the image bearing members.

5. The image forming apparatus according to claims 1 to 4, wherein the pressing member has an Asker C hardness of 50 degrees or less.

6. The image forming apparatus according to claims 1 to 5, wherein the transfer member includes an intermediate transfer medium that transfers the toner image, transferred from the image bearing member, to a sheet, the image forming apparatus further comprising:

a first transfer device configured to transfer the toner image formed on the image bearing member to the intermediate transfer medium; and
 a second transfer device configured to transfer the toner image formed on the intermediate transfer medium to the sheet.

7. The image forming apparatus according to claim 6, wherein, when the toner image is transferred from the plurality of image bearing members to the intermediate transfer medium, a black toner image is transferred to the intermediate transfer medium last.

8. The image forming apparatus according to claims 6 to 7, wherein, when the toner image is transferred from the plurality of image bearing members to the intermediate transfer medium, a yellow toner image is transferred to the intermediate transfer medium first.

9. The image forming apparatus according to claim 8, wherein, when the toner image is transferred from the plurality of image bearing members to the intermediate transfer medium, a magenta toner image and a cyan toner image are transferred to the intermediate transfer medium second and third, respectively.

10. The image forming apparatus according to claims 1 to 9, wherein the binder resin includes polyester resin.

11. Use of a toner in an image forming apparatus using two-component developer including toner and carrier, the toner

including a binder resin and additives, the image forming apparatus comprising:

a plurality of image bearing members to form toner images, the plurality of image bearing members including one image bearing member for forming a black toner image and other image bearing members for forming other color toner images;

a transfer member disposed facing the plurality of image bearing members to be transferred with the toner image from each of the plurality of image bearing members; and

a plurality of pressing units for each of the plurality of image bearing members to press the transfer member corresponding to each of the plurality of image bearing members with a given pressure,

wherein the toner has a sunken rate of additives of 40% or more, wherein the sunken rate of additives is defined as $\{(A-B)/A\} \times 100$, in which "A(m²/g)" is a BET specific surface of toner matrix before sinking additives in toner and "B(m²/g)" is a BET specific surface of the toner after sinking additives in toner,

the pressing unit for the black image bearing member pressing the transfer member with a pressure set smaller compared to other pressing units for the other image bearing members, which press the transfer member.

12. Use of a toner of claim 11, wherein the BET specific surface of the toner matrix is 3 m²/g or less.

13. The use of one of claims 11 to 12, wherein the binder resin includes polyester resin.

14. A method of forming an image using the image forming apparatus according to one of claims 1 to 10, comprising the steps of:

forming a latent image on each of the image bearing members;

developing the latent image on the image bearing member as a toner image by applying the toner prepared according to claim 1 to the image bearing members; and

transferring the toner image onto a transfer member,

wherein a black toner image is transferred to the transfer member with a given pressure set smaller than a pressure for transferring toner images of other colors.

FIG. 1

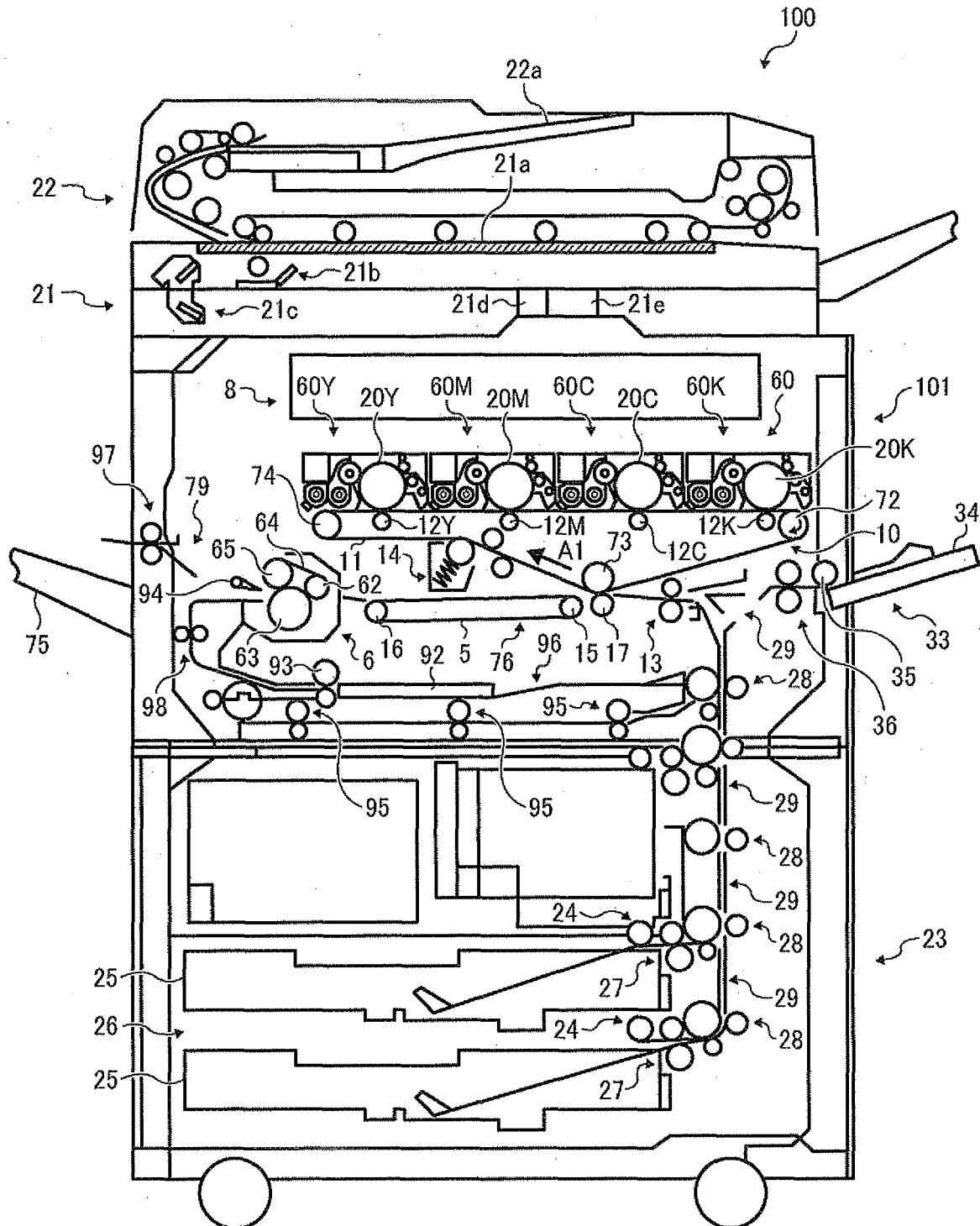


FIG. 2

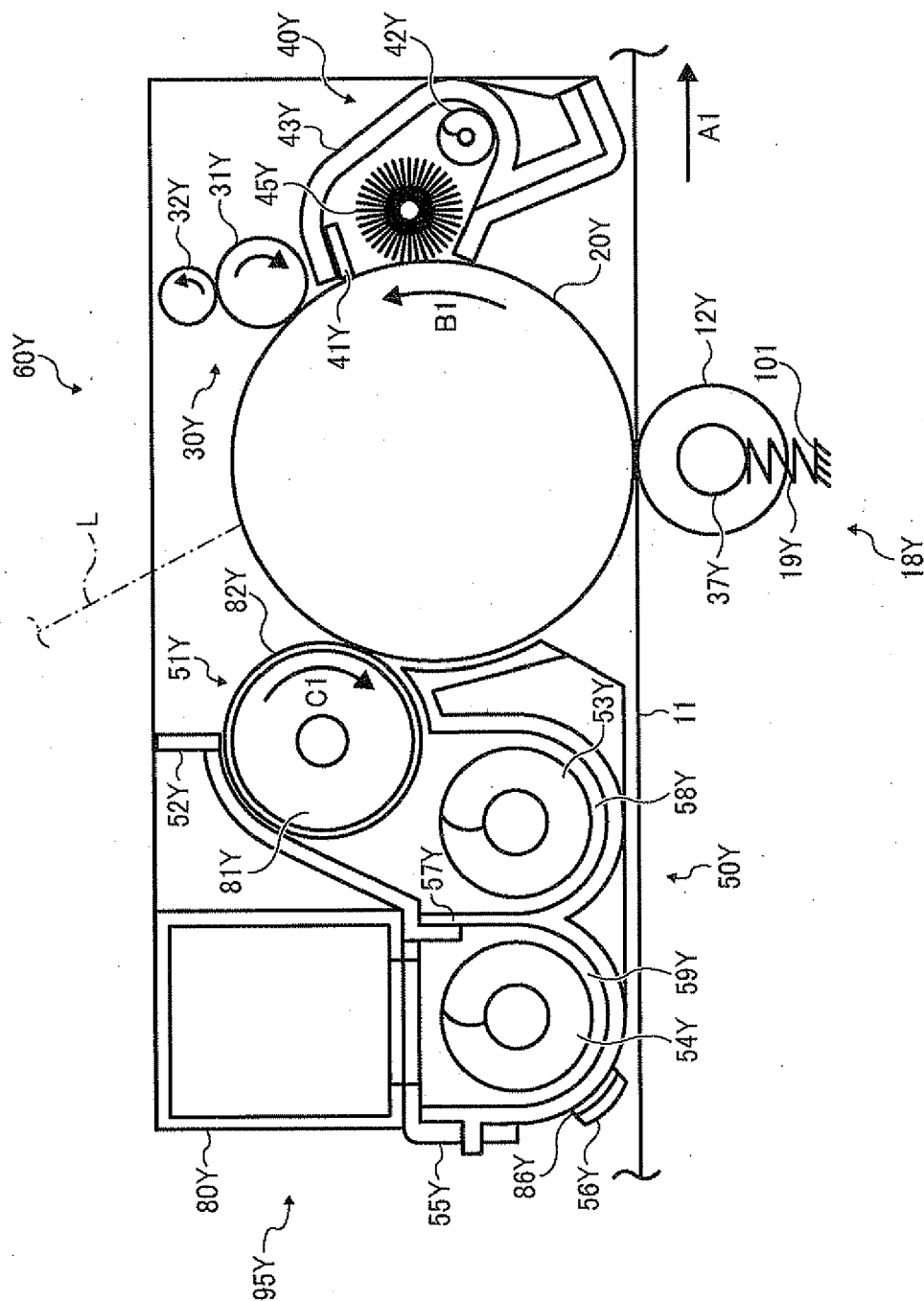


FIG. 3

		Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3	Ex. 1	Ex. 2
PRIMARY TRANSFER PRESSURE [g / cm ²]	Y	100	70	50	100	100
	M	100	70	50	100	100
	C	100	70	50	100	100
	K	100	70	50	70	50
RANK OF UNINTENDED UNEVEN IMAGE	M	3	4	5	4	4
	C	3	5	5	4	5
	K	4	5	5	5	5
RANK OF VOID	1C	4	5	4	5	4
	2C	4	3	2	4	4

FIG. 4

	Comp. Ex. 4	Comp. Ex. 5	Comp. Ex. 6	Comp. Ex. 7	Comp. Ex. 8	Comp. Ex. 9	Ex. 3	Ex. 4	Ex. 5
SUNKEN RATE OF ADDITIVES [%]	30	38	38	42	56	70	42	56	70
TONER RESIN	STYRENE- ACRYLIC RESIN	STYRENE- ACRYLIC RESIN	POLYESTER RESIN	POLYESTER RESIN	POLYESTER RESIN	POLYESTER RESIN	POLYESTER RESIN	POLYESTER RESIN	POLYESTER RESIN
PRIMARY TRANSFER PRESSURE [g / cm ²]	Y	100	100	100	100	100	100	100	100
	M	100	100	100	100	100	100	100	100
	C	100	100	100	100	100	100	100	100
	K	100	100	100	100	100	50	50	50
RANK OF UNINTENDED UNEVEN IMAGE	M	4	3	3	2	2	4	4	4
	C	4	4	4	3	3	5	4	4
	K	5	4	4	4	3	5	5	4
RANK OF VOID	1C	4	4	4	4	4	4	4	4
	2C	4	4	4	4	4	4	4	4
FIXABILITY (10 DEGREES CELSIUS/ 15% HUMIDITY)	x	x	x	○	○	○	○	○	○

FIG. 5

	ORDER OF IMAGE FORMATION	LEVEL OF UNINTENDED UNEVEN IMAGE		
		RED	GREEN	BLUE
Ex. 6	YMCK	○	○	○
Comp. Ex. 10	YCMK	○	○	×
Comp. Ex. 11	MCYK	×	×	○
Comp. Ex. 12	CMYK	×	×	×

FIG. 6

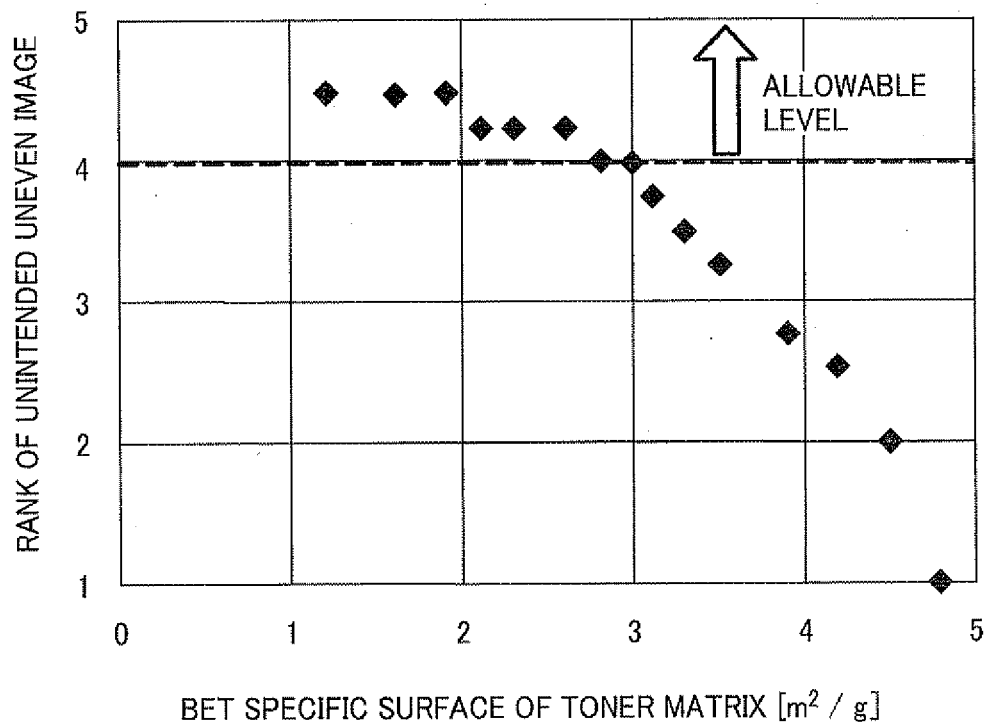
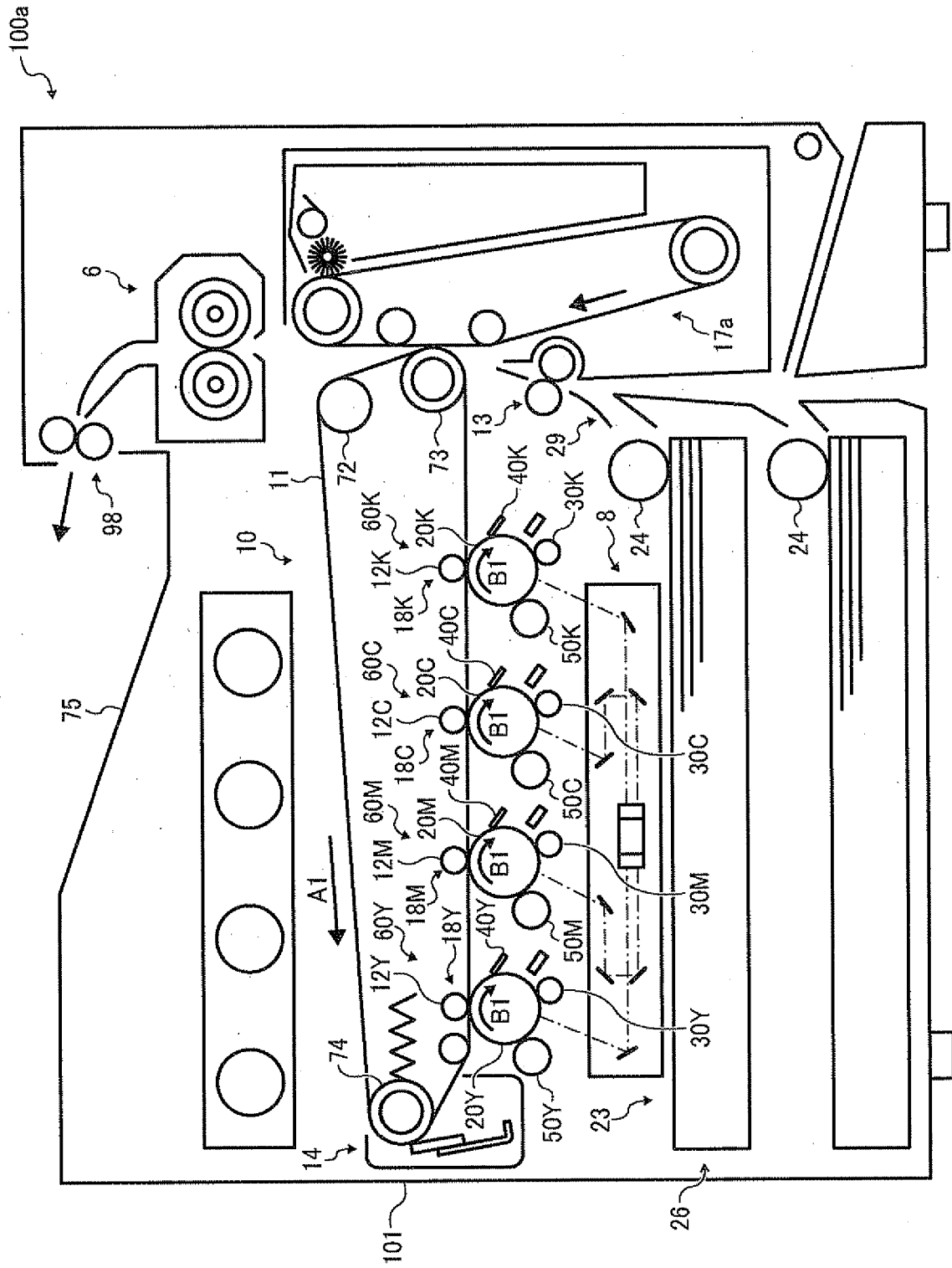


FIG. 7



REFERENCES CITED IN THE DESCRIPTION

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