US Patent & Trademark Office
Patent Public Search | Text View

United States Patent	12386284
Kind Code	B2
Date of Patent	August 12, 2025
Inventor(s)	Kikushima; Seiji

Developing device

Abstract

A developing device includes a cylindrical developing roller, a regulation member, a magnetic member, and a synthetic resin member. The regulation member includes a first opposing surface facing an outer circumferential surface of the developing roller. The magnetic member is arranged on a side surface of the regulation member. The synthetic resin member is arranged on a side surface of the magnetic member. The synthetic member includes a second opposing surface facing the outer circumferential surface of the developing roller. The second opposing surface is tilted at 40° or more but 60° or less with respect to the first opposing surface to be increasingly distant from the outer circumferential surface of the developing roller toward an upstream side in a rotating direction of the developing roller. A solubility parameter of a material of the synthetic resin member is 23 (J/cm.sup.3).sup.1/2 or more. Magnetic toner contains toner and resin fine particles.

Inventors:	**Kikushima; Seiji (Osaka, JP)**
Applicant:	**KYOCERA Document Solutions Inc.** (Osaka, JP)
Family ID:	**1000008751704**
Assignee:	**KYOCERA DOCUMENT SOLUTIONS INC. (Osaka, JP)**
Appl. No.:	**18/795862**
Filed:	**August 06, 2024**

Prior Publication Data

Document Identifier	Publication Date
US 20250053115 A1	Feb. 13, 2025

Foreign Application Priority Data

JP	2023-130000	Aug. 09, 2023

Publication Classification

Int. Cl.: **G03G15/08** (20060101); **G03G15/01** (20060101); **G03G15/09** (20060101)

U.S. Cl.:

CPC **G03G15/0812** (20130101); **G03G15/0121** (20130101); **G03G15/081** (20130101); **G03G15/0818** (20130101); **G03G15/0896** (20130101); **G03G15/0921** (20130101); **G03G15/0928** (20130101); G03G2215/0609 (20130101); G03G2215/0855 (20130101); G03G2215/0858 (20130101); G03G2215/0861 (20130101); G03G2215/0866 (20130101); G03G2215/0869 (20130101)

Field of Classification Search

CPC: G03G (15/0121); G03G (15/081); G03G (15/0812); G03G (15/0818); G03G (15/0896); G03G (15/0921); G03G (15/0928); G03G (2215/0609); G03G (2215/0855); G03G (2215/0858); G03G (2215/0861); G03G (2215/0866); G03G (2215/0869)

References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
2004/0094742	12/2003	Kawano	252/62.55	H01F 1/083
2017/0090351	12/2016	Oshima	N/A	G03G 21/18
2022/0260947	12/2021	Sakamaki	N/A	G03G 15/0896

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
2007-147915	12/2006	JP	N/A

Primary Examiner: Wong; Joseph S

Attorney, Agent or Firm: Stein IP, LLC

Background/Summary

INCORPORATION BY REFERENCE
(1) This application is based on and claims the benefit of priority from Japanese Patent Application No. 2023-130000 filed on Aug. 9, 2023, the contents of which are hereby incorporated by reference.
BACKGROUND
(2) The present disclosure relates to a developing device.
(3) A problem with conventional developing devices is that toner is likely to build up in an internal space of the developing device.
SUMMARY
(4) A developing device of the present disclosure includes a cylindrical developing roller, a regulation member, a magnetic member, and a synthetic resin member. The developing roller houses a magnetic-field generating member and rotates. The regulation member includes a first

opposing surface facing an outer circumferential surface of the developing roller. The magnetic member is arranged on a side surface, which is on an upstream side in a rotating direction of the developing roller, of the regulation member. The synthetic resin member is arranged on a side surface, which is on the upstream side in the rotating direction of the developing roller, of the magnetic member. The regulation member regulates a layer thickness of magnetic toner on the outer circumferential surface of the developing roller using the first opposing surface. The synthetic resin member includes a second opposing surface facing the outer circumferential surface of the developing roller. The second opposing surface is tilted at 40° or more but 60° or less with respect to the first opposing surface to be increasingly distant from the outer circumferential surface of the developing roller toward the upstream side in the rotating direction of the developing roller. A solubility parameter of a material of the synthetic resin member is 23 (J/cm.sup.3).sup.1/2 or more. The magnetic toner contains toner and resin fine particles.
(5) Further features of the present disclosure, and the specific benefits obtained according to the present disclosure, will become apparent from the description of embodiments which follows.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a view illustrating a configuration of an image forming apparatus according to an embodiment of the present disclosure.
(2) FIG. **2** is an enlarged view of a developing device according to the present embodiment.
DETAILED DESCRIPTION
(3) Hereinafter, embodiments of the present disclosure are described, which is preceded by description of a problem of a conventional technique.
(4) A conventional developing device may include a developing roller and a regulation blade. The regulation blade regulates an amount of toner held on the developing roller. Toner is likely to build up in a space (upstream space) on an upstream side relative to the regulation blade in a rotating direction of the developing roller.
(5) According to a conventional technique, an elastic member is disposed in the upstream space where toner is likely to build up. The elastic member is disposed so as to occupy the upstream space in a state of being in close contact with an upstream surface, in the rotating direction of the developing roller, of the regulation blade. The upstream space is occupied by the elastic member and, accordingly, buildup of toner is suppressed.
(6) The elastic member includes a conveyance-rate regulating surface facing a circumferential surface of the developing roller. The conveyance-rate regulating surface is configured to be increasingly distant from the developing roller toward an upstream side in the rotating direction of the developing roller. Toner that has left a developer storage and adhered onto the circumferential surface of the developing roller is gradually pushed back into the developer storage by the conveyance-rate regulating surface as the toner is advanced in the upstream space by rotation of the developing roller. In this way, buildup of a large amount of toner on the upstream side, in the rotating direction of the developing roller, relative to the regulation blade is suppressed.
(7) However, there is a problem that toner can be adsorbed on the conveyance-rate regulating surface of the elastic member. It is difficult to desorb the adsorbed toner from the elastic member, and the toner may aggregate around the conveyance-rate regulating surface and form aggregated toner. The aggregated toner can cause clogging and produce image smears.
(8) In view of the above-described problem, an object of the present disclosure is to provide a developing device capable of suppressing production of aggregated toner.
(9) An embodiment of the present disclosure is described below with reference to the drawings. In the drawings, identical or corresponding elements are denoted by identical reference signs, and

redundant description is omitted. In the present embodiment, an X axis, a Y axis, and a Z axis are orthogonal to each other; the X axis and the Y axis are parallel to a horizontal plane; and the Z axis is parallel to a vertical line.

(10) First, a configuration of an image forming apparatus **1** according to a first embodiment is described with reference to FIG. **1**. FIG. **1** is a view illustrating a configuration of the image forming apparatus **1**. The image forming apparatus **1** may be, for instance, a monochrome printer.

(11) As illustrated in FIG. **1**, the image forming apparatus **1** includes an image forming unit **4**, a fixing unit **5**, a sheet discharge tray **12**, a sheet conveyance path **6**, a manual feed tray **3**, a sheet feed cassette **7**, and an operation unit (not illustrated).

(12) The sheet feed cassette **7** accommodates sheets P. The sheets P may be, for instance, plain paper sheets, copy paper sheets, recycled paper sheets, thin paper sheets, thick paper sheets, glossy paper sheets, or an overhead projector (OHP) sheets. The sheets P are discharged onto the sheet discharge tray **12**.

(13) The conveyance path **6** conveys the sheet P from the sheet feed cassette **7** via the image forming unit **4** and the fixing unit **5** toward the sheet discharge tray **12**.

(14) The manual feed tray **3** is provided on a side surface on the right side in FIG. **1** of the image forming apparatus **1**.

(15) A plurality of menu setting keys for setting various menus and the like are arranged on the operation unit.

(16) The image forming unit **4** forms a toner image on the sheet P based on image data fed from an external entity (e.g., a personal computer (PC)). Specifically, the image forming unit **4** includes a photoreceptor drum (image carrier) **10**, a charging unit **42**, an exposure unit **43**, a developing device **44**, a toner cartridge **45**, a transfer roller (transfer member) **46**, and a toner removal unit **47**. With reference to a rotating direction (clockwise in FIG. **1**) of the photoreceptor drum **10**, the charging unit **42**, the developing device **44**, the transfer roller **46**, and the toner removal unit **47** are arranged in this order along a circumferential direction of the photoreceptor drum **10**. The exposure unit **43** is arranged above the charging unit **42**.

(17) The photoreceptor drum **10** is a drum having a photoreceptor; for instance, it is an aluminum cylinder having a surface where an amorphous silicon layer which is a positive-charging photoreceptor is deposited. A layer thickness of the amorphous silicon layer and a linear velocity of the photoreceptor drum **10** may be set as appropriate.

(18) The charging unit **42** performs a charging process on the photoreceptor drum **10**. Specifically, the charging unit **42** includes a charging roller **50**, for instance. The charging roller **50** is composed of a mandrel and an epichlorohydrin rubber layer covering the mandrel. The charging roller **50** is for a contact-electrostatic charging method, which places a circumferential surface of the charging roller **50** in substantial point contact with a drum surface of the photoreceptor drum **10**, and uniformly charges a surface potential of the drum surface by applying a predetermined reference charging voltage (reference charging bias), in which a direct current voltage and an alternating current voltage are superimposed, onto the drum surface.

(19) The exposure unit **43** irradiates the charged photoreceptor drum **10** with laser light L to form an electrostatic latent image. Specifically, the exposure unit **43** includes a polygon mirror (not illustrated) for guiding the laser light L, which is based on image data input from an external personal computer (PC) or the like, to the drum surface of the photoreceptor drum **10**. The polygon mirror forms an electrostatic latent image on the drum surface by scanning the drum surface of the photoreceptor drum **10** with the laser light L while being rotated by a predetermined driving source.

(20) The developing device **44** causes toner to electrostatically adhere to the electrostatic latent image formed on the photoreceptor drum **10** for development into a toner image. The toner cartridge **45** supplies toner filled thereinside to the developing device **44**.

(21) The transfer roller **46** transfers the developed toner image onto the sheet P. Specifically, on the sheet conveyance path **6**, the transfer roller **46** is in pressure contact with the drum surface of the

photoreceptor drum **10** to form a nip N between the transfer roller **46** and the drum surface. Since a voltage having a polarity opposite to that of the surface potential of the drum surface is applied to the transfer roller **46**, the toner image on the drum surface is transferred onto the sheet P when the sheet P passes through the nip N. The sheet P passed through the nip N is conveyed through the sheet conveyance path **6** to the fixing unit **5**.
(22) The toner removal unit **47** removes and collects toner remaining on the drum surface of the photoreceptor drum **10**.
(23) The fixing unit **5** heats the toner image formed on the sheet P to fix it onto the sheet P. In the fixing unit **5**, after the toner image on the sheet P has been heated and fixed onto the sheet P, the sheet P is conveyed through the sheet conveyance path **6** onto the sheet discharge tray **12**.
(24) With reference to FIG. **1** and FIG. **2**, a configuration of the developing device **44** is described. FIG. **2** is an enlarged view of the developing device **44**. As illustrated in FIG. **2**, the developing device **44** develops an electrostatic latent image on the photoreceptor drum **10** using a magnetic one-component developer (magnetic toner).
(25) The one-component developer (magnetic toner) contains toner, magnetic powder and resin fine particles. As the resin fine particles, for instance, particles of a styrene-acrylic resin may be contained. Examples of the styrene-acrylic resin include a copolymer of styrene, methyl methacrylate, and divinyl benzene and a copolymer of styrene, methyl methacrylate, and ethylene glycol dimethacrylate. A mean primary particle size of the particles of the styrene-acrylic resin is, for instance, 30 nm or more but 150 nm or less, and preferably 35 nm or more but 125 nm or less. A solubility parameter of the resin fine particles is preferably 18.4 (J/cm.sup.3).sup.1/2 or more but 19.6 (J/cm.sup.3).sup.1/2 or less, for instance. The magnetic one-component developer (magnetic toner) may contain silica particles, a binder resin, a charge control agent, and a release agent.
(26) The developing device **44** includes a development container (housing) **21**, a developer storage **11**, a developing roller **22**, a regulation member **30**, and a magnet **60**. The development container **21** defines an internal space of the developing device **44**. The magnet **60** is an example of the "magnetic member."
(27) The developer storage **11** is formed on a bottom wall of the development container **21**. Specifically, the developer storage **11** is composed of two developer storage chambers **14** and **15** adjacent to each other and extending in a longitudinal direction (vertical direction with respect to the paper surface of FIG. **1**) of the developing device **44**. The developer storage chambers **14** and **15** are partitioned from each other in the longitudinal direction by a partition plate **17** made of, for instance, a metal such as aluminum but are in communication with each other at both end portions in the longitudinal direction.
(28) The developer storage chambers **14** and **15** are respectively provided with screw feeders **18** and **19** that are rotatably mounted to convey the magnetic toner while agitating it by rotation. Since the screw feeders **18** and **19** are configured to have conveyance directions opposite to each other, the magnetic toner is conveyed between the developer storage chamber **14** and the developer storage chamber **15** while being agitated. The developer storage **11** receives toner from the toner cartridge **45** through a not-illustrated supply port.
(29) The developing roller **22** is arranged in a developing opening **23** of the development container **21**. The developing roller **22** is a roller member that includes a cylindrical developing sleeve **24** that is formed of a non-magnetic material such as aluminum and that extends in the longitudinal direction of the developing device **44** (i.e., an axial direction of the photoreceptor drum **10**) and a not-illustrated rotation shaft for rotating the developing sleeve **24** counter-clockwise in FIG. **2**.
(30) The developing sleeve **24** is arranged to face the photoreceptor drum **10** with a clearance of 0.2 mm to 0.4 mm between an outer circumferential surface **26** of the developing sleeve **24** and the drum surface of the photoreceptor drum **10**. The developing sleeve **24** houses a magnetic-field generating member. The magnetic-field generating member is configured so as to have a south pole (S**2**) as an opposite pole facing the regulation member **30** and, downstream of the south pole (S**2**), a

north pole (N**1**), a south pole (S**1**), a north pole (N**2**), a south pole (S**3**), and a north pole (N**3**) arranged in this order along a circumferential direction of the developing sleeve **24**.

(31) The regulation member **30** is a plate-like member disposed above the developing roller **22** in FIG. **2**, extending along an axial direction of the developing sleeve **24**, and made of a magnetic material, and includes a tip end portion **31** extending toward the outer circumferential surface **26** of the developing sleeve **24**. The tip end portion **31** includes a first opposing surface **32** facing the outer circumferential surface **26**. A gap of a predetermined dimension is defined between the first opposing surface **32** and the outer circumferential surface **26** of the developing sleeve **24**. The regulation member **30** regulates a layer thickness of the magnetic toner on the outer circumferential surface **26** of the developing sleeve **24** using the first opposing surface **32**.

(32) The magnet **60** is arranged on a side surface, which is on an upstream side in a rotating direction of the developing sleeve **24**, of the regulation member **30**. The magnet **60** is adhered to the side surface of the regulation member **30** with an adhesive so as to have a south pole as an opposite pole facing the developing sleeve **24** and so that its end on the developing sleeve **24** side projects less than an end, which is on the developing sleeve **24** side, of the regulation member **30**. The magnet **60** assists the regulation member **30** in regulating the layer thickness of the magnetic toner on the circumferential surface **26**. The regulation of the layer thickness of the magnetic toner on the circumferential surface **26** is achieved through physical regulation by the regulation member **30** and magnetic regulation by the magnet **60**.

(33) As the developing sleeve **24** rotates, the magnetic toner on the outer circumferential surface **26** of the developing sleeve **24** is conveyed toward the drum surface of the photoreceptor drum **10** and caused to adhere to an electrostatic latent image on the drum surface of the photoreceptor drum **10** by a potential difference between a developing bias applied to the developing sleeve **24** and a drum bias applied to the photoreceptor drum **10**. A toner image is formed on the drum surface in this way.

(34) The developing device **44** further includes a synthetic resin member **70**. The synthetic resin member **70** is arranged on a side surface, which is on the upstream side in the rotating direction of the developing sleeve **24**, of the magnet **60**. The synthetic resin member **70** extends along the axial direction of the developing sleeve **24**. Specifically, the synthetic resin member **70** includes a second opposing surface **71** facing the outer circumferential surface **26** of the developing sleeve **24**.

(35) The second opposing surface **71** is, with reference to the rotating direction of the developing sleeve **24**, located on the upstream side relative to the first opposing surface **32** of the regulation member **30** and configured to be increasingly distant from the developing sleeve **24** toward the upstream side in the rotating direction. In other words, the second opposing surface **71** is configured such that a clearance between the second opposing surface **71** and the outer circumferential surface **26** of the developing sleeve **24** gradually increases from the first opposing surface **32** toward upstream in the rotating direction of the developing sleeve **24**. A part of the magnetic toner being conveyed is gradually pushed back by the second opposing surface **71** in a direction opposite to the rotating direction of the developing sleeve **24**. The second opposing surface **71** regulates the amount of the magnetic toner conveyed to the first opposing surface **32** in this way. As a result, undesirable buildup of a large amount of the magnetic toner on the upstream side, with reference to the rotating direction, of the gap between the first opposing surface **32** and the outer circumferential surface **26** is suppressed.

(36) The second opposing surface **71** is tilted at an angle of 40° or more but 60° or less with respect to the first opposing surface **32**. With a configuration where the angle is smaller than 40°, due to excessive stress applied from the regulation member **30** to the magnetic toner, the amount of charge on the magnetic toner decreases, resulting in a decrease in image density on the sheet. The image density decreases greatly especially in a high-temperature environment. By contrast, with a configuration where the angle is larger than 60°, the magnetic toner builds up around the regulation member **30** and causes aggregation; the magnetic toner in the aggregated area becomes less prone to be regulated, which leads to an increase in conveyance rate of the magnetic toner and shortage of

the amount of charge, and produces toner streaks (vertical streaks) on the sheet.
(37) A solubility parameter of a material of the synthetic resin member **70** is 23 (J/cm.sup.3).sup.1/2 or more. Examples of the material of the synthetic resin member **70** include acrylonitrile butadiene styrene (ABS) resins and polyamide resins. Further, a difference between the solubility parameter of the material of the synthetic resin member **70** and the solubility parameter of the resin fine particles is preferably 5 (J/cm.sup.3).sup.1/2 or more.
(38) As described above with reference to FIG. **1** and FIG. **2**, since the second opposing surface **71** of the synthetic resin member **70** is tilted at 40° or more but 60° or less with respect to the first opposing surface **32**, the solubility parameter of the material of the synthetic resin member **70** is 23 (J/cm.sup.3).sup.1/2 or more, and the magnetic toner contains resin fine particles, adsorption of the magnetic toner onto the second opposing surface **71** of the synthetic resin member **70** can be suppressed. As a result, production of aggregated toner can be suppressed.
EXAMPLES
(39) The present disclosure is described more specifically below by way of Examples (and Comparative Examples). Note that the present disclosure is by no means limited to the scope of Examples.
(40) [Preparation of Silica Particles]
(41) First, 30 g of dimethylpolysiloxane and 15 g of 3-aminopropyltrimethoxysilane (both manufactured by Shin-Etsu Chemical Co., Ltd.) were dissolved in 200 g of toluene and diluted 10-fold. Subsequently, the obtained diluted solution was gradually dripped into 200 g of fumed silica particles ("AEROSIL® 130" manufactured by NIPPON AEROSIL CO., LTD.) while stirring, and subjected to ultrasonication and stirring for 30 minutes to obtain a mixture. This mixture was heated in a thermostatic bath at 150° C., thereafter toluene was removed using a rotary evaporator, and the obtained solid was dried using a vacuum dryer at a temperature setting of 50° C. until there was no further weight reduction. Further, it was heated at 200° C. in an electric furnace for three hours under nitrogen atmosphere. The obtained powder was disintegrated using a jet mill and collected using a bag filter to obtain silica particles.
(42) [Preparation of Resin Fine Particles]
(43) (Preparation of Resin Fine Particles A)
(44) Into a 500-ml flask equipped with a dropping funnel, a stirrer, a nitrogen gas inlet tube, a thermometer, and a reflux cooling pipe, 200 g of ion-exchanged water and 3 g of sodium lauryl sulfate were put. While heating the mixture to 80° C. under nitrogen atmosphere, 1 g of ammonium persulfate was added; further, a monomer mixture composed of 42 g of styrene, 40 g of methyl methacrylate, and 26 g of divinyl benzene was dripped into the flask over one hour, and the mixture was thereafter stirred for another one hour. The obtained reaction solution was cooled to room temperature, and thereafter filtered through a 300-mesh sieve to obtain an emulsion. By drying the obtained emulsion, resin fine particles A with a mean particle size of 80 nm and a solubility parameter (SP value) of 18.4 (J/cm.sup.3).sup.1/2 were obtained.
(45) (Preparation of Resin Fine Particles B)
(46) Through the same procedure as that for the resin fine particles A except for that 1 g, rather than 3 g, of sodium lauryl sulfate was added, resin fine particles B with a mean particle size of 125 nm and a solubility parameter of 18.4 (J/cm.sup.3).sup.1/2 were obtained.
(47) (Preparation of Resin Fine Particles C)
(48) Through the same procedure as that for the resin fine particles A except for that 10 g, rather than 3 g, of sodium lauryl sulfate was added, resin fine particles C with a mean particle size of 35 nm and a solubility parameter of 18.4 (J/cm.sup.3).sup.1/2 were obtained.
(49) (Preparation of Resin Fine Particles D)
(50) Through the same procedure as that for the resin fine particles A except for that 42 g of styrene was changed to 31 g of the same, 40 g of methyl methacrylate was changed to 30 g of the same, and 26 g of divinyl benzene was changed to 79 g of ethylene glycol dimethacrylate, resin fine

particles D with a mean particle size of 80 nm and a solubility parameter of 19.6 (J/cm.sup.3).sup.1/2 were obtained.

Example 1

(51) Magnetic toner of Example 1 was produced as follows. Using a mixer ("FM-20B" manufactured by Nippon Coke & Engineering Co., Ltd.), 1,100 g of polyester binder resin (manufactured by Kao Corporation, Mw: 6,500, acid value: 8.2 mg KOH/g, Tm: 96.3° C., Tg: 54.4° C.), 1,090 g of binder resin (manufactured by Kao Corporation, acid value: 11.8 mg KOH/g, Tm: 118.5° C., Tg: 59.6° C., gel fraction: 36%), 1,450 g of magnetic powder X (2×105 Ω.Math.cm, "MRO-15A" manufactured by TODA KOGYO CORP.), 200 g of charge control agent ("FCA-482PLV" manufactured by Fujikura Kasei Co. Ltd.), and 160 g of release agent ("Carnauba wax Special No. 1" manufactured by S. KATO & CO.) were mixed at 2,000 rpm for five minutes.

(52) The obtained mixture was melt-kneaded using a twin screw extruder ("TEM-26SS" manufactured by SHIBAURA MACHINE CO., LTD.) under conditions of a cylinder temperature of 120° C., a shaft rotation speed of 100 rpm, and 75 g/min. The obtained kneaded mixture was cooled, and thereafter the kneaded mixture was coarsely ground using a cutting mill ("Rotoplex 16/8" manufactured by HOSOKAWA MICRON CORPORATION). The obtained coarsely-ground material was finely ground using a pulverizing turbo mill TA (manufactured by Freund-Turbo Corporation). Subsequently, the material was input to a jet mill ("MJT-1" manufactured by HOSOKAWA MICRON CORPORATION) for fine milling and classification to obtain toner base particles Tn**1**.

(53) To 1 kg of the obtained toner base particles, 12 g of the silica particles and 1 g of the resin fine particles A obtained using the above-mentioned methods were caused to adhere as external additives by mixing them at 3,200 rpm for five minutes using a mixer ("FM-10C" manufactured by Nippon Coke & Engineering Co., Ltd.). Thereafter, screening was performed using a 100-mesh sieve (opening size: 150 μm) to obtain the magnetic toner according to Example 1.

(54) In the developing device, a synthetic resin member (mount blade) was made of an ABS resin having a solubility parameter of 23.7 (J/cm.sup.3).sup.1/2 and arranged such that the second opposing surface is tilted at 50° with respect to the first opposing surface. As a result, a developing device according to Example 1 was obtained. In TABLE 1, TABLE 2, and TABLE 3 described later, "EX1" denotes Example 1.

Example 2

(55) Example 2 is the same as Example 1 except for that the resin fine particles B were used in toner in place of the resin fine particles A. In TABLE 1, TABLE 2, and TABLE 3 described later, "EX2" denotes Example 2.

Example 3

(56) Example 3 is the same as Example 1 except for that the resin fine particles C were used in toner in place of the resin fine particles A. In TABLE 1, TABLE 2, and TABLE 3 described later, "EX3" denotes Example 3.

Example 4

(57) Example 4 is the same as Example 1 except for that the resin fine particles D were used in toner in place of the resin fine particles A. In TABLE 1, TABLE 2, and TABLE 3 described later, "EX4" denotes Example 4.

Example 5

(58) Example 5 is the same as Example 1 except for that, in place of the synthetic resin member made of the ABS resin, a synthetic resin member made of a polyamide resin having a solubility parameter of 27.8 (J/cm.sup.3).sup.1/2 was used in the developing device. In TABLE 1, TABLE 2, and TABLE 3 described later, "EX5" denotes Example 5.

Comparative Example 1

(59) Comparative Example 1 is the same as Example 1 except for that the synthetic resin member was not used in the developing device. In TABLE 1, TABLE 2, and TABLE 3 described later,

"CEX1" denotes Comparative Example 1.
Comparative Example 2
(60) Comparative Example 2 is the same as Example 1 except for that, in place of the synthetic resin member made of the ABS resin, a synthetic resin member made of a high-density polystyrene resin having a solubility parameter of 18.4 (J/cm.sup.3).sup.1/2 was used in the developing device. In TABLE 1, TABLE 2, and TABLE 3 described later, "CEX2" denotes Comparative Example 2.
Comparative Example 3
(61) Comparative Example 3 is the same as Example 1 except for that the synthetic resin member (mount blade) was arranged such that the second opposing surface is tilted at 35° with respect to the first opposing surface in the developing device. In TABLE 1, TABLE 2, and TABLE 3 described later, "CEX3" denotes Comparative Example 3.
Comparative Example 4
(62) Comparative Example 4 is the same as Example 1 except for that the synthetic resin member (mount blade) was arranged such that the second opposing surface is tilted at 65° with respect to the first opposing surface in the developing device. In TABLE 1, TABLE 2, and TABLE 3 described later, "CEX4" denotes Comparative Example 4.
Comparative Example 5
(63) Comparative Example 5 is the same as Example 1 except for that the resin fine particles A were not used in toner. In TABLE 1, TABLE 2, and TABLE 3 described later, "CEX5" denotes Comparative Example 5.
(64) TABLE 1 presents constitutions of the toners according to Example 1 to Example 5 and Comparative Example 1 to Comparative Example 5. Note that "St" represents styrene, "MMA" represents methyl methacrylate, "DVB" represents divinyl benzene, and "EGDM" represents ethylene glycol dimethacrylate.
(65) TABLE-US-00001 TABLE 1 Constitution of resin fine particles in toner Particle size SP value Toner Composition [nm] [(J/cm.sup.3).sup.0.5] EX1 A A St/MMA/DVB 80 18.4 EX2 B B St/MMA/DVB 125 18.4 EX3 C C St/MMA/DVB 35 18.4 EX4 D D St/MMA/EGDM 80 19.6 EX5 A A St/MMA/DVB 80 18.4 CEX1 A A St/MMA/DVB 80 18.4 CEX2 A A St/MMA/DVB 80 18.4 CEX3 A A St/MMA/DVB 80 18.4 CEX4 A A St/MMA/DVB 80 18.4 CEX5 E None
(66) TABLE 2 presents the synthetic resin members (mount blades) in the developing devices according to Example 1 to Example 5 and Comparative Example 1 to Comparative Example 5. Note that "ABS" represents an ABS resin, "PA" represents a polyamide resin, and "HIPS" represents a high-density polystyrene resin.
(67) TABLE-US-00002 TABLE 2 Mount blade Provided/Not SP value Angle provided Resin [(J/cm.sup.3).sup.0.5] [°] EX1 Provided ABS 23.7 50 EX2 Provided ABS 23.7 50 EX3 Provided ABS 23.7 50 EX4 Provided ABS 23.7 50 EX5 Provided PA 27.8 50 CEX1 Not provided CEX2 Provided HIPS 18.4 50 CEX3 Provided ABS 23.7 35 CEX4 Provided ABS 23.7 65 CEX5 Provided ABS 23.7 50
<Evaluation of Printing Performance Endurance Using Actual Machines>
(68) Using the toners and the developing devices according to Example 1 to Example 5 and Comparative Example 1 to Comparative Example 5 and using a monochrome printer ECOSYS® P2040dw manufactured by KYOCERA Document Solutions Inc., 2-sheet intermittent printing of an image document with a coverage rate of 2% was performed to print 100,000 sheets and 5,000 sheets in an environment where the temperature was 23° C. and the humidity was 65% and an environment where the temperature was 28° C. and the humidity was 80%, respectively. Image densities at each of the initial states, after printing 100,000 sheets in the environment where the temperature was 23° C. and the humidity was 65%, and after printing 5,000 sheets in the environment where the temperature was 28° C. and the humidity was 80%, and presence/absence of a white streak in 100,000 printouts produced in the environment where the temperature was 23° C. and the humidity was 65% were evaluated. Good: No vertical streak (white streak or black

streak) was observed in the 100,000 printouts. Bad: A vertical streak(s) (white streak or black streak) was observed in the 100,000 printouts.
(69) The results are presented in TABLE 3.
(70) TABLE-US-00003 TABLE 3 Image density (N/N) After 5,000-sheet After 100,000-sheet printing at White Initial printing high temperature streak EX1 1.43 1.41 1.31 Good EX2 1.40 1.40 1.33 Good EX3 1.44 1.42 1.34 Good EX4 1.40 1.37 1.31 Good EX5 1.42 1.42 1.29 Good CEX1 1.44 1.42 1.32 Bad CEX2 1.39 1.37 1.29 Bad CEX3 1.32 1.33 1.30 Bad CEX4 1.46 1.39 1.07 Good CEX5 1.38 1.32 1.19 Bad
(71) As described above, in Comparative Example 1 to Comparative Example 3 and Comparative Example 5, the magnetic toner built up around the regulation member and caused aggregation; the magnetic toner in the aggregated area became less prone to be regulated, which led to an increase in conveyance rate of the magnetic toner and shortage of the amount of charge, and produced toner streaks (vertical streaks) on the sheet. In Comparative Example 4, due to excessive stress applied from the regulation member to the magnetic toner, the amount of charge on the magnetic toner decreased, resulting in a decrease in image density on the sheet. The image density decreased greatly especially in the high-temperature environment.
(72) By contrast, in Example 1 to Example 5, no toner streak was produced on the sheets, and decrease in image density was suppressed even in the high-temperature environment.
(73) The developing device of the present disclosure can suppress production of aggregated toner.
(74) The developing device according to the present disclosure is usable in an image forming apparatus.

Claims

1. A developing device comprising: a developing roller being cylindrical in shape, housing a magnetic-field generating member, and rotating; a regulation member including a first opposing surface facing an outer circumferential surface of the developing roller; a magnetic member arranged on an upstream side surface of the regulation member with respect to a rotating direction of the developing roller; and a synthetic resin member arranged on an upstream side surface of the magnetic member with respect to the rotating direction of the developing roller, wherein the regulation member regulates a layer thickness of magnetic toner on the outer circumferential surface of the developing roller using the first opposing surface, the synthetic resin member includes a second opposing surface facing the outer circumferential surface of the developing roller, the second opposing surface is tilted at 40° or more but 60° or less with respect to the first opposing surface to be increasingly distant from the outer circumferential surface of the developing roller toward an upstream side in the rotating direction of the developing roller, a solubility parameter of a material of the synthetic resin member is 23 (J/cm.sup.3).sup.1/2 or more, and the magnetic toner contains toner and resin fine particles.
2. The developing device according to claim 1, wherein the resin fine particles contain particles of a styrene-acrylic resin, and a mean primary particle size of the particles of the styrene-acrylic resin is 30 nm or more but 150 nm or less.
3. The developing device according to claim 1, wherein a difference between a solubility parameter of the resin fine particles and the solubility parameter of the material of the synthetic resin member is 5 (J/cm.sup.3).sup.1/2 or more.
4. The developing device according to claim 1, wherein the material of the synthetic resin member is an acrylonitrile butadiene styrene (ABS) resin or a polyamide resin.