Improved Separating Agent for Roller Fusing

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Abstract

A release agent, in particular silicon oil, is applied to the surface of a fuser roller of a digital printer using dry toner to reduce contamination. Contamination of the surfaces is reduced or even prevented when the separating agent is diluted with a solvent having a boiling point in the range 60°C to 160°C.

As the temperature of the fuser roller is significantly above the boiling point of the solvent it evaporates immediately after application resulting in a thin and smooth layer of fuser oil on the fuser rollers.

Due the viscosity reduction by the addition of solvent, silicone oil with higher viscosity can be used and can be diluted by the solvent to the viscosity necessary for application. Thus the viscosity of the oil applied to the roller is higher after evaporation of the solvent compared to application of lower viscosity oil without dilution. That reduces volatilization of the oil off the roller that may cause oil pollution of other parts of the printer.

The solvents reduce the viscosity of the oil that much that it maybe applied to the fuser roller point wise by e.g. an ink jet application device. The image data allow controlling the quantity of oil depending on the amount of toner.

The evaporated solvent has to be removed from the exhaust air of printer by suitable filtering means before the air leaves the printer. Beside the solvent, ozone from the corona charger in the electrophotographic process has to be removed. This can be done in a special environment by first reaction the evaporated solvent - preferably a halogen containing solvent - with the ozone and then extracting the reaction product from the exhaust air by suitable filter e.g. charcoal filter.

Introduction

In copiers and printing machines, in particular in electro-photographic printing machines, toner from electrophotographic devices is applied to a printing medium for the purpose of generating an ultimate image on the printing medium that corresponds to the data provided for the desired image. In order to avoid smearing of the toner on the printing medium the toner is generally fused by simultaneously applying pressure and heat to the surface of the printing medium. For this purpose fuser mechanisms are used, which can contain various fuser elements. These mechanisms are often a fuser roller and a pressure roller that is located across a printing medium transport path from the fuser roller. The path traveled by the printing medium leads between the fuser roller and the pressure roller through the so-called nip. The fuser roller is heated for the fusing process and the pressure roller is pressed against the fuser roller. This enables the toner to melt and ultimately to fuse onto the surface of the printing medium. It is also possible that the two fusing elements, i.e., the fuser roller and the pressure roller, are identically formed and that both are heated.

To allow the printing medium to pass smoothly through the nip, the fuser roller and the pressure roller each rotate in the printing medium's direction of travel. A problem arises in this process at the moment when the printing medium on which the toner layer has been fused is supposed to separate from the fuser roller. At that moment toner offset can occur, whereby same toner detaches itself from the printing medium and becomes attached to the surface of the fuser roller. The resulting image is then severely adversely affected and the fuser roller becomes contaminated.

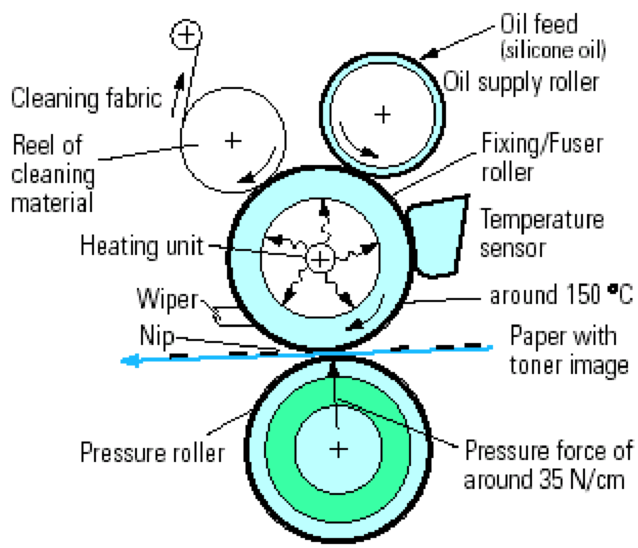

Figure 1. Example of heat roller fusing unit with *oil supply roller*[1]

Separating agents are used to solve the problem. They reduce the bond between the surface of the toner and the fuser roller, so that such bond is out-weighed by the bond between the toner and the printing medium. Accordingly, offset is substantially prevented. Silicon oil is the main choice among the separating agents in use. It is applied to the surface of the fuser roller on the upstream side of the nip. For this purpose coating rollers or fabrics (Figure 1), for example, are used to apply the silicon oil.

Once the separating agent is on the fuser roller, it must be sufficiently viscous so that it remains on the surface of the fuser roller during the fusing process and does not become transferred to the printing medium. During this time the viscosity of the separating agent is a function of the temperature. Thus, if the silicon oil must be maintained at a certain viscosity on the surface of the heated fuser roller, its viscosity at room temperature must be significantly higher. Because of the resultant high viscosity of the "cold" separating agent, the problem arises that the separating agent does not spread out homogeneously in a thin layer when being transferred from the coating roller to the surface of the fuser roller. The result is that the distribution of the separating agent on the surface is non-homogeneous so that streaks appear on the image gloss or surplus separating agent makes its way into the interior of the printing machine and then may reach the inking device. Excessive fuser oil on the paper may cause problem with finishing such as UV coating and lamination due to repellency as well.

The purpose of our work is, therefore, to improve the quality of a printed image by preventing the introduction of separating agent on the printing medium into the printing machine. This task is achieved by using improved materials and specific oil application technique.

Improved Materials

The separating agent is diluted with at least one solvent having a boiling point between 60ºC and 160°C. By addition of a solvent to the fuser oil the viscosity of the separating agent is reduced to the extent that it can be applied easily and evenly in thin layers using a coating roller.[2]

If the separating agent is then applied to the surface of the heated fuser element, the solvent evaporates out of the separating agent to such an extent that the viscosity is no longer affected by the solvent and is dependent solely upon the separating agent in use. Because the viscosity of the separating agent is already reduced due to the temperature on the surface of fuser element, the resulting viscosity is fully sufficient to prevent a toner offset. For this purpose the separating agent must have a viscosity that is lower than that of the toner but not too low to avoid the disadvantages with respect to printer quality described above.

Alternatively, more than one solvent, having varying boiling points, may be used to thin the separating agent is expressly included herein. In this way it can be advantageously possible for the temperature dependency of the mixture of separating agent and solvents to be adapted to the prevailing circumstances. It is, in particular, possible that at each point in time while the temperature of the surface of the fuser element is being raised, the viscosity of the separating agent remains essentially constant. This can make an especially even distribution of separating agent on the surface of the fuser element even more possible.

The solvent for the fuser device separating agent belongs to one of the following groups or their derivatives: THF, toluene, ethyl acetate, butyl acetate, propylene acetate, methylethylketone, Hexane, chlorbenzol, dichlormethane or 111 trichlorethane. Advantageously this solvent and its derivatives have characteristics such that they mix well with separating agents and have suitable boiling points within the required range. Specifically suitable are solvents that contain halogens.

In a further development for the separating agent to be diluted such that a viscosity is obtained that is suitable for applying the separating agent to the surface of the fuser roller. In this way, depending upon the application mechanism or element used, such as a coating roller or spray nozzles, an ideal viscosity can be achieved.

Specifically the viscosity of the diluted separating agent is less than 20%, preferably equal to or less than 18% of that of the undiluted separating agent. The viscosity of silicon oil at a temperature that approximates that of the heated surface of a fuser roller (160°C) is approximately 18% of the viscosity of the silicon oil at room temperature (Figure 2). This concentration has been shown by to be sufficient so that the viscosity of the heated silicon oil is essentially equal to or less than the viscosity of the diluted silicon oil at room temperature. In this range of dilution, the viscosity achieved is, within limits, independent of the solvent that is used. The achieved viscosity differs then by just a few percentage points from the viscosity of the heated silicon oil. Thus, in this embodiment the viscosity on the surface of the fuser element is not reduced. The separating agent can then be homogeneously distributed on the surface of the fuser roller.

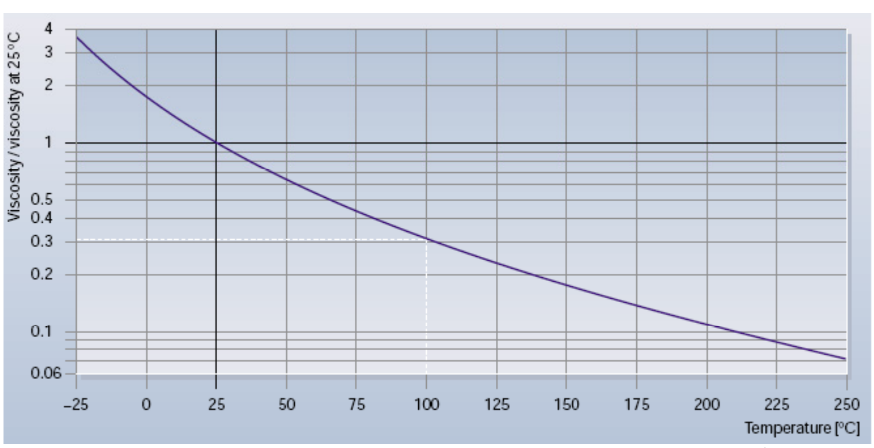

Figure 2. Temperature dependence of viscosity of silicone oil in relation to viscosity at 25°C[3]

It is even possible that one would want the viscosity of the separating agent, before it is applied to the fuser element, to be lower than when it is at the fuser temperature. This can be the case when the separating agent is sprayed or squirted through jets onto the surface of the fuser element. In this case the viscosity should not more than 80 cSt. In this case the diluted separating agent may contain more than 20% by volume of solvent up till 50% to 75%. Mainly, then, the separating agent has a viscosity that is suitable for application be a spraying mechanism. The precise percent by volume can then be a function of the separating agent used. For example, silicon oils with a viscosity of 350 cSt or 1000 cSt have, when diluted 50% or 75% respectively, approximately the same viscosity as is necessary for spraying the separating agent onto the surface of the fuser element using a piezoelectric process.

Application Techniques

The solvents reduce the viscosity of the oil that much that it maybe applied to the fuser roller point wise by e.g. an ink jet application device[4] or a “channel printing”[5] applicator instead of roller coating or web coating applicator commonly used.

The image data allow controlling the quantity of oil depending on the amount of toner. On roller surface area that comes in contact with plane paper no oil or low amounts of oil are applied. On areas with maximum toner layer another (usually higher) oil amount maybe applied.

Examples

Mixing Experiments

Mixing experiments were performed with different mixing ratios of Silicone Oil with the nominal viscosities at 25°C of 350cP and 1000cP, which are typically used in color production printers. Such silicon oils can be obtained from, for example, Wacker Silicon Oil AK.

The solvents used have the following properties:

Solvent	Boiling Point	Density [g/cm³]	Evaporation time [min] (Ether: 1)
Methylen-chloride	42°C	1.34	1.8
THF	64°C	0.90	2
Ethyl acetate	77°C	0.90	2.7
Propyl-acetate	102°C	0.9	4.8
Toluene	111°C	0.86	4.5

Figure 3 shows the viscosity of a mixture of silicone with toluene for different volume mixing ratio.

It was found that the other solvents mentioned follow the same curve within the tolerances of the measurement. They differ when the viscosity is plotted against weight percent.

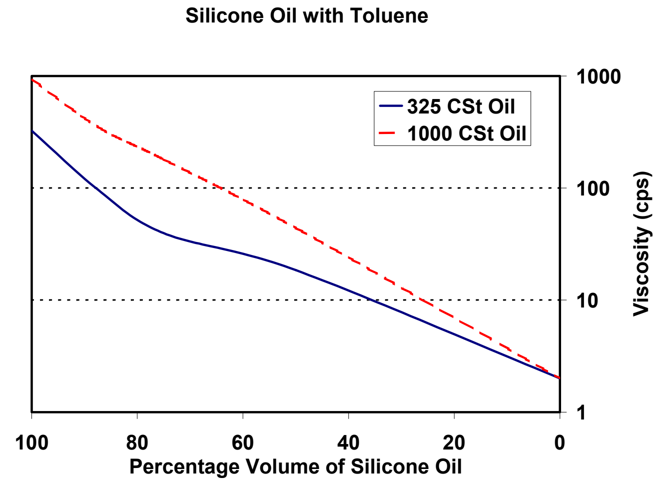

Figure 3. Viscosity of silicone oils diluted with toluene

The viscosity drops by an order, when app. 35Vol.% solvent is added to the silicone oil. The viscosity <= 80cSt necessary for application in an piezo device is achieved when app. 50% solvent is added to the 325cSt oil (or app.75% added to the 1000cSt. oil).

To achieve same viscosity (of the diluted oil) at 25°C and (of the oil with evaporated oil) at 160°C lower dilution is sufficient. The viscosity of the oils at 160°C can be determined from the master curve of temperature dependence of viscosity published in Figure 2.

By increase of temperature from 25°C to 160°C the viscosity drops to app.18% of the value at 25°C. To achieve the same reduction the addition of 20% - 25% solvent is sufficient.

Application Experiments

Example 1

Silicon oil with a viscosity of 1000 cSt (Wacker Silicon Oil AK 1000) is used as the separating agent. This silicon oil is then mixed with 75% by volume of Toluene. The viscosity of the separating agent is thereby reduced to a viscosity that is below or equal to 20cSt at 25ºC.

The separating agent is then filled into a piezoelectric mechanism, such as those conventionally used in ink jet processes. Additional heating of the separating agent in order to make application possible is no longer necessary in this situation. The separating agent can be selectively sprayed onto these areas of the fuser roller that come into contact with toner or applied to the entire surface of the fuser roller.

The surface of the fuser roller is covered with a homogeneous layer of separating agent. Because the temperature of the fuser roller is at approximately 160ºC, and because the boiling point of toluene is 111ºC, almost all of the toluene evaporates. The viscosity of the silicon oil on the surface of the fuser roller is now about 180 cSt. The amount of oil that is applied is adjusted such that, even when the maximum amount of toner is on the printing medium, toner offset is prevented.

Example2

Silicon oil with a viscosity of 350 cSt (Wacker Silicon Oil AK350) is used as the separating agent. This silicon oil is then mixed with 20% by volume of Toluene. The viscosity of the separating agent is thereby reduced to a viscosity that is equal to or below 65cSt at 25ºC. The viscosity of the diluted separating agent at 25ºC approximately corresponds then to the viscosity at 160ºC.

The separating agent is then applied to the fuser roller by a coating roller. The surface of the fuser roller is covered with a homogeneous layer of separating agent. Because the temperature of the fuser roller is at approximately 160ºC, and because the boiling point of toluene is 111ºC, almost all of the toluene evaporates. The viscosity of the silicon oil on the surface of the fuser roller is now about 65 cSt. The amount of oil that is applied is adjusted such that, even when the maximum amount of toner is on the printing medium, toner offset is prevented.

Vapor Evaporation

The evaporated solvent reacts inside the printing machine with the ozone that has resulted from corona chargers.[6] The reactive mixture is removed from the interior of the printing machine by a blower and passed through a carbon filter that removes it from the air.

Conclusions

There is a trend in the industry towards low-oil or oil-free roller fusing. As long as oil is necessary there is a need for application techniques that allow even application of thin oil layers. Our approach compensates the temperature dependence of silicone fuser oil by addition of solvents that evaporate at fusing temperatures. Additionally the dilution of fuser oil allows digitally controlled application in the toned areas of the page. The solvent or their reaction processes have to be filtered out of the exhaust air of the printer.

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Author Biographies

Detlef Schulze-Hagenest received his Ph.D. in Physics from Kaiserslautern-University in 1980. Since 1980 he is working in the field of platforms, processes and materials for digital printing with special focus on electrophotography and ink jet. He is currently Senior Engineer Advanced Technology at NexPress GmbH, Kiel, Germany, a company in the Kodak Graphic Communication Group. He is a member of the IS&T.

Dinesh Tyagi received his Ph.D. degree from Virginia Tech in 1985 from the Department of Chemical Engineering. After one year of post-doctoral position there, he joined Eastman Kodak Company and in 1993 he was appointed Research Associate. In 1999 he joined NexPress Solutions, now a company in the Kodak Graphic Communication Group and has continued to work in the area of toners and electrophotography. He has over 60 patents worldwide.