Pad Transfer System for Small Color Laser Printer

*Yasuo Yoda[1], Ryosuke Hamamoto[1], Yoichiro Maebashi[1], Kenji Kanari[1], Masaru Shimura[1], Seiji Saito[1], Kazuhiro Doda[1], Toyoshige Sasaki[2], Seishirou Nasu[2], Asako Sugiyama[2], Takuma Onishi[2], Takeshi Tomizawa[3]; *1 Peripherals Development Center, Canon Inc., Shizuoka, Japan; *2 Analysis Technology Center, Canon Inc., Tokyo, Japan;*3 Office Imaging Products Device Development Center, Canon Inc., Ibaraki, Japan*

Abstract

Canon has newly developed a transfer system that utilizes a pad as a transfer process, and adopted it on a small color laser printer, LBP5050. During transfer process, it is necessary to provide an enough transfer electric field to toner as regulating scattering caused by pre-transfer and discharge marks by separating discharge. This report clarifies that, with the conventional roller transfer system, it is necessary to minimize an upstream tension nip width, and maximize a physical nip width and downstream tension nip width in order to achieve an optimal condition. Also, by comparing the pad transfer system and the roller transfer system in their abilities to transfer, this report estimates problems that could occur in minimizing the size of devices with the roller transfer system and concludes, with the use of pad transfer system, those problems can easily be resolved. Ultimately, the pad transfer system is superior in its compactness and image quality to the roller transfer system.

Introduction

Canon released a compact, user-friendly, and energy efficient A4 color laser printer, LBP5050 on May 2008. Its innovative features include a 4-sequential tandem engine utilizing an intermediate transfer belt (ITB), S-toner, single component development system, on-demand fuser system, and pad transfer system. Table 1 below show the basic specifications of the LBP5050. Figure 1 illustrates the cross section of the LBP5050. In order to minimize the size of printer, the new technology, pad transfer system, is installed on the LBP5050 for the first transfer process. This transfer system utilizes a resin sheet and foam rubber pad which supports the resin sheet, and replaces the traditional roller transfer system. The pad transfer system is developed by analyzing the mechanism of roller transfer system, and considering conditions required to achieve the best transfer performance. This report explains reasons why the development of the pad transfer system, enabled by simulating the analysis of roller transfer system, came into play and also compares transfer performance of the pad transfer system and roller transfer system.

Pad Transfer System

Figure 2 illustrates the cross section of pad transfer unit which is part of the first transfer system of LBP5050. A pad transfer unit consists of a sheet, pad, sheet holder, pad stay, and pad holder. The sheet is fixed at the pad stay by the sheet holder. The pad stay is fixed at the pad holder, and the location of the pad transfer unit to an Organic-photoconductor drum (OPC drum) is determined by the location of the pad holder. By pressing the pad holder toward the OPC drum, the bendable sheet will be sandwiched between an elastic pad and ITB, and create transfer nip. Since ITB slides on the sheet and requires charge to retain the toner on its surface, its material uses slidable and conductive resins.

Figure 3 is an illustration of the shape of the transfer nip calculated by structural analysis. In the figure, the cross mark stands for the location of the surface of OPC drum right under the central point of OPC drum. In the pad transfer system, it is possible to control the width where the sheet and ITB contact by changing the shape of the pad and sheet, and arranging where they locate without changing the thickness of pad transfer unit.

Table 1 Specifications of LBP5050

Type	Desktop color laser printer
Printing method	Electro-photography
Photoreceptor	Organic-photoconductor drum
Print speed	B/W: up to 12ppm (A4) Color: up to 8ppm (A4)
Warm-up time	About 25s from power on
Recovery time	About 0.5s from sleep state
Typical Electricity Consumption	1.47kWh/week
Media size (W x L)	A5 to 215.9 x 355.6mm
Media weight	60 to 220g/m^2
Dimensions (W x D x H)	401 x 452 x 262mm
Weight	Approximately 16kg

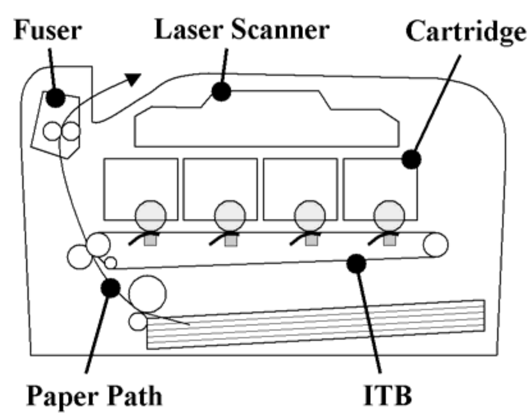

***Figure 1**. Cross-section of LBP5050*

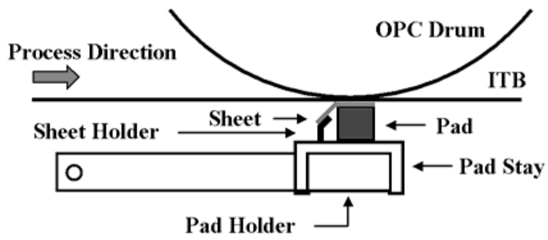

***Figure 2**. Cross-section of pad transfer unit*

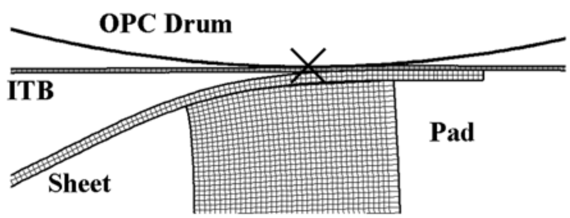

***Figure 3**. Nip shape calculation result of pad transfer system*

Roller Transfer System Simulation

First, this will examine the mechanism of the traditional roller transfer system, and find out what conditions will meet the best transfer performance quality.

Nip Shape

In a roller transfer system, the first transfer process is composed of an OPC drum, ITB, and transfer roller. Figure 4 shows the result of structural analysis where these elements are in contact. The cross mark in the figure represents a point right under the central point of OPC drum. In general, the transfer roller is placed at the central point of the OPC drum and shifted toward the process direction. This report calls this state ‘offset’.

Figure 4 illustrates the result when the offsets are 0.5mm and 2.5mm respectively. The width where the OPC drum and ITB are in contact is shorter than that of the transfer roller and ITB in contact. This is because foam rubber which composes a transfer roller is soft whereas the OPC drum is made of aluminum.

Figure 5 exhibits a contacting state of Figure 4. The state can be divided into three regions. (1) shows where only an ITB and transfer roller are in contact, (2) shows where all the three elements: transfer roller, ITB, and OPC drum are in contact, (3) shows where only a transfer roller and ITB are in contact. This report defines (1) as upstream tension nip, (2) as physical nip, and (3) as downstream tension nip. According to Figure 4, upstream tension nip, physical nip, and downstream tension nip are 0.4mm, 0.2mm and 0.9mm respectively in width when an offset is 0.5mm, 0mm, 0mm and 1.6mm respectively when the offset is 2.5mm.

Nip Shape Influence on Image Quality

Electric field simulation is applied to the nipped region obtained in Figure 4. The electric field simulation considers electrical conductivity based on Ohm's law [1].

Figure 6 illustrates an electric field between an OPC drum and ITB. The horizontal axis represents a position coordinate supposing the cross point is the original point in Figure 4. In the upper nipped region(x<0), an electric field is higher when the offset is 0.5mm than the one when the offset is 2.5mm. This is because the transfer roller is set in the upstream and electric charges that were put from the upstream tension nip move to the upstream in ITB. In the upper nipped region, an electric field between an OPC drum and ITB transfers toner. As a result, when the offset is 0.5mm, it is more likely that toner is transferred from an even upper region. In order to reduce the scattering during this process, it is necessary to minimize the width of the upstream tension nip.

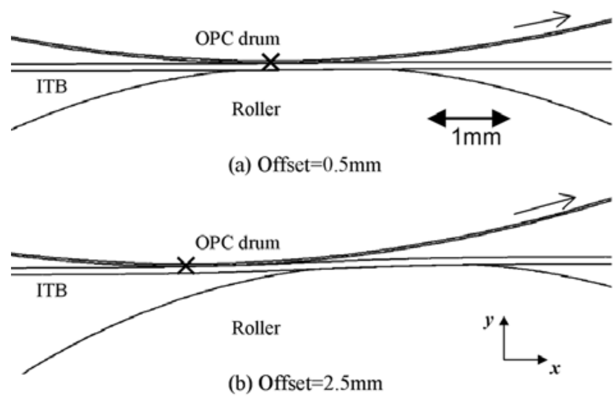

***Figure 4**. Calculation results of nip shape*

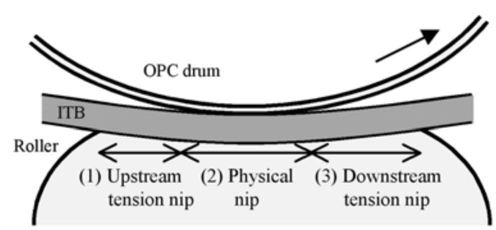

***Figure 5**. Schematic illustration of nip region*

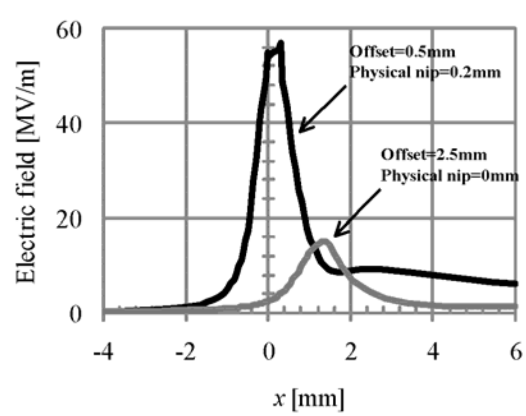

***Figure 6**. Electric field between OPC drum and ITB*

In addition, it is clear from Figure 6 that an electric field is the strongest at physical nip when the offset is 0.5mm. At the physical nip, all the three elements, OPC drum, ITB, and transfer roller get together and an air gap becomes the smallest. Consequently, the electric field becomes very strong. On the other hand, when the offset is 2.5mm, its peak reaches only about one third of that of the 0.5mm offset. This is because when the offset is 2.5mm, the air gap still remains among an OPC drum, ITB, and transfer roller. The physical nip strongly influences a transfer electric field, and it is essential for enhancing transfer efficiency to create enough physical nip.

Figure 7 displays the electric charge density in ITB when the offset is 0.5mm and no discharge is taking place in terms of transfer bias. The horizontal axis means an x axis. Seen in the figure, the electric charge density sharply increases from x= -0.4mm. It is obvious from Figure 4 that this is the point where the ITB and transfer roller begin to contact and where the upstream tension nip starts. After that, it reaches its peak around 0.0mm, which is physical nip. Then it decreases gradually till x=1.2mm which is the end of the downstream tension nip. The next Figure 8 shows an electric field in the transfer roller by arrow when the offset is 0.5mm, and the field represents flows of the electric current. In Figure 8, a current from the downstream tension nip to the upstream tension nip is observed. This is because ITB with positive charges estranges from the OPC drum and the voltage rises in the area. According to the detailed examination, the electric charges put into ITB from the transfer roller in the upper nipped region are advected to the lower nipped region along with the ITB. After returning to the transfer roller in the lower nipped region, the charges go back to the upper nipped region as shown in Figure 8. Therefore, the charges circulate in the process.

Figure 9 is a magnification of the electric field in the lower nipped region in Figure 6, and the broken line stands for Paschen's curve. The horizontal axis represents the gap length between an OPC drum and ITB. In Figure 9, an electric field in the lower nipped region is higher when the offset is 0.5mm compared to when the offset is 2.5mm. This is because there are more charges put into ITB from the transfer roller at physical nip. Additionally, since the width of the downstream tension nip is short, the charges are not able to return from ITB to the transfer roller in the lower nipped region. A high voltage in the lower nipped region contributes to separating discharge. As seen in Figure 9, after the 100μm gap when the offset is 0.5mm, an electric field curve surpasses Paschen's curve, resulting separating discharge. It has already been known from our experiences that discharge which occurs after 100μm is abnormal discharge and leaving discharge marks on toner image. In order to prevent separating discharge in the lower nipped region, it is vital to give an enough downstream tension nip.

In conclusion, to obtain the best transfer performance, the upstream tension nip needs to be small and there needs to have enough physical nip and downstream tension nip.

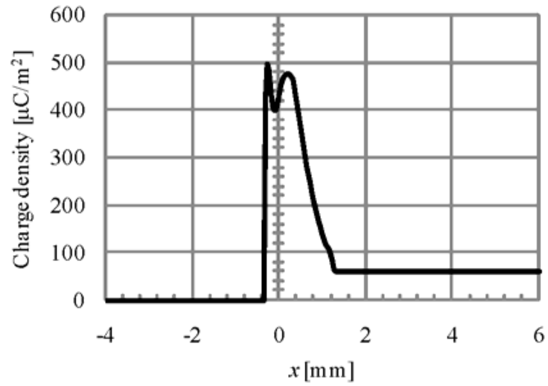

***Figure 7**. Calculation result of charge density in ITB when offset is 0.5mm*

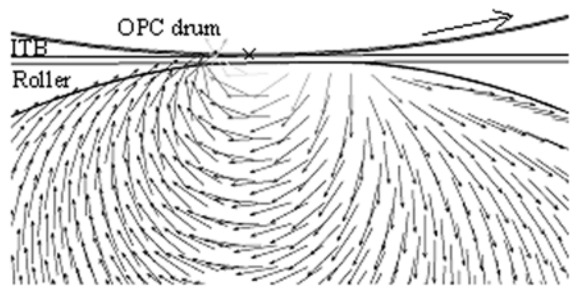

***Figure 8**. Calculation result of electric field in transfer roller when offset is 0.5mm*

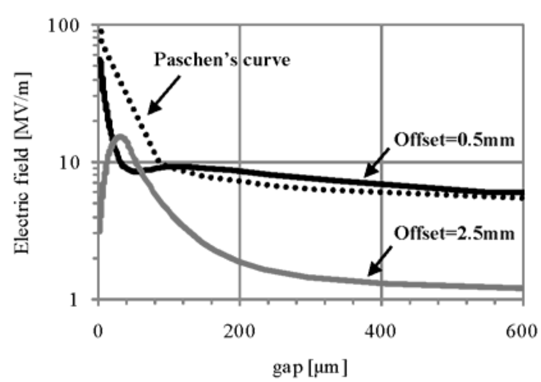

***Figure 9**. Electric field between OPC drum and ITB in downstream nip region*

Comparison of Pad Transfer System and Roller Transfer System

Next, this report will compare a pad transfer system with two roller transfer systems in their performances. The three kinds of system are used in this comparison: a pad transfer system and roller transfer systems with a 14mm roller and a 10mm roller. Figure 10 illustrates measures of each system. The roller transfer system with a 14mm roller is a conventional system. The roller transfer system with a 10mm roller is at the same height as the pad transfer system and is a miniaturized model designed for a small spaced place.

Figure 11 and Figure 12 are the simulation results that illustrate relationships between offsets and transfer characteristics. In this simulation, as it is done above, the shape of the nipped region is calculated by structural analysis, and then an electric field simulation is utilized based on the shape. Now, this electric field simulation considers discharge [1]. Figure 11 shows distance of the longest discharge gap calculated by the electric field simulation. This is based on our experience that discharge marks by downstream discharge mentioned above originates in discharge which occurs in over 100μm long gap. From Figure 11, as the offset increases, discharge in the long gap disappears. This is a result of widening the downstream nip. It is also shown in the figure that whereas the system with a 14mm roller requires a 3mm offset, the other system with a 10mm roller requires a 4mm offset. In the pad transfer system, since the contacting area between ITB and the sheet is large, an enough width of the downstream tension nip is obtained as shown in Figure 3. This reduces discharge in the long gap in a small offset.

Figure 12 shows relationships between bias and a maximum transfer electric field when the offset avoids long gap discharge in each transfer system. Calculations are done under the condition that offsets of each system are 3mm for the roller transfer system with a 14mm roller, 4mm for the roller transfer system with a 10mm roller, and 1mm for the pad transfer system. The result shows the widths of physical nip of each system: 0.5mm for the roller transfer system with a 14mm roller, 0mm for the roller transfer system with a 10mm roller, and 0.5mm for the pad transfer system. From Figure 12, the roller transfer system with a 10mm roller can only create a low transfer electric field compared to the one with a 14mm roller due to the large size of its offset which shortens the width of physical nip. Since the area where ITB and the sheet contact is broader, the pad transfer system can easily obtain a high transfer electric field with regulating discharge in the long gap.

Ultimately, there are no further potentials with roller transfer system to minimize the devices by miniaturizing the size of their rollers without leaving discharge marks. The only solution is to increase bias, but this is unfavorable in terms of designing transfer system. On the other hand, the pad transfer system enables broadening the area where ITB and the sheet contact with ease; thus, miniaturizing the devices will be attainable with the low possibility of leaving discharge marks and a high transfer electric field.

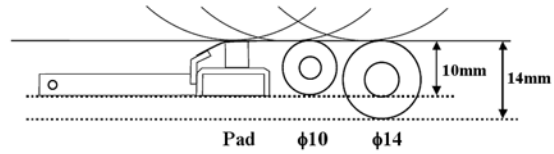

Figure 10*. Comparison of transfer system elements*

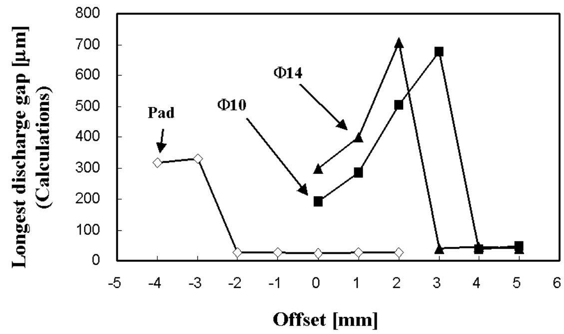

Figure 11*. Relationship between offset and longest discharge gap*

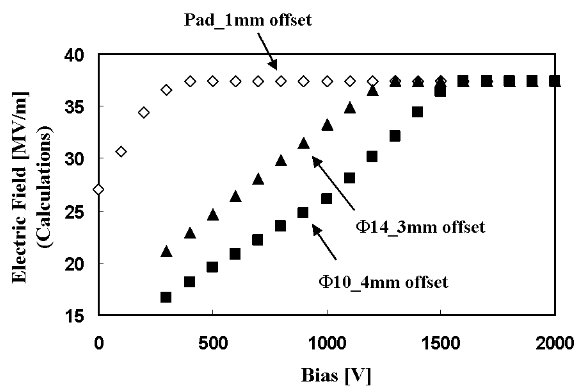

Figure 12*. Relationship between bias and maximum transfer electric field*

Conclusion

We developed a new transfer system which adopted a pad. With this system, it is viable to miniaturize devises with keeping a desirable shape of the nipped regions.

References

[1] T. Sasaki, T. Onishi, A. Sugiyama, Y. Yoda, T. Tomizawa, Second Transfer Process Simulation I, Proc. IS&T's: NIP24,p338-341 (2008).

Author Biography

Yasuo Yoda received his B.E. and M.E. degrees in Electronic Engineering from Yamanashi University, Japan in 1991 and 1993, respectively. He joined Canon Inc. in 1993 and has been engaged in the development of electro-photography.