Advanced Intermediate Transfer Belt Mechanism Driven by Photoconductor Belt

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Abstract

The intermediate transfer belt tracking mechanism driven by the photoconductor belt is one of main features of our four cycle color laser printer. This mechanism has an advantage on precise color registration performance because the intermediate transfer belt driving is not influenced by speed difference between the transfer and the photoconductor belt.

There are two major points of employing the intermediate transfer belt driven by the photoconductor belt system.

(1) A large diameter roller is employed for a nip region with photoconductor belt, and a smaller diameter roller is employed for a second transfer region. The large diameter roller improves driving force and the stability driving because of the wide nip region. The small diameter roller secures the paper peeling margin on the second transfer region.

(2) The reinforcement tapes are placed on the edges of the transfer belt. The large diameter roller has flanges that prevent the transfer belt meander. As a result, the highly precise color registration performance is able to achieve.

Background

Recently, desktop color laser printer is becoming smaller in size and lower in price rapidly. For these reasons, we have adopted the intermediate transfer drum driven by the photoconductor belt since 1993. This mechanism has an advantage on precise color registration because driving intermediate transfer drum is not influenced by the speed difference between the intermediate transfer drum and the photoconductor belt. Moreover, there is a cost merit because it only needs one driving system to drive both the intermediate transfer drum and the photoconductor belt. For our new four cycle color laser printer, the enhanced intermediate transfer system has been adopted. Instead of the intermediate transfer drum, we use intermediate transfer belt in order to expand margin of paper peeling in the second transfer region. In this machine, the intermediate transfer belt is also driven by the photoconductor belt.

In order to obtain stable driving action of the intermediate transfer belt, it is necessary to stabilize driving force from the photoconductor belt, which determines the precision of the color registration. Moreover, stable driving action of the intermediate transfer belt is able to extend the intermediate transfer belt life. Therefore, even though our machine uses the polycarbonate (PC) intermediate transfer belt, which is relatively low-price comparing to other materials; there is no need to exchange the intermediate transfer belt during the machine life.

This machine can print 8PPM in full color printing and 31 PPM in black and white. It is the top level printing speed in a four-rotation machine of this price class.

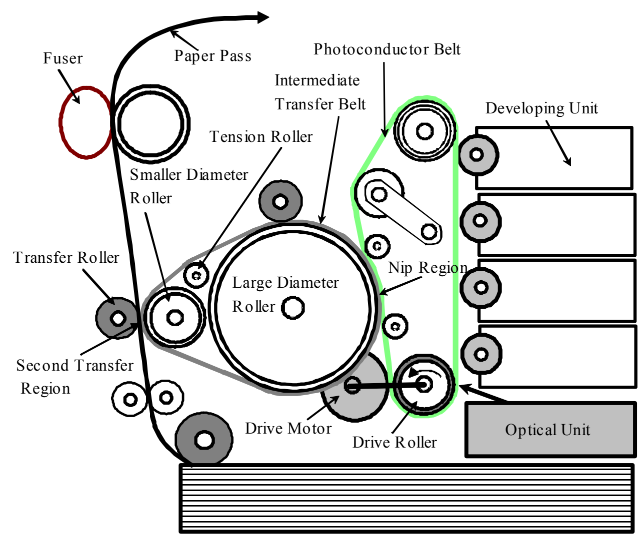

Figure 1. Schematic Diagram of the Printer with Advanced Intermediate Transfer Belt Mechanism.

Composition

Figure 1 is a schematic diagram of the printer with Advanced Intermediate Transfer Belt Mechanism.

This mechanism uses four cycle process to create full color image. In case of full color printing, first a single color image is developed on the photoconductor belt. Secondly, the image transfers to the intermediate transfer belt at the nip region. Then this process is repeated four times with four different colors. Finally, the full color image is created on the intermediate transfer belt.

Our machine uses only one motor to drive the driving roller of the photoconductor belt, fuser, and the other mechanical components except the developing units. The intermediate transfer belt obtains driving force from the photoconductor belt through the nip region.

The intermediate transfer belt is composed with three rollers: a roller with largest diameter on the photoconductor belt side, a roller with small diameter on the paper pass side, and a tension roller.

The small curvature of the small diameter roller contributes to the expansion of the paper peeling margin at the second transfer region. The large diameter roller is able to obtain the wide nip between the intermediate transfer belt and the photoconductor belt, which consequently increases the mechanical force between them.

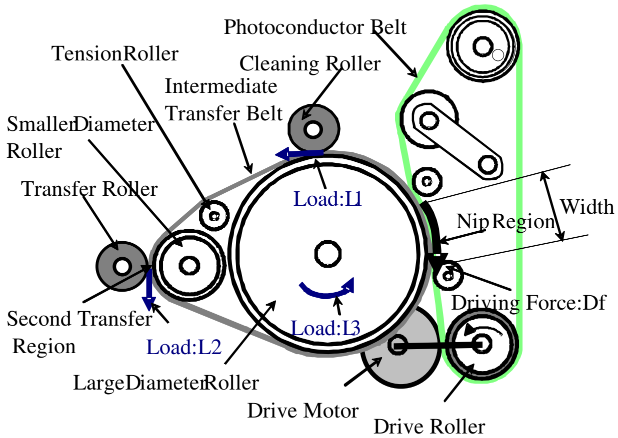

Figure 2. Schematic Diagram of the Belt Units.

Feature of Advanced Intermediate Transfer Belt Mechanism

One of the main points of Advanced Intermediate Transfer Belt Mechanism is obtaining enough driving force for passively driven intermediate transfer belt.

Figure 2 shows a schematic diagram of the belt units. Load L is total load that includes the cleaning roller's load L1, the transfer roller's rotation (passive drive) load L2, and other load L3 to drive the intermediate transfer belt.

Similar to the intermediate transfer drum used by the previous machine, the large diameter roller is used at the photoconductor belt side in order to obtain wide nip region. The wide nip region can easily improve driving force for the intermediate transfer belt driving action.

$Df = \mu (Fe + Fm)$

The driving force Df in the nip region is able to calculate using the following expression: where, μ is a coefficient of friction of the nip region, Fe is an electrostatic adsorption force, and Fm is a mechanical pressing force. It is known that the Fe and Fm are proportional to the nip width.[1]

Figure 3 shows the experimentally obtained relationship between the width of nip region and the driving force. It is obvious that the driving force and the width of nip region are in proportional relationship.

The total load on the intermediate transfer belt determines necessary driving force. If driving force is insufficient, slip between the intermediate transfer belts and the photoconductor belt occurs and the belt driving velocity becomes unstable. Since four images overlap on the intermediate transfer belt, the unstable belt driving velocity caused by the slip results poor color registration.

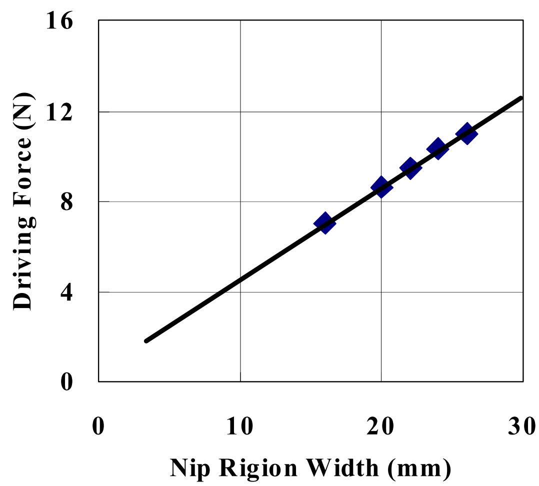

Figure 3. Relationship between the Nip Width and the Driving Force.

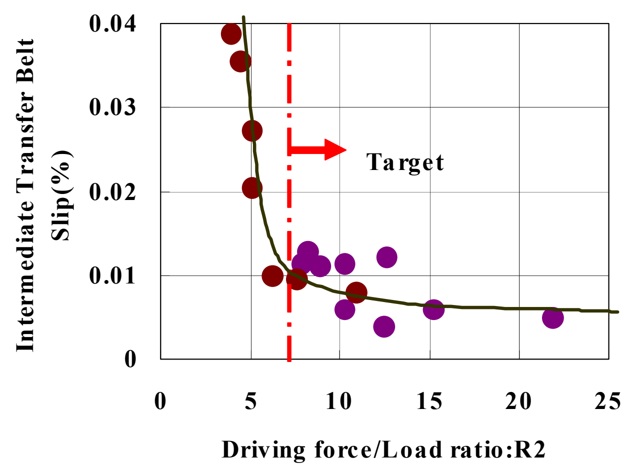

Figure 4. Relationship between Driving Force/Load Ratio and the Intermediate Transfer Belt Slip.

Figure 4 shows relationship between driving force/load ratio and the intermediate transfer belt slip. The amount of the intermediate transfer belt slip is calculated as period change/period ×100% (where period is the time required for one rotation of the intermediate transfer belt).

When the load and driving force ratio falls below about seven, the slip ratio increases and the belt velocity rapidly becomes unstable. For our machine, the force/load ratio is set to seven or more in order to maintain low slip ratio even the driving force and the load change. However, to increase the force/load ratio, it is necessary to increase either the driving force or decrease total load. Excessive driving force increases the meander force of the intermediate transfer belt and the photoconductor belt; therefore it is necessary to properly set driving force and the nip width.

Figure 5 shows average period change of the intermediate transfer belt from the print beginning to the 5th page. In case of full-color printing, the intermediate transfer belt rotates four times. The motor rotation speed is controlled by the feedback system. Using this system, we have achieved period change within ±0.003%.

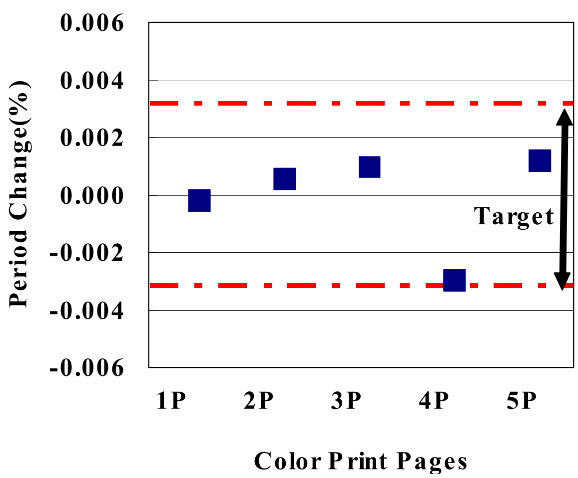

Figure 5. Average Period Change on Full Color Printing.

The flanges are installed at both edges of large diameter roller, and the intermediate transfer belt has reinforcement tapes made by 0.05mm thick PET at both edges. There are two main reasons why this system is possible. First of all, since the intermediate transfer belt is passively driven, the belt tension can be reduced; consequently reduces the stress concentration on the belt. Secondly, the contact length between the belt edge and the flange is long due to the usage of large diameter roller; consequently belt meandering force distributes evenly on the belt edges. Therefore, our new belt meander preventing system lowers the chances of belt cracking problem and accordingly extends the belt life.

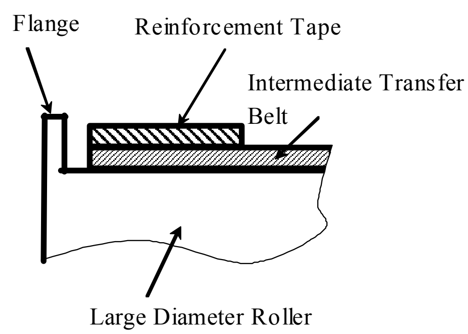

Figure 6. Cross Section of the Large Diameter Roller and the Intermediate Transfer Belt Edge.

Machine-Life Long Intermediate Transfer Belt

For extending the lifetime of the intermediate transfer belt, there are two major problems: belt meander problem and belt creep problem.

The belt meander is mostly caused by: the belt length difference of the both sides, the misalignment of the rollers inside the belt, and the misalignment between the intermediate transfer belt and the photoconductor belt. A common method to prevent a belt meander is the placing ribs inside the belt surface. These ribs constantly contact at the edge of the rollers inside the belt and prevent meander. However, this method contains a problem such as the belt crack induced by the stress concentration on the belt at the rib region.

Figure 6 shows our new optimal method of preventing meandering for our Advanced Intermediate Transfer Belt Mechanism. Table 1 shows materials and thickness of the intermediate transfer belt and the reinforcement tape. The intermediate transfer belt is made by 0.15 mm thick polycarbonate (PC) which generally uses low price class.

The belt creep occurs due to the increase of belt surface stress mainly caused by wrapping around the small curvature roller with certain belt tension. When the deformed shape of the belt remains and as the belt rotates, the belt flaps and distorts the image on the photoconductor belt. Increasing the belt tension can decrease this belt flap.

Figure 7 shows the position where the height of the belt deformation is measured. The height was measured by the laser displacement sensor at 20mm upstream position of the nip region. Figure 8 shows relationship between the intermediate transfer belt tension and the deformation height. The deformation height decreases as the tension of the intermediate transfer belt is increased, and the deformation disappears at 13N. Therefore, our machine's belt tension is set greater than 13N to reduce the belt flapping image distortion. However, it is necessary to optimize the belt tension in order to extend the belt life.

Table 1: Materials and Thickness

Intermediate Transfer Belt	Materials	Polycarbonate (PC)
	Thickness	0.15mm
Reinforcement Tape	Materials	Polyethyleneterephthalate(PET)
	Thickness	0.05mm

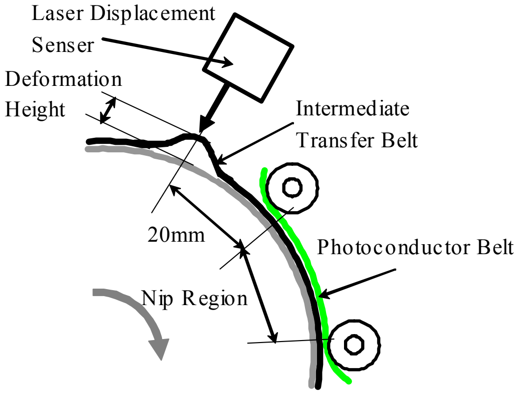

Figure 7. Cross section of the Position where the Height is measured.

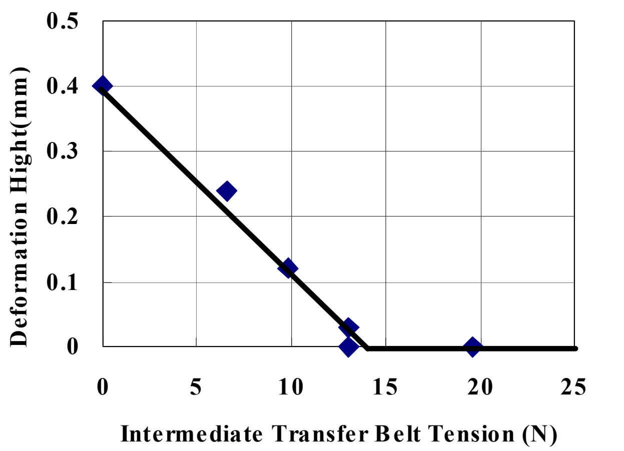

Figure 8. Relationship between the Intermediate Transfer Belt Tension and the Height at 20mm back to the Nip Region.

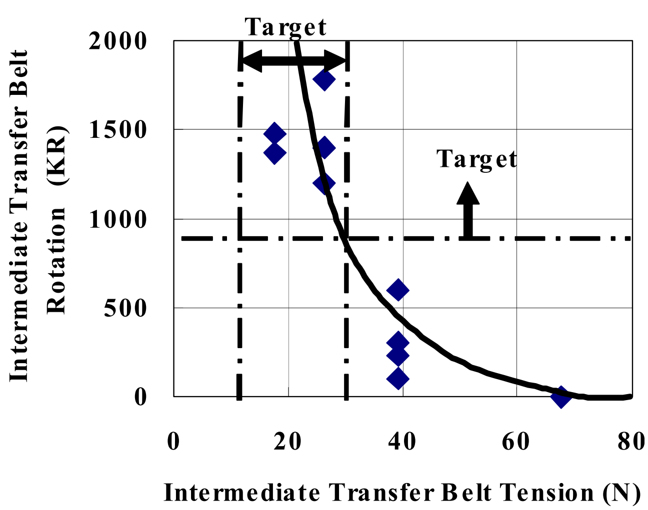

Figure 9. Relationship between the Intermediate Transfer Belt Tension and the Number of Revolutions until Cracking on the Edge of the Intermediate Transfer Belt.

Figure 9 indicates the relationship between the number of revolutions until the belt cracking on the edge occurs and the tension of the intermediate transfer belt. As the belt tension increases, the belt life span decreases. If the belt tension is under 30N, this mechanism can realize 900K revolutions without the belt crack.

As the result, our machine successfully uses the polycarbonate (PC) made intermediate transfer belt, which is relatively low price comparing to other material, through out the machine life. It also contributes to the decrease of print page cost.

Result

We have achieved low-price, highly durable, and highly precise intermediate transfer belt system. Our Advanced Intermediate Transfer Belt Mechanism provides: low-price by achieving highly precise passive driven transfer belt system, high durability by optimal belt tension system and optimal belt meander preventing system.

References

1. S. Oohara, Proceedings of Japan Hard Copy 2001, pg. 257. (2001).(in Japan)

Author Biography

Shunichi Oohara received his B.E. in mechanical engineering from the University of Tohoku, Sendai, Japan, in 1985. He has been researching and developing mechanical structures of machineries in Mechanical Research and Development Laboratory, Hitachi, Ltd., from 1985 and in Research and Development Laboratory, Ricoh Printing Systems, Ltd since 2004. He is presently researching belt-tracking mechanisms for color laser printers. He is member of the Imaging Society of Japan.