New Induction Heating Technology and System Optimization for Energy-Saving Fuser

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Abstract

For preventing global warming, reduction of environmental impact is becoming important in imaging equipments. In MFD (Multi-Function Devices), reduction of the Typical Electricity Consumption rate (TEC rate), which represents amount of power consumptions, is required. It is important to improve energy efficiency in a fuser that consumes about 70% of whole energy in a MFD, for which electrophotographic printing process is employed.

The authors and his team developed a highly efficient fuser, for which new induction heating (IH) system is employed, by improving a conventional IH fusing technology.

For optimizing magnetic energy generation and temperature field in the fuser, simulations for magnetic field and heat transfer are carried out. As a result, the new highly efficient IH fuser is developed. In this report, its capability and performance for energy saving with high productivity of the new IH fuser are also introduced.

Introduction

Energy saving during fusing is most effective to improve total energy efficiency in a MFD system, since a fuser consumes about 70% of whole energy of the system. Significant heat is supplied to toner and paper by a high productive MFD fuser in its nip region during fusing. Application of non-heating technology during preheating mode is also important; it is because the quantity of the electric power consumed in the preheating mode is very large. It means that quick temperature rise from energy saving (off) mode to standby mode without a use of the preheating mode is required for energy saving fuser.

Therefore, it is important to achieve rapid temperature rise for the fuser by decreasing thermal capacity of fusing members. Efficient use of electric power for the fuser to melt toner is also important.

In this report, we introduce our new IH fusing technology and its developing process.

Energy Saving IH Fuser

Figure 1 shows a cross sectional view of a highly efficient fuser, which is an example dealt with in this study. Thermal capacity of its fusing roller is reduced to the utmost limit. In addition to it, IH is adopted for its heat source. Thus the rapid temperature rise is achieved. The fusing roller consists of a heat insulating roller and a fusing sleeve. In this system, fusing nip is formed between the heat-insulating roller with the fusing sleeve and a pressure roller. Time for thermal conduction to the toner in the nip region is set enough.

Figure 2 shows layer composition of the fusing roller. It consists of functional layer of release layer, elastic layer, heat generation layer, heat insulating layer, and the shaft layer, shown from its surface. The heat generation layer made of a metallic material is induction-heated, and the surface temperature of fusing roller rises quickly.

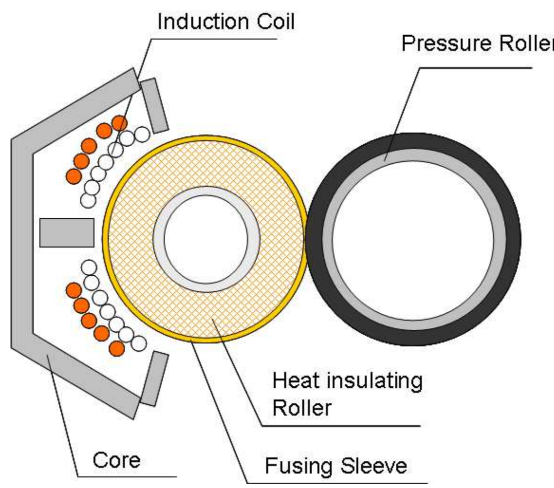

***Figure 1**. Cross sectional view of IH fuser*

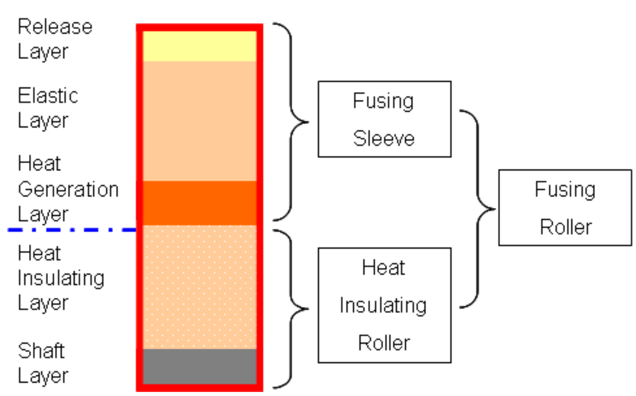

***Figure 2**. Layer Composition of Fusing Roller*

Foamed silicone rubber with a low thermal conductivity is employed as a heat-insulating layer in the fusing sleeve. Thus, the fusing roller thermal capacity is made totally low and the layer has a function for preventing thermal conduction from the heat generation layer to the inside at the same time.

Material and thickness of heat generation layer

To obtain high heating efficiency by the induction heating, we analyzed materials and thickness of the heat generation layer. The analyses of volume resistivity and the thickness of the heat generation layer are carried out by the simulation using the fuser model shown in figure 1. As a result, it is found that the difference of the heating efficiency with heat generation layer can be expressed by the eddy current load given by "Volume resistivity / thickness of the heat generation layer".

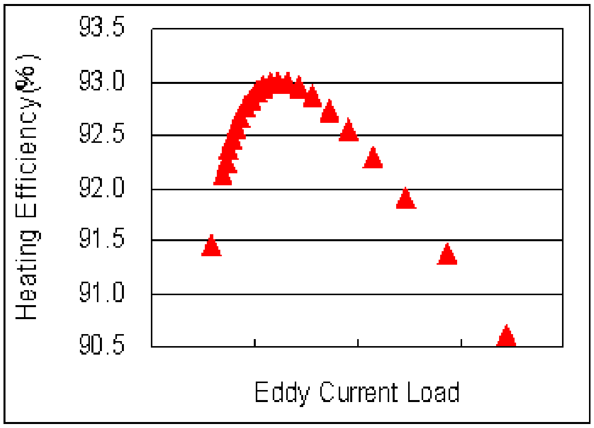

***Figure 3**. Heating Efficiency*

Figure 3 shows the correlation of the heating efficiency and the eddy current load. The heating efficiency is a ratio converted into heat generation in the heat generation layer of the electric power inputs to the fuser. So that the heating efficiency has a peak for the eddy current load, when either of the volume resistivity of the heat generation layer or thickness is decided, the other optimum value is decided. Therefore, the thickness of the heat generation layer depending on the volume resistivity of the metallic material used for the heat generation layer can be set, then heating efficiency becomes an optimum value.

Penetration of magnetic flux to the shaft

The nonmagnetic metal is used for the heat generation layer in the fuser in this study, so the magnetic flux generated by the induction coil can penetrate to the shaft layer. However, heat that generated in the shaft layer doesn't reach the fusing roller surface easily because it is intercepted by the heat insulating layer, therefore, it is desirable for the shaft layer material that is not heated by induction easily.

On the other hand, it is necessary to select a metallic material to the shaft in consideration of the bend and the withstand load. Figure 4 shows simulated magnetic flux lines. It is understood that the magnetic flux penetrates even to the shaft of nonmagnetic metal material.

Figure 5 shows a consumption rate of electric power input to this IH fuser. The shaft layer, made from the nonmagnetic metal, generates heat, and it is a factor of the decrease in the heating efficiency in the heat generation layer.

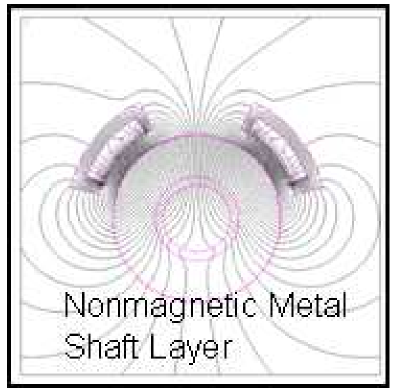

***Figure 4**. Simulation Result of Magnetic Flux*

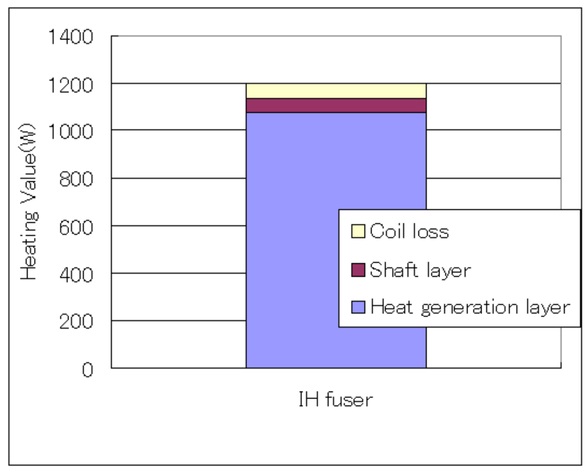

***Figure 5**. Analysis of Heating Value*

Uniform temperature distribution

To make uniform temperature distribution in the direction of longer side of the fusing roller is an important problem to obtain a uniform image in forms. Moreover, temperature over-rising in the region where the paper isn't fed is generated easily when the small size paper is fed, because the thermal capacity of the fusing member is reduced. Therefore we developed our technology that controls the heating width for various sizes of the forms.

Heating width control with sub-coil

Heating width control mechanism with a sub-coil is shown in figures 6(a) and 6(b). Figure 6(a) shows that generation of heat is not suppressed, when the current doesn't flow to a sub-coil. On the other hand, Figure 6(b) shows the flux paths in case of the heat generation layer becomes weak when the current flows to a sub-coil to generate the demagnetization flux in the direction where the magnetic flux from the induction coil is suppressed. We developed an electrical control method of the heating width by employing a sub-coil.

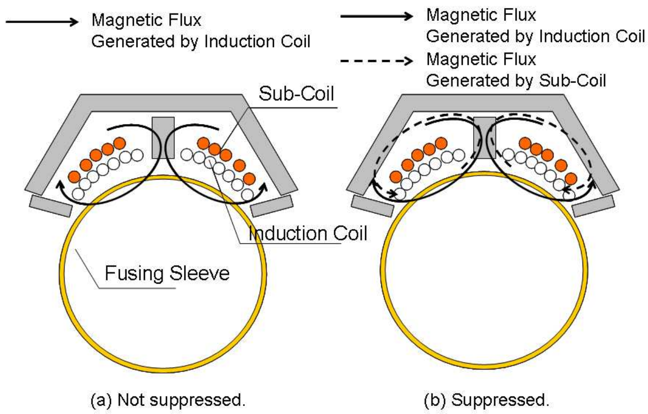

Figure 6. Principle of Sub-Coil

Uniformity of temperature distribution at edge of longer side direction

Figure 7 shows the temperature distribution in the longer direction of the fusing roller shown in Figure 1 while it had been developing. It is noted that the longer direction is not shown in Figure 1 explicitly, and it is perpendicular direction from the cross sectional view in Figure 1. The temperature of the edge of the fusing roller rises compared with the center part, and the part from the edge to the inside has lowered. The temperature irregularity occurred at the edge of the fusing roller.

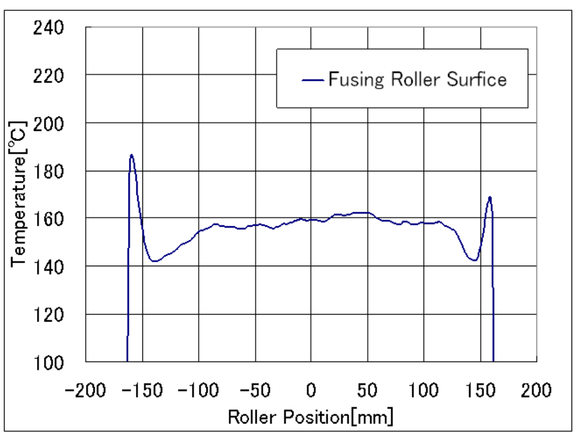

Figure 7. Temperature Distribution

For this problem, analyses of temperature irregularities at edges of the roller, by using 3D simulation for models shown in figure 8, are carried out. Heat generation distributions on the fusing sleeve are calculated varied with the coil shape and relative position of the coil.

It is found that the heat generation distribution at the edge of the fusing sleeve is greatly influenced by a relative position of the coil with the fusing sleeve in the longer direction and by the curvature radius in the coil bend part. It is clarified that eddy current is a factor of the temperature rise. When the flow of the eddy current at the edge of the sleeve significantly changes in very short distance with the position of the coil and the sleeve, the concentration of the eddy current density is generated at the edge and the local temperature rise is occurred.

We succeeded at adjusting the eddy current at the edge of sleeve in optimizing coil shape and the relative position of the fusing sleeve and the coil.

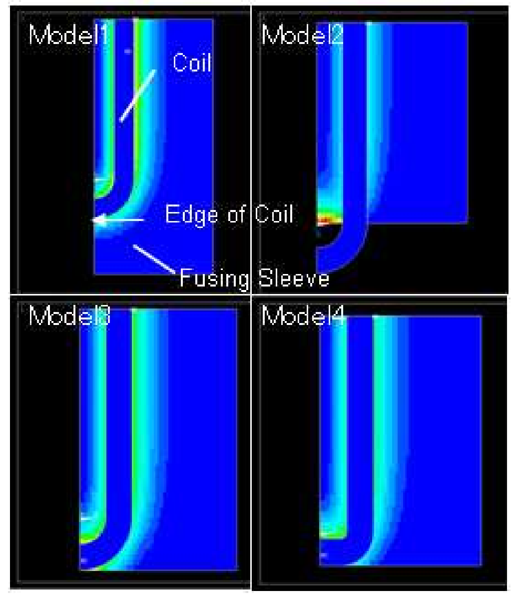

Figure 8. Edge-Model of Fusing Sleeve

Simulation of sub-coil

It is considered that arrangement of sub-coils can control the heating width, which influences the temperature distribution in the longer direction, even if the whole area of the fusing roller is heated and sub-coils are not used. Therefore, difference in the heat generation distribution by the sub-coils positions is verified by 3D simulation. In the simulation, it is assumed that two or more sub-coils are arranged.

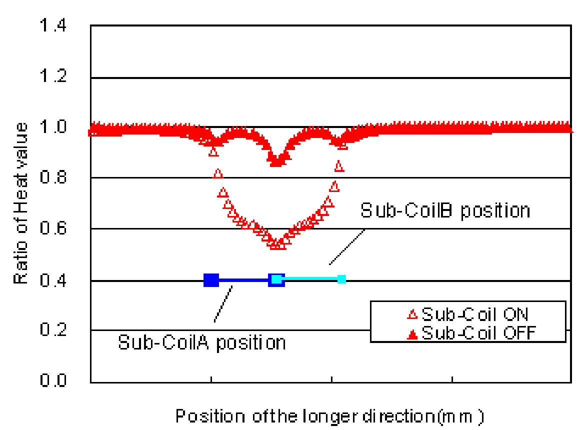

Figure 9. One Example of Simulation Result

Decrease of heat occurs in the area where sub-coils are adjoined even though sub-coils are not used. Figure 9 is one example of the simulation results.

Performances of energy saving fuser

The print speed and warm up time of imagio MP C4000/5000, for which new IH fusing technology is installed, are shown in table 1. In addition, the comparison of the TEC rate with the old model is shown in figure 10.

Table 1 Warm Up Time（W.U.T.）

	Print Speed		W.U.T.
	Color	Bk	
imagio MP C5000	50PPM	50PPM	＜ 27sec.
imagio MP C4000	40PPM	40PPM	＜ 23sec.

We have improved that the TEC rate from 4.7 in the old model to 3.9 kWh with the print speed from 45 PPM to 50 PPM. We achieved the reduction in 0.8 kWh of TEC rate with 5 PPM increase of print speed.

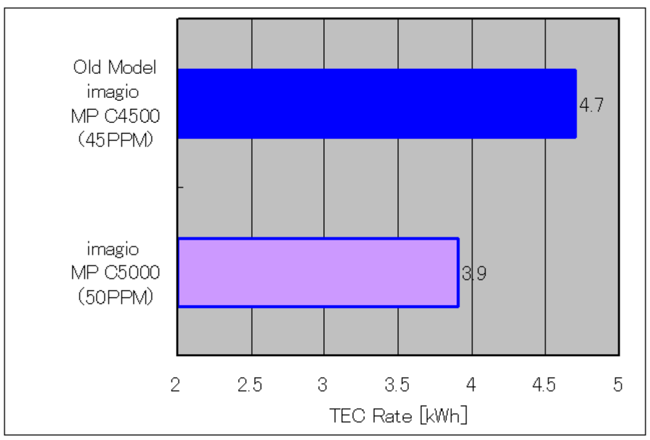

***Figure 10**. TEC Rate*

Conclusion

The development of energy saving fuser is an important subject for the current and the future electro-photographic imaging technologies.

For optimizing magnetic energy generation and temperature field in the fuser, magnetic field simulation and analysis of heat transfer are carried out. As a result, the new highly efficient IH fuser is developed.

We will continue to develop energy saving technology for the further.

References

[1] S. Ueno : Heating Width Control Technology for IH Type Fusing System, ICJ2007, 299-302 (2007) [in Japanese]

Author Biography

Hiroshi Seo was born in Japan in 1979. He received his BE and ME in 2001 and 2003 from Nagoya University, respectively. He has been developing electrophotographic imaging technologies in Ricoh Co., Ltd. since 2003