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A Study on the Fusing Temperature Distribution for Laser Printer Toner by Using Numerical Computation

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Abstract: Fusing process of laser printer is the step to fuse toner on the paper and it has a great effect on fast printing speed, decrease in waiting time and improvement of printing quality. In order to improve the quality of fusing, a study on the fusion region is required. Recently, various researches are progressing in this field. In this study, the research about the temperature distribution of fusing region is performed through numerical analysis because fusing region is one of the important factors influencing fusing quality. According to results, it is ascertained that the temperature of fusing region is relative to velocity of the paper under print and has a regular distribution to width direction of the paper.

Key words: laser printer, toner, fusing, LSU, CFD

1. Introduction

Laser printer is a device to print picture information through electro photography process. After the picture information passes through the driver, controller and LSU (Laser Scanning Unit), it goes through electro photography process consisted of electric charging, developing, decalcomania and fusing device. Then the paper prints out. As one of the these processes, fusing system consists of heat and pressure roller. Heat roller functions as source of heat and pressure roller as a device for fusing toner on the paper [1].

During the development of toners and fusers used in electro photography, evaluations of fixing strength versus electrical or melting properties of bulk toner have been carried out. However, it is difficult to model the fixing phenomena because of the lack of information about the toner microscopic behavior. The process determining the fixing are fusion and flow of the toner. Since the toner is composed mainly of amorphous polymer, and it is determined by the temperature field [2, 3], the behavior is viscoelastic, Fusing quality of the toner is changed according to fusing temperature, pressure and duration time of printing in the fusing region [4, 5]. In this paper, a method of considering the nonlinearity by improvement of the analysis method as in [6, 7], and a method show the fusion speed with temperature change are calculated. In this calculation result as in the former report are employed to introduce some systematic collection of data, i.e., samples of thermal diffusivity, heat conductivity and heat flux of the cylinder. The purpose of the study is to investigate the interactions between the toner and the paper according to the speed of the paper injection using CFD (computational fluid dynamics) simulations so that the results can be used for practical applications.

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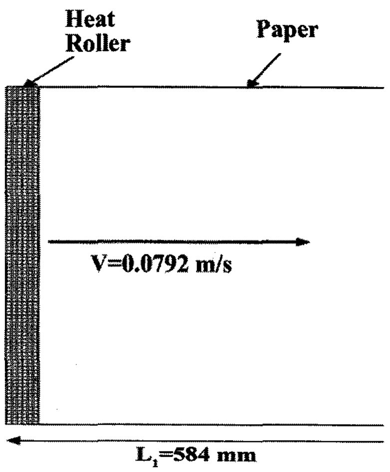
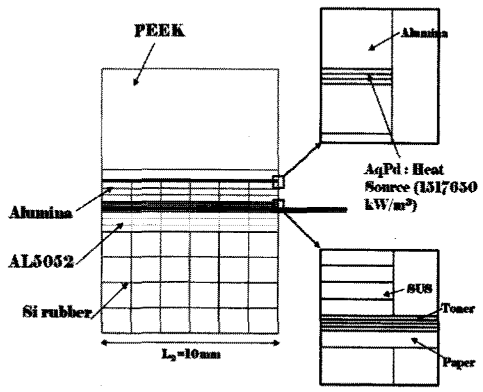
2. Numerical Computation

2.1 Numerical Model

Fig. 1 shows the printing apparatus with paper. The device consists of heat and pressure rollers. It is assumed that the rollers are still but paper and toner are moving through them. This model imitates effect of rotation of rollers. A part of the paper and the toner in contact with rollers are only analyzed as calculation region. And the paper length is established 584 mm because it is considered that there is a long time to reach from initial to maximum temperature.



(a) Moving speed of paper



(b) Material arrangement of printing divice

Fig. 1. Computational model of printer.

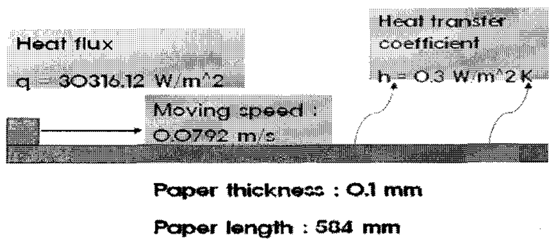


Fig. 2. Boundary conditions of heating plate and paper.

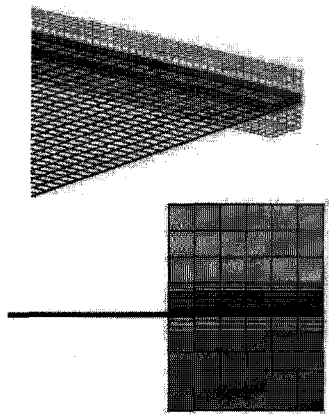


Fig. 3. Computational hexahedral grid system.

2.2 Numerical Methods and boundary Conditions

Table 1 shows the heat flux at toner surface and volume. The heat transfer features around the roller of printer have been investigated. For the various heat flux, the heating part have been set to 4054 W/m^2 and 35360 W/m^2. And Fig. 2 shows the boundary conditions of moving paper, heating source and heating plate. The grid for the calculation has been generated by the use of ICEM-CFD code, and the grid numbers used are about 70,000 nodes (Fig. 3). The commercial code (CFX-11.0) has been used for heat transfer calculations. Since the interactions between the heating source and the ambient air work is an important factor for the quality of printing, a heat transfer coefficient model has been adopted and analysis has been carried out for the heating source and the ambient air respectively.

Table 1. Heat flux at toner surface and volume

	Heat source [10^8 W/m^3]	Ave Heat Flux [W/m^2]
Case 1	1.518*0.5	4054.5
Case 2	1.518	8798.4
Case 3	1.518*2	17662.9
Case 4	1.518*3	26214.6

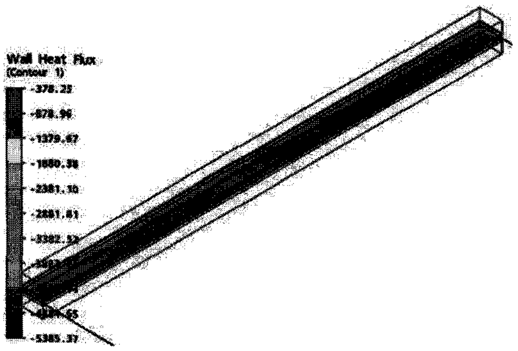
3. Results and Discussions

3.1 Heat flux at toner surface

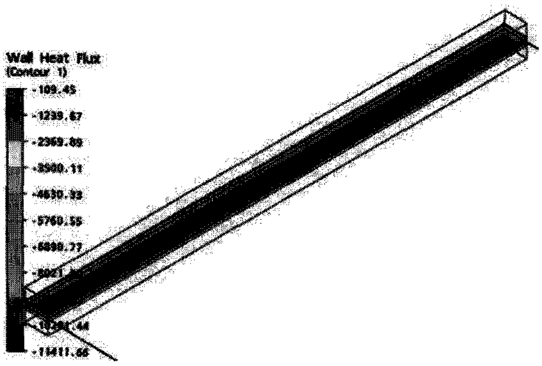
Fig. 4 shows the computational results of the surface heat flux with the change of the volume heat flux such as table 1 for heating plate of printer roller. It shows that the surface heat flux increases with increase of the volume heat flux, and the highest heat flux of the roller is 6 times higher than that of lowest heat source. A lowest heat flux is about 5400 W/m^2 and the highest is about 34,000 W/m^2.

3.2 Temperature field during fusing

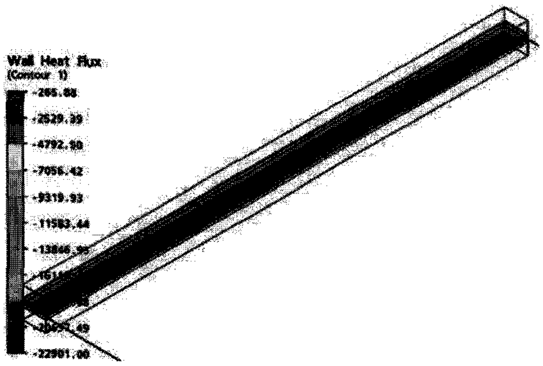
The calculated results are the temperature changes on the paper surface (paper thickness 0.1 mm), on the mid-region of the toner layer (0.05 mm). Fig. 5 shows temperature between the heat source and other materials such as in Fig. 1. A peak temperature appears on the nearby heat source. A material of heat source AqPd and aluminum, SUS have same temperature distributions at mid region of paper. In this case peak temperature is



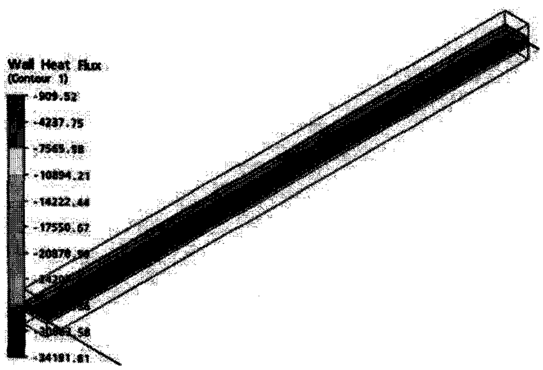
(a) Average heat flux, 4050 [W/m^2]



(b) Average heat flux, 8800 [W/m^2]



(c) Average heat flux, 17,700 [W/m^2]



(d) Average heat flux 26,200 [W/m^2]

Fig. 4. Computational results of the surface heat flux with the change of the volume heat flux.

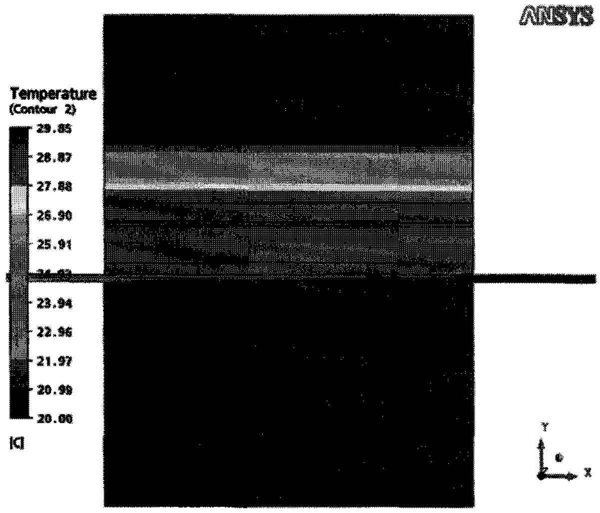


Fig. 5. Temperature distributions for each materials.

about 30°C. The maximum difference between the temperature on the toner surface and on the toner/paper interface is more than 10°C.

Temperature distribution of fusing region of laser printer acquired by numerical analysis is shown in Fig. 6. Temperature of heat roller is increased with time. It can be shown that temperature of toner fused on the paper also increases. Comparing with initial temperature of paper and heated paper, we know that maximum temperature of heated paper is 78.22°C and temperature of paper passed through heat roller is decreased because the paper is exposed in the air. As shown in Fig. 6, maximum temperature is generated from fusing region and temperature distribution of paper passed through heat roller decreases.

Fig. 7 shows the quantitative temperature profiles of the paper surface along the center line. From Fig. 6, it can be said for the cases of the temperature distributions on paper, a surface temperature increased for time marching. And the peak temperature on the paper is about 65°C at 5second.

4. Conclusions

Analysis of unsteady temperature distributions considering nonlinearity dependence on the temperature changes have been performed. As a result, the following points were revealed.

A lowest heat flux is about 5400 W/m^2 and the highest is about 34,000 W/m^2.

The maximum difference between the temperature on the toner surface and on the toner/paper interface is more than 10°C.

The maximum temperature of heated paper is 78.22°C

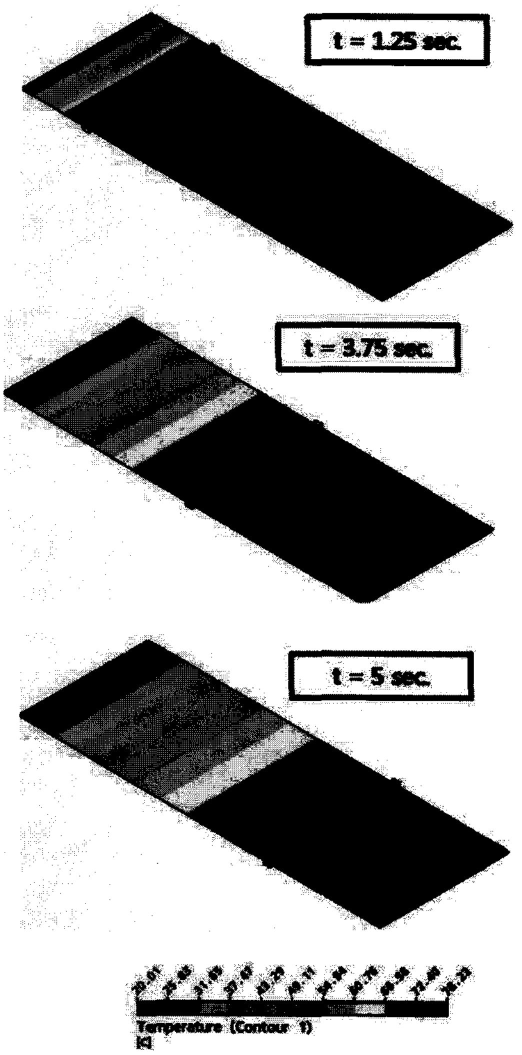
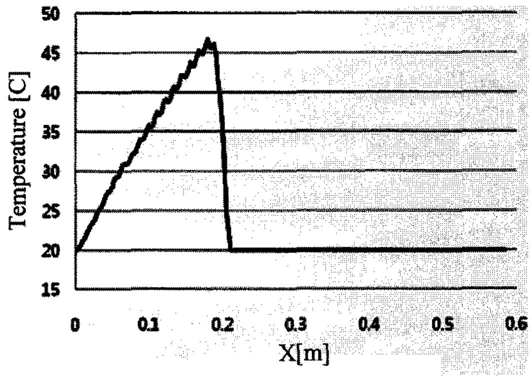


Fig. 6. Temperature distributions on printing paper for time marching.



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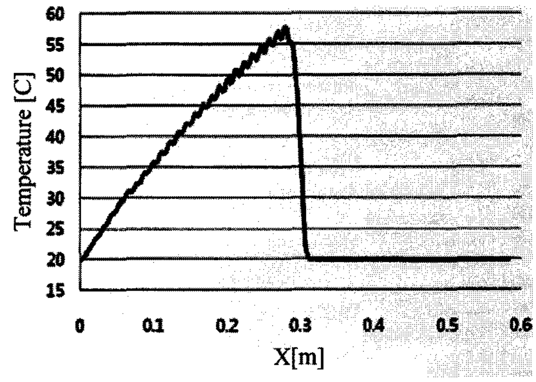

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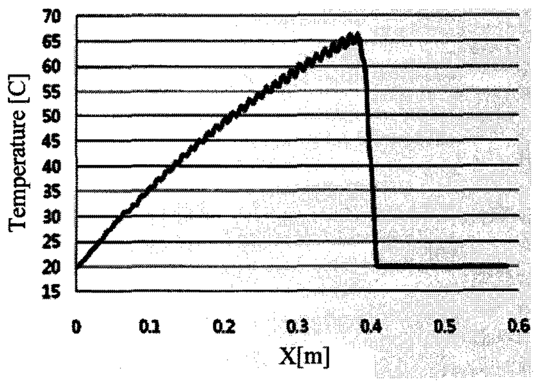

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Fig. 7. temperature profiles of the paper surface along the center line.

and temperature of paper passed through heat roller is decreased because the paper is exposed in the air.

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