Energy-saving technology for fusing systems using EDLC power assistance

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Abstract

A new fusing technology using EDLC (Electric Double Layer Capacitor) power assistance has been developed which greatly reduces the warm-up time and energy consumption. The charged power of EDLC is used for heating energy of fusing unit. The power assistance can be used for the temperature drop during the early stage of the continuous paper feeding. Furthermore, it is applicable to the acceleration of temperature rise of the fuser roller for start-up or recovery stage.

The technology is adopted in high-speed MFP from Ricoh.

Introduction

The fusing process of the electrophotography is mainly heating and melting toner resin and fixing it on paper. This process consumes large electrical power relative to any other processes. For this reason, many companies propose and practice various type of energy saving technologies target to fusing. [1]

Conventional fuser rollers take several minutes to their sufficient temperature rise because of their large heat capacities. Usually preheating is necessary during its waiting time to secure below thirty seconds restart. Then, 70 to 80% of the copier machine power is consumed during its idle time. Hence, the reduction of thermal rise time is pretty effective to energy saving.

Presently, in the region of middle to low speed machines, such as 40 to 50 cpm (copier per minute), energy saving is attained by various low heat capacity technologies and materials, i.e. film and thin roller. [2] Although, in the high-speed region over 60 cpm, it was very difficult to apply these low capacity technologies and take more than several minutes for re-start. This difficulty is one of the barriers to realize the higher level of an energy saving system.

We have been developing the energy saving technology by using a capacitor storage device, which is applicable to high speed region machines. This report gives the outline of our new energy saving technology.

Configuration of the Auxiliary Power Supply

Diagram

Fig.1 shows the block diagram of our system. In this system, the storage device acts as an auxiliary power supply which storage the electrical power from commercial power line, provides the stored electrical power to the main power for fusing when it is necessary. This makes a large electrical power supply possible.

In Japan, the regulated commercial power source is supplied 100v and 15A to common houses and offices. This means 1.5kw is the maximum usable power supply at a time. It is quite possible to increase practical power supply by an optimum and effective improvement of various machine parts. [3]

But, in principle, it is impossible to supply over 1.5kw of the maximum commercial line power. On the contrary, the auxiliary power source can supply large power, such as 3.0kw, and make high performance of heating which are impossible to the conventional machines.

EDLC (Electric Double Layer Capacitor) is adopted as a preferable storage device here. EDLC, called "supercapacitor", is a kind of capacitor, which is easy to make a large capacitance. Unlike usual chemical batteries it uses electrostatically physical charge storage phenomenon, 1) it is possible charge and discharge with large current, 2) long cycle life time (several hundred thousand times) and 3) consists of ecological materials such as highly porous carbon and aluminum.

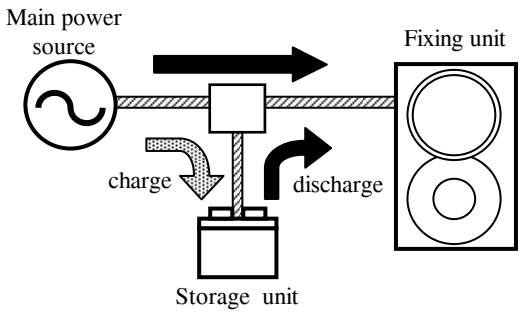

***Figure 1**. Schematic diagram of power assist system*

Auxiliary Power Source for Fusing

As shown in Fig.2 heat and supply power system of the fixation has two heaters of commercial (main) power source and auxiliary (sub) power source route.

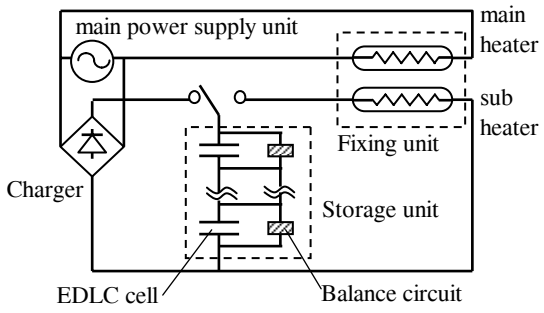

***Figure2**. Power assist system using EDLC*

Simultaneous heating of main and sub, 1) low heat capacitance fuser roller is applicable to high speed region machines, for preventing from certain temperature decay at paper pass, 2) swift temperature rise of both heaters with a large power supply at the very start.

Technical details of paper pass and start-up are discussed following sessions.

Auxiliary power source composition

Present EDLC regulated capacitor cell voltage is low as 2.5v. Then plural cells are lined in series for driving a heater as shown in Fig.2. Each cell is operated with in optimum voltage region by controlling its excess charge and voltage disperse among cells in series by the control circuit. So waste less and high storage performance can be hold for a long time. The sub heater is connected to this auxiliary power source, as a result auxiliary heating becomes possible.

Adapting such capacitor makes simpler and higher reliant auxiliary power source with following advantages.

-No productivity loss caused by waiting its charged-up: very short time is necessary to charge-up while next copy sheet comes.

-Easy maintenance of power source status: the amount of charge-up is proportional to the applied voltage, then residual amount of power.

-Very high durability: it has a very small capacitance change and internal resistance and leads a long operation period and stable drive.

-Possible very safe system: the electrical power is gradually decrease with the discharge and heating is not carrying out after its complete discharge.

-No need of voltage conversion circuit: the auxiliary power source has a very low internal resistance so that voltage decrease between terminals is very small with the large current. Then voltage adjustment or convert circuit is not necessary.

Energy Saving Fusing System with to Auxiliary Power unit

Temperature drop in the high-speed region

The relation between the copy speed and required power is shown in Fig.3. Then the power is proportional to copy speed and in the region of over 60 cpm, one need a large power source the 1.5kw. So, several solutions come up

a) increase the regulated voltage supply from 100v to 200v (80cpm ~).

b) decrease the fusing electrical power by lowering heat loss to paper.

c) storage created heat, such as a thick member fusing roller.

In the high-speed 60~75cpm region, the most favorable conventional method is c), and those machines typical temperature profile of the fuser roller is shown in Fig.4. Thin fusing roller system, serious temperature loss occurs after few tens of paper sheets passed. To prevent this, a certain thick roller is need to storage surplus heat during the temperature rise.

Even such thick roller, still serious temperature loss occurs after several hundred papers pass. But other fixation parts, such as pressure roller, body etc., are also heated and become a kind of heat sink, the machines fixation process is secured totally. Along this path, heat storage structure needs sufficiently to prevent from serious heat loss just after the first fixation starts.

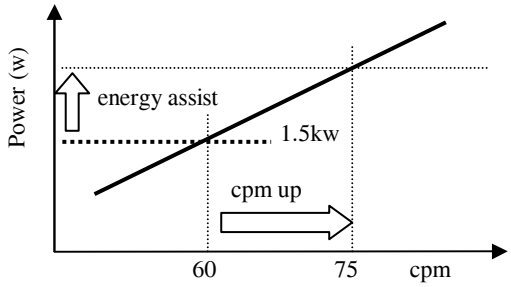

***Figure 3**. Required power for conventional fuser system*

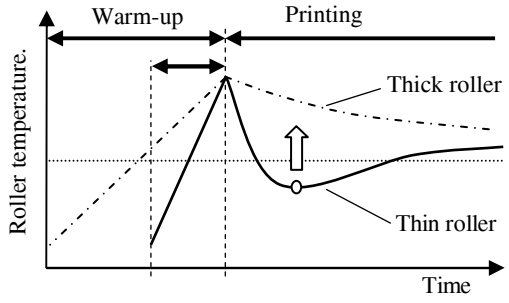

***Figure 4**. Temperature profile of the fuser roller*

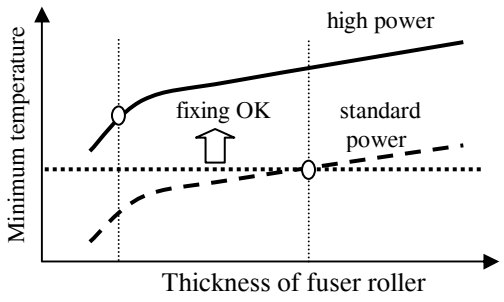

***Figure 5**. Temperature drop of fuser roll*

The lowest temperature just after a sheet pass is largely dependent on a roller thickness and supplied power, as shown in Fig.5. A thin roller cannot gain an enough temperature with the commercial line and, as a result, a sufficient fixation cannot be attained. Even so, the fixation can be secured with power increase. Then, a roller thickness can be determined not by the thermal storage ability but by the mechanical strength such as bent and destroy.

Prevention of Rapid Thermal Drop

This system can store the electrical energy instead of the thermal one. For example, the aluminum roller of a diameter 50mm, thickness 10mm roller needs 50,000J for 50deg. thermal rise, in other word 500w power supply during 100 seconds.

Fig.6 is the experimental temperature profile for various type rollers. Then 20 of 2.5v, 500F capacitor cells in series (about 30,000J) are used as the auxiliary power source for 400w halogen heater with 40mm in the diameter and 0.7mm thin fusing roller under 360mm/sec line speed (equivalent to 75 cpm).

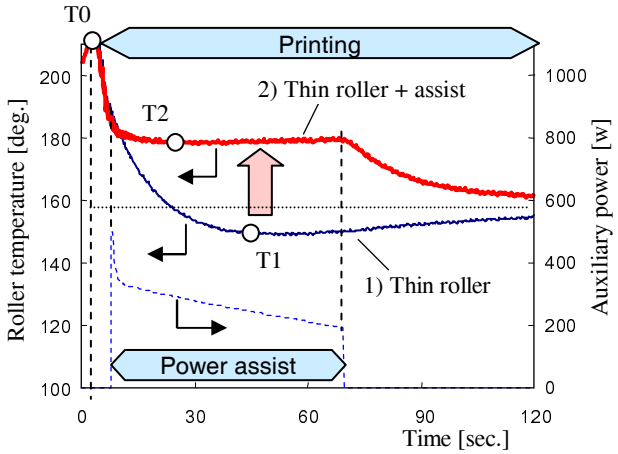

***Figure 6**. Comparison of temperature profiles for thin roller and thin roller with power assist*

Just after read to the designed temperature T0 (210deg.) the consecutive paper pass is started.

1) Thin roller (d40, t0.7) shows serious rapid temperature decrease of T1 (150deg.) where the desired fixation cannot be attained.

2) However, adding the auxiliary power supply to 1) thin roller, this set can maintain sufficient fixation temperature (180deg.). When the auxiliary power supply stops after 60sec, the temperature decreases slightly still the desired fixation can be secured because of the heat sink (i.e. there unit components are heated up too)

Temperature Rise Support

The shorter temperature rise time is necessary to popularize the energy saving, this auxiliary power systems becomes one of the possible selection.

Usually the temperature rise time conflicts the supplied power. In case of single 1.2kw commercial power source below 30seconds, 1.7kw additional auxiliary power supply makes swift start less than 10 seconds possible. The temperature rise time mainly determined by heat capacity of the roller and supplied power, hence, the rapid and sufficient temperature rise can be made, which is not possible by a single commercial power supply in principle.

When two kinds of power support are on demand such as start-up and paper pass at a time, the other subject of stability comes up. The start-up needs a large power (1.7kw), and the paper pass does small (0.5kw). The power supply has to be stable in both cases.

If a single heater is place in the system, little by little switching can reduce the average power. But this is not desirable for a thin roller because of large thermal change. For this reason, in this system, the two parallel heaters are adopted as medium power heater (1.0kw) and small one (0.7kw).

The temperature rise at the start, both heaters operates simultaneous, while single small heater operates during paper pass. The small heater is 0.7kw but practically 0.5kw during paper pass because of the voltage drop.

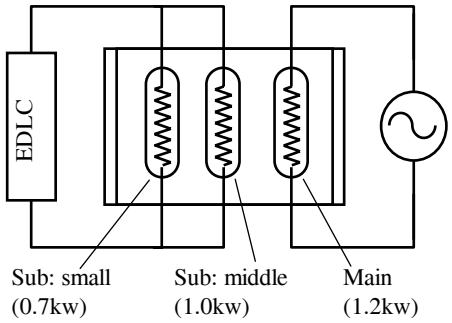

***Figure 7**. Parallel sub-heater system*

Re-set of the Initial designed Temperature

The auxiliary power supply prevents undesirable temperature drop-off, the heat storage in high temperature region is not necessary like before. Then the initial designed temperature can be revised. For example, like in Fig.8, the initial designed temperature of 200deg. with a thick roller can be reduced to 180deg. with a thin roller plus the auxiliary power supply, also, the heating time is shortened from 10sec to 9sedc. This 10% heating time reductions is very important to shorter warm-up time 10 to 30 sec.

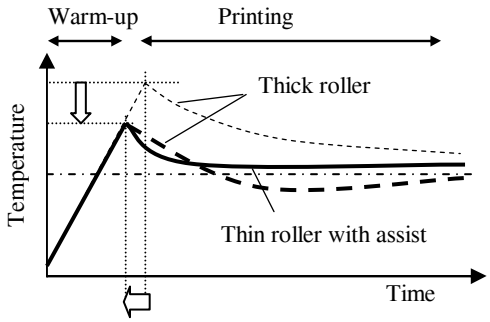

***Figure 8**. Temperature profile in EDLC usage for the lower target temperature*

Energy Saving

As previously described, this system greatly reduces the energy consumption, because warm-up time is reduced on high-speed MFP. As shown in Fig.9, the preheating power was used for keeping the temperature of thick roller in waiting time. Preheating becomes unnecessary because of shorting the warm-up time using auxiliary power. The electric power used to storage uses a part of the electric power that a thick roller consumed as heat radiation of preheating.

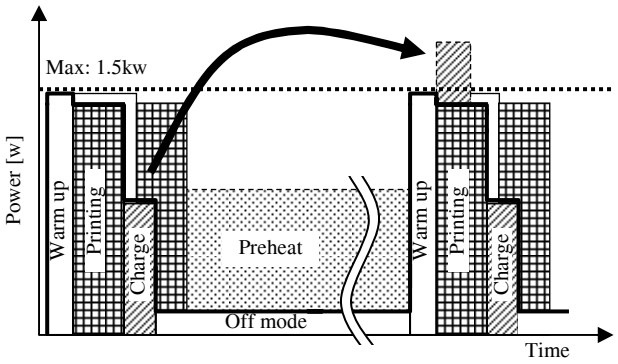

***Figure 9**. Power profile in EDLC power assist system*

Speculation of the Auxiliary power source in Machines

Above mentioned technology which combine a commercial power source and auxiliary power source and "QSU" technology which utilize a thin roller and low temperature melting toner are added and called "HYBIRD-QSU". These technologies are already on commercial machines for a Japanese market, such as imagio Neo 752 and imagio MP 7500 (high speed machine 75cpm: '03.12/'05.12 presented respectively) and imagio Neo 602ec/752ec (60/75 cpm '04.08 presented)

The detailed speculations of capacitors used in above machines are in Table.1.

Table 1 specification of the EDLCs used imagio series

	Neo 752 / MP 7500	Neo602ec / 752ec
Warm-up / recovery time	30 / 30 sec	30 / 10 sec
Cell spec.	600F 2.5V	
Module spec.	9.3wh (18cell)	18.7wh(36 cell)
Sub-heater	520w	1030 & 750w

Figu.10 shows the comparison of energy consumption efficiency and warm-up time between imagio Neo 752 and its former model imagio Neo 751('02.12 presented). In imagio Neo 752, the heat capacitance of the fusing roller is reduced 88% from former model, then reduce the warm-up time 90% (5min. to 30sec.) and the energy consumption efficiency to 59% (286 to 117 wh/h).

Energy consumption efficiency is an index of energy-saving regulation in Japan. These results cleared corresponding standards in Energy Saving law enforce in 2006.

Also imagio Neo 602ec/752ec is the first machine in this class of 60/75 cpm) 10seconds recovery from its (own) sleep-mode.

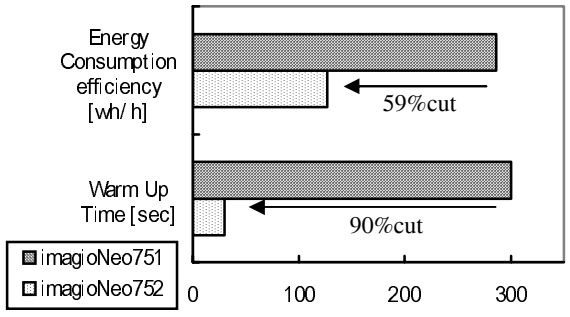

***Figure 10**.Energy consumption efficiency and warm-up time IS&T logo (note the use of bold and italics)*

5. Conclusion

We have developed our original energy saving technology, which the auxiliary power source assists the main power source when large power is required.

Applying this technology to black and white high-speed commercial machines, remarkable reductions of warm-up time (90%) are performed which former conventional models were not able to attain.

References

[1] H. Tatematsu, Technologies of Low Energy Consumption Fuser, J. Imaging Society of Japan, ISJ, vol.44, 235(2005)

[2] S. Izawa et. al., A Study on High Speed On-demand Fusing Technology, Proc. Japan Hardcopy 2003, ISJ, pg.9.(2003)

[3] M. Samei et. al., Color-Fusing technology using induction heating, Proc. NIP-19, IS&T, pg.58.(2003)

Author Biography

Kazuhito Kishi received his Master's degree in Precision Engineering from the Chuo University in 1993. He joined the Research & Development Center of Ricoh Co., Ltd. and had researched the fixing technology. He has worked at the Office Business Planning division since 2007, and is a member of the ISJ.