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Material Flow of Chemical Elements used in Electronic and Electric Equipment

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Abstract

Various kind of chemical elements are contained in electronic and electric equipment. The disposal of these materials and increasing exposure to the environment has given birth to a variety of problems.

In order to reduce these adverse effects and to create a recycling system for these metals, it is important to study the material flows present. Metals in devices such as printed circuit boards, motors used in copy machine and cellular phones were analyzed by EPMA. Furthermore the current method of recycling was investigated.

Many chemical elements were found in boards and motors. While boards and motors can and are currently being recycled, the issue of recycling magnets has yet to be addressed.

Key words: recycling, board, motor, magnet, copy machine, cellular phone

1. Introduction

Two types of electronic and electric equipments, copy machine and cellular phone, were subject of this study. The analysis of their components parts such as printed circuit board, motor and magnet were investigated.

2. Experimental

2.1 Copy machine

Copy machine consists of printed circuit board, glass, drum, motor and lamp shown in Fig.1. In this study board and motor were investigated. Furthermore magnets inside of motors were investigated.

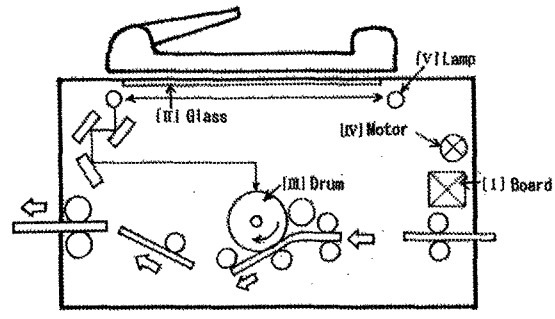

Fig. 1 Diagram showing the various components of a copy machine

Cross section of IC chip and condenser on printed circuit board were analyzed by EPMA. Lead flame, IC chip,

bonding wire, solder and so on were analyzed in printed circuit board. Cross section of condenser was also analyzed by EPMA.

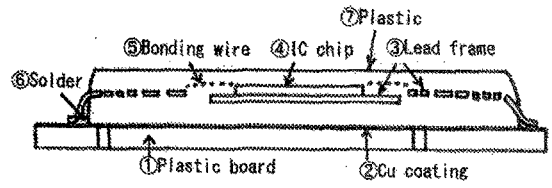

Fig.2 Cross section of printed circuit board

There are four types of motors were used in copy machine. A detailed analysis of the various components in a motor was carried out. Materials of motor parts were investigated. Magnets were included inside motors. Materials of magnets were also investigated. Motor and magnet were analyzed by SEM, because theses components were complicated shape. Recycling process of board and motor were investigated.

2.2 Cellular phone

Cross section of IC chip and condenser on printed circuit board were analyzed by EPMA. Method of analysis is same as that of copy machine. Small-sized motor in cellular phone were also analyzed. Recycling process of cellular phone was investigated.

3. Results

3.1 Analysis of the components in copy machine

(1)Printed circuit board

IC chip and condenser on printed circuit board were analyzed. Table 1 shows chemical elements of IC chip used in board. Figure 2 shows the cross section of IC chip on the board. 24 chemicals were included in IC chip and condenser.

Table 1 Chemical elements of IC chip used in board

①plastic board	C, Si, Ca, O, Al, Fe, K, Ti, (H)
②copper coating	Cu
③Lead Flame	Fe-Ni alloy (Ag and Cu coating)
④IC chip	Si
⑤Bonding wire	Au
⑥Solder	Sn-Pb alloy
⑦Plastic	C, Si, O, (H)

(H) : This EPMA isn't able to analyze hydrogen.

Table 2 Chemical elements of condenser used in board

Chemical elements	Ba, Ti, Sn, Ca etc
Main chemical	BaTiO3
Included	CaSnO3 and CaTiO3

(2)Motor

Four types of motors were used in the copy machine as follows.

(a) stepping motor (large)

(b) stepping motor (small)

(c) DC motor (main motor)

(d) DC motor (paper supply)

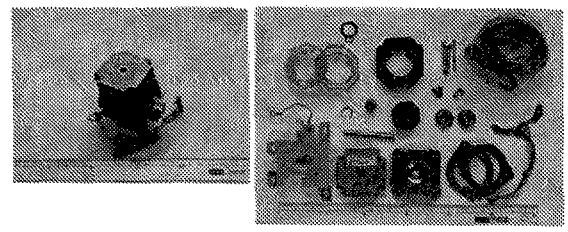

Fig. 3 A detailed analysis of the various components used in a stepping motor

Fig. 3 shows various components used in a stepping motor (a). Table 3 shows the materials of stepping motor (a) parts. It was found that there were 16 parts in stepping motor as shown in Table 3. Steel was 73%, aluminum was 18%, copper was 7%, and plastic is 2% in weight.

Table 3 Materials of stepping motor parts

①rotor	steel + Fe-Cr-Co magnets
②rotor shaft	stainless steel
③ball bearing	steel + stainless steel
④E ring	steel
⑤gear	Al die castings
⑥front cover	Al die castings
⑦rear cover	Al die castings
⑧stater	steel
⑨bobbin	plastic
⑩bobbin	plastic
⑪wire	copper wire
⑫plate	steel
⑬dumper	steel + rubber
⑭coated copper wire	copper wire
⑮bolt(large)	steel
⑯bolt(small)	steel

(3)Magnet

Four types of magnets were used in the motors as shown in Fig.4. Figure 4(a) is Fe-Cr-Co magnet used in stepping motor. This magnet is equipped inside the electromagnetic steel of rotor. Figure 4(b) and (d) are ferrite magnet used in stepping motor and DC motor respectively. Strontium (Sr) was included in ferrite magnet in order to increase the motor ability. Figure 4(c) is bond magnet used in DC motor. Ferrite magnet is probably included in bond magnet.

By recycling process of motor these magnets are probably included in iron scrap. Magnet to magnet recycling is necessary next step.

Strontium (Sr) is used as SrCO3, and Sr(NO3)2. The former is used for Braun tune of TV, ferrite magnet and optical glass. The latter is used for gunpowder and optical glass. Almost all uses is Braun tube of TV(27,300t/y as Sr) and ferrite magnet(11,600t/y as Sr). But these strontium isn't recycled yet.

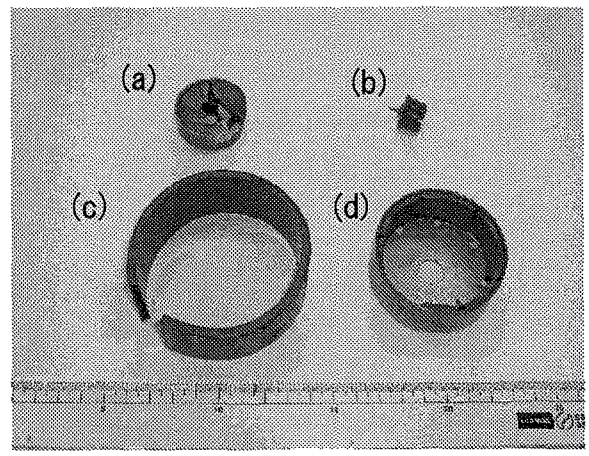

Fig.4 The magnets in the different motors

3.2 Recycling process

(1)Board

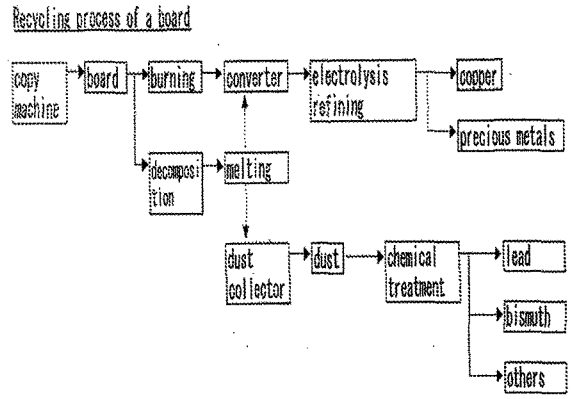

Fig. 5 Recycling process of a board

(2)Motor

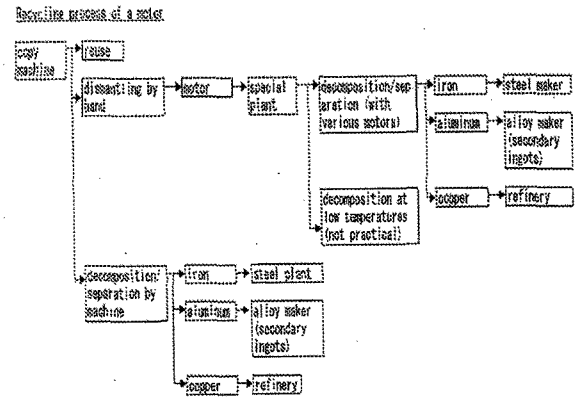

Fig. 6 Recycling process of a motor

(3)magnet

Magnet isn't recycled yet. The recycling of magnet is important, because useful chemical elements are included in magnet. The recycling of magnet to magnet is next issue.

4. Cellular phone

4.1 Board and condenser

Table 5 shows chemical elements used in IC chip and condenser in board. The board was same as that of copy machine. Two types of condenser, Ba condenser and Al condenser, were used.

Table 5 Chemical elements used in the board

IC chip	Lead flame	Fe-Ni alloy
	IC chip	Si
	Solder	Sn-Pb alloy
	Cu wire	Cu
	Plastic	C, Si, O, (H)
	Plastic board	C, (H)
Condenser	Main chemical	BaTiO3 Al(Al2O3)
	Solder	Sn-Pb alloy

4.2 Motor

Motor is equipped in cellular phone. Fig.7 shows cross section of the motor used in a cellular phone.

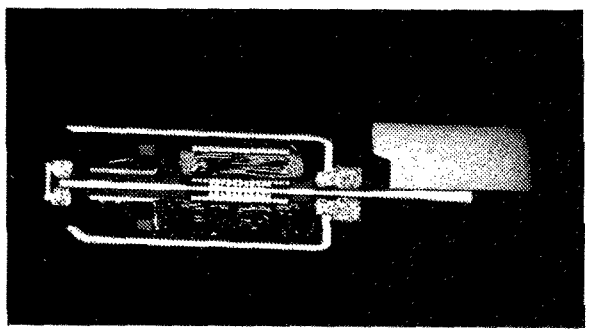

Fig. 7 Cross section of motor used in a cellular phone

Materials of motor parts are consist of tungsten, stainless steel, copper, steel, Fe-Si and Cu-Sn-Fe alloy.

4.3 Recycling process

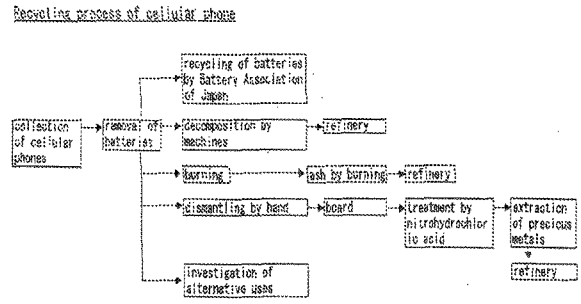

Fig.8 Recycling process of a cellular phone

Precious metals are included in board. Batteries are removed and recycled by Battery Association of Japan. After the removable of batteries used cellular phones are (1)decomposed by machines, (2)burned or (3)decomposed by hand and then treated in refinery. Precious metals, copper and useful metals are extracted. Alternative uses are also investigated.

5. Conclusion

(1)Two types of electronic and electric equipment, copy machines and cellular phones, were the subject of this study. Their recycling process and the analysis of their chemical elements were investigated. Many chemical elements were found in boards, motors and magnets. While boards and motors can and are currently being recycled, the issue of recycling magnets has yet to be addressed.

(2)Magnets are a type of ecomaterial in the field of energy. But the recycling process of magnets has not yet completely been discovered.

(3)In general, if the unique characteristics of certain materials, such as magnets, are published widely, these materials can become useful ecomaterials for product designers.

Reference

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