Reuse Strategies for Electronics and Electronic Products towards a Sustainable Society in Japan

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1. Introduction

The manufacturing community plays a major role in building a so-called sustainable society that moves from a one-way society of large-scale production, large-scale consumption and large-scale waste to one that mimics the community. In basic promotion methods for designing a sustainable society, the cycle from controlling waste of resources through production and consumption of appropriate amounts reduce to reuse and recycling, and finally to appropriate disposal are being specified to realize such a society (Ministry of the Environment 2002).

Given this situation, component parts such as copy machines, “lens with film” cameras, and so on are developing high reusability of parts in order of priority from materials and recycling to return them to original materials and producing economic effects in addition to environmental considerations. However, electronics and electronic equipment overall, while a recycling system for materials has been established with establishment of various laws and so on, reuse is still in the developmental stage.

This paper covers “lens with film” cameras and copy equipment in particu-
lar using surveys of case studies on the progress of reuse and circumstances demonstrated key to promoting reuse as projects and developments in establishing reuse.

2. Leading Examples of Reuse

2.1 Product Reuse and Part Reuse Structures

Two major categories of reuse are product reuse, in which the product is used as is as used goods, and reuse for parts, in which the component parts of a product are dismantled or taken apart and reused.

If end-of-life products have value in the market they enter the used market as reusable products. Used markets are being established for automobiles and PCs, mainly notebook PCs, and other products; however, only a very small portion of home appliances are just establishing a partial used market for foreigners.

Reuse for parts, on the other hand, involves dismantling products into their component parts, categorizing them and collecting parts with use value. In leading reuse case studies surveyed by this paper, parts are used to form new products after undergoing harsh inspection measures and so on. In some cases, companies use such products internally for maintenance parts and so on. Automobiles, PCs and the like have an established used market for products and parts and transactions are being made with reusable products (*Machine System Promotion Society 2000*).

2.2 Reuse of “lens-with-film” cameras

Reuse for parts is moving forward the most in the area of “lens-with-film” camera (LF). Fuji Film, which has 70% market share, has built a world-leading
“sustainable production system” throughout the production, reuse and recycling stages. Their cutting edge inverse engineering is highly regarded in academic and industry circles both in Japan and throughout the world.

As Fig. 1 shows, the “Sustainable Production System” aims at sustainable technology as well as saving resources and reusing parts. There are three types of technologies, appropriate production technology for assembly and reuse production technology, reuse and recycling technology and reuse and recycling design technology (product design). Sustainable technology is realized by improving these three technologies in an upward spiral.

Looking at product design in further detail, it can be categorized into designs to save resources and reuse parts and designs to recycle. Fig. 2 shows seven items for each category. One method is to design to save resources, such as “a design to take three more shots with the spare frames” enabling 27 shots
so called eco shot, on a 24-shot film, by making the body more compact and using APS film and other methods. Another method is “design to save resources by making the body more compact”, achieving about a one-half reduction from the initial product as well as the body and packaging weight. Meanwhile, with reuse and recycling, the first item is “improving durability and reliability” by simple, low-cost product design that is appropriate for ensuring heat, shock and vibration resistance. The next is “unifying materials” that can be recycled, such as body resins that use only polyethylene and which last for generations. The third is “making a unit (condensing functions)”, such as strobes of 60 to 70 parts, the shutter and lens parts, and product design that builds on the unit level with parts that can be renewed and repaired easily. The fourth is “joint design” between generations and models that unify unit parts and reduces the number of changes when a new model is launched. Finally, “automated design” makes automatic dismantling easier. This involves designing the product so it can be disabled from the front in one direction by changing from screws to
nail stoppers or dismantling from uni-directional, single operations that do not damage the reusable products, and making it possible to decide on positions for dismantling and inspections of standard position holes and so on for each part unit. A combination of separating qualities with automatic adhesive machines that strengthen curved parts with glue and make it easier to peel items off and other innovations are used as well.

The production system for single-use camera is completely automated. The product that returns to the plant via the user, the DP (developing/processing) outlet and the imaging station, is categorized by model by ID equipment. After separated using sorting equipment into in-house products and those from other companies, the plastic part of the body moves on to the dismantling and inspection process. In this process, the dismantling inspection equipment removes the lens and strobe and cleans them. Only units that have passed inspection by the inspection units move on to the single-use camera production process. The shutter-related mechanical units also go through the same process. Meanwhile, batteries and metals are recycled and the main body unit is recycled for materials and used again for a new body with recycled materials. However, to keep down the energy used in recycling for plastic materials, pellet-less technology for finely grinding the plastic without turning it into pellets is used. Full plant automation achieves as much as 50 times higher work efficiency than manual operation, explaining the profitability of the system (Morioka and Imahori 2001).

The basic approach of the sustainable production system process is first a production process for products that have passed reusability inspections and then a production process for implementing repairs on the other items. Items that cannot be repaired are sent to recycling for materials. As of 2001, the existing major models had achieved a mere 18% sent for recycling for materials with the remaining 82% used in a closed loop.
Comparing sustainable production of single-use cameras in actuality (in cases where they are not reused or recycled) with LCA (Life Cycle Assessment), as Fig. 3 shows, sustainable production has reduced CO₂ emissions by as much as 71% (Japan Science and Technology Agency 2001).

2. 3 Reuse of Copiers

Copiers, on the other hand, have the main characteristic of being provided mostly on a lease or rental basis. Additionally, roughly 90% of such contracts involve maintenance and inspection services with users. In this way, part breakdown data collected from each division reaches one million items per month. By entering this massive amount of data into a database and conducting detailed analysis, a database can also be created on required part qualities for determining part reuse longevity. Of the units collected from each user, 30% are returned to the part recycling plant and the remaining 70% are recycled into affiliate dismantling vendors (as of April 2001). According to the FY 2001 Fuji Xerox Environmental Report, a total of 59 models were recycling design products in FY 2001 and deployment control effects of new resources was expand-
ing by reusing parts that served many generations. The controlling effect from January 2001 to March 2002 was 2,200 t or, converted to CO$_2$, a reduction of 13371 t (Fuji Xerox 2003).

The part reuse plant line was installed as a comprehensive parts line in October 1997. The plant line divides the process into dismantling, cleaning, inspection and so on, with a line processing capacity of 100 to 150 units. As Fig. 4 shows, products shipped to the plant have their exterior cover removed once they have passed the operating inspection and then loaded onto a transport robot cart and dismantled as they move along their respective dismantling lines of “small”, “medium”, “large”, and “color”. The majority of dismantling work is done by human hands. Part types dismantled in the dismantling process are cleaned by shower, abrasive blasting, ultrasonic waves and so on once they have undergone external appearance inspections and crack and breakage inspections such as with ultrasonic waves acoustic emission inspections and the like to determine whether the part can be reused. Consumable parts are replaced, the unit is assembled and guaranteed to be of the same quality as a new part and then loaded onto the assembly process of the manufacturing line.

The parts for reuse return to the manufacturing process. To use these as

Fig. 4 Workflows on the Part Reuse Plant Line
parts in newly manufactured units in the same way as new parts, part quality, history and inventory control information must be provided to the manufacturing line of the new units. Here, an information system has been installed to serve the key role in supporting a sustainable system for resources. An ecological design is important for easy-to-reuse parts. Methods are used with copy machines to resolve various barriers to reuse by applying design methods. These are shown in Fig. 5. For example, longevity is a major issue, so designs for longer life are implemented in parts so they can be reused. As a result, “one-more-life design” was developed to make second and third generation use possible. For the problem of having the same short life, a method also emerged so that other parts could be reused for the same purpose by implementing designs in which it was easy to separate out parts with short life spans. For damage from wear and tear, dirt, scratches and the like, wear resistant, stronger and dust-proof designs were implemented. Furthermore, joint design and other methods have also been designed so that such parts can be used in other models as

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Fig. 5 Reuse and Ecological Design in Copy Machines
well as future models. The above reuse and recycle designs are implemented at every turn in new copy machines.

To use parts for reuse in new products, quality standards must be ensured to be on par with new parts. While it is good to grasp this when inspecting the external quality, performance, functions and so on, to meet these standards, some comparisons can only be made by setting life spans with reestablished standards such as reliability, equipment life span and so on. To this end, life spans based on variable statistical data for parts, life spans based on life span characteristic analysis data from maintenance data and other sources, and deterioration inspections (breakage gauge and measurement methods using visual inspection and ultrasonic waves) are used to determine the available life span of a part and if it can be reused.

Fig. 6 shows calculation results of environmental effectiveness when parts are reused and when they are not, illustrating the environmental impact results of reusing parts. Environmental effectiveness is calculated by dividing service

![Graph showing improvements in environmental efficiency with parts reused in copy machines.](image)

Fig. 6  Improvements in Environmental Efficiency with Parts Reused in Copy Machines
by environmental impact. Service in this case is set at a copy machine providing a lifetime copy service of 500,000 sheets, for which the environmental impact is set for CO₂ emissions and resource consumption with LCA. The results show that parts being reused improved CO₂ emission by 22.4% and an improvement of 44.5% for resource consumption compared to parts not being reused (Yoshida, Iwata, Imahori and Morioka 2002).

3. Conditions for Putting Reuse into Effect and Issues

3.1 Conditions for Putting Reuse into Effect

Leading reuse examples are beginning to show up in areas other than single-use cameras and copy machines as introduced here. These areas include automobiles, construction equipment, air conditioners for industrial use and so on. Generally, however, reuse still has a long way to go. Concerning home appliances, importance is being placed on recycling for high-grade materials with no structure for parts reuse in full-scale operation. I would like to summarize why single-lens cameras and copy machines have taken reuse as far as they have.

Fig. 7 shows three major elements for developing products that are easy to reuse in the single-camera area. The first is a “recovery system” to effectively recover products from the market. Next is the establishment of a “recycling technology” to reuse the recovered products with quality levels comparable to new products. The third is “development of new uses” for the recycled products. For single-use cameras, the recovery system involves the user finished with the product (done taking pictures) and returning the unit to the DP outlet themselves, thus resulting in high recovery efficiency since no additional costs arise for recovery through a distribution return system. Next, concerning the re-
cycling technology, quality of the recovered products on par with new products can be provided through complete automation of the sustainable production plants covered earlier. In particular, the heart of the camera, the lens, undergoes a machine inspection of 40 or more items. For single-use cameras, the component parts are basically reused for parts or recycled for materials, so developing uses for recycled parts is not that necessary. For copy machines, on the other hand, a recovery system is already in place since a lease or rental system is used to provide the product, enabling highly efficient recovery from the market. And concerning technology for reuse of recovered products with quality comparable to new products or above, technologies are available for life span and degradation inspections developed for technology and parts for reuse with collection and analysis of massive data such as breakdown history in the product’s

Fig. 7 Basic Elements of Developing Easy to Reuse Products
operation stage. For copy machines as well, nothing in particular stands out as necessary at the moment.

3.2 Prospects for Areas Still Undeveloped in Reusing Products

Looking at electronics and electronic equipment overall, reuse is still in the process of development. PCs, for example, on the point of highly efficient recovery, while having a lease structure companies, in many cases, the leasing companies end up buying the computer when the lease runs out. A system in which the PCs return to the manufacturer would be favorable. For home-use, on the other hand, there is no recovery structure in place. However, facing the enactment laws, some manufacturers have started a system from the fall of 2003 of recovering end-of-use home-use PCs through the post office. For PCs, parts are in units and the used market for products and parts continues to be made up mostly of notebook PCs. To incorporate parts for reuse in new products, development of inspection and available life span diagnostic technology is essential. Additionally, since a large volume of unusable products is expected to emerge, the development of new uses for old products and parts is desirable. Such research is in fact being implemented in various areas by PC manufacturers and many NPOs. While the three elements for establishing reuse in the PC market are still under development, a system is being put in place piece by piece. PC reuse is also an initiative issue for NPOs as well, thus, tie-ups with other NPOs, users and manufacturers are crucial.

References


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