Available online at www.sciencedirect.com
ScienceDirect
Procedia CIRP 61 (2017) 241 – 244
www.elsevier.com/locate/procedia
The 24th CIRP Conference on Life Cycle Engineering

Environmental Load Reduction by Customization for Reuse with Additive Manufacturing

Toshitake Tateno[a,*], Shinsuke Kondoh[b]

[a]Meiji University, 1-1-1 Higashimita, Tama-ku, Kawasaki-shi, Kanagawa 214-8571, Japan
[b]National Institute of Advanced Industrial Science and Technology (AIST) , AIST Tsukuba East, 1-2-1, Namiki, Tsukuba, Ibaraki 305-8564, Japan

* Corresponding author. Tel.: +81-44-934-7309 ; fax: +81-44-934-7234. *E-mail address:* tateno@meiji.ac.jp

Abstract

Additive manufacturing may promote the customization of products as it is suitable for a small lot and individual production. Because customization increases product value by altering the aesthetic and functional structure of the product without adding any physical objects, it may add new value to the reuse of products. Reuse decreases the environmental load by reducing the new material required, and some parts can be fabricated with a low environmental load by additive manufacturing for customization. In this study, the use of additive manufacturing to customize for reuse is discussed.

Peer-review under responsibility of the scientific committee of the 24th CIRP Conference on Life Cycle Engineering

Keywords: Customization, Reuse, Additive Manufacturing, Remanufacturing

1. Introduction

Environment load on production of physical products has been discussed as an important problem for realizing sustainable society. Reuse is an effective method to save energy and virgin materials for the manufacture of new products. However, there are some problems to increase the reuse market. The first issue is the reduction of the product value. Although a product may have sufficient lifetime remaining for use, aesthetic and functional values decrease gradually because of changing trends and technological progress. Another issue is the stock and supply of reuse products. It is difficult to find appropriate reuse products in a timely manner because determining who would like to release their own products for reuse is not possible.

To address these problems, we have previously proposed the promotion of module-level reuse and utilization of an information system for matching demand and supply [1]. Because module-level reuse can alter the product structure according to the demand, the customer can flexibly rearrange an original product's structure. In addition, appropriate used modules can be found easily because each module is searched for individually.

When a used module is reused for a new product, the environmental load for building the product is significantly lower than that for manufacturing a new one.

Although the importance of remanufacturing by module reuse was noticed in the previous study [1], the customized redesign and fabrication of modules for reuse has not been discussed sufficiently. In addition, the combinational selection of used modules is a more flexible method for satisfying customers' demand. In this study, a customization scheme that includes redesign for reuse is discussed. Figure 1 shows the concept of the customization scheme.

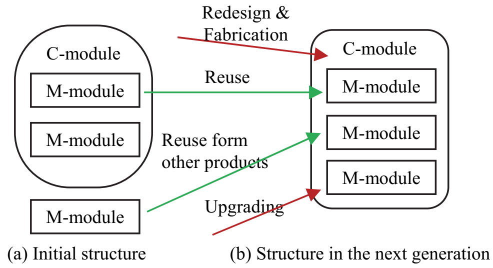

Fig.1 Concept of the customization scheme for module reuse

Peer-review under responsibility of the scientific committee of the 24th CIRP Conference on Life Cycle Engineering
doi:10.1016/j.procir.2016.11.219

For the customization scheme for module reuse, the product architecture should consist of two modules. The first is the mass production module (M-module), which is fabricated using a conventional mass production method. The other is the custom module (C-module), which may be fabricated using additive manufacturing (AM) The M-module may be reused several times or replaced with the same type of module at the point of reuse. In contrast, C-modules may be redesigned and fabricated according to customers' demand at every reuse. AM is suitable to fabricate a new custom module.

AM has been a popular topic for the last several years [2]. It can be used to directly fabricate objects in exactly the same shape as a computer model without indirect instruments such as dies or molds. Direct fabrication saves development time and cost in the case of a small lot or individual production [3]. Hence, AM may facilitate the adoption of mass customization [4]. Similarly, AM is suitable for the fabrication of customized parts or modules in reuse.

2. Effect of AM on reuse

In this section, the effects of AM on customization at the point of reuse and on remanufacturing are discussed.

2.1. Effect of AM on redesign and fabrication for reuse

In general, customization can increase product values from both aesthetic and functional points of view. Redesign for reuse is a novel method to increase a product's value at the point of reuse because it is difficult to anticipate the demand at this point when the initial product is designed. Module reuse itself implements a module-level customization because the functional set of modules can be added, reduced, or renewed according to customers' demands. However, even if only some parts could be created, the customer would be more satisfied. For example, customers often desire to renew frame cover parts because it is strongly related to human interface devices. In such a case, AM is useful because the customer can fabricate prototypes using the same process as that for the final module. The customer can evaluate the shape not only by viewing it but also by touching the prototype. Therefore, AM is an important tool for creating product values from both aesthetic and functional points of view.

Figure 2 summarizes the relations among the AM features, its advantages, and contributions to the reduction of the environmental load. With AM, the amount of reuse may increase, which reduces the environmental load.

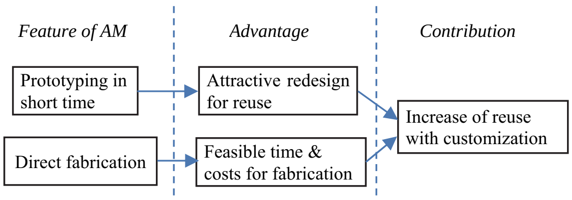

Fig. 2 Effect of AM on redesign for reuse

2.2. Effect of additive manufacturing (AM) on remanufacturing

In module reuse, remanufacturing at the customer side reduces the time and costs required for transportation. The authors previously proposed a remanufacturing system as the ubiquitous factory [1], in which an information system helps users to reuse products by receiving information on reuse procedures. The workers of the ubiquitous factory are defined as a product user, a stuff of shop near the user, or other non-specialists near the user. The ubiquitous factory system is also important to reduce the transportation required for reuse. AM is suitable for fabrication at a local site because a ubiquitous worker can operate AM devices without special knowledge and skills.

Figure 3 summarizes the relations among AM features, its advantages, and its contribution to reduction of the environmental load. AM realizes the ubiquitous factory locally, which decreases the environmental load by reducing transportation.

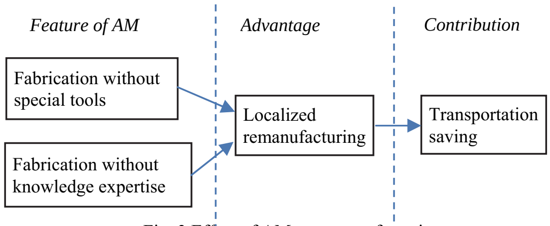

Fig. 3 Effect of AM on remanufacturing

3. Proposed information system for AM customization at the point of reuse

3.1. Effect of the information system for reuse

In general, a large amount of knowledge is required for product design. However, if certain knowledge is provided by some type of a method, even a non-specialist may design a product. Many methods can be considered for transferring knowledge. One basic method is that a design specialist always supports the customer. However, assuming that mass customization becomes popular, it is not an ideal method to occupy precious specialists with every customer's design activities. Therefore, we consider a design support system.

Here, an information system that transfers knowledge about redesign and remanufacturing is proposed. This system synthesizes using AM for reuse.

Figure 4 shows the relations among the information system features, its advantages, and its effect on environmental load reduction. As a redesign support, the system permits a customer to design an original product easily. Because AM can be used for prototyping the product, the system supports rapid product development. Moreover, the system helps customers' operations at the customer site as a remanufacturing support. In a previous study, the authors proposed an information system for disassembling and separation for module reuse [1], which saves transportation