Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 61 (2017) 275 – 280

www.elsevier.com/locate/procedia

The 24th CIRP Conference on Life Cycle Engineering

Development of Resource Efficiency Index for Electrical and Electronic Equipment

*Wang Juntao, Nozomu Mishima

Akita University

* Corresponding author. Tel.: +81-18-889-2978; fax: +81-18-889-0405. *E-mail address:* smartwjt@163.com

Abstract

The paper divides resource efficiency of smartphone into three stages; they are resource efficiency of manufacturing, utilization and end-of-life treatment. Output-input evaluation method is used for manufacturing. A real used value of each functionality of smartphone is developed for utilization. An index of resource efficiency for recycle stage is proposed. For each stage, an environmental impact coefficient and TMR are used. Finally the total resource efficiency of a smartphone is derived. This index evaluates resource efficiency both considering mechanical aspect and the real used value by people related to consumption of resources.

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

Keywords: Resource efficiency; environmental impact coefficient; TMR; real used value; functionality; accumulated; total resource efficiency

1. Introduction

Resource use is a very hot topic in the world nowadays, especially modern life heavily depends on natural resources which make the demands rapidly increasing. And it is believed that the total amount of natural resources in the world is finite. What's worse, the environmental problems are becoming more and more serious with the consumption of resources. To satisfy the continuous increasing demands for natural resources and to establish a sustainable world, resource efficient use is needed. In order to achieve resource efficiency, one of the important things need to do is to establish a common and easily understandable index that can evaluate the resource efficiency of a product easily and comprehensively.

In former researches, many kinds of methods were invented or used directly or indirectly to evaluate resource efficiency. The initial and basic method can be seen as the ratio of production and total consumption, but actually this method is more likely the productivity of science and technology. It is not only without thinking the utilization and end-of-life treatment of the product, but also fails to make a comprehensive evaluation rather than only technology and quantities. A very similar method to the above one is monetary based evaluation method, this kind of index can be described as 'resource productivity'. One of monetary based evaluation methods can be used to evaluate resource efficiency by GDP divided by Domestic Material Consumption (euro/ton) [1]. However, the big problems of these methods are lack of ability to consider the environmental impacts which are very important and matter too much right now as well as without considering the utilization value by people. Instead of evaluating resource efficiency directly by calculation of the ratio of output and input, another kind of methods focusing on the whole life time of product from resources to end-of-life treatment to analyze consumption of resource and utilization of product. This king of method aims mostly at finding out what happened along with the consumption of resources, and tries to quantify the impacts generated by the consumption of resources. Among them, a very welcomed one is life cycle assessment (LCA). LCA is a tool for the systematic evaluation of the environmental aspects of a product or service system through all stages of its life cycle [2]. Even LCA can be used to evaluate and rank the resource efficiency related to environmental impacts, and is helpful for assisting achieve more sound environment and sustainable world while utilizing resources. However, too much attention on the environment is not the initial expectation and final goal of utilization of resources, also necessity of a large amount of

Peer-review under responsibility of the scientific committee of the 24th CIRP Conference on Life Cycle Engineering
doi:10.1016/j.procir.2016.11.172

database makes LCA limited. Essentially, the initial expectation and final goal of development and utilization of resources is to satisfy with the demands of people, which means to serve people. At the same time, to make a better living circumstance and finally achieve a sustainable world, the risk of environmental impacts regarded to consumption of resources need to be well controlled. Considering these, this paper is aimed at solving these problems with a proposal of index of resource efficiency.

The index in this paper starts from the real utilization of resources, and considering mechanical aspect and used value by people, also environmental impacts all over the whole life time of utilization of resources from cradle to grave. And based on the electrical and electronic equipment, the total resource efficiency index is derived. The rest of the paper is organized as follows. Section 2 takes an overview of the whole lifetime of product and based on these section 3 brings out a proposal to make a comprehensive evaluation of resource efficiency. Finally, section 4 draws a conclusion for this paper.

2. Whole life of a smartphone

As the amount of EEE (Electrical and Electric Equipment) being larger in the world, Smartphone, as one of the very important kind of EEE, is making a big difference in the resource market. It is said that there're more than two billion smartphones being used right now [3]. Moreover, the changing speed of a smartphone is very fast. Some papers and investigations estimate that current replacement time are between 1 and 2 years, while manufactures believe that the technical lifetimes are in the order of 10 years [4]. The unreasonable development and utilization of smartphones and rapidly changing speed not only make the functionalities of a smartphone do not get the maximum use, which lead to a very big waste of resources, but also generate tremendous volume of waste that have a deep impact on the environment[5]. So it is necessary and urgent to achieve resource efficiency of smartphones and any other EEE to help build up a sustainable world. To achieve resource efficiency, a whole understanding of the utilization process of resources is very important. To sum up, the utilization process of resources contains three main stages, which means the process from resources to product, the process of utilization of product, and the process of resources returned from product.

2.1. Structure from resources to product

Resources are the fundamental physical composition of a product. This process is a chemical and mechanical process to achieve the transformation from resources to product. Actually, from a view of engineering, the goal of this process is to convert a certain amount of resources to another amount of resources. Even though the function of different products may vary very much, in terms of this process, achieving the transformation with as less as resources consumption and waste of resources will definitely make better use of the resources.

2.2. Process of utilization of product

Products are made to support some functions that can be used by people to achieve some benefits. Normally, for batch products, people's demands for them are undoubtedly demands representation for different kinds of functions that supported by the product that consists of a certain amount of resources. People's demand urges people to purchase a product for its functions, but as time goes and technologies develop, demand will drive up to a point that the owner decide to change the product. During the whole process of utilization of the product, the actual utilization extent of each function by people will change along with time, at the same time, the usage value that people benefit from each function of product will be accumulated with time. Considering the whole life cycle of a product, from production to end-of-life treatment, the whole usage value will be accumulated.

However, the used value does not mean the initial overall function value of a product, especially for an equipment with rapidly upgrade speed, like smartphone. This kind of EEE always have a 'more reserve capacity of function'. Whenever people is aimed at choosing one product, the very important point is to choose one with more capacity of function that cannot be used directly right now, which reserves to serve the future requirements. And for the overall function value of a product, in some studies, it's said that it decreases along with time due to obsolescence and other physical factors [6]. It can be showed in Fig.1. Based on these, here a definition of used value is made.

As one of the scenarios, we will make the product out of life when the used value in a point equals to the overall value. While under this scenario, the 'disposal point' can be showed as Fig.1. And then the accumulative used value will be gained as the shadow in Fig.1. Obviously, for a product with so many functionalities as smartphone, no matter the accumulative used value, nor the overall value decrease is the integration of all the functionalities of a smartphone.

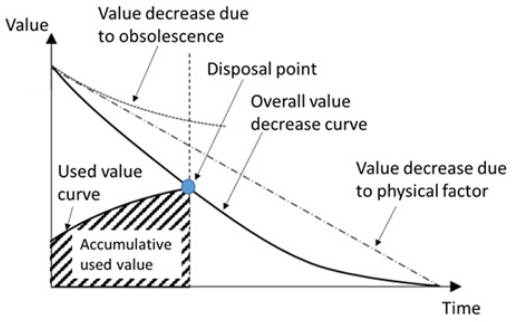

Fig.1.Accumulative Used Value while Used Value equals to Overall Value

Besides the 'disposal point' mentioned in the first scenario, sometimes people change their products without considering the utilization extend of functionalities, simply to say, just change it for its old and some subjective reasons, or sometimes insist on using even though it cannot satisfy