

Role of Product Life Cycle on Product Service System (PSS): Emerging Needs and Challenges

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Abstract: *Product Service Systems (PSS) is a concept which means product and service are integrated to meet customer requirements. It has many applications in several industries. In current researches, Product Life Cycle Modelling and Service Engineering (SE) are main methodologies to design and model PSS. This paper proposes a framework of service life cycle integrating product life cycle. Each stage of service life cycle contains a number of service processes. Each service process is modelled using Service Engineering. This paper also proposes a primary input & output parameters system for the service process model, which integrates costs, resource consumptions and states of product or customer. At the end of the paper, the authors discuss the future work to improve this model.*

Keywords: Product Service System, Life Cycle Model, Service Engineering, Product Life cycle

1. Introduction

Product Service Systems (PSS) is a system that integrates product and service to meet customer requirements and to reduce the environment impact. It is classified into three types: Product-Oriented PSS, Use-Oriented PSS and Result-Oriented PSS (Cook 2006). In recent years, some organizations have adopted the PSS into their business operation and each type of PSS is applied in different industries. Product-Oriented PSS issued in some cases which company integrates services in to product life cycle management. The typical applications of Use-Oriented PSS are car sharing, car pooling and car leasing. Result-Oriented PSS' applications include washing centre and chemical management service. In this paper, literatures are reviewed from three aspects: the concept, classification and application of Product Service System; product life cycle model in PSS modelling; Service model in PSS modelling. The first part of literature review is background information of product service system. The other two parts of literature review concern on the current modelling methodology of PSS. In current researches, product life cycle model and service modelling are widely used in PSS modelling? Many researchers integrate services into product life cycle and develop some models for Product-Oriented PSS. For the service model in PSS modelling, the blueprint is used in some papers, and Service Engineering is another more important methodology for service modelling. The typical application of Service Engineering on PSS modelling is proposed by Komoto and Tomiyama (2008), who integrate the Service CAD with the product life cycle simulator.

2. Literature Review

In this section, we the researcher have taken the adequate method and procedure as taken by the previous researchers, But we have focussed to study how the role of Product life cycle on product service system in relation with development of science and technology, whether it justify the taken hypothesis in anticipation with the entitled article “**Role of Product Life Cycle on Product Service System (PSS): Emerging Needs and Challenges**”. It influences the product service or not? Especially for the last two parts, three main limitations in current researches on PSS modelling are identified. The first limitation is that few PSS models are developed from service' perspective; the second limitation is the consideration of customer behaviour factors is very lack in current researches; the third limitation is current PSS models need more quantitative evaluation. In order to overcome these gaps, a new framework for PSS is proposed in this paper. The framework is based on service life cycle instead of product life cycle. The service life cycle includes many service processes, which can be modelled using service engineering. In addition, this paper proposes a basic structure for service process model. This structure integrates customer behaviour factors. The whole framework has a set of indicators are outputted from model that can be used to evaluate the performance of system. Consequently, this framework has a set of parameters to evaluate a Product Service System's performance quantitatively.

3. Aim and Objectives of Research:

In this invited article, the researchers have emphasized to go for research work with the following aim and objectives such as:

- To facilitate the product service System for a better consumer satisfaction.
- It increases the demand of product production and Promotion process due to consumer satisfaction and their choice.
- It focuses to reduce the cost of product production and promotion through a better service system.
- It minimizes the problems from the consumer side and enhances a good customer service through the mode of PSS.
- It takes the challenges to meet the requirements of consumer regarding the product quality, design and latest model of product with better facilities of product production and its service system.

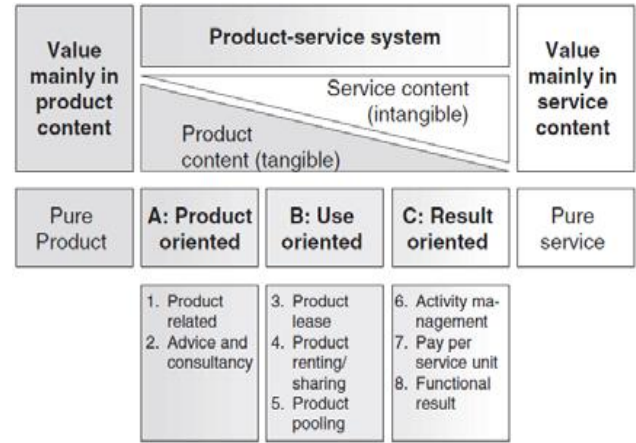


Figure 1: Main and subcategories of PSS

4. What is a Product Service System?

As the word Product Service System (PSS) is concerned, it is a way of service facilities provided by the companies upon the produced product to the customer for their maximum satisfaction.

Cook (2006) defines Product Service System as a system that integrates product and service to meet customer requirement and to decrease the environment impact. According to the research of Mont (2002), PSS is developed with the concept of functional economy and defined as "a marketable set of products and services capable of jointly fulfilling a user's need. Product/service ratio in this set can vary, either in terms of function fulfilment or economic value (Goedkoop et al. 1999)".

Classification of PSS:

PSS is classified by Cook (2006) into three types such as (i) Product-Oriented PSS, (ii) Use-Oriented PSS (iii) Result-Oriented PSS

In different types of PSS, product and service have different levels of importance. Generally speaking, in Product-Oriented PSS, product is core part whilst service is designed and provided according to the life cycle of the physical product. In Use-Oriented PSS the product's function is to provide services to customers. In Result-Oriented PSS, service can replace product to provide desired results to customers. The work of Tukker (2004) reveals relationships between service patterns and types of PSS, which is demonstrated in figure -1.

5. Hypothesis

In this research paper, we have taken the following hypothesis in anticipation with the above said research problem that The Role of Product life cycle has a tremendous impact on product service System Service by which consumers are highly satisfied due to fulfilled their required things thorough a better service facilities given by the companies upon their buying product/s.

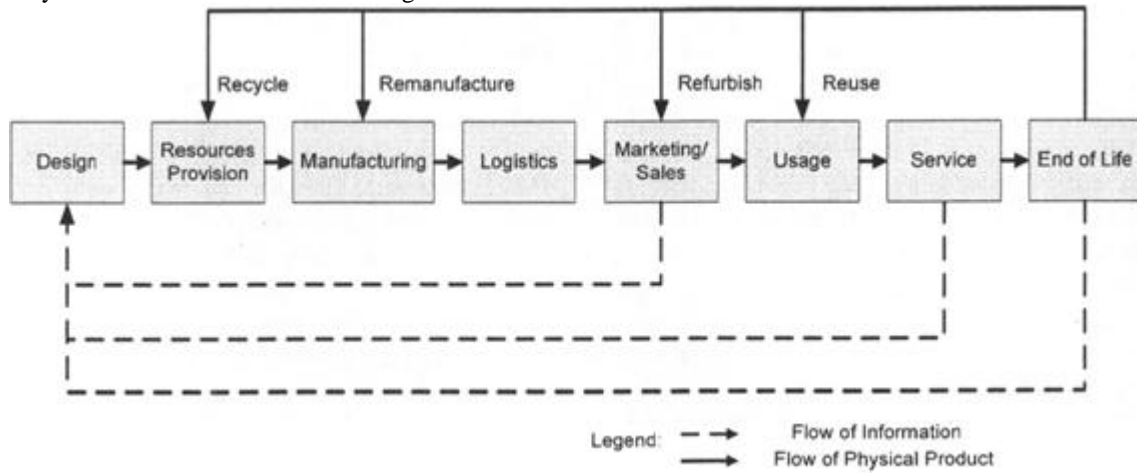
In recent years, some companies and organizations integrate services into the whole product life cycle. This type of PSS is Product-Oriented. Xerox, as an example, provides asset management for all life cycle stages after the sale of their products in order to minimise environment impacts of ownership (McAloon & Andreasen 2004). DuPont Flooring Systems (USA) has changed the business from just selling floor coverings to providing total service packs to customers that covers 'gate-to-grave' stages of product life cycle, including installation, tailored maintenance, take-back, and recycling (Goedkoop et al. 1999). One typical application of Use-Oriented PSS is car sharing, car pooling and car leasing, Williams (2007) introduces that one in four cars are purchased through leasing arrangements in Germany. For car sharing, customers can use and reserve cars when there is a need and pay rental-fees on a variable basis (e.g. per kilometre or per unit of time). This type of business can bring more efficient usage of cars (Yang et al. 2008). Another example is Swiss Mobility Schemes, which is the largest car sharing service provider in the world, has almost 60,000 members in 2004. Roy (2005) describes the application of Result-Oriented PSS in Netherland.

The government has supported building washing centres to provide washing services for residents in communities. This system can reduce water and energy consumptions. This concept also can be applied for other household services such as heating, cooling, lighting, shopping cooking and eating. Another area which the Result-Oriented PSS is applied widely is chemical management service. Yang et al (2007) introduce that this business model means customer purchases a chemical service instead of chemicals themselves. Customers pay fees based on the quality and quantity of services provided rather than the volume of chemicals sold. Kauffman et al (1999) point out that this mode can reduce chemical lifecycle costs, risks, and environmental impacts.

6. Product Life Cycle Model in PSS Modelling

Product life cycle is main focus for PSS. For many researches on PSS, product life cycle management and modelling is an important issue. Mien, Feng and Leng (2005) proposed a basic frame work of Product Service Systems integrated with manufacture, which is called 'Integrated Manufacturing and Product Service System

(IMPSS)'. This framework identifies several stages of product life cycle and services around these stages.



Framework of IMPSS, Mien et.al. 2005, **Figure 2**

Obviously, this framework is a typical Product-Oriented PSS suitable for traditional manufacturer to add services to their products, and upgrade an old business model to a new PSS Model. It is similar to the research of Aurich, Schweitzer and Fuchs's research (2006). In this paper, researchers assert that the Product Life Cycle Management is the core issue for the design of PSS. However, it is difficult to obtain enough information and data about product life cycle just depending on conceptual models and frameworks. Therefore simulation approaches are applied in the research. Takata and Umeda (2003) discuss an indicator system that is used to evaluate a product life cycle, and differences between life cycle assessment and life cycle simulation. Nonomura and Umeda (1999) also discuss the advantages of life cycle simulation in comparison with the life cycle assessment. In addition, they proposed a simulation model for product life cycle as a network of processes such as manufacturing, operation, recycling and remanufacturing.

Some researchers pay their attention to developing simulation models for particular products. Hata etc. (2000) developed a simulation model for air conditioners. The model is developed as a set of simulation events based on the usage process flow of different components of air conditioners. Komoto, Tomiyama and Ngel (2005) tried to use life cycle simulation to analyse the product service

systems. They identified the objects and relationships in a PSS. Their research illustrates that events in product life cycle will be parts of events in the PSS. Therefore, they integrated these events into the PSS simulation model.

7. Service Model for PSS Modelling

From the definition of PSS, in many cases, service plays a more important role than the product, especially for User-Oriented PSS and Result-Oriented PSS. Therefore, service is another key area for the PSS researchers. Many researchers propose methods to design and modelling PSS system. Boughnim and Yannou (2005) use the Blue print to design a PSS. They decompose PSS into four dimensions, product, service, infrastructure and network, and emphasis service engineering. In this paper, Boughnim and Yannou design the service process and identify the questions that the Service Blueprint should answer: Who does What, To Whom, How often and under what conditions the real Gross domestic Products are consumed by the consumers for enhancing the GDP of the country. Here, this model of RGDP refers about the annual average change in percentage in New Zealand, Australia and USA in recent years

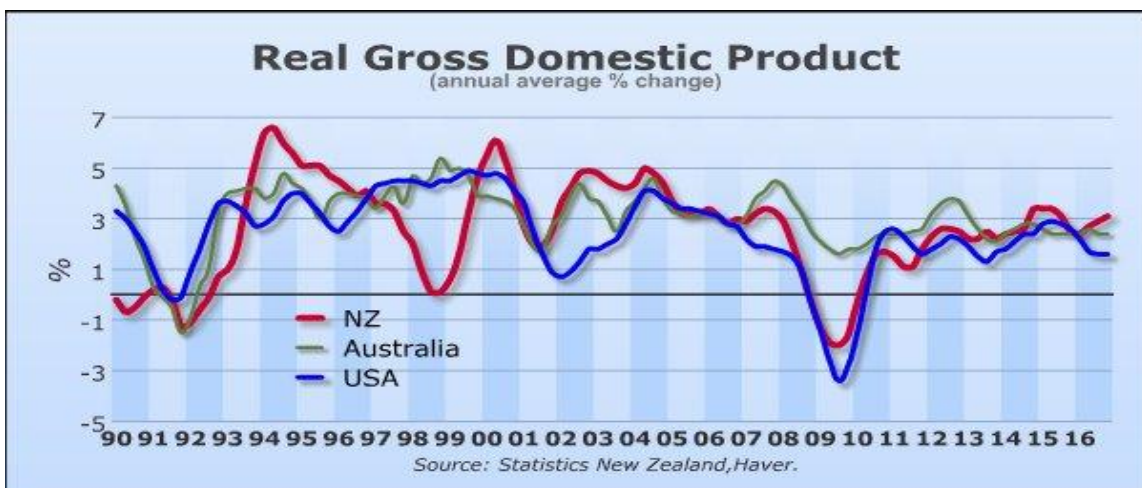
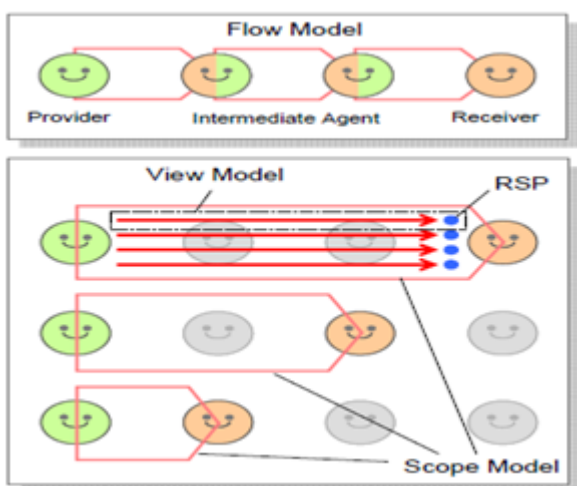


Figure 3: Refers an Average change in % of RGDP]

Similarly, Morelli (2006) also provides the design of the service process in a PSS's structure using blue print. Moreover, he uses an interaction map for indicating relationships and interactions between different actors in a system, and applies it to some cases such as shopping centres. Service Engineering is very important in PSS design and modelling. It is defined by Zirpins, Baier and Lamersdorf (2003) as the manufacturer can build customized services to their products. The service design includes the issues of modelling, adaptation, aggregation and coordination. Sakao and Hara (2006) defines service as 'the activities between the service provider and the service receiver that can change the state of receiver'. It is considered that service has three elements: service goal, service environment and service

Channel (Tomiyama 2001). The content of Service is delivered through service channel. Moreover, Sakao and Hara introduce a service functional structure including flow Model, view model and scope model in the following

Flow Model of Service



**Flow model of the relation among three Sub Models
(Sakao & Hara 2006)**

While a few researchers develop a computer-aided service design systems called service explorer (Hara, Arai & Shimomura 2006). Others, such as Sakao in 2006 focussed on connecting service engineering with the computer-aided design (CAD) system for service development. The work of Komoto and Tomiyama (2008) propose to integrate the service CAD with the product life cycle simulator for the PSS modelling. In another research of Yoshimitsu et al. (2006) investigation was conducted about the evaluation a service from the customer's view. They provided a function of calculate the receiver satisfaction and the relationship between the receiver satisfactions and attribute values of service. In this paper, Yoshimitsu et al. cite

8. Limitation of PSS Model

From the literature reviewed above, many PSS models present conceptual framework which only have qualitative analysis and are lack of quantitative measure. For example, the model of Closed loop Logistic Systems developed by Hu, Wang & Bianda (2007) and a framework called

'Integrated Manufacturing and Product Service System (IMPSS)' proposed by Mien, Feng and Leng (2005) are both short of quantitative analysis in the evaluation methods. These Conceptual frameworks and roadmaps are effective in prescribing strategies and key processes for making business paradigm changes. However, they are very difficult for companies to use in making informed decisions with clear understandings on the possible economic, environmental, and operational implications of different strategies/options for the product - service -delivery system (PSDS). Consequently, research on the evaluation of a PSS model should be strengthened with more emphasis on using quantitative approaches to support decision making. The customer satisfaction model proposed by Kano to classify the receivers' satisfaction's

The concept of service life cycle has introduced in IT area. For example, Ives and Mason (1990) propose framework of 'customer service life cycle' for e-commerce, which is shown as Figure 4

9. Classification of Customer Service Life Cycle

In customer service a service life cycle has divided into four stages and each stage includes several service activities. Stage of 'Requirements' includes needing and Specifying; 'Acquisition' has activities of Sourcing, Ordering, Paying Obtaining and Installing. This stage starts to provide service to customer; 'Ownership' includes the activities of Training, Maintaining, Monitoring and Upgrading. Retirement is the last stage, which includes Replacing, Evaluating, and Reselling and Accounting.

In this paper, service life cycle's framework is developed based on the framework shown in the following model. The modified service life cycle framework integrates product life cycle, which emphasizes the combination of service life cycle and product life cycle. In fact, this service life cycle is a service pack that business provides to a customer. This service life cycle has four stages i.e. Service Requirement, Service Deployment, Service Processing and Service Retirement, which is shown in Figure 4:

- *Service Requirement:* It is the beginning of all life cycle. In this stage, PSS provider analyses customer requirement, product & service selling, and service customization. In fact, the Service Pack is designed in this stage.
- *Service Deployment:* it includes service processes of product installation, paying, product delivering and training. In this stage, service and product are deployed and start to provide functions to customer.
- *Service Processing* includes the processes that remain quality of service, including product maintenance, repairing, upgrading, service monitoring, service renew and retraining. *Service Retirement* is the end of service life cycle, which includes service processes such as service evaluation and product take-back.

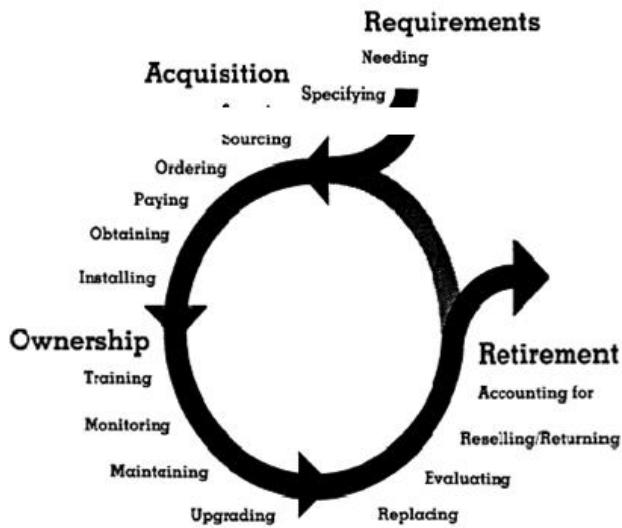


Figure 4: Refers Model of Customer Service Life Cycle (Ives & Mason, 1990)

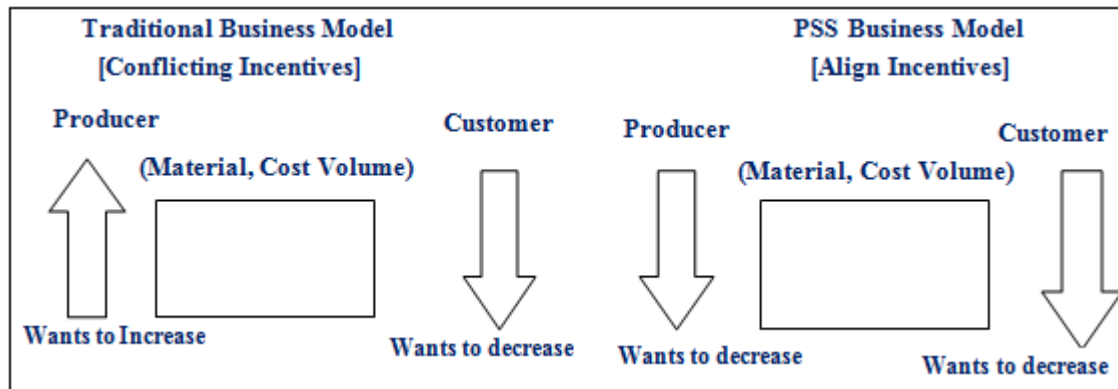
10. How to Manage Customer Life Cycle?

In management there is nice comment, regarding the customer relationship while made by marketer that “It is so easy to woo a girl but it is too difficult to woo a customer”. Thus, to manage a customer is very difficult, where a customer life cycle is proceeds number of ways for manage of customers such as

11. Stages of Customer life Cycle Management

- **Reaching:** – Your content must be properly marketed in places where people/businesses in your market will find your information. This way they will become aware of your company’s existence.
- **Acquire**– You have to understand your potential customers wants/needs so you can provide a product/service they will want to purchase. Contact them directly with personalized communication in order to convert them from potential leads to paying customers.

Customer –Producer Relationship Model for Manage customer life cycle



- **Development**– After the first purchase, keep in touch and build a relationship with your customer. Ensure they are fully satisfied with their purchase.
- **Retaining**– One time customers will become repeat customers as long as you are satisfying their needs. Care for them and continue to cultivate a relationship with them. Do not be afraid to ask for feedback. They will be happy you care about their opinion and you can use their comments to improve your product/services. Make them feel a part of the process.
- **Advocacy**– If your customers are truly satisfied, they will become brand advocates. This will spread awareness within their social circles and the cycle will come full cycle when you reach potential new customers due to your existing customers.

12. Suggestions &Recommendations

- PSS concept needs to be more strengthened.
- The point of PSS concept rests on the relationship between production and consumption.
- Incorporate post-modern perspectives.
- Towards integration of product policy and environment policy

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14. Conclusion

In sum, the above summations are summarizing that, this taken research article has presented about the role of Product life cycle on the practices of product service system where a service provider to consider from a life-cycle perspective.

This includes both considerations regarding the product and the services used during the life-cycle phases.

References

- [1] Amezquita . T. Hammond, R., Bras, B. (1995) Characterizing the re manufacturability of engineering systems. In: ASME Advances in Design Automation Conference, DE-vol. 82. ASME, Boston, Massachusetts. p. 271-278.
- [2] Aurich, J. C., Fuchs, C., Wagenknecht, C. (2006) Life-cycle oriented design of technical Product-Service Systems, J. of Clean. Prod., 14(17): 1480-1494.
- [3] Bras, B., Hammond, R... Towards Design for remanufacturing– metrics for assessing re manufacturability. In: Proceedings of the 1st International Workshop on Reuse, Eindhoven, the Netherlands, 11–13 November, 1996, and pp. 5–22.
- [4] Boothroyd, G., Dewhurst, P. (1986) Product Design for Assembly. Boothroyd Dewhurst Inc., Wakefield, RI.
- [5] Guide, V.D. (1999) Remanufacturing production planning and control: U.S industry best practice and research issues. Second International Working Paper on Re-use, Eindhoven, the Netherlands, p. 115–128.
- [6] Guide Jr., V.D.R., Jayaraman, V. (2000) Product acquisition management: current industry practice and a proposed framework. Int. J. Prod. Res. 38(16): 3779-3800.
- [7] Ferrer, G. (2001) Theory and methodology on the widget remanufacturing operation. Eur. J. Oper. Res. 135, 373–393.
- [8] Furuhielm, J. (2000) Incorporating the end-of-life aspect into product development: Analysis and a systematic approach. Linkoping studies in Science and Technology, dissertation No. 642, Department of Mechanical Engineering, Linkoping University, Linkoping, Sweden.
- [9] Ishii, K. Design for environment and recycling: overview of research in the United States. Invited paper in CIRP 5th Life-cycle Engineering Seminar, Stockholm, Sweden, September, 1998a.
- [10] Ishii, K. Modularity: A key concept in product life-cycle engineering. In Handbook of Life Cycle Enterprise: Molina, A., Kusiak, A. (eds.) Kluwer 1998b.
- [11] Ishii, K. and Lee, and B. Reverse fishbone diagram: a tool in aid of design for product retirement, in 1996 ASME Design Technical Conference: Design for Manufacturability Irvine, CA, September, 1996.
- [12] Ijomah, W. L., Bennet, J. P., Pearce, J. Remanufacturing: evidence of environmentally conscious business practice in the UK. In: Proceedings to International Symposium on Electronics and the Environment (IEEE), p. 192-196. Danvers, USA; 11-13 May 1999.
- [13] Ijomah, W. A model-based definition of the generic remanufacturing business process, PhD Dissertation, The University of Plymouth, UK, 2002.
- [14] Ijomah, W.L., McMahon, C.A., Hammond, G.P., Newman, S.T. (2007) Development of robust design-for-remanufacturing guidelines to further the aims of sustainable development. Int. J. Prod. Res., 45 p. 4513-4536
- [15] Ijomah, W.L. Enhancing decision making in remanufacturing. The 17th International Conference on Flexible Automation and Intelligent Manufacturing (FAIM), Skövde, Sweden, June 29- July 2, 2008.
- [16] Jacobs, M. (1991) the Green Economy: Environment, Sustainable Development and the Politics of the Future. p. 110–116, Pluto Press: London, UK .

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