Decision making within the conceptual design phase of eco-friendly products

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Abstract

A contribution for environment protection is the conceptual design of eco-friendly products, considering information of main product life cycle phases: Development, manufacturing, usage. Base of operations is product generation A, where the development is closed and the manufacturing/usage phase is ongoing. The designer of the subsequently product generation B has different possibilities to consider eco-friendly aspects and resource saving, e.g. incorporate Carry-Over Parts, parts for reuse, upgradeable components or parts for refurbishing. The challenge for the designer is the decision complexity: He needs a lot of eco-related information of product generation A on component-level, e.g. CO₂-emission, disassembly procedures, reliability information. This paper shows a concept, how to make eco- and sustainability-related decisions within the conceptual design phase of a subsequently product generation. The decision concept is explained by an automotive engineering example.

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Keywords: Decision making; Concept phase; Sustainable engineering; Information use of previous product generation; Knowledge management

1. Introduction

The influence of the conceptual design of eco-friendly products is very high: Within the concept phase, the engineers can define eco-friendly package, material, functionality and possible recycling strategies of the product in a
fundamental way. Base of operations – besides the current knowledge of sustainable engineering – are information from the previous product generation A. This generation is already in the usage phase of the product life cycle. Therefore, the designer of the subsequently product generation B has different possibilities to consider eco-friendly aspects and resource saving, e.g. incorporate Carry-Over-Parts, parts for reuse, upgradeable components or parts for refurbishing. The challenge for the designer is the decision complexity: He needs a lot of eco-related information of product generation A on component-level, e.g. CO₂-emission, disassembly procedures, reliability information.

This paper shows fundamentals and recommended actions, how to make eco- and sustainability-related decisions within the conceptual design phase of a subsequently product generation B. Furthermore, it is illustrated, which data and information based on the current product generation A is needed as a base for sustainability-related decision-making. The structure of the paper is as follows: Principles of decision making in the early stage of the product life cycle (PLC) are explained in section 2 and which phases/activities of the PLC are important (cf. section 3). Subsequently, it is illustrated, which fundamental activities and related information can be provided from the product design phase (cf. section 4), the manufacturing phase (cf. section 5) and the usage phase (cf. section 6) of the previous product generation A. Finally, section 7 summarizes this paper.

2. Decision making in early stage of PLC (Goal of research)

The decision-making process for designers in the early stage of product life cycle regarding the parts of generation B is shown in Fig. 1. First, parts of product generation A are classified into two categories depending on the need for product improvement of the structure or functions from the previous product generation A to product generation B. When the product generation B is needed for improvement, the part should be upgraded and designers need to redesign the product. The judgement of the need for product improvement should be considered from the viewpoint of not only the physical functionality but also environment, economic, and appearance change of the product generation B. For example, the judgement of the upgradability of automobile engine includes physical functionality such as engine power, and environmental and economical view such as fuel consumption.

Second, when parts of the product generation B are not needed for upgrade, designers judge the reusability from the status of the parts such as abrasion and corrosion. The reusable part include mirror or door of automobile. For example, approximately 70 kg CO₂ are reduced by the reuse of automobile front door [1].

Finally, when parts of the product generation B are non-upgradeable and non-reusable parts, designers judge the possibility for remanufacturing or new manufacturing (carry-over) from the view point of the amount of environmental loads and production cost. For example, it is preferable that heavy parts such as automobile engine and transmission are remanufactured and recycled as material, meanwhile hardly decomposable parts are manufactured as carry-over parts when remanufacturing of the parts end up costing more.

3. Base of operations: Product life cycle and information

The decision making process for designers within an early phase of product development phase can be supported by many data and information from the previous product generation A (and product life cycle of product A). The product life cycle of technical products can be described in four main and eight subordinate phases. The product life cycle and the product related information (- excerpt -:; examples in brackets) are as follows, cf. also [2]:

- Concept phase
  1a) Definition of the product characteristics (e.g. target specification product, system FMEA),
  1b) Development of the product concept (e.g. component specification)
- Development phase
  2a) Construction stages incl. different prototype levels and finalising of construction (e.g. technical drawings, simulations, Construction FMEA, prototype component tests, stress tests)
  2b) Preparation of manufacturing (e.g. process FMEA, machine capability, process simulations)
- Production phase
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