5 Strategies, Concepts and Objectives

It is evident that the *DfR* rules will not make up a design strategy at the product level when they will simply be put together. ISO/TR 14062 [64] could help; however, it does not systematically discuss the complete chain of steps starting from the required design strategy, and ending in marketing and product strategy. A description of the design strategy is missing. So a systematic approach to achieving an environmentally compatible product has a gap. Quella could close this gap by recommending a proposal for this missing link [79]. The design strategy could consist of a functional design, a parts and types reduction or an approach using standard components. VDI 2243 recommends following steps to develop a recycling-oriented strategy:

- Define and analyze the market and customer requirements,
- Analyze present and forthcoming regulations to forecast the future situation (legislation, guidelines, standards,...) for the sales of products
- Take the actual recovery situation in leading countries into account,
- Analyze the forerunner products and products of competitors.

These steps have already been discussed in Section 2.6 and Chapter 4, mainly from the viewpoint of development requirements. Nevertheless, there are other issues the development engineer should address; for example, the question when the product needs an updating. He should review not only the update, but analyze the complete design and, wherever necessary, improve it to increase the efficiency.

Note: The problem often entails the question how to combine and integrate several, often conflicting requirements to produce a solution.

5.1 Strategies for Realization a Redesign

If the structure of a product or its connections/fasteners is to be revised, for example to ease the disassembly, rather an overall redesign should be considered, instead of a stationary change, for example solely replacing a single screw.

A radical modification is often much more promising; this is also true for the substitution of a hazardous substance. The realization of several changes could save money, whereas a single substitution might usually cost money without bringing the desired effect.

Many products survive decades of usage, often for several generations, without changing their external appearance and functional structure. For example, some household appliances are optimized (subject to usage and technology) so that they come in the same design and shape from one generation to the next. In these cases there is not much that can be improved from the environmental point of view. Therefore, a planned innovation jump can, together with legislation, bring such products under pressure to become more environmentally compatible.

The innovation jump (see **Figure 5.1**) is characterized also by the advantage that essential characteristics of the consumption will be decreased by certain factors. Examples are the transfer from conventional light bulbs to energy saving bulbs and from those to the LED lamps. LED lamps consume, in contrast to conventional electric bulbs, only about 10 % of the energy. In Figure 5.1 the common

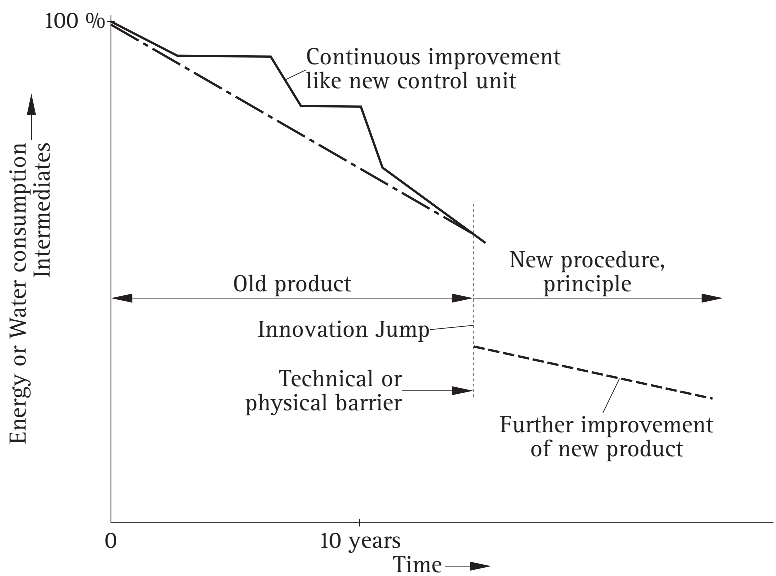

Figure 5.1 Course of the continuous improvement of the environmental properties of a product over time. If a physically limitation is achieved the possibility to improve the product ends (dotted upright line). After an innovation jump or adopting a new functional principle, or a better technology, the continuous improvement will go on but at a lower level of physical properties until the limitations of the new principle are achieved [57]

development of a product is sketched that is assumed to successively be improved for years, and into which new, innovative components are built-in. This can be, for example, a new control unit which allows some energy reduction but the physical limits of further improvement have then been approached. Another, up-to-date example is given by modern washing machines for which water consumption, volume, etc. under pre-defined conditions could hardly be improved. One potential innovation is washing with liquid carbon dioxide instead of water so that roughly half of the energy is consumed at half of the washing time. This procedure is already reality by some dry cleaners. It is worthwhile to note that the environmental impact of the machines of this generation is considerably lower. It is evident that such new procedures and their equipment usually radically differ from the ones of their forerunner.

Unfortunately, the principle of the innovation jump presented in Figure 5.1 is still not systematically adopted in practice. Some manufacturers obviously still do not understand that the competitor deploying a new, improved technology could dominate the market, by the technological progress and the innovative product, leaving others far behind.

Note: At the physical limitation of a technology development an environmentally related innovation jump should be planned in time.

1-plastic strategy

An important approach to redesign is realized by the "**1-plastic strategy**". In the E&E industry this could be called a "Two-materials-strategy" that requires, as an idealized, visionary goal, that only one conductive material and one insulator material be used. It is likely that this objective will never completely be achieved, but thereby the manifold of materials and the complexity of the product might be strongly reduced, often up to a factor ten. To achieve this objective, the designer might try to place materials of the same kind into the same component of the product. These materials might be, in the present product, placed in different components and thus not necessarily close to each other. These components might also be potentially combined together in one unit and the plastic of this unit could then be injection molded in one mold.

Alternatively, many plastics used in the product – also thermosets – could be substituted by the same kind of a higher valued thermoplastic, for example ABS, PP or modified PPO. This way, not only material can be saved, but also chances increase to combine components made of the same material, producing one, multi functional component. Potentially higher tool costs for the injection mold will be easily compensated by the simplification of the component. If the goal "1-plastic" cannot be achieved, mixtures of different plastics compatible with each other can be chosen. In his book “Recycling-oriented construction of railroad cars”, (in German) *Böhme* [80] succeeds for building the interior in a railroad car to select all different thermoplastics required so, that even upholstery plastic materials are compatible with the selected thermoplastics. So one compatible mixture of thermoplastics could be formed if the train becomes waste or the interior will be exchanged for repair.

Reduction of types and parts

Considerably large amounts of material can be saved using standard, commercially available software for reducing the number of types and parts contained in a product. By this procedure in an ABC analysis[8] B and C parts will be reduced as far as possible. The aforementioned 1-plastic strategy can certainly be combined with such a program; however, the 1-plastic strategy requires good knowledge on environmental and material science.

Strategy of functional units

In her doctoral thesis “Integrated product policy with E&E products to optimize the life cycle” ([81] in German), *Melzer* describes an implementation strategy that consists of the disassembly of a product into its functional units. Using again a vacuum cleaner as an example, functional units can be listed as follows:

- Dust absorption,
- Suction equipment,
- Dust collector,
- Fan,
- Drive,
- Power supply,
- Housing.

This implementation strategy, called “strategy of the functional units” helps to

- combine reusable components in a functional unit,
- create standardized components or select standard components (cost decrease) which might easily be “upgraded”,

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[8] ABC analysis: The ABC analysis is an economic tool for planning and decision making. It divides objects in three classes of A, B and C objects. By this simple procedure objects or processes could be weighted. For example it could be applied to group the material consumption according to values.

- decide between equal-energy-efficient (may be more expensive) and less-efficient-components (cheaper),
- order the environmental profile (bill of material, *LCA data*) of the functional unit directly with the manufacturer or supplier together with the product, and thereby the environmental impact for the optimization of the complete product can easily be calculated[9].

By applying the "1-plastic" strategy the producer will

- manufacture an individual product,
- achieve better environmental compatibility than with a standardized product.

This strategy has advantages over the life cycle. It can, however, cause higher production costs because components could not be bought directly from the market. Both strategies also can be combined.

Strategies at one glance

A detailed and comprehensive view of the different strategies is presented in [79]. As the materials of a component and of the complete product are widely known, the environmental properties can be improved by a LCA via computer programs. The optimized functional units thereby could form the backbone for ideal assembly/disassembly, or the materials will be combined in optimized units.

Manufacturers who do not produce the components themselves but buy on the market can adapt one of the above mentioned strategies, or a combination of them, using also standard software for optimizing.

It might be the main target to design a product of improved environmental compatibility, but the structure of the product has to be additionally considered. The best compatibility cannot help if the demanded, valuable materials or the components cannot easily be separated because dismantling is complex and thus labor intensive. However, with the help of computer programs the dismantling process can be simulated and analyzed. Moreover, those programs help also to modify the assembly for making it easier, and, equally important, to reduce costs.

To sum up, the new product can successively be optimized by LCA and disassembly analysis. Suitable components or materials for this purpose could be relocated so that they could easily be extracted for reuse. The best and simplest

9 The association ZVEI offers, on request, material records of components so-called "Umbrella-Specs". The German association for products and building BBS (www.baustoffindustrie.de) already has extended this information to LCA data.

way is reconstruct the product that way it can directly be disassembled into its recovery parts: In the ideal case, there should be very few materials with E&E products. Different solutions will be necessary if some of the rare trace elements also need to be recovered.

Technologies which are environmentally better compatible or more recycling-friendly

While selecting materials, a design engineer is supposed to also simplify the production process in his company and improve its environmental compatibility. For example, he can find out that compression can be cheaper than the soldering applied at the moment. Solvent-based print or inscription processes can be replaced by laser inscription. However, this requires partly different materials. In the long run it can be expected that for producing printed circuit boards new halogen-free materials will be used. They will reduce the acidic and partly dioxine forming emissions from halogenated (brominated) plastics emitted by a copper smelter or other recycling processes. Consequently, this will lead to a higher environmental compatibility of these electronic components. Because of the emissions, the recovery volumes of a copper smelter are limited for the assembled brominated printed circuit boards per oven and year (example from Germany).

5.2 Individual Concepts

The concepts introduced in the previous chapter are general; thus, they need to be modified to consider the size and industry sector of the company or the extent to which the recycling time varies in order to share the state-of-the-art the majority of manufacturers define. Therefore, these aspects will be discussed in the next chapters in detail.

Company size, diversity of products

A medium-sized manufacturer of a relatively small electro appliance selling in a market with a high variety of products and a low market volume can decide as a strategy to take the same or similar materials as the big competitors and to share also the recyclers. The small companies developing an own recycling procedure would be costly and, more important, risky because of the low recycling volumes. On the other hand where own recycling is profitable for example with ink cartridges, mailing packages containing the empty cartridges were recommended to be sent free of charge to the OEM.