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ENVIRONMENTALLY FRIENDLY DESIGN TOOLS – POSSIBILITIES OF THE APPLICATION

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Abstract: The paper introduces where and how DfE or Design for Environment is located among Dfx techniques. Those steps of the design process also need to be defined, where the tools of the DfE are suggested to keep in front of the engineer's eyes.

Keywords: design theory, methodology, Design for Environment

1. INTRODUCTION

The importance of this special field of engineering sciences is also confirmed by the energy backup of the World that is lower and lower day-by-day. Solar panels are more often seen on the roofs of houses and the range of other green energy sources is wider and wider. These energy sources make it possible that the energy consumption of the Planet is slower and less amount of pollutants get into the air. It is a task for nowadays engineers during the whole design process to pay attention to producing products for the shelves of the shops in the same quality as earlier, despite the less harmful production. This is not an easy mission and without engineering creativity it is not possible.

2. BASIC PHILOSOPHIES

2.1. 3R theory

3R theory means nothing else but recycling used materials into the product market instead of throwing them away. Reduce means decreasing the quantity of the garbage; reuse is the method when we select the parts that can be reused from the garbage during the new-product manufacturing process. Recycling of the garbage occurs when, for example, we gather PET bottles and according to chemical reactions we produce new PET bottles. This cycle is shown in *Figure 1*.

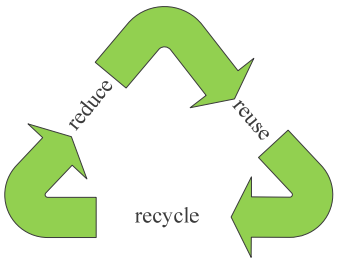


Figure 1. The 3R philosophy

2.2. Product-material lifecycle

Figure 2 shows the stages of the product lifecycle in the point of view of the material. The process starts with the extraction of the raw material, with that the production of the stock can be started. From the stock products are prepared. These products become wastage after using them. Waste can be reused in several ways. By reusing those elements of products that have longer life, than other parts, products can be fixed (*for instance scrap yards*). In case of remanufacturing elements of the product are in the production line again (*Remy Automotive*). During the recycling process new materials are produced from the used ones (gathering *PET bottles*).

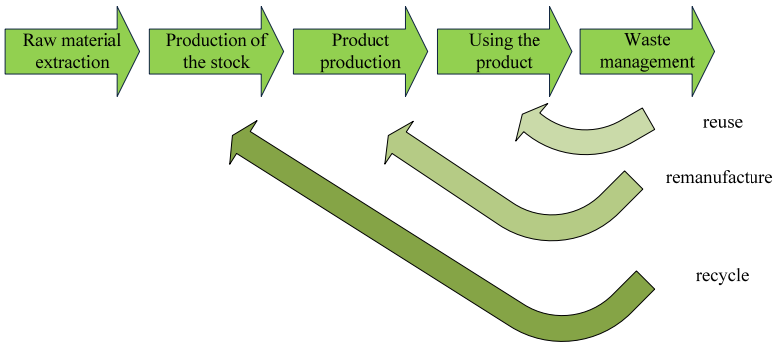


Figure 2. Product-material-lifecycle [1]

2.3. Dfx techniques

Systemizing Dfx techniques is quite a complicated task. *Figure 3* shows the approach how design activities or Dfx techniques can be gathered together into an enormous set, into a 3D space that is determined by costs (C), quality (Qlt) and quantity (Qnt). In this space there are Dfx techniques that are working as an umbrella term, so collecting other techniques in that special field of engineering. The DfE, so the Design for the Environment is a very good example, as it will be introduced later. Although in the space of design activities there are also Dfx techniques that can be defined as separate activities. These ones are denoted by the points.

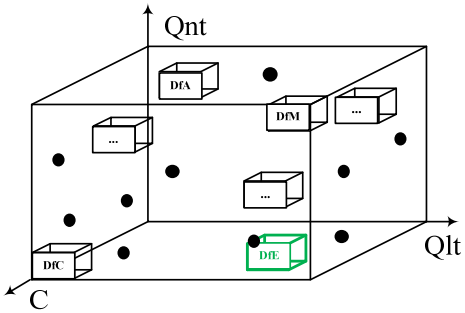


Figure 3. 3D space of Design for-activities

3. DESIGN FOR THE ENVIRONMENT

Dfx, or design according to a given viewpoint [2] can be any formal period of the design process, or any important aspect that can be followed during the whole design activity as the main principle. Dfx is an enormous set of design principles that is really hard to describe, because this set is increasing day-by-day. Scientists define more and more principles, and for those principles methods are also created. These methods denote or can denote the adaption of Dfx techniques to computer. DfE, that is Design for the Environment is collecting the aspects of environmentally friendly design. As it is shown in *Figure 4* it consists of seven essential areas. According to different aspects these can be divided into other different principles. This figure also confirms why it is so complicated to collect all the Dfx techniques and to group them.

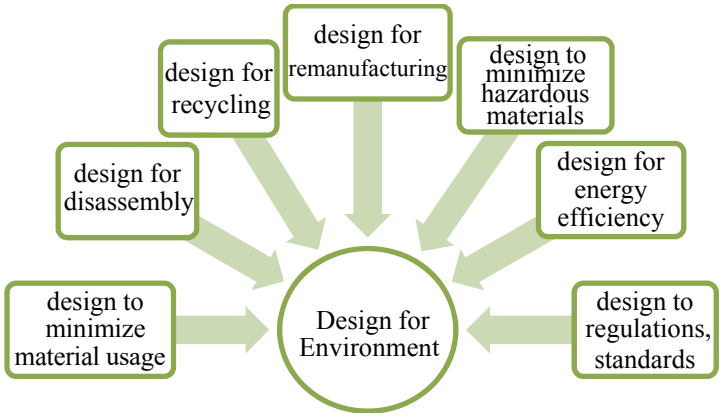


Figure 4. Design for the Environment [1]

3.1. DfE in the design process

Figure 5 introduces the whole design process on the basis of VDI 2221. The original flowchart suggested by the VDI (*Verein Deutscher Ingenieure*) on the right-hand side contains the results of the different steps. The figure modified here shows, which tools demonstrated in *Figure 4* can be adverted on the different design stages determined by VDI. It can be seen that there are DfE tools that can be considered in several steps. According to my present researches the first four steps (*Clarification and definition of the design task, Determining functions and their structures, Searching for solution principles and their combinations, Determining subassemblies*) of the design process can be important. As the basis of my present researches is the conceptual design process defined in my thesis [4] (*Figure 6*) the above mentioned four steps can be narrowed for the next three steps:

-Clarification and definition of the design task,
-Determining functions and their structures,
-Determining subassemblies.

Figure 6 [3], [4], [5] focuses on the main scope of my researches; it summarises the phase of the conceptual design. Design process according to the VDI involves the whole design process as it can be seen in *Figure 5*. The above mentioned four steps of this process

mean the conceptual design. The suggested method introduced by *Figure 6* implies a relatively simple algorithm, so the process is adaptable for computer. In the modern World of our days it significantly facilitates the task of the engineering designer.

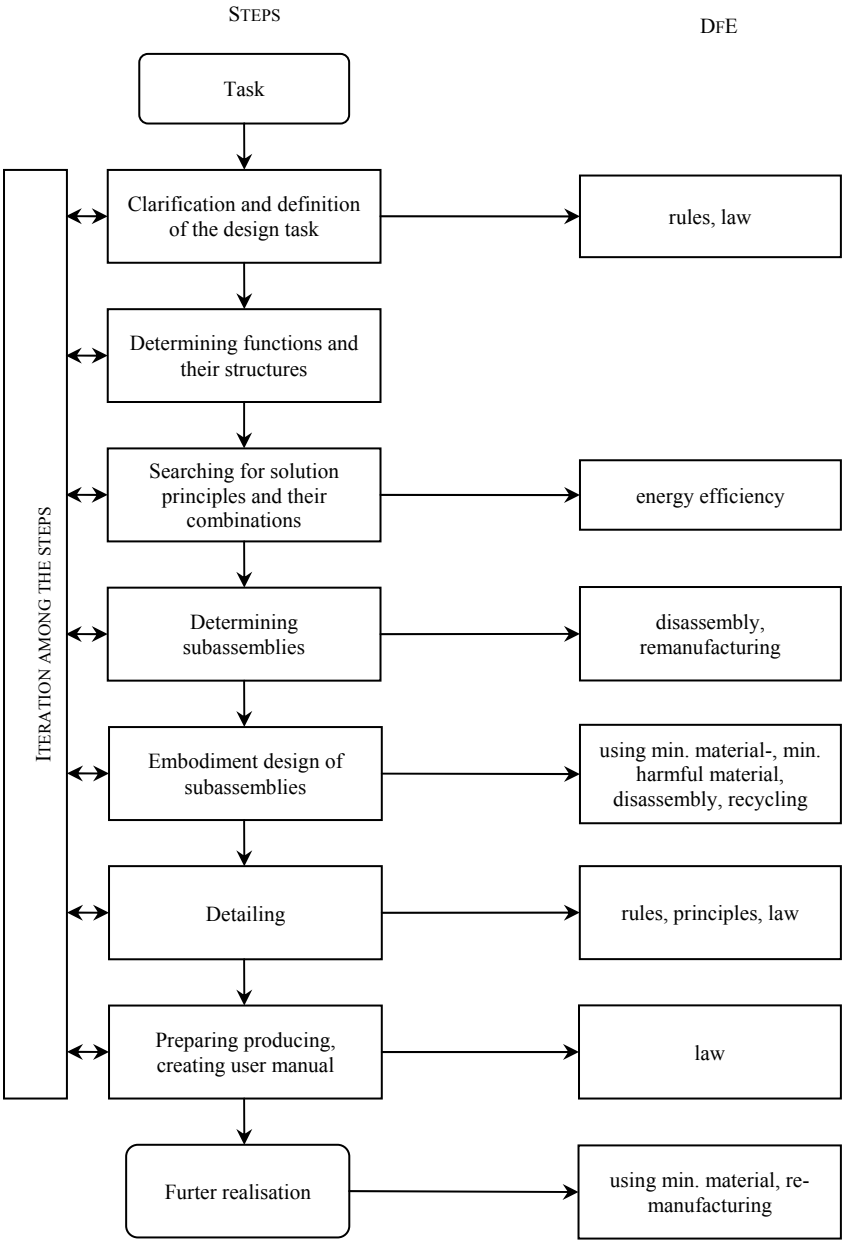


Figure 5. Design process on the basis of VDI2221 [6]

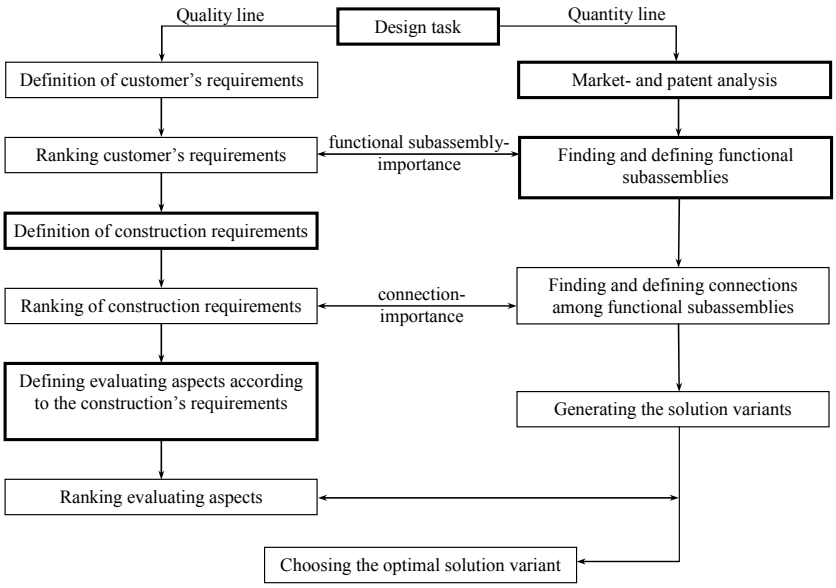


Figure 6. Conceptual design process – a suggestion

3.2. Environmentally friendly design thinking

As it is shown in *Figure 6* [3], [4], [5] certain steps of the conceptual design process are indicated by thick line. These are the steps where the creativity of the designer appears and the designer has to pay attention to the given circumstances, rules, laws and in these steps the tools of the DfE can also be taken into consideration. Let us analyse whether DfE tools indicated in *Figure 5* suggested by VDI in case of steps signed in the process suggested by *Figure 6* can also be applied or more other tools can be used!

Design task in the suggested system and Clarification and definition of the design task according to the VDI are the same. This is the step, where the prescription of rules and regulations must be analysed.

During the market and patent analysis there are two things the designer has to pay attention to. The first one is that analysing earlier solutions functional subassemblies can be determined; the other benefit is that this way concrete embodiment can be examined for the further embodiment design. So this step has an effect on the embodiment design that is the reason that all the tools of DfE can occur. But if it is only the conceptual design process we should keep in mind, a concrete DfE tool cannot be mentioned, except for rules and laws.

There is a significant difference between the two methods: VDI separates the function, the solution principle and the subassembly. In this case function means a task that is solved by different parts, assemblies of the designed product but it is not defined according to what principles what kind of assemblies. Solution principle means physical principles that make it possible for the given function to be realised. Although it is still not known what kind of assembly the given task will solve. According to VDI determining subassemblies is the part of the whole embodiment design. This is the step, where concrete subassemblies are de-

fined. In case of *Figure 6* instead of functions, solution principles and subassemblies there are only functional subassemblies. These are a little bit more specific than functions that are very abstract in most of the cases. Neither concrete subassembly is a functional subassembly. In the step of conceptual design even solution principles (*physical laws*) for functional subassemblies are not necessary to be determined.

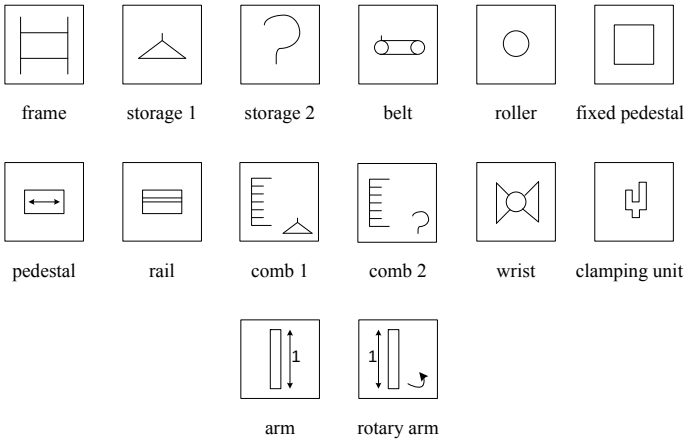


Figure 7. Functional subassemblies of assembling equipment

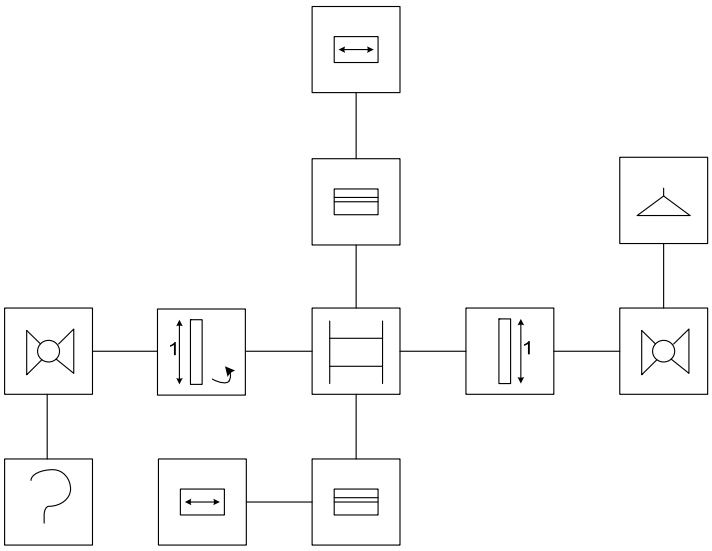


Figure 8. A possible function-structure of assembling equipment

A possible concept for hanger assembling equipment is quite an easy example for that. In *Figure 7* used functional subassemblies are introduced. A possible function-structure built

up of them is shown in *Figure 8*; a possible concept on the basis of *Figure 8* can be seen in *Figure 9*. It is foreseeable according to the figures that the functional subassembly called pedestal moves on a rail, but finding out how this movement will be realised is a further task. This kind of linear movement can be achieved by different principles; in case of this example during embodiment design it was pneumatics as an obvious solution.

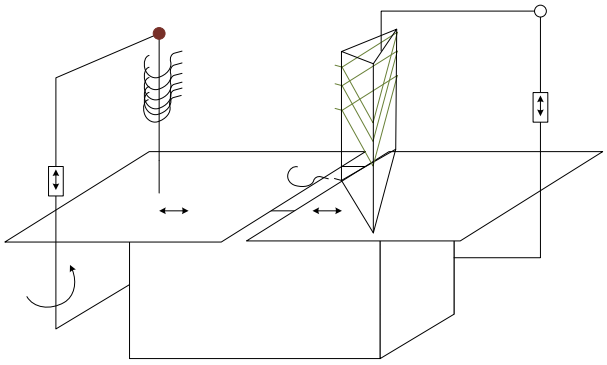


Figure 9. A possible concept for assembling equipment

According to the process introduced by VDI functions are such abstract notions as: disunite, mix, connect, etc. So these cannot be compared with the tools of DfE. And determining subassemblies is the part of the embodiment design, according to VDI.

In case of the method according to *Figure 6* defining functional subassemblies design to minimize material usage and design for energy efficiency can be used. At this point of the design process concerning a lying surface of bed functional subassemblies can be a ir-mattress, water-mattress, spring-mattress, etc. It is evident among these options mattress filled with air seems to be the most material-saving solution, because the consumer can pump it even at home. This way only a shell needs to be designed and produced. The other possibilities are more complicated in terms of production, so this way not only the material, but even energy is saved. So summing up functions a simple structure can be reached that is a key for using less material.

Defining construction requirements and the evaluation of them all DfE tools can be taken into consideration. During the design process this is the first step when expectations for the product defined in the requirements list should be examined. Construction requirements should be highlighted here that are possible to be taken into account even in the early phase of the design process like this. These requirements can be the ones rules and laws make necessary, for example protective screen at dangerous points. Using two buttons for starting the equipment pushed at the same time can be also a solution for saving the user. This solution needs two hands, the user cannot reach the moving elements during the operation. These need to be counted as separate functional subassemblies when finding and defining the functional subassemblies and as evaluating aspects when defining construction requirements. Here the designer can, and he/she has to pay attention to environmentally friendly aspects as well. So different environmental laws and orders should be studied in this phase of the conceptual design. The case when the regulation orders using cleaning equipment can be a construction requirement as well: it can be examined whether the con-

cept contains a unit like this, or not. So this means the regulations and laws in connection with the environment can be taken into consideration here in this step of the process.

4. SUMMARY OF THE NEW SCIENTIFIC RESULTS

For the suggested method in *Figure 6* according to my thesis and other earlier publications [3], [4], [5] it is easy to make an algorithm and adapting it to the computer is the main advantage. Besides that the algorithm is not eliminating the creativity and individual ideas of the designer even it appears on more points than in other earlier works. As the method ensures several possibilities for the designer-engineer for his/her experiences, ideas, results of market-analysis as parameters put into the algorithm and the software based on it, it provides an opportunity for the systematisation of the design process-results that was impossible earlier. It is also a significant result that the suggested method seems to be more effective than for instance the method suggested by VDI in the viewpoint of the environmentally friendly design as well, as the tools of the DfE are also possible to be taken into consideration in more steps of the process.

5. DIRECTIONS AND POSSIBILITIES OF DEVELOPMENT

In the case of the suggested method further analysis of DfE tools determined here has to be carried out. It must be examined how, in what ways these tools appear in the different steps of the conceptual design process. Practical examples must be collected that confirm the realisation of DfE tools suggested in certain steps of the mentioned process.

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