DESIGN TO CONNECT

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Abstract

Design to Connect is a cooperation between Howest University, Industrial Design Center and Ghent University, Laboratory Soete. The aim of the research is to create a methodology to support (industrial) designers to design mechanical connections and joining methods considering mechanical and user centred factors in the total product life. This paper gives a short overview of the most important existing methods, guidelines and tools to design and select mechanical connections. It also situate the research project and its potential added value for product designers to the existing methods. Finally a basic framework for developing the new methodology is created: Design to Connect (D2C).

Keywords mechanical connections, product life cycle, DFX, process selection

1 INTRODUCTION

The most daily used products contains more than one part. Connections and joints play therefore a key role in product design. Joining components influence the individual component complexity [1], the movement between components, the accessibility of components and functional requirements like electrical and thermal conduction. Historically, joining methods are sector and material oriented. In the past products were made with mono materials, like wood or steel. Every material has his own well known joining methods. Welding and mechanical fasteners to join metal parts, wood joinery... Today, more and more products are made with different materials [2], multi materials, hybrid materials and composite materials to fulfil the more and more requiring product needs. Product disassembly and recycling plays a major role by the increasing materials shortage and environmental aspects. In most cases the design and selection of connections and joining methods during the design process happens through the experience of the designer. In that way designers fall back on known joining solutions and there is no place for innovation. Since the degree of complexity is growing, it’s also important for designers to consider joining aspects already in the first stage of the design process [3].

2 PRODUCT LIFE CYCLE

A connection can influence the production and assembly, the use of the product and the disassembly of the components to recycle. In that way it’s important for a designer to consider the total ‘product life’ during the design of the product. Pahl and Beitz define the ‘Product Life Cycle’ (PLC): *“This cycle is triggered by a market need or a new idea. It starts with product planning and ends—when the product’s useful life is over—with recycling or environmentally safe disposal. This cycle represents a process of converting raw materials into economic products of high added value.”* [4] The PLC described by Pahl and Beitz can be simplified into six steps: Design of the product, manufacturing, distribution, trading, use or consuming of the product and finally dispose the product for recycling. These six steps are shown in figure 1. This PLC should not be confused with the ‘Product Life Cycle’ from marketing where the life phases of a product are defined in the market.

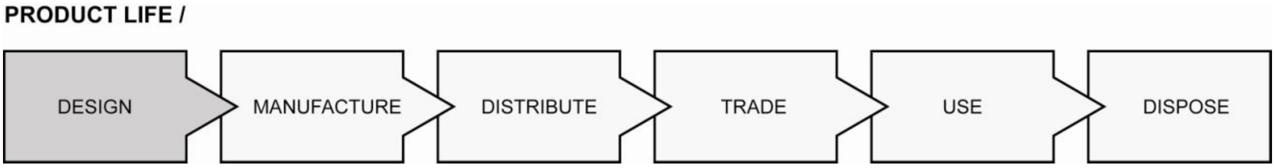

Figure 1. Product Life Cycle (PLC)

3 DESIGN FOR X GUIDELINES

To help designers select and design connections, people have already developed several methods and selection tools. Ashby and Esawi define two techniques that contribute cost-effective assembly: *"That of design to minimise part count and easy mating (Design for Assembly) and that of selecting the joining process that best suits the joint during life."* [5] The first technique, Design for Assembly (DFA), fits together with other guidelines like Design for Disassembly under the label Design for X (DFX) [6]. The most important DFX guidelines that consider joining aspects are mentioned in this paper. Design for Manufacturing and Assembly (DFMA) is developed by Dr. Boothroyd and Dr. Dewhurst. The DFMA methodology simplify the assembly and manufacturing of your designs [7]. In that way it's possible to reduce the manufacture and assembly cost of the product. Design for Recycling (DFR) are guidelines to reuse raw materials in order to move towards more sustainable development [4]. A variant is Design for Disassembly (DFD), that involves designing a product for easy disassembling. In that way it's easier to maintain, repair, and reuse product components and materials. A new evolution in DFD is Active Disassembly (AD) developed by Dr. Joseph Chiodo: *"AD technology is a method of disassembling products into their separate components using specifically engineered and/or Smart materials, adhesives to allows for a clean, nondestructive, quick & efficient method of component separation."* [8] All of these DFX guidelines are focused on one phase in the PLC: manufacturing or disposal (recycling, disassemble). There is no holistic technique or methodology that considers all the aspects of a connection in the total product life. An overview of the DFX guidelines discussed in this paper is shown in figure 2.

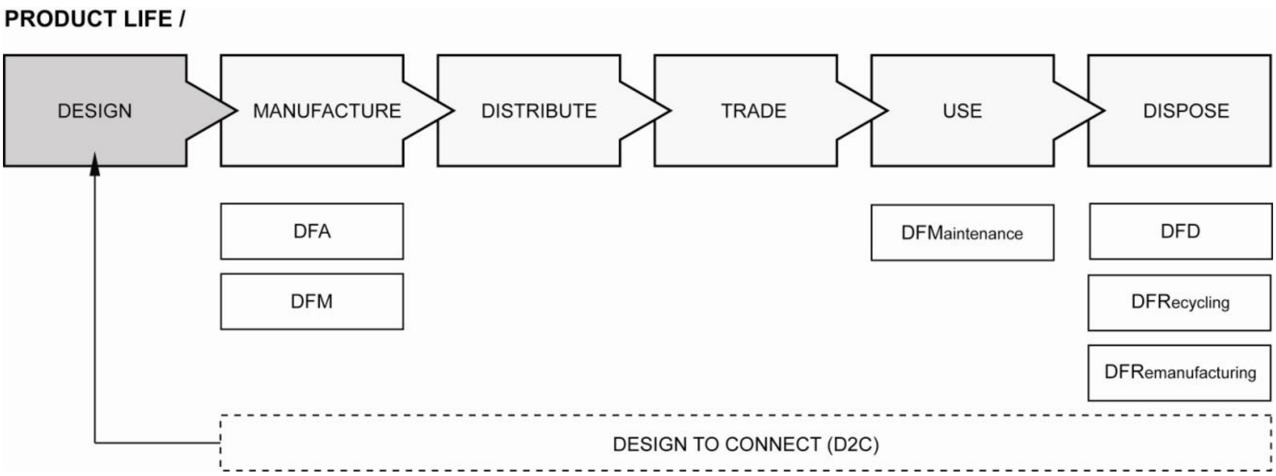

Figure 2. DFX guidelines through the life of a product

4 PROCESS SELECTION IN MECHANICAL DESIGN

The second group of techniques are the (joining) process selection methods. These tools help the designer choose the best suited joining process. Lovatt and Shercliff define three categories of (joining) process selection: "*Following an idea proposed by Ishii, process selection may be considered to fall into three broad categories: preliminary, functional and task-based. Each of these categories considers the selection of a manufacturing process at an increasing level of detail in the design process."* [3] Some research projects involved the development of a joining selection tool implemented in a software environment [9]. Several joining process selection methods/tools are already developed. 'Granta CES selector' is a powerful selection method and software tool for the selection of materials and processes developed by the University of Cambridge [10]. Some free online tools are available to select joining processes.'

Archetype joint' [11] is an online database that helps designers to select fastening and joining methods that meet their specific joint requirements. 'Dunne-plaat online' [12] is an information website with a tool that helps designers to select methods for joining sheetmetal parts. All these tools are developed for Mechanical Design problems, engineering materials and joining processes. Mechanical design considerations [13] are based on 'shape', 'material', 'function' and 'manufacturing process'. User centred aspects like 'use' and 'product personality' aren't taken into consideration in Mechanical Design. Materials like wood and textiles and connections like a zipper or 'hook and loop' aren't always involved in the selection process. In that way the designer is limited by the processes and materials that are involved in the selection database.

5 USER CENTERED CONSIDERATIONS

In Product Design the user and the interaction with the product plays an important role. Ilse Van Kesteren developed a consideration model that showed the relations between 'use', 'product personality', 'function', 'material', 'shape' and 'manufacturing process' [14]. A comparison of the mechanical design considerations and the user centered design considerations from Van Kesteren is shown in figure 3.

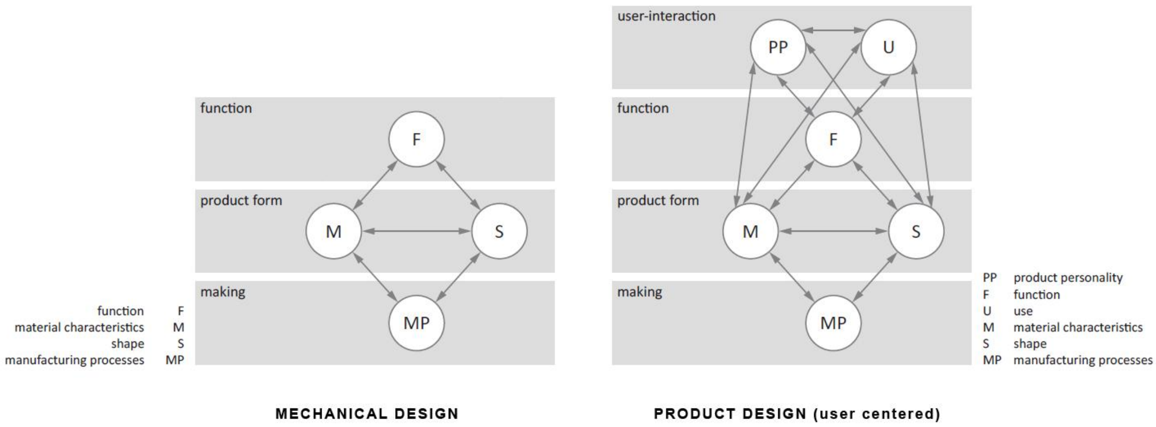

Figure 3. Mechanical Design considerations model [1] and Product Design considerations model [14]

In material selection are, beside technical information, aesthetics and tactile aspects also important. There are already some material selection tools that considered user – centered and esthetic aspects. An example is Skin [15], developed by Daniel Saakes. It's a tool that projects graphics on prototypes and objects to quickly review the aesthetics from materials. In that way it is possible to select the materials in an early stage of the design process. During the use and consumption of products, connections and joints can also play an important role for the user. Think of opening a remote control to change the batteries, change vacuum cleaner tools in a fast and easy way, personalize your cell phone cover, … In the book Materials and Design, Ashby and Johnson describe that joints can be used as a mode of expression in product design: "*Joining, too, can be used expressively. It reaches an art form in bookbinding, in the dovetailing of woods, and in the decorative* seaming *of garments. In product design, too, joints can be used as a mode of expression."* [16] To help industrial designers design and select joining methods, there is a need to develop a method that consider beside the mechanical aspects also user – centered aspects. For example the usability of a removable connection and the aesthetics or product personality of a joint.

6 DESIGN TO CONNECT

D2C wants to create a methodology that helps product designers and students to design connections in a product. The methodology must consider beside the mechanical requirements also user – centered aspects of the connection and the total life of the product (PLC). The methodology may not be material (ex. plastics) or sector (ex. machine design) oriented but a holistic approach to different defined joining problems. The methodology may not restrict the designer in here/his creative process and can be used in the first stages of the design process. Using the methodology the designer must be able to explore many possible solutions in a structured, effective and creative way and select one solution. At the end of the process the designer must be able to evaluate the founded solution with the predefined requirements. A basic framework to setup the D2C methodology is shown in figure 4.

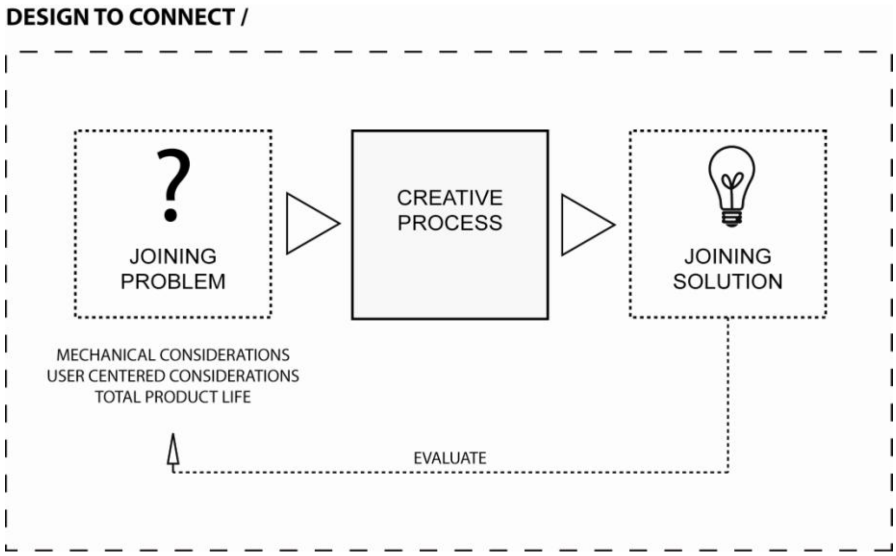

Figure 4. Basic framework to setup the D2C methodology.

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