SHAPE LANGUAGE DESCRIBES MORE THAN THE BODY

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The design of products involves the whole design process from Design Research to a product. The uncertainty becomes certainty during the design process. Product models have functional relations between all the product levels. In this paper, we investigate the lack of knowledge about shape expression by analyzing seven consumer products. We develop the knowledge of shape language from the viewpoint of design and making. The cultural influences of shape language may be an advantage for upcoming countries as India, China, Brazil, etc. Parts and products imply shape knowledge which should be analyzed on physical aspects and relations of parts. Many design decisions are made during the whole process and the knowledge content of parts grows with every decision. The quality of parts contributes to the performance of the product. We draw the conclusion that 'shape language is more than the body' because the relations in the parts are of great importance, also for the whole product.

Keywords: Shape language, design process, product, parts.

1. INTRODUCTION

The embodiment of a product involves the elaboration of a concept into a physical product. Engineering aspects determine the embodiment. In particular the shape of inner parts depends on technical requirements. The outside of the product, its visual and tactile appearance, also depends on emotional influences. The outer shape of a product expresses aesthetical and emotional qualities and elicits emotions and feelings by the users.

The function of a product is more than what in general is listed in a functional description. Function is not limited to physical or technical characteristics, but it also includes product use, interaction, context, aesthetics, appearance, image, emotion, status, etc. This paper in this area is divided as follows.

Shape of a product must be expressed with a language on many stages of the design process. During the Fuzzy Front End (FFE), global and general language expressions are used. In the detailed design stage, the shape has to be expressed more precisely; more shape properties of a monolith product or parts are defined, such as: material, manufacturing process, size, appearance.

Making parts depends on material, manufacturing process, the needed tolerance and production volume. Production time is inherent of the batch volume, for higher volumes mostly mass production is suitable.

Context influences the volume of production, which is quantified by where, how, when, which circumstances, etc. In addition, social coherence, cultural influences and sustainability play an important role.

In general, aesthetics is studied at the end of the process, when a designer checks if form, color, size, appearance, environment, etc. are fitting.

The status of a shape has many facets, depending on the stage of development in the design process and the manufacturing process. A description of the required form develops from complete uncertainty in the earliest stage, to complete certainty at the end of the design process (see Figure 1).

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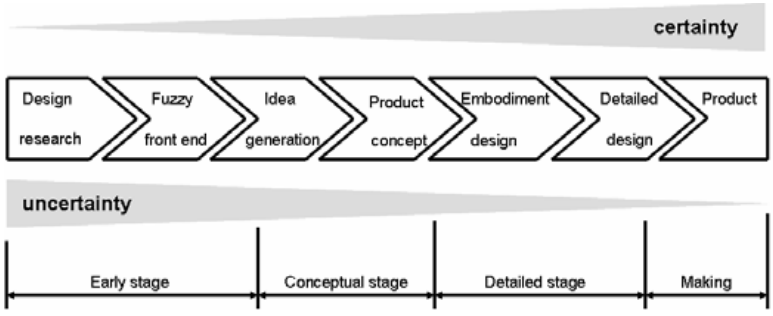


Figure 1. Design process with stages with uncertainty and certainty.

During the design process, the appearance is described more and more precise, but the final product is the result of manufacturing the product, with the designed appearance in mind. So the result depends finally on planning, manufacturing process, finishing, surface treatment, etc.

An image occurs as a shape, like a shape belongs to an image. The shape can be described in many ways. An image describes a shape with visual imagination.

2. LITERATURE

An improved abstract product model is presented in [1]. It considers functional relations as well as other linkages between components and parts. Abstract models simplify the familiar problems which may open new ways for creative ideas. Product models are simplifications that highlight the important aspects, on different levels of abstraction. Sub-functions can contribute to more levels and cannot be clearly assigned to a single, higher function. There are many methods in engineering design to generate functional models. The traditional approach of Pahl and Beitz [2] advocates the key functions, but does not consider all product levels.

In general, the primary and preferred methods of thinking are not recorded textually. So there is a need for literary tools (art language) for an adequate description or discussion [3]. It is hard to portray the process of making expression contexts of history, theory, biography, etc. In the words of Kill [4]: "Thinking about the relation between what I was writing and what I was making, that changed complete my attitude of art language use according". One should be aware of the cultural and the professional influence of the education.

The Dutch universities of technology in Delft, Eindhoven and Twente have recognizably different approaches in their study programs of Industrial Design Engineering, associated with the identities of three universities [5–7]. In this way the shape designer depends on his received education.

The shape creation is designing the form that holds all the wishes in itself, but you use the shape language for the communication and exchange of reasoning.

The shape describes the drawing that represents the idea [8]. A design system supports the birth of a new product [9]. The system is under the supervision of the designer, who designs as a human, but operates along the process with design factors to achieve the product design as a goal. Several challenges are identified for a design system, such as design process, functional approach and materialization or embodiment design.

Design decisions are made in all different stages of the design for product and parts [10]. In general, one should use who, why, what, where, how and when to collect the information for making the decisions. In a design decision matrix, these questions should be answered for the product and its parts, to organize the design progress. The design decisions are made in different design stages with a directive for the further development of the design. The systematical identification, analysis and rating of the strength of the relationships are helpful for handling the large sets of design information.

Gestalt is more than a pattern. Patterns may have characters with their relations [11]. The different views that may represent a chair are more than superposition of visual patterns or simple additions. The designers are interested in the structure and relatedness of products.

The concept development model of [12, 13] provides a definition of the key elements of the fuzzy front end. The engine powers the five elements of the NCD model they are on the top of the influencing factors. The model suggests that the ideas and concepts are iterated across the five elements. The model has more starting points from which the project begins at either opportunity identification or idea generation and enrichment.

The degree of certainty depends on where we are in the design process. In the FFE, the market aspects play an important role, and the degree of uncertainty does not develop linear. For the reduction of the technical uncertainty we are dealing with a linear decline. A designer practices creative solutions in the industrial design domain, thus steadily increasing certainty until everything is fully defined. This is the moment the design process changes into the manufacturing process.

3. DEVELOPMENT

First of all we need to define the lack of knowledge about shape. We need to overcome this knowledge gap by studying the real influences of design process. In this study should be reached substantial number of influences of design process We had the opportunity to research a graduation project which all the facets of shape and about 100 report DfA (Design for Assembly) reports. The big amount of DfA reports includes seven different consumer products.

3.1. Lack of knowledge

Shape has many facets that are unknown in the fundamental way of expression. Every part of product can be evaluated after making it. All the technical information is documented in technical drawings of a part or a product. On the drawings, two areas are of interest: the bill of materials and the title bloc. In these areas expressions may be found that describe shape.

The aspects of a part are mostly manufacturing requirements to assure the working of a part with other parts. A number of parts can be assembled to a larger whole, a product. The success of a product depends on the assembly of parts which work together to fulfill a function. Shape expressions do occur in the name of parts, but most parts are expressed by a functional name. For the parts, the technical information provides a certain safeguard that it can function within the space of a product.

Cultural aspects are also important in the shape language. Expressions of embodiment in different decades are the breeding ground for cultural expression in the shape language.

Shape language has cultural influences. For instance, the people in India fight for their identity which develops gradually, however, the world seems to see India as a part maker. The western world lets make the parts mostly in Asia, where it is done for lower prices. However, all kinds of great design are made in India, just for the Indian market. The two wheeler market may be dominated by India

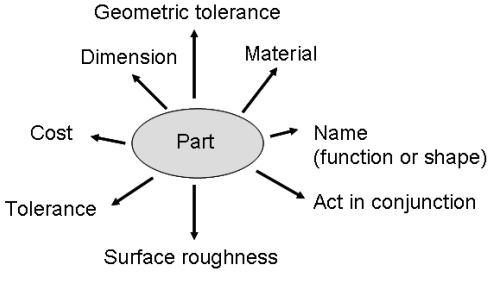


Figure 2. Aspects of parts.

design if they take the lessons of the technical development of the two wheeler market in Japan. Asia countries should make parts for the Western world and develop their own design [14].

3.2. Practice

We will develop the knowledge of shape language from the viewpoint of design and making. The activities in the design process require another shape language than manufacturing task. Design and making vary on many aspects, however, both require descriptions for products and its parts in different process stage with shape language. The context and content of the shape differs from the goals to be reached. The design process starts with a great uncertainty which gradually develops into certainty. Each design stage narrows down the uncertainty, which lead to a higher quality of the shape description. The making process requires a precise shape expression with a content that guarantees the fulfillment of the part's requirements. The parts can be assembled to create a whole product which performs the function well and propagates the psychological aspects of the product.

In general, the focus is on the design viewpoint, but the manufacturing viewpoint is also of great importance for the success of a product. If the detailed part design is not carried out well or the technical information is not documented properly then it is almost impossible to make the right part which makes a proper contribution to the product. The right use of shape language may bring about that the part description is unambiguous and is not interpreted in a wrong way. The variety in the appearance of products and parts can be substantial. This can easily lead to indistinct shape descriptions.

If in the manufacturing process the quality cannot sufficiently be guaranteed, the chance of success rapidly diminishes. The quality influences the functioning. When parts are assembled, the success depends on the worst contribution of a part. This becomes evident in lower power efficiency, causing power loss, which will be transformed in warmth and noisy operation. The designer or team has to find a balance in efficiency, to achieve acceptable values for working temperature and noisy operation. The accuracy of parts is the main influence on efficiency. Clearance between parts and weakness of parts introduces mechanical vibration which will be expressed in noise.

This knowledge is implied in the parts and assembly of products. We analyzed this in a practical exercise in which assemblies had to be optimized with the Boothroyd method. We researched a number of DfA reports from the course Technical Product Optimization in 2009–2010. The products contain a number of parts which could be categorized as norm parts or standard part, functional parts and shape parts. With a shape part we mean that the part name is described as a shape or form which can be specified by material or function. Two examples are:

(a) Rubber ring — the name specifies material.
(b) Distance bush — the name specifies a function.

4. RESEARCH METHOD

The research method used analyzing the part list of a product in 100 DFA group reports. The students wrote these reports for the lab of Technical Product Optimization (TPO), for which commercial products are used. In another course, Technical Process Analysis (TPA), the students have to make a part list, which is then used for TPO. The part list consists of part number, number of parts, part descriptions, materials, manufacturing process, and details and comments. Seven different products were concerned, which were not equally divided.

Another source of our data is the concept development of an RFID — scanner with speech synthesizer. From this process, we explored the hand sketches. Shape language is used as the creative transformer from the design criteria, such as function, form, size, RFID technology, user interface and human interaction. The results are quite different. The challenge is to select the best idea and elaborate it into a product concept and generate a model of it.

The used method [15] here is analyzing reports of different sources to known: a practical project and a graduation project. The content of the reports will be analyzed and special the description of

the part list of the practical exercise of a consumer product. The shape exploration for the concept development of the RFID-scanner will be analyzed on the content.

5. RESULTS

The number of parts of the different products ranges between 27 and 57. Products with a low number of parts are, in most cases, optimized for assembly. Using norm or standard parts for assembly costs extra time, so the number of norm and standard parts should be restricted. Functional parts have a big share in number of parts, ranging between 16 and 34. For shape parts the situation is completely

Table 1. Part identification of products.

Product								Total
Functional parts	34 62%	22 45%	31 54%	16 60%	33 77%	17 58%	19 47%	172 57%
Stand-ard parts	18 3%	21 43%	16 28%	8 30%	4 9%	9 31%	19 47%	95 32%
Shape parts	3 5%	6 12%	10 8%	3 10%	6 14%	3 11%	2 5%	33 11%
Total	55	49	57	27	43	29	40	300

Figure 3. Shape explorations at concept development of an RFID–scanner with speech synthesizer.

different. The number of shape parts is small: between 3 and 10 parts (see Table 3.1.). Shape language supports the description of parts used as shape parts and norm and standard parts description. The contribution on shape expressions is very low, but in this stage the content of a part is very high. The content means more than a body; it also expresses tolerances as well as dimension, geometry, surface roughness, material, number of parts and number of pieces.

Functional parts have certain a body which fulfills a function; the geometric form of the body is given by dimensions such as function dimensions, for example length and width, form dimensions, and manufacturing dimensions.

A selection is made of all the generated concepts which are shown in a graduation report [16]. These concepts are annotated so that access is in development. A comment should be placed, in this development are discussed by several overlapping sub problems:

- Shape design: exploration of shape, to avoid a stigmatizing character and to make an attractive design. The idea of "attractive" is shown in the collage in Appendix 3 of the graduation report;
- The ergonomic means of handling the product, implications for the user how to use the product;
- Buttons: how to group, tactile feedback or not
- RFID technology; activation, delay limits, antenna position.

The physical dimensions of the product are roughly taken into account (due to the size of the components), but not into too much detail, because the creativity of the designer should not be hindered.

Here is an abridged version of the brief displayed. The presented concepts differ to each other when it comes to the following requirements:

1. The product should have structured the various components in such a way that they do not get in the way during use;
2. It should be possible to let the product rest on a table, without tilting and/or slipping while it is operated with one hand;
3. The product must be physically and sensory ergonomically suitable for older users;
4. The RFID antenna should be (in relation to the area enclosed by the coil) practically parallel to the antenna of the RFID tag when using the product.

Selecting one of the concepts is done by evaluating the aspects of each concept with the above requirements in mind. This concept is the starting point for the final design.

6. DISCUSSION

The different interests and needs of designers and manufactures will be compared, and how they have used shape language.

In the concept development of an RFID — scanner with speech synthesizer you distinguish requirements and wishes. Most requirements are about the performance of the product. Shape language occurs in requirements like:

- the product structure with various components,
- the product should be suitable for one-handed use on a table,
- the product must be suitable for elderly people,
- the RFID antenna should be placed correctly.

The requirements need different types of shape information. This demands certain creativity of the designer, to come to the right formulation of the requirement. The structure needs terms about size and ergonomic handling of the product. The designer should research the possibilities to hold the product properly. In most cases ergonomics has an answer on what people can handle depending of size, weight and use. The one-handed use is an extra ergonomically restriction, which needs a special transformation from abstract description to a shape that fulfills the requirement.

The requirement about elderly people is of a complete different type, because the performance of human functions decreases with age. Recognizing the proper target group can be difficult. Some 80 year old people perform better than other 60 year old ones. Defining optimal requirements for the entire target group is a great effort. It is also possible to focus on a specific group, for example people who have a physical handicap. To let the device function well, the placement of the RFID-antenna is important. This implies constraints on the shape, but these constraints are not the most decisive ones for the shape character.

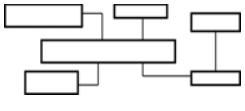
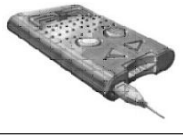
Product and parts description contain shape definitions with all kinds of terms. Some shape definitions may be clear for the customer; however, the designer has to struggle to understand the shape jargon before it can be transformed into a visual shape. The transformation will be done in a verbal (shape) expression and a visual expression (see Table 4.1.).

The designer may be happy with the visual expression while the engineer uses verbal shape expressions. The designer may use verbal expressions only for oral communication with colleagues and engineers. Images are used in the communication with the client as the visual expression of the design process. However, verbal expressions can be used to explain his visual expressions, the images.

The manufactures have another approach than designers, because their concern is making parts and assemble the parts into a product. With the detailed information on the technical drawings they should be able to produce the parts and assemble the product.

The detailed information includes physical properties such as dimension, cost, material and manufacturing properties are like tolerance, surface roughness, and geometric tolerance. The relation properties are the boundaries where the product has to function on. Shape language is the communication tool between the manufacturer and designer, for explanation what is meant with visual information, such as product hand sketch, rendered 3D model, set of technical drawings, view model, working principle etc. The shape or form should be clear before starting the production. The designer wants to express the shape on his creative way with mostly visual expressions. But the manufacture has to learn about the parts to be made, by the visual expressions of designer and the communication with the designer.

Table 2. Visual and verbal expression of products part identification of products.

Form	Visual expression	Verbal expression
Structure		Long and slim for a good holding shape which is ergonomically account
One-handed		Shape stays stable on the table when it is used in one-handed situation
Suitable for elderly		Elderly people should be able to hold the device on comfortable way
RFID-antenna		Antenna is a telescopic with a round shape and folded in and out

7. CONCLUSION

The designer and the manufacturer need shape language but the goals are completely different. The designer wants the ideas transformed in visual expression such as hand sketches, 3D models, images, drawings, etc. The manufacturer will produce parts and assembled them together. Therefore he gets technical drawings to make parts and products. The technical drawings consist of a part or an assembly. The part drawing has to express the body in number of views to make clear how the part can be produced. Shape language is used for communication by both. One joint goal is necessary for realizing products that can be successfully sold. In spite of other uses and interests, the communication should be clear and unambiguous about parts and products. The creative approach of the designer and the pragmatic approach of the manufacturer have always financial consequences for a successful product by communication.

The number of parts could be decreased for an efficient use of the material, less part making and for a reduction in assembly time.

A part is more than a body alone, because the relations are in the part self. For example an axle has diameters and length with certain relationships between them.

Shape language is not used so much anymore to express the body in detailed stage. Here are functional expressions much more used for a body description. The body is defined with dimension, but on the dimension there are options for adding extra information for realizing the functionality such size tolerances, geometric tolerances, surface roughness, etc. The shape parts are really less represented in products.

Visual expression is not easy for someone how do not have the hand sketching skills. But the visual expression tells more than 1000 words. At a design team formation the project team leader should be aware that minimal one member has this skill of visual expression.

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