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OPERATIONAL VALENCES OF INDUSTRIAL DESIGN IN PRODUCT DEVELOPMENT PROCESS

Abstract: *The paper describes how the industrial design (ID) process takes place in relation to other product development activities. Also, this article presents specific steps industrial designers follow while designing a product. We refer to the different examples to explain essential ideas such as: the shape of an object should follow its function, the benefits of investing in ID, the quality of the ID effort for a new product, the importance of ID to a particular product.*

Key words: *industrial design, aesthetics, ergonomics, computer-aided industrial design, eco-design.*

1. INTRODUCTION

Nowadays, industrial design (ID) means the decision process on functionality, shape, color, style, material, and a way to increase sales by creating products with pleasant shapes and appearance.

The design solves problems and express, communicates ideas, is artistic and commercially, oriented to practice. This means knowing the materials and manufacturing technologies, the needs of industry and of potential customers.

Heightened competition in the marketplace forces companies to search for ways to improve and differentiate their product. Large manufacturing companies effectively integrated ID into their product development process [1].

Most industrialized sector of the design is that of products with "mechanism and carcass", sector which includes many types of objects: from typewriters and computing machines to household appliances, from the equipment for professional work to the leisure equipment etc. The carcass is no longer a beautiful shape covering a mechanism, but a concordance more and more substantial with the purpose of a product in an economical and elegant manner, respecting the principles of triplet shape-technology-aesthetic.

Today, thanks to modern scientific-technical revolution, technical products manufactured in industrial series get to combine the functional qualities with the aesthetic ones, thus helping to educate consumers taste. Practice has proved that a considerable volume of modern economic activities depend not only on the technical efficacy of the product but also on the artistic quality of its design [2].

Product design and aesthetics become, in this context, trumps in the competitive dispute, real product differentiation elements, whatever their nature.

Whatever the criteria for the classification of products, depending on the degree of technological processing, destination, purpose, durability, their value, design is the most powerful tool of differentiation. The design gives the aesthetic dimension of product quality in perfect harmony with the technical and functional dimension, ergonomically, technological and, not least, environmental protection. The designer is the one who gives material replica of the desires and needs of consumers.

As a result, whatever the nature of the product, he must be designed more judiciously, more efficiently. The product must be comfortable, inexpensive, safe, and easy to use and repair, simple, economically manufactured and distributed, offering a strong competitive advantage in the target market.

One way by which companies differentiate between them is to introduce on their target markets “products with superior design". In other words, the design is no longer a luxury but a necessity. A recipe for success is to combine creative design components: performance, quality, durability, aesthetics and cost.

In this context, the paper presents some considerations on the design of industrial forms, functional and beautiful at the same time, able to delight in form, color, finishing, expressiveness of the product construction and harmonization with the environment in which they will be installed and will work.

2. RELATIONSHIP FUNCTION – SHAPE

The shape is an essential element in the production of consumer goods being generated primarily by material structure (composition), functionality and utility. Because the shape of a useful object to be beautiful, it should be harmonious, be related to the composition and composition corresponding to the object, construction, material, and manufacturing technology.

The overall trend in organization of industrial product shape aims at simplicity of shape, therefore designing of such shapes that are easily perceptible, which is easily caught by eye, to be logical, understandable and with maximum informational value [3].

A product designed without taking into account its function will almost certainly wrongly designed. The function not dictates shape, because there are several shapes for the same function, but causes a number of conditions. Within the constraints imposed by these requirements, at the design and modeling of the shape may adopt more satisfactory solutions, depending on the technology and the materials available and, in addition, on the designer's skill, so that a product designed functionally correct to become automatically pleasing and aesthetically.

The product will be successful on the market, compared to other similar products, if besides a good function it will also have an attractive shape. So it must take account of a harmonious joining of relationship function-shape elements, shape of products being designed so as to match both aesthetic reasons and functional utility.

The concern to give maximum expressiveness to industrial product involves consideration of several factors such as functional destination, construction and manufacturing materials, execution technology, report with shapes of previous products etc.

In the visual organization plan of industrial product shape, the shape chosen must be unitary, details must communicate clearly and logically product designation, to be highlighted function of the object, how to use, the ratio between the object and operator, economic justification and, not least what distinguishes the object from others in the same range.

The balance between shape-function-structure is a necessity constantly to be taken into account in the design of products. In this balance, the function express its destination (purpose for which it is made), the shape express configuration in which the object appears as a product of human activity, as goods, and structure express the manner of disposition of the matter, arrangement and cohesion of molecules to its composition.

The structure of the materials used for modeling shapes of industrial products can be: crystalline, amorphous, macromolecular, fiber, compact, porous, homogeneous, heterogeneous etc [4]. The material worth from one product to another by himself, showing different properties that can be evaluated in terms of aesthetics: structure, texture, color, destination, shine, smoothness etc.

Industrial designers focus their attention upon the form and user interaction of products. Each product should be shaped so that it communicate its function to the user. They must have a basic understanding of materials, advanced manufacturing technologies, and finishes. Their ability to express ideas visually can facilitate the product development process. Industrial designers must participate fully on product development teams. Within these teams, engineers will follow a process to generate and evaluate concepts for the technical subfunctions of a product. In a similar manner, most industrial designers follow a process for designing the aesthetics and ergonomics of a product and make simple sketches of each concept [1]. These sketches are a fast and inexpensive medium for expressing ideas and evaluating possibilities. Figure 1 shows four such sketches from a car project. The proposed concepts may than be combined with the technical solutions according to the technical feasibility, cost, and manufacturing considerations.

3. AESTHETIC DIMENSION

The aesthetic dimension of a product is not an element added to the end of their realization. This is achieved throughout the design process, signifying a way to multiply the number of products sold and to stimulate sales, and to express, communicate messages.

Products design closely links technical design with artistic design, so as to obtain the proper objects from a functional perspective, aesthetically expressive, technically perfect and economically justified [5]. Construction and logic of shape must be justified by reference to the destination of the product and its components must correlate geometrically suitable for the purpose for which the object will be produced. The material to be used and shape structures must be chosen having regard to the stresses arising from the use of the object. It is necessary also that the product manufacture does not involve too much economic efforts. Therefore it requires that the product be easy to use, easy to handle, manipulate, providing maximum comfort and efficiency as possible and require minimum expenditure for maintenance and operation.

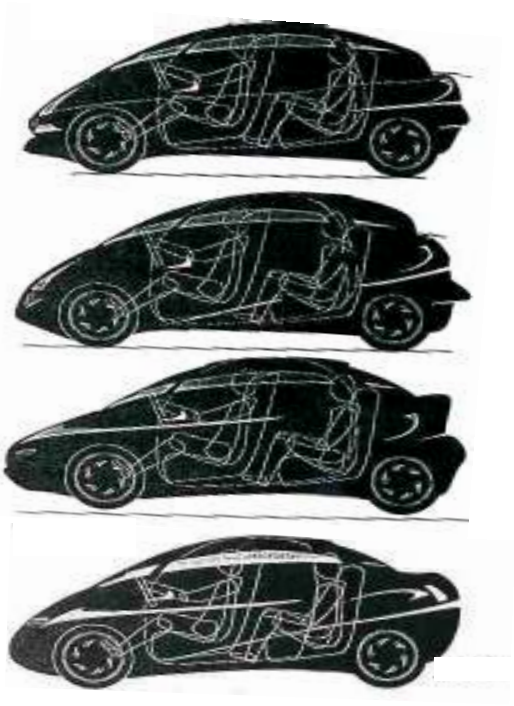


Fig. 1 Sketches from a car project [2]

The exigencies to security, ergonomics and functionality must be completed by the requirements of harmony and creativity. Industrial products have become a creative field in which has developed more differentiation by shape, color, decoration and material.

About real beauty of a product can speak only when the shape of the product responds to social function (its destination) and construction, when he is organically connected to man and the environment [6].

The aesthetic quality of a product includes several indicators which have a close interdependence. These aesthetic indicators include assessment criteria relating to product shape, structure-functionality-shape ratio, shape-material, shape-color-ornament, shape-color-fashion-details, shape-environment, appearance and finishing, packaging and presentation of products, expressiveness of factory mark etc.

The aesthetic value of a product is defined by balance, harmony, clarity, order; these aesthetic qualities being subordinated to functional and technical aspects and to its destination.

Elaboration of appearance of a product is based, in fact, on the same laws of composition, shape and color governing any artistic creation [7].

3.1 Proportion

Among the characteristics that are components of the aesthetic quality of the products is found the proportionality.

The proportion is the ratio of elements in terms of quantity, from the point of view of the size (dimensions, surface areas, volumes). It is frequently found in natural forms: Fibonacci numbers, the golden ratio and the spiral shells of mollusks. Thus, all elements of a whole are brought together after some proportions achieving harmony.

At the same time, using proportions can it determine easier the interdependence between different modes of composition, because proportions reflect constructive logic of the product. In addition, the product proportions must be correlated with human dimensions and the specific features of eyesight and visual interpretation of the product.

The simplicity, perfection of details and beauty of proportions consisted of standard elements that can be assembled in various combinations, are a contemporary trend.

3.2 Harmony

Harmony is created by satisfactory relationships between parts and the whole and of parts between them. Harmony renders the ratio of elements in terms of quality, forming the final impression agreeable and pleasant. It is an aesthetic category expressing adherence of parts, coherence of inside and outside, unity of content and shape. Obtaining a harmonious object can be achieved by the balance of the functional properties and suitable choice of the material with an adequate structure (composition).

3.3 Contrast

The contrast is a factor which stimulates perception. Contrast removes state of monotony, stimulates variability, taking into account both the whole unity. By contrast, components of an ensemble outline their own characters more and more, and when the designer found the optimum ratio between the shape, size, value and color, expressivity of the whole reaches the highest degree. In industrial products are found contrasts of lines and shapes, sizes and structures, texture, shadow and light, value, color, hot and cold, purity etc.

3.4 Line

Spatial models are materialized in shapes. Each shape, together with its components (line, plane and volume) has subjective plastic expressiveness.

Line, by varying its combinations, can lead to beautiful things, pleasant, depending on the designer's imagination and talent. The line is at the origin of shapes, can be basic (determines basic dimensions of the product) or contour line.

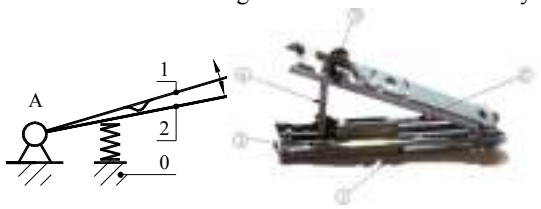
Lines can create optical illusions of shortening, elongation, narrowing, widening, and broadening, effects that can be used to emphasize, to highlight the shape, aesthetics and final quality of the construction.

Straight line expresses order, firmness, force, inner resistance of the material (fig. 2a, b).

Curved line suggests flexibility and suppleness, helping to create a dynamic feeling. Also, curved lines suggest a feminine atmosphere and add movement. The new stapler design emerged from a product vision to be considerably safe, easy to use, and to have an aesthetic appearance (fig. 2c).

The vertical line, having a "rigid, severe, male" quality, expresses strength and stability, gives the viewer an eye movement up and down, tends to elevate the surface, gives the illusion of increased space in that direction.

Similarly, horizontal lines promote a feeling of peace, relaxation and rest. Diagonal lines suggest movement and action and sometimes give the illusion of instability.



a)

b)

c)

Fig. 2 Stapler concepts [2]
a) Kinematic scheme of stapler mechanism
b) Old concept for the stapler
c) New concept for the stapler with user-friendly look

From studies about shapes perceived as groups of lines, surfaces, volumes it has revealed that the groups are made to achieve a "privileged shape".

"Privileged shapes" are regular, simple, and symmetrical (fig. 3). The best forms are those that are easily perceived, that offend, which remarks best. They are determined mathematical shapes (square, triangle,

rectangle, trapezium and ellipse), than follows natural shapes (in animals, plants) and finally are placed the fanciful shapes, intuitive.

Fig. 3 Privileged shapes inside an aircraft project [3]

The disposing of volumes, their sequence, the ratios between them, lead to the balance of shapes that make up a product, to achieving an outstanding spatial impression.

3.5 Color

Color is used for aesthetic and practical reasons in order to increase sales, to create company image and individuality note of the product.

The problem of chromatic concept requires rigor, accuracy and fairness in the use of colors, thus responding to the multiple functions performed by the product.

Color or chromatic composition must correspond to functional and technical needs, should strengthen the contour of shapes (fig. 4), allowing an optimum visual perception, as well as a certain emotional perception. In addition, color language allows communication of a certain type of information, can signal or symbolize a certain thing.

Thus, the color may be an important factor in highlighting volumes by contrast, to discern the static elements to the dynamic ones, mobiles, in highlighting the contrast between the background work and the raw material to be manufactured (at a machine tool) [5].

Fig. 4 Chromatic composition for a car

The color applied for functional purpose involves a careful examination of the function of the product in question, of the place where the product will be used, of how to use and of the objectives to be achieved.

Consequently, a reference of color to an object, justified in terms of technical and functional, in terms of consumer psychology and in plastic-expressive terms, is an important condition to maximize the aesthetic possibilities that can be achieved by the industrially manufactured product, that can bring extra satisfaction, human pleasure, he can cover his aesthetic taste requirements, it can correct and develop (fig. 5). Surface finishes, stylized shapes, rich colors and key dimensions contribute to achievement of an attractive product.

Fig. 5 Reference of color to the plane cockpit [2]

3.6 Symmetry

Symmetry is the objective quality and the expression of size and shape relationships, of order and disposing, of matching and concordance that parts of a whole have between them and in its entirety.

Being real property of an assembly consisting of elements that meet certain positioning, the parts may relate to a center, an axis, a plane and at a distance etc. The order and some internal distribution of the elements of a product are undeniable aesthetic qualities (fig. 6).

Fig. 6 Airplane with bilateral symmetry [3]

By symmetry, the objects win properties for harmony, balance, and proportionality. Symmetry determines an economy of parts, repetition of same motif, which gives a perception physiologically easier. Figure 7 shows an example of a mechanical system (hydraulic distributor) having structure symmetry (the mechanical system has two or more identical components in geometric structure, and these parts are arranged orderly according to some rule of regulation [3]).

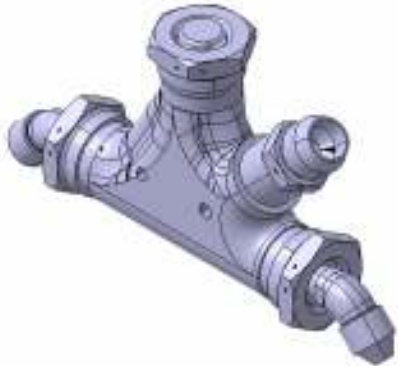


Fig. 7 Mirror symmetry structure of a hydraulic distributor [2]

4. ERGONOMIC DIMENSION

Since the period of 1950-1970, Henry Dreyfuss, considered "the conscience of the profession of designer" appreciate that industrial designers must be concerned with ergonomics and especially its functions: "if the designer manages to bring a greater safety to the consumers, make product to be desired, more efficient, more useful, then he succeeded in his work".

Today ergonomics tries to solve problems related to saving the environment by programming recycling of obsolete objects, finding ways to increase the lifetime of products, together with their structural simplification etc.

Industrial design represents a continuous adjustment of any product in shape, size and color which corresponds, at a given moment, to human requirements. Thus the designer must decide on the relations between product aesthetics and issues concerning ergonomics or its technical function. The following diagram shows that these relations are varied, depending on the technical field in which products are used (fig. 8).

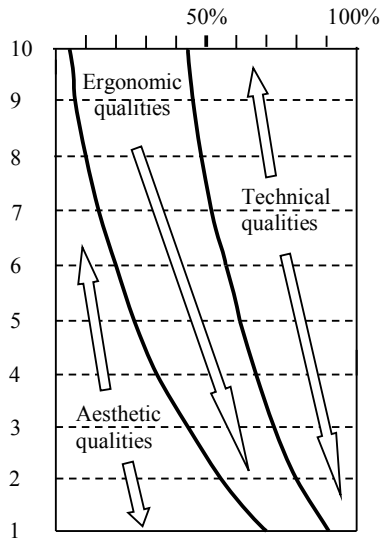


Fig. 8 Relation between aesthetics, ergonomics and technical qualities depending on the type of products [7]
1. Objects for personal use; 2. Common household objects; 3. Household objects; 4. Radio and television; 5. Medical devices; 6. Equipments used in food and textile industry; 7. Vehicles; 8. Agricultural machinery; 9. Machine tools; 10. Metallurgical and mining equipments.

5. COMPUTER-AIDED INDUSTRIAL DESIGN

Computer-aided industrial design (CAID) has become an important part of ID practice today [1].

Industrial designers use numerous virtual models to assess the overall size, proportion and shape of many proposed concepts. These models allow the development team to express and visualize product concepts in three dimensions (fig. 9).

Two or three dimensional models show the details of the design and than rendering is used for color studies and for testing customers' reception to the proposed product's features and functionality. More complex renderings may include materials or textures. These images can make use of the interaction of lights, showing the many surfaces of the model through the reflection, refraction, and transmission of light and color.

Fig. 9 Plane cockpit with functional aerodynamic shapes [2]

Using 3D CAD tools, industrial designers can generate, display and rapidly modify three-dimensional designs on high-resolution computer displays. These tools therefore facilitate visibility and communication. Figure 10 shows a 3D CAD model of an airplane that integrates the cabin illustrated in the previous figure.

Fig. 10 3D CAD concept image created using CATIA software

Virtual technology gives the possibility for all people involved within the design, production, engineering, planning and maintenance departments, to review and test concepts in the pre-contract phase of the product building process [1]. Furthermore, 3D CAD systems may be used to generate control models or drawings, and these data can be directly transferred to engineering design systems, allowing the entire development process to be more easily integrated.

6. THE ROLE OF INDUSTRIAL DESIGN IN PRODUCT DEVELOPMENT PROCESS

ID play a large role in determining the market success of the product.

An early ID concept gives the team a concrete vision of the end result of the development effort. Note that the ID process is a subprocess of the product development process; it is parallel but not separate.

From an ID perspective any product must be novel, recognizable, durable, easy to fabricate and must have strong customer appeal.

For products that are characterized by a high degree of user interaction and the need for aesthetic appeal, ID must be involved throughout the product development process. Early involvement of industrial designers will ensure that aesthetic and user requirements will not be ignored by the technical staff. Quality of the user interface is a rating of how easy the product is to use. Interface quality is related to the product's appearance, feel, and modes of interaction.

The more interactions users have with the product, the more the product will depend on ID. Consequently, each interaction requires a different design approach and aditional research.

The user interfaces must be safe, easy to use, and easy to maintain.

For products with relatively little user interaction such as some types of industrial equipment, the cost of ID is low. On the other hand, the development of an intensively visual and interactive product such as an automobile requires a large budget invested in ID. In this case the commercial success of a new automobile design (fig. 1) is highly dependent on its aesthetic appeal and the quality of the user interfaces, two dimensions largely determined by ID.

The quality of ID for a finished product can be evaluated by considering each aspect of the product that is influenced by ID. In this context there are five categories for evaluating a product [1]:

1. Quality of the user interface – how easy the product is to use;
2. Emotional attractiveness of the product – this appeal is achieved through appearance, feel, sound and smell;
3. Ability to maintain and repair the product;
4. Appropriate use of resources – how well resources were used in satisfying the customer needs;
5. Product differentiation – product's uniqueness.

7. INTEGRATION OF ECO-DESIGN IN PRODUCT DEVELOPMENT PROCESS

The energy crisis and other disturbances directly affect the consumer goods industry, causing a total reconsideration of functional object industrially manufactured. Today, functional object is a presence able to delight human glance, through his notes of harmony and balance without resorting to aesthetic solutions that are not legitimate from the perspective of uses that product will have. It is envisaged to obtain products with a long life cycle, which corresponds best to their own goal, requiring for achievement, but also for maintenance or operation, very low consumption, without endangering the environment [2].

Given the limitation of natural resources appears some moralization form of consumption, such as the concern that exists for long-life products or multifunction products and permanent interest for better use of natural resources.

The practice of eco-design aims at improving the product such that to determine in a life cycle reducing energy consumption, waste, radiation and toxins [4].

Without eco-design cannot be developed new products whose ecological parameters to be considered alongside the health, ergonomics, safety and beauty, all in the service of consumers.

8. CONCLUSIONS

1. Most products on the market can be improved by good ID - the more a product is seen or used by people, the more it will depend on good ID for its success;
2. Form, line, proportion, simetry, and color are used to integrate the product into a pleasing whole;
3. The visual qualities of the products must be considered for the mutual benefit of both user and manufacturer;
4 In production and on the market there is a veritable "explosion" of new products, made in good measure by the contribution of industrial design, which influences the determinant elements of a company's activity;
5. Without the contributions of industrial designers, who define the size, shape, product's aesthetic appeal (how it looks, sounds, feels) and its functional interfaces (how it is used), any product has little direct impact on the market;
6. Industrial designers emphasize the importance of geometry, aesthetetic, precision, simplicity, and economy in the design of products.

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