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INTERPRETING EVOLUTIONARY TRENDS TO UNDERSTAND THE DIMENSIONS OF PRODUCT DESIGN PROCESS

Abstract: *Many traditional products on the market today require significant improvements in their designs and production technology. The paper illustrates the role of today's designers in creating novel concepts and the importance of knowing the relevant trends of evolution of industrial products (as engineering systems) in accordance with the "Axiom of Ideality". A systematic approach of the ways of achieving best innovations is offered. Descriptions of these trends of new products characterized by high performance parameters are presented. Several conclusions highlight the main points of the paper. It is revealed that the study of conceptual developments in design products is of great practical importance today.*

Keywords: *conceptual development, trend of evolution, innovation, ideal product, democratic design.*

1. INTRODUCTION

The complexity of our world and the rate of change which supports contemporary society represent a challenge for today's designers. These ones must collect and process multiple informations in a creative manner.

New product ideas are the key to economic survival. This is the reason why designers must look with an open mind at life around us – not just at products, but also at their details. This does mean to be prepared to question everything, to be able to have a different view, to be able to express an alternative opinion and to be able to try new things [1].

Designers approach a problem knowing that there is always more than one solution to be found. This philosophy is one of the core skills of a designer. Achieving new ideas and innovations is feasible by exploration as many workable ideas as possible. Working with new materials, shapes, analyzing existing product to see how they work, or building models and prototypes are all valid options.

2. CHALLENGES FOR TODAY'S DESIGNERS

To come up with new ideas means to break the rules of nature or of society. Designers can obtain improvements of existing products by adapting these products in simple ways, such as changing scales, altering features or redefining attributes and properties.

Also, a designer can work with different materials that offer an incredible range of characteristics and performances in order to finish or embody the product. Developments in nano technology, composites, bio-composites, gels, foams and treatments offer designers multiple new opportunities. There are varied examples: d30, terfenol, tyvek, aerogel [2] etc.

A good design is democratic. This means that the designer must make things better for more people. Democratic design influences every stage of the development process of a product, whether it is a piece of furniture, a cooker or an industrial product. All these products are developed taking into consideration that people want functional objects that ease their lives, that look good (relationship function-form), have a good quality/price ratio, that protect the planet (sustainability) and are accessible.

A characterization of the democratic design from different viewpoints is given in figure 1. This classification is elaborated in function of main criteria required of a product and includes key considerations taken into account by any designer.

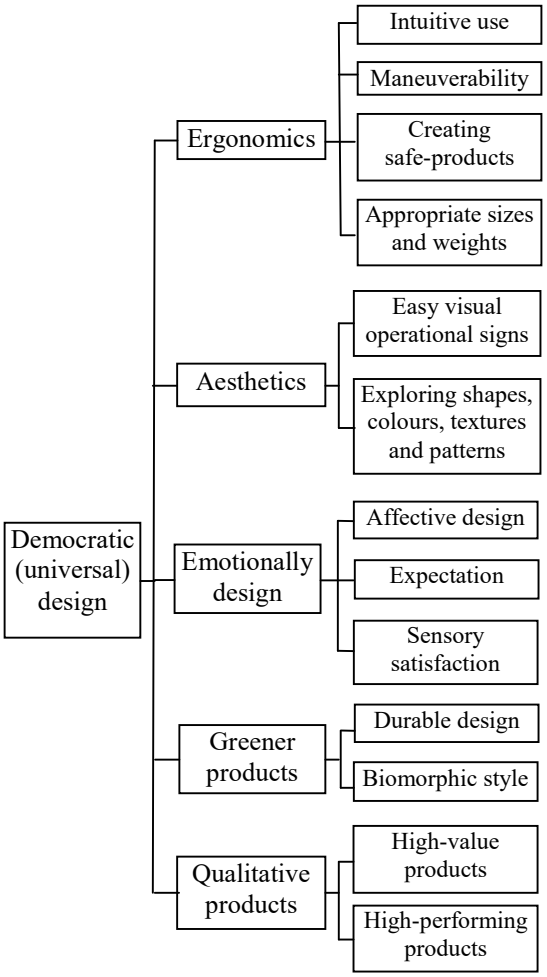


Fig. 1 Aspects of democratic design.

Make things better and accessible for as many consumers as possible (in a simple and attractive form) is a difficult challenge, but not impossible.

The challenge consist in the achievement of the five basic requirements [3] – form, function, quality, sustainability and low price – by every product designed and developed, requirements that are closely related to the democratic design and that represent the responsibilities of each designer.

Like new materials, new technologies can have the capacity to generate new product ideas on a large scale. Designers must be able to access and understand new technological developments using science journals, patent sites, technology transfer and partnerships between designers and technologists [4].

Making new connections between concepts or doing things differently can be powerful techniques that inspire creativity, helping designer to be more imaginative, more receptive to non-conventional ideas. Designers must have the courage to try new ideas, even if the concepts are not clearly beneficial and there is a possible risk of failure.

For example, using networks of different shapes allows the construction of special machines (aircrafts), designed to transport persons. In fig. 2 it is observed the essential building elements of an innovative sonic sustentation system: a network of lightweight blades that have hexagonal mesh, tensioned on a frame (reflector) with relative rectangular shape. The pattern illustrated in fig. 2b uses a new principle based on vibrations of palettes in pulsation motion to determine a loading sustentation of the mechanical system, if the number of pairs of blades is great in a sufficient measure [5].

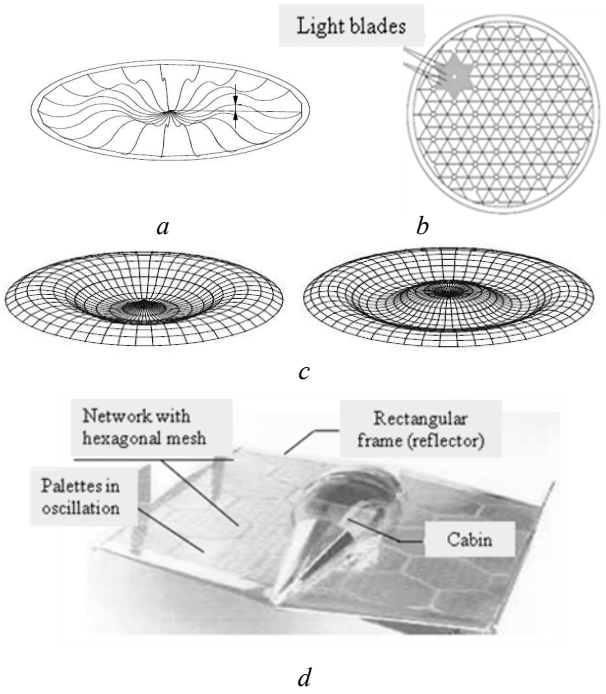


Fig. 2 Aerial vehicle using power transmission by mechanical waves
a - working principle of sonic waves in elastic strings; *b* - construction structure; *c* - mode shapes of the mechanism (obtained by modal analysis); *d* - aerial vehicle.

A designer does have the ability to innovate across a variety of fields, to identify and offer solutions for contemporary challenges through intelligence, passion, an eye for detail and capability to identify opportunities.

Adopting different viewpoints in an effort to see a problem from a number of angles, recognising the change, looking towards new materials and new technologies for inspiration and understanding the surrounding issues are all a part of the designer's imaginative function.

3. MULTIFACETED APPROACHES OF THE DESIGN PROCESS

3.1 Designing for people

A way to generate new or better products is to conduct the design process based on criteria that meet the needs of the consumer or of a specific market sector. In design, this means interpreting and understanding consumers' behaviour and decisions through their interaction with products.

3.2 Reflecting on nature's systems

There are great lessons and ideas that can be learnt from nature's systems: flora, fauna and structures of the world around us. Reflecting on life all around us is an activity that will stimulate imagination and creativity.

The study of diverse biological aspects (structures, forms, individual components, systems, and natural phenomena) and utilization by the designer of the knowledge acquired in the field of biology can lead to multilateral and better technical solutions. It's about what today is called "bionics" or "biomechanics" - interfaced discipline with other scientific disciplines.

The use of curving organic shapes, as a part of the trend for smooth, is a reaction from the clean and symmetric designs characterized by simplicity and harmony between function and form.

Application examples of solutions and constructive principles of natural systems in technique are:

- lightweight structures like shells, hot air balloons (fig. 3), honeycombs, tubes, rods and fabrics;
- aerodynamic profiles of aircraft's fuselages (fig. 4), respectively the hydrodynamic profiles of ships hulls (fig. 5), characterized by double-curved surfaces;
- start flying technique and the flight of the aircraft itself.

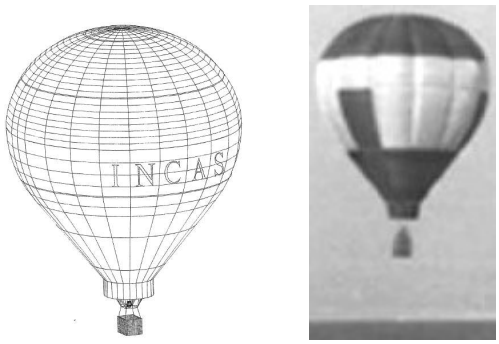
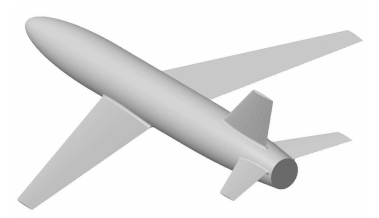


Fig. 3 Hot air balloon, AX-6 class.

3.3 Inclusive design

Inclusive design incorporates aesthetics and ergonomics. This means comfortable handles, easy visual operational signs, differentiated colors, control and maneuverability. Inclusive design is addressing the needs of the widest possible audience, inclusive for the people with disabilities. The products are made with principles that include equitability, simplicity, flexibility, intuitive use, low effort and appropriate sizes and weights, simplicity being the essence of a good design process.



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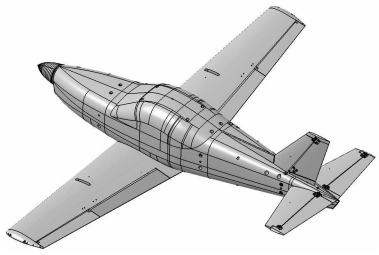
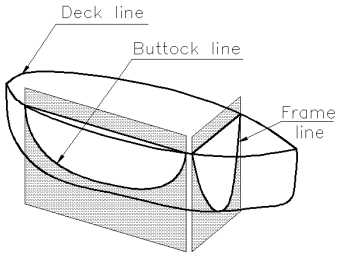


b

Fig. 4 Aerodynamic profiles of aircrafts
a, b – 3D scale models of an airplane (1:16 scale).



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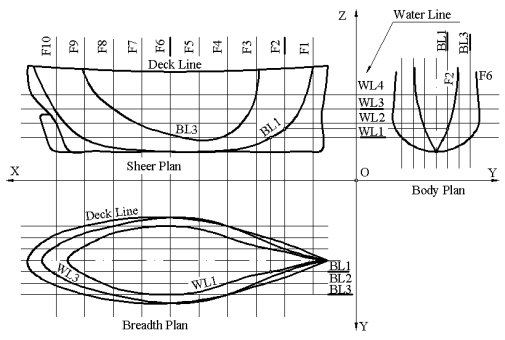

b

Fig. 5 Hydrodynamic profiles of ship hull
a – Lines of a boat;
b - Graphical method to determine the curves of intersection of different planes with a ship hull [6].

3.4 Exploring trends amongst younger age groups

This means that designers must watch what young people are doing, what they would like to see in a product, what clothes and attitudes are displayed and then interpret where these behavioural characteristics might go. To be "cool" describes the need for young people to have the latest admired products and to spend money to buy them. This trend can be exemplified by use of diverse products, very popular among teenagers, which may evolve into a culture of "cool" products:

- BMX (off-road) sport bicycles used for spectacular acrobatics, with a beneficial role in attracting new generations to bike and cycling in general;
- electric skateboards;
- electric scooters as a clean and unconventional means of transport;
- clothing and footwear sport associated with both innovation and winning.

Young people prefer casual style involving cool clothing items endowed with modern and lightly tailoring, trendy striped or in colors always in fashion, that bring freshness to any outfit. These ones avoid the stereotypical clothing already available on the market and prefer a "cool" alternative, whilst maintaining quality and style. "Enjoy Every Day" is their motto, so designers must take this into account and create sport models with simple shapes and beautiful colors for comfortable looks.

Hence it results the conclusion for designers: making new and high-performing products.

3.5 Kidult products

This phenomenon describes the design of adult products for children and children's toys for adults, because the kidult market is rapidly growing at a rate of nearly 20 percent per year.

There are a variety of kidult products: educational toys, miniature laptops, electronic games, electric vehicles controlled by smartphone, umbrellas hat, projectors night light, kitchen gadgets, kidult candy bowl holders, chess sets with pieces representing cartoon personages, action figures, nanoblocks, favourite sports players minifigures, adult versions of children's toys, mobile robots configured with different functions, drones and remote control products.

3.6 Interpreting the market requirements

This means looking at existing products to see what are the differences in cost, material, shape and manufacturing processes. A study of the meaning and development in time of a product, or related products, might help to generate a better understanding of the product's requirements.

New product development is an expression of technological and marketing innovation. While new or improved technologies generate superior physical properties adapted to the function and form of a product, or permit the manufacture of products entirely new, innovation in marketing leads to new ways of identifying and meeting the needs of consumers, showing "to whom and how to sell the product so that it can be sold profitably". Preliminary assessment of the market to ascertain trends, both technically and commercially, is a

good starting point for detecting emerging opportunities and generates new ideas.

3.7 Ideal products

All engineering systems are developed in accordance with universal "laws of evolution".

A main trend is in accordance with the "Axiom of Ideality": "all engineering systems are evolving towards acquiring a higher degree of ideality" (higher benefit-to-cost ratio) [7]. The "ideal system" is such system which does not exist as a physical entity, but whose function is still performed (high benefits with zero costs).

The following expression is used to define the measure of ideality:

$$ideal = \frac{\sum benefits}{\sum \cos ts + \sum harmful\_effects} \quad (1)$$

where:

- Σ *benefits* – quantifies the useful functions of the system;
- Σ *costs* – quantifies the direct costs and costs for society;
- Σ *harmful_effects* – quantifies failure modes, harmful functions, and undesirable aspects of the designed system outputs.

Any system by their functions has useful and harmful effects. The primordial goal of conceptual design is to maximize the useful effects by guiding the designer to conceptualize perfect products.

4. RELEVANT TRENDS MANIFESTED IN PRODUCT DESIGN AND DEVELOPMENT

4.1 Classification scheme

A classification scheme for different trends that includes examples of use is given in fig. 6. This scheme is established in accordance with other prevailing trends that have a significant role in creating and developing of a more advanced system replacing the old one, such as:

- dynamization trend – in the evolutionary process, engineering systems are becoming more dynamic, adapted to changing constraints and changing environmental conditions. This was the major development direction of improved conceptual design of machine components. The product must correspond to a changing environment because the technologies are improving, the preferences of customers are evolving, the competitors introduce new products and macroeconomic conditions are changing. The rhythm constantly increasing of the scientific and technical progress, instability of the economic parameters (material and energy resources, movement of goods), the imperative of social needs (cultural, demographic, political), and generally, the increased complexity of all human activities, require an innovative concept of permanent renewal of technical systems to adapt to the dynamics of contemporary developments;
- trend of transition into poly-systems - any system, regardless of its complexity, it's a subsystem of a more comprehensive system;
- trend of fragmenting of the basic system components - any system is characterized by a certain reunion of all subsystems to the smallest components.

Innovative solutions must respond both to the needs of consumers (any potential product attribute that is desired by the customer) and requirements for engineering design and industrial design.

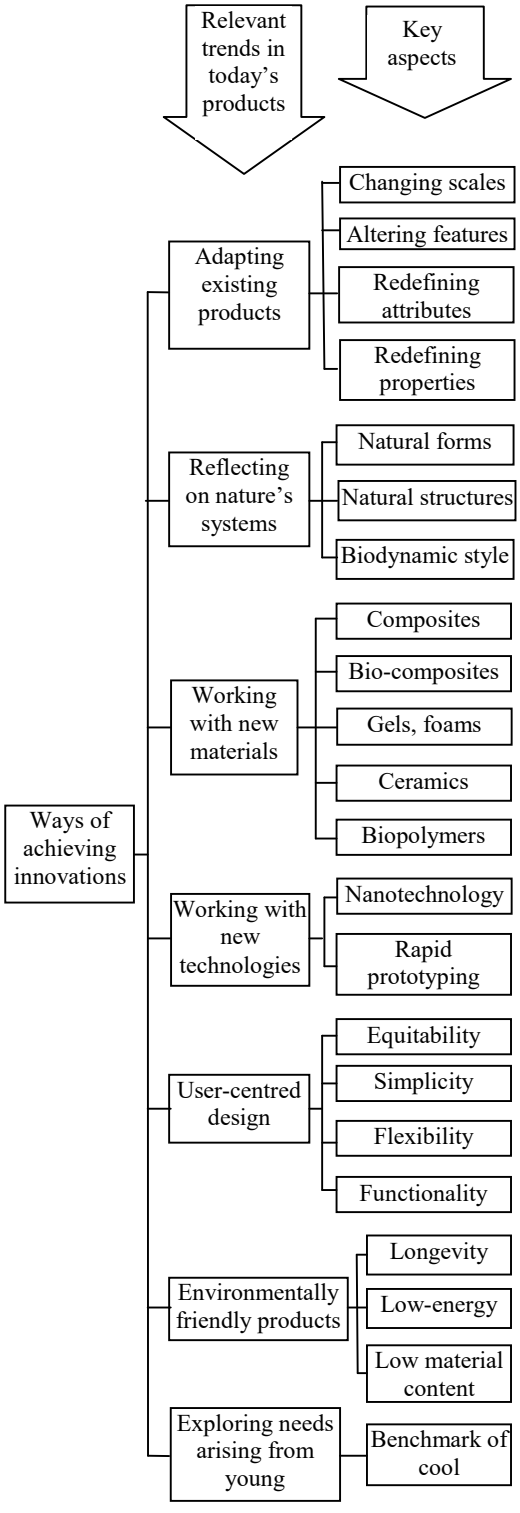

Fig. 6 Trends of evolution of industrial products.

The new, as fundamental requirement of the creation of any kind always appears in the "old" by the scrutiny of the surrounding reality, being the result of qualitative leap due to individual and collective accumulation of hard work to achieve a well-defined objective.

A necessary condition for the success of a product is that provides noticeable benefits for the customer. The products offer benefits when satisfy needs, even if the product is an enhanced version of an existing product, or it is a completely new product based on a revolutionary invention.

To do this, the designer must defines the most suitable shapes and colors in relation to the user's requirements. At the same time, the designer aims:

- to harmonize commercial requirements with technical ones;
- to optimize the use - aesthetic relationship;
- to determine the best use-quality-price ratio.

The designer must be a connoisseur of artistic and technical disciplines and to appeal to ergonomics, the value analysis and new technologies [8].

Given that the pieces are shaped to ensure their contact with other parts in the assembly to which they belong, in contact with various liquid, gaseous etc., or in contact with the man, results that the functional role is that which determines the basic forms of functional components of an assembly.

Design calculations indicate minimum sections necessary and are a guide to outline the shape in terms of homogenization of stresses and flow lines of force. Effects on form appear due to the influence of other factors such as size, material and manufacturing technology and assembly, economy of production etc.

Knowledge of such trends of evolution allows us to develop a conceptually better system. To accomplish the development process, engineering contradictions associated with the existing system must be identified and resolved.

4.2 Trends in product development

Product development requirements must take into account the trends manifested in the development of industrial products.

These trends are:

- Increasing quantitative and qualitative complexity of products (consumer goods or industrial products); if the quantitative aspect involves a large number of components of a product, the qualitative aspect considers the existence of different nature components (mechanical, hydraulic, pneumatic, electronic, electrical) to achieve the best performance indicators and also several functions;
- Development of high performance indicators (productivity, durability, load capacity, payload etc.); obtaining of high value operating parameters (pressure, speed, temperature) to ensure performance must be achieved without increasing the size and weight of the system (weight/transmitted power indicator to be as low as possible);
- Ensuring operation under extreme conditions (operation at high or low temperatures or in corrosive and with radiations environments);
- Using new materials and material structures to provide superior strength and manufacturing characteristics: plastic material reinforced with glass fibers, ceramic materials, composite materials, titanium alloy, layered structures etc., that provide specific properties (light weight, damping vibration and noise, high stiffness at low weight etc.);
- Using new technological processes of high productivity, precision and complexity through the systematic application of scientific and technical knowledge: laser machining, electro erosion, processing using robots, additive manufacturing that creates physical objects directly from 3D CAD models such as FDM (Fused Deposition Modeling), MJM (Multi-Jet Modeling), 3DP (3D Printing), SLS (Selective Laser Sintering), DED (Direct Energy Deposition), PBF (Powder Bed Fusion), FFF (Fused Filament Fabrication), LOM (Laminated Object Manufacturing), DSPC (Direct Shell Production Casting), VP (Vat Photopolimerization), SLA (Stereolithography) [9];
- Implementation and expansion of standardization of parts and sub-assemblies (through modular construction) to obtain economic benefits and quality of the product. Typification and standardization prescribe the best characteristics of the components/sub-assemblies: shapes, sizes, materials etc.;
- Automation and robotization of operation and exploitation, combined with monitoring of the functioning, carried out by measuring specific parameters of vibration, noise, temperature, pressure etc. The monitoring enables in particular when the system is out of operation, as a consequence of its deterioration;
- The use of computer-based technologies that provide a graphical user interface and allows the designer to create, analyze, manipulate, and optimize of individual parts or complex assemblies. Computer aided design 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 development process. These tools provide benefits due to reductions in design cycle time, increase design accuracy and reduce the time to produce drawings and documentation. Also, three-dimensional software provides the opportunity to easily modify and visualize complex geometric shapes of the product. Through the use of computer-aided engineering (CAE) tools, 3D CAD models are used to detect geometric interferences among structural elements and the components of entire product. Forms of CAE include finite-element analysis of thermal flow or stress distribution, kinematic and dynamic motion of complex mechanisms, modal analysis or torsional buckling analysis. These tools therefore facilitate visibility and communication;

- Achieving aesthetic shapes and colors, with favorable effects on the consumer (removing fatigue) and consequently on the growth of labor productivity.

The product of design, part of the cultural sphere, is a social good, with a great educational force, able to impose both creator and consumer of goods, a new attitude, a new state, a new "modus vivendi". Today, to be appreciated as beautiful, the industrial product must have great practical efficiency and at the same time an attractive form.

The relationship between form and functions of a product is dynamic, its evolution being determined by a multitude of economic, technical, social and psychological factors.

5. CONCLUSIONS

The paper was focused on presenting the trends of evolution of today's products for extracting the list of challenges for designers and their various working options during the product development process to genetate new or better products characterized by high performance parameters and aesthetic quality.

Today, thanks to modern scientific-technical revolution, technical products manufactured in industrial series must 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.

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, ergonomic, technological and, not least, environmental protection. The designer is the one who gives material replica of the desires and needs of consumers.

Product design helps to increase the usefulness of the product, not only in looks. Design value is given by a variety of attributes that relate to utility, safety and reliability, size and weight, shape, color, style, personality etc. The visual qualities of the products must be considered for the mutual benefit of both user and manufacturer.

Industrial designer intelligence is characterized by the ability to capture new, to multiply assumptions, to admit the priority of facts and to be fully objective. A creative group of San Francisco consider as basic skills ("basic qualification") for a creator, a complex of six traits: perseverance (comprising enthusiasm), originality, intelligence, circularity (feedback), flair (in the sense of intuition choice) and, of course, experience [10].

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. Industrial designers emphasize the importance of aesthetics, functionality, simplicity, and knowledge of trends of evolution in the design of products.

From the above it can conclude that the role of the designer is to achieve a functional and technological agreement, in form and color, in order to materialize products industrially. Withal, the designer exerts an art related to both the functional and technical side, and the side imposed by materials.

The today's design requires, on the one hand, the creation of new forms - but under the condition of correlating them with new components (technology, material, structure etc.) - and on the other hand, resistance at the tendency to copy old forms.

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