# DESIGN IN THE PROCESS OF MODERN PRODUCT DEVELOPMENT: ORGANIZATIONAL IMPACT

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*The design of an industrial product is nowadays strictly integrated into the whole process of development and production of the item and there is no longer a sequential distinction between the different phases of concept, design and manufacture, as was common in the past.*

*This paper intends to describe the different phases and techniques of the process of development of an industrial product, highlighting the implications of this modern approach in the organization of a manufacturing enterprise, in particular in terms of the personnel involved. The target is to assess how coordinated activities, use of proper IT-enabled technology and good integration between the staff dedicated to the design, to the production and to other related actions needed to develop any industrial product, are fundamental for its success and for the competitiveness of the related manufacturing enterprise.*

**Keywords:** Industrial Product, Design, Production, Organization, Integration.

## Introduction

Design is both a scientific technical and a humanistic activity. In any object a synthesis of these two cultures is realized and its design involves, beyond all the functional content, all the aspects of communication and language. Reasonable doubt arises concerning the fact that design can be realized through a method that faces different aspects in a systematic way by dividing a complex task into a series of simpler ones or, on the other hand, design can have a holistic value [Freddi, 2004].

"There are machines or mechanisms that function wonderfully well if they are carefully designed and constructed with high quality parts, assembled with care and subject to regular, effective maintenance. The relationship between a supplier of goods and services with its design consultants resembles the concept expressed above."

These are the words of one of the most famous contemporary car designers Giorgetto Giugaro, summarizing the principle that the success of any product mainly depends on the grade of integration between the design and the phases of production [Giugiaro G., Giugiaro F., Molineri G].

The main phases of the development of any industrial product are: concept, design (development and validation) and production. In the '50s, during the spread of mass production based on the Fordist model, these phases were considered sequential: once the concept of the product is finished, a detailed design follows to define the technical features and characteristics of the item. These technical requirements concerning structure, shape and materials as well as technologies and processes were transferred to production in order to manufacture the product. This traditional approach had huge limits: only when the first prototype of the product was made - already in an advanced phase of the development

process - it was feasible to become aware of possible design errors. Therefore, to correct any problems it was necessary to redesign the product or some parts of it, which was often a significant waste of time and money. The communication and interaction between people working in the design office and in the production plant were limited and often ineffective; each team was working without any comparison or discussion and the effects of this lack of integration on the final cost of the product were extremely high.

Thus the conventional product development process employs a design-build-test philosophy.

The sequentially executed product development process often results in a prolonged lead-time and an elevated product cost [Chang, 2015].

**New Organization and Personnel Patterns For An Effective And Efficient Design**

To improve the effectiveness and efficiency of the design process, the sequential approach has evolved into a more integrated and simultaneous one, where the different phases are not separated any more and the first product concept can be modified and improved through briefings and feedbacks in every stage of the process.

To this aim, the organization of manufacturing companies has changed in particular in terms of employed technology and human-resource management.

IT-enabled technology, such as computer-aided design, engineering and manufacturing (CAD/CAE/CAM) tools as well as advanced prototyping technology to support product design from concept to detailed designs and ultimately manufacturing have been developed, and are presently used in most enterprises fabricating industrial products. The e-Design approach employs virtual prototyping (VP) technology to support a cross-functional team in analysing product performance, reliability, manufacturing costs early in the product development stage and in conducting quantitative tradeoffs for design decision-making. Physical prototypes of the product design are then produced using rapid prototyping (RP) techniques mainly for design verification. The e-Design approach holds potential for shortening the overall product development cycle, improving product quality, and reducing product cost [Chang, 2015].

Concerning human resources, a closer collaboration and integration between employees and computer aided systems at different offices and departments is fundamental to the new approach. In particular designers, production technicians and planners must work together to guarantee the success of the product, achieving a correct balance between the product quality, its performance and the cost. The design can be developed inside the company or subcontracted to an external studio, in both cases the communication and sharing of the involved personnel is strategic to the final aim of producing a commodity that is convenient and works efficiently.

The figure of the designer has also evolved over the last few decades. Not long ago designers were eclectic generalists. They studied art, science, and religion in order to understand the basic workings of nature, and then applied what they learned to solve the problems of the day. Over time, the quantity and complexity of accumulated knowledge led to increased specialization among designers [Lidwell W., Holden K., Butler J, 2003], but still a good general culture is fundamental in particular to get new ideas from art, nature, cinema and to increase the ability of proposing beautiful and innovative products. A requirement to fabricate with success is the domain of several points of view and experiences, which in part

are outside the out-andout construction activity: "Who wants to build, must first look and think!" [Niemann, Winter, Höhn, 2005].

Today, design is a recognized field of cultural history. Knowledge of the classics of modern design, meanwhile has almost become common cultural property, like art and design objects are similar presented [Hauffe, 1998]. Designers need first of all to get a deep knowledge of what has already been produced by their colleagues, before starting a new project.

**The Development of the Industrial Product**

The following key points in the development of an industrial product can be considered:

1. First Briefing

The first step to start a new project is to make an in-depth analysis concerning the product the company wants to develop and the target market. It is fundamental to the designers to deeply understand the motivations, the habits and the social and psychological behaviour of the consumers who will use the product. In the two cases: an external design studio acting as a consultant or a design office internal to the enterprise, it is essential that the designers understand the company, its history, mission and corporate culture.

An analysis of substitute products and competitors to well define the company position in the market and to be able to plan some real innovation, if required, is preliminary to the whole product development process. Where does the company want to position itself? Which are the customers who will use the product? Why will they choose it instead of another similar one?

The staff involved in this first briefing phase does not only include designers, but also marketing and sale operators, production planners and technology experts. It is crucial that all these people actively participate in order to collect ideas and be able to start the definition of the product in the most effective way. From the organizational point of view, this means the implementation of good communication and the planning of meetings involving different company areas.

2. Style concept

The briefing suggests some hints to give shape to ideas that can be materialized in the concept. Designers generate the first sketches and outline drawings and the use of paper and pencil is supported by computer technology for a two or three dimensional visualization of the object. By using these tools it is possible to produce various models that allow a first assessment of the aesthetic and functional impact of the design. Some alternatives (generally three or four) are then submitted to the attention of product decision makers who will select the final one.

In this phase the owner and the Board of Directors of the company have the last word concerning the idea to be developed. It is a crucial moment to which of course also the designers can contribute to the decision with advice and suggestions.

3. Concept tuning

The proposal selected amongst the different alternatives is further fine tuned and perfected to the definitive version that will be realized. In this phase the styling is refined and colour rendering and 2D and 3D illustrations are modified and improved according to the

target of the project. It is the moment in which innovation can be introduced to differentiate the product from the previous aesthetic standard.

The engineering and modelling staff also take part in this stage to guarantee the industrial feasibility of the product, in terms of materials, technologies and production costs. This integration of the divisions is a focal point: the product should be ready for industrialization directly at the end of the first study phase to avoid radical modifications during the industrialization phase, reducing costs and production times and pursuing "time to market" objectives.

4. Virtual reality

This relatively new technique allows to virtually view and implement a styling concept in order to understand how the product appears. A full-scale model can be obtained allowing styling research in a short time, achieving reliable results in just a few weeks. Most advanced companies and design studios are provided with specific equipment to virtually represent the product. From this 3D model the engineering phase in terms of technical feasibility studies and construction of functioning prototypes can start.

Designers, engineers and company directors are generally involved in this virtual reality representation of the product as it is the first effective way to understand how the product will look and any consideration of changes can still be made without strongly affecting the final cost and time of production.

5. Style feasibility study

The style feasibility study on the definite design solution selected is necessary before the construction of a full or reduced-scale model. The consistency of the model with ergonomics and the check of legal aspects related to the product to ensure the respect of international regulations are also objectives of this phase. The design feasibility study is fundamental to check various aspects such as: assembly of various components, versatility of internal layout, analysis of the composition and manufacturability of the parts.

The engineering division, working in close cooperation with the designers, indicates and agrees on any stylistic changes to be made to the model in the processing phase so that the result complies with the original design and product.

6. Mock up

Despite the fact that rendering techniques are extremely helpful in visualizing the product and improving the project, still in some cases the possibility to construct a real-dimensions model can make the difference in allowing effective aesthetics checks on the selected concept solution. The aim is to verify the aesthetics of the model designed in the initial Style Concept phase, to implement possible improvements on the virtual model that can be "re-plotted" through mathematical values via reverse engineering or directly on the finished product. Expert craftsmen, using NC milling machines and manual techniques are able to forge different types of materials (wood, resin, plastic, etc.) to obtain a perfect mock-up of the real model. Not always will these skills exist within the company, in most cases it is necessary to sub-contract them.

7. Reverse Engineering

This is a structural method used in industrial processes, able to analyse features and details of industrial products and to generate information and parameters useful to re-engineer the entire project. The selected concept model is scanned through optical or laser technologies from which, after suitable smoothing processes, the 3D virtual model can be further modified and improved.

Through these technology artisan skills are integrated in quality design. Experts in using reverse engineering techniques and related instruments are usual members of any design office or studio and are essential in the movement towards the final definition of the product.

8. Technical Feasibility Study

Costs, materials and technologies are fundamental to define the feasibility of a successful concept.

Evaluations concerning these aspects with an analysis of investment costs and of the unitary costs of the individual parts at the end of the production cycle are carried out in this phase. At the end of these studies an effective industrialization study of the product can be developed in terms of the definition of materials and production technology, the dimensional parameters, the kind of installation of the components, the assembly procedures and of the cycle of the parts developed. A technical bill of materials is finally prepared.

Die-makers and suppliers are involved in this phase, design review sessions are scheduled in order to share and approve the solutions proposed.

9. CAD Drawings

The 3D and 2D drawings complete the technical engineering and feasibility process of the concept model and are fundamental in the prototyping phase and then in manufacturing the finished product. The drawings report the main dimensions and permitted tolerances in the entire project.

These files are shared with diemakers and die-designers who supply the components.

10. Prototyping

The prototype can be defined as the original matrix from which the series product is manufactured. It represents the synthesis of the designer activity. At this point the initial decision regarding the style concept is definitive and the prototype anticipates the production of an infinitive quantity of equal standard products. The final assessment of the product is possible through this full-scale functioning example. The prototypes are of huge value in this stage, prior to the construction of expensive series of production tools. The focus then shifts from the design of each component to the construction of the dies and the instruments necessary to create the prototypes. Finally, the prototype is tested with a real simulation.

A co-design approach is desired. Product designers, die-makers and production engineers jointly work to achieve the best result in a short time.

11. Communication

Products are recognizable according to graphic design or packaging, the value of both is important to the product's success.

According to the marketing mix and to the graphic and coordinative image of the company, a set of material proposals coherent with the corporate image and with the distinctive features of the product can be released, adding to the product the so called "intangible value".

Inner employees of the company or external consultants can take care of these aspects, sharing the designer's vision and considering the constructional characteristics attributed to the product from the production engineers.

12. Promotion

The product launch and presentation to the market is a crucial moment of the whole development process. This is an important phase to reach success in sales. Different communications activities are planned: press releases, brochures, videos, interviews and

participation in trade fairs. The choice depends on the kind of commodity and on the target market in which to effectively promote the product.

Possible expert consultants in communication and promotion can be involved working together with the marketing and sales offices of the company.

## Conclusion

The traditional sequentially executed product development process has been outdone and the present most used and successful approach is the one that integrates phases and functions.

An e-Design paradigm can be defined in terms of IT-enabledtechnology supporting the operators working for the product design and fabrication, who must closing collaborate towards the common aim. Then, beyond the use of new technology tools, human resources must be managed in an innovative way, which implies a constant comparison between alternatives and an ongoing discussion on decisions regarding the product.

Twelve steps can be identified in the development process of an industrial product. Each one is strictly connected to the others and involves staff who also participate in the other phases of the process. The company personnel dedicated to the development of products together with suppliers and consultants must be constantly aware of the final target and of all the activities involved to reach it. This collaborative awareness is essential in order to create good teamwork, to share ideas and information, so reducing costs, time to market and therefore increasing the competitive advantage of the enterprise.

Further research is needed to better define new organizational patterns that can improve the efficiency and the effectiveness of manufacturing companies, better integrating human resources planning and the use of advanced technology to develop industrial products.

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