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CONCURRENT ENGINEERING APPLIED TO KEY INDUSTRIAL SECTORS

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***Abstract*—** The use of advanced techniques in work, such as concurrent engineering, on the development of projects implies that all areas involved participate from the start of the primary phases.

Getting a correct product is the main target, with an estimated term and controlled and reduced costs. Working with a complex product within a context in design and manufacturing in a company in a highly competitive market, involves the problem domain as a key issue.

In this paper, the development of concurrent engineering is discussed in various industrial sectors, complex sectors with high competence, that require tools and a vision aimed towards the optimization of design and development of the products that are carried out in these industrial sectors.

***Keywords*—** Engineering, concurrent, industry, product, process.

I. INTRODUCTION

Concurrent engineering can be defined as a systematic approach for simultaneous integrated design of a product and related processes, including manufacturing and other support functions [1]- [3].

Concurrent engineering requires that products, processes, facilities, customer service, maintenance, and vendors are involved with the project in the first stages.

The fundamental concepts of concurrent engineering have been evolving over the years and sits bases in project management. The main objective is to get the right product at the estimated time, with reduced costs by providing the right information, personnel, materials and equipment from the most appropriate sources, who and where needed.

Concurrent engineering is a management philosophy and not limited to manufacturing companies. It is a systematic and simultaneous focus on the development of a product or process, educating all people should be involved in the first place.

The production of current company has become a matter of effective and efficient application of information technology and knowledge engineering. On the one hand, this will increase the competitiveness of a company in terms of quickly meet dynamic changes in the market. Concurrent engineering is performed to enhance the product design process with the intention of improving organizational performance.

Defining and agreeing to the product requirements is especially important when the design and manufacture of a system is part of the company [4]-[5]. To conduct a full concurrent engineering process, tools for design activities are needed. In practice, it is often difficult for companies to have a common understanding of what needs to be developed, and so the specifications contain ambiguities in the description of the product requirements.

It is key the domain of the problem in the context of a complex product designed and manufactured in a company and working in a highly competitive market.

II. RESULTS AND DISCUSSION

Until the late 1970s, the simplicity of the projects made it possible that the information of the project could be divided into a few operators and exchange of information were simple. With increasing complexity of projects, the work was divided in small workgroups, resulting in a lack of communication and a worse outcome [6], [7].

The new method of dividing labor camps did not work and a new approach was needed to optimize the process. With the help of "systems analysis" and the concept of "life cycle", together with the principles of project management and discipline, improvements began to be incorporated to the problem of the development cycle of the product / process [8]- [10].

Once the project is treated as a system with predefined elements and activities, the next significant improvement in project management is the recognition that the project should be managed by a "project team" that represents all significant participants (element / organization) identified by the system approach. These are the people who run the detailed planning, organization and control of the project [11], [12].

The documentation hitherto known on concurrent engineering has been collected and documented recently by the Institute for Defense Analyses (IDA) [13], [14],

introducing bellow the general areas covered by concurrent engineering:

1) *The dependence of the multifunctional teams to integrate the designs of a product and its manufacturing and support processes;*
2) *The use of computer-aided design, engineering and manufacturing methods (CAD / CAE / CAM) to support the integration of design through products and process models and databases;*
3) *The use of a variety of methods of analysis to optimize the design of a product and its manufacturing and support processes.*

A. Model development

AR Young proposes some methods of application to product design that follow a sequence of methodology in a systematic approach. Some of these models deal specifically with the design process itself, while others take into account the whole process of introducing a product, including manufacturing. The steps that are required during the development process are the following ones:

1) *-Identification of the need of the product*
2) *-Development of a document of specification product design*
3) *-Generation and evaluation of design concept*
4) *- Detailed Design of the most promising concepts*
5) *-Design and development of manufacturing plant*
6) *-Distribution and sale of the new product.*

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B. Application to aviation sector

A first example of the process of transformation towards the product development in an aerospace industry would be the one which is detailed next:

This transformation was achieved in two main stages: the first was to integrate the principles of concurrent engineering into an existing model of product development in an aerospace company. This stage included defining activities and their associated tools.

The second stage consisted of applying the model developed in a case of a study based on industrial research: an engine helicopter.

The three main results are detailed below:

First, an industrial case of adjusted transformation in the product development is introduced, where the adjustment of an existing model has been improved by incorporating concurrent engineering principles based on joint occurs. Second, the developed model is structured around a set of well-defined activities and associated tools that were previously scattered or redundant. Finally, the developed model was tested in an industrial project of a helicopter engine, tested to assess their value in improving the level of innovation and risk reduction.

The work was focused on early stages of system-level design [14], and the future work will be extended to the application of concurrent engineering based on sets at levels of subsystems and components.

A second example would be the one based on a framework for integrated development of space products. The framework is called “framework of overall vision” [15], as it provides the full suite of products, processes and organization of elements and their interactions since the beginning of the development process.

It uses systems engineering (IS) and concurrent engineering (IC) in an integrated manner, as part of the same framework. The framework extends the application of systems engineering process for lifecycle processes and their responsible organizations and it applies concurrent engineering at all levels of the hierarchical structure of products.

The "framework of overall vision" is supported by a method called “method of structured concurrent analysis ", that consists of the three processes of analysis: requirements analysis, functional analysis and physical analysis. These processes reflect most of the systems engineering process and they are simultaneously applied to the product, process and organizations. The outputs of the method are the requirements, functional attributes, physical attributes and interactions between all of them.

The third example would be based on the ESA (European Space Agency), which conducts assessing studies of pre-Phase-A as part of the definition of future space missions [16]. To evaluate the benefits of the approach of "simultaneous engineering" to these studies, a center for experimental design in ESA / ESTEC has been created and it is used to make an assessment of the mission of the Italian Space Agency CESAR (Central European Satellite for Advanced Research), suggesting a new approach to the evaluation and design of space missions.

C. Application to automotive sector

The importance and benefits of concurrent engineering in the automotive industry are remarkable. They work mainly the study in the areas of concurrent engineering tools, especially the tools of information technologies, such as the analysis systems of finite elements, computer-aided design and expert systems. The use of

concurrent engineering techniques is mainly applied in the development of an automotive engine and transmission, the chassis and the body [17].

In the past, the main processes in the introduction of a new vehicle on the market were developed by great manufacturers, or OEMs (OEM: Original Equipment Manufacturers), and especially the research of concurrent engineering (IC) was based on relevant publications for these manufacturers. Nowadays, the situation has changed worldwide. Great companies outsource lot of engineering work to suppliers. This outsourcing is justified by lower costs and higher quality and, at the same time, each company can use its resources in the areas where they have the technical expertise.

The actions of human resources, organization and technology improve quality in product development by improving communication and cooperation between actors. Although the importance of human resources policy is recognized, the implementation is not high [18-19].

However, most providers are still in motion "builds and breaks" [20]. The cost of introducing a new discipline as concurrent engineering and adopting new technologies such as computer-aided engineering (CAE) is substantial, as this cost is added to the operating costs and is only justifiable if it enables the development of products of higher quality in less time and with fewer people.

Many companies seek a design process that produces a high-quality product quickly and efficiently. However it is interesting to analyze product design of Toyota Motor Corporation [21] and its system development. The concurrent or simultaneous engineering principles applied to the whole (SBCE) of Toyota lead to extremely effective systems of product development. There are three broad principles that guide Toyota in the decision making in the design, each one with three different approaches to the realization of the principle.

Principle 1: Draw a map of the area of design - define feasible regions, explore trade-offs (demanding objectives towards getting others) designing multiple alternatives, and communicate the possibilities.

Principle 2: Integrate by Intersection - look feasible games intersections, impose minimal restrictions and locate the conceptual robustness; Principle 3: Establish the feasibility before Commitment - close games gradually increasing detail, remaining within games once engaged, and the control by uncertainty directive indoors of the process.

Another example of application of concurrent engineering is the one happened in the greatest US automotive company. The organizational and technological changes had to implement concurrent engineering. The desire to reduce product development time was the driving factor in a strategy designed to increase sales and market share [22]. The company was successful in reducing time to market ("time to market") that was shortened one year in its first newly designed vehicle, mainly by focusing on product, focused platform equipment that allowed an early integration of the manufacturing personnel in the development of process and product. Although technology played an important role in this transformation, organizational and human resources changes were the main facilitators.

D. Application to naval sector

Shipbuilding is a growing market with global competition and narrow profit margins. Concurrent engineering is not currently prevailing within the shipbuilding industry and yet is a technique that has been very successful in other industries. A methodology has been developed to help with the design in the leisure shipbuilding industry. The importance of a concurrent engineering environment in shipbuilding focuses on structural and production subsystems in an attempt to improve the design for production [23].

An example of application is the design of the vessel and support pieces and the manufacturing process [24-25]. A concurrent engineering solution was proposed for the design and development of a molten steel alloy low carbon steel heavy duty applicable to the structure. The yield strength and tensile strength steel wing designed steel were 480 and 600 MPa, respectively. The optimal structural design of the supports for offshore structures was evaluated using the commercial software ANSYS. The possibility of replacing a set of conventional supports for a single support was verified. The smelting process was simulated using the MAGMASOFT commercial software, and a smelting manufacturing process was designed for the proposed support. Thus, it was possible to reduce the size and weight by approximately 30% and 50%, respectively, compared with the conventional type of support.

III. CONCLUSIONS

Concurrent engineering requires that all stakeholders involved in the project participate since the beginning of the first phase. The main objective is to get the right product at the estimated time and with reduced costs. The domain of the problem is important in the context of a complex product designed and manufactured in a company and working in a highly competitive market.

Defining and agreeing to the product requirements is especially important when the design and manufacture of a system is part of the company as aeronautical, automotive and naval industrial sectors that because of complexity and competition require tools and approaches that allow an optimization in the design and the development of their products.

It is difficult for companies to have a common understanding of what needs to be developed, and so the specifications contain ambiguities in the description of the product requirements.

It is key the domain of the problem in the context of a complex product designed and manufactured in a company and working in a highly competitive market.

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