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INTEGRATED PRODUCT DEVELOPMENT

Alina Mihaela NEACSU, Corneliu NEAGU, Madalin CATANA, Mihaela Elena LUPEANU
University POLITEHNICA of Bucharest, Romania, alina_neacsu_10@yahoo.com, necor_upb@yahoo.com, mg_catana@yahoo.com, mihaela.lupeanu@yahoo.com, http://www.pub.ro/

Abstract: *This paper presents the concurrent engineering approach regarding product development. Methods such as Concurrent Engineering (CE) and Concurrent Product/Process Development (CPPD) were introduced to achieve shorter time-to-market by gathering all of the involved departments at the initial phase of the process. The early collaboration ensures better communication and planning, thus avoiding time consuming redesigning. The collaborative efforts are characterized by cross-functional teams, strong customer focus and use of visualization tools. The paper also presents the Quality Function Deployment (QFD) methodology used in concurrent product/process development.*

Keywords: Concurrent Engineering, Product development, Quality Function Deployment, Time-to-Market, Product Life Cycle

INTRODUCTION

World class product performance, cost, quality and reliability are "givens" in the global marketplace. Time-to-market and development productivity are the key measures of a development organization today. Only the fastest, most productive and best value global producers can achieve market leadership [2].

Concurrent Engineering (CE) and Concurrent Product/Process Development (CPPD) have as major goals minimizing the product life cycle, decreasing production cost, maximizing product quality and team work.

Process change studies and reports do not automatically affect change when published. Tools alone do not instantly improve time-to-market when they are turned on. There are no quick fixes or shortcuts to world-class product performance, cost structures, quality levels and competitive time-to-market. The elements of people, tools and environment must be considered within a single frame work. An integrated approach to manage change and leverage technology is required. CPPD concurrently addresses development process change, technology deployment and infrastructure implementation [2].

Quality Function Deployment (QFD) methods and software are used to convert the "voice of the customer" into predictable and measurable product specifications and requirements, within the CPPD methodology and the CE approach.

CONCURRENT ENGINEERING (CE)

Concurrent engineering may be described as the simultaneous, interactive and interdisciplinary involvement of people belonging to diverse backgrounds including design, manufacturing and field support working together to reduce the product development cycle while ensuring factors such as reliability, performance, quality, and support responsiveness [3].

Past experience indicates that there are many benefits of concurrent engineering and integrated product development, including 65% to 90% fewer engineering changes, 30% to 70% less development time, 200% to 600% higher quality, 20% to 110% higher white-collar productivity and 20% to 90% less time to market [6, 8].

CE has been around in one form or another for a very long time but its modern form may be attributed to the 1980s when the Ford Motor Company practiced the team, or concurrent engineering, approach in the design and development of its Taurus model [5]. In 1982 the Defense Advanced Research Projects Agency (DARPA) initiated a project to develop ways and means to improve concurrency in the design process and in 1987 the final results of the study were released [9].

The term *concurrent engineering* was coined by the Institute for Defense Analyses in 1986. The following year DARPA formed a working group composed of experts from government, industry and academia to evaluate the implications of simultaneous engineering for defense sourcing [4]. The group supported the concept of *simultaneous engineering* but rechristened it to *concurrent engineering*.

By the end of 1991 the U.S. government had allocated around $60 million under the auspices of DARPA initiative for developing current engineering tools and other areas. The introduction of CE to industrial sectors such as defense, aerospace and automobile acted as a trigger at the beginning of the industrial supply chain and suppliers and subcontractors played an instrumental role in rapidly spreading its use [1].

IMPORTANCE OF CONCURRENT ENGINEERING

In traditional engineering a relatively short time is spent defining the product. Traditionally, the development of a product has been seen as a cycle of plan-does-check-act-(adjust). Concurrent engineering is a process in which technical and non technical disciplines such as engineering, marketing and accounting are reunited to work interactively to conceive, approve, develop and implement product programs that meet predetermined objectives. Always focusing on satisfying the customer, these representatives work together in defining the product to be manufactured.

The major objectives of CE are:

- *enhance product quality*;
- *reduce product development cost*;
- *reduce manufacturing cost*;
- *reduce marketing time*;
- *improve manufactured products competitiveness;*
- *reduce cost of testing;*
- *increase profit margins*
- *reduce service cost* [1].

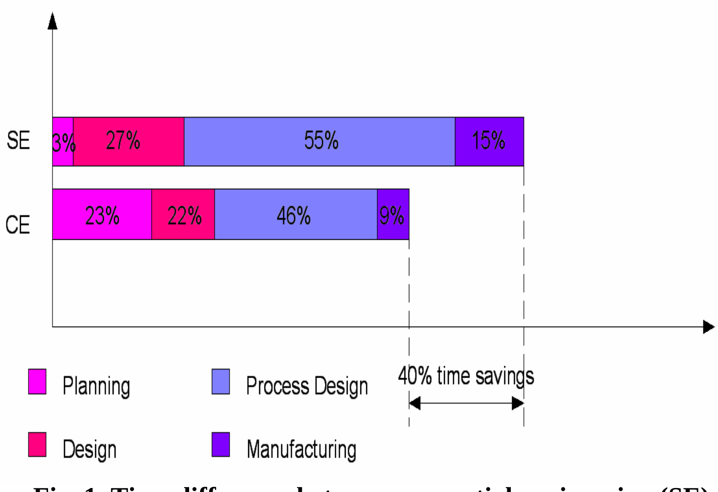

Fig. 1. Time difference between sequential engineering (SE) and concurrent engineering (CE) [4]

The CE process can be described through the following characteristics:

- *customer focus and involvement;*
- *early and continual involvement of suppliers in the design process;*
- *cross-functional, self-directed, empowered teams;*
- *incremental sharing and use of information;*
- *life-cycle focus;*
- *systematic and integrated approach;*
- *concurrent (parallel) design teams;*
- *early use of X (DFX) tools;*
- *use of modern tools as CAE, CAD, CAM, finite element analysis etc.;*
- *continuous improvement of all processes* [4].

All of these ingredients may help to reduce development time (see Fig. 1). Early customer participation can lead to less time spent on support and service, thus making more room for new projects. Bringing in the suppliers will reveal important aspects of the needed components, and the use of visualization tools minimizes the time spent on reaching a commune understanding of the product features [5].

Many methodologies and techniques can be used in the concurrent engineering process, including quality loss function, quality function deployment (QFD), design for manufacturing (DFM), Pugh process, design stress analysis (DSA), Taguchi’s robust design approach, rapid prototyping (RP), customer focused design (CFD), benchmarking and competitive analysis, and Ishikawa’s seven tools (i.e., Pareto diagram, cause-and-effect diagram, histogram, binomial probability paper, control charts, scatter diagram, and check sheets) [1].

The paper will focus later on upon the quality function deployment (QFD) methodology.

CONCURRENT PRODUCT/PROCESS DEVELOPMENT (CPPD)

CPPD is a methodology which determines related customer needs, makes competitive assessments and converts the "voice of the customer" into predictable and measurable product specifications and requirements using QFD methods and software [2]. Multiple product and process alternatives are evaluated and defined using computer simulation capabilities.

In a CPPD program the product development team does extensive manufacturing and predictive cost "what-ifs" analyses. Engineers focus on design for manufacturing, design for assembly, design for quality and design for cost. Managers use business models, decision tables and decision support systems to select market, product, manufacturing and business strategies that are "optimized" for their global competitive environment [2].

CPPD methods and capabilities are applied to improve the manufacturing approach, reduce the costs of engineering changes, lower total product cost and shorten time to market.

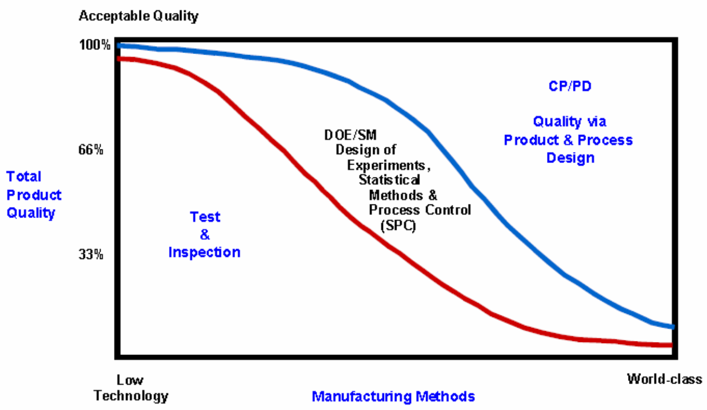

Fig. 2. Methods to achieve total product quality [2]

The level of technology and cost of total quality are key factors when assessing the manufacturing approach used to achieve total product quality. The level of technology examines the extent to which technical tools and methods are applied to the product development process and the cost of total quality evaluates costs associated with all phases of the product development and manufacturing operations (see Fig. 2).

The cost to achieve total product quality involves all product development and manufacturing phases and can be evaluated in four categories:

1. *product development costs*, such as design of experiments, durability left tests, etc.;
2. *manufacturing planning and engineering cost to develop systems for incoming inspection*, in process gauging, statistical process control, final product run-off testing, etc.;
3. *manufacturing operations cost after the product is released to production, to conduct and control quality systems;*
4. *field warranty and product recall costs* [2].

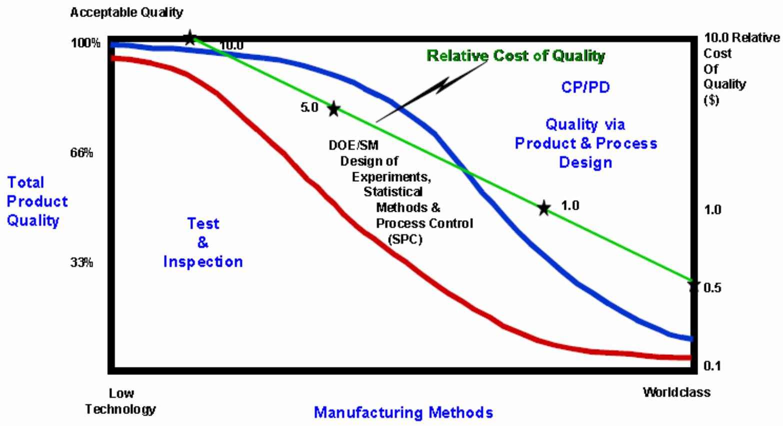

Fig. 3. Relative cost of quality [2]

One of the objectives of most CPPD programs is to reduce costs to achieve total product quality. These reductions are achieved by designing both products and processes for total quality and production control without heavy reliance on statistical or manual inspection methods (see Fig. 3) [2, 5].

Conventional design-build-test is expensive and time consuming. The objectives of CPPD are to reduce cost, save time and create opportunities for quality by eliminating engineering changes made after design release.

A major CPPD strategy is to evaluate multiple product and manufacturing process alternatives at the earliest stages of development using computer simulations. When multiple product and process alternatives are evaluated concurrently with "what-if" market and business models, better product and process decisions can be made [2].

When talking about total product cost it is estimated that 75% or more of the product's cost is "locked-in" when the first layouts are developed during the concept design phase. Internal cost reduction programs and supplier cost reduction programs "squeeze and squeeze" on the remaining 25% or less, but very little real savings can be achieved after a product concept is selected [2, 5].

Using integrated target setting, simulation and business modeling, teams evaluate multiple product and process alternatives, compare relative product and manufacturing costs of these alternatives (i.e., material costs, capital investment, amortization costs, etc.) and evaluate buy versus make trade-offs [2].

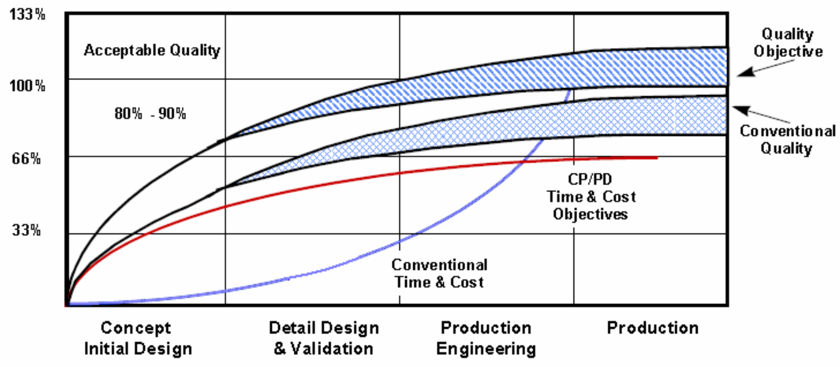

Fig. 4. Product development cost and quality (CPPD vs. Conventional method) [2]

In the product development processes used by most industrial manufacturers, at the end of the concept phase, an estimated 50% or less of final product and process decisions, to achieve total product cost and quality, have been made (see Fig. 4). Only 5% to 7% of the total product and process development budget has been expended at this stage .

The objective of CPPD programs is to be 80% to 90% certain that the correct product concepts and the correct manufacturing and assembly strategies have been selected at concept initial design, by utilizing predictive analyses and simulation capabilities (see Fig. 4).

In order to achieve World-class costs and total product quality compared with the competition, product and related manufacturing process decisions must be influenced significantly by related product family mix and volumes before detail design begins [2].

From concept development to fully implemented production, time-to-market is the final economic driver strategic. Reduced time-to-market is strategic, regardless of cost, and it determines weather the company remains viable in business tomorrow.

QUALITY FUNCTION DEPLOYMENT (QFD)

The Japanese view QFD as a philosophy which ensures high product quality in the design stage. The aim is to satisfy the customer by ensuring quality at each stage of the product development process.

QFD helps identify real customer requirements and translates these requirements into product features, engineering specifications, and finally, product details. The product can then be manufactured to satisfy the customer. QFD is an integrative process which links together customer needs, product and parts design requirements, process planning and manufacturing specifications during product development.

The two major components of QFD which are deployed into the design process are: *quality* and *function.* The "quality deployment" component brings the customer voice into the design process. It ensures design and production quality by identifying design targets and product and part specifications that are consistent with customer requirements. The "function deployment" component links different organizational functions and units into the design-to-manufacturing transition via the formation of design teams. Functional specialists are brought together to reduce miscommunication between design stages and functions. Since a team problem solving approach is appropriate for complex issues QFD is a suitable method for designing complex products [10].

THE QFD PROCESS

To understand the QFD process it is necessary to examine how it fits into the key elements of overall product development cycle: timing, performance evaluation and resource commitment.

The product development cycle can be divided into four phases (see Fig. 5).

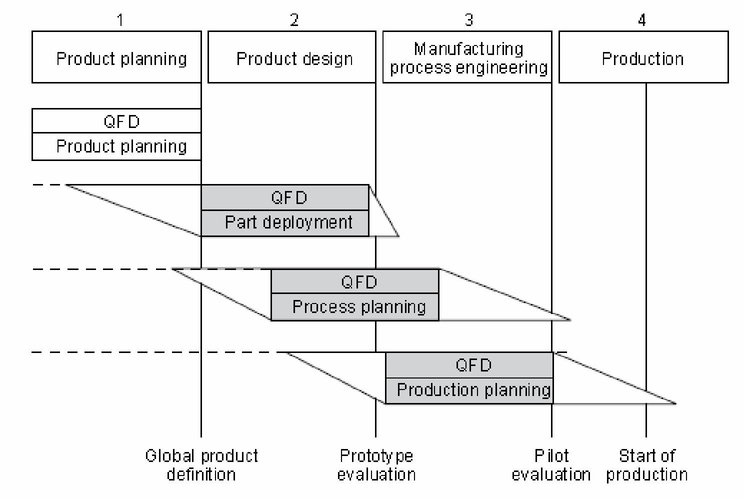

Fig. 5. The product development cycle and QFD-key events [10]

Phase one is *product concept planning* that starts with customer and market research and leads to a product plan: ideas, sketches, concept models and marketing plans.

The second phase is *product design*. The product and components specifications are developed from the product concept and protopypes are built and tested.

Manufacturing processes and production tools are designed in phase tree, based on the product and components specifications. Pilots runs for production procesess and tooling are made to ascertain product manufacturability levels and production standards [10].

Once problems in pilot runs have been resolved, the product enters production, phase four, after which it reaches the customer. At this point customer feedback serves as inputs for the next generation of products.

CONCLUSION

As the competition in today's world increases globally improving the competitiveness of manufactured products is vital.

The practice of concurrent engineering helps to generate savings, in terms of cost quality and time. Preemption of errors and early problem detection, creation of flexibility to accommodate changes and provision of the best overall input are other advantages that come from using the CE approach.

Concurrent product and process development methods and capabilities can provide significant results, such as:

- world-class standards for product quality;
- reduction of overall product costs;
- shortened time-to-market;
- reduced product and process development costs;
- significantly lowered overall product business risk [2].

QFD provides tangible benefits such as low product cost, high quality and shorter development lead times [11, 12]. Also engineering changes are fewer and take place earlier, resulting in reduced product lead times [10].

The effective use of CE, CPPD and QFD for integrated new products is strategic, and gives market advantages due to improved customer satisfaction.

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