THE IMPACT OF CAE ADVANCEMENT ON PRODUCT DEVELOPMENT PROCESS

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Abstract CAE is indispensable technology for today's advanced product development. However, prior studies do not clarify the impact of CAE on product development process and specifically its impact on the length of development period is disputable. We show that the significant role of CAE within current digital engineering framework and then CAE exploitation at earlier stage can affect positively to the length of product development. Our case suggests this benefit comes from the reduction of inefficient trial and error examination at design stage and the less frequent trouble occurred at prototyping stage.

Key words CAE, product development, up-front engineering

1 Introduction

Computer Aided Engineering (CAE)[1] is indispensable technology for today's advanced product development. Finite Element Method (FEM) which provides foundation for current CAE technology was originally proposed by Turner et al [16] in 1950's and has prevailed against alternative methods in practice because of its theoretical simplicity and simulation robustness. However, in the past, CAE exploitation required operators to have huge body of related knowledge and high-end computer so that only academic researches and/or analysis experts knew how to use it. In other words, it remained in the realm of "craftsmanship." The explosive popularization and performance advances of PC changed the circumstance surrounding the way CAE being utilized. This environmental change expanded the applications of CAE in product development and manufacturing phase and even designers can easily examine the feasibility of her ideas during conceptual planning (Kikuchi[5]). In combination with other digital tools such as CAD/CAM, CAE opened up the era of digital engineering (DE) which implies full and integral exploitation of the tools in all product related activities.

As we will see later, the rise of DE attracted researchers to investigate its impact within firms from various aspects. Among them, social scientists are mainly interested in the impact of DE as a whole not but each technology. Although we appreciate the significance of those researches, we would like to put emphasis on the necessity of examining the impact of each technology. For instance, CAD realizes virtual creation of parts making up a product and assembly and, more importantly, contributes to uniform management of the data, while CAE helps virtually analyzing a product. CAD supports information sharing without deterioration among firms but CAE does not in strict meaning. As such, the difference in characteristic may have different influence on product development process. Usually it cannot imagine that a firm introduces all DE tools at once so that careful examination of the effect each tool has may provide guidelines or requisites for firms at deciding the introduction of a tool and then making full exploitation of its potential. This paper concentrates on the impact of CAE on product development because we observe the sharp difference in the degree of CAE exploitation among firms. Specifically, the CAE impact on front-loading of product development process is analyzed.

The paper goes as follows. Section 2 reviews previous researches examining the impact of DE from social science perspective. Section 3 describes the idea of advanced CAE centered product development. Section 4 reports a case which analysis a firm turning business around successfully based on the advanced process. Section 5 concludes.

2 Literature Review

[1] Unless otherwise noted, we suppose 3D-CAD/CAE throughout the paper.

Curiously, most of prior studies analyzing the impact of DE on product development process in management research focused on that of CAD. These literatures in general suggested that the introduction of CAD facilitates front-loading of product development process. CAD makes pre-inspection of the product shape such as interference check at design stage possible. Therefore, product development personnel can reduce the frequency of design changes since they can estimate potential defects at earlier phase which is previously found at later prototyping stage (Alder[1], Robertson and Alder[11], Aoshima[2], Baba and Nobeoka[3], Takeda et al[14]).

Other researches (Fujimoto[4], Thomke and Fujimoto[15]) found, in addition to the above impact, that CAD has the effects of (1) reducing man-hour and period for development by simplifying information transfer process and facilitating concurrent activities, (2) increasing the possibility of innovative product development due to multi-dimensional information gathering and evaluation. Moreover, they insisted the benefit delivered by CAD largely depend on the organizational capability for utilizing CAD. Although many researches suggested the combining exploitation of CAD and CAE brings the synergy effect (Nobeoka[7], Fujimoto[4], Takeda[12], [13]), they don't fully examine the reason why the joint usage contributes to enhance the benefits.

Park[9], [10] is worth to be noted in detail since he sheds lights on the effect of CAE. Basically, he assumes CAE as a complimentary tool for CAD and then examines the effect of the joint exploitation on development efficiency and inter-organizational communication in Japanese automobile parts manufacturers. In Park[9], he mentioned that (1) the joint usage fostered inter-organizational communication leading to the rise in comprehensive product quality and (2) the inter-organizational communication took time longer than the time shortened development process so that actual development period became longer. Besides, he investigated the influence of implicit knowledge sharing among designers and analyzers realized by the joint exploitation on development performance. The result suggested that the joint usage helped new technology development and comprehensive product quality (Park[10]).

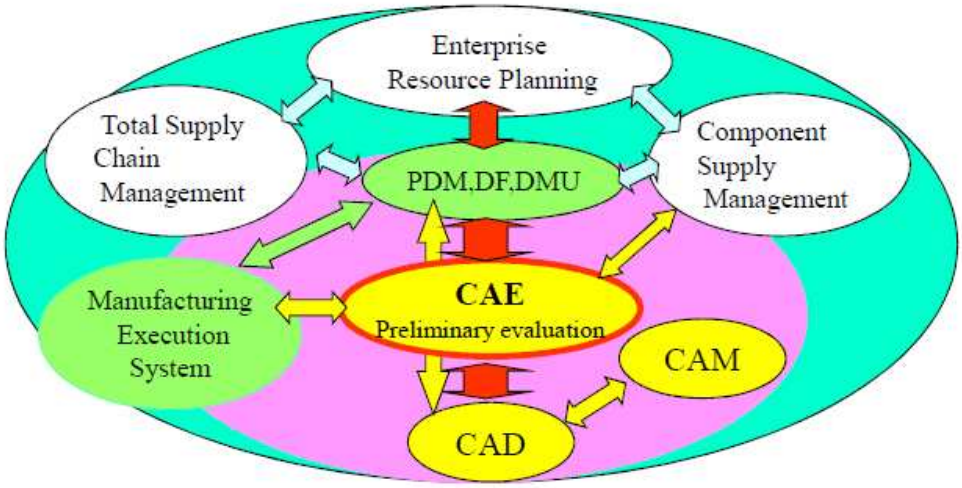
Contrary to the findings referred so far, researches and practices in engineering field such as ex Jack Lemmon, the founder of SDRC, explain advanced product development with fully CAE exploitation balances competing goals for faster development and improved quality. We intend to fill the gap exists between the both fields.

3. Analysis Centered Product development

With the prevalence of PC based CAE among manufacturing firms, CAE is no longer the exclusive tools for simulation experts and new dimension for CAE has been explored. This tendency became irresistible since the beginning of 21st century. Among them, Kojima and Kikuchi[6] suggested "first order analysis" with which designers can reflect simulation result to product design. Ohtomi[8] insisted that upstream product development process (product planning and design) determines roughly 80% of product life cycle cost so that the new CAE application ("first order analysis") at design stage to examine all possible cost accrued during PLC largely decides the product's future prospect. To put it differently, CAE seems to be a key to front-loading of problem solving activities in current digital engineering framework and thus the degree of knowledge integration in CAE defines the firm's capability as exhibit 1. On saying so, we assume CAE is the main value driver among various DE tools in current DE framework and, contrary to Park[9], CAD compliments value creation based on CAE exploitation.

Previous organization studies focusing on CAD better explains the impact of DE during the introductory phase of digital tools till the end of 20th century when the operational efficiency was the priority subject of engineering. However, current emphasis on analysis-led innovation needs CAE centered perspective examination of organizational product development capability. The main point here is how product development process takes in CAE technology and then makes the role of CAE transform within.

Exhibit 1 Concept of Analysis Centered Product Development



4. The Impact of Maximally CAE Exploitation on Product Development

This section describes how analysis centered product development affects firm's product development and eventually financial performance based on a case of a large Japanese machinery firm with the sales of some 140 billion JPY (consolidated base) in 2009 fiscal year.[2]

In the late 1990's, the firm as most of Japanese firms experienced the downturn in both sales and profit due to the bubble economy burst and thus considered the necessity to review the operating process for regaining profitability. After the throughout investigation, the firms extracted the problems concerning the product development such as delay of product development, increasing cost, inadequate marketing research and frequent troubles at prototyping stage. Among these problems, the development delay problem was serious. On average, actual development period took 1.7 times longer than projected.

Longer development period negatively affected the financial performance to large extent since it caused not only increase in development cost but also delayed market introduction of new product and thus cutback of profitable opportunity. There were two major causes for the delay:

(1) Excessive time had been spent for preliminary review and thus drafting was delayed.

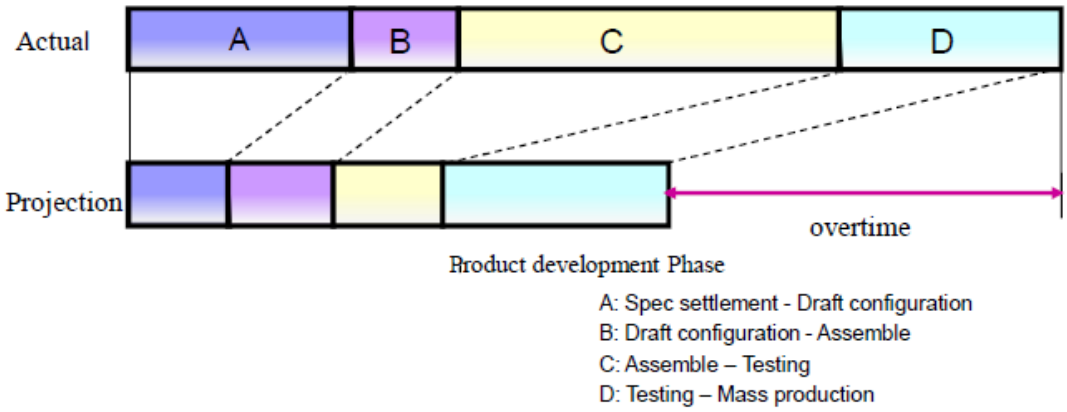
(2) Inadequate design review caused frequent trouble during prototyping stage.

Exhibit 2 depicts the result of the process analysis at that time. The examination divided the process into four phases. For instance, the period from specification settlement to draft configuration (A. in exhibit 2) was assumed to be the first. As the exhibit shows, the first and the

[2] The context of this section is based on our interview and the materials provided by the company. The exhibits owes to the lecture materials exclusively processed by an ex-personnel of the company for our institution.

third phases mainly caused the delay. The first phase delay related to (1) just above, while the third to (2). The firms eventually found excessive trial and error based review process was undergone in the phases and decided to overcome the problem with extensive DE utilization.

Exhibit 2 Comparison of Projected and Actual Product Development Period of the Firm



The firm already employed CAD and CAE at that time but the extent to which the technology was applied seemed to be limited. The management then decided to set up a strategic project which developed a product based on the advanced DE framework in support of outside CAE experts. The application of CAE in this project did not restrict to simulation as a substitute of experiment or designers utilization. The firm completely changed the product development process and went further to use CAE even at the concept design stage. The firm successfully optimized all the elements at the earlier stage and consequently realized to balance the notable performance improvement and the reduction of development period by half. Market favorably accepted the new product. Comparing to the prior product, the new product achieved 73% increase in sales volume, 67% in sales amount respectively and, as a result, the firm gained 50% market share.

This short case suggests, contrary to Park[9], [10], CAE does not necessarily caused delay in product development. The exploitation at the very early stage in the process seems to determine the CAE effect on development period. For that purpose, all the relevant information must be stored and reflected in early CAE examination.

5. Conclusion

This paper briefly explains the current DE framework and the significant role of CAE within. We then insist the necessity of research focusing on CAE to understand the benefits of and the obstacles for advanced product development since CAE can contribute to reduction in product development as the case dictates against the previous research. We don't say CAE centered product development is "evangel" for all manufacturing firms across the world. It is fair to say some conditions must be satisfied and maintenance for the full exploitation. Otherwise, huge investment in CAE soon becomes dead stock.

To clarify the factors affecting the CAE benefit on product development remains unsolved and is rendered to future research.

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