Researches Using Integrated Computer-Aided Systems for Automobile Development

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In Kookmin University, research on shortening the lead-time in developing automobiles by integrating computer-aided systems and applying virtual engineering is being carried out. To support this research, a laboratory consisting of various computer-aided systems was constructed. A sample project, that of developing an R/C car (radio controlled car), was carried out for research into how to integrate computer-aided systems efficiently for concurrent engineering and how to apply the technology of virtual engineering.

Keywords: CAx, Concurrent Engineering, Virtual Engineering, Digital Mockup (DMU), PDM

1. INTRODUCTION

Manufacturing companies are trying to shorten the lead-time in developing products that satisfy customers' needs [1,2]. Automobile companies also want to develop new cars in 18 months, as Chrysler and Toyota have already shown is possible. There are many computer-aided systems such as CAD, CAE, CAM, PDM and DMU systems that are used in a company. In order to shorten the lead-time in developing automobiles, it is essential to integrate the computer-aided systems, which enable concurrent engineering.

In Kookmin University, research on shortening the lead-time in developing automobiles by integrating computer-aided systems and applying virtual engineering are being performed [3,4,5,6]. To support this research, a laboratory consisting of various computer-aided systems was constructed. In the laboratory, 47 copies of Catia^{TM} were installed as a CAD system, which plays the most important role in design. We installed TeamPDM^{TM} of Dassault Systems as a PDM (product data management) system, VisMockup^{TM} of EAI as a DMU (digital mockup) system and Z-master^{TM} of CubicTek as a CAM system. As CAE systems, ADAMS^{TM}, DFMA^{TM}, CFD-ACE+^{TM}, Star CD^{TM}, Ansys^{TM}, Nastran^{TM}, HyperMesh^{TM}, PamCrash^{TM} and DADS^{TM} were used. A sample project, that of developing an R/C car (radio controlled car), was carried out for research into how to integrate computer-aided systems efficiently for concurrent engineering and how to apply the technology of virtual engineering.

The following research was performed in this project.

First of all, we established a development process under integrated computer-aided systems for concurrent engineering. We defined the development process using CAD, CAE, CAM, PDM and DMU systems and progressed through the project developing an R/C car based on that process.

Second, we tried to apply the technology of virtual engineering. Our research was particularly focused on the application of a DMU. During the development process, various DMUs are generated from a CAD model according to their usage. The application of a DMU for visualization was well formalized compared with other applications. A DMU for visualization was tightly integrated with a PDM system, which enabled engineers to use the DMU data of any hierarchical level in the product structure at any place. It was used in the design review, collaborative design and the publication of various manuals. The application of a DMU for virtual testing was not well defined and is still under research. The results of this research are expected to be valuable in saving a great deal of time and cost when companies develop automobiles. Generally, automotive companies spend a lot of time and cost on many tests such as strength tests, durability tests, ride/handling tests and crash/safe tests. Although the CAE activities were performed manually in this project, we were interested in formalizing the process of various virtual tests using DMUs in the corresponding virtual test laboratories.

Finally, one of the purposes of this project was to train graduate students to utilize the integrated computer systems efficiently. They used various computer systems to accomplish the term project, the development of an R/C car. During the course, they gained experience of many kinds of computer-aided systems and the whole process of developing a product using computer-aided systems.

2. PLANNING COMPUTER SYSTEMS FOR VIRTUAL ENGINEERING

In order to apply virtual engineering technology in developing a product, we should integrate various kinds of computer-aided systems and customize a lot of modules that have not been formulized. We planned to construct the related system as shown in Fig. 1.

The lower part of Fig. 1 shows the utilization of computer-aided systems in developing a product, which is easy to apply. Engineers design a product by using solid systems such as Catia^{TM}, analyze the product by using CAE systems with the solid data generated in solid systems, and generate NC data from the solid data. Although there are some interface problems, it is possible to use such systems seamlessly. Prototypes are produced after some activities such as manufacturing, purchasing and assembly. As some errors occur in manufacturing, purchasing, assembling and testing, the design is modified. If necessary, the same process is applied to the second design, such as manufacturing, purchasing, assembly and testing.

The upper part of Fig. 1 represents the process to virtual engineering based on the current computer systems explained previously. The prototypes generated on the computer systems are called digital mockups (DMU) [7] in contrast to the physical prototypes. The data generated in the solid modeling system is generic DMU [5], which will be used throughout the whole virtual process, that is, virtual design, virtual manufacturing and virtual testing. In contrast to the generic DMU, the DMUs used in the specific areas such as virtual design, virtual manufacturing and virtual testing are called application-based DMUs [5]. The application-based DMUs retrieve data from the generic DMU and add more information for their engineering activities.

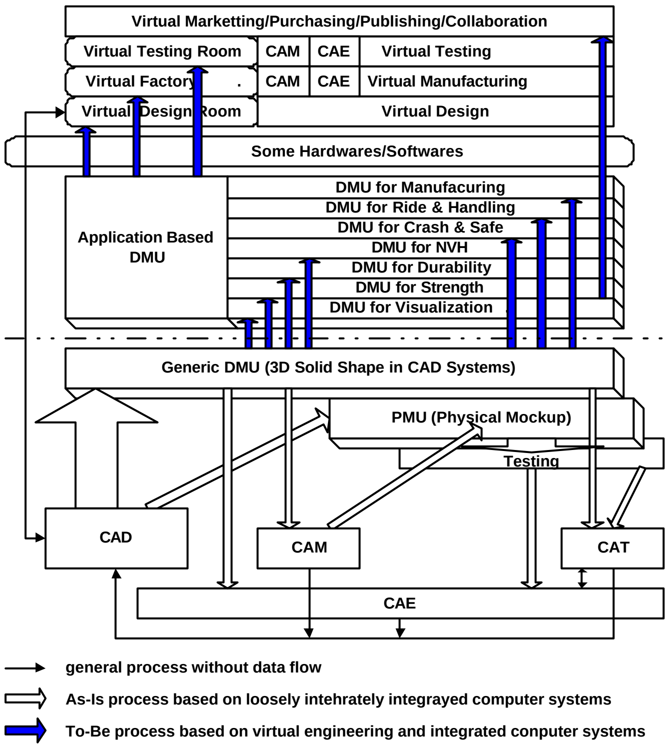


Fig. 1. System architecture using various computer-aided systems and virtual engineering technology [5]

Among application-based DMUs, a DMU for visualization is well defined for use in concurrent engineering. It retrieves simple facet data from a generic DMU (solid model data). It can be used easily with a simple viewer in all departments. The infrastructures of the computer systems shown in Fig. 1 are a PDM system and the Internet.

3. CONSTRUCTION OF COMPUTER SYSTEMS IN A LABORATORY

In order to verify the plan shown in Fig. 1, a laboratory consisting of various computer-aided systems was constructed as shown in Fig. 2. Some basic systems such as CAD, CAM, PDM and DMU systems were installed in the laboratory. Some CAE systems such as Nastran™, ADAMS™, DFMA™ and CFD-ACE+™ were also installed in that laboratory. In addition to those CAE systems, a lot of CAE systems installed in other laboratories were also used.

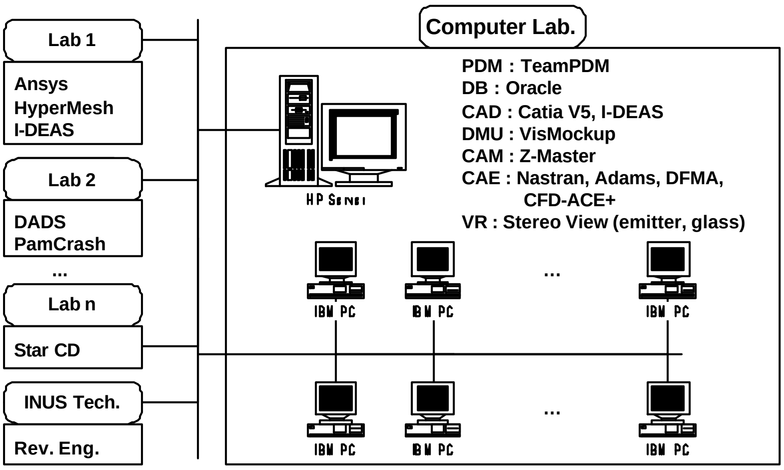


Fig. 2. System layout constructed for researches on CE & VE

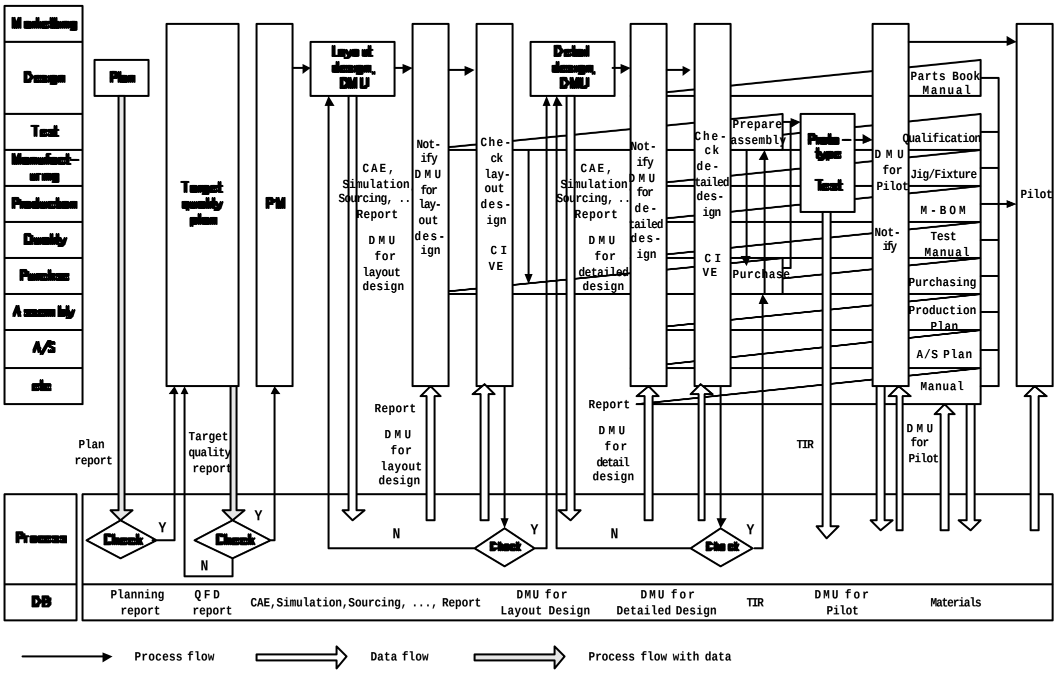


Fig. 3. Development process supporting CE using PDM and DMU systems [8]

4. DEVELOPMENT PROCESS FOR CONCURRENT ENGINEERING

A development process proposed by Lee [8] was used in the project as shown in Fig. 3, which utilizes PDM and DMU systems for concurrent engineering.

5. TARGET PROJECT: DEVELOPMENT OF AN R/C CAR (RADIO CONTROLLED CAR)

A target project developing an R/C car was accomplished at the constructed laboratory according to the process given in Fig. 3. The purpose of this target project was to simulate a development process under integrated computer systems and give some intuitions to graduate students and researchers on VE.

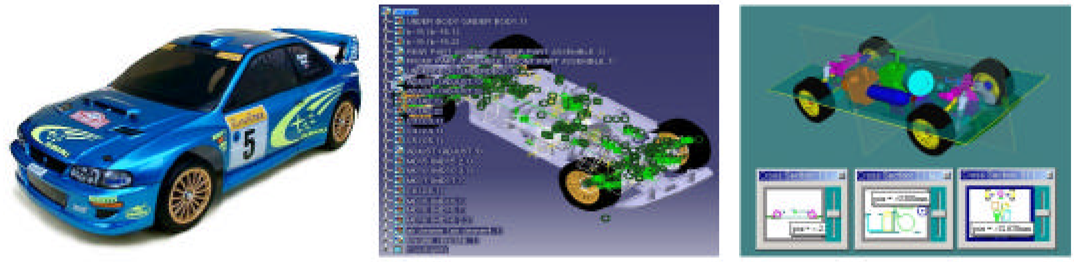
5.1 PLANNING

A project to develop an R/C car was planned by using the QFD (Quality Function Deployment) technology [1,2]. Some requirements were converted as numeric target values that support the engineer's decision. The QFD tables prepared in planning were used and modified until the project was finished.

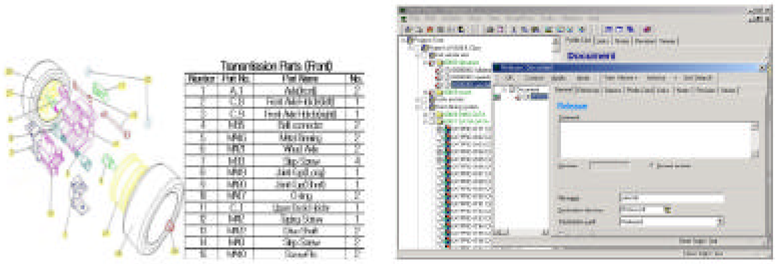
5.2 DESIGN

In the design department, engineers used Catia as design system. The solid data were converted as visualization DMU data and stored on a PDM system. DMU data support concurrent engineering by making it easy for engineers to inquire the solid shape of a part or an assembly.

Fig. 4 shows some design activities in developing an R/C car. Fig. 4 (a) shows the shape of a target R/C car, Fig. 4 (b) is a solid shape designed in Catia, Fig. 4 (c) shows the shape on DMU system, Fig. 4 (d) shows a parts list generated by using the DMU, and Fig. 4 (e) is a PDM system that manages all data needed for development.



(a) (b) (c)



(d) (e)

Fig. 4. Design activities

5.3 ANALYSIS

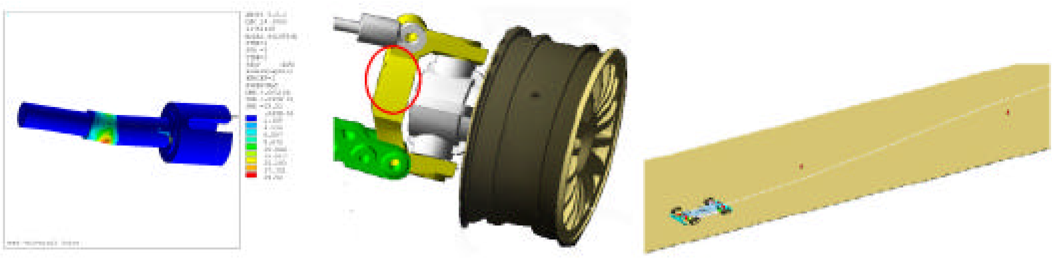
Various CAE systems shown in Fig. 2 were used to analyze the designed product. CAE analysis is very important for achieving virtual testing. It should be performed from layout design to testing. In this project, we applied CAE activities manually throughout the whole development process. If the interface between the CAD system and the CAE system is formalized, virtual testing will be possible [1].

Fig. 5 (a) shows the result of strength analysis by using Ansys. Strength analysis is the most basic work out of all the CAE activities. Fig. 5 (b) is the result of dynamic analysis by ADAMS^{TM}. The red circle means that there is interference between two parts during the steering motion. Fig. 5 (c) shows the simulation of lane change. It shows the behavior of a car when it changes its lane. This technique can be enhanced to a pothole test and a virtual proving ground test with more research and work. Fig. 5 (d) shows the analysis of natural frequencies of under frame performed by HyperCam^{TM}. A vibration test also carried out for correlation between CAE analysis and a real test. Fig. 5 (e) shows a front crash analysis by PamCRASH^{TM}. Offset and oblique crash analyses were also performed. Fig. 5 (f) shows the result of CFD analysis performed by StarCD^{TM}, pressure distribution when the R/C car drives at the velocity of 50 km/h. The surface of the car body was achieved by laser-scanner. 3D meshes for CFD analysis are generated from the scanned surface.

From the results of CAE activities, some design changes were made. We replaced seven parts from the first prototype and made the second prototype, which showed better functions than the first one.

5.4 PRODUCTION AND POST SALES SERVICE

The engineers at the departments of production and post sales service reviewed the designed product carefully from the layout design and suggested some design-changes reflecting the views of production and post sales service. In the production department, they generated NC data from the solid data created in the design department. They also used the DMU in making a parts list and a maintenance book. M-BOM was created based on E-BOM stored in the PDM system.



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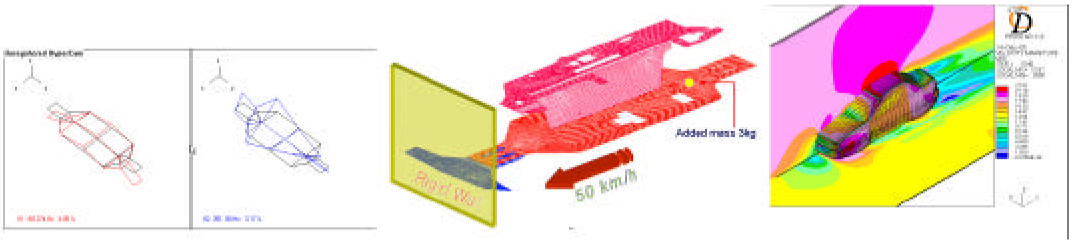

(d) (e) (f)

Fig. 5. Analysis activities

6. CONCLUSION

In this project, an R/C car was developed to simulate product development under integrated computer systems. The following research was carried out.

First, we established a development process under integrated computer systems, particularly the PDM and DMU systems. The target project progressed according to the defined process.

Second, during the course of the project, although the activities were restricted to the integration of various computer systems, how to apply the technology of virtual engineering was continuously considered, as the final goal of this project was to achieve the technology of virtual engineering. We tried to formalize the interface between the computer systems, which was thought to be a way toward virtual engineering.

Finally, the educational aspect of this project was emphasized. As the project progressed, graduate students became accustomed to the computer systems and the technology of virtual engineering.

Recently, manufacturers have been trying to introduce computer-aided systems and IT systems in developing products. In the future, we will do research into more the efficient methods of how to apply computer-aided systems and IT systems in developing products. The sample project presented in this paper gave a strong intuition to the students and researchers who previously had no experience in integrated computer systems and IT systems.

7. ACKNOWLEDGEMENTS

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