Network Based Engineering Design Education

Kang-Soo Lee[1] and Sang Hun Lee[2]

[1] Hanbat National University, Daejeon, Korea
kslee@hanbat.ac.kr
[2] Kookmin University, Seoul, Korea
shlee@kookmin.ac.kr

Abstract. In graduate class, education on shortening the lead-time in designing and developing products by various computer-aided systems in a network and applying virtual engineering was carried out. To accomplish such a purpose, network based education about engineering design was applied. Some laboratories consisting of various computer-aided systems were constructed and connected by a network. A sample project to develop a radio controlled (R/C) was carried out in order to practice the design of a product based on network based technologies. While students were doing the sample project, they had experienced how to use various computer-aided systems efficiently in a network for concurrent engineering and how to apply the technology of virtual engineering.

1 Introduction

Manufacturing companies are trying to shorten the lead-time in developing products that satisfy customers' needs. [1, 2] They have many computer-aided systems such as a computer aided design (CAD) system, computer aided engineering (CAE) system, a computer aided manufacturing (CAM) system, a product data management (PDM) system and a digital mockup (DMU) system that will be more powerful if they are integrated by a network efficiently. In order to shorten the lead-time in developing a product, it is essential to integrate various computer-aided systems, which enables concurrent engineering. Therefore network based engineering design education is necessary to use various computer systems efficiently.

Some researches on shortening the lead-time in developing products by integrating computer-aided systems and applying virtual engineering are being performed. [3, 4] To do these kinds of researches, laboratories consisting of various computer-aided systems were constructed. The laboratories have 47 copies of Catia™ as a CAD system, which plays the most important role in design. We installed TeamPDM™ of Dassault Systems as a PDM system, VisMockup™ of EDS as a DMU system and Z-master™ of CubicTek as a CAM system. As CAE systems, ADAMS™, DFMA™, CFD-ACE+™, Star CD™, Ansys™, Nastran™, HyperMesh™, PamCrash™ and DADS™ were used. A sample project to develop a radio controlled (R/C) was carried out to practice the design of a product by network based technologies. While students were doing the sample project, they had experienced how to integrate computer-aided systems efficiently for concurrent engineering and how to apply the technology of virtual engineering.

The following researches were performed in this project.

First of all, we established a development process using a network for concurrent engineering. We defined the development process using CAD, CAE, CAM, PDM and DMU systems and did the project developing an R/C car based on that process.

R. Khosla et al. (Eds.): KES 2005, LNAI 3681, pp. 48–55, 2005.

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 were generated from a CAD model according to their application. The application of a DMU for visualization was well formulated 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. Generally, automotive companies spend a lot of time and cost to test strength, durability, riding/handling and crash/safety of a car. Although CAE activities were performed manually in this project, we were interested in formulating 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 many computer systems efficiently in a network. They used various computer systems to do the sample project, or, the development of an R/C car. In the project, they experienced many kinds of computer-aided systems and the whole process to develop a product using computer-aided systems in a network.

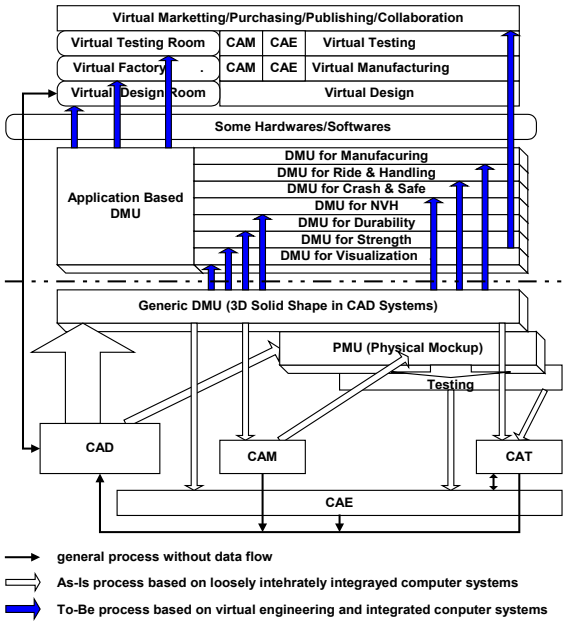

Fig. 1. System architecture for network based engineering design education

2 Computer Systems for Network Based Education

In order to apply network based technology in developing a product, we should integrate various kinds of computer-aided systems and customize many modules that have not been formulated. We constructed the computer systems based on 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™, 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. If some errors occur in manufacturing, purchasing, assembling and testing the product, the design will be modified. If necessary, the same process is applied to the second design, such as manufacturing, purchasing, assembling and testing.

The upper part of Fig. 1 represents the process of virtual engineering based on the current computer systems in a network explained previously. The prototypes generated on the computer systems are called digital mockups (DMUs) [5] in contrast to the physical prototypes. The data generated in the solid modeling system is a generic DMU, 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. The application-based DMUs retrieve data from the generic DMU and add more information for their engineering activities. Among application-based DMUs, a DMU for visualization is well defined to be used. It retrieves simple facet data from a solid model and adds some simple data on it. All members can check it easily with a simple viewer. The infrastructures of the computer systems shown in Fig. 1 are a PDM system and a network.

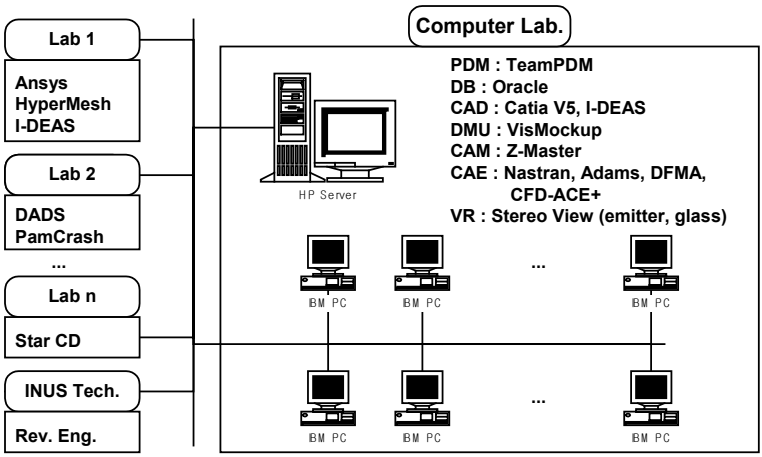

Fig. 2. System construction for network based engineering design education

3 Construction of Computer Systems in Laboratories

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

4 Development of a Remote Controlled (R/C) Car Using Network Based Method

A sample project to develop an R/C car was accomplished at the constructed laboratory according to the process [6] given in Fig. 3. The purpose of this project was to simulate a development process based on the proposed method and give some intuitions to graduate students about network based engineering design. This project consisted on some engineering activities such as planning, design, analysis, manufacturing and service.

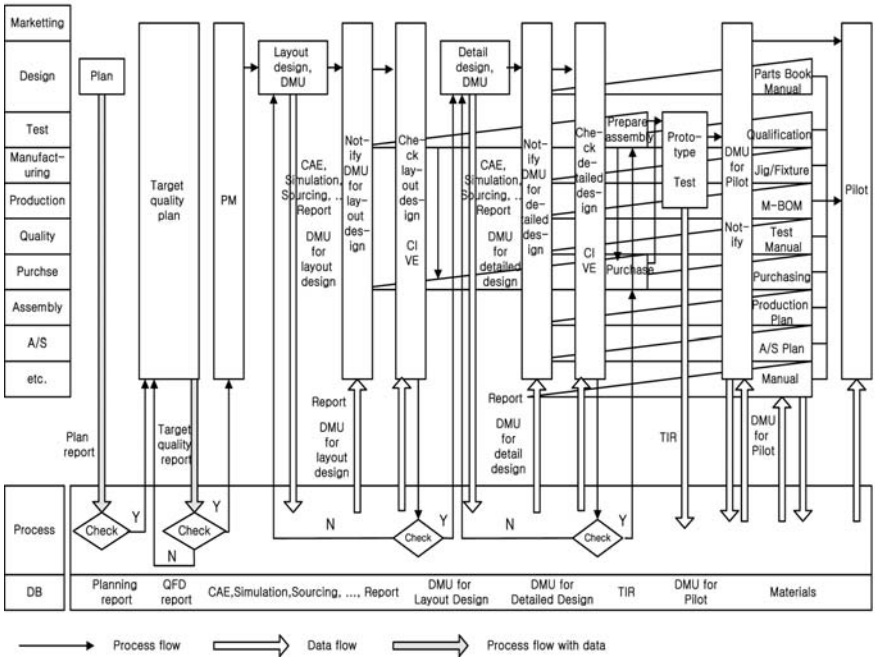

Fig. 3. Development process for concurrent engineering using networks

4.1 Planning

A project to develop an R/C car was planned by using the Quality Function Deployment (QFD) method. [1, 2, 7] Some customers' needs 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.

4.2 Design

In design stage, engineers used Catia™ as a design system. The solid data were converted as visualization DMU data and stored on the PDM system. DMU data helped concurrent engineering by making it easy for engineers to check 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 the R/C car to be designed, Fig. 4 (b) is a solid shape designed in Catia™, Fig. 4 (c) shows the shape on DMU system, and Fig. 4 (d) is a PDM system that manages all data needed in development.

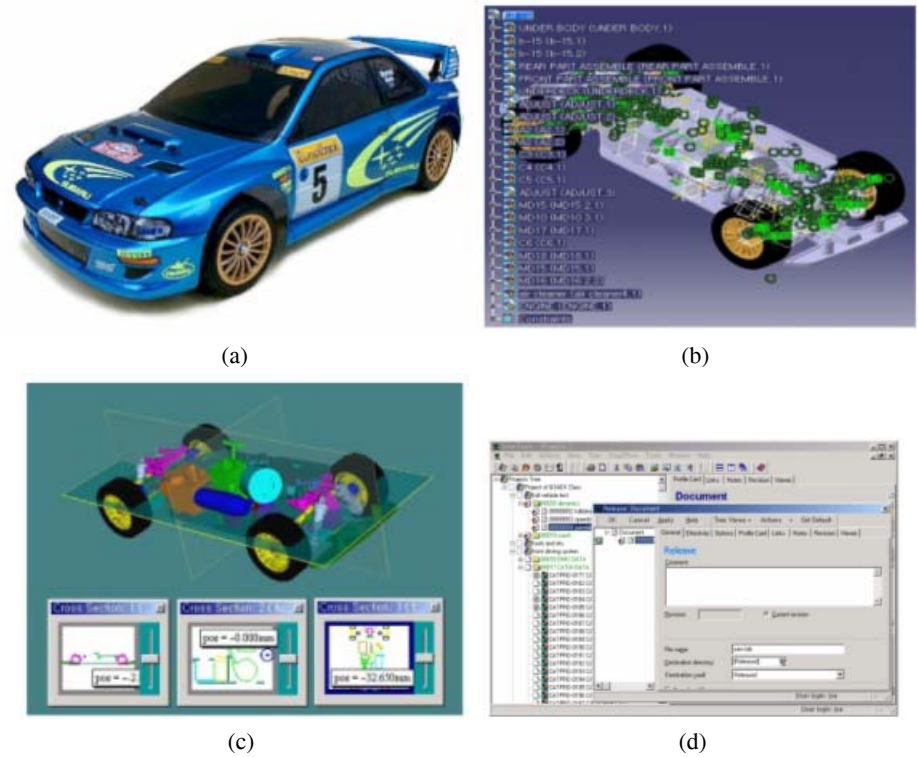

Fig. 4. Engineering design activities based on networks using various computer systems

4.3 Engineering Analysis

Various CAE systems shown in Fig. 2 were used to analyze the designed product. CAE analysis is very important for virtual testing. It should be performed from layout design to testing throughout all the development process. 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 formulated, 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™. 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 proving ground test with more research and work. Fig. 5 (d) shows the analysis of natural frequencies of under frame performed by HyperCam™.

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 reverse engineering technique with laser-scanner. 3D meshes for CFD analysis were 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 those of the first one.

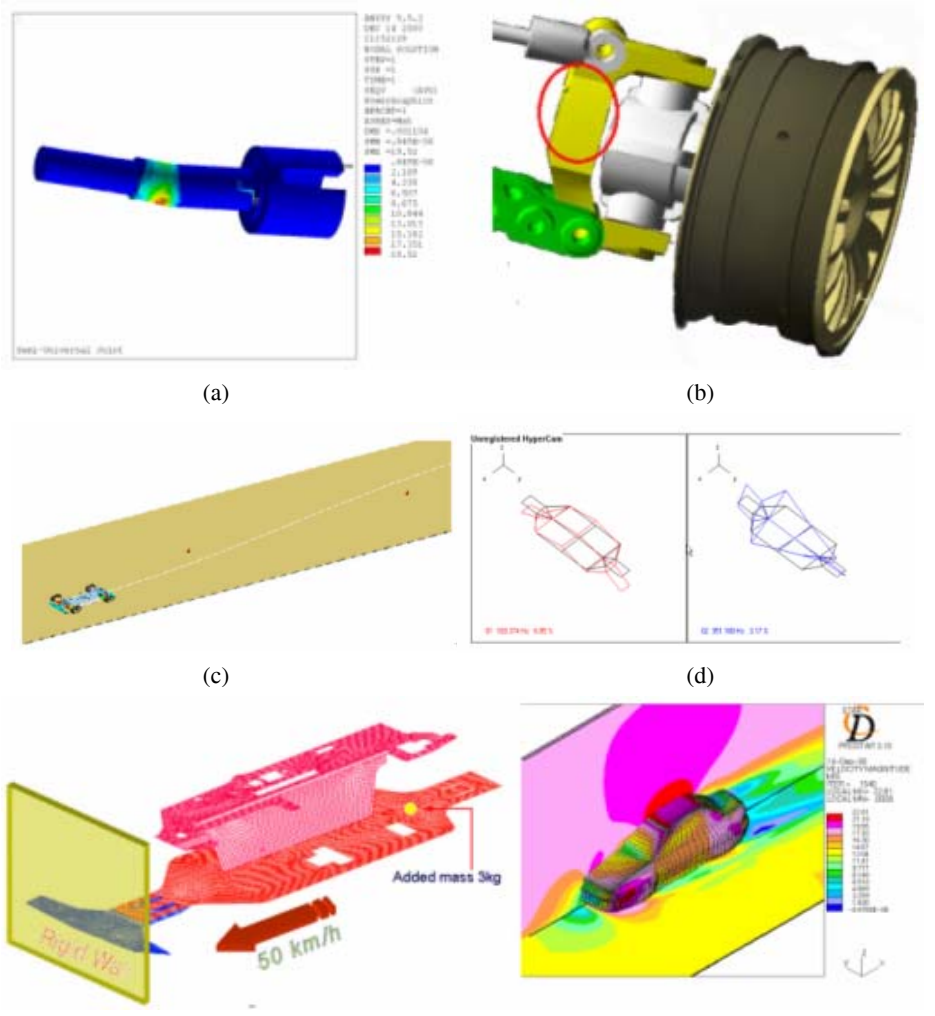

Fig. 5. Engineering analysis activities based on networks using various computer systems

4.4 Manufacturing and Service

Engineers at the departments of manufacturing and service reviewed the designed product carefully and suggested some design-changes reflecting the opinions of production and post sales service. In the manufacturing 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, manufacturing bill of materials (M-BOM) was created based on engineering bill of materials (E-BOM) stored in the PDM system.

5 Conclusion

In this project, an R/C car was developed to simulate product development based on the proposed method using various computer systems integrated in a network. The following researches were carried out.

First, we established a development process various computer systems integrated in a network, particularly the PDM and DMU systems. The sample project progressed according to the defined process.

Second, although some activities were performed manually, the students became to know how to apply the technology of virtual engineering in the design of a product. We tried to formulate the interface between 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 integrated in a network and the technology of virtual engineering.

Recently, manufacturers have been trying to introduce some computer-aided systems in developing products. In the future, we will do research into more the efficient methods of how to apply computer-aided systems using networks 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 various computer systems integrated in a network.

Acknowledgement

This work was supported by the Post-doctoral Fellowship Program of Korea Science and Engineering Foundation. (KOSEF)

References

1. Prasad, B.: Concurrent Engineering Fundamentals, Prentice Hall (1996)
2. Hartley, J. R.: Concurrent Engineering: Shortening Lead Times, Easing Quality, and Lowering Costs, Productivity Press (1998)
3. Heo, S.J.: Survey on the application of virtual engineering to automotive development, Proceedings of a symposium on automotive technology (1999) (in Korean)

4. Han, S.H. and et al.: Report on the technology used for shortening the lead-time in developing new cars (1998) (in Korean)
5. Lee, K.: Principles of CAD/CAM/CAE Systems, Addison Wesley (1999)
6. Lee, K.-S. and et al.: A case of digital mockup system implementation for improving product development process, Proceedings of 2000 Korean CAD/CAM Conference (2000) 247-252 (in Korean)
7. Hauser J.R., Clausing D.: The House of Quality, Harvard Business Review May-June (1988) 63-73