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INTEGRATION OF CAD AND CAE IN SME'S FOR PRODUCT DEVELOPMENT

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Abstract - Small manufacturing enterprises face a number of challenges when integrating computer aided design (CAD) tools and computer-aided engineering (CAE) tools into their design processes. One of the most significant challenges is interoperability across the wide range of commercial CAD and CAE tools. Although many of these tools support industry data standards and claim to be interoperable, the connection between them is not seamless. This paper summarizes studies of tool integration activities at one small manufacturer. The paper shows the enhancement of the product development process resulting from replacement of a two dimensional CAD system with a three-dimensional CAD system and creation of an in-house capability to perform finite element analysis (FEA), replacing analysis that had previously been outsourced. As a result of these experiences, the manufacturer learned that improved productivity and superior designs could be obtained by integrating analysis into the design process at the earlier stages of conceptual and preliminary design.

Keywords - *CAD; CAE; Product Development; FEA Tools; SME's*
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I. INTRODUCTION

A small manufacturing enterprise (SME) providing custom-designed, precision, electro-mechanical equipment to the industry was faced with increasing competition in a market. Maintaining market share required this SME to provide faster deliveries, lower prices, and enhanced product performance. This SME initiated a program to adopt advanced computer-aided design (CAD) and computer-aided engineering (CAE) tools to improve their design and engineering capability and achieve these business goals. This paper presents integration of 3D CAD and FEA tools on SME for product development in design and engineering process.

The insertion of the analysis tool into the design process is facilitated by the ability of advanced CAD tools to produce 3D representations of the product design, and by the ability of the FEA tool to accept product design information from the CAD tool. The integrated model provided automated verification of component interfaces, enabling the SME to identify and correct design errors during the design phase, rather than after the components were manufactured.

The SME addressed several challenges encountered during the creation and use of the integrated model. Due to the complexity of the product, the integrated model became quite large as the design progressed, creating difficulties in loading, updating, and storing the model. The SME developed a number of strategies to manage the size of the model. These strategies resulted in specific procedures defining effective ways to synthesize, organize, and utilize design data within the CAD tool.

The starting point of FEA is the creation of a 3D model of the product to be analyzed. The availability of a 3D model from the CAD tool offered the opportunity for the SME to transfer this model to the FEA tool. Although the FEA and CAD tools shared several common interface standards, the transfer of a 3D model from the CAD to the FEA tool was not without difficulty. In general, the CAD model contains considerably more detail than is required by the FEA tool.

II. COMPUTER AIDED DESIGN FUNCTIONS

CAD tools are the most common class of computerized tools used in the engineering and design process today. Introduced in the 1960s and much improved since then, these tools have replaced many of the drafting tables and machines used to generate engineering drawings. Early CAD tools were designed to produce a 2D representation of an item to be manufactured; many current CAD tools capture a 3D representation.

CAD tools capture a geometric model of the product to be built. The latest generation of 3D CAD tools is particularly well suited for the development of three-dimensional geometric models with all of the detail needed for manufacturing. From this model, the CAD packages can then produce the documentation needed for procurement and manufacturing. These CAD tools also include some capacity for the capture of material data, and the calculation of mass properties, although these capabilities may be limited.

III. FINITE ELEMENT ANALYSIS FUNCTIONS

Although less widely used than CAD, various CAE tools are also found throughout industry. Where CAD is used to define the form of the design item, CAE is used to define the function of the item. CAE tools provide the engineer with the ability to analyze, model, simulate, and optimize a design.

FEA tools are one common class of analytical CAE tools. FEA tools, when applied to a mechanical structure, offer the engineer insight into the stresses, deflections, modal frequencies, and mode shapes of the structure. In addition, FEA can be applied to other types of analysis, including heat transfer, electrostatic potential and fluid mechanics.

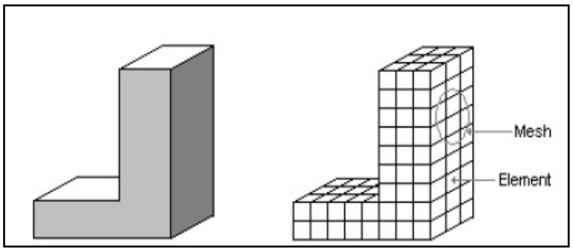

Fig.1 : Mesh Generation Using FEA Tools

FEA tools also provide a means to capture a 3D representation of the item to be manufactured. The model generation facilities of FEA tools tend to be less user-friendly than those of CAD systems. Once the geometry of an item is defined, the item is partitioned into a number of small elements by overlaying a three-dimensional mesh on the item, as shown in Fig.1.

IV. SME ENVIROMENT

The business of the SME that is the subject of this paper is providing custom-designed, precision, electro-mechanical equipment to the aerospace industry. Each unit is built to meet specific, defined performance requirements from the customer. To meet the performance requirements specified by the customer, the design must conform to certain critical performance factors (CPFs). The SME addresses these CPFs during the design process using various analytical tools. The design of the mechanical structure of the product is driven by the conflicting goals of

- Optimizing structure size to meet payload requirements
- Minimizing structure mass
- Maximizing structure stiffness
- Minimizing structural deflection under load
- Maximizing structural mode frequencies

V. DESIGN PROCESS IN SME

This section describes the design process used at the SME prior to the integration of CAD & CAE. The design process is illustrated in Fig.2.

The design process begins with the initial inquiry from the customer. In response to a detailed set of customer requirements, the SME studies the requirements and develops a conceptual design using in house CAD tools. This design is analyzed to assure conformance to CPFs. Due to the need for rapid response and multiple iterations, the SME performs this initial analysis in-house to avoid. Advanced analytical tools were not available within the SME; thus these initial iterations analyses are performed using manual calculation methods. The SME iterates the conceptual design/analysis process until the CPFs are met.

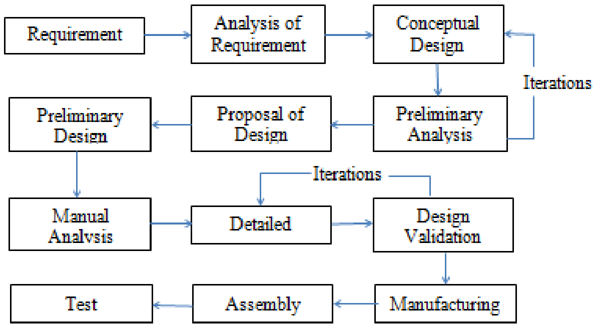

Fig. 2 : Design, Analysis and Manufacturing Process

Based upon the conceptual design, the SME generates a detailed technical proposal. The SME continues the design process with a preliminary design effort. During the final design effort the SME performs some design analysis using manual or computer-aided calculations. Due to the lack of detailed analysis, the designers attempt to assure conformance to the CPFs by making conservative design decisions. After the design is completed, it is subjected to a design validation analysis to assure conformance to customer requirements. This final analysis is typically outsourced, and is performed using CAE tools such as FEA, kinematic modeling, dynamic modeling, or simulation. The validated design is then released for production.

VI. SME GOALS AND STRATEGIES

The SME established clear business goals to drive the engineering design process improvement. These business goals are summarized below:

- **Reduce product performance risk:** The equipment was custom-designed and manufactured to meet stringent performance specifications from the customer. Any error in engineering, design, or manufacturing could compromise performance.
- **Achieve faster deliveries:** Typical product delivery times could range from 3 to 24 months, depending upon the size and complexity of the product.
- **Reduce costs.** Increased competition was resulting in reduced prices for equipment. To maintain adequate market share and profit margins, cost reductions were needed.
- **Enhance product performance :** Markets were demanding continual increases in product

performance. Superior performance was seen as a factor to distinguish the SME from the competition

The SME devised three strategies to pursue these goals.

Strategy 1: Integration of 3D CAD for product design

Replacement of existing 2D CAD tools with an advanced 3D CAD tool will allow the SME to create an integrated 3D model of the complete system. This model will include complete definitions of the interfaces between all components of the system.

Strategy 2: Integration of FEA to predict performance of product

Using FEA allows the SME to predict product performance and validate the design during the design cycle. FEA activities would be given to experts. This strategy supports the goals of the SME.

Strategy 3: In-house FEA early in the design cycle

Developing an in-house FEA capability allows the SME to use FEA as an integrated part of the design process, rather than as a post-design effort to validate the design. This strategy supports the goals of the SME.

VII. IMPLIMENTATION OF THESE STRATEGIES

The SME devised a three-stage plan to implement these strategies

1. Analyze and revise (if needed) the current design process to optimize it for the integration of 3D CAD and FEA.
2. Introduce 3D CAD into the design process.
    - Evaluate and acquire the appropriate 3D CAD tool.
    - Acquire the appropriate resources (computer hardware) to support the 3D CAD tool.
    - Train the design staff on the use of the 3D CAD tool.
    - Establish monitoring processes to evaluate the effectiveness of the 3D CAD tool.
3. Introduce in-house FEA into the design process.
    - Modify the design process to use FEA during the early stages of design, rather than the current practice of using FEA for validation of a completed design.
    - Evaluate and acquire the appropriate FEA tool.
    - Acquire the appropriate resources (i.e., computer hardware) to support the FEA tool.
    - Establish monitoring processes to evaluate the effectiveness of the FEA tool.

Using above mentioned strategies, the modified design, analyze and manufacturing process shown in Fig.3.

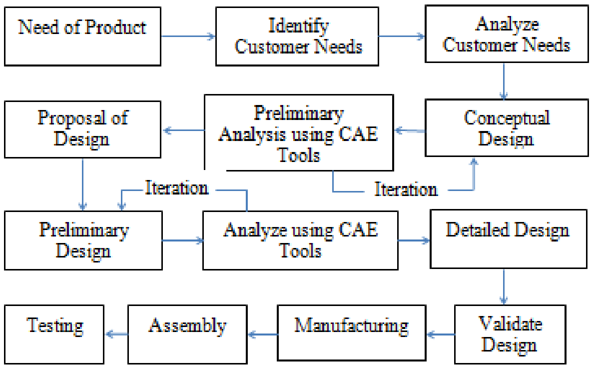

Fig. 3 : Modified, Analyze and manufacturing Process

VIII. CONCLUSION

Integration of 3D CAD and FEA into a design engineering environment can have a wide ranging effect upon an SME. The SME must approach the integration activity as a technology adoption process rather than a singular event, recognizing that changes in technology, process, staff skills and staff responsibilities will be required. This report demonstrates that

SMEs can successfully adopt 3D CAD and FEA technology by managing key issues within the adoption process.

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REFERENCES

[1] Xuan F. Zha," Platform-based product design and development", Knowledge-Based Systems 19 (2006) 524–543

[2] Akshay Mutha, Shaligram Pokharel," Strategic network design for reveres logistics and remanufacturing using new and old product modules", Computers & Industrial Engineering 56 (2009) 334–346

[3] Osman Kulak a, Selcuk Cebi," Applications of axiomatic design principles",Expert Systems with Applications 37 (2010) 6705–6717.

[4] Hsu-Fang Hung, Hsing-Pei Kao," An integrated information system for product design planning", Expert Systems with Applications 35 (2008) 338–349

[5] Marvin Berkowitz," Product Shape as a Design Innovation Strategy", J PROD INNOV MANAG 1987:4:274-283

[6] Raymond S. Hartman," An empirical Model of product design", International Journal of Industrial Organization 7 (1989) 419436. North-Holland

[7] G.G. HEGDE," Diagnostics design: A product support strategy", European Journal of Operational Research 38 (1989) 35-43

[8] Xiuzi Yea, Hongzheng Liu, Lei Chen, Zhiyang Chen, Xiang Pan, Sanyuan Zhang," Reverse innovative design—an integrated product design methodology", Computer-Aided Design 40 (2008) 812–827.