Implementation of Product Realization in Engineering Curriculum for a Changing World

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Abstract

This paper presents an overview of a proposal involved in the development of a new engineering program where in design and manufacturing courses are sequentially reorganized giving birth to a new program in Product Realization. The program helps the students in designing the product and process right from the conceptual stage by combining the company strategies with the customer requirements (making sure that what they produce is what the customer needs) till the product is packed off to the customer. The program teaches the engineer an efficient way to envisage the product, design a competent production process, and build a perfect marketing concept for that particular product.

Introduction

The major problem faced by engineers today's is about building a better product on time, using the latest technology and within the budget. The art of handling complex machinery using latest technological innovations in manufacturing and creating better products for tomorrow can be developed by engineers only by making them realize the concept of Product Realization. Implementation of the principles of Product and Process development in the engineering curriculum will group together all the necessary forces needed to make products which have better quality, are more affordable, and which can be produced on time. There is a constant importance given to introducing the concept of product realization in the engineering curricula by introducing various design and manufacturing courses. Usually it's the design part that dominates over the manufacturing courses, making the engineering students lack the vital production edge. These courses are also not compatible with real time product realization projects.

This paper presents an overview of a proposal involved in the development of a new engineering program where design and manufacturing courses are sequentially reorganized giving birth to a new program in Product Realization. The program helps the students in designing the product and process right from the conceptual stage by combining the company strategies with the customer requirements (making sure that what they produce is what the customer needs) till the product is packed off to the customer. The program teaches the engineer an efficient way to envisage the product, design a competent production process, and build a perfect marketing concept for that particular product.

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The Production Realization Process- Phases

The proposed courses would be structured as phases throughout the four-years of Mechanical Engineering Education. These Phases are:

Phase I- Teaming and Project Management
Phase II– Design and Numerical Analysis
Phase III- Prototyping and Experimental Analysis
Phase IV- Manufacturing.

Each phase has a unique importance with due relevance to the stages of product development in an industry. These phases could be grouped in a set of product development activities that are quite similar to the activities involved in the development of a product, at a large organization. These activities involve in teaming, scheduling of events, and product design through the end disposal of the product. These phases of activities, though complex, have a collaborative and a concurrent approach. There is effective team development incorporated into each phase and there is efficient information sharing between all phases. Figure 1 shows the information transfer between each phase.

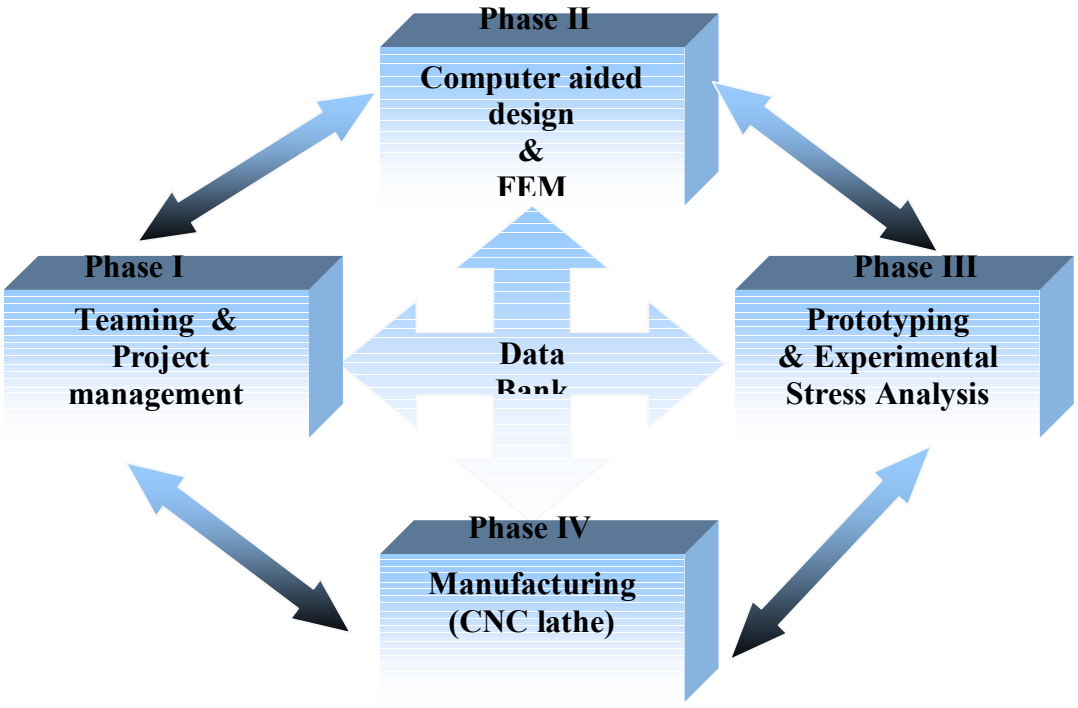


Figure1: Data sharing among the phases

Product Realization Process- Goals

The proposal's aim is to instill effective Implementation of Product Realization concepts into the engineering curriculum in order to:

1. Train the students in effective team building exercises and promote collaborative problem solving approaches.
2. Improve project planning, scheduling and crisis management skills in the students.
3. Effectively train the students in the principles of IPPD, which is a mixture of traditional concepts of concurrent engineering and Quality Management.
4. Let the students have real time experience, in understanding the effective interactions between the designs and manufacturing stages of product development in an organization.
5. Make the students realize that the project success is highly dependent on the whole engineering process right from the stage of Teaming and Project Management to the final Manufacturing and Documentation stage.

The Phases

Phase I- Team Building and Project Management:

In the first phase, the freshmen engineering students are introduced to the concept of Team Building and Project Management. The whole Product Realization program, inclusive of the four phases, is considered to be a system, headed by a program director, which acts as a CEO of this system. Individual professors, who are experts in their related phases, head that particular phase. These phases are still divided into teams, which consist of students and are headed by a team leader. The professor keeps a check on the activities of the team leader who is responsible for the achievements of his team. This type of environment helps the students gain the necessary experience of working in an organization.

Team building:

In this phase the students are divided into teams and are taught the importance of working in teams, through which IPPD is carried out. They are taught that teams consist of representatives from all fundamental disciplines working together with a team leader to build a successful and perfect solution, recognize and resolve issues, and make right decisions at the right time. The students are even taught the steps to be taken in effective team building. These steps will include in selecting, the right team size, team hierarchy, team leader, team member selection, team co-operation, team dynamics, team charter, team meetings, and about team training.

Project Management:

The students are taught about the fundamentals of project management. They are taught that managing a successful project deals in application of knowledge, skills, tools, and techniques. They must learn to a broad range of activities in order to meet the requirements of the particular project. They are even trained in the basic components of project management,

which are, Initiating, Planning, Executing, Controlling, and Closing. Apart from this training, instruction in the field of project integration management, scope management, time management, cost management, quality management, human resource management, communication management, and risk management are also given[7].

Phase II-The Design Phase:

In this phase the second year engineering students (sophomores) are trained in the vital design process. In the first phase, the students are divided into groups headed by their individual team leaders. In the design phase, the students are presented with a common project. Each individual group has to contribute to the success of the project by completing their tasks efficiently. The conceptual design team first analyses the problem and generates a new conceptual design. It is then sent to the remaining design teams who develop the conceptual design into the final product using the principles of Design for Manufacturing, Robust Design and Design Optimization. The students are trained to work on high-end design packages like Pro-E, Solid Works, and to analyze their products using numerical analysis packages like IDEAS. Figure 2 shows the division of the design phase into subsequent teams.

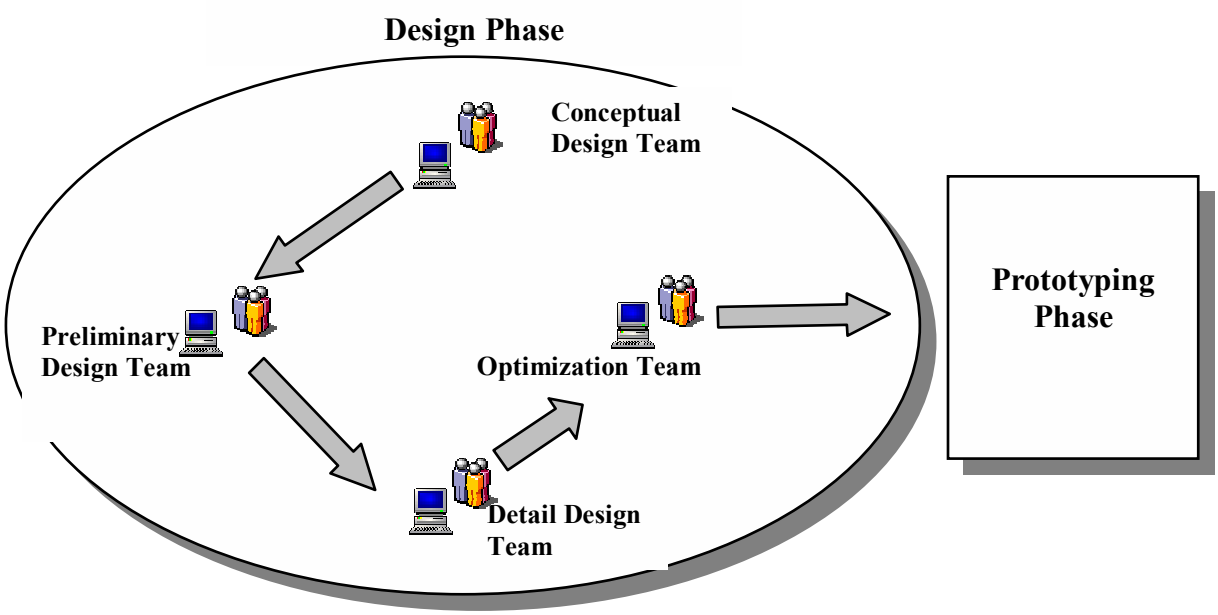


Figure2: Design phase

Phase III-Prototyping and Experimental Stress Analysis Phase:

In this phase, the third year mechanical engineering students (juniors) are trained in Rapid Prototyping techniques and Experimental Stress Analysis. The prototyping stage receives the final optimized design from the design phase. Using this design, the students are required to

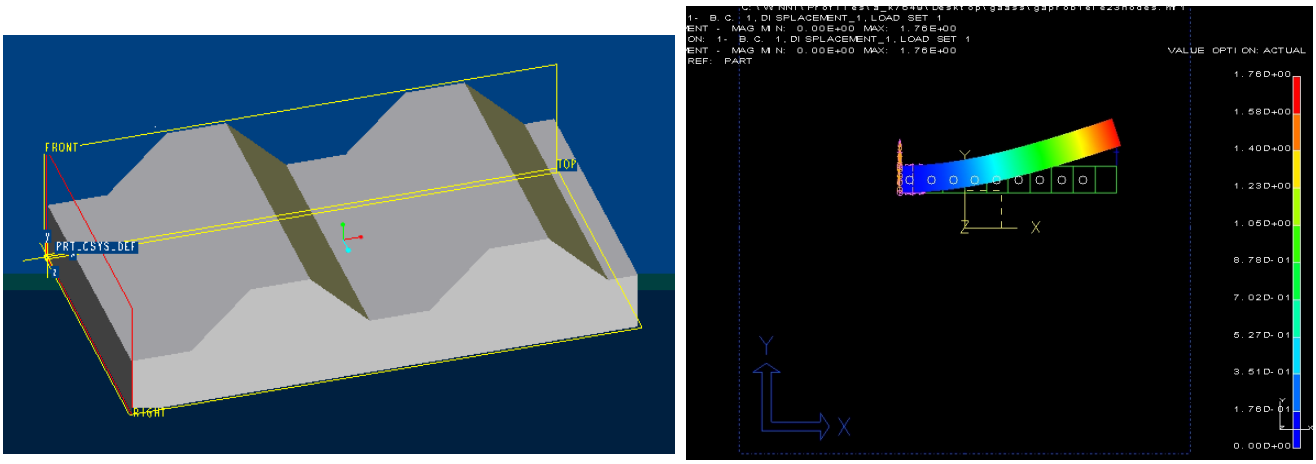


Figure 3: A Pro-E drawing and Finite Element Analysis using IDEAS.

make a prototype of it using a Rapid prototyping technique called Stereolithography. Then the students are required to analyze the stresses involved the product using experimental techniques. Figure 3 shows the design of a part using Pro-E and Finite Element Analysis for a part using IDEAS.

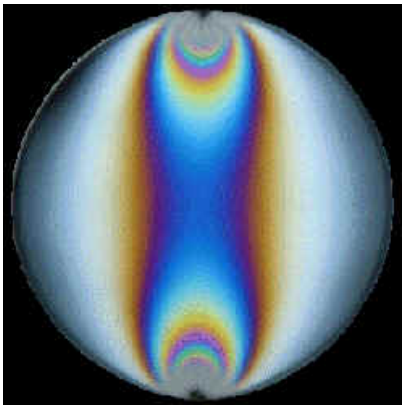
Stereolithography:

This is the most common RPT technique, and it produces acrylic and epoxy parts. Parts having fine geometric details and high accuracy are produced. The required geometry is produced in thin layers (0.1-0.25 mm). A CNC-controlled laser beam cures a pattern in the surface of a fluid photosensitive polymer. The hardened layer is then stepwise lowered allowing the fluid to cover the part. It is an additive process of rapid prototyping[8].

Experimental Stress Analysis:

The rapid prototype part thus made is then analyzed experimentally for possible stresses formed in the part during its application. It's seen that numerical analysis does not necessarily consider all the stress factors involved in the real time application. So an experimental stress analysis is conducted. For this purpose the prototype is mounted on to a photo elastic bench and is subjected to various mechanical loads. Then using the principles of photo elasticity, and by visualizing "fringes", the stresses involved in the product are calculated. Any suggestions or corrections to be made in the part are again sent back to the design phase and the part is redesigned with

suggested modifications. Figure 4 shows the photo elastic stress analysis of two parts under compression and tensile loads respectively.



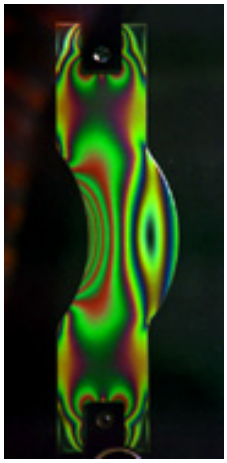


Figure4: Photo Elastic Stress Analysis.

Phase IV-Manufacturing Phase:

The final design is then sent to the Manufacturing phase. Here the mechanical engineering seniors are taught various manufacturing techniques namely, CNC machining, Injection molding, and other. The students are taught software's such as Smart Cam and C-MOLD.

SmartCam:

It is an effective CNC code generating system which helps in easy and advanced code generations for CNC turning and milling machines. It has a powerful drawing editor, which allows us to graphically define the part, including 3D contours, and then to produce the code.

C-MOLD:

C-MOLD is a set of integrated CAE simulations for plastics molding processes. These include injection mold filling, co-injection molding, injection/compression molding, gas-assisted molding, reactive molding, and blow molding. It is an intelligent manufacturing tool, used to vastly improve productivity and enhance the part quality.

The final year students complete the product realization process by manufacturing the final product using one of the manufacturing techniques taught to them. Figure 5 shows the concurrent process planning involved in the structuring of the courses. Figure 6 shows a layout of the proposed product realization labs.

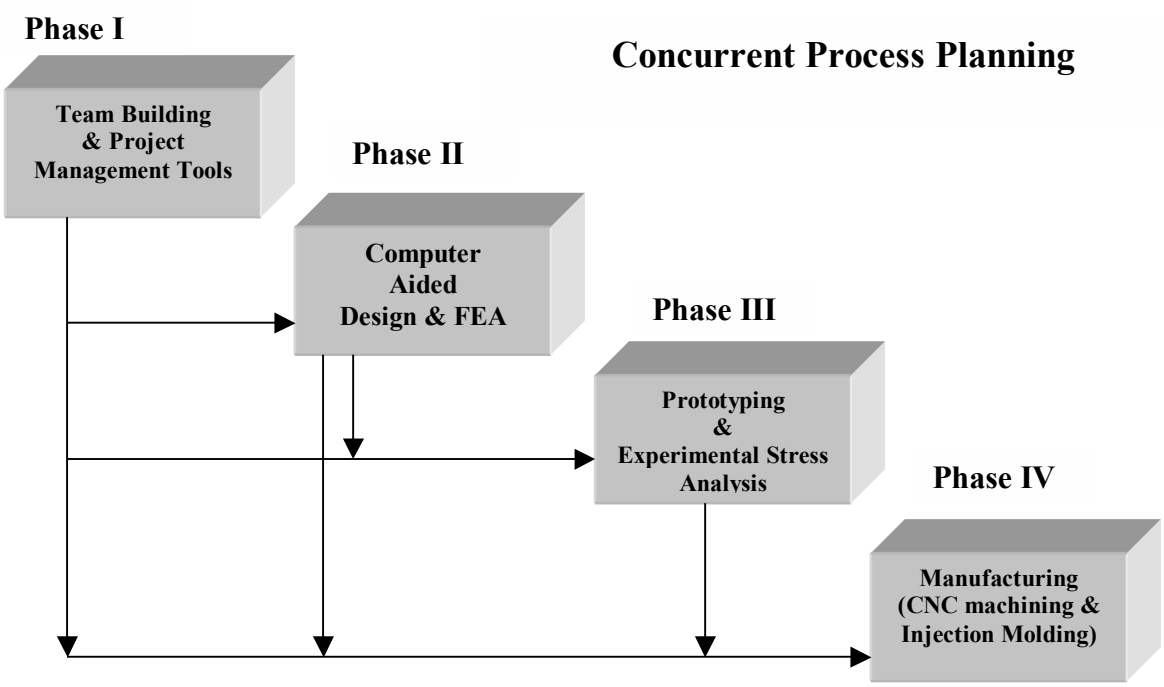


Figure5: Concurrent Process Planning

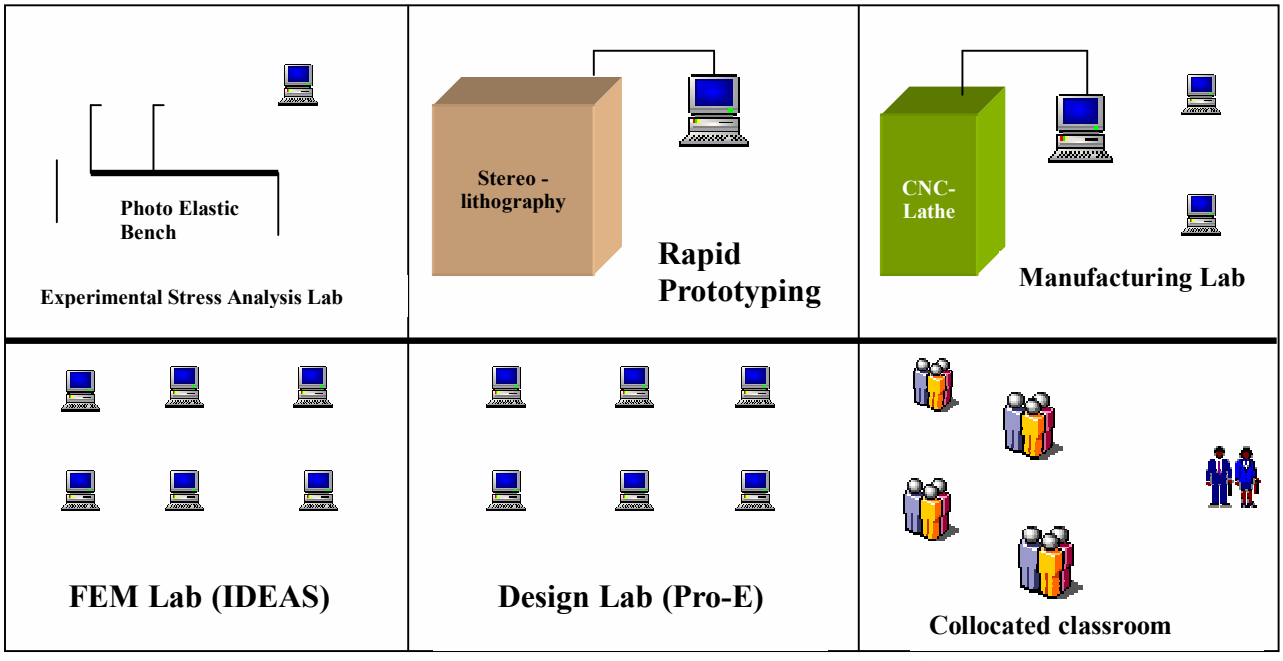


Figure6: Product Realization Labs

Conclusion

This paper presents an overview of a proposal involved in the development of a new engineering course where in design and manufacturing courses are sequentially reorganized giving birth to a new program in Product Realization. The program aims to effectively train the students in the principles of IPPD and to give them real time experience, in understanding the effective interactions between the designs and manufacturing stages of product development in an organization.

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