An Innovative Lean Six Sigma Approach for Engineering Design

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Abstract—**One of the trends emerging in the New Product Development (NPD) is the development of lean and six sigma activities. Material cost and design time have to be optimized in order to make the system effective and deliver the design at the shortest time of market with good quality. This paper deals with the approach associated to optimization of above mentioned problems. It is done with the strategy of Six Sigma and philosophy of Lean by using Topology optimization.**

***Index Terms*—Lean, Six Sigma, Topology Optimization**

I. Introduction

A. New Product Development

The need to create customer-relevant business processes is a recurrent theme in marketing particularly those dealing with the nature of marketing, competitiveness and strategies. Today's successful firms learn and re-learn how to deal with the dynamics of consumers, competitors and technologies, all of which require companies to review and reconstitute the products and services they offer to the market.

Of the many factors associated with successful NPD, processes and structures which are customer-focused recur. A customer focus may be manifested in NPD in numerous ways, spawning much research into the nature of new product activities: their nature, their sequence and their organization [1].

In this competitive world, the time to market with good quality and lower cost is very important in an industry.

B. Six Sigma

Six Sigma is a business management strategy, originally developed by Motorola that today enjoys wide-spread application in many sectors of industry. It seeks to identify and remove the causes of defects and errors in manufacturing and/or service delivery and business processes. It uses a set of management methods, including statistical methods, and creates a dedicated infrastructure of people within the organization who are experts in these methods. Six Sigma aims to deliver "Breakthrough Performance Improvement" from current levels in business and customer relevant operational and performance measures.

Business or operational measures are elements like:

- Customer Satisfaction Rating Score
- Time taken to respond to customer queries or complaints
- % Defect rate in Manufacturing
- Cost of executing a business process transaction
- Yield (Productivity) of service operations or production
- Inventory turns (or) Days of Inventory carried
- Billing and Cash Collection lead time
- Equipment Efficiency (Downtime, time taken to fix etc.,)
- Accident / Incident rate
- Time taken to recruit personnel

Six Sigma initiatives are planned and implemented in organizations on "Project by Project" basis. Each project aims not only to improve a chosen performance metric but also sustain the improvement achieved.

Each Six Sigma project carried out within an organization follows a defined sequence of steps and has quantified financial targets (revenue increase, cost reduction or profit increase).

Six Sigma projects follow two project methodologies inspired by Deming's Plan-Do-Check-Act Cycle. These methodologies, composed of five phases each, bear the acronyms DMAIC and DMADV

1) DMAIC (Define, Measure, Analyze, Improve, Control) is used for projects aimed at improving an existing business process
2) DMADV (Define, Measure, Analyze, Design, Verify) is used for projects aimed at creating new product or process designs

C. Lean

Lean is a philosophy and set of management techniques focused on continuous "eliminating waste" so that every process, task or work action is made "value adding" (the real output customer pays for!!) as viewed from customer perspective. Lean "waste elimination" targets the "Seven Wastes" namely:

1) Excess production and early production
2) Delays
3) Movement and transport
4) Poor process design
5) Inventory
6) Inefficient performance of a process
7) Making defective items

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D. Lean Six Sigma

If six sigma ideas combined with lean, then it is called as "Lean Six Sigma".

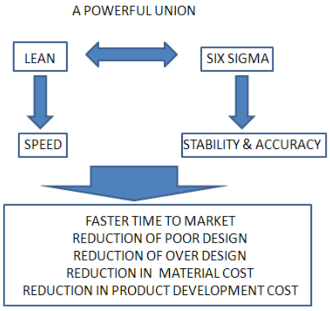

Fig.1. Lean six sigma

E. Topology Optimization

Topology optimization is a mathematical approach that optimizes material layout within a given design space, for a given set of loads and boundary conditions such that the resulting layout meets a prescribed set of performance targets. Using topology optimization, engineers can find the best concept design that meets the design requirements. Topology optimization has been implemented through the use of finite element methods for the analysis, and optimization techniques based on the method of moving asymptotes, genetic algorithms, optimality criteria method, and level sets.

In some cases, proposals from a topology optimization, although optimal, may be expensive or infeasible to manufacture. These challenges can be overcome through the use of manufacturing constraints in the topology optimization problem formulation. Using manufacturing constraints, the optimization yields engineering designs that would satisfy practical manufacturing requirements.

Today, all the modern manufacturing enterprises are striving to develop best optimized reduced weight and cost effective products that meet the intended design functionality and reliability. In this scenario, structural optimization tools like topology and shape optimization with manufacturing simulations are becoming attractive in product design processes. These tools also aid in reducing product development times. In last few years, topology optimization has emerged as the valuable tool to develop new design proposals especially in automobile and aircraft industries. Topology optimization calculates the optimal loads compatible design, under specified boundary conditions and constraints. This result in an innovative design proposal irrespective of dependency of the designer experience and conventional design approaches [3].

II. Problem Statement

The main problem arising in the offshore design centre is "the time to deliver the design". In addition, the cost reduction in material and quality is needed.

III. Objective of This Paper

- To optimize design
- To reduce the time to make the design
- To reduce the weight of the material, so cost reduction take place
- To fulfill above needs with quality

IV. Working Methodology

A. Design for Six Sigma (DFSS)

DMADV is sometimes synonymously referred to as DFSS

Steps to be followed

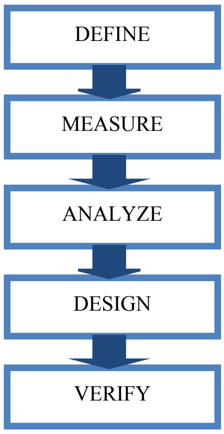

Fig. 2. Six sigma approach

DEFINE: identify purpose, identify and set measurable goals from the perspective of both the organization and stakeholder, develop schedule and guidelines for review, identify and assess risks

MEASURE: define requirements, define market segments, identify critical parameters for design, design scorecards to evaluate design components that are critical to quality (CTQ), reassess risks assess production process capability and product capability

ANALYZE: develop design alternatives, identify the best combination of requirements to provide value within constraints, develop conceptual designs, evaluate, select the best components and develop the best available design

DESIGN: develop a high level design, develop exact specifications, develop detailed component designs, develop related processes, and optimize design

VERIFY: validate that the design is acceptable to all stakeholders, complete pilot test, confirm expectations, expand deployment, document lessons learned.

B. Lean

By using advanced tool as "Topology Optimization", we are making our design as lean one. It means that the time to take deliver the design will reduce and weight of material will also be reduced.

C. Steps to be followed

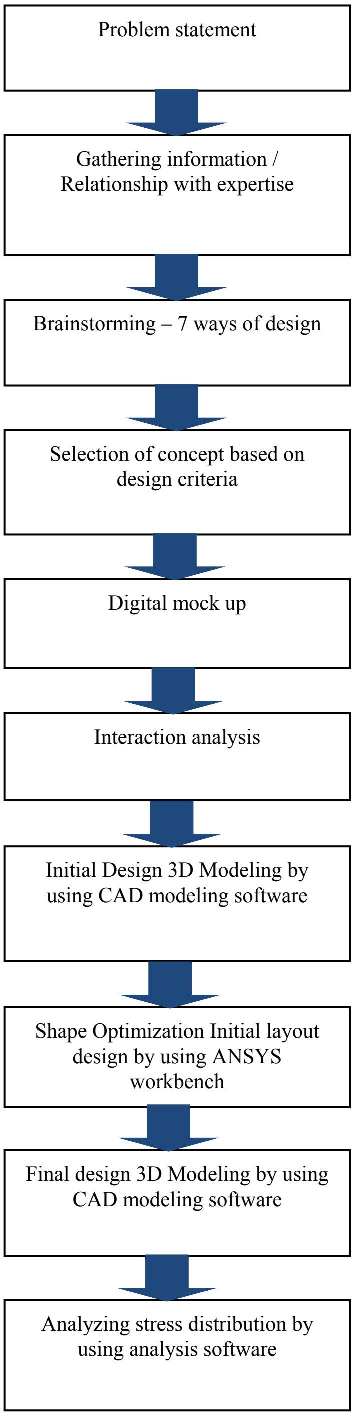

Fig. 3. Lean Six Sigma Approach

D. Gathering information

Before we can go further in the design process, we need to collect all the information available that relates to the problem. Novice designers will quickly skip over this step and proceed to the generation of alternative solutions. We will find, however, that effort spent searching for information about your problem will pay big dividends later in the design process. Gathering pertinent information can reveal facts about the problem that result in a redefinition of the problem. We may discover mistakes and false starts made by other designers. Information gathering for most design problems begins with asking the following questions. If the problem addresses a need that is new, then there are no existing solutions to the problems, so obviously some of the questions would not be asked [6].

1) Are the problem real and its statement accurate?
2) Is there really a need for a new solution or has the problem already been solved?
3) What are the existing solutions to the problem?
4) What is wrong with the way the problem is currently being solved?
5) What is right about the way the problem is currently being solved?
6) What companies manufacture the existing solution to the problem?
7) What are the economic factors governing the solution?
8) How much will people pay for a solution to the problem?
9) What other factors are important to the problem solution (such as safety, aesthetics and environmental issues)?

E. Categories of gathering information's

1) Patent searches. Just about any company with an interest in intellectual property conducts patent searches on a regular basis. These searches play a role in suggesting what's available by identifying new exploitable technologies – and what isn't available, because someone else got there first.
2) Technical literature reviews. Individuals in the companies 'never stop reading', reviewing the technical literature within their disciplines and often beyond, and attending key conferences and exhibitions. These reviews keep up-to-date both their knowledge of the latest developments and their awareness of who the 'key players' are in the field. Seminal papers are often distributed to other colleagues. Often team members are deputed early in a new project to conduct a review oriented to the project or to specific aspects of it; the results of such a search are summarized and reported to the team.
3) Analysis of legislative requirements and regulatory standards. Awareness of such requirements and standards satisfies more than legal obligations for conformance; sometimes grappling with the constraints they impose leads to reformulation and innovation; sometimes it simply improves performance by focusing efforts on what is realistic within the rules.
4) Review of the competition. At the start of a project, competing products – or related existing products – are analyzed, with attention to technology, customer requirements, and market forces.

F. Relationship with expertise

It is striking how many of the disciplines require expertise, either in terms of breadth and depth of experience, or in terms of expert reasoning, such as the identification of deep structure in problems and solutions [6]. The characteristics are

1) Expert problem solvers differ from novices in both their breadth and organization of knowledge; experts store information in larger chunks organized in terms of underlying abstractions
2) When categorizing problems, experts sort in terms of underlying principles or abstract features
3) Experts remember large numbers of examples – indeed; the literature suggests that experiencing large numbers

of examples is a prerequisite to expertise. Expert's memories of previous examples include considerable episodic memory of single cases, particularly where these are striking. Implicit learning requires large numbers of instances with rapid feedback about which category the instance fits into

4) Experts form detailed conceptual models incorporating abstract entities rather than concrete objects specific to the problem statement. Their models accommodate multiple levels and are rich enough to support mental simulations.

G. Digital Mock Up (DMU)

It is a concept that allows the description of a product, usually in 3D, for its entire life cycle. Digital Mockup is enriched by all the activities that contribute to describing the product. The product design engineers, the manufacturing engineers, and the support engineers work together to create and manage the DMU. One of the objectives is to have an important knowledge of the future or the supported product to replace any physical prototypes with virtual ones, using 3D computer graphics techniques. As an extension it is also frequently referred to as Digital Prototyping or Virtual Prototyping. These two specific definitions refer to the production of a physical prototype, but they are part of the DMU concept. DMU allows engineers to design and configure complex products and validate their designs without ever needing to build a physical model [5]. The benefits are

1) Reduce time-to-market by identifying potential issues earlier in the design process.
2) Reduce product development costs by minimizing the number of physical prototypes that need to be built.
3) Increase product quality by allowing a greater number of design alternatives to be investigated before a final one is chosen.

V. Expected Outcomes Of The Methodology

A. Six Sigma

- minimize future problems
- minimize variability
- maximize satisfaction
- deliver what is desired in a timely fashion

B. Lean

- Reduces the time to deliver the design
- Reduces the weight of the material, so cost reduction takes place

C. Background of the Expected Outcomes

If we will apply topology optimization in the concept stage itself, it reduces the time to deliver the design. Because, analysis done in the concept stage, so we know that where maximum stress and displacement are coming. From the result, we will add ribs and other features for strengthening purposes. Otherwise, we will do the design roughly without knowing where it is needed. After analysis, sometimes we will remove it. It takes times to deleting and adding the feature which is needed. In this way, we can meet "the time to deliver the design".

D. Facts

- Customers are important
- Speed, agility, quality and low cost are linked
- Eliminate variation and defects; focus on process flow to deliver quality, speed and low cost
- Data is critical to making sound technical decisions
- People have to work together to make improvements that customers will notice

VI. Conclusion

If topology optimization is used at the concept level of the design process to arrive at a conceptual design proposal that is then fine tuned for performance and manufacturability. This replaces time consuming and costly design iterations and hence reduces design development time and overall cost while improving design performance. This result in an innovative design proposal irrespective of dependency of the designer experience and conventional design approaches. Hence, we can deliver the design to market in short time by implementing "Innovation Lean Six Sigma" approach.

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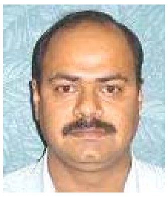

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