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A Lean Design Approach for New Product Development

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ABSTRACT: This paper proposes an integrated and structured new product development methodology based on lean design approach involving the application of specific lean and six sigma tools. The integrated new product development approach is aimed at not only to reduce the manufacturing lead time, manufacturing cost and time to market but also to improve the quality of new product developed by maximizing the product performance from customer point of view and improving market acceptance of new products. The proposed approach helps to identify and eliminate design wastes, which are neither visible nor serial and are observed only when the product hits the manufacturing shop floor. A case study involving design and development of Safe Alert®, a force measuring device for orthopaedic and lower limb injury patients is explained

KEYWORDS: Lean QFD, costing, Design of Experiments, and Failure Mode Effective Analysis.

I. INTRODUCTION

The methodology to design a product involves the following steps.

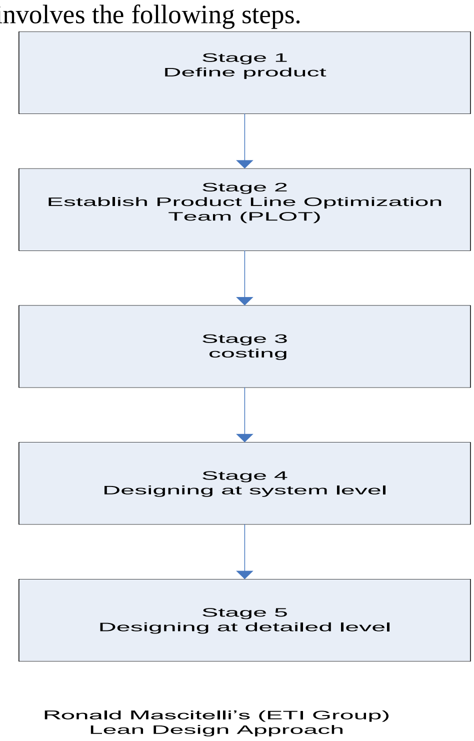

Figure 1: Lean Design approach

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1) Define product requirements

A lean QFD is used as a voice of the customer tool to define product requirements based on customer's needs and market desire. Lean QFD is mainly used to determine critical to quality measures and critical to lead time process in new product development since a lean QFD uses defined ranking system and weighing system to quantify results also it proved to increase the distinction between ratings for process parameters. Any increase in performance, features or quality that overshoots the customer needs will result in increased development time and manufacturing cost without an associated price increase. Undershooting of customer requirements would result in a dissatisfied customer, loss of price and market share.

Lean QFD is carried out in two phases,

Phase 1:

Determining Critical to Quality Process using a customer interface (Questionnaire) divided into four sub-phases.

Phase 1a: Relates each customer need to product technical characteristics

Phase 1b: Relates each technical characteristic to the product part characteristics

Phase 1c: Relates each products part characteristics to the process parameters required to achieve those characteristics.

Phase 1d: Relates each process parameter to a process step in part production.

Phase 2:

Determining Critical to Lead Time Processes

The process results from Phase 1 are carried into phase 2.

Phase 2a: The CTQ process steps are assigned process times because they could also be critical to lead time. The time for each step is the time required to complete the step during the production of one part.

Phase 2b: The CTQ process times do not consider delay and hence delay processes in part production must also be identified. A delay process is a process that links the CTQ process steps in part production and more than one delay process can link two CTQ process steps.

2) Establish Product Line Optimization Team (PLOT)

When a new product is created, a Product Line Optimization Team can be established to determine how the new product will fit within existing material inventory, processes, and factory layout and core competencies.

3) Costing

The target cost is established by first determining the market price of the product and subtracting the market price with target margin which is performed during the conceptual design stage. The target must be broken down into system or module level to be effective, when complex products are developed by large team of engineers and such target decomposition is performed based on historical average product cost breakdown. According to A.T.Kearney, target costing approach has four major limitations; targets cannot provide insight into what is possible whether the product could be produced at even lower cost being profitable? The second limitation is that system or module level targets are highly arbitrary and fail to consider all factors. The third limitation is that since market prices are a moving target achieving the target costs corresponding to current or today's will not yield the desired profitability in the year or more to implement the improvements. The price of competitor products would have fallen and are improved. The final limitation is that target costing provides no real insight of how the product should improve.

Therefore material costs, unit costs and tooling costs are individually developed for the safe alert insole.

4) Design at System and detailed level

A list of possible alternative concepts are developed and optimal concept is chosen therefore the possible opportunities for customizing the product is determined by the design team therefore platform design considerations are incorporated into the rapidly solidifying design. Platforms leverage design efforts from one product to many other related products. For example automobiles have various platforms such as engine platforms, suspension platforms etc which allows developing product lines that require less overall engineering and manufacturing effort. Other concepts such as modularity and scalability are considered to capture economies during future product line expansion. Modularity is defined as plug and play concept to design the products to provide flexibility of features.

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Designing at detailed level involves determining the compatibility of new design to fit existing and planned manufacturing processes. Six sigma tools such as Design of Experiments (DOE) and Failure Mode Effective Analysis (FMEA) were used to optimize design variables and predict the failure. DOE was chosen because it is the only powerful tool capable of dealing successfully with the usual situation of multiple design and process variables having interactive effects on product performance. DOE also has the capability to perform robust design which involves designing a product to perform consistently in the face of uncontrollable manufacturing or use environment factors.

5) Design the Manufacturing Environment for the product design.
Manufacturers have to ensure that they meet customer requirements and produce high quality products while maintaining a low cost. Our approach integrates the manufacturing step in the product development process using simulation as a tool for determining the manufacturing strategy (job shop, hybrid, cellular etc) and facility layout.

Case Study
RKK Technologies is a company that has invented and manufactures a force-measuring device for orthopaedic and lower limb injury patients. The company is a small start-up that expects to have at least a 50% market share upon the initial offering of the product to the public. Currently, prototypes are manufactured at a small prototype company in Chennai. In the near future the team of inventors will convert the small prototype shop into a full production manufacturing facility.

The company's initial product is an insole that measures force on the lower limbs of a person's body. The insole is designed for a physician to program the maximum amount of weight the patient can place on the area of surgery or injury. If the patient breaches the set threshold amount, the insole provides biofeedback in the form of an audible or vibration warning. The product's competitive advantage is the combination of the following qualities: small, inexpensive, disposable, accurate and capable of biofeedback.

Stage1: Defining Product Requirement using Lean QFD
A lean QFD was used to determine the critical to Quality (CTQ) characteristics which are measurable aspects of a product that were obtained through voice of customer. It is extremely important that the design of a product should meet customer needs and satisfy customer expectations. The critical to Quality aspects of the safe alert insole that were identified as critical in satisfying customer needs are:

- Accuracy of force measurement – within 10% of applied force
- Comfort – cell design and amount of silicon
- Low weight – for circuitry and pressure transducer box
- Alert system functionality – system must alert the customer if they exceed the threshold of weight programmed by the doctor. System must also have a versatile alert system, if patient does not want a loud audible alert; they have the option of a silent, vibration alert.
- Price – the patient wants a low cost foot force measurement system.
- Ease of Use – the patient wants the insole to be easy to insert and operate. Also they want minimal protrusion of the device.
- Long battery life.

All of the performance and other standards that were identified above must be addressed to meet customer requirements and ultimately satisfy the customer. The CTQ's are being used to aid in the design of the product. The design features are currently being decided based on what the customer wants and those aspects that are critical to the proper functioning of the product.
Step 2: PLOT team
Step 3: Costing
Product associated costs that are associated with all material costs, tooling costs, production unit costs were estimated.
Step 4: System and Detail Level Design
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A DOE was conducted on several of our foot force measurement prototypes to observe and analyse trends and dependencies among input variables. The setup of three input variables, each with three levels, was tested at random. Our goals of the DOE were to determine 1) if one variable has a significantly higher impact on the process than others, 2) if any trends or thresholds exist, and 3) if the components have the necessary capacities and performances to carry out their intended applications.

II. CONCLUSION

A total cost of around rupees 1500000 was required to produce a foot measuring device. The most noticeable outcome was an apparent threshold, or "max out", at 0.23 V when significant force was applied. The cause of this threshold was found to be an insufficient capacity of the pressure transducer (of 2.5 psi). Therefore, a new pressure transducer of 15 psi that can accommodate higher levels is now used in the current product... Overall, these observations were useful in determining the variables that correlate both directly and indirectly with the critical performance measures of our product, and the outcomes have currently been incorporated into the current insole.

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