September 2020

USING VALUE ENGINEERING TO ACHIEVE DESIGN-TO-COST

DJH Engineering Technical Newsletter

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Introduction

Product cost is of ever-increasing importance to manufacturers as cost margins are slim and profits are continually challenged by changing commodity prices, supplier agreements, changes in competitor pricing, fluctuations in sales forecasts, and unexpected costs such as warranty claims. While very often cost reduction is addressed in the later design stages or even after production has begun, treating cost as a design parameter can be an effective strategy to not only meet cost targets but avoid the unnecessary efforts/costs of design changes later in the product development.

What is Design-to-Cost

Design-to-cost (DTC) is a common strategy for cost reduction during the product development process. The driving principle of DTC is to treat cost as a design parameter during the product development phase. A product's cost structure begins with the basic cost of production materials and labor—however, this does not paint capture all associated product life cycle costs. The DTC concept seeks to consider recurring production costs, non-recurring costs, product costs, and product price or acquisition costs.

What is Value Engineering

One approach to achieving DTC is performing the Value Engineering steps to cost identification, analysis, redesign, and implementation. Value Engineering (VE), or Value Methodology (VM), is a systematic approach for improving products—as well as processes and projects[1]. The goal of VE is to achieve an optimum balance between a product's functionality, performance, safety, and cost. An effective, expedited approach to VE was offered by David Meeker and James McWilliams in "Structured Cost Reduction: Value Engineering by the Numbers."[2] These steps include:

- Redesign the product to achieve a cost savings. This is mainly a form of cost avoidance through the reduction of parts, simplification of assembly process, and use of lower cost parts.
- Renegotiate component cost, or source components through alternate vendors at a lower price.
- Substitute components using equivalent parts of lower cost. Often the replacement part is of lower quality so it must be validated to ensure it still meets design, durability, and quality targets.
- Sourcing any custom parts through alternate lower cost suppliers, or outsourcing parts that are made in house.
- Removing product features that are of lower importance to the end customer in order to offer a more focused final product at a lower cost.

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[1] See: https://www.value-eng.org/page/AboutVE

[2] See: http://web.mit.edu/meeker/Public/VE_Triage_Paper_Final.pdf

How is Value Engineering applied in a systematic framework to achieve a cost goal

Meeker and McWilliams propose having a structured, methodical approach to cost reduction to dynamically address cost concerns at all stages of the product design process and in post-production. This allows manufacturers to quickly react to cost reduction requests and continue pursuing cost improvements even as a product's direct cost and manufacturing cost are reduced. The starting point of this system is establishing a product cost baseline by tracking the costs of each individual component that the product is comprised of using a cost database.

The main function of a cost data base is to record and track all the relevant cost data for all parts which compose a product or family of products. This data should include part costs (including direct material cost as well as manufacturing costs), bills of materials, tooling cost considerations, and a system to track part quantities and where parts are used—if the same parts are used throughout a variety of products. This data forms a baseline of product cost and should be checked and updated periodically as the product design evolves.

The next step in the cost reduction process is to identify where the highest cost exists in the product. Often, the most expensive component is not the main cost driver of a product—one must consider the extended cost of a component which is a product of piece part cost and quantity used. With the part extended costs calculated, an ABC/Pareto analysis can be performed to sort parts into categories according to their contribution to total cost. A common strategy to categorize parts is as follows:

- A Class: parts which account for 50% of the total product cost—this tends to sum up to about 10-15% of the total parts.
- B Class: parts which account for the next 40% of total costs for a total (summing to a total of 90% costs)
- C Class: part which account for the last 10% of total costs—this may represent a high quantity of parts, up to 70%.

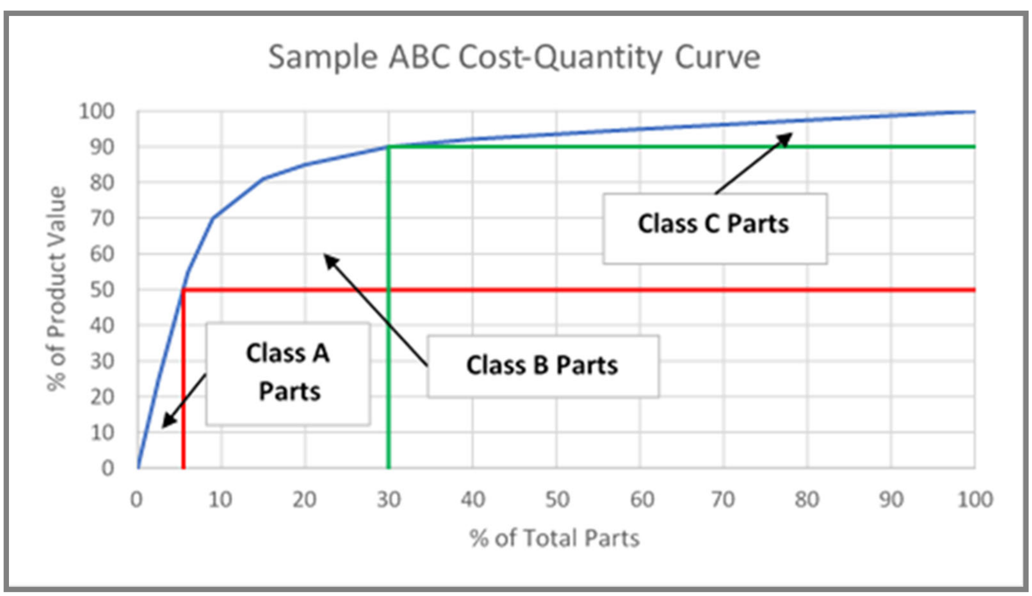

Figure 1: Sample ABC Cost-Quantity Curve

The ABC/Pareto analysis sorts the product part list in order of decreasing cost impact. It also prioritizes which parts should be approached for cost reduction first based on their impact to the total product cost. It should be apparent that cost reduction on Class A parts will have the biggest impact to total product cost, Class B parts will be the next most impactful, and Class C parts will have the least cost impact. This understanding should allow for an appropriate expenditure of cost reduction efforts to achieve an optimal return on investment.

It is important to understand that that direct cost (cost of materials) and manufacturing cost is only a portion of the total product cost. Across many assembled product industries, part costs typically account for only 40%-60% of the final price seen by the consumer[3]. The remainder of the total cost can be attributed to a variety of indirect costs and overhead including research and development, marketing and sales expenses, etc. These costs can be challenging to trace directly to a particular product as they tend to be fixed or time period-based costs for a manufacturer. Often times, these indirect costs are common to multiple products and must be divided among each product—not always in a manner that is fair. Understanding a manufacturer's overhead structure is important to guide how cost reductions decisions are made.

Applying the VE Method to Cost Reduction

With a part selected for cost reduction, we propose the following actions to be investigated for their cost impact. These actions are organized in hierarchical order from highest potential cost impact to least—although it is worth noting that the last action, de-featuring, can also have significant cost impacts.

Redesign

Redesign can be pursued at two stages in the product engineering process: prior to production and post-production. Prior to production, the redesign process overlaps significantly with Design for Manufacturing (DFM) and Design for Assembly (DFA). These processes have been shown to significantly impact product cost when considered from the outset of a product engineering process[4]. DJH Engineering Center can validate this from our experience. Our recommendation to clients is to consider cost impacts and pursue cost reduction efforts throughout the design process. When attempting redesign after a product has gone into production, additional considerations must be made including the impacts of product re-qualification, re-tooling, ability to retrofit on earlier production runs, added complexity for dealer and service networks, and logistics of mid-production product changes.

Typical redesign activities include:

- Minimize part count and manufacturing processes. Redesign components such that they can perform multiple functions where possible, eliminating the need for additional parts. A common method DJH uses to achieve this is through manufacturing process changes—such as casting conversions, use of composite materials, etc. Look to use common parts throughout the product and across additional product lines. Increasing part volumes through part commonality will decrease piece part costs. Consider alternate manufacturing processes that minimize or eliminate the need for secondary manufacturing steps. Simplify machining processes by avoiding complex shapes that cannot easily/quickly be achieved through standard milling and turning.

- Reduce weight and size. Weight is directly related to product material costs. Overall part size also has an impact on tooling costs as well as secondary costs considerations such as part shipping and storage. Performing optimization activities (such as topology optimization) are a quick path to a weight/size optimized part. Weight reduction deserves particular attention as it can have a multiplying effect leading to opportunities to reduce cost in surrounding components and structures and improved product performance/efficiency in mobile equipment.

- Use appropriate materials. Often, part design starts with a particular material in mind even before the part's functionality and durability are validated. There are several reasons for this including engineer familiarity with materials, existing material stock of manufacturing facility, and historical material cost structure. This can lead to the use of over-engineered materials which drive cost into the product. We recommend several cost considerations for part material selection:

[3] Christian Koehler and Robert Weissbarth. "The Art of Underengineering." *Strategy+Business* (Spring, 2004) See also: https://www.strategy-business.com/article/04114?gko=2d85d

[4] Manufacturers Say They Cut Product Cost by Half Using Design for Manufacturing and Assembly." *DFMA Newsletter* (April 2000).

- It can be worthwhile to evaluate material decisions in the latter stages of part design where geometry, material, and cost can all be considered in parallel.

- It can also be beneficial to revisit historical material decisions/legacy parts for cost opportunities.

- Material prices fluctuate which can lead to increasing part costs over time. Designing a part with consideration to alternate materials can allow for future supply changes to keep up with the lowest commodity prices.

- It is important to understand that there is a tradeoff between factory overhead costs and the introduction of a new lower cost material. In certain cases, it may be more cost effective to use a higher cost material that is stocked in great quantities than to add a new lower cost material to a manufacturing facility.

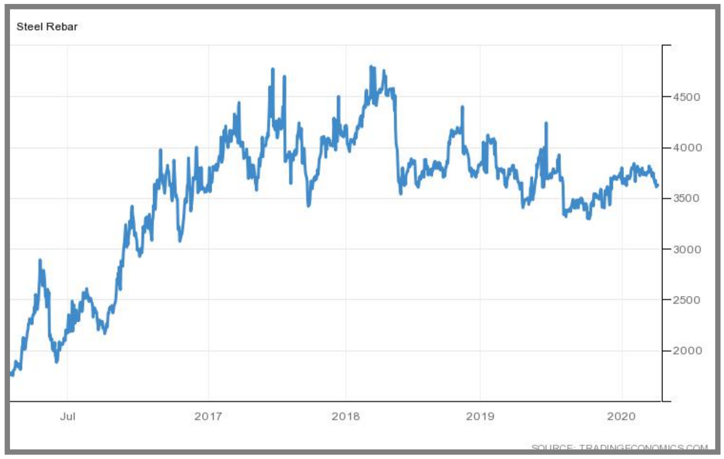

Figure 2: Cost of Steel 2016-2020

- Reduce scrap. Scrap is an underutilization of raw materials which can be impactful to a parts cost. While scrap material can sometimes be recycled to recuperate part of its cost, this requires additional manufacturing effort. Designing parts with stock material sizes and nesting in mind can ensure maximal use of raw materials and minimizes material waste.

- Do not overengineer, exceed original specs or overshoot customer needs. Koehler and Weissbarth note that up to 70% of a product's price is driven by specifications and design. Exceeding specifications or adding in functionality beyond what is critical to the end customer can add unnecessary cost into the product. Here are a few examples of overengineered areas outside of the usual:
    - Use of stronger than necessary part or material with excessive specifications.
    - Painted B-surfaces of parts that are not visible—as long as rust is not a concern, omitting paint can save secondary process cost.
    - Using high quality surface finishes on parts that the customer does not interact with or see up-close. Reducing the part quality requirements can greatly save part costs and reduce scrapped parts.
    - Well-intentioned part commonality efforts can lead to over-engineered products. Evaluating cost versus commonality is critical to achieving optimal cost reduction.

Renegotiating Existing Costs

A quick and efficient way to reduce product costs is to pay less for the parts and material which are currently being purchased. This can be done by negotiating lower prices with current suppliers or sourcing parts through new suppliers. Negotiating strategies are beyond the scope of this paper but it is worthwhile to note that we have found significant cost savings by quoting and sourcing parts through new suppliers.

Component Substitution

When common or off-the-shelf parts are being used, there is an opportunity to reduce cost by replacing them. We have found multiple strategies to be efficient for component substitution:

- Use standard parts or look to standardize parts to increase volume. Higher part volumes can yield lower costs for both parts that are manufactured in house or purchased from suppliers.

- Look to standardize manufacturing processes to make the most of existing manufacturing resources. If a unique manufacturing process or factory station is required for a low quantity part, redesigning those parts to eliminate this process/station will reduce manufacturing overhead and free up factory space. Alternatively, one can look at outsourcing the part to a supplier that specializes in the unique process.

- Re-use existing designs/processes to save non-recurring design/engineering costs.

When pursuing component substitutions, it is key to recognize that new components may require additional validation activities to ensure that final product specifications and quality are met—such as limited test builds.

Re-Sourcing/Out-Sourcing

As mentioned earlier, continually evaluating the cost of supplier parts and re-quoting can keep a manufacturer on top of the lowest cost opportunities. Similarly, one must also critically look at parts made in-house for out-sourcing opportunities. Often, highly specialized suppliers can offer aggressive pricing and suppliers in Asia benefit from low labor costs. Out-sourcing should be approached with some caution. Longer supply chains, shipping timing and logistics, as well as maintaining internal core competencies should be carefully considered when evaluating out-sourcing. Additionally, out-sourcing will often require similar validation activities as component substitution.

De-Featuring

Product specifications are a major driver of final product cost—specifications can account for up to 70% of product costs as previously mentioned . De-featuring is a highly involved, critical look at the product with the intent to remove features or functions which are of lower value to customers. Understanding what features and functions are critical to customers (needs) and which are nice to have (wants) is crucial when approaching a de-featuring effort. This process requires input from sales and marketing teams as well as direct customer input through surveys, focus groups and customer advocacy groups. Customer input especially should be critically evaluated: customers will often request advanced product attributes without a full appreciation of their impact to product cost. The product sales records as well as market research into competitive products should be used to correlate to the customer input. This will result in a more accurate understanding of where customers see the most value in the product. With this information, a manufacturer can make justifiable decisions to relegate standard product attributes to optional features—at additional cost to the customer—or remove low value features all together.

Conclusion

The value engineering methods covered in this paper are effective approaches when pursuing product development with design-to-cost in mind. The key to successful cost reduction—and an overall healthy product cost structure—is to make Value Engineering a continual effort throughout the product design process and in the production stages by re-evaluating supplier costs and investigating alternate suppliers, investigating part substitutions, and re-negotiating prices. Oftentimes, the need for cost reduction comes up unexpectedly and a rapid response is needed. In these cases, the most efficient approach is to target the critical high cost parts identified by ABC/Pareto method using the least impactful Value Engineering methods: renegotiation, component substitution, and re-sourcing/out-sourcing. Re-design and de-featuring efforts, while being very effective at achieving cost savings, require a greater amount of effort from engineering and design as well as product testing and validation.