International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

Automotive Product Development Lifecycle Optimization through Value Engineering and Value Analysis (VAVE) Techniques

Vinay Kumar Singh[1], Rahul Kumar[2], Rajit Ram Singh[3], Ajay Singh[4]
Tata Technologies Ltd. Lucknow[1], Tata Technologies Ltd Jamshedpur[2],
Tata Technologies Ltd Lucknow[3], Oriental University Indore[4]

Abstract: **This paper presents automotive product life cycle cost analysis & optimization through Value Engineering and Value Analysis Techniques. In India, automotive market is getting dynamic due to increased competition, entry of automotive giants, globalization, product pricing, etc. To sustain these factors, one has to come up with strategic way and focus must be given on defining product worth, functions, features, customer need, quality and identifying & minimizing the wastages during the product design & development process. This paper focuses on the value engineering and analysis techniques for optimizing the design and development cost through elimination of non-value adding processes and activities and also focuses on the VAVE principles can be effectively applied. VE is highly versatile and may be applied for cost improvements in practically all spheres like products, process, services and systems. A case study has been conducted mainly focusing on the fuel tank neck locking mechanism for selected concept evaluation based upon decision matrix & paired comparison for reduced inventory at supplier end, reduced process cost and end Customer satisfaction.**

Key words: - VE, VA, Cost containment, profit margin, product cost, SWOT analyses, Product Function etc.

INTRODUCTION

Value Engineering is a sequential and disciplined approach to evaluate the worth or usefulness of a product for the intended customer or consumers. It targets on desired functions of Product, process, service and system there by maintaining performance, aesthetics, optimum life-cycle cost, quality reliability, safety intact. It is used when the process is applied to new product development while The Value Analysis (VA) is used when the value process is applied to existing products (Gerhardt, D. J., & Rand, P. I. 2006). The Value Engineering has two dimensions worth and cost. In Indian automotive industries Value Engineering approach is not fully utilized. It's most effective approach available to identify and eliminate unnecessary costs in design, testing, manufacturing, operations, process, materials, maintenance etc. It's application to product design and development, specifications and practices is less well known, its effectiveness in these areas have been proven (Mostafaeipour, A. 2016). VE is a creative thinking which is applicable for exploring best alternative ways for carrying out the various factions at the optimized cost. A product or service is generally considered to have good value if that product or services has appropriate performance and cost.

$$Value = \frac{Worth}{Cost} \qquad Value = \frac{Benefits}{Resources}$$

Cost is what we pay for ownership of the product and worth is what we should pay for the ownership of the product expecting the same functionalities of the product. For instance; automotive music system is available in the market ranging from Rs.10,000- 35,000/- but the common customer is expecting cost to be around Rs.5,000/- which is justified. Here Rs. 10,000 to Rs 35,000 are cost of ownership of the product and Rs. 5,000 is worth.

$$Value\ Gap = Cost - Worth,\ Value\ Index = \frac{Cost}{Worth} > 1$$

$$Value\ Index = \frac{Cost}{Worth} = 1$$

Value is the most cost effective way to reliably accomplish a function that will meet the user's needs, desires and expectations (Khan, K. A., & Houston, G. D. 2000). It should be kept in mind that increasing the value of the product/services doesn't necessarily mean increasing the cost of the product. Value can be increased by increasing the benefits/worth and reducing the resources etc. Value engineering is targeted to identify and capture the low percentage of the factors in any product that affects the greatest percentage of the cost. Value engineering does not take any decisions weather this proposal is ok or not, it just provoke/tries to get people to think that there are different/ equivalent ways to perform the work. It attempts to minimize the design life cycle time. It's an exercise or technique which any body can apply in a proper defined design format under the guidance of VE specialist. It basically provides the yardstick for designing the product with optimal cost with end user expected product quality. Not only during the different life cycles of product VE can be applied but also it can be applied when project budget overruns or cost problem exist or value important is required. In such situations this proves as an important decision making tool which takes care of business & customer needs. During World War II many industries were faced problem of material shortage, during such critical situation efforts were made by industry people to use different techniques in order to retain the function of the product by either providing the substitute to the existing material or changing the product design keeping the product performance same/improved. Further, during 1947 based upon different approaches step by step system was developed and named as" Value Analysis". In 1959 the Society of American Value Engineers (SAVE) was incorporated in Washington, D.C. for connecting the practitioners and enabling the growth of the profession. In 1977 The Indian Value Engineering Society was formed. During this period different small growing American industries have adopted VE techniques to improve their product performance, profit margins and also for enhancing their market competitive position.

We can reduce the product cost by localization of imported parts, resourcing from a different supplier, design changes, value analysis, supplier negotiations, supply chain cost review, benchmarking, competitive evaluation, alternate manufacturing process & re-evaluate customer needs.

CONCEPT

VE identifies the product performance parameters wherever improvement or breakthrough is expected. Value Engineering uses the team work principle like during the product life cycle different stack holders, functions contributes the product cost, cost effectiveness is improved when all the involved uses their talent towards common goal. Value Engineering initially aimed at identifying the functions of the product via basic function, secondary function, one time function, all time function (Dell'Isola, A. 1997). The basic function is the needed performance characteristics of the product which is necessary in order to perform its operation or sell. Whereas secondary functions are additional performance characteristic of a product. All the costs which are directly associated with the performance of a particular function are known as cost of function (Smith, L. R. 2001, November). Further function cost analysis is performed to identify the component cost of a product in relation to the value as expected by the customer. The outcome this analysis is to enhance the value of the product while maintaining the cost/reducing the cost of the product without reducing its value (Sullivan, J. L., & Hu, J. 1995).

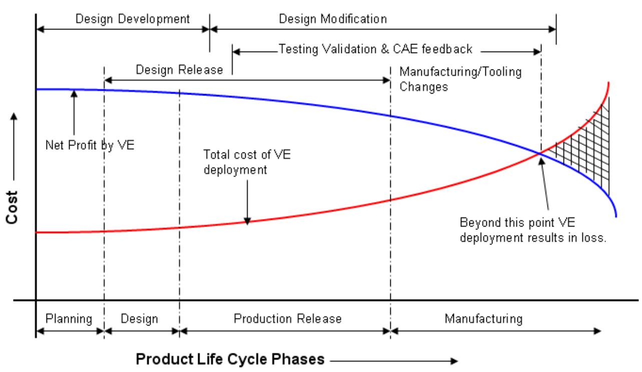

Figure 1Value Engineering Deployment Effect During Lifecycle of Product

As per above figure 1, when the product is going to through different life cycle phases VE can be deployed. But its involvement at initial stage provides more profitability and less cost of VE deployment (Asiedu, Y., & Gu, P. 1998).

Functional cost analysis can be used during Product life cycle at below stages:

1. Planning and Strategy Building, 2. Concept Evaluation, 3. Concept Building, 4. Design & Development, 5. Testing & Validation, 6. Production Release, 7. Manufacturing

1. Planning and strategy Building: This is the initial phase of any product in its life cycle. The objective of this phase is basically to understand the market requirement via market analysis, competitor data analysis based upon these product specifications are finalized. This phase also involves understanding different manufacturing options, different product proposals, sourcing strategy, marketing and export strategy, collaboration strategy.

2. Concept Evaluation: In this phase key characteristics of the product are identified along with the target customer, key competitor/bench mark product. Different concept alternative are identified.

3. Concept Building: In this stage product profile via competitive bench mark, customer requirement (using QFD-Quality Function Deployment) is completed. This also involves performance and weight analysis, finical analysis, styling and specification development with this stage product specifications, feature list, test plan of the product, styling and packaging are freezed.

4. Design & Development: Here concept packing, layouts functional performance are confirmed. For proto type to build design release starts. Cost and weight targets are fixed manufacturing process facility plans are defined for product, styling is reviewed and approved this also evolves design analysis and simulation, DMU – Design Mockup.

5. Testing & Validation: In this phase initial proto models of the product are prepared based upon the released design. Further this proto types are subjected to functional performance test, validation. Cost and weight targets are checked against defined one. Tooling and Component reliability test plans are defined. In this stage proto types are builds and tested for durability and reliability and refinement. The parts which developed with the help of final tooling will be finally tested for validation in this phase lesser design modifications are expected.

6. Production Release: In this phase conformability of tooled up parts and production equipment and facility have been commissioned. This also ensures completion of design and validation of the product and gives clearance for the final production facility.

7. Manufacturing: In this phase pre-lunch of the product happens which is transferred to end customer. This product also useful for displaying at exhibition review and advertisement.

Above mentioned different product life cycle stages contributes to the cost of the product this framework helps the organization to shorten the product life cycle time and enables for identification and resolution of the problem in the development stage itself.

METHODOLOGY

Product cost is becoming an important factor of success within industry (Roy, R. 2003). For applying VE in any product/project systematic application of recognized techniques is very important. It's kind of organized plan of action for VE deployment including implementation of recommended changes in the design and concurrent engineering concept as well (Sapuan, S. M., Osman, M. R., & Nukman, Y. 2006, Sato, Y., & Kaufman, J. J. 2005). Once the VE deployment scope area is identified from product life cycle, value engineering methodology is used which uses value engineering Job Plan. VE job plan involves, analysis of the function of the product, alternatives for design, acceptance of fact not to degrade the performance of the product expected from user & identifying the cost to perform each of the function. For the effective deployment of VE all the below mentioned job plan steps must be used along with team effort.

1. Orientation phase, 2. Information phase, 3. Function phase, 4. Creativity phase, 5. Evaluation phase, 6. Recommendation phase, 7. Presentation Phase, 8. Implementation phase

1. Orientation phase:

The objective of this phase is to understand the area where VE to be used which will lead to profit, improve product performance and increases customer satisfaction. Before starting any VE project below two things must be considered: first Product or item must show poor value or poor performance and second product or item should be of higher cost or higher volume. In case of automotive industries the product design might be of complex nature. The project where very less time given for design usually contains more scope for VE savings (Rush, C., & Roy, R. 2000, July). The components which are of intricate shape, difficult to produce or expensive provides more scope for VE study.

Index of potential = (Expected study savings / Expected study cost) x Probability of deployment (1)

Where,

Expected study savings = Product cost before VE – Expected Product cost after VE (in Rs.)

Expected study cost = VE study cost + Deployment cost (in Rs.)

Probability of deployment ranges between 0 - 100% represented by decimal. 0 % represents no probability of deployments, 100 % (1.0) represents confirmed probability of deployment.

When VE study is having higher index of cost saving potential it should be considered on first priority for VE efforts

Illustration:

Let us say we would like to introduce plastic coolant tank instead of metallic coolant tank.

Assumption:

1. Cost of existing metallic coolant tank is Rs 1200.
2. Cost of plastic coolant tank is Rs 800.
3. Expected required volume of plastic coolant tank 300 Nos.
4. Expected cost of tooling development Rs 10. Lacs
5. Expected VE study cost Rs 40,000
6. Expected deployment cost Rs 2. Lacs.

Here,

Index of potential = {(1200- 800)/ (40,000+2, 00,000) x 300}/10, 00,000 = 0.0000005

From this it's clear for requirement of just 300 plastic coolant tank, tooling development cost of Rs 10,00,000 is not worth to pay. Hence concluded for lesser index of cost saving potential VE should not be deployed.

Based upon above study it's clear that in the VE Project study where index of potential is high that should be prioritized for VE deployment.

During orientation phase objective and scope of the project should clear to the all VE team member in order to assure direction of the study. Time limitation for completion of each relevant phase of VE job plan must be prepared. All the collected information can be summarize so that team can plan further course of action for VE deployment.

2. Information phase:

The objective of this phase is to collect the adequate information of the design to be studied for VE consideration. This phase mainly consist of identifying the potential of the project for VE through studying the life cycle cost & wherever low value of the product is observed target value need to be defined and gathering of detailed information and data of the product via identify all the cost and analyze the competitor data for the same product portfolio. In a typical VE study following types of data are recorded;

3. Function phase:

The goal of this phase is to systematically analyze and describe the various functions of the product along with costs and relative worth. The customer purchases the product because it provides required function at a cost which customer is ready to pay if product fails to perform its intended function then such a product is of no use to the customer in such case value engineering cannot improve its value.

A. Classifying the product functions: For any product functions can be divided into basic function and secondary function.

- *Basic Function:* The specific function for which the product is made and designed. This is the performance feature that must be accomplished.
- *Secondary function:* It the supporting function the product performs.

Illustration:

In case of mobile phone basic function is "communicate", secondary function "aesthetic"

4. Creativity Phase: The objective of this phase is to brainstorm the basic function of high cost design elements, identify the product elements where potential of Value enhancement is available there by providing the alternate ways to perform the function of the product.

5. Evaluation Phase: In this phase different VE proposals which have been studied for product are discussed in depth using Decision matrix, Paired Comparison Matrix
6. Recommendation Phase: Objective of this phase is to collect additional data to thoroughly analysis the best VE proposals.
7. Presentation Phase: Objective of this phase is to share the recommended VE proposal in front of the decision maker committee in such manner that the best VE proposal is projected for selection.
8. Implementation Phase: The objective of this phase is to ensure that the recommended VE proposal gets implemented as per the plan so that the savings starts happening or project function enhancement whichever is projected gets reflected in actual.

I. Case Study

To support the importance of VAVE technique and validation during the early phase of product design and development, a recent case study is conducted on "Value Engineering & Value Enhancement of Fuel Tank Cap & Locking Mechanism". Following steps were used while conducting the case study,

1. *Team Information:* the value approach was started after the formation of a team comprising of nominees from different areas of product development phase including design, development, quality, finance, etc.
2. *Information phase:* the existing design of fuel tank cap and locking mechanism consist of 23 parts. Out of these, the VE approach is applied to find out the functional requirements of each of these parts so as to identify the wastage area and consequently removing those to make the design optimal. The current layout of fuel tank and its inlet is shown in figure 2. Following table shows the sub-assembly cost break-up of the existing parts:

TABLE I COST DETAILS OF EXISTING FUEL TANK CAP & LOCKING MECHANISM

Particulars	***Cost (Rs)***
Lock Assembly Arrangement	50
Assembly Cap	96
Hinge Bracket	25
Lock	120
Neck	90
Total Cost	381

3. *Function phase:* In this stage each assembly is considered for study and its different functions are identified using Verbs & Nouns process. Each components were segregated/listed on his functions (Basic/Secondary/Unnecessary). Basically in this phase we conducted a systematically analysis for describing the various functions of the product along with costs and relative worth of each components of product. Once all the functions of the parts / assly.

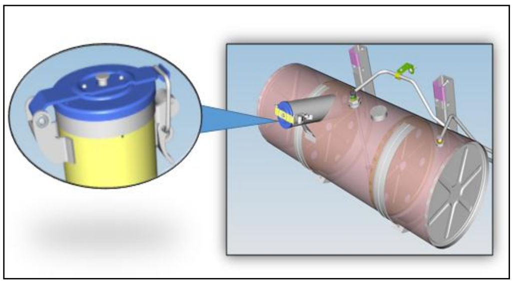

Figure 2 Traditional Fuel Tank & Cap Locking Mechanism

4. *Creativity phase:* the cost worth analysis was carried out with the brainstorming phases to find out that the total no. of components may reduce to 17 nos. without effecting the functionalities of assembly. Design optimization of fuel tank filler neck. Here length of existing filler neck which is projected inside the fuel tank can be reduced by 20% there by reducing the total raw material required for filler neck, welding operation required on the neck portion, weight reduction of assly.
5. *Evaluation phase:* the modified design was evaluate in terms of functionality, assembly, service, manufacturing, safety and maintenance to findout that the study is worth of implementation into the production and is able to meet the necessary requirements.

6. *Recommendation Phase:* Implementation of lock and key arrangement with single key for fuel tank cap locking, engine ignition & door lock Advantages are value enhancement of the existing fuel tank, saving of Rs.19/Vehicle, Customer satisfaction via. Customer need to maintain only single key for fuel tank cap locking, engine ignition @ door lock. No Need to use separate lock and reduced inventory at supplier end. The traditional locking mechanism of filler neck is having total 23 sub parts which calls for more assembly time at supplier end, increased inventory, and complex working mechanism, which requires separate key for locking which ultimately leads to dissatisfaction of customers since they have to carry two /three keys with them.
7. *Implementation Phase:* as per the above case study, the idea was further refined and implemented into the Production lot resulting into the considerable cost saving without effecting the features and quality. The following table shows the cost break-up after the design modification implementation and shows saving of Rs 19/vehicle. Modified figure is represented below:

TABLE II POTENTIAL SAVING DETAILS

Description	***Cost (Rs)***
Lock Assembly Arrangement Removal	50
Assembly Cap Removable	96
Hinge Bracket Removal	25
Neck	90
Lock	130
Total Cost of Existing Fuel Tank cap & Locking Mechanism	381
Total Cost of New Fuel Tank cap & Locking Mechanism	372
Cost Saving	381-372 = 19
No. of Vehicles to be produced in FY 15-16 = 72000	
Total Saving = 72000 x 19 = 13.68 Lacs	

II. CONCLUSION

The product development and preliminary application of VE/VA technique is a powerful tool for product cost optimization which attacks on product design, procurement, production inventory, product assembly process, product manufacturing stages, etc. Prior involvement of VAVE techniques during concept and design stage of new product phases reduces the overall lifecycle time and reduces product cost, wastage (lean), increase product reliability, high customer satisfaction, etc. resulting in better and optimal techniques and methodologies for product cost optimization. A case study has been conducted to optimize the cost of a sub- assembly of automotive component. With the use of VAVE technique, the product cost has been optimized with around 6% reduction. The cumulative effect on the cost saving for the large lots will result into considerable amount of saving. It not only saves or optimized the product cost but also plays a great role in the overall organization profit margin. Consequently, the implementation of VE/VA techniques is planned into the major areas of automotive Product design and development across the organization.

ACKNOWLEDGMENT

This study is carried out in scope and role of VAVE technique in product design and development life cycle optimization. A case study has been conducted for cost worth analysis. The authors sincerely thank Mr Satish Kumar & Mr Yasir Abbas for design analysis support and Mr Rahul Kumar & Dr M K Arya for cost benefit analysis. The authors extend their regards towards publication chair Prof. Praveen Kumar Agarwal for his valuable comments and suggestions.

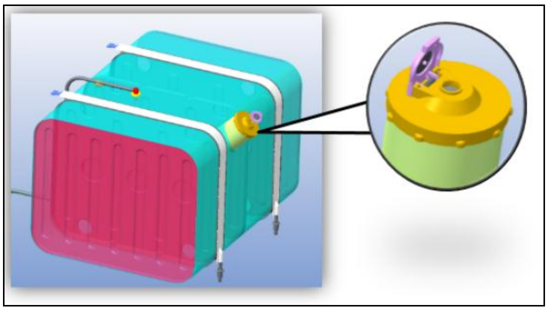

Figure 3 New Fuel Tank Cap & Locking Mechanism

AUTHOR DETAILS:

Vinay Singh did his B.E. in Mech. Engineering from SGSITS Indore in 2007.He is pursuing doctorate in Management from IMS Indore. He is currently working as Team Leader in KBE&DPDS- Tata Technologies Ltd-Lucknow.

Rahul Kumar did his B.Sc. (Engg.) in Mech. Engg. From NIT Patna in 1995 and his M.Tech. in Solid Mechanics and Design in 1998 from IIT, Kanpur. He is currently working as Program Manager in KBE&DPDS Tata Technologies Ltd-Jamshedpur.

Prof. Rajit Ram Singh did his ME in Digital Electronics from IET Indore. He is currently working at Oriental University Indore as TPO.

Prof. Ajay Singh did his ME in Thermal Engineering from Patel Institute of Technology Indore and is working at Mathura Devi institute of Engineering Indore.

REFERENCES

[1] Khan, K. A., & Houston, G. D. (2000). Design optimization using Life Cycle Cost Analysis for low operating costs. BOMBARDIER AEROSPACE DOWNSVIEW (ONTARIO).
[2] Mostafaeipour, A. (2016). A Novel Innovative Design Improvement using Value Engineering Technique: a Case Study. Journal of Optimization in Industrial Engineering, 9(19), 25-36.
[3] Sapuan, S. M., Osman, M. R., & Nukman, Y. (2006). State of the art of the concurrent engineering technique in the automotive industry. Journal of Engineering Design, 17(2), 143-157.
[4] Smith, L. R. (2001, November). Six Sigma and the evolution of quality in product development. In Six Sigma Forum Magazine (Vol. 1, No. 1, pp. 28-35). ASQ.
[5] Gerhardt, D. J., & Rand, P. I. (2006). Managing value engineering in new product development. Value World, 29(2), 26.
[6] Roy, R. (2003). Cost engineering: why, what and how?
[7] Dell'Isola, A. (1997). Value engineering. Practical Applications… for Design, Construction, Maintenance & Operations. RS Means Company Inc. Kingston MA.
[8] Sato, Y., & Kaufman, J. J. (2005). Value analysis tear-down: a new process for product development and innovation. Industrial Press Inc.
[9] Sullivan, J. L., & Hu, J. (1995). Life cycle energy analysis for automobiles (No. 951829). SAE Technical Paper.
[10] Asiedu, Y., & Gu, P. (1998). Product life cycle cost analysis: state of the art review. International journal of production research, 36(4), 883-908.
[11] Rush, C., & Roy, R. (2000, July). Analysis of cost estimating processes used within a concurrent engineering environment throughout a product life cycle. In7th ISPE International Conference on Concurrent Engineering: Research and Applications, Lyon, France, July 17th-20th, Technomic Inc., Pennsylvania USA (pp. 58-67).