WHITEPAPER

Value Engineering: Cost-reduction of On-Road & Off-Road Vehicles

Amit Gilotra
Dhruvil Kandoi

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L&T Technology Services

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Abstract

This Paper presents a study on the cost reduction of On-Road and Off-Road Vehicles using the Value Engineering approach. Value Engineering is an effective tool in identifying areas where cost reduction can be achieved. In order to effectively do this, various approaches in specific areas of focus are discussed.

Keywords - Value Engineering, Cost Reduction, Automotive, Product development.

1. Introduction

Since the beginning of the automotive industry’s history, the major automotive companies have pursued several differentiation strategies in the production of passenger cars. Technology and market changes created potential for Henry Ford to modify the rules of the game by adopting the classic strategy of leadership by cost, based on lower production costs of a standard model sold at low price. Ford dominated the industry quickly at a world level. However, by the end of the 1920s, economic growth, growing familiarity with the automobile and technological changes had created adequate potential for General Motors to change the rules once again, using the strategy of differentiation with a wide range of products and details at a premium price. With the growing increase in competition, in the most recent decades, companies sought to create higher value in their products for customers. Japanese companies like Toyota succeeded in doing so, with products of higher quality at a lower cost. Therefore, Automotive Original Equipment Manufacturers (OEMs) must include projects designed to lower product cost and to enhance the value to the customer as growing competitiveness, leads to customers demanding products with better quality and functionality, without an increase in price (Roy et al., 2004). The performance of a product and a good part of its cost are defined in its development (Dekker and Smidt, 2003) and for that reason, in order to optimize these two parameters, a correct approach of cost management in the PDP is necessary.

This paper demonstrates the importance of developing products not only with quality, but also with cost and functionality in conformity with customer values. These three characteristics, denominated as the ‘‘survival tripod’’ by Cooper (1995) and Cooper and Slagmulder (1997), are considered as rules for the success of companies, which should balance this tripod in accordance with market requirements and the company strategy. Also, according to Cooper and Slagmulder (1997), the correct term should be ‘‘cost management’’ and not ‘‘cost reduction’’, because the latter simply implies the reduction in functionality and quality of products, while the real task would be to provide exactly the same function with better quality, but at lesser cost.

2. Scope of the Study

The scope of the paper encompasses the cost reduction exercises performed on three off-road vehicles, one on-road electric utility vehicle and one on-road hybrid vehicle. Areas of powertrain were excluded from the scope of the study for the very reason of a huge re-engineering and changeover cost involved with any change in these areas. Also the study does not look into the aspects of de-contenting/de-featuring of the vehicles in order to reduce cost.

3. Which "Costs" to Target for Reduction?

An automobile is a complex system made of multiple sub-systems and interfaces. Thus when a cost reduction exercise targets a complete automobile it becomes imperative to understand the build-up of costs in the product. A cost build-up in a vehicle starts right from the concepts designed for the simplest of the support brackets up to the last operation on the assembly line and further till the vehicle lands in the display section of showroom. Of the various costs that come into picture during this process, there are many which can be directly controlled and few which would otherwise need a large scale re-engineering of the complete vehicle programme to achieve control over the cost.

Starting with the final built-up cost i.e. the sales price of the vehicle, it is made up of two components: price to dealer and dealer's commission. The component of price-to-dealer is made up by summation of total cost of vehicle and cost of sales. The total cost of sales again is a combination of total manufacturing cost and general overheads. This total manufacturing cost is once again made up of components such as total direct material cost, cost of value addition (i.e. assembly, painting, testing, etc.) and factory costs and overheads. Hence it is the total direct manufacturing cost of the vehicle that becomes the base reduction cost as there is no engineering control over the other components.

4. Cost Flow Analysis

Similar to Value stream mapping, the first step in this exercise is to understand how the cost flows inside the vehicle. This helps in the identification of and differentiation between high cost items and low cost items in the vehicle. Based on this knowledge of the cost, we judge whether the cost of any component justifies its function or rather the value it delivers. Also known as the Function Cost Worth(FCW) Analysis, it helps us in realizing and shortlisting areas with high, medium and low potential of cost reduction.

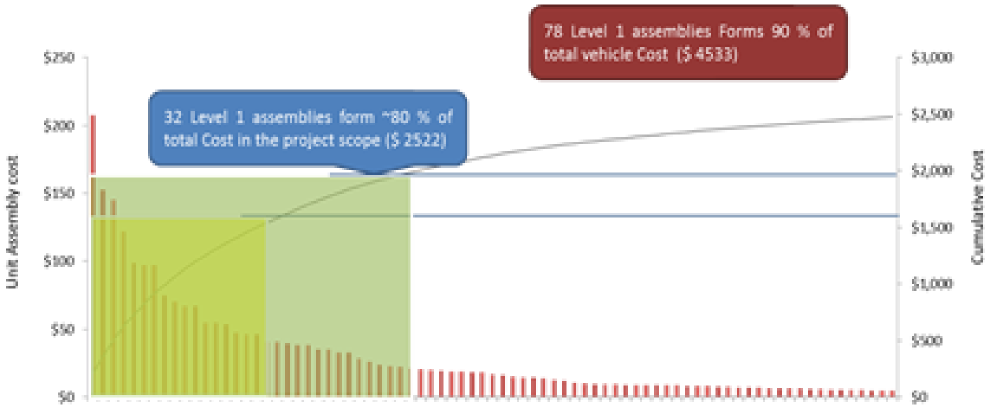


Fig. 1: Cost Flow Analysis of Level 1 assemblies of an off-road vehicle showing areas of high and medium potential reduction.

As highlighted in fig.1, out of 78 level 1 assemblies, 32 assemblies constitute almost 80% of the total vehicle cost. Thus these assemblies present the first areas that would be targeted for the cost reduction. This analysis presents to us a roadmap for the rest of the cost reduction activity as now, with the knowledge of reduction potential we can actually prioritize and target strategic areas of reduction, thus allowing us to approach the complete vehicle systematically.

5. Approaches to Cost Reduction

The overall approach to the complete cost reduction is multifaceted and involves many variables like form, function, fit, etc. that need to be looked into and balanced both in isolation as well as in conjunction to others evaluating the downstream implications of these on the overall design. Thus there needs to be an outline which helps in systematically evaluating the designs as well as ensuring a broad level perspective on all major aspects of the product development.

5.1. Direct Material Cost Reduction (DMCR)

This is first and one of the most direct approaches to cost reduction. Cost reduction via material can be realized in two major ways, first is to reduce the material from any design while second is to design with a cheaper material alternative. Before going for a material reduction, it is important to understand the end function of the design and analyse how the design behaves under load conditions i.e. how are the stresses generated and distributed in the design. This can provide insights into areas which may have significant material but do not contribute much to the load sharing in the design. Such areas can be re-designed with less material and yet not change the form of the component significantly.

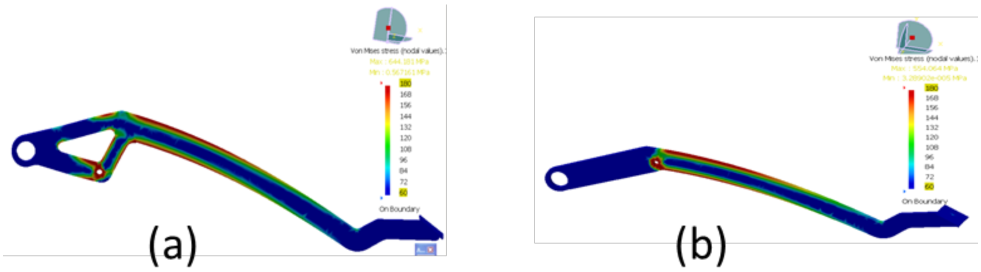


Fig. 2: Redesign of brake lever: (a) existing, (b) proposed.

The redesign of a brake lever, shown in fig. 2, is an example of cost reduction through material reduction. Based on the study of load distribution through the existing lever, a re-design is proposed with similar stress distribution pattern. The re-designed lever has 28% less material compared to the existing.

Other approach of DMCR is by re-designing the existing component using an alternate material. In this approach many aspects of the initial design such as load bearing capacity, size, shape, manufacturability and other parameters are altered due to change in material. Thus the re-designing in such cases is extensive or sometimes completely new. It is important to keep in mind that when the material of the existing design is completely changes, there are many downstream implications of raw material, inventory, manufacturability and processing, assembling, handling, etc. that come into picture and so does the costs attached with these. Thus it is of utmost importance that the cost reduction is calculated considering the changes in the downstream cost components.

Fig. 3 shows an example of plastic cargo box which has been redesigned in sheet-metal. In this changeover from plastic to sheet-metal, all the downstream costs such as tooling, assembling, welding, etc. has been evaluated and compared to each other and the calculations present a savings of $36 per piece over the plastic variant. The new design has an added advantage of better load handling over the previous design. Hence, a change of material in this case has not only saved cost but also improved the end function of the component which is an additional value proposition to the OEM.

Fig. 3: Redesign of Cargo-Box: (a) new design in sheet-metal.

A third approach to DMCR is to go for a Weight optimization of complex components using Finite Element Analysis (FEA) Techniques or to perform a Factor of Safety (FOS) Analysis on the existing designs to identify areas with more-than-necessary material conditions.

5.2. Manufacturing Process Cost Reduction (MPCR)

The Manufacturing Process Cost Reduction approach focuses on the manufacturability and assembly aspects of the designs and to evaluate and identify possibilities of manufacturing the same component using alternate cost effective processes, or look for changing the way of assembling of components or their level of assembling or the type of fastening techniques and such other aspects. A secondary objective of this approach is to save cost through simplification of the overall production process and reduce lead time. Although these factors indirectly influence the design still they are important and integral to the overall vehicle cost and hence an evaluation of these aspects becomes imperative.

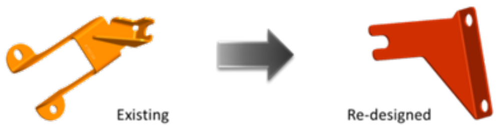


Fig. 4: Redesign for Manufacturability (DFM) of Shift Cable Bracket

Fig.4 demonstrates the MPCR approach by highlighting how minor re-designs can lead to better manufacturability of the components. They can not only improve their end functionality but also simplify the overall design in the process. Yet the reach of the MPCR approach is not limited to design of components but can be extended over the improvement and simplification of manufacturing processes too. Fig. 5 highlights this point in much detail.

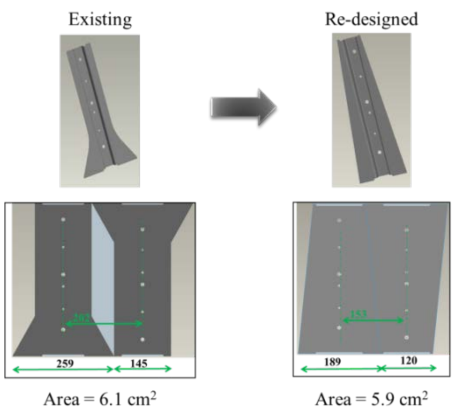


Fig.5: Redesign of chassis support for reduced sheet scrap

Fig. 5 shows the re-designed chassis support along with the strip layout before and after the redesign. A minor change in the profile of the pillar had improved the strip utilization by 24% and helped lower the corresponding scrap losses and the costs associated with each respectively. Similar to the examples discussed above the same approach can also be effectively utilized to analyse the assembly aspects of the designs.

Fig. 6: Redesign for Assembly (DFA) of Suspension Control Arm

Fig. 6 shows the redesign of suspension control arm of a double wish-bone type suspension. The initial suspension arm was fabricated using 10 pieces welded together. Also a closer look at the design would show that the welds would experience shear stresses when under load. The re-designed arm improves the existing design in many aspects. Firstly, it reduces the piece count to 5 with is straightway half of the existing. Secondly, the new design has pieces welded together in such a manner so that the welds do not experience any loading but the loads are shared by the structural members themselves. Thus, this redesign not only reduces cost but also maintains the end functions and reduces the failure rate of the design.

5.3. Parts Standard Cost Reduction (PSCR)

The Parts Standard Cost Reduction approach focuses on bringing about standardization in the designs. This also means to improve the overall modularity of the systems as well as to promote part commonization as much as possible in the overall design of the vehicle. One of the biggest areas where cost reduction through standardization can be realized is the use of fasteners throughout the vehicle. This would need a study and documentation of all the fasteners used in the vehicles and then analysing the variety of fasteners used. Based on the criticality of the area of application, decisions can be made on which sizes of fasteners can be replaced by the next higher common size. From the design standpoint, this may be an area where a replaced fastener may be of a higher specification then demanded by the design and the design may be said to be an overdesigned one, but by increasing the volume of fasteners of specific size we are actually reducing the variety and hence all the costs related to a particular type can be completely eliminated. Fig. 7 highlights the recommendations for reduction in fastener variety for a particular complete vehicle.

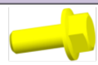
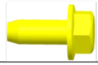
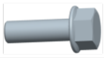
Conclusion	Part No.	Description	Qty.	$ Cost/Unit	Image
Preferred	7518702	BOLT-M8X1.25X20,HXHDFLG	6	0.054625	
Can be Replaced	7518555	BOLT-M8X1.25X20,HXFLG	12	0.110513	
Can be Replaced	7516734	SCR-M8X1.25X25-HX/FL-Y/D	5	0.06767575	
Preferred	7512094	SCR-#14X1-1/4 LG,HI/LO/TAPER-M	9	0.06662325	
Can be Replaced	7512098	SCR-#14X1.0 LG,HI/LO/TAPER-M	5	0.08514725	
With reference to the all above fastener commonization exercise, we can eliminate 13 part counts.					

Fig. 7: Fastener commonization study (Not complete list)

Similar to fastener commonization, there can also be commonization possible between variants of the same vehicle. This not only eliminates many components which otherwise would have been fulfilling same end function in the variants of the vehicle but also brings about uniformity in the operations. All these leads to reduction of the many cost components otherwise attached to these different designs and accumulate in the overall cost built-up.

Fig. 8 presents an example on the commonization of steering assembly between similar products A & B. The costs associated with each of the components in the assembly are indicated with the images and overall assembly costs are mentioned.

Another interesting observation that was made here is the minimum cost (in USD) for each type of component and whether a common steering assembly can be designed to suit both products using the minimum cost components.

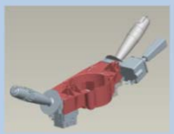
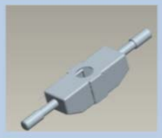
Components	Cost	
	Product A	Product B
STEERING WHEEL ASM	 24.30	 26.63
STEERING COLUMN	 83.32	 49.77
ELECTRONICS	 37.73	 45.85
TOTAL (STEERING ASM)	148.98	122.25

Fig. 8: Commonization of steering assembly of on-road utility vehicles

5.4. Supply Chain Cost Reduction (SCCR)

Countries like India and China, with their new found capabilities of cheap labour and large scale high volume production, present opportunities for low cost sourcing. It has been realized that for many of the sourced components, landing costs of parts sourced from these countries are much less than those from European manufacturers. Additionally, cost reduction can also be realized by locating of sources nearer to the production facilities or markets rather than to stick with the existing supplier base.

Second area of focus on the SCCR approach is the assessment of logistic network and optimizing these costs through re-design for improved containerization and improved handling.

Although the approaches discussed here are in isolation yet most of the time the areas and approaches overlap. It is obvious that re-designs in any of these areas have downstream implications to the overall system and hence the best way out is a design which encompasses combination of best possible attributes of all the above approaches. The discussed approaches to cost reduction merely provides an outline to a systematic study of the entire vehicle but it is the job of the engineer to objectively evaluate the downstream engineering changes such as tool changes, process changeovers, assembly line modifications, and others. The key to any successful re-design lies with a smart trade-off between many of the design variables which affect the overall design of the vehicle.

5.5. Cost Reduction through Design Innovation (CRDI)

Fig. 9 shows the redesign of a chassis of an on-road utility vehicle from backbone type to ladder type. With a new ladder type chassis, it became possible to relocate battery boxes, eliminate counterweights, simplify overall routings, install cheap leaf suspensions in place of costly double wishbone suspensions, and reduce the weld in the chassis by 60%. Additionally, it improved the stress distribution on the chassis and eliminated high stress areas having high chances of failure thus in turn improving product life.

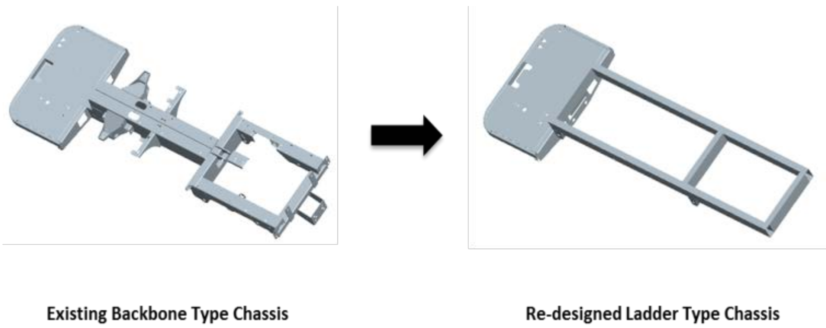


Fig. 9: Chassis Redesign from Backbone to Ladder Type

Not often we come across changes or redesigns which can trigger resultant engineering changes to such a scale that it becomes an almost new product development in itself. Also the changeover investment is huge and with longer periods for Return of Investments (ROIs). Such changeovers can be justifiably termed as Cost Reduction through Design Innovations. While these provide an unprecedented scope & flexibility for changeovers, CRDI also have the highest changeover costs linked with them and hence although powerful, these are tools that must be used judiciously.

CRDI can be effectively realized in terms of system level simplification, as in the case of example shown in fig. 9 where a complete vehicle layout is simplified. These Innovations should target towards a systematic combination of multiple functions in turn eliminating several others and thus lowering the cost. The cost reduction proposals attached to such Innovations have to be considerably larger in order to manage ROI periods.

6. Project Outcomes

The various approaches discussed above, helped to carry out a systematic study and re-design of systems and components pertaining to on-road & off-road vehicles have also helped achieve a successful cost reduction for each of the vehicles. Table 1 lists the cost reduction numbers achieved against the various products.

Table: Final cost reduction figures for various vehicles

Product	% Cost reduction
Off Road Vehicle 1	8 %
Off-Road Vehicle 2	12 %
Off-Road Vehicle 3	11 %
Electric On-Road Vehicle	19 %
Hybrid On-Road Vehicle	16 %

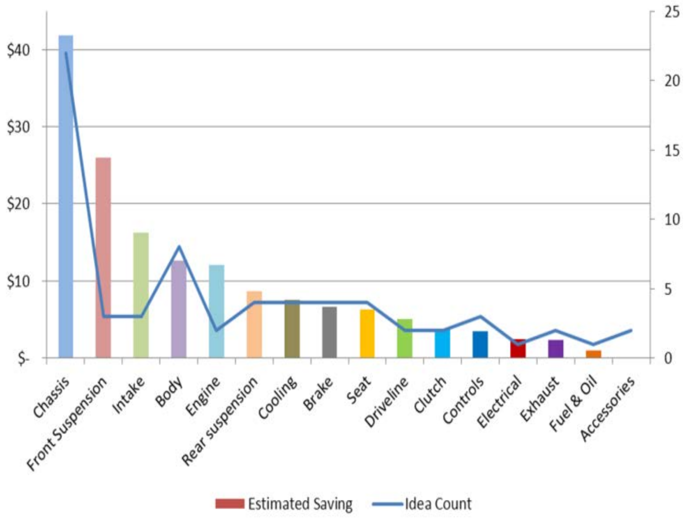


Fig. 9: Module wise cost savings & idea count for Off-Road Vehicle 3

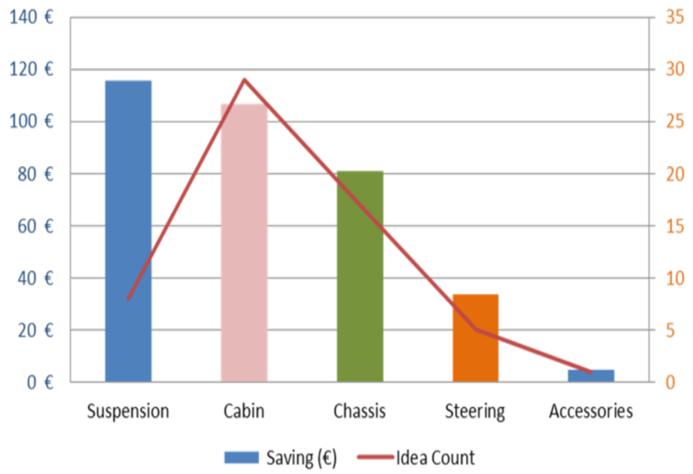


Fig. 10: Module wise cost savings & idea count for Electric On-Road Vehicle

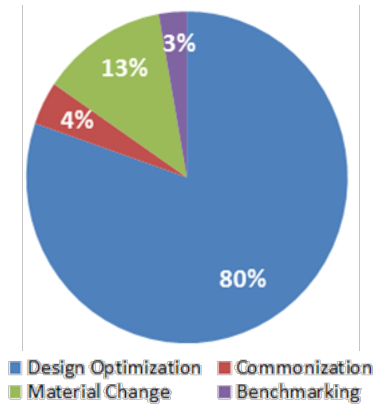


Fig. 11: Approach-wise cost saving percentages for Off-Road Vehicle 3

7. Conclusions

The exercise was collaborative effort by L&T Technology Services and a client, who as a process, had been constantly reducing cost of their vehicles over every year. L&T Technology Services was invited to take a fresh look at the selected vehicles for Value Engineering of the vehicle. This was a "First time" for L&T Technology Services & the major challenges were to precisely identify which costs to reduce and at the same time manage the downstream implications on the overall engineering changes, implementation period, costs of change-over and expected ROIs. In answer to these challenges, a multifaceted approach to cost reduction was employed. The areas of major focus were: Chassis, Suspensions, ROPS, Intake System, Seats, Trims and Electricals. The cost reduction cycle also employed special exercises such as FEM analysis, Material optimization for plastic and casting components, Welding optimization, Cost vs. Weight Analysis and human simulation.

With this designed approach L&T Technology Services have been able to successfully offer a 8-19 % reduction in cost per product to the client, leading to the beginning of a promising engagement in the niche area termed "Special Projects" with specific focus on the activities of Vehicle Teardown, Competitor Benchmarking, Should Costing and Sourcing, and such other exercises enabling the customer to gain a competitive edge in an already mature market & re-vamping products for market re-launch.

Today L&T Technology Services has completed projects amounting to USD 3 Million and have prospects worth USD 2 Million in pipeline. L&T Technology Services, not only has created a successful long term partnership with the client but has also added a unique offering to its list establishing itself as one of the first and foremost runners in the areas of Vehicle VAVE.

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