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WEIGHT REDUCTION OF FLYWHEEL APPLYING VALUE ENGINEERING: A CASE STUDY

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ABSTRACT
In this paper the concept of Value Engineering, its job plan and the effective implementation of it through a case study approach has discussed. This work presents the basic fundamental of Value Engineering and its different phases that can be implemented in any product to optimize its value. A case study is discussed of a flywheel in which the material of the product is changed according to the value engineering methodology. The material is chosen such that the weight is reduced without affecting the value of the product and its design. Hence the weight is reduced as a result of the analysis.
Through the application of Value Engineering profits are maximized without hindering the reliability of the product. With the effective utilization of the technique the final outcomes comes out to be a successful showcase of value engineering.

Keywords: Value analysis/Value engineering, FAST diagram, Weight analysis, various phases of VE, Case study.

INTRODUCTION
The concept of value engineering had come in to existence during World War II, when the manufacturing industries were facing the problem of material shortages as the consumption increased for war needs (Charles et.al. 2005). Value engineering has been successful implemented in several construction projects worldwide (USEPA, 1977). In India some value engineering concept have been in practice in construction industry since last two to three decades but in industrial sector there is complete lack of understanding of different concepts of value engineering and methods of its implementation.
Value engineering is a problem-solving approach based on creative and positive thinking that is used to fulfil the required function(s) and provide the appropriate quality at the minimal cost. It is also considered as a process, a methodology and a job rather than a program. Value engineering requires significant upfront planning and time to secure full savings benefits. The biggest obstacle in executing the VE projects is often the needs to validate the product design changes and to solve issues like cost, time, and risk (Mansour Farid Fam 1999). Tabatabai-Gargari and Elzar ka in 1998 described that how the integration of knowledge-based systems and computer-aided design systems could generate design alternatives and improve the accuracy of cost estimates, in two major steps in a typical value engineering study.
Value Analysis is a continuous improvement process driving cost reductions during the production phase of the product life cycle. In other words, VA is a creative, organized approach with the objective of optimizing life cycle costs and of the performance of a system, facility or building. The extremely simple concepts of value engineering make it suitable and applicable in different industrial sectors, like construction industry, textile industry, power sector, automobile sector etc. Within India the prospects of implementing value engineering in the corporate and Industrial sector are bright, but it required proper understanding of different concepts of value engineering.
This study aims to discuss the basic techniques of *Value Analysis & Value Engineering (VAVE)* and how cost reduction through VAVE ideas can be implement ted under the six phases (i.e. Information, Creativity, Evaluation, Development, Presentation and Implementation).
Value Analysis is an effective tool for cost reduction and the results accomplished are far greater. It improves the effectiveness of work that has been conventionally performed as it questions and probes into the very purpose, design, method of manufacture, etc., of the product with a view to pinpointing unnecessary costs, obvious and hidden which can be eliminated without adversely affecting quality, efficiency, safety and other customer features.
Value Engineering is an organized/systematic approach directed at analyzing the function of systems, equipment, facilities, services, and supplies for the purpose of achieving their essential functions at the lowest life-cycle cost consistent with required performance, reliability, quality, and safety [1]. Society of Japanese

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Value Engineering defines VE as: “A systematic approach to analyzing functional requirements of products or services for the purposes of achieving the essential functions at the lowest total cost” [2].
Value Engineering is an effective problem solving technique. Value engineering is essentially a process which uses function analysis, team- work and creativity to improve value [3]. Value Engineering is not just "good engineering." It is not a suggestion program and it is not routine project or plan review. It is not typical cost reduction in that it doesn't "cheapen" the product or service, nor does it "cut corners." Value Engineering simply answers the question "what else will accomplish the purpose of the product, service, or process we are studying?"[4]. VE technique is applicable to all type of sectors. Initially, VE technique was introduced in manufacturing industries. This technique is then expanded to all type of business or economic sector, which includes construction, service, government, agriculture, education and healthcare [5].

MOTIVATION

With increasingly competitive global world markets, companies are under intense pressure to find ways to cut production and material costs to survive and sustain their competitive position in their respective markets. Since value analysis is a key element and a good resource for a buyer in reducing such costs. Hence, development of an effective and rational value analysis model is naturally desirable.
In conditions where the market determines the price, any attempt to reduce costs or recover losses through redesign and improvement activities will provide a major return to the business throughout the life of the product. This total lifecycle saving can amount to a large financial saving.
There are many modern competitive trends and pressures that make the VA approach a valuable activity within any business.

LITERATURE REVIEW

Value analysis was the initial form of value management. It was initiated in the Second World War when materials, especially metal, were reserved by the Allied government for armaments. Therefore manufacturers needed to find alternative materials for production.
Jose Arocha (1999) studied a communication platform between industrial designers and engineering designers. Expanding on the meaning of value, the product needs to be not only mechanically efficient but also to satisfy human needs, which are often irrational. Value engineering is based on function analysis and customer information to optimize design related factors in particular situations, and has been utilized in the construction industry for many years.
Lou [2001] studied value engineering and risk management. In a complicated system development, the decision is made through an organization structure, which consists of people with different backgrounds. The undetermined factors in the project often confuse the team member in decision-making. Value engineering can be utilized as a systematic development framework and can be helpful in risk management.
Kou [2001] studied the vertical cooperate framework in Taiwan’s electronic industry. The research investigated the switching mode power supply industry to find out how to use value engineering to enhance the product function, reduce the product size and keep the thermal management ability within a reasonable range.
Venkateswaran, J., and Son, Y., (2005) In fundamental terms, VE is an organized way of thinking or looking at an item or a process through a functional approach. Value analysis is an effective tool for cost reduction and the results accomplished are far greater. It improves the effectiveness of work that has been conventionally performed as it questions and probes into the very purpose, design, and method of manufacture etc. of the product with a view to pinpointing unnecessary costs.
Dekker H, Smidt P., (2003) this challenge expresses a reduction of the cost-value-ratio of a product. Target costing and value engineering are applied to approach this ratio from different perspectives as target costing focuses on the achievement of market prices through the deduction and enforcement of allowable costs within the development of a product, while value engineering aspires the increase of value through either an increase in functionality or a reduction of resources (e.g. costs).
Prahalad CK, et.al., (2000), Firms transferred large shares of their value creation in terms of development and production to their supply chain network. As a result, manufacturing either in-house or at suppliers emerge as further drivers for costs or values of a product that need to be considered explicitly by approaches aiming for a decrease of the cost-value-ratio.
Lockamy and Smith (2000) elaborate that customer requirements are the major cost driver in manufacturing firms. Moreover, they state that TC is not necessarily focusing on costs.
Haskins C. (2010), Value Engineering (VE) is a systematic process to achieve “the essential functions at the lowest lifecycle costs consistent with required performance, reliability, availability, quality, and safety” for a certain product. VE is not focusing on cost reduction, but on an increased value. It is a function-oriented

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approach that illustrates the ratio between "what you get" (function) and "what it costs" (resource) as definition of value.

Formentini M, Romano P. (2011) determine that besides improving the value of a product, VE provides other benefits like reduce risk, improve quality, understand customer requirements of a knowledge transfer in multi-project settings.

Christopher et al. (2005) propose to take a supply chain network perspective on costs. Based on the concept of make-or-buy decisions, a component is either manufactured by the firm in-house (make-decision) or purchased from a supplier (buy-decision).

B. Likar, D. Križaj, P. Fatur, (2006), A *product* can be defined as something that can satisfy a certain need or wish of the user. The importance of physical products is not the pure fact that we owe them but it is important what the product has to offer. Physical products are only used to deliver services, and are only the packaging that has to fulfill a certain function. In a successful business system, a product must have all the necessary functions, for which we optimize costs and this is the main purpose of Value Analysis (VA).

G. Devetak, (2007), When a company develops a new product, it usually has to face with the problem of determining an appropriate price for this product. In the first step, the company has to define what it wants to achieve with the product, as this will basically take influence on the product's price range. If the company takes great care in choosing the target market and positions the product carefully, then it will be relatively easy to form the price strategy as well.

J. Cerqueiro, L. López, J. Pose, (2011), VA turned out to be a very important means for improving the quality and reducing the costs of products/services in companies which use VA. At the same time these companies can systematically orient their knowledge and the creative flow and thus create efficient competitive advantages.

Kotler Philip, John A. Caslione (2009), there are many reasons for a structured approach of the value analysis as a means of a logical cost reduction. These reasons can be divided according to their source – reasons found inside a company (insufficient information in terms of design) or reasons initiated by the product's or service's market (pricing, environmental protection, new technologies, materials etc.).

N. Rich, M. Holweg, (2000), The VA process enables the company to eliminate weaknesses at the time when production already started and therefore it stops paying for activities, which are of no value for the buyer, but only create costs, which are transferred to the buyer.

N. Rich, M. Holweg, (2000), The basic principle to offer value for the lowest or optimal production costs – directs all actions taken in the process of VA and enables the transformation of all improvement related ideas into commercial benefits for the company and its customers.

M. Leber, (2004), Value Analysis is organised as a creative method which aims at precisely and effectively pointing out unnecessary costs – costs which do not contribute to quality, provide usefulness, prolong the product's lifespan or improve the external appearance of a product and other characteristics, desired by the customer.

Semolič, (2008), Value Analysis can be defined as a systematic overview process which is used for existing or new product models for comparing a product's functions chosen by the customer to fulfil his/her demands at the lowest possible price and in accordance with the stated performance and the required reliability.

PROBLEM DEFINITION

Value Engineering is a systematic and creative effort that analyzes the function of items or systems to ensure required functions are achieved at the lowest possible overall cost. In automobile industry day to day new problems are arises which need close control so that we can save financial loss of the organization.

Despite the fact that many large automotive companies have abused and misused Value Engineering, their supply base is growing and using Value Engineering. The need to do so is real as they are all under extreme competitive global pressure to control costs.

It is general opinion that this increase in the use of Value Engineering is a result of companies needing to find the best tools available that will help them to fight the intense global competitive pressures of today. They have found that the recent popular methodologies such as Lean Manufacturing, Six Sigma, Design for Manufacturing (DFM) and others are not broad enough or powerful enough to get the job done by themselves. Value Engineering is necessary and required to help companies improve their bottom-line.

The use of Value Engineering will be essential for companies to survive in the future. The rigorous use of the Value Methodology up front needs to be formally applied, not as an "ad hoc" or lip service activity.

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WEIGHT REDUCTION OF AUTOMOBILE FLYWHEEL BY VE: A CASE STUDY

5.1 Introduction:

VE is a technique for determining the manufacturing requirements of a product/service; it is concerned with its evaluation and finally the selection of less costly conditions. VE is a process for achieving the optimal results in a way that quality, safety and reliability and convertibility of every monetary unit are improved. It is usually applied in the analysis and design of a product. In fundamental term VE is a organized way of thinking a process through a functional approach.

Society of Japanese defines "A systematic approach to analyzing functional requirements of a products or services for the purpose of achieving the essential function at the lowest total cost".

5.2 Case Study:

In this report we have discussed a part 'Flywheel' which is manufactured in automobile equipment manufacturing sector.

Value engineering methodology is applied to the flywheel. The steps used in the analysis are as follows:

1. Detailed information about the part is collected.
2. Functional definition worksheet is prepared.
3. Creative worksheet is developed.
4. Evaluation is done with decision matrix.
5. Finding and recommendations
6. Results

5.3 Current Scenario in Indian Agriculture Industry:

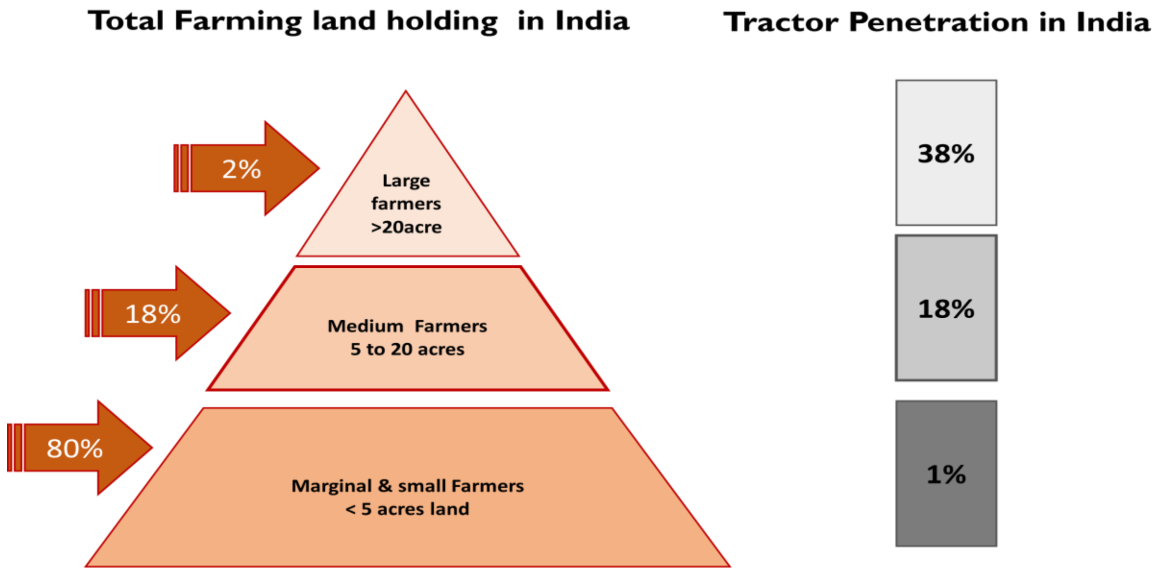

Figure 1 Current Scenario in Indian Agriculture Industry

Need: Concern from present source

Use of bullocks is very laborious.

To cultivate 1 acre of land, farmer has to walk 18 kms

Productivity less Bullock users say field operation and is very time consuming.

Requirement – In Pursuit of value

1. What functions is the customer buying?
2. What functions does he really want and need?
3. Is there a more cost-effective way to achieve those functions?

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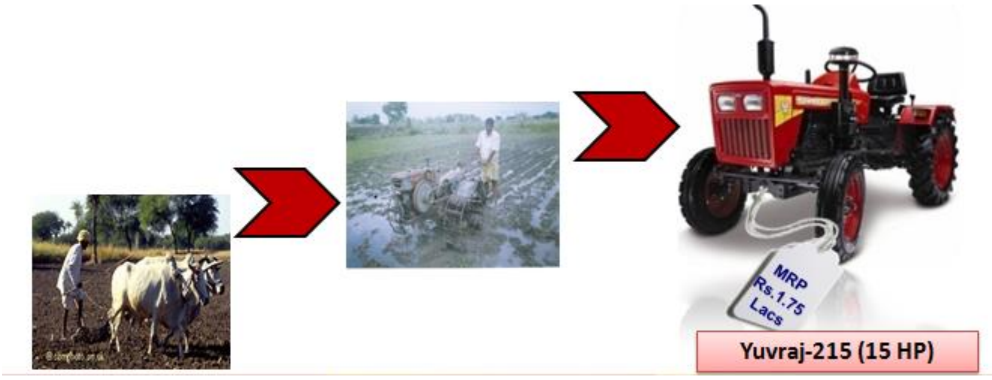

Figure 2 Yuvraj 215 tracto

Value Engineering is applied to the Flywheel of a “YUVRAJ 215 TRACTOR”.
The steps used for this purpose are as follows:-

5.3.1 VA/VE Job Plan:

The project or workshop approach is well structured and has stood the test of time. It is followed on a pre-determined time frame to arrive at a result. The job plan follows an eight step approach, as below:

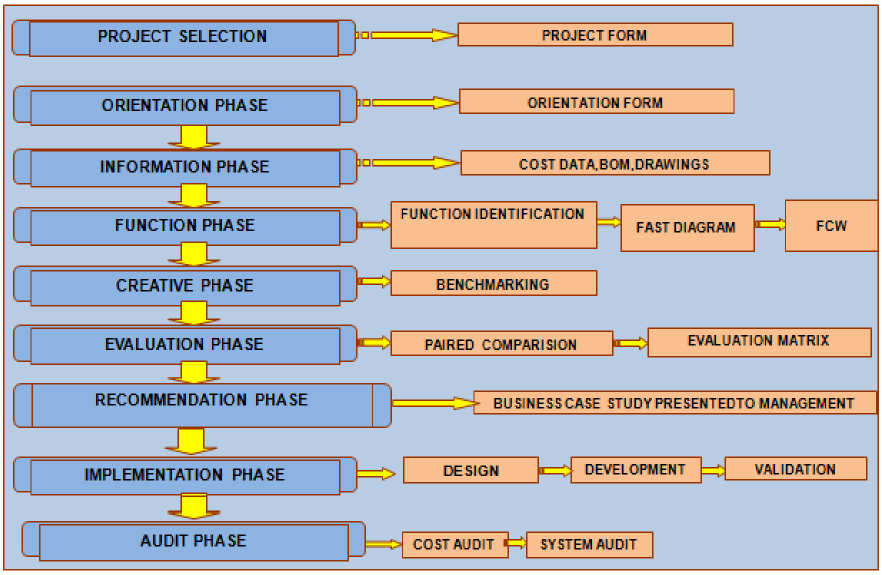

Figure 3 VE Job plan

1. Selection phase:

This phase consists of- Training, Project selection and selection of appropriate cross- functional teams. The selection of the cross-functional or multi-disciplinary team is the most important one. In the beginning, the only common thing amongst the members is the VE project. Projects are either given by the management or selected by the team. Normally the projects are selected through ABC analysis, Customer / operational- pain areas. The team decides through consensus on having a regular meeting once a week with scheduled time and venue. If the project is given by the management, the members should discuss all the positive and negative aspects of the same. If the project is to be selected by the team, they should look into the following:

Project Selection – Pareto Analysis:

Product selected is Flywheel of a tractor. The present specifications of this part and its material used are costlier than the average industry cost. Value of this product can be increased by maintaining its functions and reducing its cost or keeping the cost constant and increasing the functionality of the product.

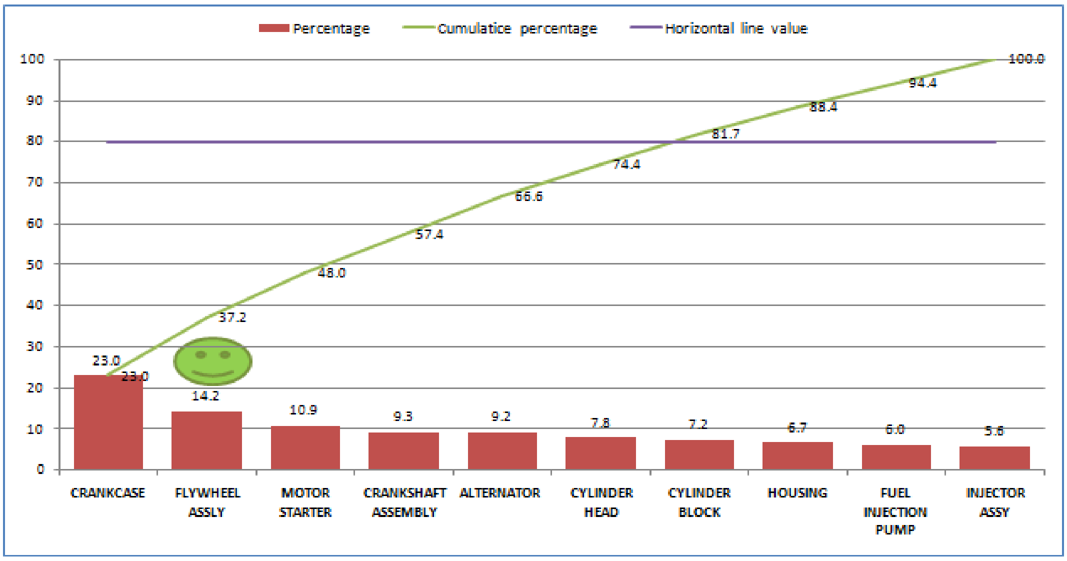

Figure 4 Pareto diagram for Yuvraj 215 Engine

2. Orientation Phase

This phase consists of- Training, Project selection and selection of appropriate cross- functional teams. The selection of the cross-functional or multi-disciplinary team is the most important one. In the beginning, the only common thing amongst the members is the VE project. However, during the training, as they learn together & work together on the project, they become very cohesive. They are able to appreciate each other's outlook and use the collective knowledge and skills of all of them.

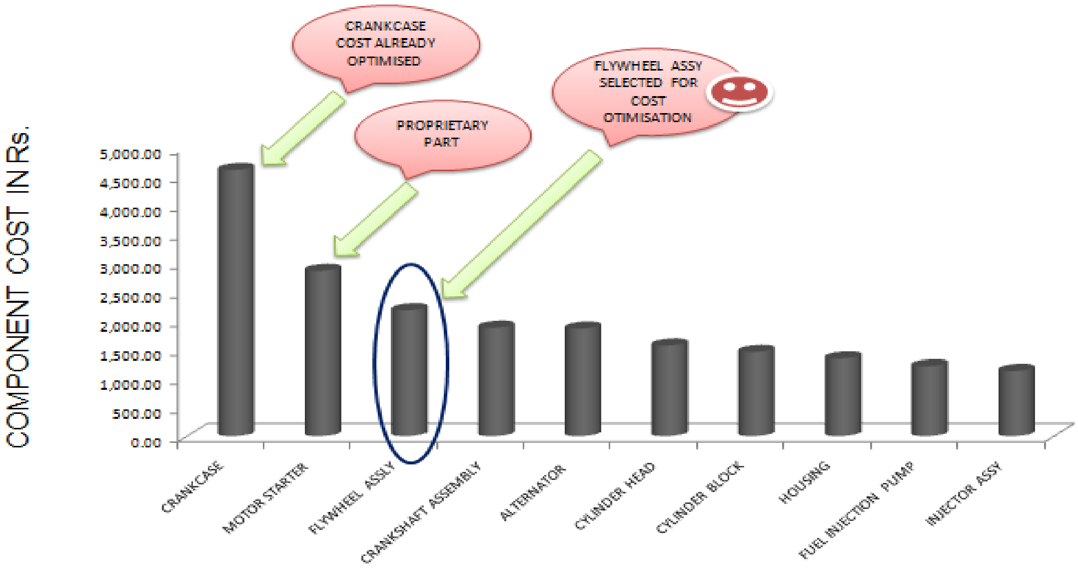

Figure 5 Components with highest cost in Agni engine

Projects are either given by the management or selected by the team. Normally the projects are selected through ABC analysis, Customer / operational- pain areas. The team decides through consensus on having a regular meeting once a week with scheduled time and venue. If the project is given by the management, the members should discuss all the positive and negative aspects of the same. If the project is to be selected by the team, they should look into the following:

3. Information Phase

After selection of the project, the team collects all relevant data. The success of the VE Project is essentially dependent on how well accurate information is collected, arranged and used by the teams. They collect the present data, such as consumption, material specifications, Item wise, operation wise costs, and design performance, standards they conform to, history, supplier quality problems, field performance, sales and marketing views. They also collect Customer feedback on performance, convenience in operation and maintenance. The data should always be collected from primary sources.

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The **accuracy of the information is most essential.** In the next phase we use this information for functional analysis.

Information Phase- Product Integration

Yuvraj Engine Specification
Flywheel assembly design
Part description : Yuvraj Flywheel assembly
Raw material : FG XXX
Cost of flywheel assembly : Rs. x/-
Weight of part : 29 Kg / Tractor

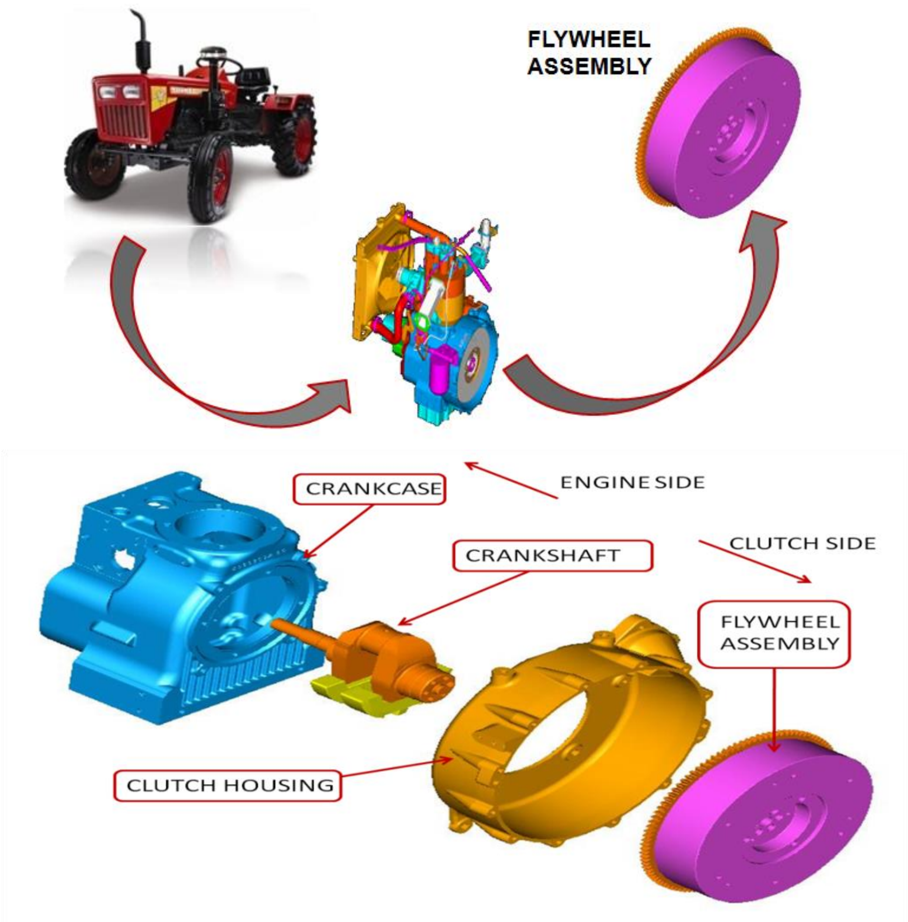

Figure 6 Flywheel assembly

4. Functional Phase – Function Identification

The gathered data is organized and the functions are defined by the team. First **Higher Order** or **Overall Function** is defined. Then each **basic** and **secondary Function** are identified and defined in 2 Words (an active verb& a measurable noun). This is very essential for identifying surplus or unwanted Functions. We also identify **use** function and **sell** functions.

All the Costs are for the functions only. Hence, we **allocate the cost** to **each Function**& thus **Function Cost** is arrived at. The Team establishes the **Worth** of the Function using either one of the Creative or Theoretical Method. The **difference between the Function Cost and Function Worth is identified as the Value gap**. This is known as **F-C-W Chart**. This helps us to identify where maximum saving potential is possible. Function-Cost-Worth Analysis or FCW Analysis is a powerful chart which helps us identify the high value gap areas for action. It must be born in mind that the value gap is the target for finding alternate way of doing. One may not be in a position to completely bridge the gap, owing to lack of technology or User acceptance.

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Table 1 FCW Chart

Sr. No.	Part Description	Verb	Noun	Function type
1	Flywheel	Store	Energy	B
2	Flywheel	Supply	Energy	S
3	Flywheel	Transfer	Motion	S
4	Flywheel	Position	Device	S
5	Flywheel	Dampen	Vibration	S
6	Flywheel	Generate	Friction	S
7	Flywheel	Mount	Parts	S
8	Flywheel	Balance	Mass	S
9	Flywheel Ring Gear	Engage	Parts	S
10	Flywheel Ring Gear	Facilitate	Rotation	S
11	Packaging	Resist	Corrosion	S
12	Packaging	Protect	Part	S

Functional Phase – Function Analysis and System Technique:

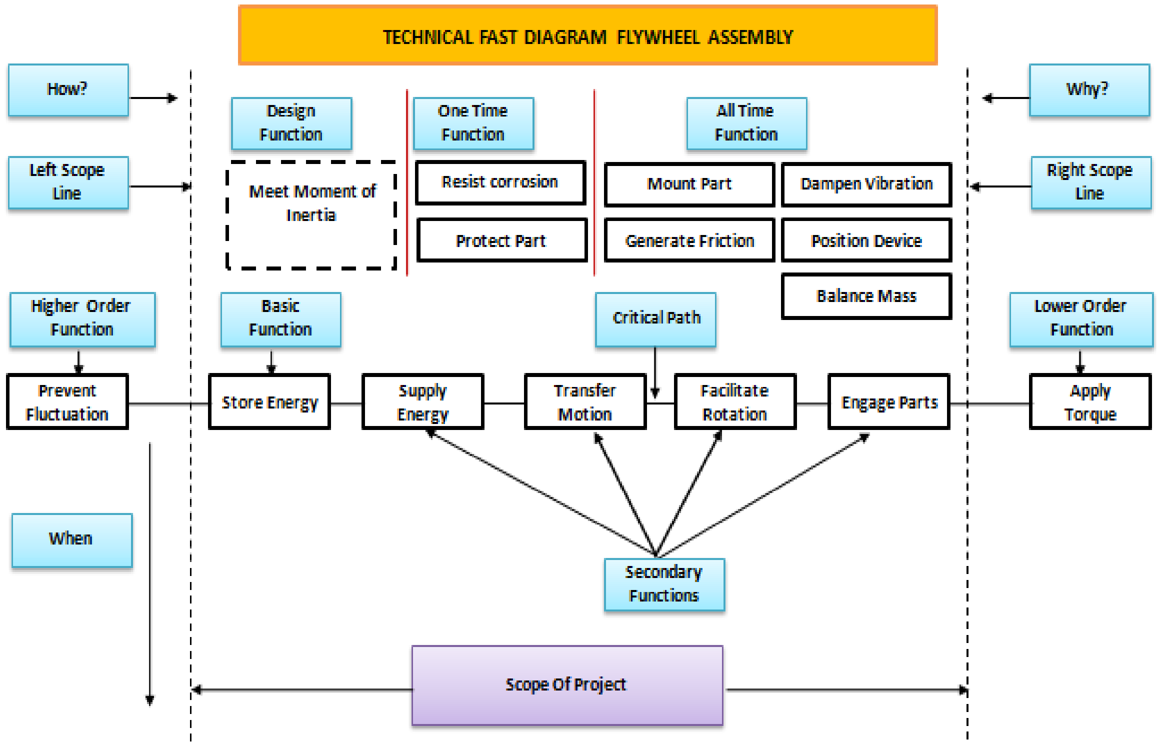

Figure 7 FAST diagram

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Function Phase – Function Cost Worth (FCW):

Table 2 Function cost worth

Component	Sub Parts	Function			Present Cost (P)	Basis of Worth	Worth cost Rs (Q)	Value Gap Rs (P-Q)	Value Index (P/Q)
		Verb	Noun	Type B/S					
Flywheel Assembly	Flywheel	Store	Energy	B	0.25X	Optimize the outer diameter	0.2X	0.05X	1.25
		Supply	Energy	S	0.1X	Optimize the weight	0.05X	0.05X	2.00
		Position	Device	S	0.01X	Delete the timing & provide alternate location	0.08X	0.002X	1.25
		Dampen	Vibration	S	0.01X	Optimize the cross section area	0.0092X	0.0008X	1.09
		Generate	Friction	S	0.02X	Alternate material	0.018X	0.002X	1.11
		Mount	Parts	S	0.02X	Alternate assembly design	0.015X	0.005X	1.33
		Balance	Mass	S	0.01X	Optimize balnace mass	0.008X	0.002X	1.25
		Transfer	motion	S	0.1X		0.1X		1.00
	Flywheel Ring Gear	Engage	Parts	S	0.15X		0.15X		1.00
		Facilitate	Rotation	S	0.2X		0.2X		1.00
	Packing	Protect	Shipment	S	0.07X	Recyclable Packaging	0.065X	0.0005X	1.08
		Resist	Corrosion	S	0.06X	Alternate oil grade	0.05X	0.01X	1.20
				Total	1.0 X		**0.87X**	**0.13X**	**1.14**

5. Creative Phase – Brain Storming

During Brainstorming these ideas were listed:-

- Eliminate Chromium & Provide Alternate Material
- Spoke Type Flywheel Design
- Eliminate Non functional Machine Area
- Use Circular Box With Scrap Metal With Chips
- Integral Ring Flywheel
- Flywheel With Pocket Type Cavity
- Use Alternative Material For Flywheel
- Optimize Flywheel Design
- Alternate Material For Ring Gear
- Reduce No. Of Mounting Bolt
- Clutch Pilot Bearing On Flywheel
- Reduce Dowel On Flywheel
- Optimize Surface Between Clutch And Flywheel
- Optimize Cast Critical Profile

Total 14 Ideas Generated.

6. Evaluation Phase

Here the team develops and refines alternate methods generated during the creative phase. These are then evaluated to select acceptable method. The team then arrives at one or more feasible methods offering the best value. This is also where lot of subjectivity could creep into the decision-making. Hence, it is essential to use the methodology that will help in selecting best overall idea, with maximum objectivity.

Ideas generated us are shortlisted with respect to:

- Performance criteria
- 'Gut Feel Criteria' on basis of experience
- Voting on ideas

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Evaluation Phase – Paired Comparison

Table 3 paired comparison

Difference	**Major : 9/1**		**Medium: 7/3**		**Minor: 6/4**	**Balance: 5/5**
	Criteria	B	C	D	E	Score
A	**Development cost**	A3 B7	A5 C5	A7 D3	A6 E4	21
B	**Validation (Performance)**		B7 C3	B5 D5	B6 E4	25
C	**Savings**			C7 D3	C5 E5	20
D	**Implementation on Time**				D5 E5	16
E	**Environmental sustainability**					18
Total						**100**

Evaluation Phase – Decision Matrix

Table 4 Decision matrix

7 out of 14 ideas taken for further analysis								
Sr. No.	Ideas	Development cost, 1 = High cost, 10= No cost	Validation 1= More time 10= less time	Savings 10=Large saving 1=No saving	Implementation Time 1=More time 10=Less time	Sustainability 10= High 1= Low	Total	Rank
	Criteria	A	B	C	D	E		
	Criteria weight age	21	25	20	16	18		
1	Alternative material Flywheel	8	3	3	8	1	449	5
2	Flywheel weight optimization	6	3	8	5	8	585	1
3	Elimination of non functional machining	8	7	2	6	2	515	2
4	Alternate material for ring gear	8	3	3	7	1	433	7
5	Optimize profile to simplify core design	5	4	5	7	5	507	3
6	Clutch pilot bearing provision on flywheel	4	4	7	3	5	462	4
7	Flywheel rim cross section	3	2	5	6	7	435	6

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	design optimize							

7. Recommendation Phase

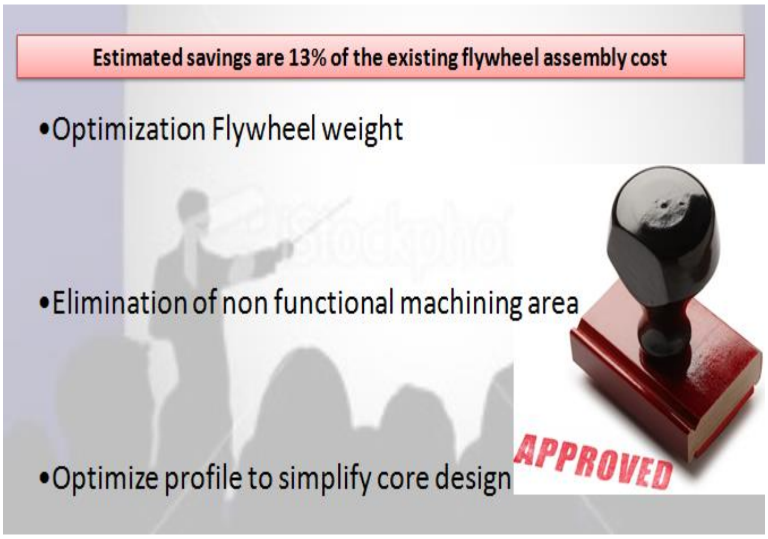

Figure 8 Recommendation phase

Clearances given to go ahead for design optimization of flywheel

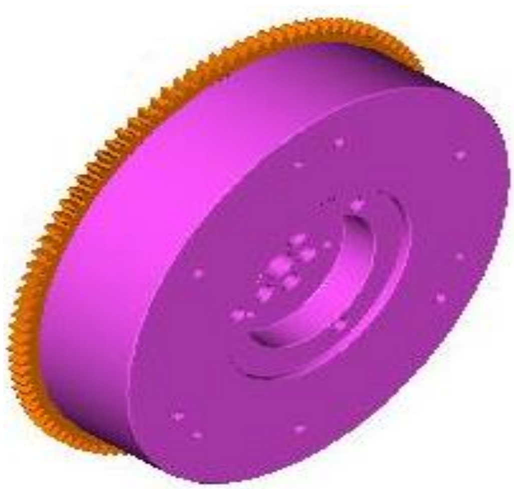

Figure 9 Optimized Flywheel

8. Implementation Phase:

- Project Planning
- Design, Design Review, DFMEA
- Drawing release for Prototype parts
- Prototype fitment trial
- Lab validation
- Tractor level validation
- Vendor part per approval process (PPAP)
- Assembly PPAP
- Start of Volume Production

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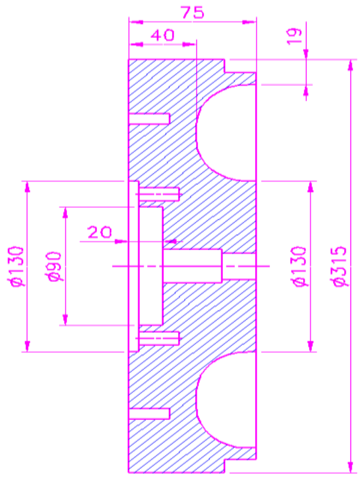
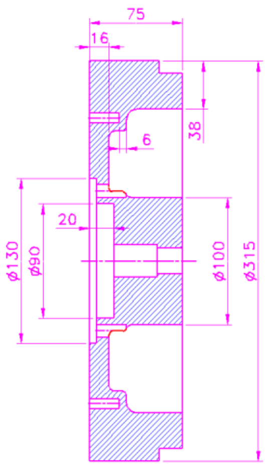
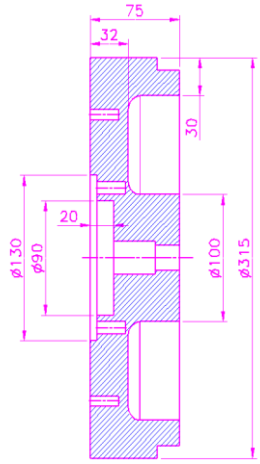


EXISTING FLYWHEEL

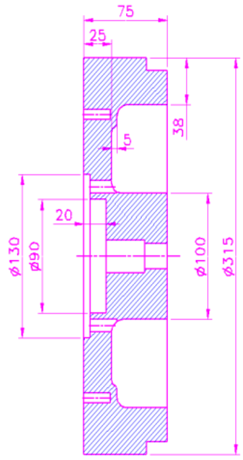
Figure 10 Existing flywheel
Weight: 29 Kg
M.I – 0.374 Kg/m^2



Proposal-1
Weight-25kg

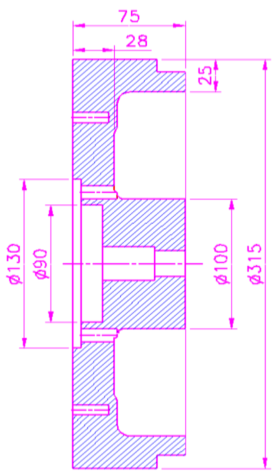


Proposal-2
Weight-26Kg

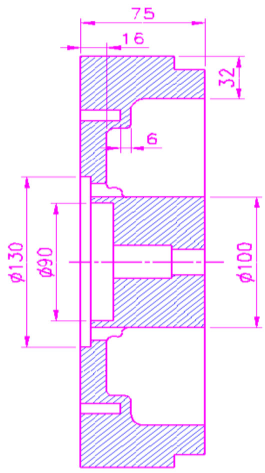


Proposal-3
weight-26.5Kg

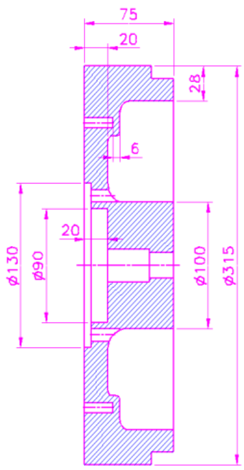
M.I- 0.376 M.I- 0.373 M.I- 0.386



Proposal -4
weight-23.8Kg



Proposal-5
Weight- 23.6Kg



Proposal-6
Weight-23Kg

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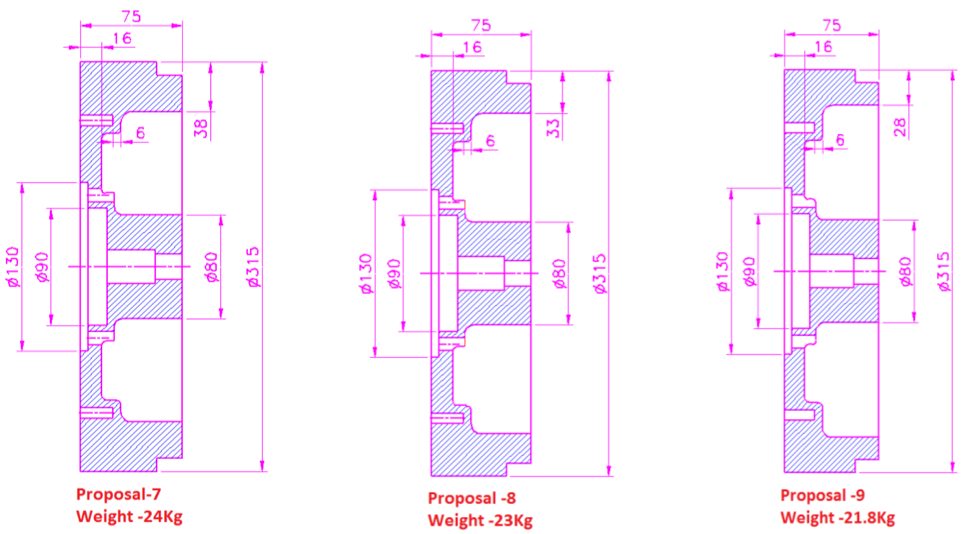
M.I – 0.339 **M.I- 0.355** **M.I- 0.343**



M.I- 0.373 **M.I- 0.355** **M.I- 0.334**

Figure 11 Proposed flywheels

Table 5 CRE proposal data

Agni Flywheel CRE Proposals data as per CAD						
Models	Weight	Radius of gyration		Moment of Inertia		Remarks
	Kg	mm	m	Kg*mm2	Kg*m2	
Existing	28.91	113.70	0.1137	373813	0.374	
Proposal 1	25.05	122.57	0.1226	376355	0.376	Weight saving by 3.86
Proposal 2	26.22	119.22	0.1192	372663	0.373	Weight saving by 2.69
Proposal 3	26.50	120.71	0.1207	386110	0.386	Weight saving by 2.41
Proposal 4	23.82	119.34	0.1193	339193	0.339	Weight saving by 5.1 but M.I. less
Proposal 5	23.60	122.59	0.1226	354684	0.355	Weight saving by 5.31 but M.I. less
Proposal 6	23.27	121.45	0.1215	343189	0.343	Weight saving by 5.64 but M.I. less
Proposal 7	24.37	123.70	0.1237	372881	0.373	MTG Profile Change & not feasible
Proposal 8	23.13	123.80	0.1238	354524	0.355	MTG Profile Change & not feasible
Proposal 9	21.84	123.62	0.1236	333814	0.334	MTG Profile Change & not feasible

Summary of CRE proposal

Table 6 Summary of CRE proposal

Description	CRE proposals									Current 3D model
Proposals	1	2	3	4	5	6	7	8	9	Existing
Mass of Flywheel (Kg)	25	26	26.5	23.8	23.6	23	24.3	23	21.8	28.89
M.I (Kg.m^2)	0.376	0.373	0.386	0.339	0.355	0.343	0.373	0.355	0.334	0.374

Proposal 1 selected for further development as Moment of Inertia is near to existing and weight saving is around 3.77 Kg.

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9. Development Phase:

Figure 12 (a) Pattern - (Drag)

Figure 12 (b) Pattern - (Cope)

CAE analysis for Flywheel design optimization

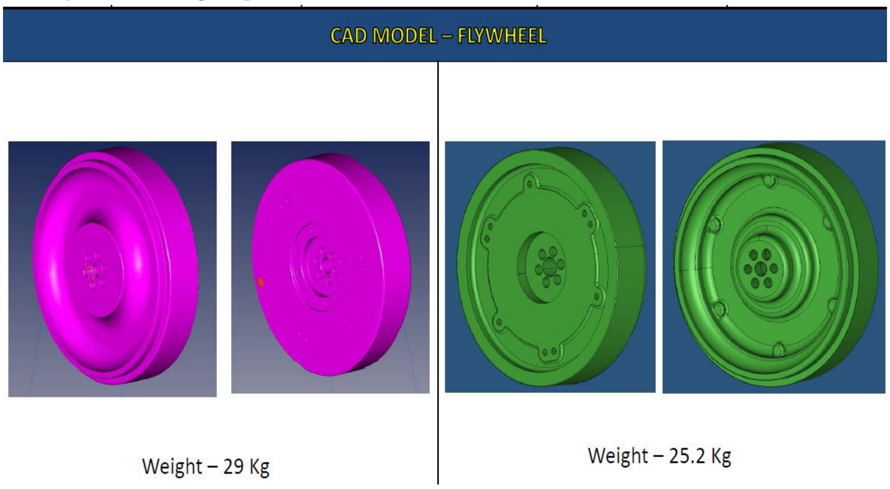

Figure 13 CAD Model- Flywheel

10. Validation Phase:

Engine Test Result:

Table 7 Engine test result

Response Time data with existing & Proposed Flywheel in Acceleration / Deceleration Test on Engine level			
No Load condition			
Existing Flywheel	Response time in Sec	Proposed Flywheel	Response time in Sec
Low idle to High idle	5	Low idle to High idle	5
High to Low Idle	11	High to Low Idle	12
Load condition			
Low idle to Rated speed	6	Low idle to Rated speed	7
Rated speed to Low idle	11	Rated speed to Low idle	10

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Figure 14 Field photographs

11. Audit Phase

Once the project is implemented and the results are achieved, it is essential to get it audited. Management will accept only an audited project and its gain as official. Technical, system and financial audits are to be done. This confirms the said savings. After verifying, the auditors intimate the management about the results.

On successful completion, the team should thank all concerned and celebrate the success

- Weight saving 3 Kg in Flywheel assembly & hence Rs. 180 per tractor
- Energy conservation & contribution to sustainability

RESULTS AND DISCUSSIONS

The goal of any organization is to increase its customer's satisfaction by adapting services and products to new standards which are according with what clients want to receive. The success of a value engineering program depends on the teams those coordinating different VE activities, which needs critical and careful observation of group dynamics such as management, team leadership, trust building and conflict resolution among different segments of value engineering systems. A FAST diagram can work as an effective communication tool because it facilitates discussions among the VE team members. Moreover the implementation of Value Analysis & Value Engineering in industry is easily feasible if all the segments of process flow chart for VAVE are carefully studied and followed.

This study illustrates the theories of Value Analysis & Value Engineering in manufacturing Industry through Go Fast Approach with the help of FAST Diagram and to identify the opportunities for its use and application as a Quality Management tool.

The present study recommends the followings for the successful implementation of value analysis & value engineering in the manufacturing sector:

- Most of the value engineering concepts are extremely sound and possess a very good application prospects in the automobile industry, but there is a lack of knowledge pertaining to its successful implementation, which can be addressed through proper guidance and education.
- It is essential to utilize value engineering concepts and implement it with broader mindset.
- The success of any cost reduction concept needs better coordination with all segments (other parties) of the value system that plays an influential role in project and component level costing.

On successful implementation of VAVE in manufacturing industry the following benefits occurred for the organization:

- Weight saving 3 Kg in Flywheel assembly & hence Rs. 180 per tractor
- Energy conservation & Contribution to Sustainability

CONCLUSIONS AND FUTURE SCOPE

7.1 Conclusions:

- From this Case Study it is observed that how the value engineering is used for the weight reduction without the change in the product design & its value. A proper decision matrix is prepared for choosing the appropriate alternative from the feasible choices available.
- Value analysis is a technique with immense possibilities, and systematically employed, it can achieve great economies and increased efficiency. Although good results have been obtained in several individual cases in

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some industries, only a large scale and systematic application of this technique in all industries, and in defense production, can result in substantial economies on a national scale.

- The Value Engineering process and procedures are generally well defined and well-understood at all levels in the industry. VE is recognized as an effective way to improve the performance of a product with reduction in cost.
- The quality (qualifications and experience) of the team leader and specialists is a key ingredient to the success of the VE program. It is more effective and influential on the performance, quality, and cost of a product when done relatively early in the production schedule.
- This valuable technique, if systematically employed, promises rich dividends, and, among other things, enables greater use of indigenous raw materials and equipment by import substitution. It is, therefore, of special significance to a developing country like India which has adopted a programme of rapid industrialization in the face of paucity of foreign exchange and other handicaps.
- Value engineering methodology is a powerful tool for resolving system failures and designing improvements in performance of any process, product, service or organization.
- The goal of any quality cost system is to facilitate quality improvement efforts that will lead to operating cost reduction opportunities. The strategy for using quality costs is quite simple.
- Continuously evaluate and redirect prevention efforts to gain further improvements.

7.2 Future Scope:

In future, VE/VA technique can used in other industry like machine building, ship building, steel industry to reduce the cost of the product and to enhance the quality and productivity of the product.

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