Chapter 18

Value analysis

18.1 What is value analysis?

Value Analysis is a major cost reduction and control techniques with systematic approach to ensure that a specific product or component is designed and manufactured to serve all the desired functions at the minimum cost without diminishing quality, reliability, performance and appearance. Since the functional value of a component is analyzed with reference to the design and engineering aspect, this technique also is called value engineering. It is a systematic and creative analysis to identify the functions of a product or a component and to provide the desired function at the lowest total cost. By eliminating the unnecessary design features which add neither to quality nor to the appearance of the product.

In short value analysis involves critical examination and analysis of the design of a component akin to the modern DFSS tool of DMAIC, with reference to its functional value. It is a systematic and creative method using proven method, to obtain the same or better performance at a lower cost so as to improve the value of goods or products and services by critical examination of its function. Value Engineering seeks to optimize value for the money in projects and emphasizes on analyzing the functional values of all design features of a component making it a special among all DFSS tools.

It has been used in almost every kind of application. It helps people creatively generate alternatives to secure essential functions at the greatest worth referred to as value as opposed to costs. It is also known as Value Management, Value Planning, Value-Added Value Engineering, Functional Analysis and a host of other names as illustrated in paragraph 18.3.

18.2 Definitions of value analysis

Some definitions of Value Analysis, which also give an insight into the technique, are:

> *A discipline action system, attuned to one specific need: accomplishing the functions that the customer needs and wants at the lowest cost.*
>
> Miles (1972).

Work Organization and Methods Engineering for Productivity.
DOI: https://doi.org/10.1016/B978-0-12-819956-5.00018-2

A proven management technique using a systematized approach to seek out the best functional balance between the cost, reliability and performance of a product or project.

Zimmerman (1982).

Systematic analysis that identifies and selects the best value added alternatives for designs, materials, processes, and systems. It proceeds by repeatedly asking "can the cost of this item or step be reduced or eliminated, without diminishing the effectiveness, required quality, or customer satisfaction?"

Business Dictionary.

Value Analysis/Value Engineering as an intensive, interdisciplinary problem solving activity that focuses on improving the value of the functions that are required to accomplish the goal, or objective of any product, process, service, or organization.

Value Engineering: The Forgotten Lean Technique by James R. Wixson.

Value engineering is a systematic and organized approach to provide the necessary functions in a project at the lowest cost. Value engineering promotes the substitution of materials and methods with less expensive alternatives, without sacrificing functionality. It is focused solely on the functions of various components and materials, rather than their physical attributes.

Investopedia.

Value engineering can be defined as an organized effort directed at analyzing features, systems, equipment and material selection for the purpose of achieving the essential functions at the lowest life cycle cost consistent with the required performance, quality, reliability and safety.

US General Services Administration.

The value methodology (VM) is a systematic and structured approach for improving projects, products, and VM, which is also known as value engineering, is used to analyze and improve manufacturing products and processes, design and construction projects, and business and administrative processes.

SAVE.

A professionally applied, function oriented, systematic team approach used to analyze and improve value in a product, facility design, system or service.

SJVE.

18.3 History of value analysis

Value Analysis was conceived by Lawrence Miles at General Electric Co. in 1945 based on the application of function analysis to the component parts of a production shop in view of shortages of skilled labor, raw materials, and component parts during World War II. While America adapted the term Value Engineering, Europe adapted the term Value Analysis. By 1952 value engineering began its growth throughout industry.

The Public Law 104−106 of US states, "Each executive agency shall establish and maintain cost-effective value engineering procedures and processes."

The Federal-Aid Highway Act of 1970 too has recognized the effectiveness of value analysis, made the first Federal Highway reference to VE, requiring that "in such cases that the Secretary determines advisable plans, specifications, and estimates for proposed projects on any Federal-Aid system shall be accompanied by a value engineering or other cost reduction analysis."

Some of the acronyms related to value Engineering are

- VA/VE Value Analysis and Value engineering
- VM Value Management
- VMd Value Methodology
- VAVE Value Analysis/Value Engineering
- FA Functional Analysis
- FAST Functional Analysis System Technique
- SAVE Society of American Value Engineers
- SJVE Society of Japanese Value Engineering
- INVEST Indian Value Engineering Society
- INVAVE Indian Journal of Value Analysis/Value Engineering.
- DARSIRI Data (collect), Analyze, Record ideas, Speculate, Innovate, Review and Implement
- CSVA Canadian Society of Value Analysis
- IVM UK Institute of Value Management

18.4 What is value?

Here the term value is distinguished from price or cost because value is more an abstract concept referring to the cost benefit aspect. It is the ratio between a function for customer satisfaction and the cost of that function. Functional worth is the lowest cost to provide a given function.

Value is a perception, hence customers will have their own perceptions on how they define value. However, we can relate value to quality, performance, style, and design in comparison to the product cost.

In fact, value is the performance of a product in relation to the function what the product or service is supposed to do in relation to the cost and expenditure needed to create it.

Value =

If the numerator is increased without increasing the denominator, Value increases. In other words, a product can be engineered for improved value by either increasing the quality, reliability, availability, maintainability, serviceability etc., for the same cost or by reducing cost for the same degree of the above factors of quality, reliability etc. In short value analysis results in more functions at the same cost or same function performed at lesser cost. The manner in which the thinking is applied gives the concept its name value analysis, and the planning the analysis in the design function gives it the name value engineering. We can say that Value Engineering is the functional aspect of Value Analysis, which refers to the analytical overall concept. This chapter hence uses the term value analysis as a synonym to the term value engineering, as cited in paragraph 18.3.

18.5 Value analysis

As stated before, value analysis is a methodology to increase the value of an object. Value analysis is a planned, scientific approach to cost reduction, which reviews the material composition of a product and production design so that modifications and improvements can be made which do not reduce the value of the product to the customer or to the user. The object to be analyzed could be an existing or a new product or process, and it is usually accomplished by a team following a work plan.

18.6 Objectives of value analysis

1. To reduce production and total cost as illustrated by the case study per paragraph 18.12.
2. To improve operational performance.
3. To improve product quality.
4. To reduce the manufacturing costs.
5. To improve customer-supplier relations.
6. Cost avoidance on future programs.
7. To reduce in product variations.

18.7 Typical benefits of value analysis projects

The benefits of value analysis, which fulfill the above objectives, can be summarized as below:

- Value analysis aims to simplify products and processes. Thereby increasing efficiency in managing projects, resolve problems, encourage innovation and improve communication across the organization.
- Value analysis enables people to contribute in the value addition process by continuous focus on product design and services.

- Value analysis provides a structure through cost saving initiatives, risk reduction and continuous improvement.

18.8 Functions of a product as the customer sees

Value Analysis is based on a study of functions of a product or service. It involves the identification of functions from the knowledge of the customer needs. The first approach to the identification of functions should be focused on basic functions. These functions are those for which the customers believe they are paying. There are usually only one or two basic functions per product or service.

All the functions can be grouped as below as per their levels of importance:

- The basic function which is the very purpose of the product or service.
- The secondary functions are those not directly accomplishing the primary purpose, but support it from a specific design approach. These can also be subcategorized as use functions or aesthetic functions.
- Use functions are those, which answer the question how the basic function is achieved. For example, if the primary purpose of a bottle is to contain a liquid, the secondary purpose can be strength to support the contents even when dropped or transparency so that the contents can be identified without opening the bottle.
- Aesthetic functions, whose purpose is only to add beauty or esteem value to the product and are associated with feelings. In the above example, the attractive color or shape provides the aesthetic function.

It is generally found that the primary functions are achieved by 20% of the total cost whereas the secondary functions account for 80% of the cost. This is the crux of Value Analysis.

Once you identify the functions, they must be written down in 2 words, a verb and a noun, as further explained in paragraph 18.10.3.

18.9 Functional value of a product

Functional value or use value of a product is the purpose the product fulfills and is an attribute that provides the customer with functional utility, which can be distinguished from other values of a product as illustrated below.

- **Cost value:** is the cost of manufacturing and selling an item
- **Exchange value:** is the price a customer is prepared to pay for the product, or service
- **Place value:** Same item may have different values at different places. For example, a glass of water in a desert.
- **Time value:** An item may have a high value at certain point of time. Once the time is passed, it may lose its value. For example, blood transfusion to a patient during an operation.

- **Esteem value:** is the prestige a customer attaches to the product
- **Fancy value:** Apart from the prestige or esteem value of possessing an esteemed commodity, this author wishes to introduce a new type of value called fancy value, when buyers consider the value of a commodity to be directly proportional to the selling price and buy them just for the fancy of purchasing a costly item. For example if a certain pair of shoes of an certain brand and quality are sold for a certain price at one shop, and an identical pair of shoes of the same brand and quality are sold at 10% higher price in a mall, some people prefer to buy from the higher priced shop, just to satisfy their fancy of buying a commodity in a fancy mall

18.10 Methodology of value analysis

The creative mind required for value analysis makes it comparable to the method study that analyzes and improves the manufacturing operations, while value engineering analyzes and improves the design factors. We can say

Method study: production:: value analysis: design

Hence the methodology for value analysis is similar to the SREDDIM of Method study, as explained in Chapter 6 on Method study. Nevertheless, in case of value analysis, it is split into 8 phases, the terminology for each phase being as follows:

The 8 phases of value analysis

1. General phase
2. Information phase
3. Functional phase
4. Investigation phase
5. Creative phase
6. Evaluation phase
7. Recommendation phase
8. Follow-up phase

18.10.1 General phase

After identifying the existing product or the process to be analyzed, its general description is given indicating the functions and design features etc., of the product as well as its components. List the basic functions (the features for which the customer is paying), as identified by the function phase.

18.10.2 Information phase

Additional data like the operational sequences or the time standards are recorded. These data would assist in analysis and in the comparison of the proposed process with the existing process.

18.10.3 Function phase

Identify and list all the functions of the product or process, for which the customer is paying. Here it is necessary to indicate each function in only two words, a noun and a verb. This enables conciseness. By trying to describe a function in a sentence, we may unwittingly combine 2 or more functions which would cause confusion in our analysis. Table 18.2 of the case study provides an illustration to this concept.

Again, while identifying a function, specify it so as not to limit the ways in which it can be performed. For example, don't say 'screw nameplate' but say 'attach a nameplate', since the nameplate can be attached not only by screwing but also by soldiering, riveting, or gluing etc. The later specification would help us in thinking of alternative solutions for this function.

Once all the functions are listed, isolate the basic function followed by all the secondary functions. This will help in our analyzing each of the secondary function is really necessary or can be done away with. Given below are the criteria and guidelines, as already illustrated in paragraph 18.8, to distinguish between the basic and secondary functions

- Basic function is the primary reason for an item or system. It is the performance feature that must be achieved if it has to perform its purpose.
- A secondary function is the features of an item which supports the basic function, and even without that function, the item can perform its functions. For example, the primary function of paint is to protect the surface, while the secondary function is to give a good appearance.

Guidelines for defining the functions

- The function shall be defined only by 2 words, a verb and a noun.
- The noun shall be measurable and/or countable.
- The noun shall as far as possible signify the design based constraint.
- The verb shall be active and effect the noun directly.
- The function shall be verifiable.

18.10.4 Investigation and creative phases

While all required data is collected and recorded in the investigation phase. It is the creative phase and is the heart of the methodology. Since these 2 phases overlap each other, they are discussed together in this paragraph. All the points discussed in paragraphs 8.5–8.7 including the brainstorming, in the chapter on 'Examine and Develop' with respect to creativity are applicable here.

The objective of this phase is to find a better way to do the main function by asking the following questions for each of the identified function and determine the relative importance of each function, preferably by asking a representative sample of customers.

- Does it contribute value? (Is there something that does not contribute value?)
- Is the cost in proportion to the function realized?
- Does it need all its parts, elements, procedures?
- Is there something else to do the same function?
- Is there a standard part that can do this function?

18.10.5 Evaluation phase

- Each idea generated should be analyzed and developed in a manner to be more logical and practical making it function better.
- Identify barriers like mind set concepts opposing the idea and discuss whether the barriers hold strongly against the ideas. Isolate and eliminate them, but after recording them for future reference.
- Choose two to four ideas among them and make a comparative study regarding the cost as well as performance.

18.10.6 Recommendation and follow-up phases

After all, since any analytical study has to be approved by the top management, it is hence imperative that the value analyst team prepares a report detailing the several factors considered as detailed earlier emphasizing the net cost saving as well as the functional improvements achieved and submit the same to the top management as their recommendation. Once the recommendation is accepted, the operatives and other related personnel will have to be trained and regular follow-up with the implementation has to be maintained. This phase is similar to the steps Install and Maintain of method study.

18.10.7 Darsiri methodology for value analysis

Some books cite a 7 step DARSIRI methodology which is similar to the above 8 phases and as follows,

1. Data (collect),
2. Analyze,
3. Record ideas,
4. Speculate,
5. Innovate,
6. Review and
7. Implement.

18.11 Function analysis system technique (FAST)

Function Analysis System Technique (FAST) is a graphical representation of the functions identified during the value analysis program. It builds upon value analysis by linking the simply expressed, verb-noun functions to describe complex systems in a logical sequence, visualize the need for and role of each major component and prioritize them.

18.12 Case study

The JLO division of the Surat Unit of the Ralli group manufactures a 25 cc petrol engines used for agricultural sprayers and cycle rickshaws. A major component of this engine is the clutch base plate of the transmission assembly, whose main function is to absorb the thrust exerted by the clutch plate during the power transmission. This being the costliest component of the engine, a value engineering study was conducted as detailed below. This would provide a clear understanding of the methodology and benefits of value engineering.

Component: Clutch Base Plate in the Transmission Assembly of a Petrol Engine

(i) General phase: The general information about the function of the Clutch Base Plate is as follows.

The 25 cc JLO petrol engine, used in agricultural sprayers and cycle rickshaws has a clutch base plate as a part of the power transmission system. This component is under study being one of the costliest components in the transmission assembly (Fig. 18.1), as described briefly as under.

The drive from the clutch shaft is through the gear (which rotates freely on the clutch base) and the friction plates on one side and the clutch plate, the clutch base and the clutch shaft on the other side. In the normal running, the friction plates hold the gears tightly against the clutch plate, (and hence on to the clutch base), transmitting motion by friction under pressure. When the clutch pin is released the friction plates move to the right against the spring pressure, thus releasing the pressure between the gear and the clutch plate, thereby enabling the gear to rotate freely on the clutch base.

(ii) Information phase: The clutch base is machined from 80 mm dia EN8 steel bar, as per Fig. 18.2. The sequence of operations (Table 18.1) is as under.

(iii) Functional phase: The functions of the clutch base plate and their functional levels are indicated in Table 18.2.

It may be noted that the primary function is specified as 'Absorb Thrust' while others like facilitate Drive (from pinion to drive shaft) are categorized as secondary. This conforms to the fact that by fixing

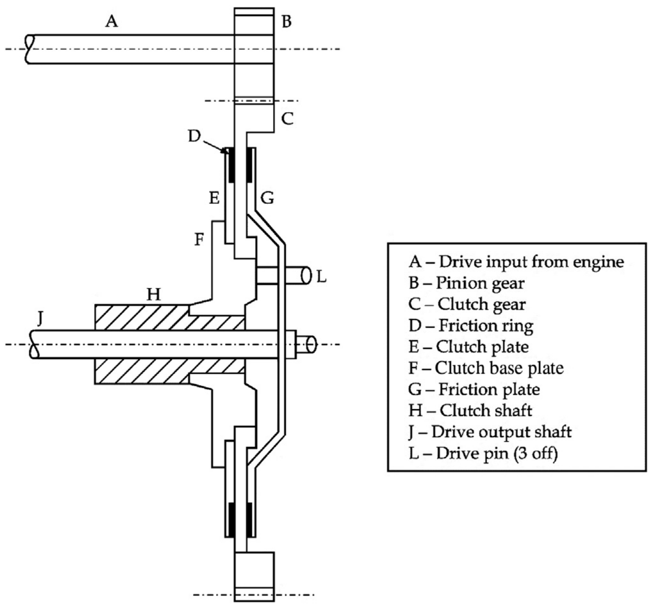

FIGURE 18.1 Clutch transmission assembly.

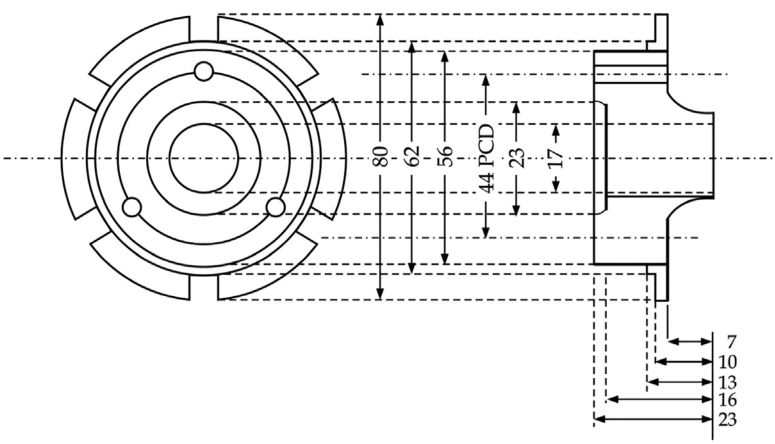

FIGURE 18.2 Clutch base plate.

the clutch plate firmly onto the drive shaft and making the gear rotate freely on it, it may be possible to transmit the drive through the clutching and declutching action. But the spring thrust is so high that the clutch plate would fail and it is the clutch base plate that will absorb the thrust and thereby enable the friction and the clutch plates to perform the clutching and declutching action and transmit the power without deforming the plates.

TABLE 18.1 Operation sequence.

Machined on bar stock			Machined on forging		
Op. No.	**Operation**	**Std. time (m)**	**Op. No.**	**Operation**	**Std. time (m)**
1	Cut blanks 28 mm thick	2.60		–	
2.	Load on lathe, face one side, drill 17 dia and counter bore	8.00	1	Load on lathe, face one side, drill, and ream 17 dia and counter bore	8.20
3	Bore 17 mm dia	5.80		–	
4	Fix other side on chuck, face and turn 23 mm dia	8.00		–	
5	Countersink	0.50	2	Countersink	0.50
6	Copy turn first side	4.20		–	
7	Copy turn second side	3.93		–	
8	Broach key way	2.50	3	Broach key way	2.50
9	De-burr key way	1.00	4	De-burr key way	1.00
10	Mill 6 slots	6.75	5	Mill 6 slots	6.75
11	Drill 3 holes	1.50	6	Drill 3 holes	1.50
12	Countersink 3 holes	0.80	7	Countersink 3 holes	0.80
13	Tap 3 holes	1.50	8	Tap 3 holes	1.50
14	Grind 55.3 dia	3.00	9	Grind 55.3 dia	3.00
15	Grind 62 mm dia	2.00	10	Grind 62 mm dia	2.00
16	Face the boss	1.00	11	Face the boss	1.00
17	De-burr, coat anti rust and store	3.00	12	De-burr, coat anti rust and store	3.00
	Total time	**56.08**			**31.75**

(iv) Investigation phase: If we analyze the costs involved in sustaining each of the 5 functions, we can notice that the total cost of maintaining the secondary functions account to as much as 80% of the total cost. Especially the secondary function of 'facilitate drive' can be rated as the costliest due to the cost of providing the flange and the slots.

This should give an idea as to which design features should be questioned more thoroughly to get maximum cost reduction by changing only the minor and secondary design features.

(v) Creative and evaluation phases: While the finished piece of the clutch base plate is 300 gm the raw material used is 80 mm blank weighing 1200 gm, thus 75% of the material being lost as scrap.

Table 18.1 pin points the operations that take unusually high machining time. The first step in the application of creativity is to identify the alternative processes to replace the high cost operations viz 2 and 4 (facing), 3 (boring) and 10 (milling) which account for 90% of the total operational time.

Hence the flange feature of the existing design, which contributes to abnormally high cost, is considered for value analysis and 3 alterative designs are proposed.

(vi) Recommendation phase:

(a) Design change No. 1: Changing the RM specification to forged steel. Change the raw material to forged steel instead of a cutting from an 80 mm EN8 (BS970) steel bar. The clutch base shall be made from forged steel with a maximum of 1 mm excess material where only at these points where machining is required, This will reduce the machining time to a bare minimum besides reducing the scrap to 15%. The total machining time is estimated at 8 minutes.

- The quoted weight of the forged blank of specification EN 8 steel is 500 gms and the price of this forged piece is Rs. 7.25 per piece (Rs. 6.25 for IS 226-MS).
- Table 18.3 below compares the costs between fully machined and forged component, yielding a direct saving of Rs 4.55 per piece by replacing bar stock with forged pieces.

(b) Supplementary design change No. 2: Integration of the flange portion of the base plate with the clutch plate itself by screwing (Fig. 18.3).

By looking at the component and its assembly with the clutch plate, it can be deduced that the flange portion and its milling is designed purely to hold the clutch plate and to receive positive power transmission. The axial movement of the plate with respect to the base is not required. In fact, there were initial complaints that the plate tends to slip into the gap between the gear and base when the clutch is released.

Analyzing the available bar sizes and the ideal overlapping, a bar size of 75 mm dia is considered optimal with a potential saving is Rs 30,000 per annum.

TABLE 18.2 Functions of the clutch base plate.

Sl. No	Functions		Functional level		Remarks
	Verb	Noun	Primary	Secondary	
1	Facilitate	Drive	–	Yes	To pinion
2	Resist	Bending moment	–	Yes	
3	Support	Weight	–	Yes	Of the reduction assembly
4	Absorb	Thrust	Yes	–	From the clutch plate
5	Provide	Location	–	Yes	For drive pin

TABLE 18.3 Cost comparison in changing to Forged steel.

Sl. No	Cost element	Fully machined component		Forged component	
		Details	Cost in Rs.	Details	Cost in Rs.
1	Raw material cost	1.2 kg of EN-8 bar at Rs 5.75/kg	6.90	Vide quotation	7.25
2	Hacksaw cutting	Sub-contracting	2.00	Nil	–
3	Machining	**56.08** m	7.10	31.75 m	4.20
	Total		**16.00**		**11.45**

Note: The prices and costs were as prevalent in the 1970 when this study was undertaken. Nevertheless, the comparison between the existing and the proposed processes is valid as on date. Fig. 18.2 indicates the dimensions of the clutch base plate after machining. It is to be noted that there is no dimensional variations of the machined piece, whether from bar stock or from forged stock.

Salient features of this design change are

1. The bar stock size is reduced from 80 mm to 75 mm resulting a further saving of Rs 3.45 core piece in material cost and Rs 1.50 per piece in machining cost, i.e. Rs. 4.95 per piece. The total saving by implementing both the recommendations is

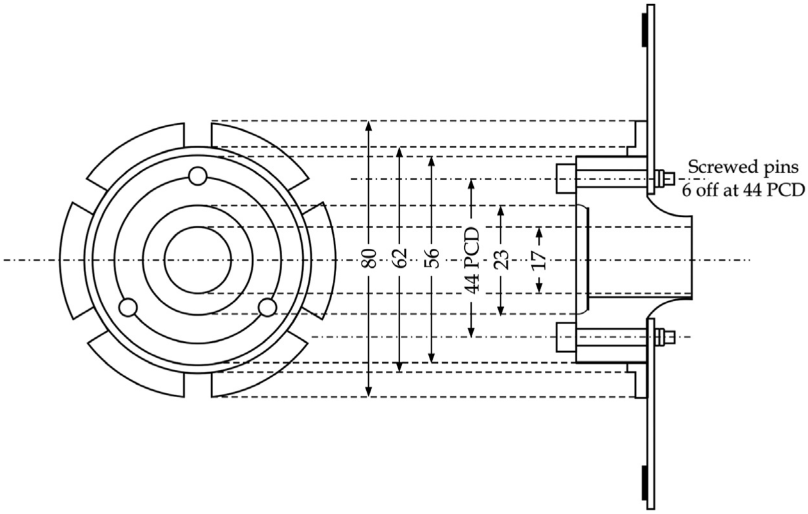

FIGURE 18.3 Clutch base plate - design change no. 2.

hence Rs. 4.55 + Rs. 4.95 or Rs 9.50 per piece. At 2000 pieces per month, the monthly savings potential is Rs 19,000.

2. The new design for the clutch plate Fig. 18.3 has circular holes instead of complicated serrated slots possibly reducing the procurement cost.
3. The 3 pins presently screwed on to the clutch can themselves be used to fix to the clutch pate. By this, the costly milling operation can be eliminated. The proposed design has 6 holes for better strength and power transmission.
4. The provision of nuts may involve slight modification on the crankcase, without effect on any functional design of the latter.

(c) Supplementary design change no. 3: Reducing the bar size: The bar procured is of 80 mm OD. It is provided with a 19 mm bore to match with the clutch shaft and is provided with two steps at 55 mm dia and 62 mm dia, the former to match with the clutch plate and the latter to match with the gear. Discussions with the R&D revealed that the additional step has no functional value and that the 62 mm step can be reduced to 58 mm. Thereby reducing the OD to 75 mm from 80 mm. Table 18.4 indicates the cost reduction achieved by reducing the bar sizes ignoring the reduced machining time.

(vii) Follow-up phase:

- Recommendation No. 1, viz to change to forging component, has been accepted and implemented. Net saving is Rs. 4.55 per piece or Rs. 9000 per month

TABLE 18.4 Cost reduction Achieved by reducing the bar sizes.

Sl. no	Radial overlap in mm	Bar dia required in mm	Wt. in kg per meter	Reduction in weight from 80 mm bar in kg/m	%age reduction in weight, thereby in raw material procurement price.
1	9	80	39.5	–	–
2	8	78	37.5	2.0	5.0
3	7	76	35.6	3.9	10.0
4	6.5	75	34.7	4.8	12.2
5	6	74	33.8	5.7	14.5
6	5	72	32.0	7.5	19.0
7	4	70	30.2	9.3	23.6

- Recommendation No. 2 viz Integration of the flange portion of the base plate with the clutch plate itself, by screwing, was accepted in principle but was deferred due to involvement of a change in the die of the aluminum casting of the crankcase. Correspondence was initiated with the supplier nevertheless without much positive result in this direction. Net saving is s 4.95 per piece or Rs. 25,000 per month
- Recommendation No. 3, viz reduction in the OD of the bar stock to an optimal level was withheld due to the design imposition from the principals. Expected savings Rs. 19,000 per month.

18.13 Conclusion

It can be seen from the case study that Value Engineering which has been practiced by industrial engineers even when the concept of Six Sigma did not exist, is still prevalent and has become a significant tool of Design for Six Sigma (DFSS).

The savings illustrated in the case study may appear to be too small to call for a citation. But in 1974 when this study was done, the petrol price was Rs. 1.50 per liter and rice was nearly a rupee per kg., compared to today's prices of Rs 85 and 60 respectively!

Criteria questions

1. What do you understand by Value Analysis? How it is different from Method study? (18.1)
2. Distinguish between SREDDIM and DARSIRI. (18.3, 18.10.7)

3. What are the different functions performed by a product? (18.8)
4. What are the different forms of value? How do you distinguish between functional value and cost value? (18.9)
5. Justify the statement 'Method Study: Production: Value Analysis: Design'.
6. List the phases of Value Analysis. (18.10)
7. Discuss the significance of function phase. (18.10.3)
8. What is DFSS and how does Value analysis achieve it? (18.1, 18.13)

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