Modelling of interrelationship of cost factors of product life cycle

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ABSTRACT

In an effort to achieve a competitive advantage and to face the global competition, Manufacturing firms and designers are adopting Life Cycle Costing (LCC) analysis. The product life cycle costing approach can help track and analyse the cost factors associated with full life phase of a product. By extant review of literature the cost factor included in life cycle analysis are: Market study, Manufacturing, operation, service, disposal and quality control. The main objective of this paper is to identify and deduce interrelationship among various cost factor which are included in the life cycle cost analysis of a product .Integrated model using Interpretive Structure Modelling (ISM) for cost affecting life cycle costing is developed and the structural relationship between these cost factor are modelled, Further the analyse of driving power and dependency of cost factor is done with the help of MICMAC technique which shall be helpful to manager to identify important criterions and to tell the direct and indirect effect of each criterions on life cycle costing analysis. Results show that market study cost act as a strong driver.

KEYWORDS: Life cycle costing (LCC), Interpretive structural modelling (ISM).

1. INTRODUCTION

With growing competition and fierce battle for establishing one's dominance in the market, the implementation of life cycle cost analysis among manufacturing firms is becoming a convincing approach as it emphasizes heavily on cost control. Life cycle costing is the method of evaluating the total expenditure incurred on the product from the very point of concept development to the end of life of the product.

Before market and aftermarket are the two stages to ascertain the product life cycle of a recently developed product to be launched in the market. Market entry stages are described as the procedure from the concept stage to the sales and marketing stage. Aftermarket entry stages are origination, maturity and slump stages (*Pazarceviren & Dede, 2015*).

Life cycle cost (LCC) can recognize the cumulative cost in the product design, manufacturing, service, waste disposal and other factors from the economic viewpoint of decision-makers and make effort to curtail the total cost (Jiamin Fang, 2015).

2. OBJECTIVE

The overall objective of this paper contains as follows

- To find out the important cost factors in each of product life cycle.
- To develop interrelationship among various cost factors.
- To categorize cost factors into four categories on the basis of driving and dependence power.
- To optimize product life cycle cost with interrelationship between various cost factors.

3. LITERATURE REVIEW

In general, LCC model estimates the life cycle of a product. The various cost components are identified with the help of LCC model and these cost components are discussed in this literature study as follows.

3.1. Market study cost

A product life cycle consist of five stages including research and development, manufacturing, distribution, use and end of life in which R&D consist of the cost for market research and product development *(Jeong & Lee, 2009).* Market study cost has been considered under concept and definition cost which measure the cost of the economic feasibility to know whether the system will provide better economical results or not *(Castro-Santos et al., 2016); (Laura & Vicente, 2014).*

3.2 Manufacturing Cost

The evaluation of manufacturing cost can be considered from the initial process conception stages onward, and considered as important as product quality and safety *(Sinclair & Monge, 2010).* We can directly calculate the manufacturing cost by unit cost per hour and manufacturing hours of the product *(Deng & Yeh, 2011).* The consumers are benefitted by the low manufacturing cost by reducing running costs with a limited penalty to the manufacturer *(Witik et al., 2011).* The lower manufacturing cost has a great influence which directly lower the product overall cost *(Folgado et al., 2010).* Also, manufacturing cost is considered while assessing the environmental performance and life cycle cost. *(Witik et al., 2011).*

3.3. Operation cost

The total operation cost is defined as the sum of the withdrawal cost and the inventory cost of materials which is stored in the succeeding work station *(Miyazaki et al., 1988*). It has been seen that operation cost acquires large share in the product life cycle, and accounts for the large amount of emission of greenhouse gases and total energy usage *(Du & Peng, 2010).* In the operation stage of a life cycle of a product, operation cost is a prominent cost and by optimization of spare part strategies and logistics support operational cost can be decreased *(*Jun & Kim, 2007*).*

3.4. Quality control cost

A risk neutral manufacturer, the quality control policy includes per unit inspection cost and the cost of defective items and in the long run, the optimal price depends on this policy *(Tapiero et al., 1987).* According to management review a habit is made by quality control of using the data from traditional accountancy with a great amount of suspicion and must try to convince the accountants of the justice of this suspicion *(Williams et al., 1999).* Therefore, quality control cost is the costs incurred in ensuring and assuring quality as well as the loss incurred when quality is not achieved *(Hwang & Aspinwall, 1996).* In the industries, quality control can be improved by adopting six sigma techniques *(Tchidi et al., 2012).*

3.5. Service cost

The manufactured products has a specific maintenance requirement that includes service cost of product which is referred as maintenance cost of product e.g., assembly and disassembly cost *(Ma et al., 2018).* The service costs of defense and aerospace sector can account for up to 75% of the life costs of military provision through the product life cycle *(Huang et al., 2011).* Therefore, while predicting for long- term commodity prices requires a transportation planner which includes both initial capital costs and future service costs *(Skolnik & Brooks, 2013).*

3.6. Disposal cost

Disposal refers to elimination of the waste product without recovering any intrinsic value,i.e. electricity or heat. The disassembly costs are decreased in this analysis by using this option, but continues to be a bad environmental choice *(Ishii et al. 1994).* Moreover, in various literature works, the waste scenario is hypothesized, an average cost for the disposal is taken into consideration *(Peri et al., 2012).* In LCC analysis disposal cost was considered using stochastic point processes during the operation of power generation and repair costs and modelling maintenance *(Waghmode & Sahasrabudhe, 2012).*

4. ISM Methodology

Interpretive structural modelling is an interactive learning process for developing inter-relationship among specific elements constituting a problem or an issue. It also helps to produce graphical representations of complex systems. The two most crucial concepts necessary to precisely understand the ISM methodology are: The concept of transitivity and reachability.

The relationship to be established between various elements require certain terminology to be defined which are as follows:

Four symbols brought into use to signify the direction of relationship between the elements are:

I: element i influences element j

J: element j influences element i

Y: element i and j influences each other

N: element i and j will not influence each other

With the initial entry using these symbols a structural self-interaction matrix is devised which is later converted into initial reachability matrix by representing above information in form of binary matrix.

ISM technique involves following steps:

- Various cost factors affecting LCC are identified.
- Establishing the contextual relationship among the cost factors.
- Formation of Structural self-interaction matrix (SSIM).
- Formation of initial reachability matrix (IRM).
- Formation of final reachability matrix.
- Partitioning of final reachability matrix.
- Formation of conical matrix.
- Formation of diagraph.

- Formation of ISM model.
- MICMAC analysis

In this work, after following the steps as mentioned above final reachability matrix, result of all iterations and ISM based levels of variables was obtained as shown in table 1, table 2 and table 3 respectively. Accordingly, diagraph showing the level of cost factors has been developed (Ref. Figure 1) and driving and dependence was developed as shown in figure 2.

Table 1: Final reachability matrix (FRM)

S.NO		1	2	3	4	5	6	Driving Power
1	Market study	1	1	1	1	1	1	6
2	Manufacturing	0	1	1	1	1	1	5
3	Quality control	0	1	1	1	1	1	5
4	Service	0	1	1	1	1	0	4
5	Disposal	0	0	1	1	1	0	3
6	Operation	0	1	1	1	1	1	5
	Dependence	**1**	**5**	**6**	**6**	**6**	**4**	

Table 2: Result of all Iterations

Cost Factors	Reachability	Antecedent	Intersection	Level
1	1,2,3,4,5,6	1	1	III
2	2,3,4,5,6	1,2,3,4,6	1,2,3,4,6	II
3	2,3,4,5,6	1,2,3,4,5,6	2,3,4,5,6	I
4	2,3,4,5	1,2,3,4,5,6	2,3,4,5	I
5	3,4,5	1,2,3,4,5,6	3,4,5	I
6	2,3,4,5,6	1,2,3,6	2,3,6	II

Table 3: ISM based levels of variables.

S.NO	Cost factor	Levels
1	Market study cost	III
2	Manufacturing cost	II
3	Quality control	I
4	Service	I
5	Disposal	I
6	Operation	II

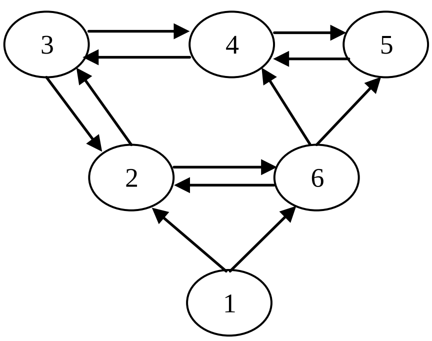

Figure 1:Diagraph showing the level of cost factors

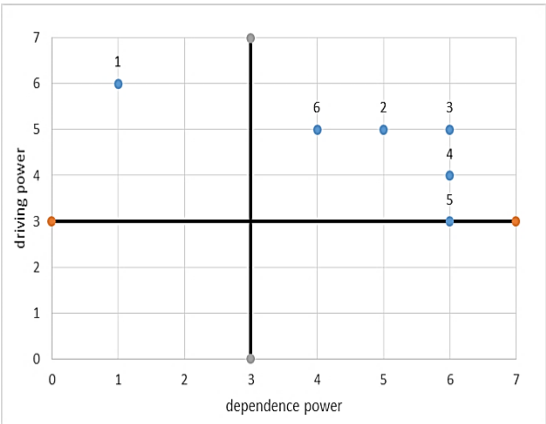

Figure 2: Driving power and dependence diagram

Conclusion

The objective of this research was to identify and analyze the important cost factors and their inter-relationship so that during life cycle cost analysis of the product managers may effectively deal and optimize the life cycle cost of the product. In this research, an ISM based model was used to analyze the inter-relationship among different cost factors of product life cycle. Some of the valuable findings from the study are as under.

- From the driving power and dependence diagram, it is observed that one cost factor, namely market study cost have strong driving power and is less dependent on other cost factors. Therefore the independent variable is strong driver and may be treated as the most important of all cost factors, so managers need to address this cost factor as a priority in life cycle cost analysis of a product.
- From the driving power and dependence diagram it is observed that disposal cost has weak driving power but dependent on the other cost factors. This cost factor is at the top of the ISM hierarchy, therefore is considered as the most important cost factor. Decision taking authorities should, therefore, accord high priority in evaluating this cost factors for analyzing the life cycle cost of a product and should understand the dependence of this cost factor on other cost factors.
- The cost factors namely manufacturing cost, quality control cost, service cost, operation cost have strong driver power as well as strong

dependence. Any action on them has an effect on others and also a feedback effect on themselves.

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