APPROACHES TO LIFE-CYCLE COST ANALYSIS IN METALLURGY

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Abstract

The article describes and analyzes specific approaches to calculation of life cycle costing (LCC) as a part of Life-cycle Cost Analysis (LCCA). LCCA is an approach to assessment the most cost-effective alternative in comparison to other alternatives when each of them is equally suited from a technical point of view. LCC includes the analysis of the cost over entire life of product (castings). Several specific approaches to calculation of life cycle costing and the differences between them are analyzed. The attention is paid especially to answering the question of what types of cost included in specific models are differ. Typical including costs are acquisition costs, design and development costs, cost of repairs, spares and failures, downtime cost, cost involved by loss of production, cost of maintenance and disposal costs. Differences are shown on the examples. At the end, an overview of the use of individual approaches is provided.

Keywords: Life cycle costing, lean manufacturing, waste elimination, process manufacturing

1. INTRODUCTION

The aim of the article is to compare different LCC methods and show which of these methods can be use in metallurgy. Linking costs throughout product life provides a comprehensive view of product value added. For metallurgical products, the preparatory and implementation of production plays a major role. However, even in this case, it is necessary to think about the next phase of life, such as the lifetime and liquidation phase. The end-of-life phase of the product and disposal involve the costs of disposal and recycling. If a component is built into the product, its disposal costs are just a part of the cost of liquidation for the entire product. The article presents a comparison of few selected methods. Their advantages and disadvantages for application to individual processes of the castings life cycle are described and subsequent recommendations for their implementation are proposed. Furthermore, the suitability of choosing the correct methods, with a reference to different results in the overall cost of the product, is shown.

2. LCC METHODS

The economic analysis process is one that evaluates the total cost of investment for production, its costs involved by ownership of investment and lifetime costs of the system or product. The life cycle cost analysis is applied for it [1]. Thanks to lifecycle cost management, we can manage and optimize the life-long features and nature of assets with design and implementation. This fact is in a match the goals of the owners, users and companies [2]. The LCC intervenes in optimizing the cost of ownership, acquisition and operation of tangible assets throughout its useful life. It is attempting to identify and quantify all significant costs associated with that lifetime using a technique of present value. The LCC deals with the quantification of various options to ensure that an optimal asset mix is adopted. It allows to study the optimum LCC selection and to provide a certain compromise between the cost categories during the life of the asset [3]. Cost categories include all cash flows that occur during the life of the castings. From the definition of the LCC previously provided, the LCC covers all the expenses incurred regarding it, from the acquisition to the disposal of the product at the end of its useful life. Several approaches of LCC exist. The differences between them are in identification of costs [4]. Defining the cost structure involves cost pooling; so that potential compromises can be identified to achieve optimal

LCC. The nature of the defined cost structure depends on the required depth and breadth of the LCC study to design a range of alternative structures. It is appropriate to divide the costs into three categories [5]:

- Engineering and development
- Production and implementation
- Operation

LCC methods have a different usability. For sustainable manufacturing is necessary to use a LCC model. This model is serve as the primary engineering economy model [6]. The methodology of the application the LCC is still a problem in engineering. Most of the companies are not able to implement this method correctly [7]. LCC models using the simulation models as simulation Monte Carlo. The final results are inherent with the uncertainty of the input data into simulation [8]. Not all methods involve a whole range of costs, and then decide how to use them. The following **Table 1** shows the individual methods with their brief description. **Table 2** shows an overview of the shortcuts used for each method.

Table 1 LCC methods [9]

Method	Description	Figure
General Life Cycle Cost Model I	Suitable for multiple application areas	LCC = RC + NRC
General Life Cycle Cost Model II	It focuses on the area where logistics costs play a major role	LCC = APC + ILC + RC
General Life Cycle Cost Model III	Suitable for areas with a large share of input costs and connectivity to other systems	LCC = RDC + CAS + IC + TC + OSC
General Life Cycle Cost Model IV	Cost-effective method for cost division at LCC by phase	LCC = CP + DP + PP + OP
General Life Cycle Cost Model V	A method suitable for generic expression of products in the preparatory, production, functional and disposal phases	LCC = RDC + PCS + OSC + ReDC
General Life Cycle Cost Model VI	Suitable for product with low-priced disposal phase versus development and investment phases	LCC = RDC + IC + OSC

Table 2 Shortcut of LCC methods [own study]

Shortcut	Description
LCC	Life Cycle Costing
RC	Recurring Cost
NRC	Nonrecurring Cost
APC	Acquisition or Procurement Cost
ILC	Initial Logistic Cost
RDC	Research and Development Cost
CAS	Cost of Associated Systems
IC	Investment Cost
TC	Termination Cost
OSC	Operating and Support Cost
CP	Cost Associated with the Conceptual Phase
DP	Cost Associated with the Definition Phase
PP	Cost Associated with the Procurement Phase
OP	Cost Associated with the Operation Phase
PCS	Production and Construction Cost
ReDC	Retirement and Disposal Cost

3. LCC IN METALLURGY - CASE STUDY

The casting factory in this case study is focusing on aluminium castings. The data was obtained from the company's information system. The input costs were set for a sample of one casting, which followed the life cycle during the production phase. The lifetime of casting during the operating phase is determined by the overall life of the entire product, which is the part of it. The company delivers selected casting to the automotive industry; the overall lifetime is due to the life of the car. The connection for the individual shortcuts (**Table 2)** is added to each type of costs (see **Table 3**).

Table 3 Type of costs for each shortcut [own study]

Costs	Type of costs
Project documentation	NRC, APC, RDC, DP
Prototype	NRC, APC, RDC, CP
Salary	RC, CP, RDC
Business travel	NRC, ILC, PP
Material	RC, PCS
Energy	RC, PCS
Depreciation	RC, IC, PCS
Credit	RC, RDC
Production tools	RC, PCS
Machining	RC, PCS
Maintenance	RC, PCS
The mold	NRC, APC, CAS, PCS
Logistics	RC, PCS
Maintenance	NRC, OSC, OP
Disposal (Recycling)	NRC, TC, ReDC

All data is measured by company employees. Subsequent calculations are based on these data. Therefore, the results are rounded to two decimal places. The using of discount rate is necessary for considering the time value of money. For the calculation, discount rates were determined using the ROE (Return of Equity) indicator, determined within the ten-year accounting period. The average ROE ranged between year 2005 and 2014 is 5.34 % [10]. The results of each model of LCC are showed in **Table 4**.

Table 4 LCC for each method in CZK [own study]

LCC model	LCC per 1 product	LCC per 1 batch (120 000 products)
Model I	366.69	44,002,520
Model II	366.53	43,983,200
Model III	68.70	8,244,320
Model IV	26.30	3,155,600
Model V	366.56	43,987,520
Model VI	61.21	7,345,400

As shown in **Table 4**, each of methods calculates different values of LCC and some of them are not suitable to use in the casting life cycle costing. The problem with different values of LCC is caused by absence of production costs in calculation in some methods. The methods (model III, IV and VI), which absented of production costs, are recommended in the area of military equipment or building construction. For manufacturing (foundries) the models of LCC I, II and V are recommended.

4. CONCLUSION

Models of LCC and cost categories are described. The using of each method is determined by the costs inputs of each method. There are methods which are focusing on logistical part or lifetime of each product. These methods are unusable for metallurgy industry. The field where are the methods focusing is influence by the individual variables in the equation. The differences between the methods are huge and influence the final calculation of the decision maker's ability to provide the necessary cost data. At the edge of Industrial Revolution 4.0 is still quite difficult to monitoring individual cash flows. In the future it will be easier monitoring individual cash flows and cost categories with on-going digitization and information interconnections. As a result, more sophisticated and sophisticated methods for casting and production quality assessment will be more widely used in sectors where are hardly traceable, such as the foundry industry.

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