

# Cost Model of the Product in Design Stage

Ying Liu, Ming Yu, Zuozhi Zhao, Ruichun Duan

**Abstract**—Cost management is one of the most important ones among the 22 challenges that facing Chinese large and complex engineering projects. Therefore it's quite necessary to figure out what the cost is and why the cost is such value. This paper brings out a cost model applicable for the product in design stage. It's constructed by two aspects: cost impact factors and cost calculation. In order to facing various state of the product, the cost model splits into two with Forward cost model dealing with pioneer products and Backward cost model existed ones. There are applicable procedures of these two cost models and a short discussion based on their application. The cost model can be more accurate with more information presented.

**Index Terms**—Cost impact factors, Cost calculation, Forward cost model, Backward cost model

## I. INTRODUCTION

Nowadays, more and more companies are seeking ways to get a better performance in such a competitive market. In Ming's<sup>[1]</sup> research, there are 22 challenges facing Chinese large complex engineering projects such as scope management, time management, integration management, requirement and claim management, management and control the staged results, methodology and tool management, information, data and parameters management, maturity of technology, key technology tackling, prospective research on specialized topics, configuration management, system integration, decision making among different solutions, ensuring of feasibility of the solution, procurement management, policy and standard management, risk to project, risk to users, customer relationship management, cost management, human resource management and communication management.

Among these 22 challenges, cost management is one of the most important ones. One reason is that there is more chance to influence the cost in the design stage as showed in Figure 1. The chance becomes smaller and smaller with the time going. On the other hand, the cost transparency is always missing in the design stage due to confidential rules or communication problems in the supply chain, even within the functions of one company. Thus this paper would like to present an applicable cost model of the product showing what the cost is and why the cost is such value, in which way may help the designers understand the cost well and find solutions to

reduce the cost. Besides, it may also help the company get a competitive seat on the negotiation table while sourcing.

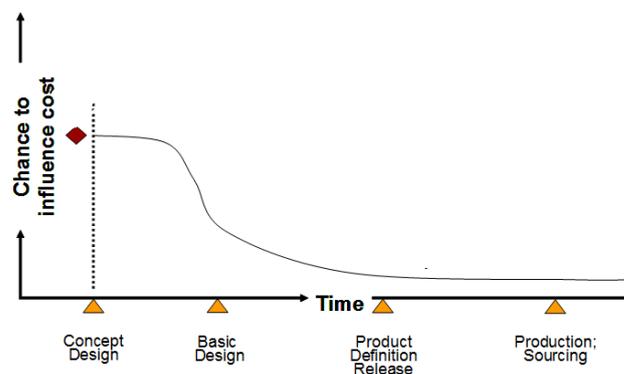


Fig. 1. Cost information is needed early in the development stage<sup>[2]</sup>

In the next chapters, the paper will detail explain the cost model on its two aspects of cost impact factors and cost calculation. The Cost model splits into two to facing various product states with Forward cost model dealing with pioneer products and Backward cost model for the existed ones. There is a short discussion on these two cost models based on their application. Last part is some conclusion on the limitation of the cost model and some future work.

## II. COST MODEL

When dealing with the cost of the product, the most common questions may be what the cost is and why the cost is such value. In order to answer these questions, "Cost impact factors" is used to cover all the factors that may have influence on the cost and "Cost calculation" is used to calculate the value of the cost with information of the cost impact factors presented. The structure of the cost model is showed in Figure 2.

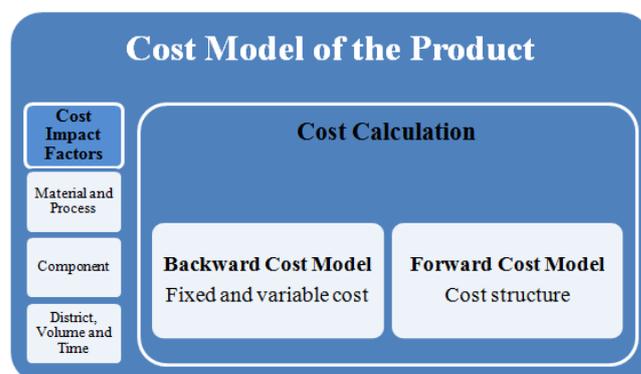


Fig. 2. Structure of the cost model

### A. Cost Impact Factors

In Anderson and Pyane's book<sup>[3]</sup>, they pointed out that the cost impact factors should include time, district and volume.

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After researching on the transform strategies of the multinational firms in the industry, we found that the material and process domain is the most important ones for them to search for innovative development<sup>[2]</sup>. In this way, this paper adds these two factors as well. In order to cover all the impact factors, component is added to present all the left ones being specified to the product. In short, there are altogether six cost impact factors: time, district, volume, material, process and component.

**Time:** The time cost is one important category in the cost management. For different time horizon, the value of the elements in the cost structure which will be explained in the following chapters may change with the time.

**District:** District refers to the geographical position of the manufacturing process. It may influence the material price, the unit cost of the human resource or the equipments, the transportation and inventory cost, and also the policy, the tax etc.

**Volume:** Volume is the number of products manufactured in the same batch. It will influence the investment of the equipment and the tooling, and also the set up time etc.

**Material:** Material refers to that make up the component of the product.

**Process:** Process refers to that required to fulfill the manufacturing of the product.

**Component:** Component refers to different parts of the product or different products including various design features.

#### B. Cost Calculation

Cost calculation is used to estimate the cost with a definite value. For different product state, there are different ways of calculation. When dealing with existed products, historical data may help to predict the new product with only some design features modified. But for pioneer product, with few historical information presented, the estimated cost can be a sum-up of the cost calculated in each process. Here, fixed and variable cost is used to define the way of the cost calculation for existed product and cost structure for the pioneer product. Accordingly, fixed and variable cost is part of the Backward cost model and cost structure for Forward cost model.

##### 1) Fixed and Variable Cost

When calculating the cost of each process, it can be noted that almost every calculation is made up of fixed cost and variable cost. Fixed cost is some constant that not related to design features, it can be a set up time, or some test cost which is mostly constant only related to frequencies. On the other hand, variable cost is the cost that related to design features. For example, if the process is to mill several sockets, for just calculating the milling cost not considering setup, it would be the number of the sockets times the cost of milling per socket. In this case, the variable is the number of sockets.

##### 2) Cost Structure

The cost structure includes the cost elements for both component and products. Refer to all the elements raised<sup>[4-6]</sup>, this paper taken the cost structure into four categories such as manufacturing cost, logistics cost, quality cost and additional cost.

**Manufacturing cost:** covers the cost of materials and

components, human resource and equipment. This one may take a very large percentage of the total cost, and may also be the easiest one to be quantified as it can be get by the unit cost times the time unit.

**Logistics cost:** refers to the transportation and inventory of the materials, rough-machined or fine-machined components.

**Quality cost:** Considering the total life cycle cost management, the quality cost must not be ignored. The quality cost includes inner cost which covers the tests, failure diagnosis, the repetition work and wastes related to quality problems, the outer cost which covers the field failure, deposit and legal obligation related to quality problems.

**Additional cost:** refers to the cost of design, management, promotion, sale and after-sale etc.

### III. DISCUSSION

Both Forward cost model and Backward cost model have their own ways of cost calculation to deal with different kinds of product. At the same time, they also have their own procedure of application. In this chapter, the procedures are showed followed by a simple application on the matching product.

#### A. Backward Cost Model

The Backward cost model is most suitable when there is historical data which could be used for statistical analysis. With some mathematical formula established, the cost can be easily calculated with different value of parameters in the cost model, which are mostly related to the component.

The procedures are shows in the following:

1. Choose the product with various design features and parameters stated.
2. Collect the historical cost data detailed to manufacturing process.
3. Use statistical methods to decide key variables, and get the cost formula by regression.
4. Validate the formula and revise if needed.
5. Repeat step 3 to step 4 until all the processes and design features are checked.
6. Summarize the cost according to design features or process into total cost estimation.

With the help from Siemens, this cost model is applied to the compressor disk (which is part of the gas turbine) with relatively good results. For this product, it's facing the localization problem from Germany to China. With enough information presented by the factory in Germany, the Backward cost model leads to a good calculation formula to estimate the total cost of the product with variable within 10%. For each process, the cost is calculated by the mathematical formula with variables being the design features. And the total cost is a summation of all the process. After localizing, some parameters in the cost model may be adjusted to the new environment, but the relationship will not change as that of the parameters

#### B. Forward Cost Model

The forward cost model is on the other hand most suitable when some new product is developed, where few historical data could be referenced. Here the cost is estimated by the

summarization of the cost estimated of each manufacturing process of the product. The reason to use forward cost model is that it can be verify the information from the suppliers and it's also a reliable way to estimate the cost of the product.

The procedure to use the forward cost model is as following:

1. Choose the product with various design features and parameters stated.
2. Design the manufacturing process for the each part of the component.
3. Collect unit cost information required in the manufacturing process.
4. Calculated the cost of each part of the component by a summarization of the cost of each manufacturing step.
5. Repeat step 2 to step 4 until all parts of the component are included.
6. Summarize the cost into total cost estimation.

Still, with the help from Siemens, the Forward cost model is used to apply on the compressive inlet casing which is also part of the gas turbine. There's little information of the product since it's sourced from outside. The final estimation of the cost is on the same magnitude with the price presented by the suppliers. In this case, the software named DFMA is used help the amounts of calculation<sup>[2]</sup>. It may not go through details here.

#### IV. CONCLUSION

In this paper, a cost model structured by cost impact factors and cost calculation is presented. There are altogether six cost impact factors as time, district, volume, material, process and component. Different cost calculation ways is used to dealing with different product state. Cost calculation of fixed and variable cost in Backward cost model is most suitable for existed product while cost structure in Forward cost model is suitable for pioneer product. The application procedures of both these two cost model are showed.

In the case of applying Backward cost model on the product of compressor disk, the variance of the final formula is within 10%. With more information presented, the formula should be more accurate accordingly. In the case of applying Forward cost model, the estimated cost results in the same magnitude of the price presented by the suppliers.

When cost impact factors in the cost model changes, the coefficient may change as well. The future work may be the research on the influence of the cost impact factors on the final cost estimation. With more information provided, the final cost estimation must be more accurate

#### REFERENCES

- [1] Ming Yu, Ying Liu, and Adrian Koehlein, Challenges of Chinese Industrial Solution Projects, ICSEEM\_20, 2010
- [2] Technical report 2011 on cost management research, project document, Tsinghua University, 2011
- [3] Anderson and Pyane, Advancing competitive companies in 21st century: development of agile products under massive customization, 1999
- [4] XU Xinsheng, FANG Shuiliang, GU Xinjian, A Model For Manufacturing Cost Estimation Based On Machining Feature , Technology and Innovation Conference, 2006
- [5] MA ziqing, WANG xiulun, OUYANG qing, cost estimation model of the manufacturing process, Advancing manufacturing technology, 2005(5)

- [6] SHI xianming, GUO bo, Manufacturing decision model based on cost optimization, Manufacturing Automation, 2003-12