



PSO-based back-propagation artificial neural network for product and mold cost estimation of plastic injection molding

Z.H. Che *

Department of Industrial Engineering & Management, National Taipei University of Technology, 1, Sec. 3, Chung-Hsiao E. Rd., Taipei 106, Taiwan, ROC

ARTICLE INFO

Article history:

Received 21 November 2007

Received in revised form 7 January 2010

Accepted 7 January 2010

Available online 13 January 2010

Keywords:

Plastic injection molding

Cost estimation

Back-propagation network

Particle swarm optimization

Factor analysis

ABSTRACT

To simplify complicated traditional cost estimation flow, this study emphasizes the cost estimation approach for plastic injection products and molds. It is expected designers and R&D specialists can consider the competitiveness of product cost in the early stage of product design to reduce product development time and cost resulting from repetitive modification. Therefore, the proposed cost estimation approach combines factor analysis (FA), particle swarm optimization (PSO) and artificial neural network with two back-propagation networks, called FAPSO-TBP. In addition, another artificial neural network estimation approach with a single back-propagation network, called FAPSO-SBP, is also established. To verify the proposed FAPSO-TBP approach, comparisons with the FAPSO-SBP and general back-propagation artificial neural network (GBP) are made. The computational results show the proposed FAPSO-TBP approach is very competitive for the product and mold cost estimation problems of plastic injection molding.

© 2010 Elsevier Ltd. All rights reserved.

1. Introduction

To improve business competitiveness, the concept of concurrent engineering (CE) with a shortened product development period and lower cost should be introduced in the product design phase (Wei, 2007). The CE argued key factors affecting product design in the product life cycle should be considered in the initial design phase of R&D to reduce life cycle cost. Kayis, Arndt, Zhou, and Amornsawadwatana (2007) stated negligence of the coordination between design and other stages of product life cycle will cause many or late design modifications, resulting in unnecessarily increased cost. Therefore, to execute the above tasks, many strategies related to design, such as DFX (Design for Manufacture, Assembly, Cost, etc.) have been proposed (Piedras, Yacout, & Savard, 2006). In those strategies, subsequent works are utilized during the product design stage, to avoid conflicts between design and subsequent works, increased product costs, and a waste of resources.

To utilize resources and reduce production costs, it is necessary to analyze and estimate cost, and further control the cost during the initial product development period. Niazi, Dai, Balabani, and Seneviratne (2006), Yang and Lin (1997), Rehman and Guenou (1998), and Tu, Xie, and Fung (2007) proposed the product cost in the concept design stage accounts for only 6% of the total cost, but determines 70–80% of product cost and 80% of quality. Thus, cost estimation is very important, as shown in Fig. 1. If suitable

plans can be selected at the concept design stage, cost can be effectively reduced. For the same aspect, Serpell (2004) established initial concept cost estimation to help decision-makers obtain cost information in advance. However, cost estimation would lead to uncertainty and risk in the project development stage. This study solved the cost estimation problem based on expert knowledge and historical experience to improve the accuracy and reliability of cost estimation.

Roy, Rush, and Gorroño (2003) introduced the cost estimating rationale capture (CERC) at the concept design stage to help the aviation industry control costs. CERC was developed for providing information related to costs, to help industries reduce cost and increase gains. Lima, Pereira, and Pereira (1995) analyzed the cost configuration within transmission systems, and determined the cost estimation of subsystems so the system could be fully utilized. Although the cost estimation at the initial design stage is an approximate value, it is a key index to decide whether products should be developed. Over-estimation would result in wasting resources, and under-estimation would result in inferior quality. Therefore, if costs can be correctly estimated according to customer demand at the initial design stage, resources can be effectively used to achieve the purpose of cost control.

In product structure, because the R&D and processing technology of plastic materials have advanced, the plastic injection molding process is advantageous in shortening the production cycle to increase productivity, ability to form products with complex exterior, low plastic waste, high precision of product size, high stability, and complete automation. It is the most widely used plastic

* Tel.: +886 2 2771 2171x2346; fax: +886 2 7317168.

E-mail address: zhche@ntut.edu.tw

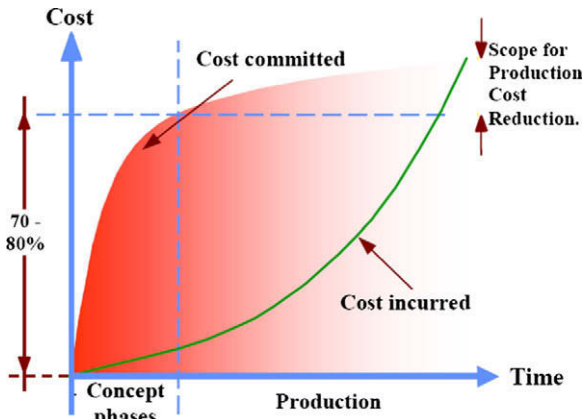


Fig. 1. Cost change time of project stages (Rush & Roy, 2000).

molding technology for mass production. Take toy development as an example, plastic injection parts account for over 80% of the entire toy parts, and most of the other parts are just standard accessories (such as screw and screw cap) (Wang, Che, & Lin, 2005).

Takahiro (2005) forecasted global consumption of plastic injection molding products would increase. However, in cost estimation, although there have been many studies on plastic cost analysis (Kent, 2006), these analyses were generally only concerned with products or components with a finished detail design (design variables have been decided). Specific costs of products or components that are uncertain at the initial design stage are seldom estimated. According to our practical experience, general studies regarding product design suggest either feasible design solutions for unknown products, or solutions to reduce costs and prolong product life for known products. These studies assumed given component characteristic parameters (material, size, and precision) and production processes for cost analysis, while the analyses neglected uncertain products. Because information at the initial concept design stage is incomplete, and the cost elements of the product interior are not specifically defined in terms of quality requirements and feasible technology for product functions, it is difficult to analyze product cost precisely. However, conventional product cost analysis is often based on direct estimation from the experience of designers, a certain level of qualitative analysis, and subjective determination without a set of effective and rational methods to reduce cost estimation error, thus resulting in variance of estimated costs by different decision-makers.

Therefore, there are four major study purposes: (1) Collecting parts cost data from interviews with plastic injection companies and establishing the database of plastic injection products. (2) Using FA to extract the characteristic data which is used as the input factors for the proposed cost estimation model. (3) Proposing the FAPSO-TBP approach for cost estimation, integrating FA, PSO, and two back-propagation networks. This approach uses two networks for product cost and mold cost estimations separately. (4) Comparing the solving performance of FAPSO-TBP, FAPSO-SBP and GBP to verify if FAPSO-TBP has an excellent ability to solve the problems defined in this study. The FAPSO-SBP uses one network for product cost and mold cost estimations simultaneously. The GBP approach, developed by Wang (2007) is the common back-propagation artificial network without PSO interference.

The structure of this paper is organized as follows: in Section 2, the background of plastic injection cost, back-propagation artificial neural network, and PSO are introduced. The structure of the proposed FAPSO-TBP approach is presented in Section 3. In Sections 4 and 5, the model application and the comparative analyses are conducted to evaluate the performance of the proposed approach. Finally, conclusions are given in Section 6.

2. Literature review

2.1. Cost of plastic injection molding

The demand for plastic products has increased because of their low cost, rapid injection speed and molding, and automatic production technology (Takahiro, 2005). Wang (2007) pointed out plastic injection products have been widely used in various household necessities and high-tech commodities. For gaining a bigger target market share and the advantage of leading the product price, the plastic injection product manufacturer should control the cost of the product being developed at the development stage to find the profit percentage following price competition (Wang, 2007).

Cost analysis of plastic injection molding is an instrument to analyze the design for manufacture, specifically for molding plants or injection molding plants. Plastic injection cost is discussed in three aspects, which are the R&D department, mold plant, and injection molding plant, as shown in Fig. 2. Finally, the plastic injection cost can be obtained by summing the three aspects. The product parametric cost estimation is detailed as follows (Yen, 1998; Zhang, 1995):

(1) *R&D department*: Demand quantity of products to be developed are investigated first. Before production, the R&D department discusses drawings, estimates the net weight of finished products, and conducts technical analysis using value engineering. Then it determines the Design for Manufacture (DFM) based on the characteristics of the prototypes and size to analyze the overall cost.

(2) *Mold plant*: The number of mold cavities is determined by analyzing the cost, mold material, weight, depreciation expense, and product demand.

(3) *Injection molding plant*: The net weights of the finished products and weights of the runner are calculated. The plastic injection machining mode is selected based on mold size, then material cost, modification cost, rework cost, and manufacturing costs are calculated.

After the R&D department analyzes the above factors, the mold plant would determine the number of mold cavities based on the amount of demand for the products, and determine mold cost based on material, weight, and the depreciation and expense of the molds. Next, the injection molding plants would calculate the weights of the runner and gate based on quality and appearance, to calculate the material cost. Then, mold machines are selected based on injection weight, projection area on the product, size and height of the molding products, and then modification and rework costs are calculated. Last, optimal offering price is determined (Kent, 2006).

Based on the above, plastic injection cost consists of design/R&D cost, mold cost, and molding products cost. The sum of the last three is the plastic injection cost. This study only considered the costs of the mold and injection molding parts, without taking into account design/R&D cost due to consideration of cost analysis for new product development.

2.2. Application of the back-propagation (BP) artificial neural network in cost estimation

The artificial neural network is an information processing system of the biomimetics neural network. It is defined as an artificial neural network consisting of many simple and inter-connected processing units, and is used to simulate the cerebral nervous system of humans or organisms (Kumar, 2005).

The BP artificial neural network uses the gradient steepest descent method to minimize energy functions. Because the multilayer

Download English Version:

<https://daneshyari.com/en/article/1134892>

Download Persian Version:

<https://daneshyari.com/article/1134892>

[Daneshyari.com](https://daneshyari.com)