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Back Propagation neural network modeling for warpage prediction and optimization of plastic products during injection molding

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ABSTRACT

Warpage of plastic products is an important evaluation index for Plastic Injection Molding (PIM). A Back Propagation (BP) neural-network model for warpage prediction and optimization of injected plastic parts has been developed based on key process variables including mold temperature, melt temperature, packing pressure, packing time and cooling time during PIM. The approach uses a BP neural network trained by the input and output data obtained from the Finite Element (FE) simulations which are performed on Moldflow software platform. In addition, a kind of automobile glove compartment cap was utilized in this study. Trained by the results of FE simulations conducted by orthogonal experimental design method, the prediction system got a mathematical equation mapping the relationship between the process parameter values and warpage value of the plastic. It has been proved that the prediction system has the ability to predict the warpage of the plastic within an error range of 2%. Process parameters have been optimized with the help of the prediction system. Meanwhile energy consumption and production cycle were also taken into consideration. The optimized warpage value is 1.58 mm, which is shortened by 32.99% comparing to the initial warpage result 2.358 mm. And the cooling time has been decreased from 20 s to 10 s, which will greatly shorten the production cycle. The final product can satisfy with the matching requirements and fit the automobile glove compartment well.

1. Introduction

Plastic Injection Molding (PIM) is an advanced technique to process plastic products. As one of the most significant evaluation indexes of the quality of plastic articles, warpage of plastic during the injection molding process has attracted more and more attentions. Many researches have been carried out to reveal the relationships between process variables and warpage of the plastics to reduce the warpage of injected plastic products.

In 2010, Deng et al. proposed a hybrid optimization method that combines a Mode-Pursuing Sampling (MPS) method with the genetic algorithm for minimizing the warpage of injection molded plastic parts. And the warpage value of a food tray plastic part was minimized by using the proposed method [1]. Farshi et al. demonstrated an optimization method for injection molding process parameters by using sequential simplex algorithm. And they minimized the warpage as well as the shrinkage of a kind of automotive ventiduct grid by the proposed method [2]. Shi et al. proposed an adaptive optimization method to minimize the warpage of the injection molding parts based on neural network [3]. Kurtaran et al. considered mold temperature, melt temperature, packing pressure, packing time and cooling time as the key process parameters during PIM. And they got the optimum process parameters resulting in the minimum warpage value of a bus ceiling lamp base by using artificial neural network and genetic algorithm [4]. Ozcelik and Sonat performed the warpage analysis on the Computer-Aided Engineering (CAE) software Moldflow platform and they found that packing pressure is the most influential parameter on the warpage of Polycarbonate/Acrylonitrile Butadiene Styrene (PC/ABS) material by using Taguchi experimental method [5]. Huang and Tai also indicated that packing pressure has the greatest influence on the warpage of plastic parts, followed by mold temperature, melt temperature, and packing time, while the warpage is only slightly influenced by the gate dimension and the filling time in thin shell injection molding. And the optimum values for those parameters were revealed [6]. Kong and Kim studied the effects of processing conditions, package geometry and materials on the occurrence of the warpage, and they pointed out that a lower molding temperature and a smaller coefficient of thermal expansion can significantly reduce the warpage value of the plastic parts [7]. Erzurumlu and Ozcelik minimized the warpage of the plastic parts by using Taguchi optimization method, the signal-to-noise (*S*/*N*) ratio and the analysis of variance (ANOVA) [8]. Wang et al. minimized the warpage of the front panel of large Liquid Crystal Display (LCD) TV by the application of Taguchi experimental design

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