OPTIMZATION OF HEAT TREATMENT PROCESS PARAMETERS USING NEURAL NETWORKS AND NELDER-MEAD ALGORITHM

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Abstract: Metallurgical processes consist of different and complex production operations. One of them is heat treatment. Hardness value is an important response variable for heat treatment process. Heat treatment parameters and interactions between each other are not known clearly. Hence it is hard to define convenient parameters for requested hardness value. In this study, effects of heat treatment parameters on hardness are modelled using back propagation artificial neural network (BPANN) model. BPANN is used to formulate a fitness function for predicting the value of the response based on the parameter settings and then Nelder-Mead algorithm takes the fitness function from the trained network to search for the optimal heat treatment parameters (furnace heat and heat treatment time) combination.

Keywords: Heat Treatment, Neural Network, Hardness, Modelling, Nelder-Mead Algorithm

1. INTRODUCTION

High quality and cheap parts are always preferred by costumer. This situation is result of the increasing competition. There are some uncontrollable parameters in heat treatment process because of using different raw material in casting process. Trial-and-error technic has been used for investigate to optimization of materials processing for a long time (Song and Zhang, 2001). Thus increases cost and makes products less qualified. According to Lahoucine-Abaih et al. the most important control factors for the mechanical properties are the chemical composition and the tempering treatment after the quenching (Lahoucine-Abaih et al. 2007)

In this study, Back Propagation Artificial Neural Network (BPANN) model is used for determining the effects of heat treatment parameters on hardness. Modelling and also prediction specialty of BPANN is used for increasing casting parts quality and decreasing manufacturing costs. BPANN trained with heat treatment parameters that determined as input and hardness value that determined output. BPANN is used to formulate a fitness function for predicting the value of the response based on the parameter settings and then Nelder-Mead algorithm takes the fitness function from the trained network to search for the optimal heat treatment parameters (furnace heat and heat treatment time) combination. This study is applied in a casting factory that produces casting grinding media for the cement and mining industries.

The flexibility and simplicity of neural networks have made them a popular modelling and forecasting tool across different research areas in recent years. A variety of neural network models have been developed, among which the back-propagation (BP) network is the most widely adopted in the present study. According to Song and Zhang an artificial neural network can be applied very well to model the effects of the heat treatment technique on mechanical properties (Song and Zhang, 2001).

2. BUILDING THE NEURAL NETWORK MODEL AND OPTIMIZATION

The use of artificial neural networks has become popular. Material properties such as hardness, tensile strength, fatigue, and yield strength are a complex function of many parameters such as alloying elements and heat treatment conditions and developing theoretical models that can quantitatively predict these