

An approach to the optimal design of technological parameters in the profile extrusion process

Hong Yan ^{a,*}, Juchen Xia ^b

^a School of Mechanical-Electrical Engineering, Nanchang University, 339 Beijing Dong Road, Nanchang 330029, China

^b State Key Laboratory of Die Technology, HuaZhong University of Science and Technology, Wuhan 430074, China

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Abstract

An approach for the optimal design of technological variables in the profile extrusion process was proposed, which integrates a finite element simulation technique, an artificial neural network and a genetic algorithm and configures a reasonable die-hole layout for a non-symmetric profile extrusion process. The comparisons between computed and experimental results indicated that the optimal design model is effective and feasible. The numerical simulation for an angle aluminum extrusion process was conducted using the optimal results of the die-hole layout. The mesh distortions at different stages of the extrusion process were described in detail. The distribution of the velocity at the die opening was also obtained. This is helpful for the proper determination of the profile extrusion technology and optimization of the die design.

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1. Introduction

The computational modeling of extrusion is now well established. Within the last 20 years, the finite element method (FEM) has become a powerful technique to simulate metal-forming processes. Nowadays, the finite element numerical simulation not only can describe precisely the metal flow process, but also can give the fixed values of various physical fields, which is a powerful tool to carry out the optimal design of technological parameters and to predict defects in the deformation process [1]. However, a lot of trial-and-error computer tests are required in order to study the influence of the various technological parameters on the forming process. If the optimal design of the technological parameters is conducted using the finite element method, many calculations are required, which results in the waste of resource. The orthogonal test method is a scientific experimental approach based on the development of probability and mathematics statistics, including the equalization disperse and regularity comparison [2]. This method can reflect relatively all-around situation with few experiments, which can consider many

factors and targets. The artificial neural network (ANN) is an artificial intelligent approach simulating the manner of the brain neural delivering information, which can provide a new approach to solve the simulation of non-linear system and to make the prediction for unknown models [3,4]. ANN possesses the characteristics of auto-organize, auto-learn, auto-adapt and non-linear dynamic manage, etc. which can considerably reduce the numerical simulation time. The genetic algorithm (GA) is a scientific optimal approach simulating the creature evolutionary mechanism on computer with the natural choice and genetic mechanism [5,6]. GA is a huge parallel, stochastic and auto-adapting search algorithm that borrows the operations and themes from natural evolution, which can solve the optimal problems of both the continuous derivative function and the discrete derivative function. In this paper, ANN was adopted to set up the system model and GA was used to figure out the optimal problem of assembled parameters such as the selection of technological parameters in the design of a profile extrusion die.

2. An approach to the optimal design of the technological parameters

Because the extrusion section is complex in the profile extrusion process, the metal flow from the extrusion die is not uniform, which causes the crosscracking, bending, distorting and twisting on the extruded product. To improve the quality of

* Corresponding author. Tel.: +86 791 8304570; fax: +86 791 8305064.

E-mail address: hyan@ncu.edu.cn (H. Yan).

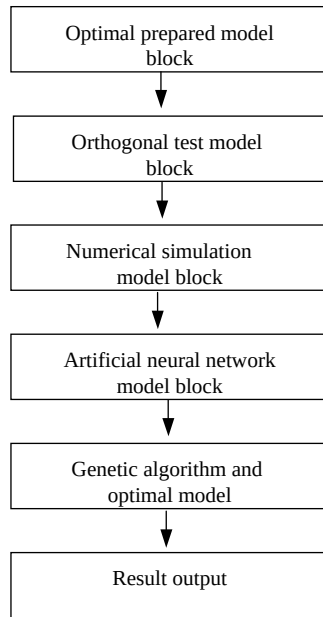


Fig. 1. Optimal design model of technological parameters.

the piecework, the die-hole layout must be taken into account in the design of the profile extrusion die, which is the optimal problem of assembled parameters. In this paper, an approach to the optimal design of technological parameters is presented based on our previous work [7], integrating FEM, ANN and GA, shown in Fig. 1. The functions of various model blocks are presented as follows:

- (1) *Optimal prepared model block.* The optimal objective function and main technological parameters are determined with this model block. The restrain scopes of the technological parameters are determined on the basis of the practical experience.
- (2) *Orthogonal test model block.* Based on the orthogonal principle, a standard pattern—orthogonal table is specified, which arranges the test scheme. A few tests are used to gain the interaction of the design parameters, which can reduce numerical simulation time.
- (3) *Numerical simulation model block.* Based on the plastic finite-element method, the numerical simulations of the profile extrusion-forming process are conducted with the scheme supplied by an orthogonal test to acquire the objective functional values and to prepare the learning samples for the artificial neural network. The numerical simulation based on the optimal results is carried out to provide the helpful information for the die design.
- (4) *Artificial neural network model block.* The network model is trained by the learning samples of the numerical simulation results, which is served as the knowledge source after trained and tested. The objective parameter function values required by GA are gained by the spread application ability of multiplayer ANN.
- (5) *Genetic algorithm and optimal model block.* GA having global convergence is used as the optimal algorithm. The main technological parameters in the profile extrusion

process are optimized with the objective functional values obtained by the ANN model.

- (6) *Result output.* The main optimal technological parameters are exported with this model block, the results such as the stress and strain are also exported by the numerical simulation model block.

3. Optimization of the technological parameters for a non-symmetric angle aluminum profile extrusion process

3.1. Selection of the objective function

The selection of the objective function is associated with the specific research object. It is important to balance the metal flow velocity in the profile extrusion process. For this purpose, the standard deviation of the velocity field (SDV) is chosen as the objective function. SDV is defines as

$$SDV = \sqrt{\frac{\sum_{i=1}^N (V_Z^i - V_Z^{ave})^2}{N}} \quad (1)$$

where N is the nodal point number in an interested region, V_Z^i is the axial nodal velocity in a given plane, and V_Z^{ave} is the average axial velocity in a given plane. The optimal goal is to make it the minimum for SDV of the extruded product.

3.2. Selection of the design variable and its restrain scope

Calculation of the die land length in the profile extrusion process is conducted under the certain layout of the die hole. First, the proper die-hole layout is found with the well-balanced metal flow velocity in the front of ensuring the die strength. Second, the fluctuation of the metal flow velocity is

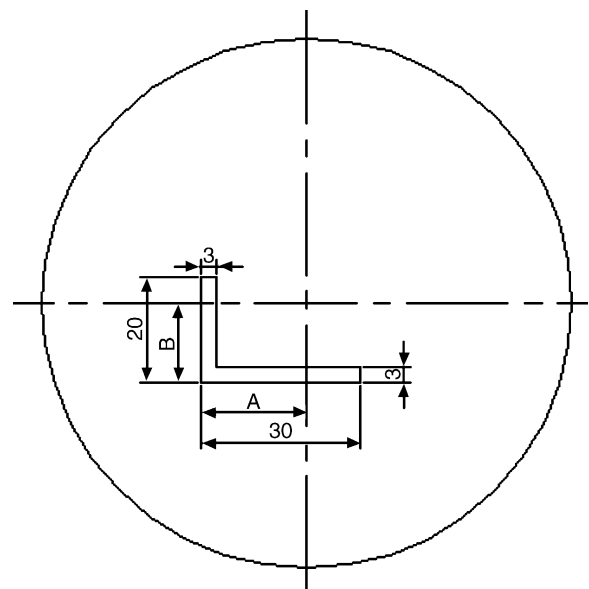


Fig. 2. Design figure of die-hole layout for a non-symmetric angle aluminum profile extrusion process.

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