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Optimization design of abrasive belt grinding parameters

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Abstract: The mechanism of abrasive belt grinding is more complicated. The design variables in the abrasive belt grinding parameters are selected, the objective function is determined, the constraints and mathematical models are established, and the optimized design of the abrasive belt grinding parameters is transformed into two-dimensional Nonlinear optimization problems can be optimized for specific belt grinding process parameters for increased productivity. Reducing production costs has certain reference significance.

1. Introduction

Abrasive belt grinding is one of the advanced machining methods developed in the 1960s [1]. It is a new type of grinding process that is efficient, economical, versatile and has the name of “universal grinding”. Abrasive belt grinding is a new type of high-efficiency grinding and polishing process that grinds, grinds and polishes the surface of the workpiece with high-speed moving abrasive particles according to the shape of the workpiece. During the grinding process, the effects of different abrasive grains may be different, that is, a part of the abrasive grains act as a sliding friction, part of the ploughing, and some cutting, even if different parts of the same abrasive grain and the same part are in different processing time. The role played is not the same. The explanations for grinding mechanism, chip formation, grinding force, grinding temperature, grinding heat, etc. involve basic sciences such as physics, mathematics, elastoplastic mechanics, fracture mechanics, tribology, computer science, etc. The belt grinding mechanism is more complicated [2-4]. The serious wear of the belt directly affects the quality of the workpiece, and the wear of the belt is the result of a combination of factors such as grinding force, grinding process parameters, workpiece material, grinding fluid and moving form. The process parameters are particularly important, so optimizing the design of the belt grinding parameters can greatly improve the quality and efficiency of the grinding.

2. Optimized design of grinding parameters of abrasive belt

When grinding the belt, when the machining task (the technical requirements of the workpiece and the workpiece material) and the process equipment (machine tool, tool, fixture) are fixed, the radial feed amount, the axial feed amount and the workpiece movement speed It is an important design variable for the grinding belt grinding process parameters. Since the axial feed amount mainly depends on the width of the abrasive belt during processing, the choice is small. Therefore, the optimal design variable of the abrasive belt grinding process parameters can be radial. Feed rate and workpiece movement speed. Expressed in matrix form as [5]:

$$X = [X_1, X_2]^T = [f_r, V_w]^T$$

The optimization goal for abrasive belt grinding is usually the maximum profit margin. Any grinding process must achieve the lowest cost and highest productivity with the guaranteed quality. When other conditions are constant, the highest productivity means that the metal is ground at the most per unit time. Therefore, in this optimization design, the volume of metal ground by unit time is at most the optimization target, so the objective function expression is:

(1) When there is no axial feed:

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$$f(x) = Z_w = 1000V_w f_r B$$

Where – the belt width (unit: mm), when the belt type is fixed, its width is a constant.

(2) When there is axial feed:

$$f(x) = Z_w = 1000V_w f_r f_a$$

The optimized design is optimized by the axial feed belt grinding as the research object. which is:

$$\max f(x) = 1000 f_r X_1 X_2$$

In actual machining, the specific radial feed is given or determined by actual machining.

Considering the working conditions of abrasive belt grinding and their influence on the grinding parameters of the abrasive belt, the constraints of this optimization design are as follows:

(1) Design constraints determined by machine power

Considering the reliability of the working time of the belt grinding machine, the cutting power required for the grinding machine to work must not exceed the effective power of the machine tool, ie:

$$P_C = C_P (V_w f_r)0.7Bk \times 10^{-3} \le P_E \eta_m$$

$$g_1 = C_P (X_1 X_2)0.7Bk \times 10^{-3} - P_E \eta_m \le 0$$

Where – the transmission efficiency of the belt machine tool is usually taken as =80% to 96%;

- Calculate the coefficient.

(2) Design constraints determined by machine tool feed

In order to ensure the safe working of the belt grinding, the radial feed must be within the range of the machine's rated feed, ie

$$f_r \le f_{r\max}$$

After finishing:

$$g_2 = X_1 - f_{r\max} \le 0$$

Where – the maximum radial feed defined by the belt grinding (unit: mm).

(3) Design constraints determined by the machine feed mechanism

In order for the grinding head feeding mechanism to work normally, the friction caused by the pressure required by the workpiece must not exceed the tangential force of the workpiece, otherwise the workpiece will not be able to drive normally. Therefore, it is generally taken during the grinding of the abrasive belt. The specific coefficient depends on the grinding amount, the processing material and the grinding fluid. 5~2 times. The grinding wheel grinding ratio of the grinding wheel is about 1.5 to 2 times. 5。 When the plasticity of the workpiece material is smaller, the smaller the grinding wheel, the current ratio is generally taken to be an intermediate value of 0.35. Therefore, the material can be taken according to the material of the workpiece. When the plasticity of the workpiece is small, a smaller value can be taken, and a larger value is obtained. among them:

$$F_P = C_F (V_w f_r)0.7Bk$$

Where —— calculate the coefficient;

——The resultant force of the workpiece during the machining process.

After finishing, it is obtained:

$$g_3 = F - R_y C_F (X_1 X_2)0.7Bk \le 0$$

(4) Design constraints determined by the surface roughness of the workpiece

According to the grinding requirements, the surface roughness of the machined workpiece must not exceed the value specified by the workpiece design. Since there are many factors affecting the surface roughness, it is generally believed that the radial feed has the greatest influence on the surface roughness. Under normal production conditions, to simplify the analysis, the calculated values of the theoretical roughness are obtained:

$$f_r \leq \sqrt{Ra\theta / 0.321}$$

In the formula R_a - the surface roughness value specified in the design of the workpiece (unit: μm)

θ——The cone angle of the abrasive belt cutting edge (unit: rad)

After finishing:

$$g_4 = X_1 - \sqrt{Ra\theta / 0.321} \leq 0$$

3. Establishment of mathematical model

According to the design variables, objective functions and constraints determined above, the mathematical model of the optimization design of the abrasive belt grinding process parameters can be obtained. The volume of metal grounded per unit time is at best optimized, that is, the maximum is maximized, and the maximization and minimization are equivalent. Therefore, the mathematical model of the optimization design of the abrasive belt grinding process can be expressed as the equation (13). Show:

$$\left.\begin{array}{l} \min f(x) = -1000 f_r X_1 X_2 \\ s.t. g_i(x) \leq 0, i = 1,2,3,4 \\ X = [X_1, X_2]^T = [f_r, V_w]^T \end{array}\right\}$$

This optimization design problem is a nonlinear programming problem. It belongs to the two-dimensional nonlinear optimization problem and can be solved by a specific constraint optimization algorithm.

4. Summary

In the process of abrasive belt grinding, because it is a dynamic process, the situation is relatively more complicated. Using the optimized design method, the process parameters of the abrasive belt grinding are optimized and the effect is obvious. It can not only avoid the lack of experience, but also has certain reference significance for improving productivity and reducing production cost.

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