Research and Analysis on the Relationship between Geometric Parameters and Cutting Force of Mechanical Milling Tool

Dongya Li[a,*], Ming Wei

Applied Technology College of Soochow University, Suzhou, Jiangsu, 215000, China

[a] 82837381@qq.com

*corresponding author

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Abstract: Milling is a complex nonlinear cutting process. The selection of reasonable cutting parameters has a great influence on the cutting force and cutting power of milling, and it has an important influence on the quality of machining parts, the service life of cutting tools and equipment. As a tool to deal with complex nonlinear problems, parametric algorithm is widely used in engineering field. By establishing a reasonable neural network and calculating cutting force and cutting power quickly and accurately, the cutting parameters can be optimized and the machining cost can be reduced..

1. Overview of Milling

China is a recognized manufacturing country in the world, metal processing is the most important processing method in manufacturing, paint is one of the most important and commonly used processing methods in metal cutting, and occupies an important position in manufacturing. At present, many researchers at home and abroad are building grinding models by stages to study the changes of sharpness and power of machine tools, and then to study the severity and energy consumption of machine tools in order to save production costs, improve competitiveness, and implement the national low carbon strategy. in the machining process, it is difficult to accurately calculate the shear force and shear force. especially under different shear parameters, the parameter network, as a tool to deal with nonlinear problems, has been widely used in engineering, and the best use of parameter network.

This paper collects 30 sets of data through mill test. the constructed input is braking speed [VC]、 feed speed [F]、 return air speed]. according to the parameter algorithm, a set of equations are established to calculate cutting force and shear force quickly and accurately under different cutting parameters, and select reasonable grinding parameters, thus reducing cost and cutting cost.

1.1. Introduction to Milling

From the point of view of processing, the design and performance of the equipment itself, the environment, the ability level of the operator, the material and geometric parameters of the separator, the processing of the blank, the clamping mode and so on will affect the milling force and the milling force.

In terms of cutting theory, there is no accurate theoretical derivation for chip breakage, plastic deformation, rough cutting machine tool model, mathematical model or empirical formula for different milling methods; mathematical models such as empirical temperature and vibration effect during cutting are determined. From the experimental point of view, some factors in the grinding process are difficult to accurately measure, even can not be measured, many experimental factors are affected by the environment, it is difficult to accurately copy in the laboratory.

As mentioned above, the grinding process is a typical nonlinear physical process, and it is difficult to determine a more accurate grinding model. therefore, most of the current calculation and optimization of grinding process parameters ignore the factors with less influence, and the nonlinear process is transformed into a linear research process.

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1.2. Milling Tests

The equipment used in the experiment is the mcv-l1165 machining center produced by binsheng company (see figure 1). the equipment was improved by an integrated system for measuring spindle power, torque and on-board operating box torque. The main shaft of real-time processing plant consists of servo engine of Japan FANUC Company, with maximum power 11 kw, maximum torque 70 n183m.

Figure 1 Machine plus test equipment

The copper adopts cemented carbide spiral milling cutter, the material y330, specification is "BRIN93430"\9215;53,4 teeth.

The blank material is 40 Cr steel, which is the standard steel of our country, the national standard is "alloy structural steel "(GB/T 3077-1999), the foreign standard is" alloy steel for mechanical structure "(JISSG 4053-2003), hot forged coal and alloy steel bar (ASTM a29-a29m-2016), heat treated steel, alloy steel and automatic steel standard specification (ISO 683-18-1996). 40Cr steel is one of the most widely used steel, widely used in equipment and tools manufacturing, but also a large number of steel in the world.

1.3. Experimental Data

In the experiment, such as general metal cutting, the blank parts are fixed on the three-claw chuck on the bed surface to find the center, and the milling mode is down-milling and straight-walking knife. to facilitate data processing, the author preprocesses the data to conform to the common units of international unit system, transforms the units of feed [f]] into mm/r, more conform to the common units; and converts the spindle speed [n]](r/min) according to the formula [v=pdn/1] Variable to tool linear speed [v](m/min), torque (N?) m) transform to cutting force F (N) according to formula [, and use normalization method, it is more convenient for data calculation.

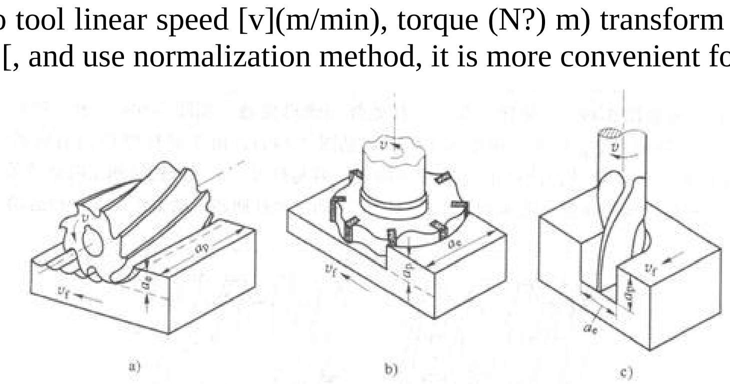

Figure 2 Mechanical milling cutters

2. Parameter Calculation Milling Parameters

2.1. Brief Description of Parameters

This parameter is artificial neural network (ANN). through a large number of studies and experiments, the working process of biological neurons can be simplified, and the processing mechanism of complex biological neurons can be simulated by mathematical methods, which can directly solve complex nonlinear problems.

The parameter algorithm is different from other traditional algorithms. With the constant change of variables and the increase of data volume, the accuracy of traditional algorithm or optimization algorithm is gradually reduced. and the neural network algorithm has the ability of self-learning. with the change of variables and the increase of data samples, the calculation results will be more accurate, and the optimization effect will be more significant and better.

For very complex nonlinear problems such as milling, the artificial neural network has a strong ability to solve and process, and is a turbid and "correct" solution method.

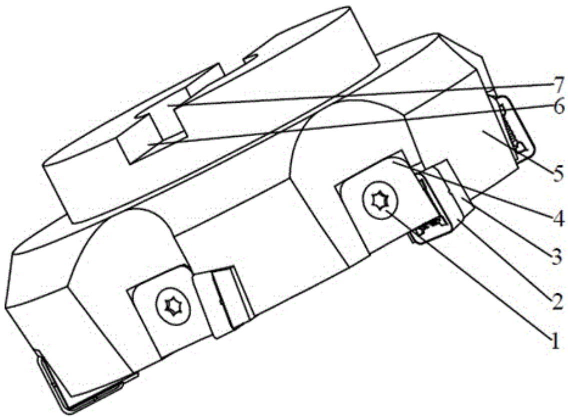

Figure 3 Mechanical milling cutters

2.2. Application of Parameter Algorithm In Milling

To the specific problem of the number of samples [np]] collected by milling machining experiments, construct a multi-layer parametric network. here, the number of network input layer elements [ni]] and the number of output layer elements [no] are fixed. the number of hidden layer layers [nhnum] hidden layer and each hidden layer element [nhjj=1,2,..., nhnum] is unknown.

First, it is necessary to determine the reasonable structure of the parameter network, that is, to obtain the number of hidden layer layers and the number of units per hidden layer.

Generally, find design variables representing weights and thresholds [z*], make [f (z*)=0]. the author uses the NNCGOA method to perform the optimization calculation. if [f (z*)<ε]([ε] represents the minimum that makes the objective function [f (z)] obtain), the parameter structure is reasonable; if [z*] is not satisfied <ε]ε], the parameter structure is unreasonable [6].

Where [Op,l (z)] represents the calculated output of unit [l]] of the [p] sample output layer, the objective function can be expressed as:

[f (z)=12 npp=1(z) npp=npp=2,12 npp=1(z)]2](1)

According to the theory of algebraic equations [7,8], when [n=na]], the solution satisfying the equation can be found, which is the minimum condition that the hidden layer structure satisfies.

[At n=na], optimize the total dimension of the design variables in the objective function:

[n=(ni+1)nh1+j=0nhnum-1(nhj+1)nhj+1+(nhnhnum+1)no](2)

the upper formula ,[ni]、[no]、[np] are all known quantities, the number of hidden layers [nhnum]] and the number of units per hidden layer [nhjj=1,2,..., nhnum] can determine the reasonable structure of the required parameters.

Actually, minimize when the design variable does not produce redundant conditions, usually using 1~3 layers.

When the number of hidden layer layers is fixed, the formula (2) is an equation or an indefinite equation about the number of hidden layer elements [nhjj=1,2,..., nhnum].

If [nhnum=1] is taken, the formula (2) is:

Noni+np·no](3) nh1+(nh1+1)

[nh1] is an integer, calculated by formula (4):

[nh1=[(np-1)noni+no+1+0.9]](4)

When [nhnum=2] is taken, formula (2) is an indefinite equation containing [nh1]] and [nh2]] two unknown quantities:

[(ni+1) nh1+(nh1+1) nh2nh1+(nh2nh1+1))

[nh2=[(np-1) • no-(ni+1)nh1no+nh1+1+0.9]], take different [nh1] to calculate [NH2], and get the combination of [nh1] and [NH2].

When [nhnum⩾3], then (2) is the indefinite equation of [nhjjnhnum⩾1,2,..., nhnum], which can be obtained by [nhnhnumnhnum⩾h (n h 1,...,1)] relation. The total dimension of the corresponding design variable can be obtained in each combination case [ncj], take [min|ncj-na|] the corresponding structure as the desired structure, and then the design variable [n=ncj].]

For avoiding redundancy of design variables, the best structure is [n=na].]

The number of input layer elements [9] is [ni],] based on the actual condition of milling machining and the application of parameters. there are three input variables, i.e. cutting speed [vc]、 feed [f]、 back cutter] ap]; hidden layer element number is [nh]; output layer element number is []. there are two output values, i.e. spindle cutting force [F]、 spindle power [P]; sample number is [].30 sets of data were collected in experiments. according to the above theory, a three-layer network can be established, as shown in figure 3. As the whole network has three layers, that is ,[nhnum=1], it can be calculated that the hidden layer can be satisfied with 10 units, and the total dimension of the design variable, that is, formula (2), can be reduced to:

[n=(ni+1)nh+(nh+1)no](6)

The input and output of the above network are respectively expressed as [xp,yp], where [p=1,2,..., np].. The formulas for calculating input and output are as follows:

[xp={ xpi}ixp=1,2,..., niypxp={ xpk}kxp=1,2,...,...,

Through the above three-layer network, the weights and thresholds of the network are unknown. for each sample input [xp], through complex nonlinear operations of weights, thresholds, and Sigmiod action functions, an output [op], is obtained and its overall mean error [12· npp=1 npnpp=npp=yp-opnpp=npp=2] approaches zero.

Considering the average error of the network as an objective function [see formula (8)]: if the network weights and thresholds to be obtained are design variables z, then the unconstrained nonlinear optimization problem for the calculation of network weights and thresholds for a given sample condition is constituted [see formula (9)]:

[f (z)=12 npp=1]2](8)

[minfz,z∈Rn](9)]

The objective function of the problem is:

[f (z)=12 npp=1(z) npp=npp=2](10)

where ,[z] is a design variable, representing weights and thresholds.

The total dimension of the design variables is:

[n=(ni+1)nh+(nh+1)no](11)

Corresponding distribution relationships between weights, thresholds and design variables [z]] are:

[z(nx):nx=(j-1)(ni+1)+i,i=1,2,⋯ni,j=1,2,⋯nh:express wj,i nx=j • (ni+1),j=1,2,⋯nh:express θ j](12)

[Let nnc=(ni+1)nhz(nx):nx=nnc+(k-1)(nh+1)+j,j=1,2,⋯nh,k=1,2,⋯no:express wk,j nx=nnc+k • ? nh+1, knh+1,2, no: indicate

[z=z(1),z(2),…,z (n)](14)

The design variable can be determined by an optimization method for any given [z(0)],][z*], makes [fz]] obtain a minimum value [fz*], which is the minimum point. combined with milling experiments ,[ni=3, noni=2, npni=30, nhni=10] form a computable neural network. the weights and thresholds of each layer are obtained by parameter calculation (see table 2).

According to the above calculation, the average error between the calculated value and the actual processed value is 0.000 029 80. through the above weights and thresholds, the following equations can be constructed for quickly calculating the spindle cutting force and power consumption of the device when any given cutting parameter is given.

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