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INFORMATION TECHNOLOGY AND IT'S APPLICATION IN THE PRODUCING PRECISION OF COPPER TUBE

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ABSTRACT

Uniform Design, Finite Element Simulation, Artificial Neural Networks, Genetic Algorithm had been integrated to optimize the die geometric parameters of copper tube produce. The browser, WEB server and database structure of copper tube processing quality information management system were designed, The SPC technology of intelligent diagnosis analysis and processing were realized quality information storage, sharing, analysis and application. It is a kind of realization of copper and copper alloy tube production process intelligent design very good method.

Keywords: *Artificial Neural Network, Finite Element Method, Expert System, Copper Tube*

1. INTRODUCTION

With the constant enlargement of the enterprise, the enterprise quality management structure and quality management system operation efficiency are put forward more and more highly demand. The rapid development of information technology brings new revolution to the enterprise quality management mode change [1]. Because the quality is the most basic element of the modern enterprise core competitive ability, how to use information technology to optimize enterprise quality management process, integrate enterprise resource, realize the rapid transfer of quality information and response, achieve quality management of the collaborative operation and quality data of scientific analysis, promote enterprise technology improvement and brand promotion, is an important problem that many enterprises face.

The modern enterprise quality management technology and the development of the advanced manufacturing model brings great changes in the future manufacturing enterprise quality management technology coverage, form of organization, management mode, the optimization method, the support platform and tools and so on. The enterprise quality management changes wider and deeper, the quality system and related system integration demand are higher and higher. The process of the multi-function business management and more cooperation between the departments based on WEB will become the main directions of quality management information development in the future.

Copper tube processing expert system is a high technology product.It means IT chemical processing about copper tube forming analysis technique, it templates with copper alloy tube rolling process , comprehensive investigation on modern copper processing industry of roll, drawing technology. It not only reflects the advanced and creative of copper pipe production technology, but also develops extended space and security for enterprise production technology. This system is composed of a number of relatively independent modules; they can be used alone, and can be used combination. It can improve the product quality, shorten the production cycle, reduce the cost, speed up the enterprise capital circulation, especially has more prominent advantages for varieties and specifications of products; It helps to improve the automation and information degree of the enterprise manufacturing .It can also enhanced the ability of products change responding to the market. The system can realize the main process of rolling process of intelligent process design and quality control according to product requirements. workers who lack of professional knowledge can work out accurate standard processing technology, and can solve all kinds of practical problems of the copper tube processing [2, 3].

Section 2 presents research method on the information technology and its application in the producing precision of copper tube. Section 3 presents the copper pipe production process.

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Section 4, presents the copper tube rolling production line quality information management. Section 5 presents the three-roll planetary rolling modeling and cad parametric design. Section 6 presents the prediction forces of three-roll planetary rolling. In the last section, we give a conclusion to the whole paper that it is a good method to realize intelligent design of copper and copper alloy tube production through the information technology.

1. RESEARCH METHOD

According to the problem of low efficiency and large quantity of the casting process design, The knowledge reasoning, neural network, genetic algorithm, the finite element simulation, test design, CAD parametric design and statistical analysis technology were applied to the process design and parameters optimization. Their respective technical advantages are fully developed and the faults of low intelligent degree, single design method and difficult knowledge acquisition about traditional expert system are overcome. The main research methods are as follows:

1.1 Knowledge inference

After summing up and sorting the expert knowledge, knowledge is mapped to structure or program that can identify for the computer according to the knowledge expression model, the system can work in coordination with logical way.

1.2 Neural network

Neural network has highly nonlinear fitting property and wide adaptability of multiple input multiple output problem .It has advantages in the processing associative memory, reasoning in image thinking, and ability in self-learning and self-organization

1.3 Genetic algorithm

Genetic algorithm is used to search the optimization process parameters. Especially suitable for processing complex and nonlinear problems in the traditional search algorithm and has been widely used in engineering field.

1.4 Finite element modeling

Finite element technology suitable for solving all kinds of complicated boundary and nonlinear problem, etc. and is used in processing field that can improve product quality, reduce product development cycle, reduce the cost and improve productivity.

1.5 CAD parametric design

Software of Auto-CAD is widely applied with its outstanding engineering graphics capability. Using the automation service function of ActiveX Auto-CAD can be secondary development to realize parametric design and can comprehensive treatment of the design calculation, data processing and graphics drawing.

1.6 Experiment design

Experimental design is a technology that is theoretically based on probability theory and mathematical statistics. It arranges experiment economically and scientifically. The main content is to discuss how to reasonably arrange the experiment and correct analysis of experimental data, so as to achieve with less test time, lower cost for the purpose of optimization scheme as soon as possible.

2. COPPER PIPE PRODUCTION PROCESS

Copper pipe production process-- Planetary rolling tube for billet method. This process is invented by the Finland OUTOKUMPU company, which is called the roll (Casting and Rolling) process. This technology has the short process, high yield, low cost, less equipment investment and other significant advantages, which is the current advanced ARC copper pipe production technology. In the whole process, each procedure such as: horizontal continuous casting and rolling, disc pull, winding, etc. It can be regarded as a continuous production process, but the process between each other is independent, the process for the products is of cohesion. The processing method is a kind of hybrid processing methods, is unification of continuous process and discrete processing, and process stability is good.

3. COPPER TUBE ROLLING PRODUCTION LINE QUALITY INFORMATION MANAGEMENT

Copper tube rolling production line quality information management is based on the enterprise internal LAN to realize information integration and sharing and can dynamic track with information about the quality in the process of process, which can reflect the workshop master plan (workshop production capacity), planning decomposition, raw materials, semi-finished, finished products and present situation and mutual relations, equipment operation, workers proficiency, product processing ability, etc. Shop information data acquisition system is set up at first, the process will be the quality of the product information recorded in a database; then design the quality analysis tool, including the process capability indices calculation tools and all kinds of SPC control chart tool [3]; At the last design quality of the diagnostic tool,

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analysis data come from SPC technology. [4, 5] and provide analysis report for management to make decision.

Copper tube processing quality information management system is based on the enterprise internal LAN to realize information integration and sharing, to shop in the process of information about the quality of dynamic tracking, which reflects the workshop master plan (workshop production capacity), planning decomposition, raw materials, semi-finished, finished products and present situation of mutual relations, equipment operation, workers proficiency, product processing ability, etc. The first set up shop information data acquisition system, the process will be the quality of the product information recorded in a database; Then for the quality analysis tool design, including the process capability indices calculation tools and all kinds of SPC control chart tool; The quality of the diagnostic tool design, the application of SPC technology on acquisition in data analysis, and provide analysis report for management decision making. Copper tube processing process quality management information system data flow is shown as shown in figure 1.

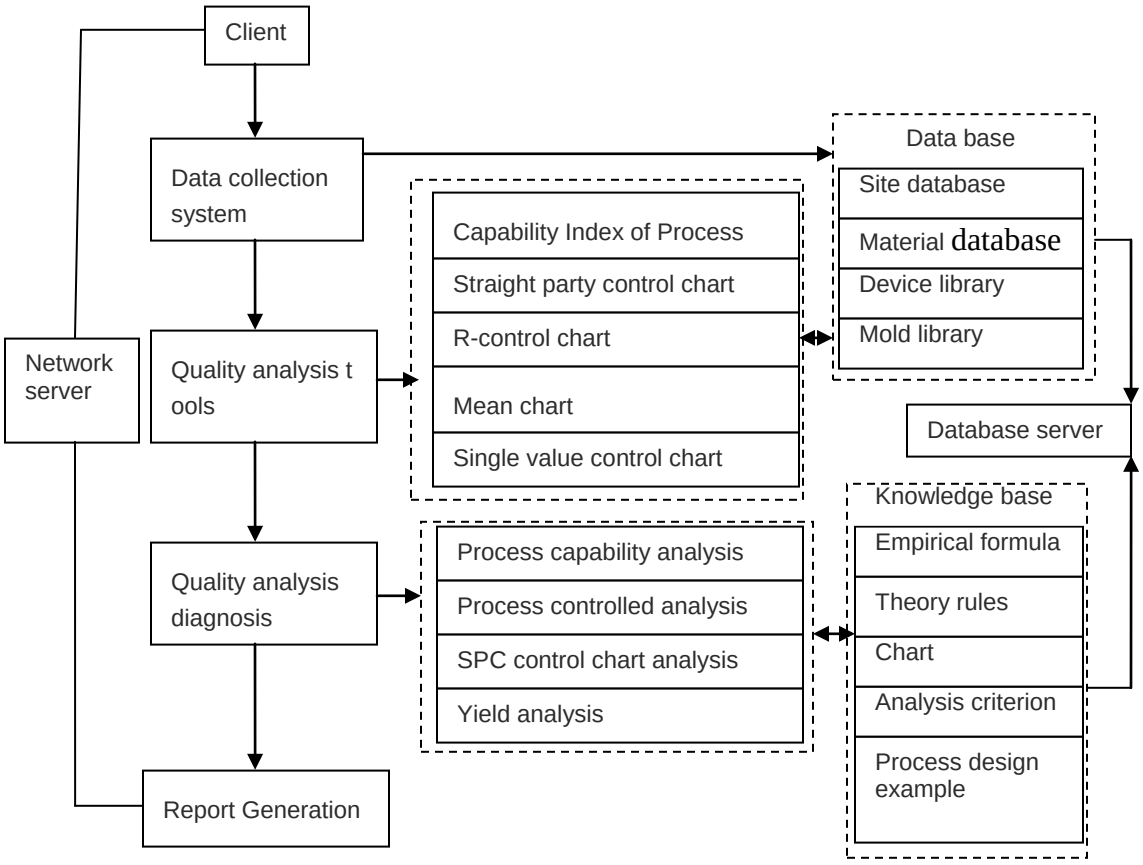

Figure 1 Copper tube processing process quality management information system data flow

Quality information monitoring system is based on the production data management system, and is cored of the quality monitoring system knowledge, after testing and analyzing the quality statistical analysis tool, the analysis results reflect the quality of the production status and quality defects solutions can be obtained, and the quality of the statements given in the form of quality report, in addition, the quality analysis of the result will be stored in the database backup as history that is used as reference for future work of quality information. Quality information monitoring system consists of production process management module, and online quality monitoring module and off-line quality management module.

Production process management module is responsible for the storage and process related to technical data, including quality related operators, equipment, measurement value, material, process

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and other factors of management and logistics management, product batch number tracking etc.

Online quality monitoring module is responsible for the quality of the product in the process data monitoring, the system can give warning information in time for serious quality problem to prompt process rectify.

Off-line quality management module is mainly service for the workshop quality manager personnel. Use SPC technical analysis method, the quality of products information can be researched and analyzed further, so to get the trend of product quality change, to form quality report on the basis of it.

The database system contains process database and production database. Data in the database including are not only from the on-line detection system, but also from hand added, all of which can be used as a quality monitoring system knowledge data base. Knowledge base of quality monitoring system is the core of the whole system; it stores a lot of rules and knowledge related with quality control. It can be divided into three levels: first, quality tools analysis module, mainly responsible for the analysis that proposed by user according to the analysis carried on by the specified quality tools. Second, the results of the analysis judgment module, mainly responsible for the results of judgment according to the quality tools explaining the principle, make the analysis results to be directly used in production. Third, defect analysis diagnosis module, mainly responsible for the defects result according to the expert database theories to find reasonable solutions.

Due to the diversity of users (including the operator, process technician, quality control officer, confidence center, enterprise leadership, etc.), the system provides a multi-user function corresponding authority distribution, which is according to different user, different management levels. In order to share the public data, feedback information quickly, inquire conveniently and quickly, the system uses the three layers of B/S (browser/server) structure. The first is the user interface layer, including the necessary data type testing, data input window. The second is the application service layer, main process authority inspection, data process and other process. The third is the database server management, cooperate with ERP system that enterprises are implementing, SQL SERVER2000 is used as database, and the main subject is the structure of database. It also includes part of the data that processed during the storage process development. The three layers of B/S structure makes the client interface friendly, daily management work can completed through the simple operation. System module is placed in WEB server; its design, maintenance, and update are convenient. Based on the workshop of internal Intranet, users B/S mode, are assigned according to the different permissions, visiting different business logic module, to conduct their own business process, WEB server will be asked to return the results to the client browser through other resource requests put forward by the database server.

4. THREE-ROLL PLANETARY ROLLING MODELING AND CAD PARAMETRIC DESIGN

To realize parametric modeling roll, roll shape parameters are shown in figure 2. Two dimension roll contour line rotate around the x axis to get three dimensions. After build a three dimension model of roll, roll orientation realized through the graphic translation transformation. The transform steps are following:

（1） Translation L Along the x axis (roll positioning distance);

（2） Rotation Angle β around the z axis (Angle of roll);

（3） Rotation angle α around the x axis (deflection Angle);

（4） Translation A along the y axis (revolution radius of planetary wheel).

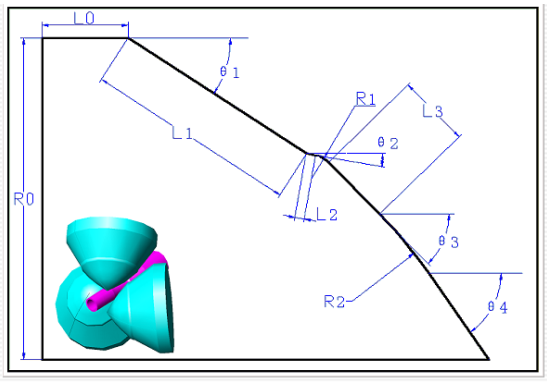

Figure 2 Roll parameter Settings

General translation transformation matrix for:

$$M_3 = \begin{bmatrix} \cos\beta & \sin\beta & 0 & L\cos\beta \\ -\sin\beta\cos\alpha & \cos\beta\cos\alpha & -\sin\alpha & -L\sin\beta\cos\alpha + A \\ -\sin\beta\sin\alpha & \cos\beta\sin\alpha & \cos\alpha & -L\sin\beta\sin\alpha \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

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Based on the above analysis, in order to realize parametric modeling, Auto-CAD software secondary development is made. First all roll shape parameters are input, roll model is established. The sample diameter and roll process parameters such as deflection Angle, inclination Angle, roll distance and planetary wheel revolution radius are input. Translation matrix M3 is calculated to realize roll translation change, roll position is determined through judgment of roll and sample intersection gradually approximation. According to the roll position, mesh equation is used to calculate contacting point coordinates of the roll and the work piece. It can output the starting point and vector which acts as the input of the finite element simulation of the roll axis.

The program has realized: (a). The parametric design and output roll diagram; (b). the position of the roll is determined by the sample. It also means roll orientation is determined by roll axial positioning distance L. It determines the latter (three roll inscribed circle), and controls rolling pipe diameter finally; (c). Work piece initial model generated through calculating contact point between roll and work piece

5. PREDICTION FORCES OF THREE-ROLL PLANETARY ROLLING

Three-roll planetary rolling process parameters include roll deflection Angle α, Angle β, the latter (three roll inscribed circle diameter), roll autobiography speed and revolution speed, cart speed and friction coefficient, etc. [4-7]. In the practical production of copper tube, roll deflection Angle α and roll rotation speed can be adjusted; coefficient of friction changes with the wear degree of the roll. Other parameters are constant or have little impact. In order to study the relationship between the rolling force and the three factors that declinations Angle α, roll rotation speed and friction coefficient, MSC. Marc software is used to simulation three-roll planetary rolling in CTES system. Rolling force is predicted combining with the FEM and ANN.

Because of the complex of the space roll shape modeling, CAD of the roll is obtained through Visual basic combined with Auto-CAD for parametric design according to the parameters after design. Chart is put into the MSC. Marc. Finite element such as material parameters and boundary conditions are set according to the results of physical simulation. The finite element simulation model which being shown in figure 3 is established

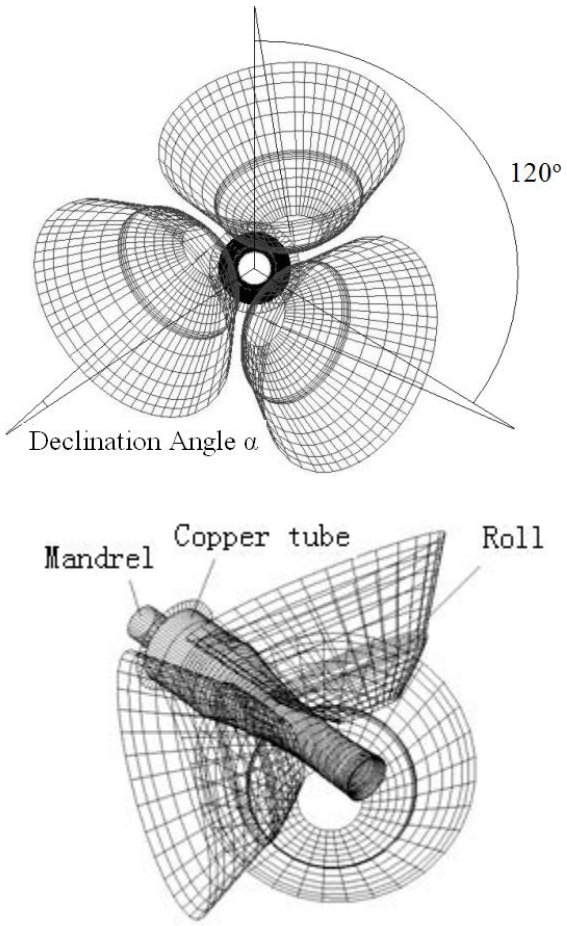

Figure 3 Finite element model of three roll planetary rolling

6. UNIFORM DESIGN FOR FINITE ELEMENT SIMULATION SAMPLE ARRANGEMENT

It needs a lot of training samples for training in the ANN (neural networks). Considering the advantages of uniform design and the actual situation that many levels of planetary are rolling, the finite element training samples use the even design in this paper. According to different materials of copper alloy tube, each designs a set of finite element simulation scheme of three roller planetary rolling simulated. Three factors are arranged: friction coefficient (0.4 0.7), the deflection Angle (6 ° - 9 °) and roll speed (90 RPM - 180 RPM). Each factor comes from 25 levels, and each of 25 group simulation. The mean square error (MSE) criteria for the DPS software are used in this paper. Simulation results for the neural network training samples designed by uniform structure and rolling force are shown in table 1

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Table 1 finite element training sample of uniform design

No.	Frictional factor	Deflection angle	Roller revolution (rpm)	Rolling force (t)
1	0.65	8.25°	101.25	25.44
2	0.675	8.75°	165	44.61
3	0.575	9°	120	27.44
4	0.6	7.25°	90	23.54
5	0.6875	6.75°	150	32.03
6	0.4375	8.375°	172.5	42.71
7	0.4625	8.625°	93.75	23.99
8	0.4125	8°	112.5	30.95
9	0.6125	8.5°	131.25	31.66
10	0.6625	6°	123.75	27.08
11	0.425	6.375°	135	31.74
12	0.5875	6.5°	168.75	27.47
13	0.7	7.5°	108.75	25.64
14	0.4	7.375°	153.75	35.6
15	0.5125	6.625°	116.25	29.4
16	0.475	6.125°	161.25	34.24
17	0.5375	7.875°	138.75	33.56
18	0.4875	7.625°	127.5	31.6
19	0.55	6.25°	97.5	25.7
20	0.5625	8.125°	157.5	37.63
21	0.525	7.125°	180	33.9
22	0.625	7°	142.5	26.01
23	0.45	6.875°	105	25.34
24	0.6375	7.75°	176.25	33.77
25	8.875	0.5°	146.25	36.91

7. ANN TRAINING AND ROLLING FORCE PREDICTION WITH ANN

The three layers Feedback forward network which activation function hidden for sigmoid type, Purelin type activation function choose by the output layer [8]. The input layer takes three nodes, the output layer takes a node, hidden layer takes 13 nodes. Finite element simulation training sample arranged according to the uniform experiment design. The finite element simulation results study through ANN, valve value and weight matrix for neural network obtained after training. A mapping relation model is set up, which maps the relationship between the process parameters and the rolling force.

Finite element simulation results are trained by ANN, force mapping relation between process parameters and the rolling model set up after the ANN training, and the size of the rolling force under different process conditions can be calculated quickly. In order to validate the effectiveness of the ANN, three different process parameters combination that does not be included in uniform design schemes are tested for rolling force. Table 2 is the forecast results. Relative error between prediction results and finite element simulation are within 3%, which prove that the ANN precision meets the requirements and rolling force can be successful predicted.

Table 2 Prediction results of three roll planetary rolling force

Deflection angle（degree）	7.0	8.0	9.0
Frictional factor	0.3	0.3	0.3
Roll rotation speed (revolutions per minute)	180	180	180
Rolling force prediction（t）	36.28	42.63	45.92
Simulated rolling force（t）	35.8	41.3	44.9
Relative error	1.3%	3.2%	2.3%

8.CONCLUSION

It is a good method that realizes intelligent design of copper and copper alloy tube production through integrated the knowledge reasoning, neural network, genetic algorithm, numerical simulation, uniform design and CAD parametric design and database expert system.

Copper tube processing quality information management system are developed and implemented under the three layer structure of the browser/ WEB server/database. The enterprise production processes are achieved controllable, intelligence and information though the enterprise internal ERP system implementation and information integrated and shared between the enterprises internal departments. Intelligent diagnosis analysis and processing of the SPC realize quality information storage, sharing, analysis and application of database technology. The system is designed for intelligent rolling technology of the copper alloy tube. The successful application of the system plays a positive role to improve the efficiency of the business administration, reduce the production cost and improve of the quality of copper continuously.

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