Advanced in Control Engineering and Information Science

Development and Application of Intelligent Model Knowledge Base for the Plate Hot Leveler

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Abstract

The Intelligent model control system is the core of the third hydraulic reversible leveler, and Intelligent Model Knowledge Base is the base of the control system. The information and it's precision contained in knowledge base determines the accuracy and applicability of the model control system. This article describes the creation of a knowledge base, it's structure, access to knowledge and the Application in system. This Knowledge Base uses Oracle 10G database system and HP 380 Server clusters to realize the management function. The system has successful application in new strength leveler, which is of high automatic and efficiency. The application shows that the quality of products is impressively improved.

Selection and/or peer-review under responsibility of [CEIS 2011]
Keywords: Plate steel, Leveler, Intelligent Model, knowledge Base;

1. Introduction

In recent years, with the continuous innovation of plate production technique, growing competition in the steel market and increasing the width of plate products, customers have higher requirements of

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flatness, meanwhile widely used the TMCP (controlled rolling) process in the line of plate production, leading to the low temperature, high yield strength and inhomogeneous cooling when the steel pass the leveler. Above situation more often lead to the poor production of plate type, and put higher requirement for the control of plate. On the plate production line, as the key equipment for assurance the quality of plate, the leveler directly related to the productivity and delivery of products, while the old-fashioned leveler and control system have been unable to meet new technological requirements. It would become an inevitable choice that every steel company use the third generation leveler, which has many advantages, concluding the high strength equipment, high stiffness and high degree of automation. Taiyuan Heavy Industry and Taiyuan University of Science and Technology jointly developed with the four-fold for hydraulic reversible plate 11 rolls leveler that it was domestic self-developed and had intellectual property with the whole new generation of full force leveler.

The control system of leveler based on distributed control systems of multi-protocol fieldbus, while the system core of Taiyuan University of Science and Technology independently developed Smart straightening process model and knowledge-based systems. For constituting the network monitoring system, the whole system used Profibus, Industrial Ethernet connecting the main drive PLC, hydraulic servo control PLC, engineer station, operator station and HP380 server clusters. Transmission medium included a four-core multimode fiber, shielded Ethernet cable, DP dedicated network lines. Thus these composed the distributed network control system of multi-protocol fieldbus and transmission medium. Through connected to the full range of level 2 system, it could complete the acquisition of basic information sheet, including thickness, width, plate number and other real-time data. In the process computer, the engineer station had to set the leveling model and knowledge base, for different materials, temperature, board type, width and thickness to establish the parameters table of process model. Using the intelligent model system calculated the pressure correction, the frequency of correction and the required theoretical data of press quantity and calculated the leveler linear spring, nonlinear frame deformation and summed up the required experience data of press quantity. Through above data, we can obtain the press quantity technology of leveler. Knowledge-base based on HP380 server clusters and Oracle10G database, while the client-server configuration structure used to realize a real-time data acquisition and analysis system [1-2].

2. System development environment

System development environment mainly including WINDOWS 2003 Server operating system, in addition to including pcs7 software, industrial data bridge package, oracle 10G database and VB6.0 Software Development Platform.

The Hardware includes Siemens Industrial Computer, HP DL380 G6 server clusters, etc. The server clusters using blade servers of HP DL380 G6. The server product used 5500 series of a new framework of Intel's Nehalem. Another, it have many optional functions, such as hosting type DIMM of DDR3 or without buffer DIMM, variety of SAS or SATA hard drives and embedded RAID.

3. The Intelligent model control system structure

The control system include IBA data loggers, PLC engineer station, L2 engineer station, L2 server, HMI screen works stations, and 2 sets of operator station, S7-400 series PLC, the remote station ET200, switches and other components. The hardware structure shown in Figure 1.
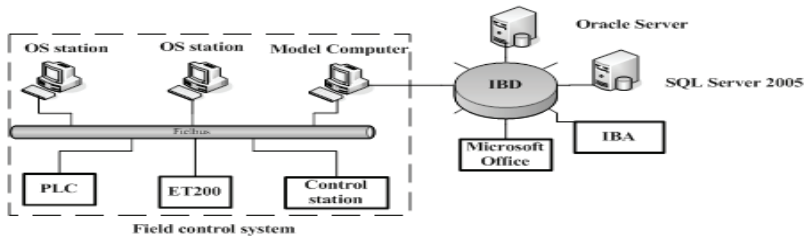
Fig.1. System structure diagram

4. Establishing Intelligent knowledge base

The knowledge-base of leveler plate model is based on physics experiment of plate, concluded the integrated real-time database of leveler process steel. The database includes real-time data module, the original sheet material library module, data management and analysis module and other parts. Real-time data recording module is mainly responsible for real-time data of leveler and the process settings of plate, such as pressure, torque, motor speed, press quantity etc; the original material library module is mainly based on the actual physical experiment platform to test the original parameters of steel performance. And it can provide various kinds of basic performance parameters of steel under the different temperatures and conditions. Meanwhile it can provide original processing parameters for the leveler. Therefore it might obtain the straightening process for different steel grades and different specifications sheet. These are the core and key of knowledge-base. The function of data management module is to manage, analyze real-time data, give the results, report printing for all data in the database.

Among them, to establish the material library of original plant is a key step in the whole system. It can provide the original system parameters for the intelligent process model. Then the model system calculated the values of theory process according to the material's original parameter. Knowledge-base needed to collect the material data from all testing, including the Young's modulus, Poisson's ratio, mass density, yield stress, hardening coefficient and so on. Through the specimens experiment in the Gleeble 1500 simulation we can get the original data. The test material used the finished steel from the medium plate plant of Capital Steel Cooperation. When a piece of normal production process into standard sample, we will do the test of multiply samples and take the expected sample as the standard value. Through analyzed the test results we can get the relationship among the stress, strain and temperature, and obtain the material yield strength, elastic modulus and other parameters with temperature variation. Finally, using the mathematical method fit the experimental data and established the materials model of steel in a variety of temperatures.

Following is the tests of the Q345 steel under different temperature .The pictures are about the stress - strain curve [6].
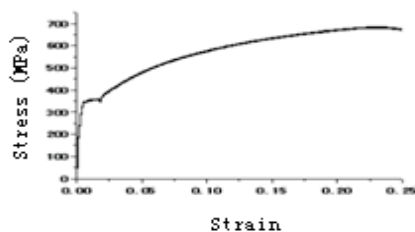

Fig.2 Q345 steel at room temperature stress - strain

Through the analysis of experimental data we can obtain the basic material model parameters, so as to provide the original parameters for process model, and then get the results of process setting of leveler. The material of original parameters obtained from the test, and in the used stage it could learn continuously through the intelligent algorithms. All these are to adapt the field conditions and different manufacturer process, thus to improve the adaptive capacity of the model system. Here is obtained the material's original parameter table of Q345D. Different kinds of steel have its own original parameter table, and all the tables constitute the knowledge base of the straightening process.

Table 1. Experimental conditions of different temperature yield strength of materials

T (℃)	500	550	600	650	700	750
Yield strength σ (Mpa)	241.4	233.6	190.9	160.8	120.7	99.31

Table 2. Experimental conditions of different temperature elastic model of materials

T (℃)	500	550	600	650	700	750
Elastic model E (Gpa)	54.3	53.3	50.2	49.5	48.3	46.7

Table 3. Materials post-yield harding law

500℃		600℃		700℃	
Strain	Stress (Mpa)	Strain	Stress (Mpa)	Strain	Stress (Mpa)
0.025	292	0.025	302.6	0.0125	134.4
0.05	345.5	0.05	332.1	0.025	138.5
0.075	383.5	0.075	345.1	0.0375	139.3
0.10	408.5	0.10	350.9	0.05	140.5
0.125	422.7	0.125	351.4	0.0625	140.8
0.15	428.6	—	—	0.085	141

Knowledge Base System is built on real-time database system of HP380 server cluster with hot standby function. Meanwhile it had the real-time data mirroring backup of hard disk. The self-developed software system based on the database management system of Oracle 10G. The whole system uses the customer - server model, through the communication system to connect the control system for achieving good together.

5. Application of the Intelligent knowledge base

Mainly function of intelligent process model is calculated each roller reduction, force, torque and curvature parameters according to the data of parameter table in the knowledge base. Meanwhile, according to the plate to determine the bending of the roller, it can achieve automated straightening of leveler. The whole process system of leveler made up three parts, including knowledge base of original material, process model and self-learning model. Knowledge base of original material are mainly stored the data of physical properties from various plates, provided the original calculation material for the process model. The process model is mainly based on the plate's physical characteristics of different field geometry data to calculate the setting value of theoretical straightening process. Self-learning model introduce the neural network, mainly to resolve the calculation error from unmeasured parameters [7-8].

Intelligent process model used for continuous calculation of bending model, considering the factors such as offset of the neutral layer, material characteristics and the Bauschinger effect, we can accurately

calculate the parameters of per bending unit, such as bending curvature elastic complex curvature, residual curvature, straightening force and torque and so on.

According to the original material knowledge-base we can obtain the model parameters of various boards. When the plastic deformation rate of entry and export is confirmed, we can seek out its values and bending quality. Getting the actual setting value of roll system, we can solve the force in straightening roller. Intelligent process model can accept the parameters of the straightening roll system, the parameters of pressure correction and the basic parameters of material which were inputted to the computer program shown in the picture. Through the computer program calculated we can get each of the process values and power parameters of every roll at a time [9].

In a steel mill, the experimental measurement equipment is installed in the fourfold hydraulic reversible 11 rolls leveler. And the measured data is transmitted to the control system archive database. Through comparing with the calculated values of theoretical models, we know the values more consistent. If the number of sample is sufficient and the learning time is enough, the theoretical calculations and actual measurements will be more consistent by the training form the neural network and self-learning modules.

6. Summary

The whole system has been applied in the hydraulic reversible 11 rolls leveler in many Iron and Steel Companies. It is well running, reasonable structure and function improve to achieve a highly reliable automation straightening, avoiding the fluctuations of product quality caused by the manual mode of production. And it achieves fusion with MES, greatly improve the company's production efficiency. What's more, it achieves a rapid and accuracy control in the hydraulic leveler. For this reasons, the hydraulic leveler have an important role in the plate production, and improved the quality of product.

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