REAL-TIME TESTING SYSTEM OF ROLLING FORCE IN DOUBLE-WEDGE CROSS WEDGE ROLLING

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Abstract

In double-wedge Cross Wedge Rolling (CWR), the online monitoring system of the rolling force in H630 was introduced in order to attain the whole movement of rolling force. It can measure the rolling force on line in the course of single-wedge and double-wedge CWR, and the rolling force was attained and analyzed by Ansys/Ls-Dyna 3D, the result is almost the same as the testing result with the error of less than 9%, so the validness of this system is substantiated.

1 Introduction

Cross wedge rolling (CWR) is one kind of advanced manufacturing method, it refers to a metal forming process in which a cylindrical billet is plastically deformed into another axisymmetrical part by the action of wedge shape tools moving tangentially to each other. It is used widely with high raw material saving, high efficiency in production and low noise [1,2].

Usually, the widely used CWR is referred to the single-wedge CWR for its simple tool designing [3,4]. With the enlargement of CWR parts, especially the longest half-shaft parts, the disadvantages over single-wedge CWR appear, such as heavy equipment needed and high manufacturing cost. Compared with the single-wedge CWR, the double-wedge CWR, needs the less diameter of tool and less area of rolling tool, hence the small dimension rolling machine with the multi-wedge CWR tool can be used in multi-wedge CWR instead of the large one, so the manufacturing cost is saved, and less equipment weight is need.

Rolling force is one of the important parameters in roll designing, it play important roles in stiffness designing, strength verification, etc [5]. In single-wedge CWR production, the rolling force testing is ignored for the cause of less rolling force and the strong strength of roll mill. But in double-wedge CWR, the rolling regularity included the rolling force is very complicated and the rolling force is so heavy, that the quality of workpiece is difficult to attain if no further measurement is used in the double-wedge CWR production than in the single-wedge CWR one. As a result, the reliable method is needed to obtain the variation of rolling force.

Based on the above situation, the real-time testing system of the rolling force is devised in single-wedge CWR and double-wedge CWR, it can be successfully used in double-wedge CWR deforming mechanism experiment, CWR production and so on.

2 Build-up of the testing system

This system is composed of 5 devices as the following.

1) Rolling mill

Fig 1 Layout of rolling force sensor
Rolling mill H630 is used; its main technical parameters are as the following [1].
The main rolling force is 16 tons.
The lowest rolling temperature: 800°.
The rigidity in mill base with preloaded tensile force: 300 tons/mm.
The stiffness of rolling mill stand without preloaded one: 100 tons/mm.
The rolling forces are obtained online during rolling at real-time.

2) Pressure sensor
Two cylinder stress sensors are used in experiments, it belongs to the resistance stress sensor, with each one installed under the binding nuts, shown in Fig. 1 a) and b). It is composed of the elastic parts and strain slice. It is initialized on the electric universal experiment machine under the control of computer. The standardization result is shown in fig. 2.

3) The 5-channel signal amplifier
The 5-channel signal amplifier is mainly composed of the amplifier card, K803, from Kerixin Corporation. It is used to eliminate the false signal and enlarge the rolling force signal with high precision. It has one channel supplement and 4 channels signal standardization, and each one can amplified the signal 1000 times independently. So it is suitable in signal processing in industry very much.

The main technical parameters is as the following:
The input channels: 4 channel signal standardization and one channel complement.
The amplifying times: from 0 to 1000 times separately.
Output voltage: 0 to 5 volts.
Compensation temperature: 0° to 50°.
Supply electric voltage: from minus 15 volts to positive 15 volts.

4) The data-collecting card: ad7202
It is made by the Ruibohua Controlling Technology Corp. Limited, by the high speed collecting adaptive-datum (AD) chip, the high precision amplifier, the high FPGA logic chip etc, the aim to collect data with high-speed and high-precision is attained with the following advantages:
1) AD high precision: AD collecting precision 12 bits with the error of less than [-0.5, +0.5] LSB.
2) AD high speed: the collecting speed in single-channel reaches 100Ksps(Sample Per Second), and more than 90,000 sample per second in multi-channel.
3) The programmed amplifier: the amplifying time can be set to 1,2,4,8,or 10,100,1000, independently.
4) The electric current monitored: once the testing resistance is mounted, the aim in electric current inspection can be obtained.
5) AD timing by hardware: The hardware timer in the card can emit intermits on time, basing on the command, therefore the exact time norm can be attained. Especially in the Windows 2000 operation system, the high precision datum collecting can be attained with high precision timer.

5) Computer
Computer Pentinum III, with the EMS memory 256MB, the video EMS memory 16MB , 17 inches color display.
Fig. 3 shows the layout of this system. Card K803 and power supply is mounted in 5-channel signal amplifier. The AD7202, datum-collecting card is inserted into the computer main board.

3 Rolling Force Online Testing Principle

The online rolling force testing principle is shown in Fig. 4. The whole rolling process is divided into knife zone, the stretching zone and the sizing zone [1,2,3]. The rolling force shows itself with different regularity. The rolling force from rolling work piece acts on the elastic element of sensor; the elastic distortion comes into being, and it is transformed into resistance variety $\Delta R$ from strain slice. The output voltage is in positive proportion to $\Delta R$ by the Wheatstone bridge, and the output voltage is in positive proportion to rolling force $F$ too.

This signal is amplified and suited well by AD620 with higher precision and stability. With the help of K803, the according surrounding temperature is obtained, the voltage compensation is realized and amplified, and therefore the voltage in according surrounding temperature is attained.

By the interface of AD7202, the voltage signal is sent into the computer and shown in the display. By the standardization, the voltage signal is deduced into outside force and shown in the screen.

In order to restrain the resonance disturb, all the lowliness circuit should be equalized to 0 volt, it was linked to the ground [3].

4 Testing result and analysis

With the process parameters of area reduction 40%, spreading angle $6^\circ$, forming angle $30^\circ$, and rolling temperature 1050 $^\circ$C, the rolling force testing result is shown in Fig. 5. With original billet length 113 mms and 260mms, the rolling force regularity in single-wedge CWR and double-wedge CWR are shown there separately.

Based on Fig. 5, under the similar condition, the rolling force variation in double-wedge CWR is similar to the one in single-wedge CWR, and the maximum rolling force in double-wedge CWR is...
double the maximum rolling one in the single-wedge CWR. This conclusion is in accord with the theoretical formula of rolling tension [1,2].

With the help of software Pro/e 2001, the model of double-wedge CWR is setup and imported into the ANSYS/LS-DYNA, the Finite Element Method (FEM) result is shown in fig. 6 with area reduction 25%, forming angle 32°, spreading angle 6°, and the heating centigrade 1157°, the testing result in the same condition is also shown there.

Compared with two curves, the conclusion can be drawn that the simulation value is a little more than the testing result with the error of less than 9%.

Now that Finite Element Method can be applied into CWR with exactness [1], the values of both testing result and simulation one are reliable; both of them reflect the variation of rolling force in CWR.

5 Summaries

1) The online testing system is feasible in monitoring the variation of rolling force in multi-wedge cross wedge rolling.

2) The variation of rolling force in double-wedge CWR is similar to the one in single-wedge CWR, and the max rolling force in double-wedge CWR is double the one in single-wedge CWR.

3) The rolling force regularity of double-wedge CWR provides an important guide to Cross Wedge Rolling tool optimization design and strength checking.

References


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