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Research Article

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The realization of high-speed data acquisition in the intellectualization control system

Su Chunjian* and Li Tiantian

College of Mechanical and Electronic Engineering, Shandong University of Science and Technology, China

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ABSTRACT

Monitor in real time is the most important link during the 4 basic key elements in the intellectualization of sheet metal forming, which adopts effective test means to reflect the mechanics parameter and geometry parameter of the processed target's characteristic. It is well realized for high-speed data acquisition using virtual instrument technique based on LabVIEW as the system controlling software and using the system hardware composed of the portable computer, 6062E portable data acquisition card, four-slot chassis for signal conditioning, eight-channel module for strain-gauge and eight-channel module for analog output is given in this paper. This paper mainly introduces the realization of high-speed data acquisition based on LabVIEW virtual instrument to real time monitor for intelligent bending system.

Key words: Bending; intellectualization; LabVIEW virtual instrument; signal acquisition and controlling

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INTRODUCTION

The intellectualization of sheet metal forming is the crossing subject of sheet metal forming theory with control theory and computer science. According to the characteristics of the workpiece to be worked, utilizing physical quantities easy to be measured, material properties and optimum technique parameters can be determined in real-time, and then the forming process can be completed automatically with the optimal processing parameters. It can not only change the face of the stamping process, but also will promote the transformation of stamping machine, and holds great significance in decreasing sheet grade, eliminating technical difficulty of mould and equipment adjustment, shortening the time of debugging model, completing processing by optimum forming parameters, and improving yield and productivity.

Monitor in real time is the most important link during the 4 basic key elements in the intellectualization of sheet metal forming, which adopts effective test means to reflect the mechanics parameter and geometry parameter of the processed target's characteristic. This paper mainly introduces the realization of high-speed data acquisition based on LabVIEW virtual instrument to real time monitor for intelligent bending system.

THE BENDING INTELLECTUALIZATION CONTROL SYSTEM

According to theory analysis and numerical simulation, the influence factors of free bending process of wide sheet metal are material property parameters and geometric parameters of blank and mould in addition to bending force and stroke. And, the single valued relationship exists between aim bending angle after unloading and bending stroke. So, the aim bending angle can be controlled by controlling bending stroke, and the bending intellectualization control system can be established. As figure 1 shows that system can be divided into four parts according to working principle:

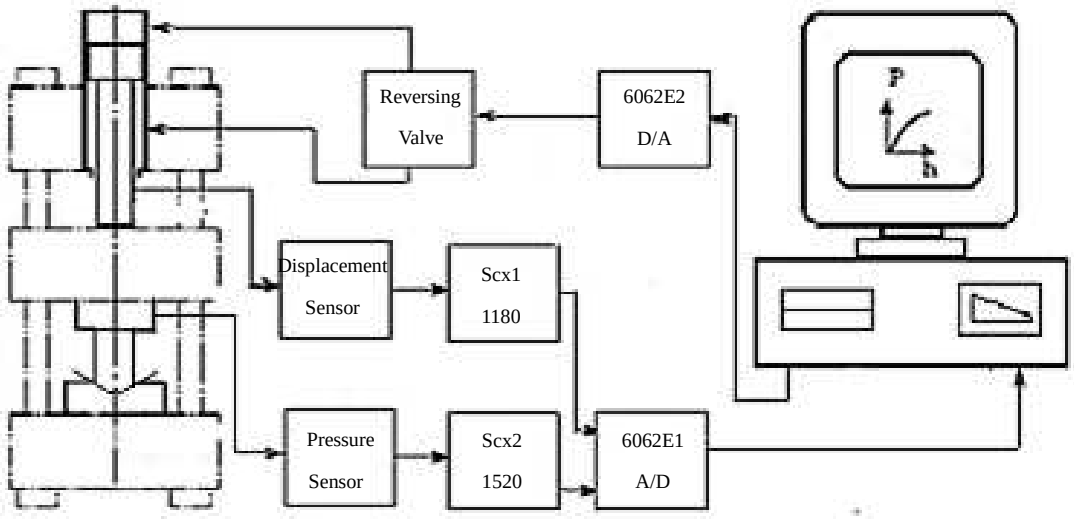

Fig.1 The bending intellectualization control system

(1)The process monitoring part is composed of sensor, A/D card, industrial computer, display program and acquisition and recording, which reflecting bending stroke (h)and bending force (P) are converted into voltage signals(V_h and V_p) by displacement and pressure sensor pass by conditioning module(Scx1-1180 and Scx2-1520). The two voltage signals conwert from analogue to digital value by A/D card（6062E1）and are input into computer. The record show program set in the computer stores the above two physical quantities in the form of data files in the computer automatically, and shows the P - h curve on the display in the real time during the bending process.

(2)The parameter identification and prediction part is mainly composed of computer and the relevant software. The information of P , h and ect obtained by monitored will be transfered to the neural network identification module after learning and training which identifies material performance parameters in real time according to specific nonlinear mapping relationship. Then, regarding the material performance parameters of final recognition, aim bending angle α_0 , and sheet thickness t as input parameters which will be transfered to neural network prediction module to predict the optimum technology parameter— bending stroke h_{α_0} .

(3) The real-time control part is composed of computer, control program, D/A card（6062E2）, three unit four passage reversing valve, controller, relevant module and ect. Control system regards the bending stroke as feedback signal and sents out control signal according to the optimum technology parameter given by prediction model. D/A card will convert the digital quantity of voltage signal into analog which will be input three unit four passage reversing valve to bring the reversing valve into action and achieve the goal of controlling bending stroke.

(4)System executive part is mainly composed of hydraulic press, experimental equipment and etc. Hydraulic system is composed of motor, hydraulic pump, relief valve and three position four-way electromagnetic directional valve, which adopts self-made general-utility hydraulic press.

THE HIGH-SPEED DATA ACQUISITION SYSTEM BASED ON LABVIEW VIRTUAL INSTRUMENT

The graphical programming software (LabVIEW) based on G Language is an innovational software product of American National Instrument Corporation NI, which can perform graphic combination operation against virtual instrument software under the intuitive environment and is widely applied in the fields of automatic test, data acquisition and control, process monitoring and industrial automation.

Generalized data acquisition which includes analog input and analog output is a process that coverts the pysical signal such as voltage, current, temperature and pressure into digital quantity and passed to the computer. The data acquisition program library of LabVIEW is a driving control program which includes many data acquisition cards. Usually, a card can accomplish many functions. The users must set up good hardware configuration of acquisition cards before using them. The principle of data acquisition system based on LabVIEW is shown in the figure 2, and the figure 3 is the real system.

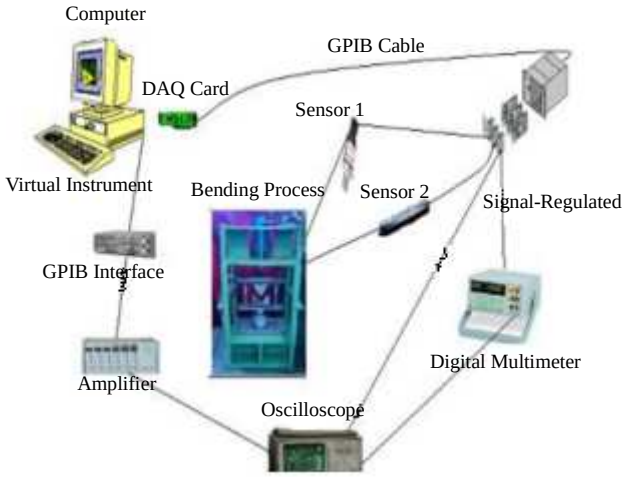

Fig.2 The principle of data acquisition system based on LabVIEW

Fig.3 The real data acquisition system based on LabVIEW

On the basis of specific applications and own existing technical resources to choose data acquisition hardware. The system adopts notebook date aquisition card (Card-6062E), toshiba notebook computer (Satellite3000), four-slot chassis for signal conditioning (SCXI-1180), eight-channel module for strain-gauge (SCXI-1520) and the wiring terminal (SCXI1314), eight-channel module for analog output (SCXI-1124) and the wiring terminal (SCXI－1125).

THE REALIZATION OF HIGH-SPEED DATA ACQUISITION

Data acquisition card (National Instruments DAQCard-6062E) provides high performance E series technology to laptop with PCMCIA (PC card) slot and portable equipment. It can obtain 16 single-ended analog input (8-way difference) of 500 ks/s sampling rate and 12bit resolution. DAQCard-6062E is a multifunctional synchronous high-speed data acquisition card based on PCI bus which is produced by the NI company, it can be directly inserted into any bus expansion slot with PCI bus in the computer, constituting the acquisition, monitoring, input system and output system of analog voltage signal or digital signal. Its various performance indicators are as follows.

Input Precision: 12bits
Sampling rate：500kS/s
Analog input：16SE/8DI
Input range：±0.05V～±10V
Input span：15gear number
Analogue output：2
Output accuracy：12bits
Number I/O：8
Numeration/Timer：2

When using a DAQCard - 6062 data acquisition card, setting the sampling frequency be greater than 1 ks/s dynamic

sampling, its acquisition program flow chart is as shown in figure 4. Using the technology of buffer (buffers) here, in this case, the buffer is one part of the PC memory (not FIFO buffer on the data acquisition card), it is used to temporarily store data. For example, it is difficult to collect thousands of data per second and display or make data graphical in one second. But we send the data in acquisition card to the Buffer first, they can be quickly stored first, later again to rediscover their displays or analysis. It is important to note the Buffer is associated with the speed and capacity of operation. The DAQ card has the DMA performance, analog input operation has a lead to the high speed computer memory hardware channel, which means that collected data can be directly sent to the computer's memory.

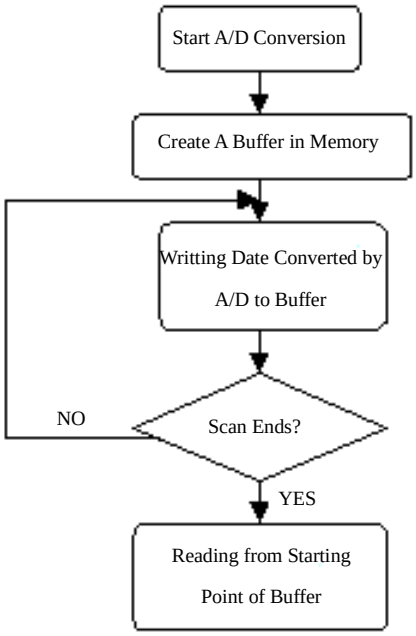

Fig.4 Dynamic program acquisition flow chart chart

In addition, in the LabVIEW software programming, each template of DAQ in the function template, such as AI Config, AI S tart, AI Clear, AI Read and AI Acquire Waveform are compile into a complete collection procedures. Among them, AI Config configurates the parameters of integrated circuit board; AI Start starts the parameters of configuration integrated circuit board which has the cache; AI Read reads data from the buffer; AI Clear ends data collecting and releases the related internal resources. The figure 5 shows the setup of VI for realizing high-speed data acquisition in program. The buffer size controls the memory size taked up by AI Config which used to collect data. Setting of Interchannel delay, the default value is -1. When select the default value, the system sanns as the highest scanning rate of the acquisition card (usually a few microseconds) and adds ten microseconds that the system consumpts to set up the Interchannel delay. It is about twelve microseconds for the DAQCard-6062. Users can also set up the value by themselves, experiments show that the DAQCard-6062E can be set to 2 to 3 microseconds at least.

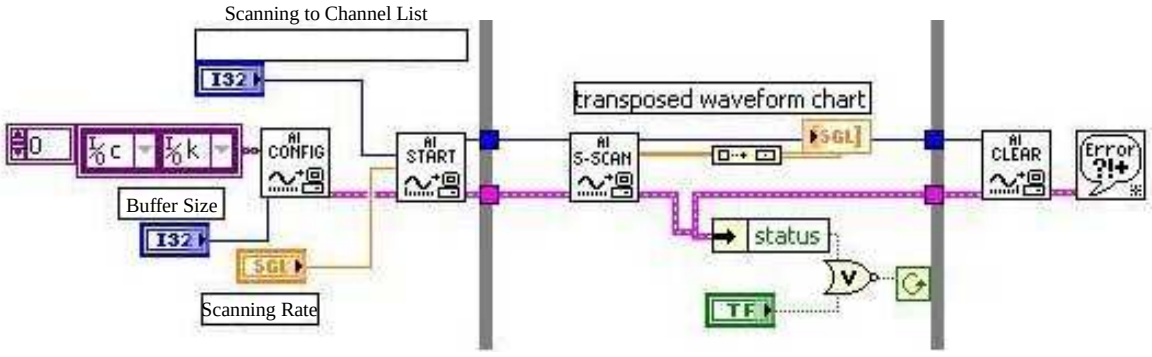

Fig.5 The setup of VI for realizing high-speed data acquisition in program

THE DEVELOPMENT OF SYSTEM PROGRAM

The system is on the basis of every parameter required acquisation and actuators required control during intelligent bending experiment to program. System design is divided into several aspects as below:

(1) to determine which signals will be acquisitioned , the acquisition module and which known conditions will be inputed by control panel;
(2)to output the required parameters of the next module and determine the target value according to the completed recognition and operation module of MATLAB;
(3)to regard the outputs of completed prediction and operation module of MATLAB as the outgoing signal of the next actuator;
(4)to determine the control module and the control object.

System flow chart is shown in figure 6.

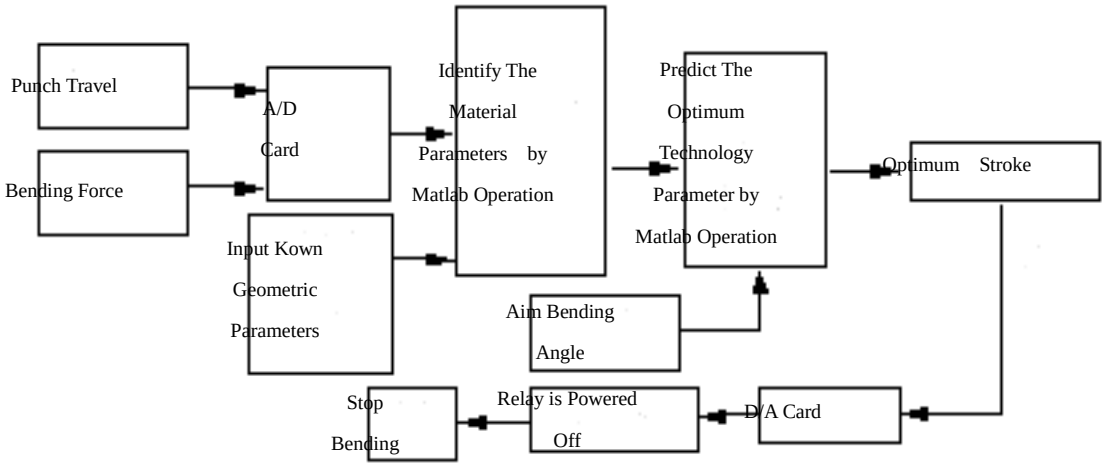

Fig.6 Flow chart of system

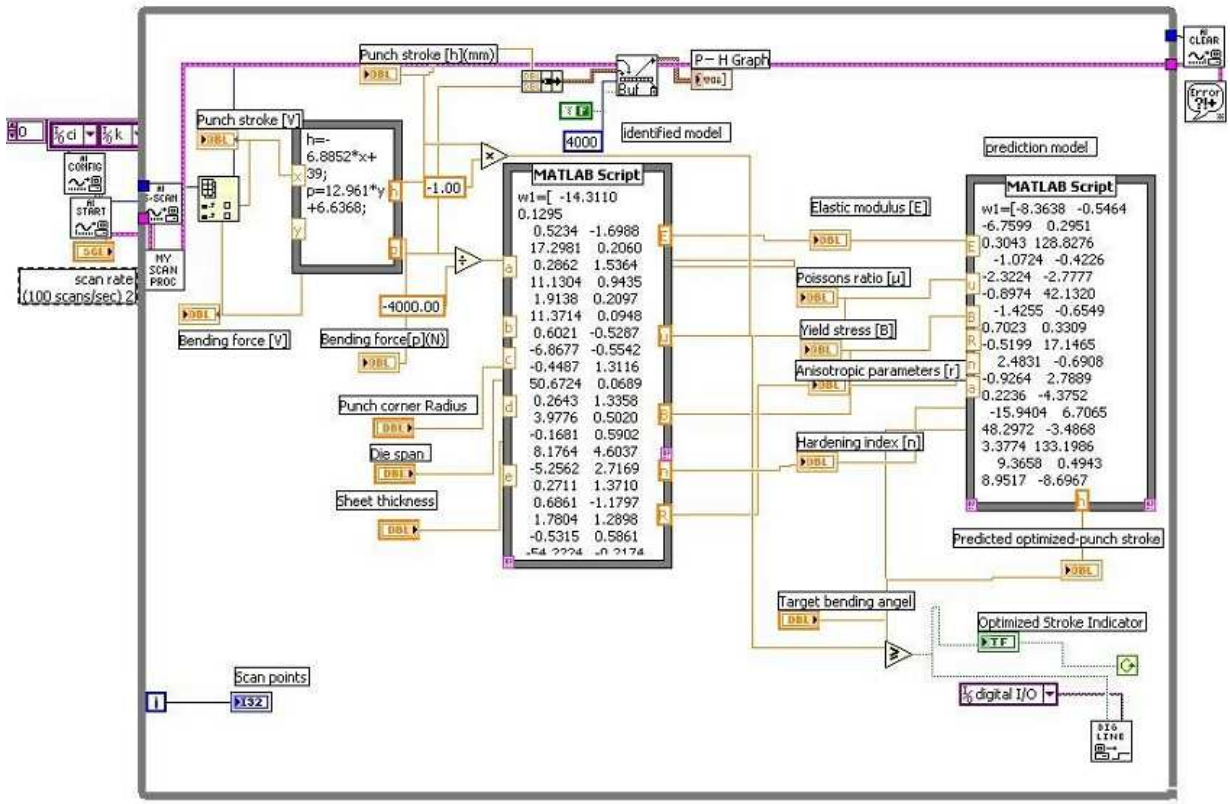

Fig.7 Main frame chart of bending intellectualization data acquisition and control system

The role of the neural network identification model of this system is to identify the material performance parameters and working parameters in real time using the easy monitored physical quantities. During V-shape free bending of

wide sheet , the easy monitored physical quantities are bending stroke h and bending force P , at the same time, the parameters such as sheet thickness t , punch radius r_p , radius of die r_d and die span l_d will influence bending process, so, to redard the above parameters as the input variables of network. However, to regard the material performance parameters which are waited recognition as the output variables of network. The material performance parameters which are waited recognition include elastic modulus E and Poisson's ratio ν during plate elastic deformation, strength coefficient B and hardening exponent n during plate plastic deformation, and coefficient of normal anisotropy r .

The output is optimum bending stroke H_a in prediction model. The influencing factors of optimum bending stroke are sheet thickness t and aim bending angle α_0 in addition to n , B , R , E and μ obtained by real-time recognition, so that the input parameters are n , B , E , μ , t and α_0 . The figure 7 shows the main block diagram of intelligent control system of sheet bending forming which developed by LabVIEWsoftware.

THE ANALYSIS OF OPERATION EFFECT

The experiment selects three kinds of materials, such as copper, aluminum and steel. Three materials of different performance parameter have different bending springback value. Different bending angle also leads different springback value. Conducting bending control experiment under the conditions of table 1, the date results are shown in the table 1. The $P-H$ curve in figure 8 is the bend molding control curve of copperplate at aim bending angel of 90°.

Table.1 Experiment result of three kinds of materials

Material	Sheet Thicknes s/mm	Aim Bending Angle/°	Predictional Punch Travel /mm	Actual Control Punch Travel/mm	Absolute Error/mm
Copper Plate	1	90°	35	35.05	0.05
Copper Plate	1	120°	26	26.07	0.07
Aluminum Plate	1	90°	32	32.06	0.06
Aluminum Plate	1	120°	24	24.04	0.04
Steel Plate	1	90°	30	30.09	0.09
Steel Plate	1	120°	23	23.06	0.06

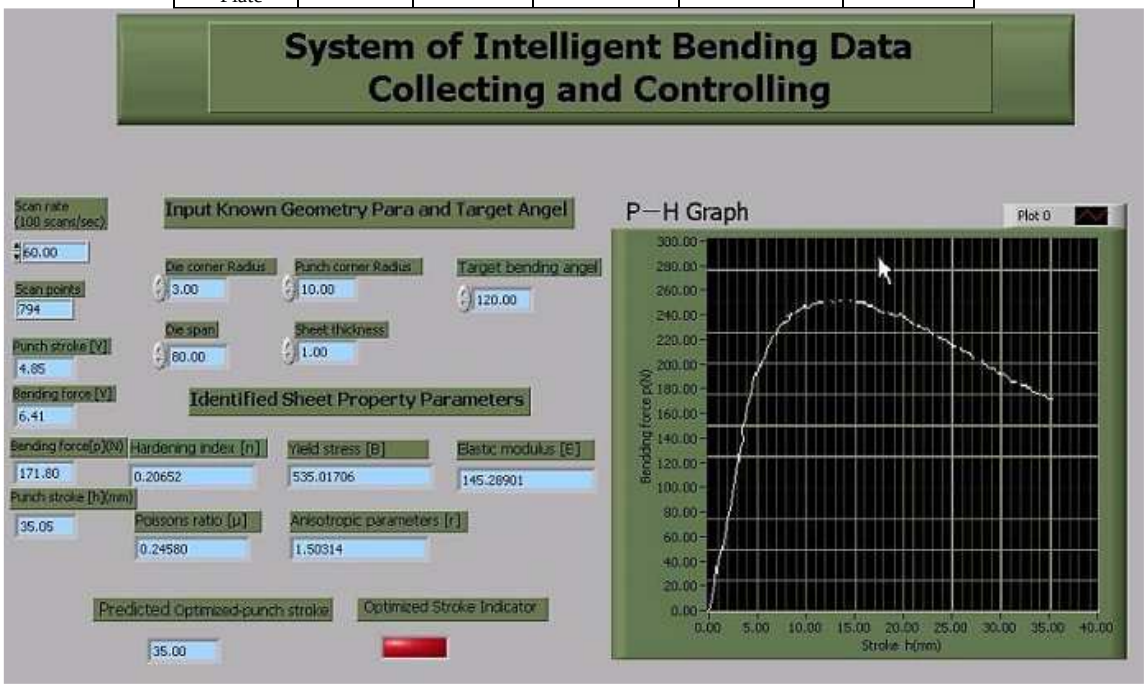

Fig.8 Control panel of bending intellectualization data acquisition and control system

From the above results, we can reach that there has slight error between predictional punch travel and actual control punch travel. This is because when the control signal was given and the actuators have lag, but the resulting error within the scope of the required accuracy.

This paper adopts FFT test technique to test system performance. During the test, the system employs internal clock to acquisition, the sampling rate is 140MSPS, the input signal is 8.57MHz sine wave, the counted actual SNR is about 57.66dB by Matlab software, the significant digits of the DAQCard-6062E for sine signal sampling of 8.75MHz is 11.5, the harmonic distortion (THD) is－52.16, the spurious free dynamic range (SFDR) is 53.43dB. This system has a number of excellences such as fine system performance, flexible software control ability, and strong anti-jamming ability. The system can well realize high-speed data acquisition and satisfy the speed and accuracy requirement of the identification and prediction of neural network model.

CONCLUSION

The signal acquisition and controlling system is well satisfied intelligent sheet bending requirement using virtual instrument technique based on LabVIEW as the system controlling software and using the system hardware composed of the portable computer, 6062E portable data acquisition card, four-slot chassis for signal conditioning, eight-channel module for strain-gauge and eight-channel module. This system has a number of excellences such as fast signal collecting, advanced operating table, higher signal-processing ability, high-assembly, fine system performance, flexible software control ability, and strong anti-jamming ability, in which the one-channel maxinum acquisition rate of acquisition card can reach 500000Samples/s, the actual SNR is about 57.66dB, the significant digits of the DAQCard-6062E for sine signal sampling of 8.75MHz is 11.5, the harmonic distortion (THD) is－52.16, the spurious free dynamic range (SFDR) is 53.43dB. The system can well realize high-speed data acquisition and satisfy the speed and accuracy requirement of the identification and prediction of neural network model.

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