Study on Arc Welding Seam Tracking of TIG Welding

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Abstract. In this paper, the welding seam tracking system based on rotating arc TIG welding is studied. The design of pid controller for the hardware, software, signal acquisition, filtering and weld deviation identification of the system is deeply studied. And the conclusion is obtained, which lays a foundation for the tracking of rotating arc weld in TIG welding.

1. Introduction

As a common processing technology in industrial production, the importance of welding process is self-evident. It can realize the solid connection between product parts and finally form a complete product. Welding technology is widely used in various fields of production; its role is increasingly prominent. The software part includes system data acquisition, processing and control program based on C language. Hardware and software cooperate to realize automatic tracking weld and automatic welding. By designing trigger pulse shaping circuit to ensure accurate data collection, Combined with median filter, mean filter is used to filter the collected arc voltage. The method of left and right integral and characteristic harmonics is used to accurately identify the welding seam deviation. In order to overcome the difficulty of determining the control object and nonlinearity of the traditional PID controller, by using fuzzy PID controller, the parameters of PID are determined by fuzzy control, and the parameters are adjusted in real time. Thus, the precision of seam tracking in TIG welding is improved significantly.

2. Hardware composition of TIG welding seam tracking system

And metal inert gas arc welding (MIG welding) and other automatic welding of the difference is, the TIG welding inverter circuit in arc welding, high frequency oscillator oscillation frequency and output voltage up to 150.260KHz, 3000V, electronic circuits, software program in such a high frequency and voltage under very easy to follow bad or disturbed. Therefore, it is necessary to design a reasonable TIG welding system, minimize the adverse effects of high frequency and high voltage system of welding. In addition, the welding current can be generated when dozens or even hundred, the formation of the magnetic field will do normal work disturbed welding system. The hardware system is the foundation of software system running so study on TIG welding.TIG welding system hardware hardware system is very necessary including welding, signal acquisition, control signal. The three part of the data acquisition system for the acquisition of arc voltage signal. Then, it is transmitted to the industrial control computer for filtering treatment, then the weld deviation is identified, then the motor on the cross slide block is controlled by the control module to make the corresponding action to achieve the seam tracking, and the final welding is completed by the welding part. The system structure is shown in Figure 1.

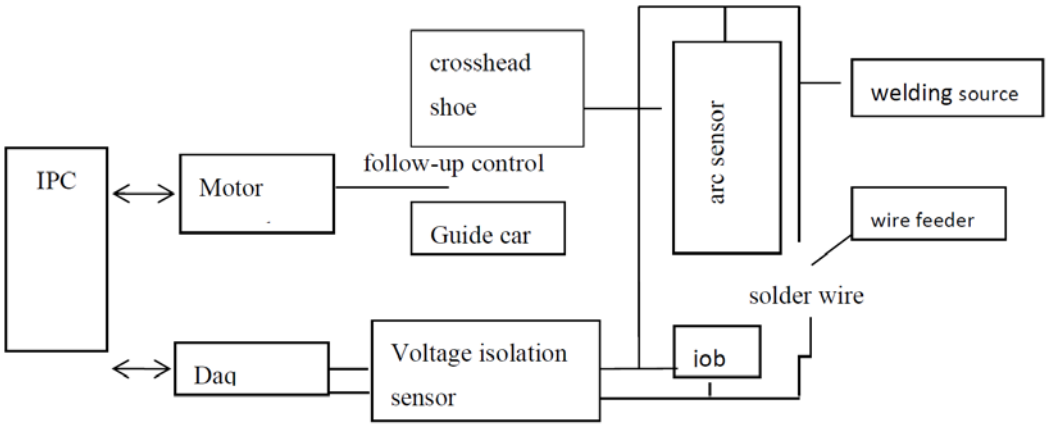

Fig 1. TIG welding seam tracking system structure diagram

2.1. Welding part

a). Guide rail moving mechanism

The mechanism is mainly composed of cross slider and moving car, which is controlled by motor, and the speed of moving car determines the welding speed. The direction and speed of the cross slider determine the offset direction and velocity of the TIG welding torch.

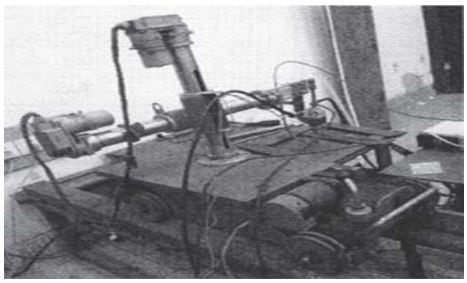

Fig 2. Physical drawing of guide rail moving mechanism

b). Welding power source

The welding power source used in this system is the WSM-315 inverter pulsed argon arc welding machine produced by Panasonic / Panasonic, which belongs to the automatic and manual welding dual-purpose welding machine. The soft switch technology is used to improve the working conditions of the IGBT tube. The reliability of IGBT is greatly improved. It has the functions of overvoltage, undervoltage, overcurrent, overheat protection, excellent welding performance, pulse welding, accurate control of spot welding time, minimum current of 10A, welding torch switch, welding machine ejecting argon gas, Welding torch discharge, you can start the arc.

c). wire feeding mechanism

The main components of the wire feeding mechanism are the guide mouth, the wire feeding machine, the wire feeding pipe and the control box, wherein the wire feeding pipe and the guide nozzle need to be designed according to the actual situation. During the welding process, the wire feeding mechanism is responsible for feeding the welding wire from the wire feeding mechanism and adjusting the speed and the start of the wire feeding by the control box. The wire feeding mechanism adopted in the study is shown in FIG. 3.

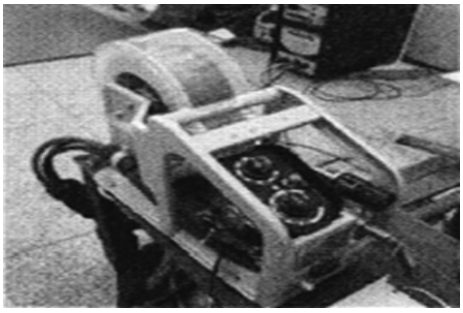

Fig 3. Physical drawing of wire feeding mechanism

When the wire feeding mechanism is installed, it should be ensured that it is the same as the welding direction.

2.2. Signal acquisition and processing system

The signal acquisition and processing system is mainly composed of select arc sensor and voltage isolation sensor, the former is responsible for collecting arc signal and transmitting signal to voltage isolation sensor for depressurization, and then data collection card is used to collect data.

a). Rotating arc sensor

The core components of the arc sensor are hollow shaft motor and optical code disk. The principle is to collect the arc signal and adjust the welding torch position according to its variation. The optical code plate of the rotating arc sensor is fixed on the hollow shaft and rotates along with the shaft. The optical coupling is mounted on the outer wall of one side of the sensor, and the position of the welding torch can be determined and adjusted with the optical code disk, and the pulse of collecting data can be transmitted. The tungsten needle in the hollow shaft is used as the welding torch, and the protective gas is input from the upper end of the hollow shaft. Spray through the nozzle at the bottom of the welding torch to protect the pool.

b). Voltage isolation sensor

The main function of the voltage isolation sensor is to depressurize the arc voltage transmitted by the arc sensor, so as to facilitate the acquisition of data by the data acquisition card.

c). Data acquisition card

The arc voltage signals transmitted by rotating arc sensor and separated by voltage isolation sensor are collected.

2.3. Control systems

The control system mainly includes the industrial control computer, the control circuit board and the cross slider. The principle of the control system is to filter the arc voltage signal collected by the signal acquisition system and to identify and extract the deviation. Then the control quantity is calculated by the PID controller, and then the welding is controlled by the control system according to the calculated control quantity.

3. Signal processing and weld deviation identification of weld seam tracking system

The collected signals must be processed before seam tracking. In order to prevent the weld from being contaminated by tungsten electrode, the TIG welding system adopts isolated arc starting, such as high frequency and high voltage, which will interfere with the arc voltage signal. Therefore, it is necessary to filter and process the collected signal before extracting the deviation. Considering the detection, acquisition and processing of the signal in this system, all of them are programmed by VC. It is realized by personal computer; therefore, the method of software filtering is used to filter the collected signal. Many software filtering methods have been successfully applied in the corresponding field by scholars from all walks of life. In order to realize the automatic tracking of welding seam, first of all, the deviation of weld must be obtained, and then the control quantity can be obtained by the

corresponding control method. Therefore, the extraction of deviation is the precondition of seam tracking. At present, the commonly used methods of deviation extraction include left and right integration method and characteristic harmonic method.

3.1. Arc Voltage signal processing method for TIG welding system

Software filtering is digital filtering. The principle is to distinguish useful signals from interference signals by certain software algorithms. The common software filtering methods include median mean filtering and amplitude limiting filtering. Many other software filtering methods have emerged after the research of many scholars. For example, mathematical morphological filtering, wavelet filtering, minimum filtering, particle filtering and so on. The tracking accuracy of weld seam and the quality of test results are directly affected. Different filtering methods are suitable for different systems. In this system, the median filtering method is used to process the collected signals.

The median filtering method is a nonlinear smoothing technique, whose principle is to sort the collected signal samples. Then, the median value of each sample value in one domain of a signal sample is replaced by the sample value, and the surrounding sample value is close to the approximate real value. The method can effectively eliminate the isolated noise points.

Suppose that there is a discrete periodic signal containing N elements $x(t)$ x (f), N is an integer, and the vector is expressed as: $x(t)=\left[x_1(t),x_2(t),.....x_N(t)\right]$ the N signals are arranged in ascending order: $x(t)=\left[x_{(1)}(t),x_{(2)}(t),.....x_{(N)}(t)\right]$ where $x_{(1)}(t)\le x_{(2)}(t)\le .....\le x_{(N)}(t)$ You know, N is an odd number $x_{med}=x_{\frac{N+1}{2}}(t)$, and N is an even number, $x_{med}\frac{\left(x_{(\frac{N}{2})}(t)+x_{(\frac{N}{2}+1)}(t)\right)}{2}$.

3.2. Deviation identification and extraction

TIG when welding arc length exceeds a certain value will extinguish the arc, so the height direction in the welding process, the need to constantly adjust the deviation relative to the weld center. The welding torch height deviation deviation to identify relatively simple the rotating arc sensor V groove welding lateral deviation recognition using characteristic harmonic method, shows that in the existing literature, the characteristic harmonic deviation detection method has high signal-to-noise ratio.

a). Longitudinal deviation identification

Based on the static characteristics of TIG arc welding rotating arc sensor analysis, arc rotate in a certain radius, and at a given welding current and wire feed speed, rotating arc sensor scanning arc voltage for a week to obtain the mean value and the arc length is approximately linear relationship, arc voltage value can be obtained according to the size of the arc length. The rotating arc sensor for each scan a week acquisition of N voltage value, assuming that V (n) pressure value of real-time acquisition of the arc, the average acquisition of N voltage of the voltage value is given: $V_0=\frac{1}{n}\sum_{N=1}^{n}V(N)$

b). Transverse deviation identification

The welding part used in this study is V shaped groove, and the angle between the weld slope and the horizontal plane is set β, The arc scanning radius is r period of $2T$, Angular velocity is ω, The transverse deviation between the axis of the rotating arc and the center of the weld seam is e, For convenience analysis, look along the welding direction and set the torch to be on the right side $t=0$, Torch height in a rotation cycle $H(t)$ The law of its variation can be obtained from the following formula.

$$H(t)=\begin{cases} Hc-(\cos\omega t+\sin\varphi)\gamma\bullet\tan\beta, 0\le t<\dfrac{T}{2}+\dfrac{\varphi}{\omega} \\ \{Hc+(\cos\omega t+\sin\varphi)\gamma\bullet\tan\beta, \dfrac{T}{2}+\dfrac{\varphi}{\omega}\le t<\dfrac{3T}{2}-\dfrac{\varphi}{\omega} \\ \{Hc-(\cos\omega t+\sin\varphi)\gamma\bullet\tan\beta, \dfrac{3T}{2}-\dfrac{\varphi}{\omega}\le t<2T \end{cases}$$

4. Design of TIG welding seam tracking software system

In order to realize the automatic tracking test of welding seam, in the successful acquisition of rotating voltage signal, and through software filtering and deviation extraction, but also need to design a controller can meet the tracking precision. This chapter mainly designs a welding system can meet the control requirements of the rotating arc welding of steel sheet TIG controller has been discussed above. There are many kinds of common control methods, including PID control theory with its own characteristics, has been widely used in many practical engineering application, it uses the proportional, integral and differential three invariant parameters to adjust the system, so it is for the nonlinearity and uncertainty, it is difficult to obtain ideal control effect in recent years, the fuzzy controller (FC Fuzzy Controller) has attracted more and more scholars and engineering technology favored fuzzy controller to rely on people's practical experience, according to the specific The control system of fuzzy expression, then control the controlled object. This method does not require a specific control object model, strong anti-interference ability, can be applied to the nonlinear controlled object. However, to be successful in the application of fuzzy control to a new system to control the experience first to get rich, can fuzzy controller is designed. The appropriate welding stability of the mechanism, the rotation frequency of the rotating arc sensor, the melting rate, many factors in high frequency and high voltage and welding environment of the scene led to the whole process is a process often complex. Therefore, this system adopts the method of combining PID controller and fuzzy controller the control experience through PID controller, and then design a fuzzy PID controller is appropriate.

4.1. Welding torch height control

The torch motion of the system with three degrees of freedom, in addition to the car movement, deviation in the welding process of the right and left direction required by the controller to control the cross slider to implement the rectification. In the vertical direction of welding torch, welding and welding of the slider car equipped with the workpiece is almost the same in the same horizontal plane, TIG welding arc the length of the arc voltage and the approximate linear relation, the arc voltage value reflects the torch position, then, can control the height direction on the torch. The steps are as follows:

a). the corresponding arc voltage value V1 of the ideal arc length was obtained by several experiments.

b). the voltage value of the arc in the actual welding process is V2:

c). the difference between Y1 and V2 is calculated, AV=V1 a Y2;

d). according to the size and direction of AV to determine the magnitude and direction of the welding torch needs to be adjusted. When AV is positive, indicating the torch height than the ideal height to be high, the welding torch need to adjust downward until AV=0; when AV is negative, indicating the torch height than the ideal lower gun needs to on the adjustment, until AV--0.

4.2. Design of the controller of the transverse sliding block

In the welding process, the welding carriage to go forward, in the V type weld produced continuously on the left and right deviation, in order to meet the requirements of welding seam tracking precision, the need to continue to adjust the direction about the torch. This section mainly designs the lateral slide controller, design concept for the three parameter incremental PID controller the amount k_p, k_i, k_d as fuzzy control, and fuzzy controller design.

5. Conclusion

In summary, the text has carried on the thorough research around the hardware and software of the TIG welding rotary arc welding seam tracking system. The main research works are as follows: ①. The hardware platform of the TIG welding arc welding seam tracking system was constructed and constructed. The various components of the hardware system and corresponding working principle, performance and application methods were analyzed. In view of the actual need of TIG welding seam tracking, we designed the cross slide motor drive circuit board, the optocoupler signal shaping circuit board and the low-pass filter circuit board. ②. The median filter method is adopted to effectively filter the collected arc voltage signal data. ③.The deviations obtained from the characteristic harmonic method are used to prepare the TIG welding seam tracking software based on VC. The PID controller is used to acquire the control experience, and the fuzzy controller is designed to realize the deviation control. Use fuzzy rule to set three parameters of PID in real time.

Acknowledgements

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