Ethernet Solutions for Communication of Twin-Arc High Speed Submerged Arc Welding Equipments

Kuanfang He
Hunan Provincial Key Laboratory of Health Maintenance for Mechanical Equipment, Xiangtan, China
Email: hkf791113@163.com

ZhuoJie Zhang, Jun Chen, and Qi Li
Hunan Provincial Key Laboratory of Health Maintenance for Mechanical Equipment, Xiangtan, China
Email: 314929120@qq.com, qjchenjun2008@126.com and richie.lsq@163.com

***Abstract*—The ethernet technology is used in multi-arc submerged arc welding systems communicate with each other. The structure of twin-arc high-speed SAW (Submerged arc welding) equipments based on Ethernet is proposed. The welding equipment technical requirement for Ethernet is discussed. The crucial implementations of Ethernet TCP / IP in the welding equipment is presented including designs of ARM (Advanced RISC Machines)-based intelligent control unit, communication program, synergistic controlling procedures and monitoring program of welding process. The results of experiment show that the synergistic controlling for welding process, arc-starting and arc-ending are achieved with the characteristics of high transmission speed, large capacity and reliability. The formation of weld seam is improved with arc stability, and the technology of twin-arc high speed arc welding is achieved.**

***Index Terms*—Ethernet, communication, TCP/IP, multi-arc high speed submerged arc welding, monitoring and controlling**

I. Introduction

Submerged arc welding is a high efficiency welding method, which is one of the most widely applied technologies in welding manufacture [1]. With characteristics of high efficiency, deep penetration, perfect weld seam forming and high degree of mechanization, submerged arc welding is particularly applicable to the heavy plate and long weld seam [2]. In recent years, the introduction of advanced technology to twin-arc submerged arc welding has become the research hotspot. Database technology was introduced to develop of expert system for the submerged arc welding [3]. Based on improved BP neural network, the model of twin-arc high speed submerged arc weld shape was established to optimize the welding parameter [4]. In order to master welding mechanism, temperature field numerical simulation of twin-arc submerged arc welding process were calculated and analyzed [5]. Time-frequency analysis methods such as wavelet transform were introduced to analyze arc signal in non-stationary submerged arc welding, which were used to assess the arc stability of submerged arc welding [6,7]. The computer-controlled technology has also been used in twin-arc submerged arc welding [8,9].

In fact, twin-arc submerged arc welding system is not simple stitching of the independent two or more welding units. Complete twin-arc welding process is a coordination welding equipment of inverter power source, wire feeder, traveling agency and so on, which relies entirely on network communication system with coordinated action. The traditional communication were mostly realized by field bus, RS-485, RS-232 in the monitoring system of twin-arc or multi-arc welding system [10,11,12]. With the development of embedded Ethernet technology, which has characteristics of high transfer rate, anti-interference ability, large capacity and simple structure. The Ethernet technology has been applied in the field of welding. Base on network control, welding knowledge management system was researched [13]. Ethernet technology was also used to research remote monitoring and control system for arc welding inverter [14,15]. Asymmetry data transmission channels in a cascaded network was implemented based on Ethernet communication[16]. A dual-CPU spot welding controller was designed based on Ethernet [17]. The measurement and control module were designed and applied based on Ethernet [18].

Therefore, the embedded Ethernet technology provide a probability for communication of twin-arc submerged arc welding system[19,20]. The Ethernet technology was used in twin-arc submerged arc welding systems communicates with each other in this paper. The structure of twin-arc high-speed SAW equipments based on Ethernet was discussed. A embedded Ethernet system for twin-arc high speed submerged arc welding based on ARM and Ethernet control chip based was built, which provided a hardware and software platform of high real-time capability, reliability and low cost for the communication between different welding equipments.

II. Structure of Ethernet Solutions for Communication of Twin-Arc High-Speed SAW Equipments

doi:10.4304/jcp.7.12.3052-3059

Fig.1 shows the proposed structure of communication of twin-arc high-speed SAW equipments based on Ethernet. The idea is that each welding equipment is a intelligent control unit, is an independent agent with a great deal of autonomy and good interaction, the agent can solve independently local problems and maintain the interaction coordination to other agent. Each module of the intelligent, behavior, distribution of information and control is great flexibility and parallelism.

The intelligent control unit achieves data exchange with the remote monitoring computer, and also complete displaying and settings of the system parameters at the same time. The remote monitoring computer system is responsible for monitoring, acquisition of welding parameters, preservation, processing and displaying. The inverter welding power supply as Ethernet node is responsible for procedures control, mathematical operation to feedback of welding parameters, generation of pulse-width modulation (PWM) waveform. The inverter welding power supply as the host machine of twin-wire welding system is also synergistic controlling with the slave inverter. In addition, the wire feeder A , wire feeder B and traveling agency as Ethernet nodes are in coordination of the entire system under synergistic controlling mode, and complete control and drive for traveling and wire feed by DC motor speed adjustment.

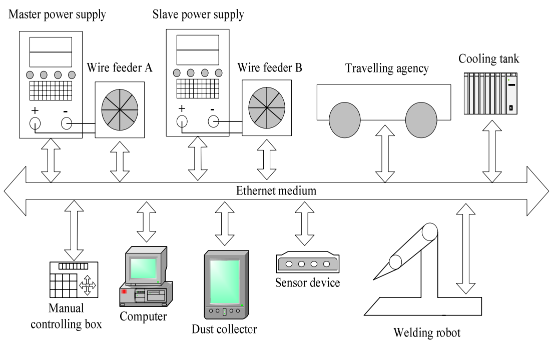


Figure 1. The proposed structure of communication of twin-arc high-speed SAW devices

In communications network built by Ethernet, each welding device is a node on the network. The greatest advantage of this structure is to advance acceleration for the information flow and data of the entire control system, and also realize sharing of welding information in high degree. For end users, the most important benefit is to improve the overall performance of the welding system, because the various components of the system can share information and work closely. For example, the current and voltage data information of welding power supply are shared for the travelling agency, the travelling speed is based on arc current or voltage. The data are also available for welding monitoring equipments to share as a source of quality controlling. Fault diagnosis information can also be transmitted on the network, which is help for solutions to fault. Advanced welding control algorithms can be developed on a PC, and then downloaded via Ethernet to the welding equipment and peripherals, system performance is enhanced, and functionality is customized or refreshed. The computer with Ethernet interface could be responsible for two-way communication Ethernet gateway, and this connection to the wider range of network gateway arc welding process can be automated as a part of the whole plant. Sensing equipments including vision sensors, laser sensors and arc sensors are essential components of intelligent welding robot technology, automatic tracking and weld penetration controlling technology of welding process.

III. THE WELDING EQUIPMENT TECHNICAL REQUIREMENTS FOR ETHERNET

Intelligent control unit is representative of the specific welding equipment in twin-arc high-speed submerged arc welding equipment by Ethernet, which is defined as calculation unit for solving mechanism of the controlling problem, is also considered to have certain properties that achieve a functional model of the computer program unit and its associated physical entity. The intelligent control unit has goals, behavior, and a particular area of expertise, it can act on their own and the environment and respond to the environment. In the twin-arc welding system, the intelligent control unit is the characterization of welding inverter power supply, wire feeder and the cooling water tank. Fig.2 is internal structure model of the intelligent control unit. It consists of a database, control module, environmental responding and communication module. In addition to a timely response to the abnormal situation, the control unit makes plan for short-term behavior used of certain strategies, judge the future through the relevant knowledge, and achieve collaboration of control units through language and other communication. These functions should be existing at same time, parallel implementation, and good real-time.

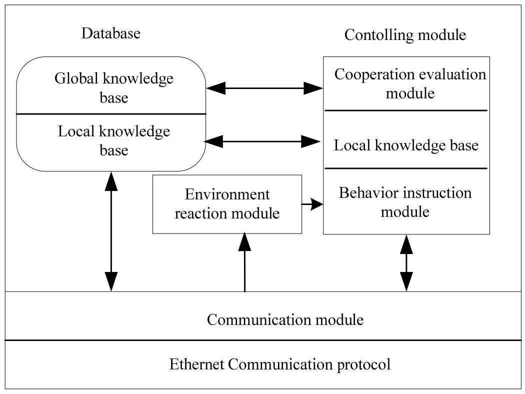


Figure 2. Construction model of intelligent control unit

Intelligent control unit is independent and autonomous entity with data processing capabilities and external communications. On Ethernet, they are located in the node with distributed architecture, which communicate between the ethernet-compliant by protocol specification language and establish the twin-wire distributed control network.

According to the internal structure of the intelligent control unit model, and the analysis of their common functions, the general design requirements of intelligent control unit can be summed up as follow:

(1) It is a hard real-time embedded system. The responding time of message from internal and external events or other intelligent control unit must be as short as possible, otherwise we will lose real-time of synergistic control of the distributed system and fail to work closely with the degree of coordination. So it is necessary to choose a higher speed of the microprocessor such as 32-bit bus of the digital signal processing (DSP) and ARM.

(2) It has communication capabilities, Ethernet is the core of a distributed control system, is a carrier of the welding process control unit in collaboration mode. Communication interface is to ensure the data is transported between the control units, the two sides do not need understand specific features and implementation mechanisms of their own, only through the exchange of data to obtain the necessary command and status information. Communication interfaces include physical interfaces, data buffer unit, the interface control unit and data processing unit. Physical interface must follow the definition of interface pins and electrical specifications of field bus layer

(3) In order to avoid duplication design of control unit to the different functional requirements of the welding equipment, hardware and software requirements should be cut, portability and scalability. Therefore, embedded real-time multitasking operating system is necessary in the process of system design.

IV. ETHERNET TCP / IP IMPLEMENTATIONS IN THE WELDING EQUIPMENT

A. The ARM-based Intelligent Control Unit

Fig.3 shows the digital welding power supply structure with LPC2214 as its CPU. LPC2214 is a 32-bit RISC processor with ARM7 Thumb Debug Multiplier ICE (TDMI) as its core. And its maximum main clock frequency is 130 Million Instructions per second (MIPS). ARM integrates the merits of the DSP and the 8-bit Microcontroller, which runs at a high speed while includes complete peripheral equipments. The 128-bit storage interface of the LPC2214 and the exclusive expediting structure make the 32-bit program run at the maximum main clock frequency. Still it covers almost all the peripheral functions of a digital welding system required as follows, four channels of 10-bit A/D converter whose converting time is 2.44μS，two 32-bit timers, six channels of Pulse Width Modulation (PWM) output, two Universal Asynchronous Receiver/Transmitter (UART) compatible with the 16C550 industrial standard, one high-speed Inter Integrated Circuit (IIC) interface, two Serial Peripheral Interface (SPI) interfaces, two Controller Area Network (CAN) interfaces. When the system works, the ARM generates two PWM signals with the phase shifted 180°which will then drive the Insulated Gate Bipolar Transistor (IGBT) after photoelectric-isolation and power-amplification.

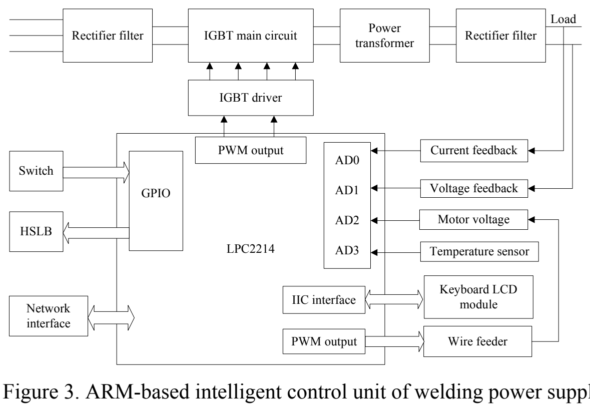


Figure 3. ARM-based intelligent control unit of welding power supply

The arc welding power supply output will be decided by the PWM duty once the arc welding inverter structure and the transformation ratio are defined. Change the duty as some certain regular and the expected technological parameters will be worked out.

The duty is set by (1) and (2):

$$MR0 = \frac{F_{pclk}}{F_{pwm}} \tag{1}$$

$$D = \frac{MR1}{MR0} = \frac{MR3 - MR2}{MR0} \tag{2}$$

F_{pclk} is clock of the peripheral equipment, F_{pwm} is frequency of pulse width modulation. MR0, MR1, MR2 and MR3 are the values of the registers respectively.

According to the pulse voltage parameter, real-time control on pulse width can be realized by adopting digital Proportional-Integral-Derivative (PID) algorithm with the negative feedback welding current signal. Still the ARM controls the keyboard and the Liquid Crystal Display (LCD) module through IIC interface and the speed of wire feeder through a PWM output. The Network interface is for communication with other welding equipments.

The advantages of the ARM-based intelligent control unit are as below:

(1) The tasks are dynamically switched by the Central Processing Unit (CPU) according to their priority levels to ensure smooth real-time control. When a task is waiting to start, the CPU does not wait but to serve the other ready tasks of higher priority. For example, when the A/D transformation against the output voltage has been started, the CPU can serve other tasks as feeding the watchdogs etc. before the transformation is finished.

(2) CPU is made use of to its maximum so that every task will be run forthwith.

(3) Reliability of the software in controlling system will be greatly improved. The programmers may easily manage the complicate applicable program. They are just expected to program the tasks separately without worrying about forgetting the possible cases during task running. Therefore, the programming is eased. Possibility of making mistakes is reduced while the reliability of the program is increased.

The ethernet interface is composed of RF45 connector and controller of DM9000AEP. The DM9000AEP is a fully integrated and cost-effective low pin count single chip fast ethernet controller with a general processor interface. It conforms to the ethernet standard, supports IEEE802.3x flow control for full-duplex mode and semi-duplex CSMA/CD mode, integrated 10/100M transceiver with AUTO-MDIX, 16K Byte SRAM, 8/16Bit data bus, interrupt request and I/O base address selection. The operation of the internal register is simple. The ethernet interface use a RJ45 connector integrated with network transformer, and connect to the host computer by twisted pair wiring, which achieves communication based on the ethernet. The hardware schematic diagram of the ethernet interface shows in Fig.4.

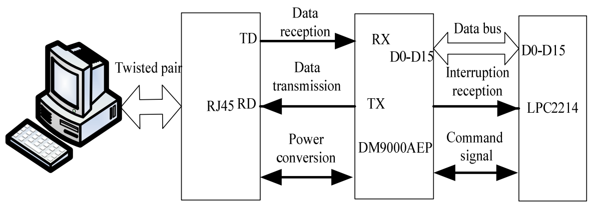


Figure 4. Hardware schematic diagram of the Ethernet interface

B. Communication Program

The high efficiency and speed communication of ethernet is the priority to ensure the sampled data to be transmitted to host computer rapidly, ethernet controller DM9000AEP is used to realize data communication between the monitoring module and the host computer. The programming of DM9000AEP can be easily accomplished by operating the internal register.

Because the data packets will be received by host computer, the collected welding current and voltage signals should be packed by the TCP / IP protocol standard, and then transmitted to the host computer by DM9000AEP. In embedded systems, the TCP / IP protocol is consisted of application layer, transport layer, network layer and network interface layer. According to the requirements of digital monitoring system for high speed submerged arc welding, communication program based on TCP/IP protocol was designed in this paper. The flow chart is shown in Fig.5.

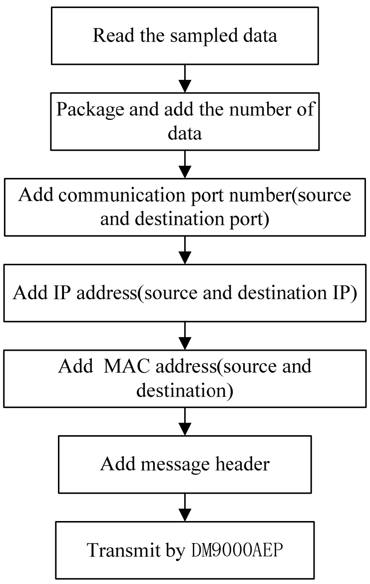


Figure 5. The communication protocol flow chart

C. Controlling Program

In order to ensure that the slave machine received command from the host, the communication handshaking protocol between master and slave are defined, that is, the slave machine send a feedback confirmation byte to the host after receiving the command from the host machine at each time. The low 4 bytes of the confirmation byte is the same to the order received, high four bits are the fixed characteristics of 0101. For example, the command byte received from the host machine when enter the stage of the base value is 10100001, then confirmation byte back to the host is 01010001.

If the host receives the effective confirmation byte after sending a command within 200μs, it is a complete of the communication process. If do not receive a confirmation byte within a specified time, then re-issued again. It exit and issue a communication failure alarm information when do not receive a confirmation bytes after five times of the re-issued. The process is shown in Fig.6, the dashed line express content and direction between the master and slave messages.

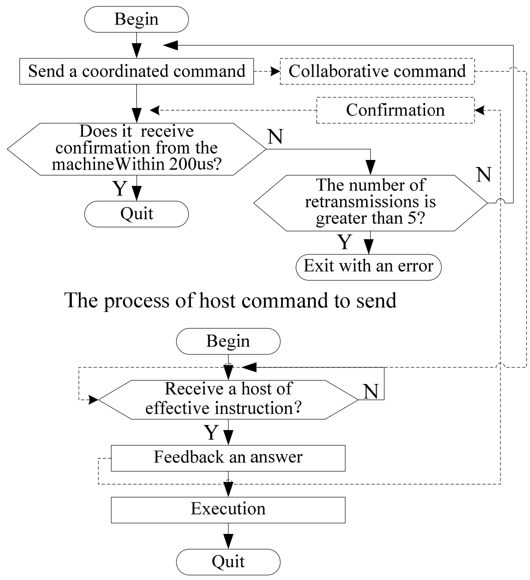


Figure 6. Scheme of handshake protocol between master and slaver

In the control of twin-arc submerged arc welding, to obtain satisfactory weld seam quality, sequential control of the master and slave arc starting and ending is the utmost importance. In ordinary twin-arc submerged arc welding process, the two wires are in the relationship of one after another relative to the welding direction. The two wires burning simultaneously when welding power starting. But because of the space between the two wires, there were two sections of the same length with the wire spacing at the head and trail of the weld seam, which were actually only suffered from the thermal effect of a single arc, as a result, collapse phenomenon would be caused at the head and trail of the weld seam.

To guarantee the uniformity of weld width and reduce the collapse level, starting and ending of the two welding power sources could be controlled in a certain procedure. At the starting of welding process, start the master power and welding vehicle firstly, when the back wire moved to the initial start position of the front wire, then start the slave power. At the ending of welding process, stop the master power and wire feeding when the front wire moved to the preinstalled destination, the traveling agency continues walking, when the back wire moved to the preinstalled destination, stop the traveling agency and reduce current and voltage of the back wire gradually, the program delay three seconds, use arc back burning to fulfill the crater, then cut off the slave power supply source and stop wire feeding. By application of the sequential control of the master and slave power supply source and traveling agency, the narrow head and trail of the weld seam can be prevented, and the collapse level at the ending of weld seam also be reduced, a better weld seam quality was obtained. The flow chart of welding sequential control is shown in Fig.7.

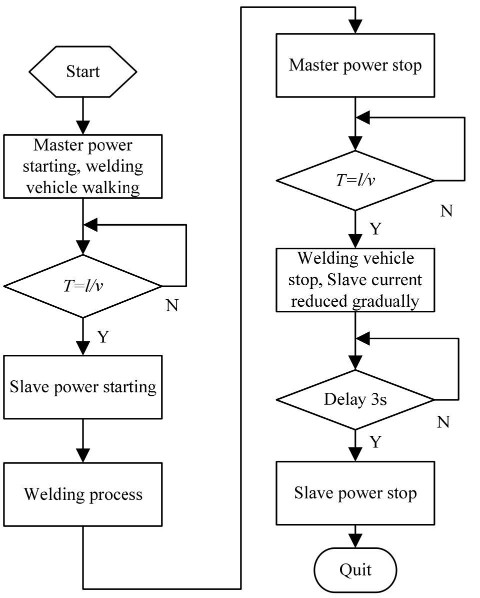


Figure 7. The flow chart of welding sequential control

PID is adopted to be the controlling algorithm for power supply source outputting. PID is a linear controller, which is based on the deviation of the given value *r*(t) and actual outputting values *c*(t) as following:

$$e(t) = r(t) - c(t) \tag{3}$$

The controlled value is constituted by the linear combination of deviation of the proportional P, integral I and derivative *D*. The rule of the controlling can be written as:

$$u(t) = K_p\left[e(t) + \frac{1}{T_I}\int_0^t e(t)dt + \frac{T_D de(t)}{dt}\right] \tag{4}$$

The transfer function of (4) is:

$$G(s) = \frac{U(s)}{E(s)} = K_p(1 + \frac{1}{T_I s} + T_D s) \tag{5}$$

Where K_P is proportional coefficient, T_I is integration time constant, T_D is differential time constant.

The actual control algorithm used discrete PID is expressed by:

$$u(k) = K_p e(k) + K_I\sum_{j=0}^{k} e(j) + K_D\left[e(k) - e(k-1)\right] \tag{6}$$

Where k is the sampling sequence number, $u(k)$ is the inputting deviation of k , $e(k-1)$ is the inputting deviation of k -1, K_I is integration time constant, K_D is differential time constant, T is sampling period.

When the actuator is needed to control the amount of increment, the incremental PID formula is obtained by (6), the K-1 outputting can be obtained by the recursive principle as following:

$$\begin{aligned} u(k-1) = K_p e(k-1) + \\ K_I\sum_{j=0}^{k-1} e(j) + K_D\left[e(k-1) - e(k-2)\right] \end{aligned} \tag{7}$$

The incremental PID control algorithm is obtained by the subtraction of (7) and (6)

$$\begin{aligned} \Delta u(k) = K_P\left[e(k) - e(k-1)\right] + K_I e(k) + \\ K_D\left[e(k) - 2e(k-1) + e(k-2)\right] \end{aligned} \tag{8}$$

The practical outputting is

$$u(k) = u(k-1) + \Delta u(k) \tag{9}$$

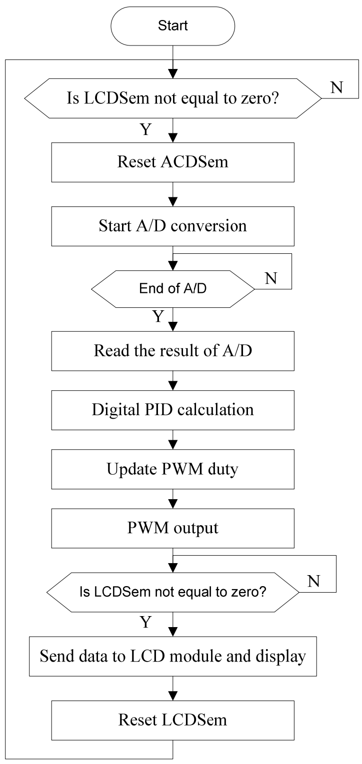


Figure 8. Complete voltage controlling procedure of a constant voltage character arc welding power supply

Fig.8 is a complete voltage controlling procedure of a constant voltage character arc welding power supply.

D. Welding Process Monitoring Program

The welding process monitoring procedure is used to complete the acquisition and real-time display of welding parameters, the A/D transformation subprogram is called to convert the collected current and voltage signals into digital, then packed by the ethernet controller DM9000AEP and transmitted to the computer, receive and display program were called to realize dynamic monitoring of the welding process. The flow chart is shown in Fig.9.

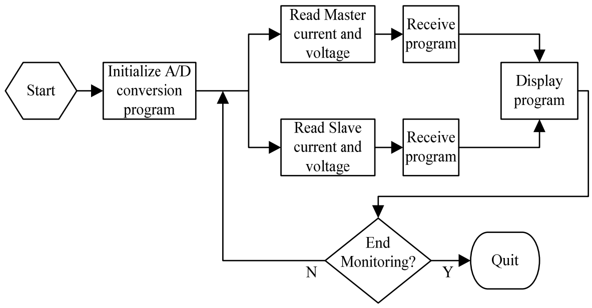


Figure 9. The welding process monitoring procedure

V. EXPERIMENTS

The ethernet communication system designed in this paper was applied to do testing experiment in high-speed twin-arc submerged arc welding process. Testing experiment conditions: MZ1250+MZE1000 submerged arc welding inverter power source, low-carbon steel plate, thickness of plate is 20mm, front wire Φ5mm and back wire Φ4.8mm, wire grade H08A, welding flux HJ431, and surfacing method was adopted. In these testing conditions, chose the arc starting and ending program and set the wire spacing when monitoring system started. The criterions and parameters were shown in Table I, relevant current waveform and weld seam appearance were shown in Fig.10.

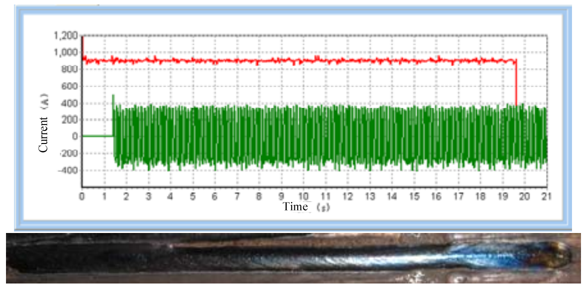
TABLE I.

THE CRITERIONS AND EFFECTS OF TWIN-WIRE SAW

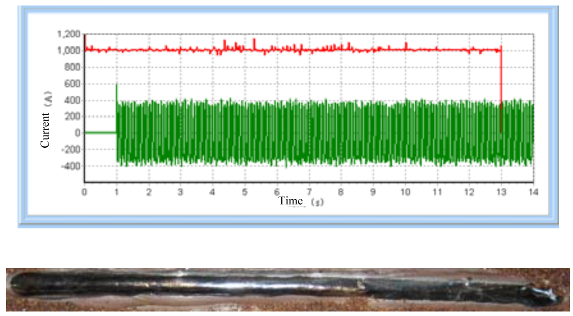
Current (A)		Voltage (V)		Welding speed (m/min)	Wire space (mm)	Welding conditions
Front wire	Back wire	Front wire	Back wire			
910	770	42	43	1.4	30	welding process is stable and welding seams performing well
1010	780	42	44	1.8	30	welding process is stable and welding seams performing well
1080	810	42	44	2.0	33	welding process is stable and welding seams performing well

It can be seen from the figure that there were no short circuit and arc interruption in the welding process, the process was stable, and the arc starting and ending were well and perfect forming of weld seam.

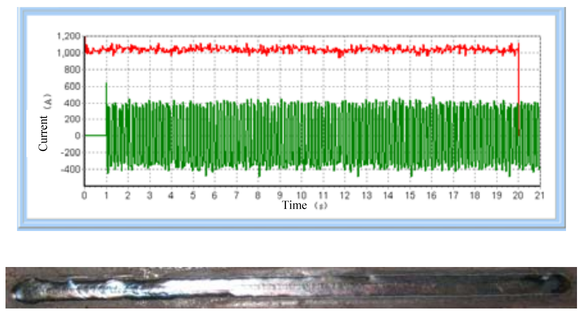
In the experiments of twin-arc submerged arc welding, it can be seen from the testing results that the monitoring and controlling system based on ethernet can real-time display electrical parameters in welding process, has well performance of stabilization, the collapse level was avoid and the weld seam appearance was greatly improved.



a) Front wire: I=910A, U=42V; Back wire: I=770A, U=43V; Welding speed V =1.4m/min



b) Front wire: I=1010A, U=42V, Back wire: I=780A, U=44V; Welding speed V =1.8m/min



c) Front wire: I=1080A, U=42V; Back wire: I=810A, U=44V; Welding speed V =2.0m/min

Figure 10. Waveform of current and voltage and welding seam

VI. CONCLUSIONS

The ethernet communications which has characteristics of high speed, large capacity and high reliability is applied to the dynamic monitoring and controlling of high-speed twin-arc submerged arc welding process in this paper, The structure of twin-arc high-speed SAW equipments based on ethernet is proposed. The welding equipment technical requirements for ethernet are discussed. The crucial implementations of ethernet TCP / IP in the welding equipment is presented including designs of ARM-based intelligent control unit, communication program, synergistic control procedures and monitoring program of welding process. The proposed system guaranteed the stability and order of welding process. The testing results indicated that the system was achieved the technology of twin-arc high speed arc welding, and the collapse phenomenon at the head and trail of the weld seam was effectually avoided, and the weld seam performance is improved.

ACKNOWLEDGMENT

Project supported by National Natural Science Foundation of China (51005073), Hunan Provincial Natural Science Foundation of China (11JJ2027), Project of Hunan Provincial Research Scheme (2011GK3052), Innovative special project of Hunan Science and Technology Agency research conditions(2012TT2044), also from Aid program for Science and Technology Innovative Research Team in Higher Educational Institutions of Hunan Province, are gratefully acknowledged.

REFERENCES

[1] D. J. Tusek, “Factors affecting weld shape in welding with atriple-wire electrode,” Metalurgija, United States, Vol. 41, pp. 89-92, February 2002.
[2] D. J. Tusek, “Narrow-gap submerged-arc welding with a multiple-wire electrode,” Metalurgija, United States, Vol. 41, pp. 83-88, April 2002.
[3] K. F. He, S. S. Huang and D. Y. Sun, “An Expert System for Submerged Arc Welding,” Journal of South China University of Technology (Natural Science Edition), China, Vol. 36, pp. 79-82. August 2008.
[4] K. F. He, J. G. Wu and X. J. Li, “Prediction Model of Twin-Arc High Speed Submerged Arc Weld Shape Based on Improved BP Neural Network,” Advanced Materials Research, United States, Vol. 216 pp194-199, March 2011.
[5] K. F. He, X. J. Li and J. G. Wu, “Three-Dimensional Temperature Field Numerical Simulation of Twin-Arc High-speed Submerged Arc Welding Process Based on ANSYS,” Advanced Materials Research, United States, Vol. 216 pp 188-193, March 2011.
[6] K. F. He, S. W. Xiao and J. G. Wu, “Time-Frequency Entropy Analysis of Arc Signal in Non-stationary Submerged Arc Welding,” Engineering, United States, Vol.3 pp.105-109, March 2011.
[7] K. F. He, J. G. Wu and, X. J. Li, “Wavelet Analysis for Electronic Signal of Submerged Arc Welding Process,” IEEE Computer Society, China, vol. 3, pp. 1139–1142, January, 2011.
[8] K. F. He, S. S. Huang and X. J. Li, “Digital Synchronic Control System for Twin-arc Co-pool High Speed Submerged Arc Weld (SAW),” China Mechanical Engineering, China, Vol. 22, pp. 235-239, February 2011.
[9] H. T. Xue, J. Y. Li and X. N. Zhang, “Welding arc information acquisition and analysis system,” Transactions of The China Welding Institution, China, Vol. 24, pp. 19-22. January 2003.
[10] H. B. Zhang, S. S. Huang and Y. Q. Zhou, “Characteristics of twin arc GMAW with a common weld pool,” Electric Welding Machine, China, Vol. 34, pp. 25-27, November 2004.
[11] F. Q. Zhao, J. Z. Wang and J. X. Tang, “Research on Dynamic Rescheduling Program Base on Improved Contract Net Protocol,” Journal of Software, Finland, Vol. 6, pp. 798-805, May 2011.
[12] T. M. maarouk, D. E. Saidouni and M. Khergag, “Towards a calculus for distributed, real-time and mobile systems,” Journal of Software, Finland, Vol. 7, pp. 564-574, March 2012.
[13] J. Huang, Z. F. Cui and Y. G. Pi, “Research on welding knowledge management system base on network control,” Electric Welding Machine, China, Vol. 39, pp. 34-37, September 2009.
[14] B. Cao, F. Liu, and M. Zeng, “Research on remote monitoring and control system of arc welding inverter,” Electric Welding Machine, China, Vol. 38, pp. 34-37, May 2008.
[15] Y. Shi, D. Fan, J. Song, “A network control system of welding machines based on Ethernet,” Transactions of The China Welding Institution, China, Vol. 26, pp. 21-24, April 2005.
[16] M. P. Xie, J. Wu and Y. Kong, “Implementation of asymmetry data transmission channels in a cascaded network based on Ethernet PHY,” Journal of Jilin University(Engineering and Technology Edition), China, Vol.41, pp.210-213, January 2011.
[17] W. Yang, D. Q. Li, “A dual-CPU spot welding controller design based on Ethernet,” Machinery Design & Manufacture, China, pp.244-246, January 201.
[18] Y. Chai, Y. T. Wang and H. Chen, “Design and Application of Measurement and Control Module Based on Ethernet,” Computer Automated Measurement & Control, China, Vol. 12, pp. 1188-1191, December 2004.
[19] C. G. Guo, J. Zhu and X. L. Li, “A Generic Software Monitoring Model and Features Analysis,” Journal of Software, Finland, Vol. 6, pp. 395-403, March 2011.
[20] P. He, J. H. Wen, K. G. Wu and P. Li, “Multi-objective Service Monitoring Rate Optimization using Memetic Algorithm,” Journal Of Software, Finland, Vol. 7, PP. 990-997, May 2012.

Kuanfang He, who was born on December 13, 1979 in Hunan province, received master degree in 2006 and PHD in 2009 from South China University of Technology, research field are dynamic monitoring and control for electromechanical systems.

He has been working at Hunan University of Science and Technology since 2009, mainly engaged in theory and practice of teaching, scientific research. His research interest is dynamic monitoring and control for electromechanical systems.

Dr. He is a member of Hunan Province instrumentation Institute. In recent years, he has presided one National Natural Science Foundation of China and two provincial research projects, obtained three provincial academic reward, published more than 20 academic papers.

Zhuo Jie Zhang, who was born on june 21,1989 in Hunan province, received bachelor degree in 2012. He is a undergraduate student of Hunan University of Science and Technology. He mainly engaged in theory and practice of scientific research. His research field is intelligent detection technology of welded structure.

Jun Chen, who was born on April 6,1987 in Hunan province, received bachelor degree in 2011. He is a undergraduate student of Hunan University of Science and Technology. He mainly engaged in theory and practice of scientific research. His research field is dynamic monitoring and control for electromechanical systems.

Qi Li, who was born in 1987, received a bachelor's degree of electronic information science and technology in 2009. He is studying for a master's degree in Mechanical and Electronic Engineering at Hunan University of Science and Technology, and his research interest is signal processing and quality control of high speed submerged arc welding.