Modern Applied Science
www.ccsenet.org/journal.html
Vol. 3, No. 4
April 2009

The Research of Inverter Welding Power Source Based on DSP for Self-shielded Flux-cored Wire

Xiao Li, Liangyu Li, Tianqi Wang & Xu Yang
Tianjin Key Laboratory of Advanced Mechatronics Equipment Technology
Tianjin Polytechnic University
Tianjin, 300160, China
E-mail: lixiao0412@hotmail.com

Abstract

Based on DSP (Digital Signal Process), a inverter welding power source has been introduced. By designing of the software of system and circuitry of wire feeder, constant-voltage external characteristic for self-shielded flux-core wire and stable wire feed speed are acquired. To optimize the parameter, lots of tests had been done. To apply to pipe welding, the weld process is stable and credible. The facility is easy to use and multifunctional.

Keywords: Pipeline welding, DSP, Self-shielded flux-core wire welding

1. Introduction

As a special logistic facility, pipeline has extended every aspects of our life. In large-scale pipeline construction, the traditional electrode welding technology could not match the process of project, which has been replaced by semiautomatic self-shielded flux-cored welding. The process used to effectively reduce the cost and time limit for a project, raising productivity. So the prospect to apply is wide. This problem has been studied previously (Liu, 2006, p.34-35). The semiautomatic self-shielded flux-cored wire for filler and cosmetic welding is one of the common methods in pipeline project. The welding equipment is universal which is used in both semiautomatic welding and shielded metal arc welding. Thus the project needs fewer welding machines and techniques outfits, which reduce the total equipment cost. As a result, by way of a advanced construct technology, the semiautomatic self-shielded flux-cored wire welding is widely popularized in long pipe welding especially in big caliber long tube. This problem has been studied previously (Wang, 2007, p.23-24). Therefore a inverter welding power source based on DSP for self-shielded flux-cored wire has been devised, which can match the Self-shielded Flux-cored welding technology.

2. Design of Integrated Structural

The integrated structural design is shown in figure 1. First, the 380V three-phase alternating current is alternated by commutating and filtering into 540V direct current. Then in the control of the control circuit, to use IGBT DC transition (the inversion) 20 KHz exchange of high frequency power. The transformer and 2nd rectification is available for welding of low voltage DC.

In designing of the integrated structural of inverter welding power source system controlled by DSP for Self-shielded Flux-cored Wire, We should first consider software and hardware of rational resource allocation in order to achieve speed and flexibility of balanced. The hardware is highly responsive and reliable. And the characteristic of the software is flexible and adaptable. In this specific design, taking into account the main system circuit working at several 100 amperes, the control circuit of main circuit is constituted by the operational amplifier and PWM chip. Then it can improve the security and reliability of system.

3. Design of Control System

To adapt to the complexity of inverter welding power source, the control circuit taking PWM circuit as the core, adopt current and voltage negative feedback closed-loop control. The output current and voltage regulation is realized. And we can obtain external characteristic, the dynamic characteristic as well as the welding sequential control that meet the requirements adoption of the control circuit.

The main process is to let the feedback current and voltage signal go into DSP by signal processing circuit using a Hall sensor. Through analysis of feedback voltage and current by software, according to the system of different external characteristic, we can determine at this point the system carries on the control to the electric current or the voltage. The current and the voltage closed loop adjustment realized through PI circuit on control panel. That control the SG3526

chips to produce two groups of PWM signal that differs 180 °phase with the dead area. IGBT's turn—off time is determined by EXB841 which is a part of driving circuit. Thus it may control and regulate the output voltage and current.

We choose the TI Corporation's LF2407A DSP chip as the core chip. A/D, D/A transformation circuit, outside expand memory, SPI vision module, 3.3V-5V voltage transformation circuit and JTAG simulation port have been designed. The program could been debugging online in the computer through simulator with JTAG port. In simulation process, the outside expand ROM has high running speed and easy erased. When debugging program completely, the program should solidify in-chip FLASH. When running pattern has been set to micro-controller, the welding source power will run by itself separated from computer.

4. Design of Wire Feeding System Hardware

Negative feedback voltage and positive feedback current has been adopted in this control configuration of timing system. Armature voltage of wire-feed motor is regulated by the way of pulse width modulation (PWM). By introducing negative feedback voltage into the control system, the motor's speed could stabilize at set value. Positive feedback current is used to compensate voltage drop for armature resistance, which causes the rotational speed to be stable. The frame of feeding system is shown in figure 2.

In this system, the difference of set value and voltage feedback value with the addition of current feedback value is regarded as control signal, which were operated by operational amplifier. Control voltage signal to corresponding dutyfactor PWM signal transformation is completed by SG3525. After enhanced by driver circuit, PWM signal actuates the wire feeding machine's movements.

5. Design of Software

The static characteristic of self-shielded welding with flux-cored wire belongs to rising characteristic. Adopting constant wire-feed system, constant-voltage arc welding is selected from external characteristic, which causes arc self-regulation to be strong. And the welding parameter stability is best. Arc self-regulation means that the welding power source would reduce or increase the current when the arc is lengthened or shortened because of disturbing. Application of this static characteristic, arc restores the original arc length automatically. The sensitivity of arc self-regulation determined by $\Delta v_m / \Delta l_a$ (Δv_m --variable of melt speed, Δl_a --variable of arc length), the specific formulation is

$$\frac{\Delta v_m}{\Delta l_a} = -\frac{\alpha_m}{d^2} * \frac{E_c}{K_s} \tag{1}$$

Where, α_m --melting coefficient of wire, d --diameter of wire, E_c --electric field intensity, K_s --stability coefficient of external characteristic, a minus sign-- The arc length change and the melting speed's change is opposite.

Regarding constant-voltage and slowly dropping characteristic arc welding power source, the sensitivity of self-regulation arc will meet the requirement when declining slope of $\Delta v_m / \Delta l_a$ is less than 4V/100A.

5.1 Design of Constant-Voltage Characteristic

Program expressed in c language, is composed of main, initialization, collection, state judgment, display, striking arc and welded subprogram. The cellulose type welding is also a function of the welding source. Thus the welding source offers two choices of cellulose type welding and self-shielded flux-cored wire.

The feedback voltage and current in welding collected by A/D converter channel are stored in variable value before data processing. The predetermined values of voltage and current input by knob are converted from analog signals to digital signals. Here, the first step is judging which mode of welding has been selected. Secondly, if flux-core welding mode had been selected, the program would access in corresponding subroutine. The host program figure is shown in figure 3.

Here, according to feedback digital values, it can be judged whether the state is idling or arcing. If the arc was not burning, the program will call striking arc subroutine which adopts low feeding speed and heavy current. After arc burning, normal arcing program will be executied of normal feeding speed and preset voltage value.

The voltage preset is converted to simulated value with the D/A converted chip. In order to stabilize the output, the preset voltage and the feedback voltage make the adjustment through the PI controller. Then the output is used to control SG3526 chip which generates a PWM waveform, to drive IGBT. So according PI controller, the constant-voltage output keep stable. Flux-cored wire welding subroutine is illustrated in figure 4.

5.2Anti-jamming Design of Software

Built-in watchdog timer in LF2407A DSP will overflow when the program is disordered because of disturbing. Then a reset signal generated by watchdog will restart the running program.

In order to obtain real-time data collecting and system controlling, the disturbing signal in channels must be eliminated, ensuring the reliability and rationality of the system design. The digital filtering approach is selected in the system. In

the light of analyses of the data selected, a median average filtering approach has been successfully developed, which reduces the influence of the random disturbance. Median average filtering, which has been used in both filtering pulse interference and smoothing wave, focuses on the merits of media filtering and average filtering. That is to say, it has an effect on both rapid and slow interference. The median average filtering approach may be described like this. Got rid of the max and min value in multiple date in one sampling, the arithmetic mean value of rest date is taken as reference value in one sampling cycle.

6. Experiments and Analyses

The static external characteristic of self-shielded flux-cored arc welding measured on the basis of experiment is shown in figure 5. As a result of the preset voltage and feedback regulation of PI, the voltage is stabled in preset value, to which meet the requirement of self-shielded flux-cored arc welding. The voltage may be adjusted by knob on the panel to apply to various welding conditions.

The voltage and current oscillogram traced by an oscillograph is shown in figure 6, which apply to self-shielded flux-cored wire with a diameter of 1.6 millimeters. The upside line denotes voltage, and the other current. As shown in figure 6, the voltage fluctuating steadily, ensure the welding process stable. The current is in direct proportion to feeding speed. Thus the current stability is determined by feeding speed. The current will be adjusted swiftly owing to arc self-regulation, for restoring the arc changes in length caused by interference.

7. Conclusions

(1) A new control circuit based on DSP and feeding wire system are designed, which runs stably and securely.

(2) Constant voltage external characteristic can be obtained by design of hardware and software, and it meet the process of self-shielded flux-cored arc welding.

(3) Using software to control is an agile approach. Multiple functions may be obtained by modifying software only.

References

Liu,Jing, Jiang,Guoqing & Luo Qimin. (2006). Application of Flux Cored Arc Welding to Long Distance Transmission Pipeline. *Welding Technology*, 3(6), 34-35.

Wang, Wenyan, Zeng, Jiuling, Sun, Wei & Xie Xinwen. (2007). Application of Flux Cored Arc Welding to Long Distance Transmission Pipeline. *Pipeline Technique and Equipment*, 3 (5), 23-34.

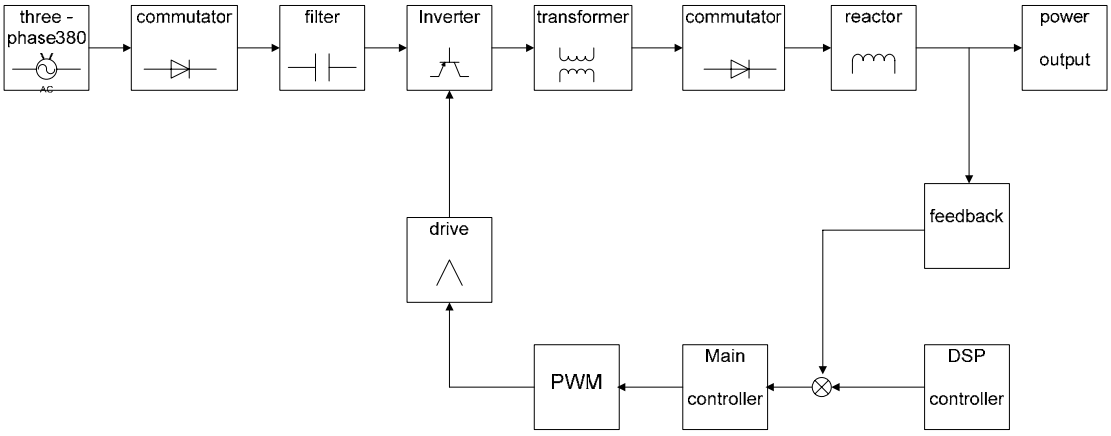

Figure 1.The integrated structural design

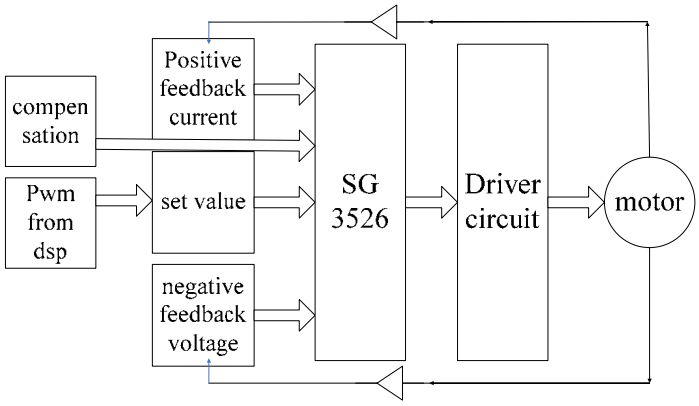

Figure 2. Scheme of feeding system

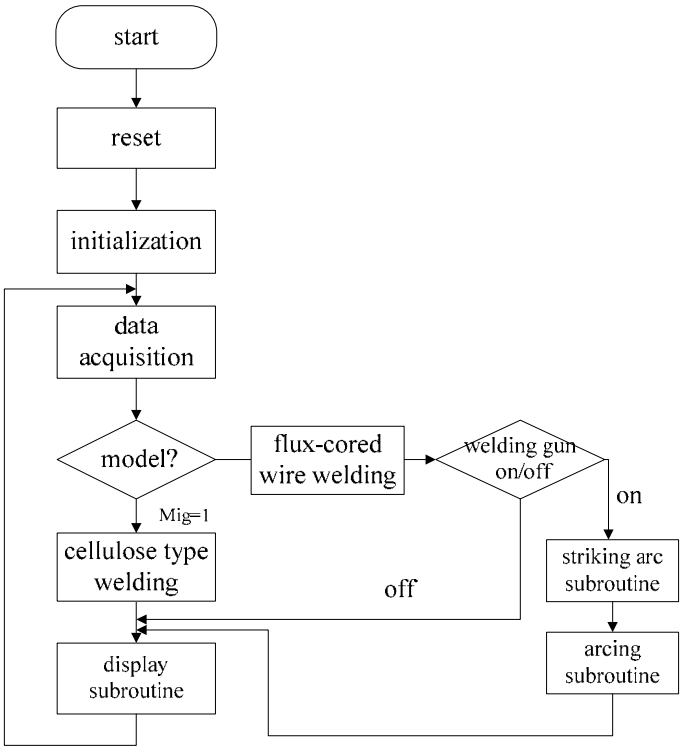

Figure 3. Main program layout

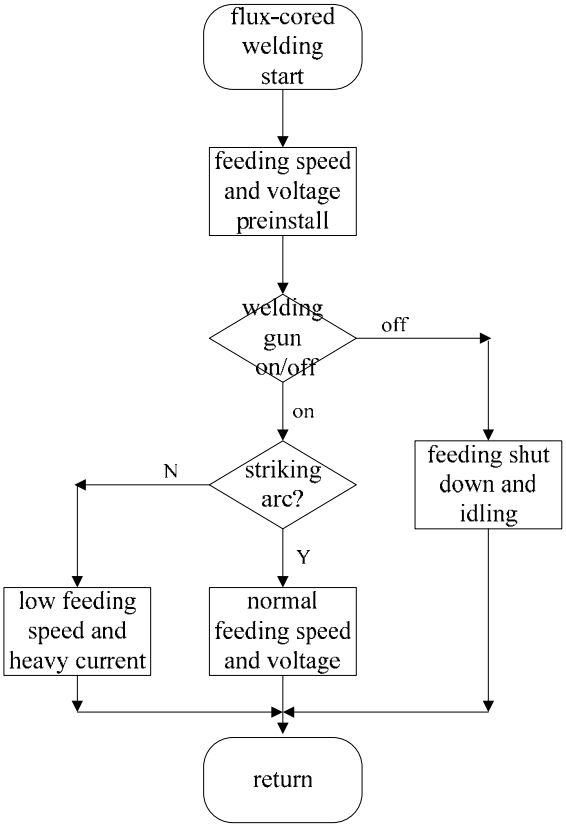

Figure 4. Flux-cored welding subroutine layout

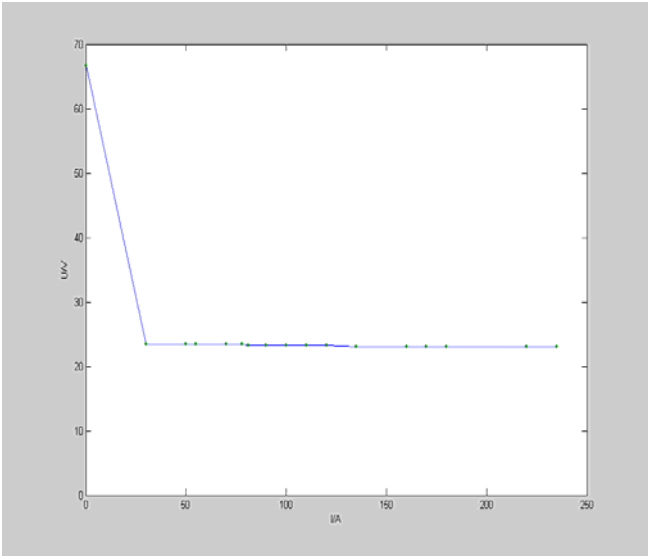

Figure 5. Scheme of constant-voltage external characteristic

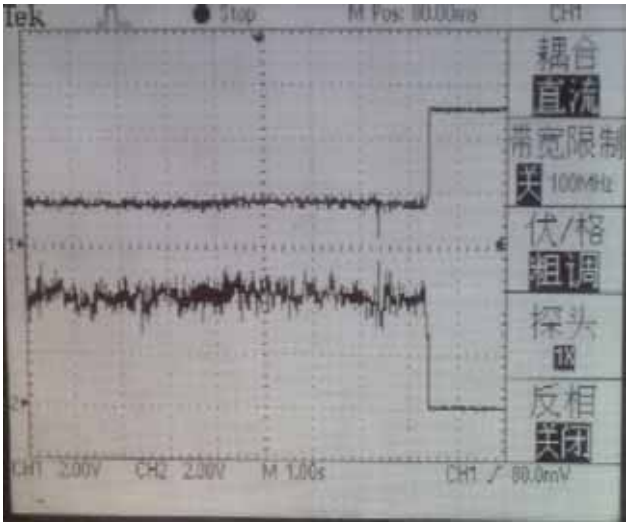

Figure 6. The oscillogram of voltage(23.8V) and current(200A)