

Research on menu-typed man-machine interaction system of digital TIG welding machine

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Abstract A digital man-machine interaction system controlled by communications between two processors of TMS320F240 and AT98C2051 was researched in the paper. The system is easy to set and modify welding process parameters by keyboards, and display information of welding site by LCD (Liquid Crystal Display). As one part of multi-task system about TIG welding machine, the coordination of man-machine interaction system with other tasks is the main point to the stability and reliability of its operation. Experiments result indicates that the system is stable, operation-flexible, high precision, and anti-interfering.

Key words man-machine interaction system, digitalization, two-processor, menu

0 Introduction

More and more research on digitalization of welding machines has occurred since the first digital welding machine^[1] of the world was manufactured by Fronius company in 1990's, which has become a main trend of the development of welding machines^[2]. Man-machine interaction system is external appearance of digital welding power source.

Man-machine interaction system is the direct operation interface between human and machine, which is a window for the operator to send messages and instructions to machine and observe parameters and information about working site. As an interface, it must be friendly, flexible, multi-function, reliable, compatible, positive, and etc^[1,3]. Some big welding manufacturers have had products with man-machine interaction system through LCD (Liquid Crystal Display) and keyboards to set welding process and welding process parameters, and display information about work site. For example, TransSynergic 4000 / 5000 and TransPuls Synergic 2700 / 4000 / 5000 made by Fronius Company in Austria, which has a multi-function man-machine interface for pulse MIG welding, DC MIG welding, manual welding, and TIG welding, with different materials and different diameters of welding wire;

MK CobraTig 150 made by MK Products, Inc. in America, which has friendly programming interface with LCD; Automatic M microprocessor-based weld control made by Miller Electric Mfg. Co. which can be used for MIG welding, pulse MIG welding, and self-adapting pulse MIG welding. All above have man-machine interface processor-based to set functions and parameters through keyboards and display by LCD, which focus on the way of function keyboards. Article^[4] introduced a man-machine interface based on PC (Personal Computer). The research in China, unfortunately, on welding power sources based on microprocessors is limited to control systems, with few researches and reports about digitalization of man-machine interaction system in welding machines^[3].

1 Selection of man-machine interacting ways

Suitable ways for man-machine interacting in working site of process control are menu or asking-answering conversation or function keyboards. Asking-answering conversation is low efficient, less flexible, low speed, inconvenient to modify and expand. Function keyboards are so arbitrary with less standardization as to cause trouble in memorization and operation. Menu is the most extensive and earlier-used man-machine interacting way by which

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the operator can choose one from a series of items, and every possible item can be displayed on the screen with the form of menu. Operators can learn and use the menu interaction quickly. Meanwhile, in menu interface, the operator selects menu items with fewer inputs, which is difficult to make mistakes.

A friendly menu-typed man-machine interaction system was implemented in this research through the communication between two processors: one controls the display of liquid crystal, another controls the operation of keyboards and working site. During welding, the operator can be under the guide of the system and finish the process of man-machine interaction.

2 Design idea of man-machine interaction system about TIG welding

Menu-typed man-machine interaction systems in respect of welding machines can be used to accomplish a series of functions. For example, setting welding parameters, choosing welding process, modifying and displaying parameters dynamically, indicating welding moments during welding, and etc. Meanwhile, it is important to use fewer possible keyboards to fulfill required functions in order to reduce hardware.

Four keyboards, "MENU", "CONFIRM", "UP", "DOWN", were used in the research, and the display content was distributed to six interfaces: friendly interface, menu interface, parameter pre-set interface, parameter-modifying interface, welding waiting interface, and welding site interface. Man-machine interacting process with the four keyboards and the six interfaces is showed in Fig. 1.

As long as the welding machine on, a friendly interface is displayed, meanwhile the system monitors user's keyboard operation. When "MENU" is detected by DSP, the system enters menu interface. There are three options in it: Pre-set, Weld, and Exit. User moves the cursor and chooses items by "UP" and "DOWN". When "CONFIRM" is detected on Pre-set item, system enters parameter pre-set interface, it is in this interface that the operator does preliminary work by the system. When "CONFIRM" is detected on Weld item, system enters welding waiting interface. When "CONFIRM" is detected on Exit item,

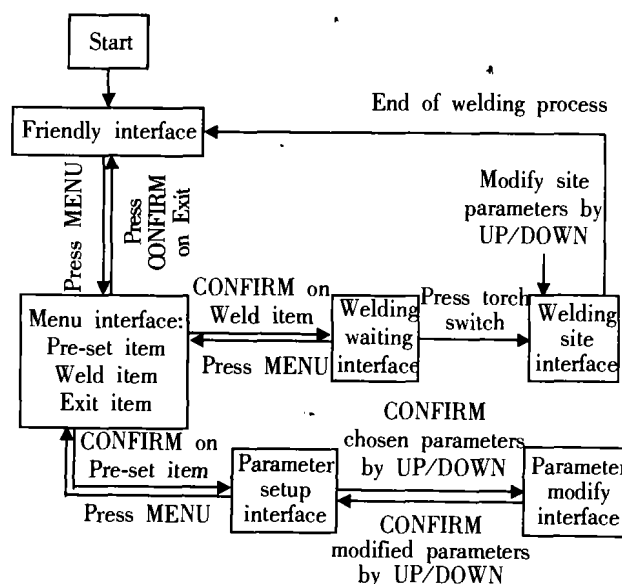


Fig. 1 Man-machine interaction process by keyboard operation and liquid crystal display

the system will be back to friendly interface.

The number of pages regarding parameter pre-set interface is corresponded to the number of parameters required by welding process. So eight parameters are needed for TIG welding process: Pre-Gas time, Post-Gas time, ascending time of welding current, descending time of welding current, igniting current, welding current, initial current, ending current. The operator can choose parameter pages by "UP" and "DOWN". When "CONFIRM" is detected on some parameter page, system enters parameter-modifying interface, the operator can modify the value of the chosen parameter by "UP" and "DOWN" until a required keyboard value is set, then the system goes back to parameter pre-set interface by "CONFIRM". The operator can use this way to modify values of other parameters until every single parameter is set, then system can be back to menu interface by "MENU".

When the welding torch on detected in welding waiting interface, DSP controls the system to enter welding site interface in which DSP monitors, samples and controls. The man-machine interaction system displays dynamically every moment of welding process and main relevant parameters, meanwhile, the operator can modify the welding current value of working site by "UP", "DOWN". The system will be back to the friendly interface automatically at the end of welding process.

3 Working principle of man-machine interaction system in TIG welding machine

3.1 Hardware principle of man-machine interaction system in TIG welding machine

Multi-processor system is one of the best ways for the real-time concurrency operation of multi tasks^[5-7]. TMS320F240 digital signal processor was used in our research as the main purpose of TIG welding control, and AT89C2051 single-chip processor was dedicated to real time display of welding field by communicating with TMS320F240. A display block of liquid crystal based on character, MDLS16465, was used to meet the need of dynamical display.

During the process of man-machine interacting, TMS320F240 scans the keyboards in real time. The keyboard scanned can be judged by the keyboard value. After process judgment, corresponding message is sent to AT89C2051 to display, which will be dynamical display about welding site. During welding, TMS320F240 samples parameters from the working site in real time through A/D, and sends data disposed to AT89C2051 to display dynamically. The working principle of the man-machine interaction system centered by TMS320F240 is showed in Fig. 2.

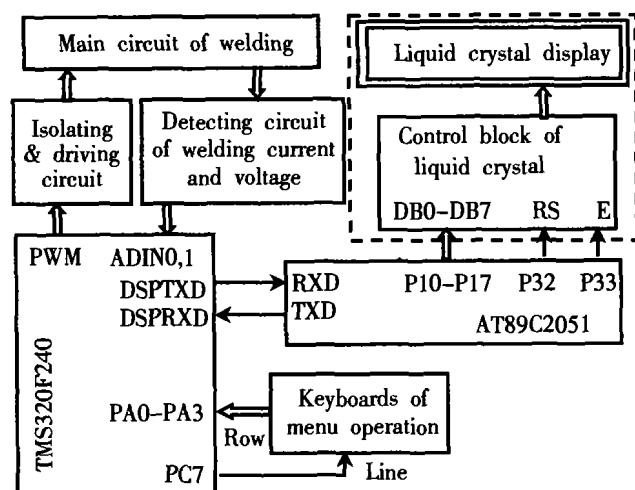


Fig. 2 Block diagram of operating principle of TIG welding control system centered by TMS320F240 controller

The communication between TMS320F240 and AT89C2051 is asynchronous based on software protocol. TMS320F240 transmits flags and data to AT89C2051 and receives data from AT89C2051 by serial communication based on signals DSPTXD and DSPEXD.

The four keys are arrayed in a line, so a line wire (PC7) and four row wires (PA0 - PA3) are required. TMS320F240 samples welding voltage and current through ADIN0 and ADIN1. PWM (Pulse Width Modulation) control signals are provided through PWM interface on-chip.

As a data port, the P1 of AT89C2051 sends control bytes and display codes to MDLS16465, AT89C2051 receives flags and data transmitted by TMS320F240, judges according to flags, displays correlated information according to data.

3.2 Programming principle of man-machine interaction system in TIG welding machine

A DSP main-controlled process of man-machine interaction system are involved six moments that are distributed to the system work based on the six display interfaces discussed above: friendly display moment, menu selecting moment, parameter selecting moment, parameter modifying moment, welding waiting moment, and welding operation moment, which can be represented as moment 1, 2, 3, 4, 5, 6 easy to discuss. The friendly interface is displayed while the machine is switched on, which is determined by different machines and different requirements.

The main task of DSP is to scan keyboards continually, dispose keyboard value, and switch operation moment if necessary. Moment 2 can be entered when "MENU" pressed. The operation meanings of "UP", "DOWN", and "CONFIRM" are different in moment 2, 3, 4, 5, and 6, therefore, when one of this three keyboards detected, DSP is supposed to judge which moment of the system is in. The operation meanings of keyboards in different moments are showed in Table 1.

Table 1 The meanings of keyboards in different moments

	Moment 2	Moment 3	Moment 4	Moment 5	Moment 6
MENU	Holding	To 2	To 2	To 2	To 2
UP	Select menu	Select parameter	Parameter plus 1	Holding	Current plus 1
DOWN	Select menu	Select parameter	Parameter minus 1	Holding	Current minus 1
CONFIRM	Pre-set: to 3 Weld: to 5	To 4	To 3	Holding	Holding

4 Experimental results

Some experimental results of the man-machine interaction based on keyboard input and MDL16465 display through the control of two processors, TMS320F240 and AT89C2051, is showed in Fig. 3. Fig. 3a is a friendly interface, the content of display can be changed according to practical situation and user's requirement. Fig. 3b is menu selection interface and the cursor is on Pre-set item. Fig. 3c and Fig. 3d are Pre-Gas time page and welding current page in parameter-modifying interface. Fig. 3e is welding waiting interface. In this moment, when the system has detected the welding torch on credibly, it will enter the welding process and interact between man and machine during welding process; otherwise, when the system detects the welding torch is off, but the "MENU" is available, then the system will be back to the friendly interface. Fig. 3f is a dynamical image when welding is ascending in welding site interface. The first line of the image indicates that is the moment of welding current

ascending, the second line shows one minute left for the ascending moment, the third line displays welding current and welding voltage dynamically.

5 Conclusions

Some conclusions, based on a lot researches and experiments, have been gained as follows.

(1) The experiments have showed that the menu-typed man-machine interaction system in our research implements perfectly the design idea to display information as much as possible from the working site including operating process, welding process, site message, and others such as warning and prompting if necessary when practical situation considered.

(2) Our experiments indicate that there are two points about the reliability of the man-machine interaction based on two processors of TMS320F240 and AT89C2051. One is the reliable communication between TMS320F240 and AT89C2051, another is the speed match among the manual operation of keyboards, the display of CLD and instruction executing of TMS320F240 and AT89C2051.

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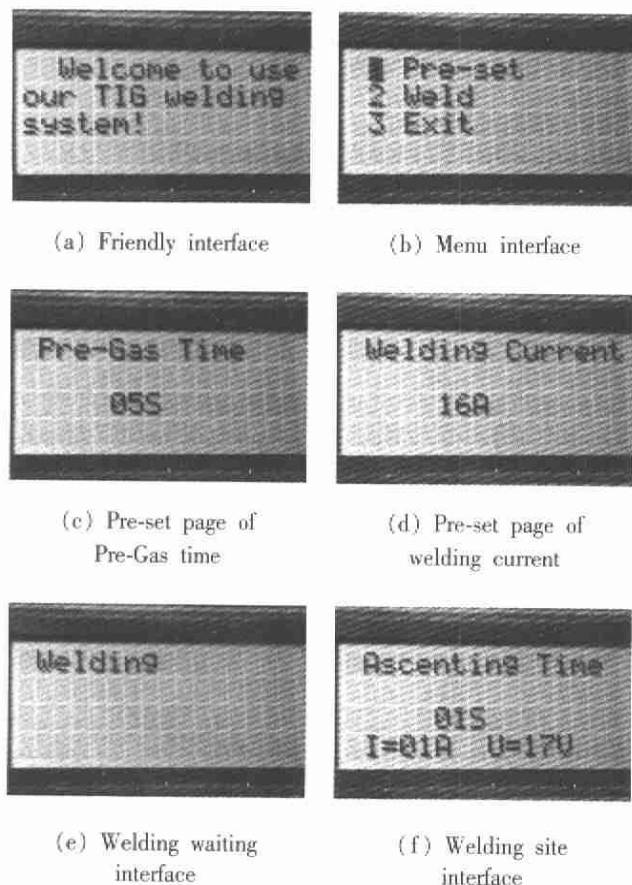


Fig. 3 Main display interface of man-machine interaction about TIG welding