Development of "S-MAC" for 100-Axis Car-Body Welding Jigs Supporting DeviceNet

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1. Introduction

The Control System Division has presented a number of solutions with "S-MAC" system. Of these solutions, most of those related to motion control are the solutions using the motion control language "AML" and SERCOS devices.

This article will discuss a solution different from most of the preceding solutions, a positioning controller for the super-multi-axis welding jigs that uses the DeviceNet device based on the "SMS-30" platform of the S-MAC PC series of the Sanyo Denki's industrial PC.

2. Background to Development

Welding jigs with a positioning pin are used to secure the positions of automotive parts to be welded. Traditionally, welding jigs provided for each different model or each different set of specifications needed to be exchanged each time models or specifications changed, requiring a longer time for the tools to be exchanged. It is under such a circumstance that the need is arising for a production plan that categorizes welding processes by the model and specifications in order to increase production efficiency. Since such conventional jigs are provided exclusively for each different set of specifications, as many of them would be needed as are the sets of specifications, requiring quite a large space to store them, which is not so easy to secure.

There arose a demand for a jig that would solve the problems associated with those exclusive tools, in other words, a tool that gives you a higher degree of freedom, while requiring only a small installation area. This perception has led Nissan Shatai to seek ways to build a super-multi-axis welding jig fitted out with a mobile positioning pin while Sanyo Denki has proceeded with developing its motion control portion. Fig. 1 is a conceptual sketch of the welding jig with parts attached to it, and Fig. 2 is the appearance of the super-multi-axis welding jig.

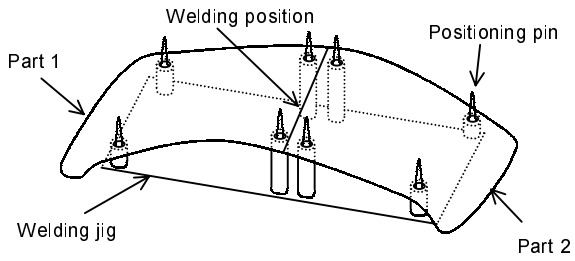

Fig. 1 Conceptual Sketch of the Welding Jig with Parts Attached

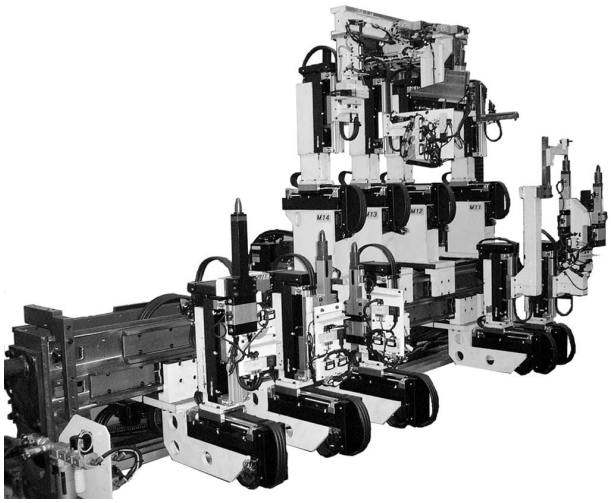

Fig. 2 Appearance of Super-Multi-Axis Welding Jig

3. Specifications

Table 1 lists the system specifications of the motion control for the welding jig, Table 2 lists the specifications of the industrial PC "SMS-30", and Table 3 lists those of the controller.

Table 1 System Specifications

Item	Description
S-MAC PC	SMS30DC3S200
DeviceNet I/F	5136-DNP-ISA (SST)
PLC	C200PC-ISA03DRM (Omron) C200PC-EXP (Omron)
Servo amp	"PB" Series 4-Axis Control Amp (Condensation-free type) PB1D002C1U0
Servo motor	PBM565DXC22 (without brake) PBM565DCC21 (with brake)
Number of axis to control	Up to 100 axes (4-axis amp × 25)
OS	Windows NT Embedded 4.0 class 2

Table 2 "SMS-30" Specifications

Item	Description
CPU	K6-2E 233MHz (AMD)
Memory	64MB
Storage device	Compact flash card (Type Ⅰ) Drive C: 96MB Drive D: 48MB
LAN	100BASE-TX, 10BASE-T
Expansion slot	ISA slot × 3 (PLC, with DeviceNet I/F) PCI slot × 1
Fan for CPU	None (cooled by radiation fins)
Power supply	+5VDC ±5%

Table 3 Controller Specifications

Item	Description
Operation	Operated from PLC via PLC's shared memory
Response	Returns response to PLC's shared memory
Run mode	Cycle run, Step run, JOG run Home position return run
Number of programs	Up to 64
Number of steps	Up to 250 steps/program
Interlock I/O	Input: 16/amp, Output: 16/amp
Start delay time	Up to 300msec
Simplified ABS capability	Capable of restoring position at start-up
Against power outage	No faulty operation when power fails unexpectedly

To control as many as 100 axes with DeviceNet, we have come up with an amplifier capable of controlling 4 axes. Fig. 3 shows the amp, "PB" 4-axis amplifier. This amplifier allows us to get around the restriction of the DeviceNet protocol that limits the number of nodes (stations) per network to 64, thus making it possible for one network to control 100 axes. The reduced size of the 4-axis control amp, combined with the condensation-proof finish, allows the amplifier to be installed inside the welding jig, reducing the overall system size. In comparison with traditional systems using serial communications, this product is successful in offering some advantages brought by incorporating field networks.

Fig. 3 "PB" 4-Axis Amplifier (right: tennis ball)

4. Overview of Control System

Following is the outline of the control system for the super-multi-axis welding jig.

4.1 System Configuration of the Control

Fig. 4 is the system configuration of the control.

Motion control is provided by "SMS-30" via DeviceNet interface while the sequence of overall process, reading of data from various sensors installed on HMI (Human Machine Interface), and welding jig, and operation of the valves are controlled by I/O control PLC. PLC is physically built into the PC frame in the hardware configuration but it is placed on top in the hierarchy of configuration of the control.

The servo amp, installed inside the welding jig, reduces the total length of wiring because of DeviceNet interface, resulting in a substantial reduction of the control panel size.

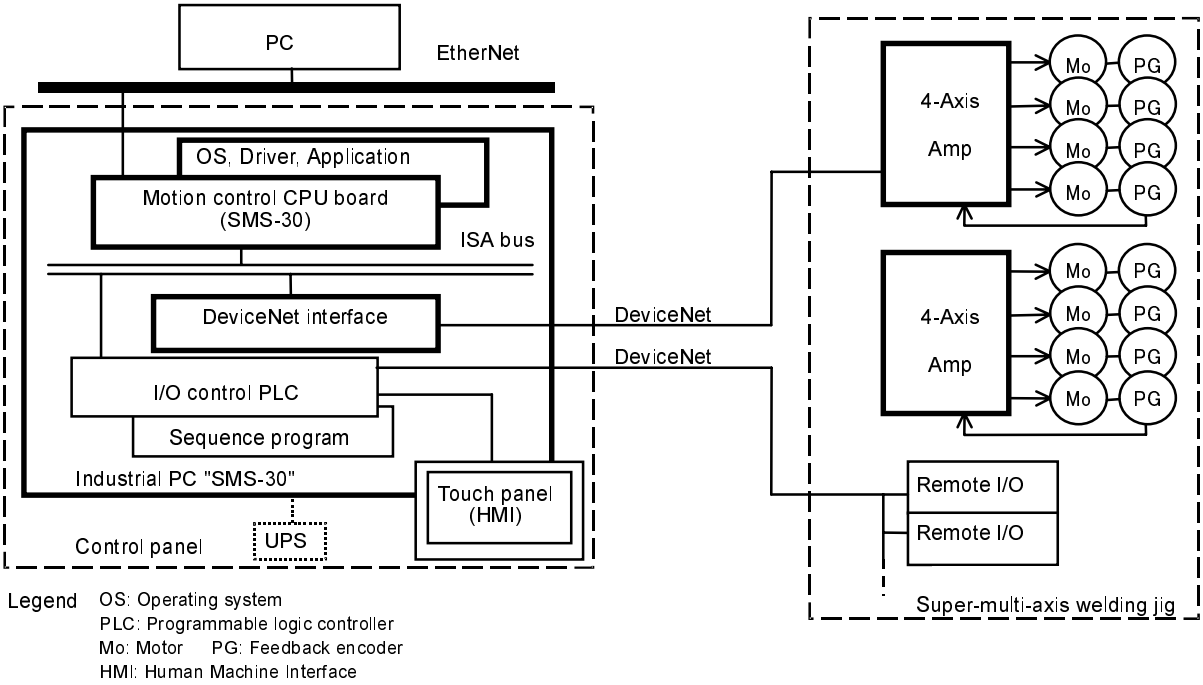

Fig. 4 Control Circuit Block Diagram

4.2 Software Configuration

Fig. 5 is the software configuration.

Windows NT 4.0 Embedded is used to run this system, reducing the software size, so that it can operate with compact flash. The Windows NT Embedded proprietary write filter is also used to prevent physical writing to the system drive, thus protecting the file system against accidents caused by power failures.

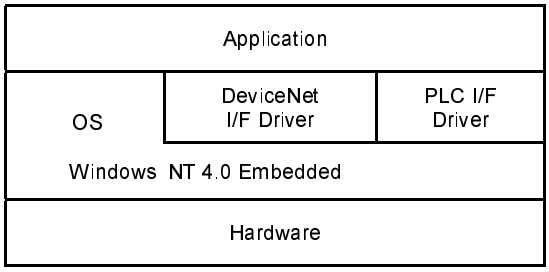

Fig. 5 Software Configuration

4.3 Main Capabilities

The application provides the following capabilities.

4.3.1 Motion Control Capability

The motion control is performed in the way specified by the PLC command. The examples of the run mode are the followings: Cycle-Run-Mode, which is one of the programmed auto-run mode; Step-Run-Mode, which is used for debugging the program; Jog-mode; Home-Position-Return-Mode; and Parameter-Change-Mode.

Up to 64 programs can be saved, each containing up to 250 steps. Programs can be loaded via Ethernet.

The time delay caused when all the axes are activated at once is held to 300msec or less, thus preventing axes from interfering with one another for the super-multi-axis-welding jig.

4.3.2 PLC Communication Capability

PLC communication is provided such that the contents of the PLC data memory to be written through a HMI are passed to the motion control. This capability can be separated and changed to allow connection with another PLC or software.

4.3.3 Error Logging Capability

Errors, warning, and information that arise while the application is running will be displayed and logged onto the file. The system administrator will be notified of errors occurred in the system by e-mail. He can also view the error information from a remote location.

4.3.4 UPS Monitoring Capability

The contact point signal from UPS (Uninterrupted Power Supply) is used to prevent the system from shutting down when power fails.

5. Conclusion

We have succeeded in satisfying customer demand for a higher degree of freedom, which is the prime purpose of this development, without having to extend the tact time. A significant improvement has been made in the jig. Although the new product requires a footprint 150% larger than traditional ones, it can be used for all car models, requiring no additional jigs.

The new product comes with a PLC as demanded by customers so ladder programs can be executed, reflecting our consideration for those end users who are used to using PLC as well as the method we have come up with to facilitate the introduction of the newly developed super-multi-axis welding jig. We believe it is a success that we installed the PLC.

But costwise, it might have been better to have the sequence control taken care of by the application. It is out of this consideration that we have implemented the application such that the communication with PLCs is separate to make future change easier.

Although this article has only described the controller, you should be reminded that this solution would have been impossible had it not for the PB Series 4-axis all-in-one type amplifiers and the motors, which have been developed jointly with the Servo System Division.

Finally, we express our gratitude to Nissan Shatai and others for their cooperation in this development.

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