ON THE DEVELOPMENT OF A MICROCOMPUTER CONTROLLED MANIPULATOR FOR ARC WELDING IN A SEMI STRUCTURED ENVIRONMENT

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ABSTRACT

A microcomputer controlled manipulator has been developed for the purpose of welding in a two dimensional workspace. This paper discusses the development of the three axis system and describes the control and hardware necessary to achieve the objectives of controlling the welding operation. The programming technique and the program structure for the development of the manipulator is also discussed. The robot performed satisfactory welds of consistent quality. Clearly the tedious and unpleasant task of repetitious welding was better accomplished by the gantry robot. Other benefits that resulted were labour savings, increased throughput, and rapid adaptation to production changes. A second generation robot is being developed and will be located within the flexible manufacturing cell at the Automatic Manufacturing Laboratory (AMT) at the ML Sultan Technikon. This will be using ultrasonic sensors for seam tracking and artificial intelligence for precise control required for robot arc welding. This work is currently in progress.

INTRODUCTION

Robots can be classified according to their application, their configuration or their load capacity. The classification according to application, a few to mention are :

(i) Materials handling robots
(ii) Assembly robots
(iii) Welding robots
(iv) Paint spraying robots.

However, the various types can be distinguished more clearly by classifying them according to their operating principle namely:

(i) Cartesian coordinate
(ii) Cylindrical coordinate
(iii) Polar coordinate
(iv) Articulated arm coordinate
(v) Gantry
(vi) SCARA.

In 1992, literatures were available on spot welding robots and hardly were any on arc welding robots. A project was carried out to design and construct an arc welding robot manipulator to weld water tanks. The operating structure chosen for this project was the gantry. Three degrees of freedom were achieved to weld in two dimensions and the third degree of freedom was used to compensate for the decreasing length of the continuously used welding electrode, which was fed manually.

The Intel 8085 microprocessor was employed to control the two stepper motors and an ac motor located on the manipulator to enhance its flexibility. The microprocessor provided the built in intelligence that the system demanded in order to respond with the maximum speed and efficiency to the diverse and changing demands required by the system.

Robotic manipulators have been used in welding cells for long time in order to improve welding quality. Substitution of mancraft in welding cells where a robot welds only few different parts every time in the same pattern, such as spot welding commonly used in the automobile industry, is not a very difficult task. But in a flexible, just in time, and CAD customized production approach, different parts are to be welded demanding an "*intelligent*" robot-welding concept

MANIPULATOR

The robot arm shown in Fig. 1 is design to weld in two dimensions, X and Y directions. The controller and the power supply to the manipulator is shown in Fig.2. The block diagram of whole system is shown in Fig. 3.

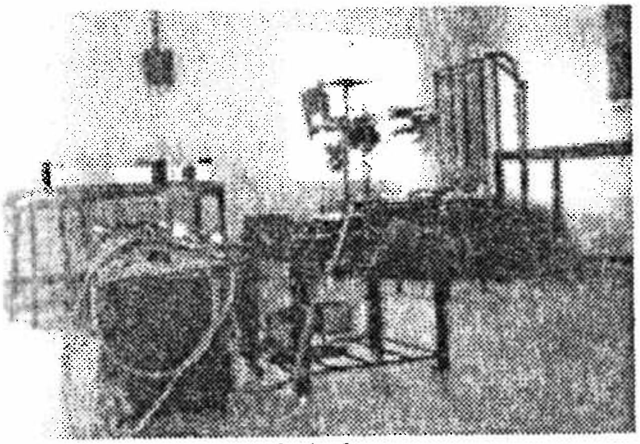

Fig. 1 Manipulator

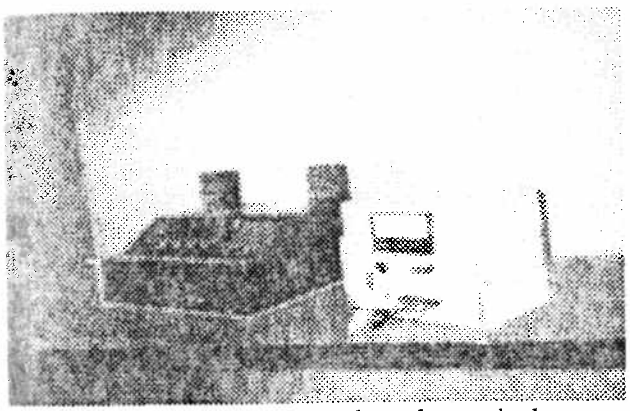

Fig.2 Controller and power supply to the manipulator

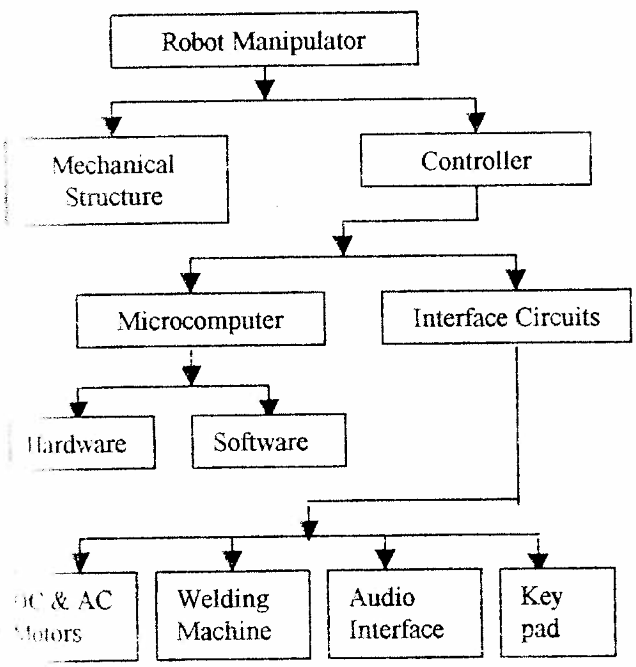

Fig. 3 Block diagram of the manipulator system

The controller constitutes the microcomputer system and the interface circuits. The interface circuits are for the welding machine, motors and the audio player to the microprocessor. The audio output aids the user in setting up instructions and the successful use of the robot arm without any human assistance.

The robot arm has three degrees of freedom that is in X, Y and Z directions. Welding is performed in X and Y directions. The movement of the end-effector in Z-direction is essential to maintain a minimum distance between the burning electrode and the workpiece in order to keep the arc flaming.

The working envelope of a robot is defined by the points that can be reached by the maximum and minimum movements of each axis or of a combination of axes. The envelope or volume generated that is quoted according to the manufacturer's literature is normally that taken from the mounting flange at the end of the arm. The working envelope of the robot arm developed is 30 cm by 20 cm at most, depending on the welding process parameters - welding current, arc voltage, travel speed and electrode length. The working envelope is shown in Fig. 4.

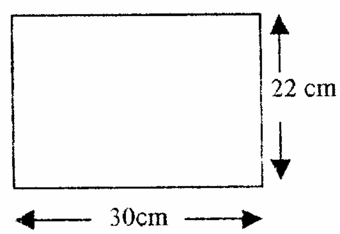

Fig. 4 Working envelope

Three high torque motors are employed for the movements in the three directions. The drive mechanism consists of leadsrews, gears and belts. The leadscrew provides a means of obtaining large mechanical advantage. The ISO trapezoidal form of threads was constructed with pitch of 2.5 mm and mean radius of 7.875 mm. Details into the design of the drive mechanism are given in [1].

CONTROLLER

The controller consists of microcomputer and the interface circuits. The microcomputer used in this project is SDK-85 consisting of Intel 8085 microprocessor. The Intel 8085 is one of the versatile eight-bit microprocessor. The salient features of the SDK-85 design kit are:

- High performance, 3 MHz 8085A CPU (1.3μs instruction cycle).
- popular 8080A instruction set.
- Direct teletypewriter interface.
- Large wire-wrap area for custom designed circuit.
- System monitor software in ROM.

The SDK-85 has bidirectional serial and parallel communication facilities. There are interrupt capabilities available and all bus signals are TTL compatible.

Two stepper motors and ac motor were used for the arm movements. The stepper motor driving sequence was generated by the microprocessor and high power transistors were employed in the driver circuitry. The use of stepper was made for precise start and stop positions. The frequency at which the pulses are applied to the stepper determines its speed. The ac motor turn on and turn off was also controlled by the microprocessor using a transistor as a switch. The inputs to system were entered through a keypad interface. The inputs are made to instruct the manipulator on the dimension of the working envelope required for a particular welding job.

Tactile sensors were employed for safety reasons. Microswitches were used to stop the ac motor the moment the electrode was burned out and also in the case where the microprocessor control failed. The microswitch sends a closed-switch signal to the controller indicating that the path is present. At this stage non-contact sensors were not employed. The audio interface consists of a recorded set of instructions that is played on the request for help on the operation of the manipulator.

The manipulator's end effector is the electrode holder of a welding plant constructed in Department of Electrical Engineering, Abubakar Tafawa Balewa University, Nigeria. The welding plant has capabilities of providing a maximum current of 130 Amperes.

SOFTWARE

The flowchart for the robot arm is shown in Fig. 5. Assembly language programs for the flowcharts were written using the 8085 microprocessor instruction set. The manipulator was designed to use electrodes of fixed length and therefore a new electrode has to be replaced for every welding operation undertaken and when this is done, it is indicated to microprocessor through a push button. An emergency interrupt is provided for safety reasons. This interrupt will halt all the activities of manipulator till it is manually clearly by the supervisor.

TEST RESULTS

The manipulator was tested for welding in all the three directions of various lengths. The gantry robot welder did perform pretty well and quiet fast in comparison to a human welder. The perfection of weld highly depended on the welding current selection based on the workpiece.

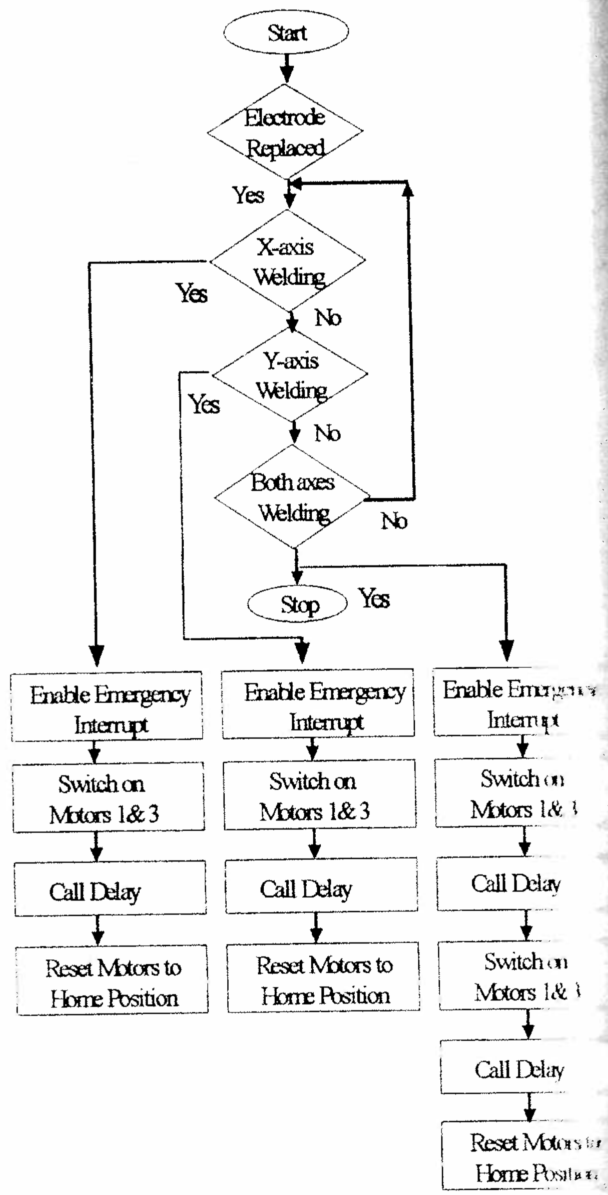

Fig. 5 System program flowchart

SECOND GENERATION MANIPULATOR

A second generation manipulator using real time vision system coupled with a neural network controller is being designed. The feasibility of incorporating ultrasonic sensors has being investigated in Ref. [2].

The vision system will be used for guiding the welding torch as well as for seam inspection. This vision system is to be mounted onto the moving gantry in close proximity to the welding head and will be continually repositioned by means of a stepper motor. The system will comprise a strategic lighting system, two standard CCD cameras [600 *800 pixels], a frame grabber and a digital signal processor.

It is envisaged that the digital signal processing will be carried out in the Hypersignal software in real time running on a PC32 card. A very large number of parameters of the welding seam will be proposed to the classifier probably a neural network for both manipulator guidance and weld inspection.

Ref. [3] propose a novel tracking control system based on two gain layer schemes. In this model, the neural network controller block in the Venugapal-Sudhaka-Pandya model is replaced by the fuzzy neural controller MANFIS [4].

The learning process of the fuzzy neural controller is accomplished as follows:

a) The initial controller parameters will be determined offline i.e. using the users knowledge of the system and then with a PD controller
b) The controller will then be incorporated into the control loop to be trained real time, while controlling the manipulator.

CONCLUSIONS

Real time tracking of robotic arc welding has been an active research area for some time. The proposed design will go a long way in improving the quality and production of welded products and, removes the hazardous working conditions associated with arc welding.

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