Development of a Fully-Mechanized Welding Robot System on Construction Site

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ABSTRACT

This paper introduces a new welding robot system used in the construction site. This system is able to perform welding all around the columns by using laser sensors. The shape of the groove is determined by laser sensors and welding conditions are determined for horizontal welding position.

The considered application is a horizontal position multi-layer welding of box column to column joint with single bevel groove. The entire system consists of a laser sensor, the robot, a slag removing apparatus, a nozzle cleaning apparatus and a carriage that is loaded with all the mentioned equipment.

1. INTRODUCTION

At present, although different companies have developed various kind of welding robots, they are limited to partially automated applications. The slag removing, nozzle cleaning and wire cutting task are still performed manually. Moreover, the installation of these robots to the columns and the recognition technique of the groove causes problems and effect the accuracy.

In this study, we have developed a robot system to overcome aforementioned manual operations and to improve the accuracy of recognition technique. The slag removing, the nozzle cleaning and the wire cutting tasks have been automated. The installation task has been improved.

2. OUTLINE OF ROBOT SYSTEM

2-1. ROBOT SYSTEM

Fig. 1 and Fig. 2 show the developed robot system. The column to column joint is prepared to be buttwelded by robot. Single bevel groove is considered as edge preparation. The setup, Fig. 2, shows the location and the installation of welding robot, laser sensor, slag remover, nozzle cleaner and the carriage.

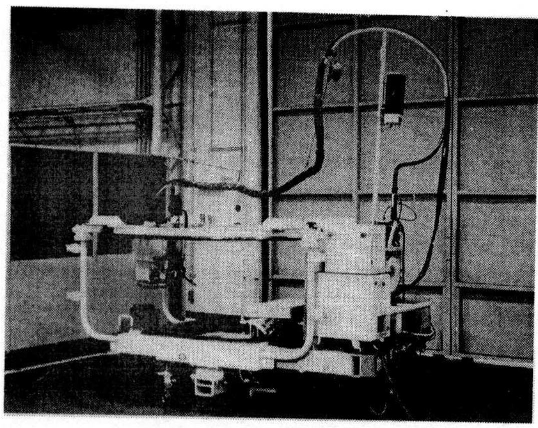

Fig.1 Appearance of Robot System

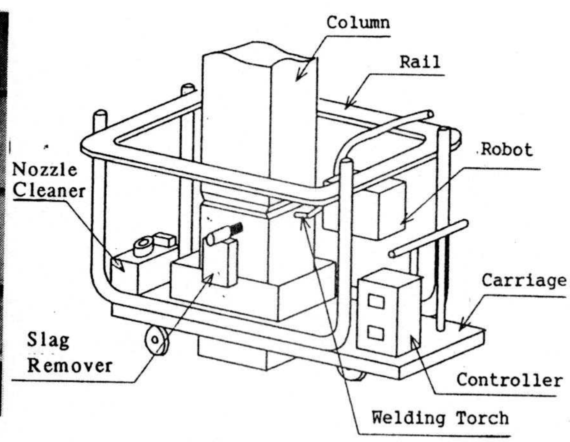

Fig.2 Robot System

2-2. ROBOT CONTROLLER

The robot has total 5 axes 3 of which are directional axes and the remain 2 are rotational axes (Fig.3). The controller has weld sequence setting function, welding condition auto-setting function, wire touch sensing function, weaving control function and arc sensing function for exclusively for arc welding applications.

This particular controller selects the appropriate welding condition and it determines the motion path of the torch according to the information of groove shape gathered by laser sensor (Fig 4).

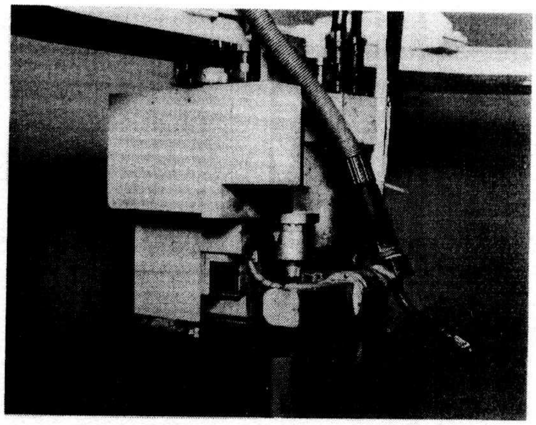

Fig.3 Appearance of Robot

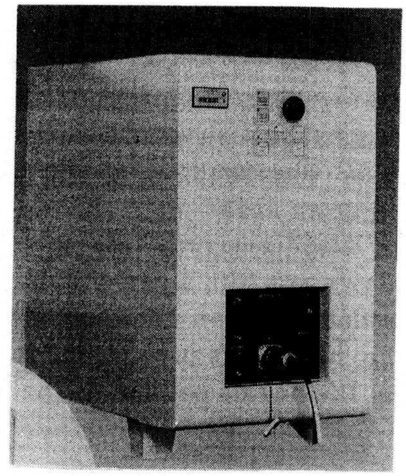

Fig.4 Appearance of Controller

2-3. LASER SENSOR

The recognition of the groove shape is performed by using a three dimensional laser sensor system. This system is a non-touch sensing method and it determines the shape and position of groove.

The radiated laser slit light is detected by a CCD camera. This detected slit light is used to measure the shape of the groove as shown in Fig. 5. The calculated date about the shape of groove is entered into the robot controller in order to determine the motion start point for robot welding.

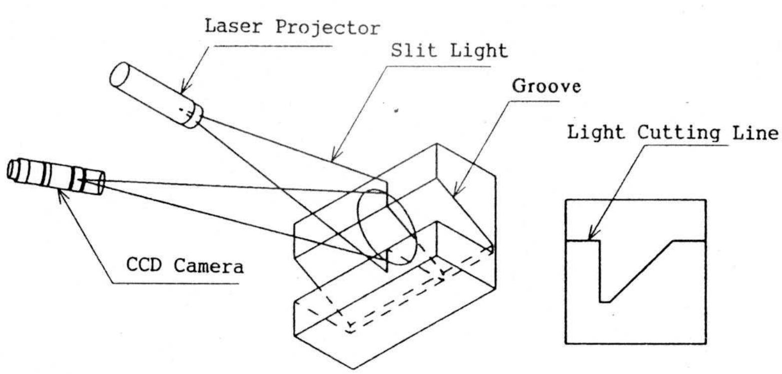

Fig.5 Laser System

2-4. AUTOMATION OF SLAG REMOVING, NOZZLE CLEANING AND WIRE CUTTING TASKS

After welding is performed, the slag remover runs on the carriage and cleans the slag by beating with a multi-needle chisel. The beating is performed by air pressure. The multi-needle chisel travels on a rail around the column with up-and-down axes.

The slag removing task is performed by controlling the rail travel and up-and-down axis with a servo motor guided by robot controller. The correction in the vertical direction of groove is ensured by motion of up-and-down axis (Fig. 6).

The nozzle cleaner performs the cleaning of the outside and inside of the nozzle, the nozzle coating of spatter preventing liquid and the wire cutting (Fig.7).

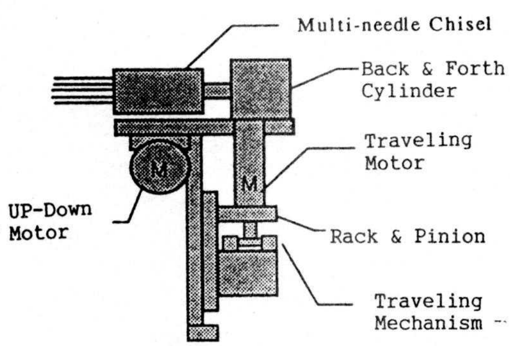

Fig.6 Slag Remover

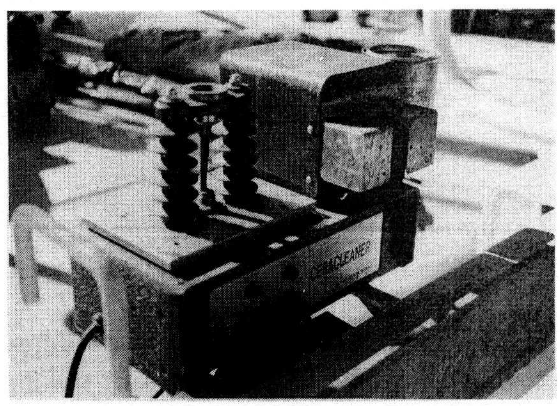

Fig.7 Nozzle Cleaner

3. OPERATION SEQUENCE

Considering operation, at first, a manual welding of initial layer and cutting of the erection piece are performed by workers. Second, the carriage is installed to the column manually. Following this steps, the robot starts to work without supervision. The sensing, the automatic welding, the nozzle cleaning and slag removing are performed at each layer full-automatically (Fig. 8).

The automatic welding and the nozzle cleaning by robot are carried out for each pass.The sensing and slag removing are performed full-automatically from the beginning layer to the final finish layer. The operator only enters the required work condition from the menu window by selecting the appropriate items. It is a no-teaching procedure. The robot controller selects the welding condition based on groove width from the welding data base. According to the data calculated from recognition step, the controller moves the torch to the aimed point and starts to weld. After the robot finishes the entire work, the workers disassemble the carriage from the column.

Consequently, the manual operation by workers is only required for manual welding of initial layer, cutting of erection piece, installing and removing of carriage. The rest of the task is being performed automatically with out supervision.

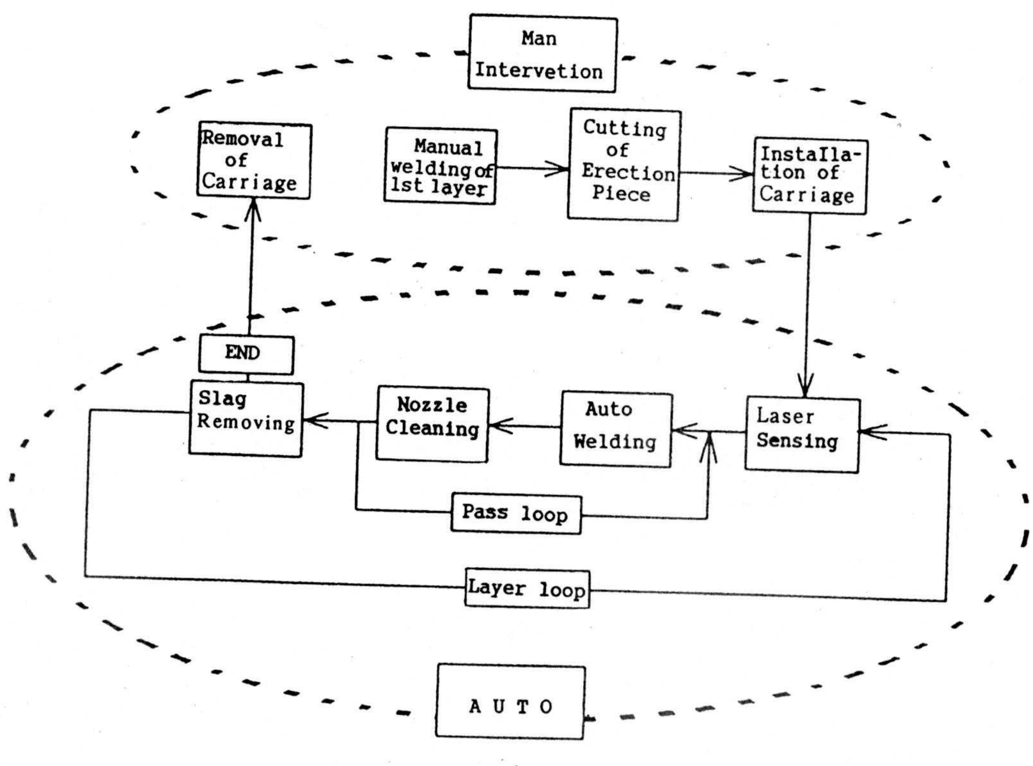

Fig.8 System Flow Chart

4.WELDING TASK

4-1. GROOVE DESIGN AND WELDING PARAMETERS

The considered column are box columns with 490x490 to 800x800 box sections and with 22 to 80mm thickness. The groove shape is single bevel with 35° groove angle and 7±1mm root gap. Moreover, the groove height is 850 mm from floor and the joint type is butt joint.

4-2. NON-DESTRUCTIVE INSPECTION AND MECHANICAL PERFORMANCE TEST

The ultrasonic test was executed on the performed weld joints. The required standard was reached and the harmful defects were not seen. In order to evaluate mechanical properties, tensile test Charpy impact test was applied to deposited metal and the butt weld joint. The results of mechanical test were satisfactory.

Fig. 9 shows the macro picture of weld section of 650x650 column with 45mm thickness, 35° groove angle and 7$\pm$1mm root gap. As it is seen in Fig. 9, a uniform penetration and a satisfactory result are reached.

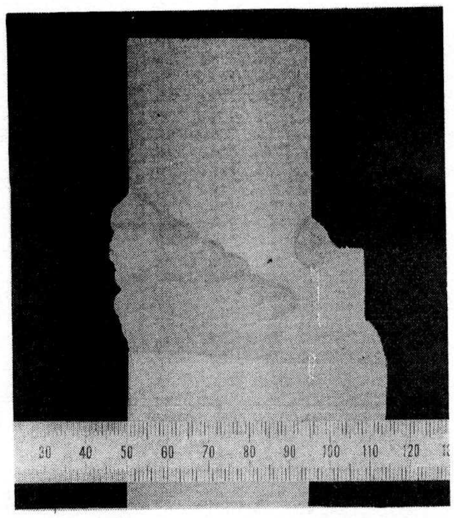

Fig.9 Sectional Macro

5.CONCLUSION

In November 1995, this developed system was applied in the field. Starting from now, we will find out the problems and the points that should be improved both in welding task and robot system. Based on the experience of field work, extensive efforts will be made to develop a robot system in order to automate the entire welding task without need of supervision and to satisfy the requirements of users completely.

REFERENCE

(1) Hiroyuki Matsumura et al.," Development of Automatic Welding for Horizontal Column joint ", Weld Society Meeting, No.152,1995 .