PRACTICAL APPLICATION OF ARC WELDING ROBOT AND JOINT DESIGN FOR ROBOT WELDING OF STEEL STRUCTURES

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ABSTRACT: This paper introduces the present status of application of arc welding robots, construction, engineering subjects, design requirement, example of desing modification for welding by arc welding robot. As a conclusion closer co-operation of robot engineer, welding engineer and structural designer is emphasised.
This is the summary of the work done by Working Group for IIW Commission XV, chaired by the author.

1. PRESENT STATUS OF APPLICATION OF ARC WELDING ROBOT

In Japan, industrial robots were first adopted to a production line at the end of 1960's. During 1870's, the spread were rather slaw. Thus at the end of 1970's only about 10 manufacturers brought them into their production lines. However, the trend swung upward dramatically in 1980's; a number of manufacturers began to apply them. Their use was wide spread to welding, transfer and handling, assembly, painting and inspection. The number of working robots are bigger in the order. Especially in the field of welding, the use of spot welding robots by the automobile industry played a substantial role in the eider use of industrial robots. Arc welding robots has been increasing also in 1980's. The explosive prevalence of arc welding robots is due to developments in mechatronics because arc welding robots require more complicated movements with higher accuracy than spot welding robots do. The arc welding robot is basically used as a single unit. However there appeared large scales systems which consist of 10 to 50 sets of of robots in a production line.

At present, extensive FMS (Flexible Manufacturing System) and FA (Factory Automation) have been attaind in automobile and costruction machinery industry. And also industries such as shippbuilding and

steel works where the application of robots is relatively difficult at the beginning of 1980's, the application of robots welding is currently being progressed.
The arc welding robots has been mainly introduced to the manufacturing of the parts of the automobil, costruction machinery, metal products, electric machinery and others, as well as steel structures and steel bridges.

2. FUNDAMENTAL CONSTRUCTION OF ROBOTIC ARC WELDING SYSTEM AND WELDING ENGINEERING SUBJECTS

Robotic welding systemes range from a simple one to the fully automatized one where a whole line from loadinf-on to -off of work is also automatized. Furthermore, there is a system where the robots itself moves as it is welding such as in welding of large structure.
Fig.1 shows the framework of hardwares and softwares of a fabrication system where a comparatively large scale workpiece is automatically loaded in, clamped to jig and positioner, welded and loaded off. Fig.2 shows the framework of hardwares.
In actual operation of arc welding robot the interruption of a system is often caused by the misconducts of each component. Hence, further improvements of each component are needed for the sake of bebeficial use of the system.
The arc start missing is one of the important problems to be improved. In addition to this, the spattering problem is also important. Spattered products which adhere on nozzle and tip induce troubles such as bad gas shielding of weld metal and sparking between nozzle and work. The consumption of contact tip is influenced on the stability of wire feeding and deflection of aiming point of tip. In order to decrease the consumption, new concept tip configuration and the special tip with abrasive protector is appeared.

3. FUNDAMENTAL DESIGN REQUIRED FOR ROBOTIC WELDING

There are lot of part structures and welding joints which are far from being suitable for robotic welding judged from the strucure and function of welding robot. Thertefore, investigations on countermeasures are required in such a manner, what kinds of part structures and joint preparations are suitable for robotic welding in order to make more reliable and productive robotic welding.
Summary of major factors relating to appropriate design for robotic welding is as follows.

1) Acceptability to robotic welding
2) Interference between welding torch (robot's arm) and work piece
3) Suitable joint design for arc sensing
4) Suitable welding position for welding robot
5) Joint design which reduces complicated positioning

There is much room to improve welding design and process planning at the pre-welding stage. Countermeasure to be taken areas followa:

1) To increase suitable joints by changing design based on better understanding of robotic welding characteristics
2) To elevate productivity through design change
3) To reduce manual welding man-hours by minizing areas where only a welder can weld because of difficulty in robotic welding.
4) To improve weld quality and reduce repair welding by optimizing welding posiotion and welding condition

Industries which use a lot of robots and are successful in making productivity higher are paying great efforts to these points.

4. EXAMPLES OF DESIGN APPLOACH AND PROPOSAL OF JOINT DESIGN

Fig.3 and 4 show the limitations of distance between welding joints and column plates for robot arm entrance.

Table I is an example of propsal to the joint design of plate girders.

5. CONCLUDING REMARKS

In order to extend the application of welding robots to welding in the near future, the followings are required.

1) Improvement and better maching of each component of the arc welding robot system which consists of robot itself and supporting equipments, such as positioner jigs, transfer devives, welding machines and others.
2) Improvement of joint design which enables easier application of robotic welding and accumlation of softwares of welding operation.

Various modifications in structural design can be discussed from the following three points of view, these are bevel design (by robot engineer), joint design (by welding engineer) and structural design (by structural designers). It is important that robot engineer, welding engineer and structural designer have closer connections each other, they understand each other, and they exchange informations each other.

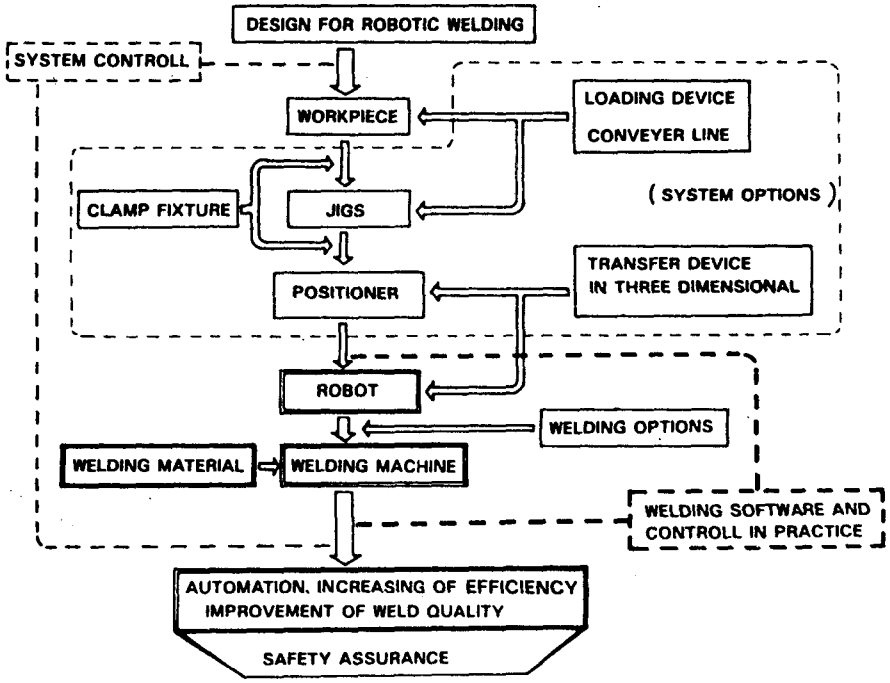


Fig. 1 Fundamental block diagram of arc welding robot system

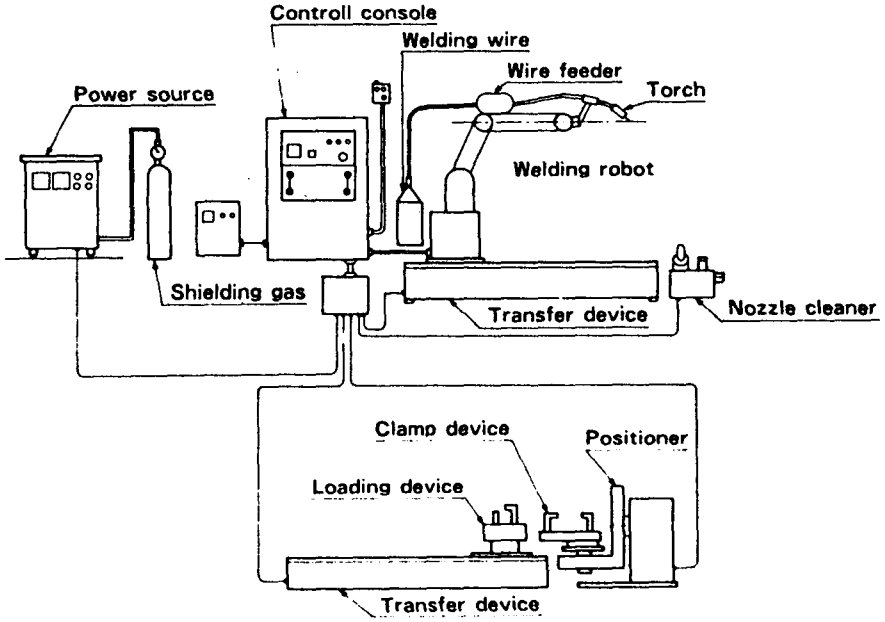


Fig. 2 Fundamental construction for arc welding system

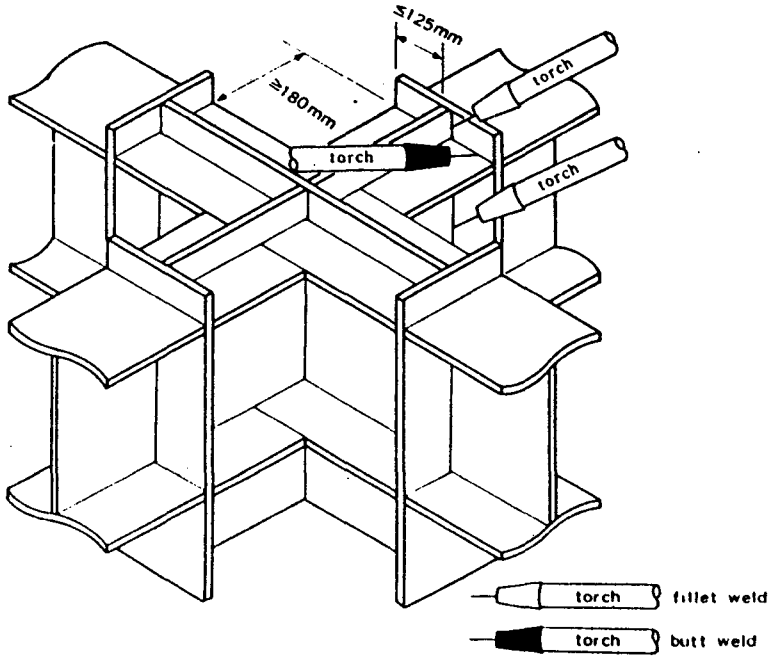


Fig. 3 Limitation of flange width and space of robot arm entrance

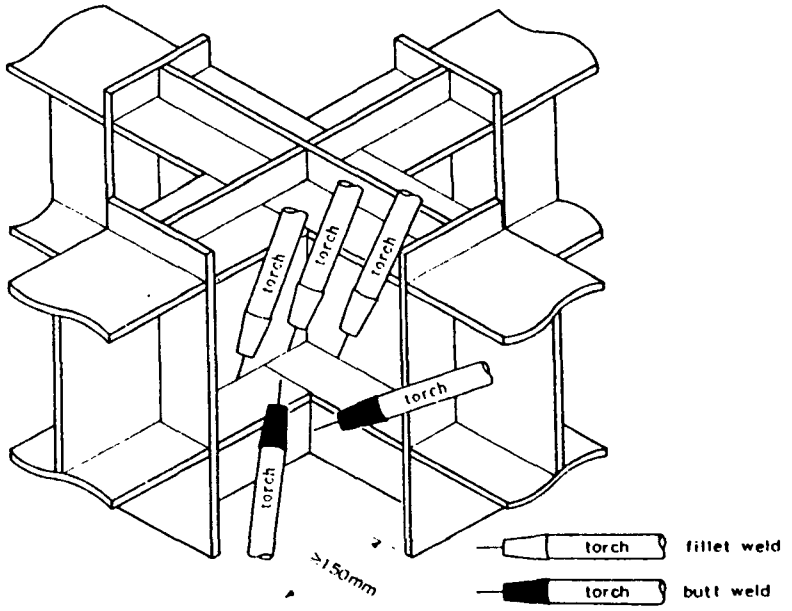
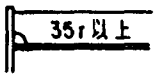
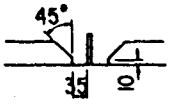
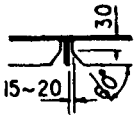
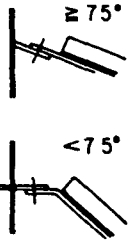


Fig. 4 Limitation of distance between welding joint and column flange

Table I Structural design suitable and unsuitable for robot

Point of View	Item	Design suitable for robot	Examples unsuitable for robot	Note
Joint Design	Treatment of ends of end stiffener	 scallop size ≧35r, boxing	 corner-cut, welding later	To detect start and end of weld
	Space between H stiffener and V stiffener			To make continuous welding of V stiffener
	Scallop size of V stiffener	≧35r	30r	To detect start and end of weld
Structurol Design	Arrangement of V stiffener and H stiffener	outside girder and inside girder :same side	outside girder :same side inside girder :reverse side	To increase rate of application for robot
	Fitting on V stiffener to web plate	 90° ± 2°		Necessity for development of robot suitable for structure