Mechanised Welding with Robot

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Since the end of World War II, many advancements have taken place in the heavy engineering industries and in this progress, welding has played an increasingly dominant part. The growth and development of industries made it necessary to develop new welding processes for more and more rigid applications, higher production and better economics.

The hand or manual welding, which was very commonly used all over the world gradually lost its place to semi-automatic and automatic welding. In automatic and semi-automatic welding, continuous welding electrodes are used instead of stick electrodes used in hand welding and the welding techniques used are MIG/MAG welding, TIG welding and submerged arc welding. With the introduction of automatic and semi-automatic welding, the engineering industries got a great advantage from the welding as well as the production point of view.

In semi-automatic welding, the electrode is continuously fed by wire feed system to the joints, to be welded by the help of hand operated welding gun while in automatic welding, the welding head moves automatically and is not manually controlled. In addition, the striking arc is made automatic and self adjusting. A number of technical improvements have been made from time to time on automatic and semi-automatic welding equipment and by adding welding components viz. guiding and control devices, mechanical positioning devices, manipulators, roller beds etc. it has been possible to adopt welding for specialised and tailored applications at reasonable cost.

When mechanising or automising of welding processes are involved, as with practically all mechanising, it is understood that the products which are to be manufactured, in most cases, must be adapted so that they are receptive to the automatic process concerned. This is a necessity with arc welding, since arc welding in itself is a relatively complicated process, which normally requires a close collaboration between man-machine-workpiece.

Since mass production items must be profitable, with the available technique it is not possible to produce articles in shorter series or to use several variants or to weld joints which lack sufficient precision, continuity or regularity.

Thus mechanised or automatic welding equipment is restricted to certain types of products to be mass-produced and where the joints geometry is simple. In certain cases, type-restricted equipment can be made adaptable for a great number of welding objects or for different variants of objects. Further, welding of simple circular or linear joints can often be automized with standard round welding benches or automatic beam carriage machines.

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Since a large range of articles, to be welded, could not take advantage of automatic welding, for some time there has been a demand to be able to carry out arc welding profitably on such work pieces that do not comply with the earlier requirements. Through development in the robot engineering field, it has now been possible to handle quite a number of those workpieces profitably with sufficient accuracy.

The innovation of industrial robots opened new opportunities for working in the most difficult environment round the clock. With high precision, compact design and large programme memory, the industrial robots help to achieve a higher rate of production per invested monetary unit. To-day there are about a 100 manufacturers of industrial robots and about 2,500-3,000 industrial robots have been sold all over the world. To bring about environmental improvements and at the same time do away with tiring and monotonous welding operation has been an essential objective for our development work for a long period. We, therefore, made a survey of about 25 types of industrial robots of different makes and found 6-8 robots suitable for use in welding. Of these we have selected two types for development and can present two different makes of robots, equipped with welding equipment and specially designed for programme controlled welding for carrying out gas metal arc welding with sufficient accuracy. One robot is of ASEA make, system IR 6-6 and is programmed by a mini computer and the other robot is of TRALLFA make. TR 3000 and is based on the already known spray painting type.

For some years, industrial robots are used by some other manufacturers to carry out resistance welding like spot welding.

When using an industrial robot in combination with welding equipment, the following points should be considered :—

1. Stability.
2. Repetitive Accuracy.
3. Utilisation during production time.
4. Ease of programming.
5. Amount of freedom of action.
6. Storage of programmes.
7. Speeds of individual robot movement.
8. Lifting capacity.
9. Price.

STABILITY :

When welding, it is very important that the robot quickly assumes a stable stopping position after having carried out a movement, as the demand for stability is very important when welding. Thus, any flexing in the robot arm or wrist or arm movements cannot be accepted in welding.

REPETITIVE ACCURACY :

Repetitive accuracy is one of the most important functions when welding with a robot. Here the demands are very high. Improvements in the robots tested for welding have gradually been done in connection with this.

To-day, in about half of the robots, repetitive accuracy can be set from $\pm$0.1mm to $\pm$0.5 mm. In the majority of cases, this is sufficient when MIG/MAG welding.

For more accurate TIG welding, or where higher precision is required as on MIG welding of thin materials, it can be stated that the robots are likely to need further improvement.

UTILISATION DURING PRODUCTION TIME :

As is the case with all productive units, to obtain an acceptable return from a welding robot installation, a high degree of utilisation is clearly required. 90-95% of the production time is a reasonable demand to set on a robot installation exclusive of the time required for replacement of filler material in or on the welding equipment. The lower figure applies to more complicated fixture installations, a greater number of operational cycles, etc.

EASE OF PROGRAMMING :

It is important that the programming process does not require special knowledge. The welding operator must learn how to programme the welding process, so that his experience and skill in the welding field contribute to the end result.

The robot is programmed by means of a minicomputer. The programme memory is built up of semi conductor memories, which can be re-programmed. The operation programme is stored in

fixed programme memories. The programming process is carried out by means of push buttons on a movable control panel.

AMOUNT OF FREEDOM OF ACTION :

To obtain as good a flexibility as possible in the working range of the robot, a relatively large number of degrees of freedom are required. For non-production applied welding robots, five degrees of freedom is the minimum requirement. Additional degrees. of freedom can be necessary due to the design of the workpiece. These additional requirements, however, can often be included in the welding fixture, manipulator or welding positioner.

The following are suitable degrees of freedeom :—

(a) Rotary movement.

(b) Arm movement, radial.

(c) Arm movement, vertical.

(d) Wrist bending.

(e) Wrist turning.

STORAGE OF PROGRAMMES :

The movements of the robot are programmed by means of a cassette recorder of one type or other. Step by step, each position is stored in a memory. Consequently, it is possible to use the robot to weld one object and when the cycle is completed, switch over and weld a different object without changing to another cassette. Thus, by recording welding operations on a tape recorder, the robot gives great flexibility. Waiting time, signal inputs to other associated position indicators are then included in the programme as well.

SPEED OF INDIVIDUAL ROBOT MOVEMENTS :

To cover as many welding operations as possible, it is a requirement that the individual movements of the robot can be steplessly set from almost 0 to approximately 0.04 m/s (2.5 m/min.) welding travel speed.

This can generally be achieved by a great number of the existing robots on the markets but, in addition, fast movement of at least arm and turning are required. Some of the robots most suitable for welding have a maximum speed of around 1-1.5 m/s. This can be considered sufficient.

LIFTING CAPACITY :

Robots of a high precision generally have a relatively limited lifting capacity. The lifting capacities are usually in the order of 5-10 kg. This should be sufficient for MIG/MAG welding, but should other welding processes be desired, e. g. submerged-arc welding, the lifting capacity can be increased upto ten times. Normally, a battery is included as a stand by source of supply should the main supply be interrupted. This battery can maintain the contents in the programme memory for an appreciable time, say 45 minutes after failure of the main power supply.

PRICE :

For minimising machine investment, the price of the industrial robots should be very attractive. The present day prices of such robots are roughly around $40,000 to 60,000 inclusive of control equipment and programme but exclusive of welding and fixture equipment.

In order that satisfactory results shall be obtained for type-restricted equipment, as well as welding robots, the following should be considered :—

°Select material with good weldability

°Material is to be free from paint, impurities, grease, oil, mill scale and so on.

°Careful joint preparation with good fit-up

°Important that the relative joint positions to one another and in relation to a point of reference (such as working plan, drilling hole, shoulder) on the workpiece are similar. Tolerance varies from case to case but generally applies that the thinner the material, the closer the tolerance required. The joint type has also importance, just as demand on penetration, resistance, and so on.

If these requirements are kept, experience so far obtained from using welding robots shows that they can open up new operational fields for the welding industry.

Earlier stated demands for automatic welding concerning large production series of workpieces, to some extent joint preparation, can be altered. Continuous joints to be welded are no longer required. It is quite possible to discuss robot welding of workpiece with relatively short, more or less continuous recurring weld joints. In certain cases demands on fit-up and joint preparation do not need to be set higher than for semi-automatic welding. With semi-automatic welding, arc time of approximately 35% is normal value, while with robot welding, the arc time can reach 80-90%.

Welding equipment designed by us for gas metal-arc welding, connected to robots, consists of the following units :—

* Thyristor controlled welding rectifier, stepless adjustment by means of a single control, with outputs for programme settings.

  One can in a simple way steplessly regulate welding voltage via small control signals. This makes the rectifier very suitable for use when automatic welding together with robot welding, where one can pre-programme welding parameters by means of a programming unit, in order to later change the parameters during welding directly from the robot control equipment.

* Thyristor-controlled wire feed unit for solid or tubular welding electrode.

* Programming Unit with possibility to preset up to five rectifier programmes for welding current and arc voltage.

* Welding hose with water-cooled contact tubes.

* Smoke evacuation unit.

* Spatter cleaning device for welding nozzle.

ADVANTAGES

Experience so far obtained from using welding robots shows that they can open up new operational fields for the welding industry. Workpieces which have not previously been handled by automatic welding can be welded profitably using a robot.

The following are the advantages of robot welding :—

(a) Improved working environment by doing away with tiring and monotonous welding operations and where welding fumes are removed.

(b) Productivity can be increased considerably.

(c) Uniform and high welding quality.

(d) A flexible welding installation for welding different types of workpieces.

(e) Shortened work cycle, at which work in progress is reduced.

(f) Investment cost is low as opposed to that of special welding installations.

(g) Easy handling and programming.

(h) Adaptability, in most cases to existing constructions.

CONCLUSION

In all probability, the development in the robot field will be very fast and fully programmed controlled welding lines for arc welding of complex workpieces will most likely become a reality.