Application of new automatic welding equipment and welding technology in the future construction machinery field

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Abstract. The production efficiency of machinery manufacturing industry is affected by the automatic welding equipments and technologies directly. Through introducing the working principle and applicable working conditions of new automatic welding equipments and welding technologies, the writer uses laser tracking equipment and welding deformation technology to analyze the possibility of application of automatic welding technology in the field of construction machinery, so as to provide useful reference for improving the quality of mechanical welding, reducing production costs and strengthening brand effect.

Keywords: automatic welding, laser tracking, double wire triple arc welding, cold arc welding, fish scale welding

1. Introduction

The global manufacturing industry is declining nowadays. The PMI index of the global manufacturing industry has continued to decline by the end of 2018. The market stock of the construction machinery industry is far larger than the market demanding, and it is facing unprecedented challenges. Looking at the whole market, the total construction machinery manufacturing industry has entered a state of poor operation. The shrinkage of the production of the world's major well-known construction machinery industry and the corresponding measures that they are taking indicate that the future development of the industry will still be in a cold winter. Facing with such a severe market situation, improving product quality, reducing production costs and using costs, and widening the gap between brand effects are the keys to win the battle. After more than two centuries of continuous development in the construction machinery industry, the threshold of traditional manufacturing technology has been greatly lowered, and production automation, lightweight products and energy-saving have gradually become the focus of future competition.

With the development of industrial robotics technology, it has been widely used in machinery manufacturing industry, such as cutting, welding, painting, assembly, etc. It improves the product quality and production
efficiency of manufacturing industry significantly, and the technology is matured day by day, which undoubtedly raises the new height of construction machinery manufacturing industry. However, Industrial robots also has its disadvantages. Let's take welding robot as example, its material is expensive, lamella piece can't be tracked by arc accurately, easy deformation structure cannot be welded accurately by using multilayer multichannel method, thin wall pipe joint cannot be welded, and fusion at the root of narrow groove is not so good. The writer solves the above technical bottleneck with the experience which was learned in the practice of the automatic welding equipment and welding technology.

2. Application of Laser Tracking Equipment
The key of robot automatic welding is intelligent positioning and arc tracking technology. At present, most intelligent positioning technologies of welding robots mostly use welding wire contact method, and some welding robots choose nozzle contact positioning technology. For example, IGM welding robot. With the application of laser tracking equipment, the deficiency of intelligent positioning and arc tracking technology is effectively supplemented.

2.1. Searching Principle of Welding and Its Defects
The robot contact positioning circuit is a constant open loop. When the welding wire or nozzle contacts the workpiece, the constant open loop closes. The robot built-in relay closes. The processor records the position information of the contact point. In the positioning process, the deviation between the actual position of the reference point on the workpiece surface and the programming position can be determined, and the corresponding welding procedure can be corrected.

When the errors of welding positioning occur, the position of the weld seam will change with the robotic automatic correction, which is the most fundamental reason for welding defects in robotic automatic welding. Taking contact positioning of welding wire as example, in order to ensure the positioning accuracy, it is necessary to control the dry elongation of the welding wire when positioning. At this moment, the role of wire clamping gun cable is very important. With the aging of the clamping gun and the blocking of the clamping cylinder, the reliability of the clamping wire decreases gradually. In the case of sheet metal welding below 3mm or back welding with face positioning, the change of dry elongation will easily lead to the deviation of positioning, which will lead to welding defects. In addition, there are many factors which affect the contact positioning accuracy of welding wire, such as damage of conductive nozzle, surface quality of workpiece, conductivity of welding wire and so on. Similarly, the contact positioning of the nozzle also has its disadvantages, such as the nozzle is easy to be deformed by heat, the nozzle is easy to be adhered with spatter, and the conductivity of the nozzle is reduced.

2.2. Arc tracking technology and its defects
At present, the seam tracking technology used in automatic welding on the market is arc tracking technology. In the process of fillet welding or thick plate welding, the welding gun generally needs to swing horizontally. Because of the different dry elongation of the welding wire, the actual welding
current is different from the set current. The shorter the dry elongation of the welding wire, the bigger the actual welding current, and the longer the dry elongation of the welding wire, the smaller the actual welding current. Using this principle, the welding robot can process the detected electrorheological changes and the position of the welding torch in real time by corresponding software, and then correct the actual welding trajectory of the robot, so as to ensure that the center line of the welding trajectory is always in the middle of the groove, and at the same time ensure the consistency of the height direction of the welding torch and the welding seam [1].

Among many droplet transition forms, jet transition welding is the most ideal arc tracking state which has stable process, less spatter, large depth and perfect welding seam[2]. In order to ensure a good arc tracking state, the actual welding current is greater than the minimum current from the droplet to the jet during the welding process. Taking 1.2mm ER50-6 wire mixed gas shielded welding as an example, its welding critical current is 240A, when the welding current is lower than 240A, arc tracking accuracy tends to be unstable. So the arc tracing technology is suitable for welding of high current and medium thickness plate structure. When the thickness of the plate is less than 5mm, the arc tracking accuracy begins to decline, and when the thickness of the plate continues to drop below 3mm, the arc tracking function fails. Another important factor that makes thin sheet metal unsuitable for arc tracing technology is that it is easy to overheat the edge with smaller lap edge during welding. The higher the temperature, the larger the resistance and the smaller the welding current. When the arc tracking is used, the gun will automatically correct to the direction of the smaller current, which will lead to the deviation of the weld bead and the melting of the base metal with short lap edge. In addition, the surface quality of weld, joint quality, chemical composition of welding wire and mixed gas will affect the arc tracking effect.

2.3. Laser tracking principle and characteristics

Laser tracking is a technology that laser irradiates a moving target and controls the direction of the measurement system according to the deviation angle between the laser signal reflected from the target and the optical axis of the measurement system. Laser tracking system usually consists of laser illuminator, laser detector, information processing system and servo system. The laser signal emitted by the laser illuminator to the target is reflected back by the target and projected onto the detector through the optical system. Laser detectors are generally four-quadrant photodetectors. If the signal reflected back from the target has a deviation angle from the optical axis of the measurement system, the area of the spot projected on the photodetector in the four quadrants is not equal. The corresponding angular deviation signal is obtained after the information is processed. This signal drives the servo system to make the measurement system turn to the target until the deviation angle is zero, thus it can complete the process of laser tracking [3].

The laser tracking device developed at present can not only realize efficient seam tracking, but also realize intelligent seam positioning. Laser positioning can not only make use of laser ranging technology for contact positioning of weld seam, but also use laser imaging technology to measure the height and transverse position deviation of weld seam at one time. The non-working time of robot can be reduced by 5-8 times [4]. Therefore, the application of laser tracking technology can effectively solve the defects of welding positioning and arc tracking technology.

Laser positioning and laser tracking technology can solve the problems of variation of dry elongation
and fluctuation of welding current, but higher quality of workpiece surface and joint precision which it requires are high. Rough weld surface or fluctuating joint gap will generate diffuse reflection in laser imaging and reduces the laser tracking precision. Because of the relatively large volume and high cost of the laser tracker, it can be generally used as a supplement to the contact positioning and arc tracking technology and applied to the welding of large open structural parts or thin plates.

3. Welding Deformation Control Technology

During welding, the melted metal and the base metal near the seam expand by heating, thus it results plastic deformation. When solidified, the metal which is in the welding part and near the welding seam shrinks, this will result internal stress in longitudinal and transverse, which makes the longitudinal and transverse shrinkage of the weld part and forms the deformation. As cold shrinkage and thermal expansion are inevitable during welding, so the welding deformation is inevitable. We can only control but not eliminate welding deformation completely. There are many factors affecting welding deformation, such as the features of base metal, form of weld seam, welding heat input, welding direction, joint clearance, deposited metal amount, etc. Under certain welding environment, reducing welding heat input and optimizing welding sequence are undoubtedly the most effective methods to control welding deformation. The following introduction of welding technology provides a new direction for reducing welding deformation.

3.1. Cold Arc Welding Technology

with the advancement of industry, the application of thin sheet and light metal structure parts is more and more extensive. In order to reduce plate welding deformation and avoid plate overheating breakdown, the welding heat input of this kind of plate must be controlled. In the process of welding, short circuit transition welding with low current and voltage is the best choice for traditional thin plate welding [5]. The droplet contacts with the molten pool before it disconnects from the electrode end directly. The arc is put out and short-circuited. The droplet transfers to the molten pool under the action of electromagnetic contraction force generated by the short-circuit current and surface tension of the liquid metal. At the moment of short circuit, the voltage drops sharply and the current rises gradually as the resistance decreases. At the moment of droplet falling off, the voltage rises sharply to ensure the arc reburning, while the current can only slow down under the action of inductance. At this moment, the current and voltage both are high, and welding defects such as arc instability, undercut, welding spatter and breakdown are easy to appear.

Cold arc welding technology is to use digital signal processor to quickly adjust the current and voltage according to feedback at the moment of arc reburning, and to reduce the welding current at the moment of arc reburning, so as to ensure the stability of arc reburning. After arc initiation, a small pulse current is given to make the arc obtain higher arc energy and promote the re-nucleation of melt droplets. The cold arc welding technology makes the melting droplet transition period stable, guarantees low heat input, and greatly reduces the welding spatter caused by traditional short-circuit transition.

3.2. Technology of Double-wire Three Arc Welding

The welding parts in the construction machinery industry are mainly medium and thick plates. Double-wire automatic welding can effectively improve the welding efficiency. It is widely used in the
welding of key seams such as loading mobile arms, big arms of excavator and crane. In addition to increasing welding efficiency, welding heat input also increases greatly. Thermal deformation after welding has always been a problem troubling the construction machinery industry.

Different from traditional double-wire welding, double-wire three arc welding can form a third arc between double wire arcs. In the double-wire three arc welding system, the arc power used to melt the wire is much larger than that used to melt the base metal. The melting efficiency is greatly improved, and the welding heat input is significantly reduced. The arc power between three arcs can also be allocated by intelligent control of digital signals. When higher melting depth is needed, the arc power for melting base metal can be increased, the arc power for melting wire can be reduced, and enough heat input can be guaranteed for melting the base metal. Similarly, when it is necessary to control the welding deformation and improve the welding efficiency, the arc power used to melt the base metal can be reduced and the arc power used to melt the welding wire can be increased to ensure sufficient melting efficiency.

3.3 Fish Scale Welding Technology
The difficulty of thin-wall pipe welding lies in the control of welding posture, especially the welding of joints of through-line pipe wall. Traditionally, tungsten argon arc welding, brazing or short-circuit transition gas shielded welding are often used in the welding of such welding seams. Among them, the cost of tungsten argon arc welding is high, the welding strength of brazing is difficult to guarantee, and gas shielded welding is difficult to control the heat of welding when vertical welding and cross welding are used, which is easy to break down the pipe wall.

The introduction of fish scale welding technology provides a possibility for automatic welding of bridge rail and tower crane support frame. During the whole process of fish scale welding, the robot always makes a step forward movement. For each distance the robot goes ahead, it will stay in the same place for a while, and then steps forward gain, and so on until the end of welding. When the robot stops, the welding power source starts arc welding rapidly. When the robot moves, the welding machine switches off instantly. The ratio of pulse of fish scale welding is 35%~55%(generally 40%) per second. Compared with the traditional welding process, the whole welding heat input is greatly reduced, all position welding can be realized, and the welding seam is flaky fish scale. At present, it has been widely used in welding bicycle and motorcycle frame, fitness equipment and medical equipment.

4. Concluding remarks
The welding equipment and technology outlined by the writer is only the corner of the iceberg of many new welding technologies. Welding automation technology is a comprehensive subject which integrates welding, automation, machinery, hydraulic pressure and measurement. It requires stable preparation before welding, skilled process monitoring and professional performance maintenance. Even if the advanced welding technology is available, the ideal welding quality cannot be achieved without proper structure, mature welding technology, stable joint quality and excellent personnel quality. In increasingly fierce competition of today, the construction machinery industry should consolidate the traditional technical essence internally and study the advanced technology from external, upgrade the new manufacturing level with advanced production technology continuously.
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