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Design and fabrication of friction stir welding automatic end-effector for industrial ABB IRB1410

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ABSTRACT

The paper proposed modelling and fabrication of friction welding end-effector for ABB IRB1410 robot. A dynamical version of pressure welding processes joins material without reaching the fusion temperature called friction stir welding. As welding occurs in a solid state, no solidified structures are created thereby eliminated the brittle and eutectic phase commonly in fusion of welding at high strength aluminium alloys. In this paper, the Friction welding is applied to aluminium sheets of 2 mm thickness. A prototype setup is developed to monitor the developed a main forces and tool temperature during the operation. The pressure of a gripper plays a significant role in tool rotation and developing torque. Fabrication of tool has done. Force calculations are done by placing the sensors on the outer surface of a gripper. Methods of evaluating weld quality are surveyed as well.

KEY WORDS: Friction Stir welding, Welding process

1. INTRODUCTION

Friction stir welding (FSW) new and processing a solid state welding technology developed by Welding Institute (TWI) of UK in 1991. Due to the energy efficiency, environment friendliness and versatility, thus the joining technology has applied in various industrial applications, such as shipbuilding, railways, automation and aerospace industries. Compared with convention of fusion welding techniques, FSW is mainly characterized by joining material without reaching up to fusion temperature, it avoids the problems caused by melting metals. As a result, all type of aluminum alloys, even that are classified an non-weldable by traditional fusion welding techniques, it can be welded through FSW process.

Industrial robots is been increasingly used in the FSW process to replace a commonly-used machines because of the excellent repeatability, production flexibility, and low cost. Smith (2003), developed an FSW system which is integrated to the ABB IRB 7600 articulated robot, and capability of implementing a three-dimensional contours welding to various position with excellent force feedback control was proved. Bres (2010), establish a model-based framework which gives the simulation, analysis and optimization of friction welding processes of metallic structures using industrial robots.Applied on-line sensing and path compense methods to obtain a high and defect-free welding in robotic FSW process. The Demonstrate of a successful development and evaluation of a closed-loop control system for robotic friction welding that plunge control force and tool interface temperature by varying spindle speed and commanded vertical device position.

Welding Process: In Friction Stir Welding, the part is to weld and joined by forcing a rotating tool to penetrate into the joint and then moving across the entire joint. The solid-state joining process is been promoted by the movement of a non-consumable tool through the welding joint. It consists mainly of three phases, in which each one has been described as a period where the welding tool and workpiece to move about each other. In the first step, rotating tool is vertically displacing into the joint line (plunge period). Then period is followed by the dwell period in which the tool is held steady above workpiece rotating. The velocity between an rotating tool and the stable workpiece produce heat on mechanical interaction which results in friction work and plastic material deformation. The heat is dissipated to the neighboring material, promoting an increase in temperature and consequent material softening. After this two initial phases, welding operation can be carried out by moving either the tool or the workpiece about each other along the joint line. Figure.1 gives a schematic representation of the FSW setup and operation.

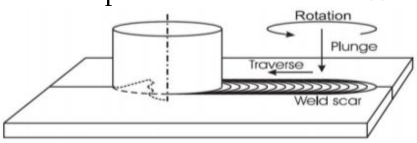

Figure.1. Friction Stir Welding Setup

2. METHODOLOGY

The approach towards the making of the end-effector has been split into different steps which go like designing, fabrication, quality control and controlling the robot. Figure 2 says the steps of the methodology of the project. The first aware is to initialize and identifying the problem. The second step is developing the concept to overcome the problem which has been defined in first step. Once the concept is prepared for the identified problem, the different possibilities of an concept are sketched out and studied. The minimum solution for the concept has arrived after the studies. The next step is to develop the conceptual idea of a three-dimensional model using modeling software by SOLIDWORKS. The various calculations are done such as DH parameters. Then analysis of the compound model to identify fundamental properties had been carried out. Next stage is to fabricate the weld tool and interface to ABB IRB1410. Then an algorithm and program are to be developed for the ABB Robot for the purpose of friction welding operation by friction welding end-effector. Finally, the friction welding is interfaced with the robot for verifying the algorithm and program in real time.

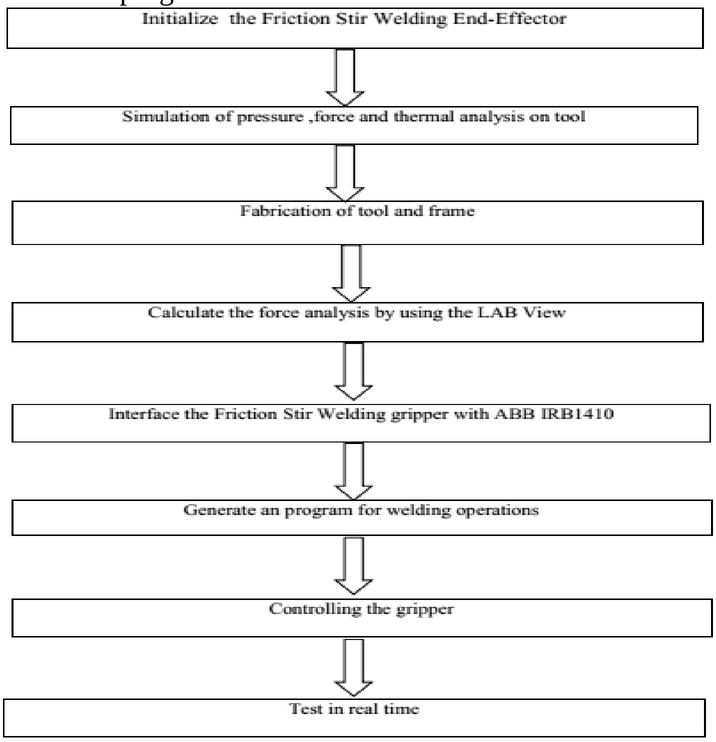

Figure.2. Flow chart of Methodology

Materials Used: Various materials were procured, and their properties are studied. Some of the material proposed is as follows: Aluminium alloys, HCC (High Carbon Steel), HSS (High-Speed Steel), Chromium.

Experimental Set-Up: The ABB IRB1410 gives an fast and continuous work cycles which boost efficiency. The robot is produced in arc welding applications which resulted in outstanding and performance and value, ensuring a short payback time. This robot is capable of handling a capacity of 5kg at the wrist with an 18kg additional load on the upper 16 arm. Superior levels of controlling and path follow accuracy provide excellent work quality.

ABB IRB1410 is known for the stiff and robot construction. This to translates into low noise levels, a long interval between routine maintenance and for long life. The working area of robot is large and has long reached. The compact design is a very slim wrist and high-performance operation even in the challenging and restricted locations. Easy-to-use all functions that are included in as standard IRC-5 robot controller are made available via the patented programming and operation interface unit - the Flex Pendant.

Table.1. Specifications of ABB IRB1410

Robot	**Handling Capacity**
Supplementary load On axis 3 On axis 1	 18kg 19kg
Number of axes	
Robot manipulator	6
External devices	6
Integrated signal supply	12 signals on upper arm
Integrated air supply	Max .8 bar on upper arm
IRC5 controller variants	Single cabinet, compact
Max. TCP velocity	2.1 m/s
Continuous rotation of axis	6
Weight of robot	225kg

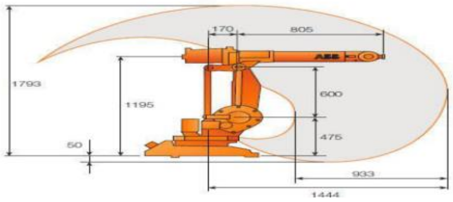

Figure.3. Working range for IRB 1410

Design: 3D modeling software was used to design the model of the friction welding. The model will be with a rigid aluminum structure as the body with an HSS tool cover at the bottom and pneumatic gun. Each model of the segment was created separately and assembled. Calculations were done to determine the amount of torque required is to move these designs with a pneumatic gun.

In this section, explained about the result of research and at same time given to the comprehensive discussion. Results will be present in figures, graphs, tables and others that make the reader understand quickly. Thus, the discussion can be made in several sub-chapters.

Design of Weld Tool: The first aware of the design process is to develop the weld tool for friction welding. Here the pin is threaded with dia.4mm the connecting the shoulder here the dia.15mm, with a concavity which is shown in figure 4.

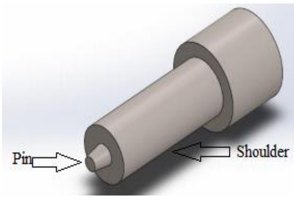

Figure.4. Design of weld tool

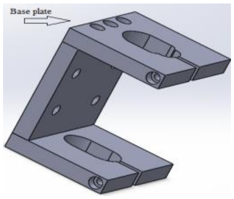

Figure.5. Design of Base Plate

Figure.6. Pneumatic Gun

The next step of assembly is to mate the base plate to the tool and mounted to the base plate of an end effector which has been shown in figure 5.

The next step is to assembly the pneumatic gun with a revolution per minute (RPM) 22,000, torque 2.1N-m which mounts on the base plate with an assembly of tool to the pneumatic gun which aware in figure 6.

Fabrication and Mounting to Robot: The fabrication of weld tool with the HSS material, with the required hardness of material heated up to 900^0 c and quenched in oil as shown in figure 7.

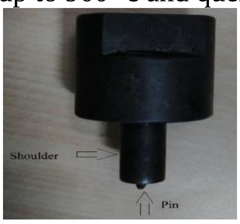

Figure.7. Weld tool

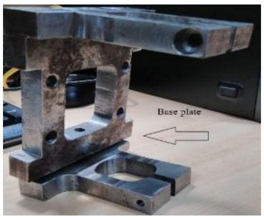

Figure.8. Frame

The frame with cast iron material which having a stability to avoid the vibrational feature and to withstand with the robot as seen in figure 8.

This robotic welding is used to implement an FSW operation of some aluminum alloy plates. In this operation, the spindle of the robot system is controlled to weld in x direction of the tool frame with a constant travel speed v and rotation speed ω. The other welding operation conditions for the experimental parameters are listed in Table 2.

Table 2. Robotic FSW experimental conditions

Parameters	Name/Value	Unit
Weld Material	AL6082	
FSW tool type	HSS	
Material Thickness	3	mm
Torque	2.1	N-m
Rotational Speed	12,000	rpm

The next step is to assembly the tool and frame and the pneumatic gun, to the ABB robot as shown in figure 9. The overall view of the setup, mounted to the robot after the fabrication as shown in figure 10.

Force Measurement: The force measurement can be detailed by using LABView software by taking the pressure sensor which is mounted to the base plate, the force analysis which shown in figure 11. The next step is the wire diagram of the pressure sensor has been mount on the baseplate to read the generated pressure and force by the weld tool is shown in figure 12.

Figure.9.Assembly of setup

Figure.10.Overall Setup

Figure.11.Force measurement

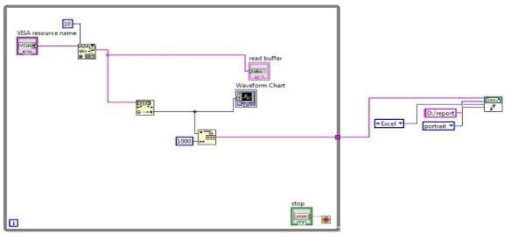

Figure.12.Wire diagram

3. RESULTS AND DISCUSSION

A detailed study over various welding robots has been done. Friction welding can adapt to different diametric changes of shoulder and pin diameter weld tool. This friction welding by ABB IRB1410 robot can say the lighter material easily be welded and can control the RPM of the pneumatic gun by flow control valve. This robot can have moved within it robot work cell with its reachability. The design of weld tool and base plate were done, and fabrication has done, trails were made, analyzed and rectified for the friction welding. Weld quality test will carried out as the future work. The experimentations are carried out on the robot to make it efficient enough to move over the material to weld the similar and dissimilar weld plates. Friction weld can be conduct on this robot with a pressure range of 2-5bar. For better welding and larger thickness of work-piece it can be weld by other robot like the robot having a high amount of payload. The figure 13 shown below say the welding carried out by using ABB IRB1410.

Figure.13. Welded plates

4. ACKNOWLEDGEMENT

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REFERENCES

Bres A, Monsarrat B, Dubourg L, Birglen L, Perron C, Jahazi M, and Baron L, Simulation of friction stirs welding using industrial robots, Industrial Robot: An International Journal, 37 (1), 2010, 36–50.

Cook G, Crawford R, Clark D, and Strauss A, Robotic friction stir welding, Industrial Robot, 31 (1), 2004, 55–63.

De Backer J, Christiansson A.K, Oqueka J, and Bolmsjo G, Investigation of path compensation methods for robotic friction stir welding, Industrial Robot, 39 (6), 2012, 601–608.

Fehrenbecher A, Smith C, Duffie N, Ferrier N, Pfefferkorn F, and Zinn M, Combined temperature and force control for robotic friction stir welding, Journal of Manufacturing Science and Engineering, Transactions of the ASME, 136 (2), 2014.

Mishra R.S, and Ma Z.Y, Friction stir welding and processing, Materials Science and Engineering, Reports, 50, 2005, 1–78.

Nandan R, Deb Roy T, and Bhadeshia H, Recent advances in friction-stir welding - process, weldment structure and properties, Progress in Materials Science, 53 (6), 2008, 980–1023.

Smith CB, Hinrechs J.F, and Crusan W.A, Robotics Friction stirs welding the state of the art, In 4th Friction Stir Welding International Symposium, Addison-Wesley, 2003.

Thomas W.M, Nicholas E.D, Needham J.C, Murch M.G, Temple-Smith P, and Dawes C.J, International patent application and GB patent application, Technical report, The Welding Institute, London, UK, 1991.