Design and Fabrication of Friction Stir Welding End-Effector for an ABB IRB1410 Robot

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Abstract

Friction Stir Welding is a developing technology used in various Industrial applications due to the energy efficiency, environment friendliness and versatility. In this, we proposed modeling and fabrication of friction welding end-effector for ABB IRB1410 robot. We have a design in Solid Works and design analysis in ANSYS. Force calculations are done by placing the sensors on the outer surface of a gripper. Methods of evaluating weld quality are surveyed as well. The Friction welding is applied to aluminum 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 work is done. The application of friction welding is used for the joining of the two dissimilar materials. It is used in industrial application with the perfect welding of work piece.

Keywords: ABB IRB1410, Fabrication, Friction Welding, Design, Pneumatic Gun

1. Introduction

Friction Stir Welding (FSW)1 because of its energy efficiency, environment friendliness and versatility, it is applied in various industries including shipbuilding, railways, automation and aerospace. Compared with a 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 metals2. As a result, all type of aluminum alloys, even that are classified a non-weldable by traditional fusion welding techniques, can be welded through FSW process3.

Industrial robots are being increasingly used in the FSW process to replace a commonly-used machines because of the excellent repeatability, production flexibility, and low cost4. In5 developed an FSW system which is integrated to the ABB IRB 7600 articulated robot, and capability of implementing a three-dimensional contours welding to the various position with excellent force feedback control were proved. In6 established a model-based framework which gives the simulation, analysis and optimization of friction welding processes of metallic structures using industrial robots. Applied on-line7 sensing and path comprise methods to obtain a high and defect-free welding in robotic FSW process8. The Demonstrate of 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.

1.1 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 has been promoted by the movement of a non-consumable tool through the welding joint. It con-
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Figure 1. Friction Stir Welding Setup.

This paper as follows: The experimental methodology of introduction in Section 2. In Section 3, the data of design, followed by the fabrication of tool and frame. Part 4, force analysis by using the LAB View. In Section 5, conclusion and future. Finally, acknowledgment of the paper will be given in Section 6.

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 the first step. Once the concept is prepared for the identified problem, the different possibilities of a 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 resistance welding is interfaced with the robot for verifying the algorithm and program in real time.

Figure 2. Flow Chart of Methodology.

2.1 Material Used

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

3. 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 know 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 the same time given to the comprehensive discussion. Results will be present in figures, graphs, tables and others that make the reader understand quickly2,5. Thus, the discussion can be made in several sub-chapters.

3.1 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 3.

![Figure 3. Design of Weld Tool.](image)

The next step of assembly is to mate the base plate to the tool and mounted to the base plate of the end effector which has been shown in Figure 4.

![Figure 4. Design of Base Plate.](image)

3.2 Fabrication and Mounting to Robot

The fabrication of weld tool with the HSS material, with the required hardness of material heated up to 900° c and quenched in oil as shown in Figure 6.

![Figure 6. Weld Tool.](image)

The next step is to assembly the pneumatic gun with a Revolution per Minute (RPM) 22,000, torque 2.1N-m which mount on the base plate with an assembly of tool to the pneumatic gun which aware in Figure 5.

![Figure 5. Pneumatic Gun.](image)
The robot welding system is used for implementing a Friction Welding operation of aluminum alloy plates. The experiment with the spindle of the robot system is controlled to weld in x direction of the tool area with a constant travel speed $v$ and rotation speed $\omega$. There are other welding conditions for the experiment conditions are listed in Table 1.

![Figure 7. Frame.](image)

### Table 1. Robotic FSW experimental conditions

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Name/Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weld material</td>
<td>Al6082</td>
<td></td>
</tr>
<tr>
<td>FSW tool type</td>
<td>H13</td>
<td></td>
</tr>
<tr>
<td>Material thickness</td>
<td>3</td>
<td>mm</td>
</tr>
<tr>
<td>Torque</td>
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<td>N-m</td>
</tr>
<tr>
<td>Rotational speed</td>
<td>22,000</td>
<td>rpm</td>
</tr>
</tbody>
</table>

The next step is to assembly the tool and frame and the pneumatic gun, to the ABB robot as shown in Figure 8.

![Figure 8. Assembly of Setup.](image)

The overall view of the setup, mounted to the robot after the fabrication as shown in Figure 9.

![Figure 9. Overall Setup.](image)

## 4. Force Measurement

The force measurement can be detailed by using LAB View software by taking the pressure sensor which is mounted to the base plate, the force analysis which shown in Figure 10.

![Figure 10. Wire Diagram.](image)

The next step is the wire diagram of the pressure sensor has been mounted on the baseplate to read the generated pressure and force by the weld tool is shown in Figure 11.
5. Results and Conclusions

A detailed study over various welding robots has been done. Friction stir welding can adapt to various diametrical 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 move 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 be carried out as the future work.

The experimentations are performed 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 carried out by this robot with a pressure range of 2-5bar. For better welding and larger thickness of work-piece can be weld by another robot like the robot having a high amount of payload. The Figure 12 shown below say the welding carried out by using ABB IRB1410.

6. References