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Fabrication of Semi-Automatic Friction Stir Welding Machine for Soft Materials

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Abstract

Friction welding process is the most simple, economical and productive methods in joining materials. In this work, a semi-automated friction stir welding machine was fabricated for soft materials. A hand drilling machine was the main component in this machine. The controlling welding process was done by electronic devices. The mild steel friction tool was manufactured for this purpose. Lead alloy is chosen as work piece according to the capacity of hand drilling machine. A successful lead alloys plates were welded by this machine.

Keywords: Friction stir welding machine; Manufacturing; Drilling machine; Soft materials; Control

Introduction

Joining includes a wide variety of methods to join two pieces of solid material into one [1]. Joining metals by welding has been under constant development for thousands of years [2]. Friction welding (FW) method is one of the most simple, economical and highly productive methods in joining similar and dissimilar metals [3]. There are mainly two types of FW, rotary FW (RFW) and Friction Stir Welding (FSW). FSW was developed by Thomas et al. [4] for joining soft metals, as aluminum alloys, which were generally considered difficult to weld using fusion welding techniques. Many similar and dissimilar materials were welded by FSW process [5-7]. The FSW process consists of the insertion of a rotational tool, formed by a pin and a shoulder, into the abutting surfaces of pieces to be welded and moved along the weld joint, as presented in Figure 1. A high-quality solid-state joint is formed. Today there are around 300 companies worldwide which perform FSW on one or more machines [1].

FSW is widely used in the automotive, aircraft and aerospace industrial applications. Specific FSW machines were used with different characteristics and configuration. According to Mendes et al. [8], three kinds of machines are reported in literature as viable to perform FSW. These machines are:

- Conventional machine tools such as milling machines, can be used to perform FSW [9,10]. For the purpose research, milling machine is converted into friction stir welding machine by some modifications [11].
- Dedicated FSW machines or custom-built machines [12], fabricated to satisfy special product requirements, and for example parts for decks of ships [13].
- Industrial robots [5,14,15], which are robotic machines.

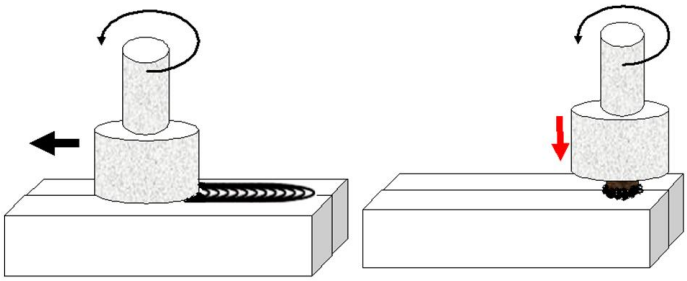

Figure 1: *FSW process.*

According to a literature, a limited FSW machines were fabricated using conventional hand drilling machine, such as realized by Siddiqui et al. [16]. The majority of these machines are controlled manually. The objective of this work was to

fabricate a semi-automated FSW machine by using conventional hand drilling machine and some electronic devices.

Experimental Procedures and Discussions

Components of FSW

This section presents the details of the main components of the semi-automated friction stir welding machine and their functions. Figure 2 shows the general view of a semi-automated friction stir welding fabricated in this work. The components of the mechanical part (Hand drill machine, motors) are connected to the computer by electronic devices (Arduino, power supply, and two digital stepper motor drivers).

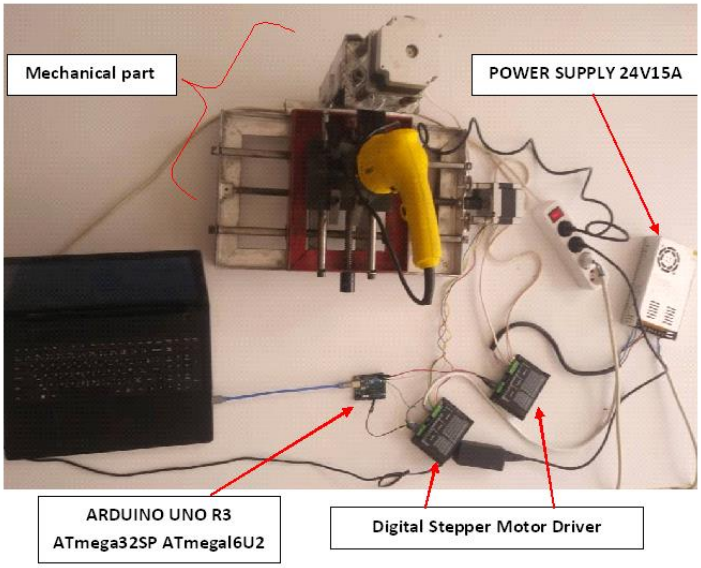

Figure 2: *General view of a semi-automated friction stir welding machine.*

The mechanical part of a semi-automated friction stir welding machine was designed to obtain detailed engineering drawing and the manufacturing (Figure 3). The manufacturing of the mechanical part is fabricated with high rigidity.
(Figure 4) presents the mechanical part of a semi-automated friction stir welding machine.

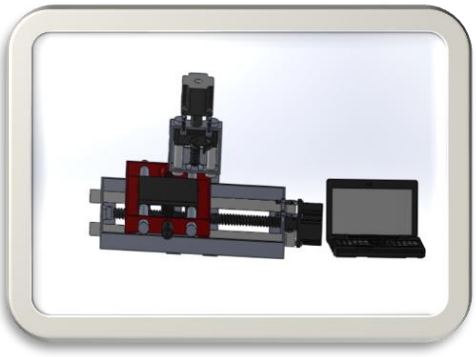

Figure 3: *Design of a semi-automated friction stir welding machine.*

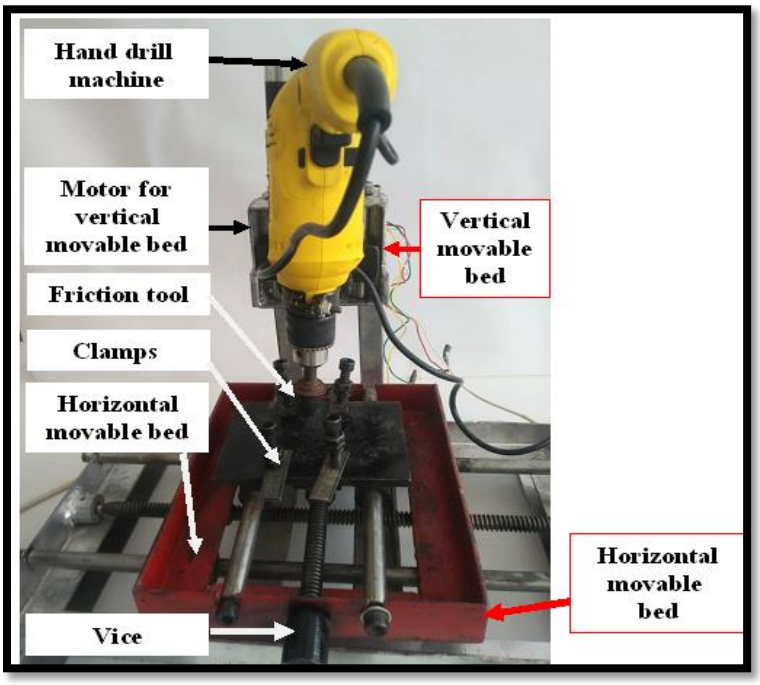

Figure 4: *Mechanical part of a semi-automated friction stir welding machine.*

This part is composed of:

- Vertical movable bed, which can move up and down. The vertical movement is performed by a motor (NEMA34 JK86HS67-5904).The hand drilling machine (Stanley SDH600) is fixed on this moving bed. The maximum rotating speed is 2600 rpm.
- Horizontal moving bed, which can move linear. The movement is performed also by the same motor (NEMA34 JK86HS67-5904) as fixed on vertical movable bed. The speed of the horizontal moving bed varies from 5 to 3000 mm / min.
- The vice is used to hold the work piece in a straight manner. It moves towards both forward and backward direction.
- A fastening system is mounted on the horizontal bed. Four clamps fixe the two work-pieces by tightening of four screws. Siddiqui et al. [16] reported that the high stress developed between plates (Fig. 1) due to the rotation of tool which tries to separate the plates, for this reason a clamping force is required to fix the plates for successful welding process.
- Friction tool, which is fixed to the hand drilling machine.

Friction tool is made up of mild steel (Figure 5). Mild steel has a high melting point and hardness values than many soft materials such as aluminum alloys or leads alloys.

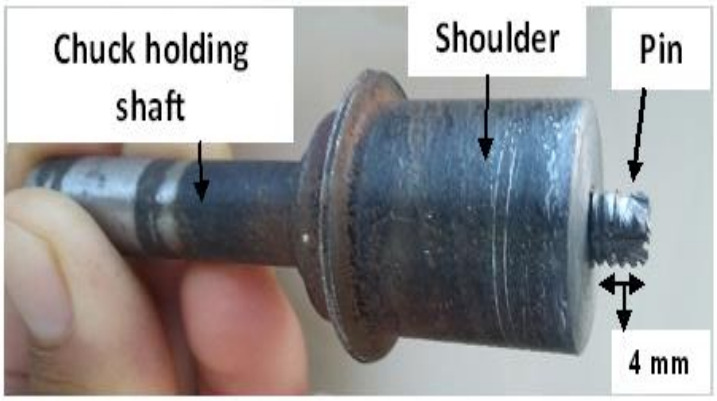

Figure 5: *Friction tool.*

Controlling mechanical part of FSW machine

We noticed that all different movement of the mechanical part of FSW machine is controlled by installed software in the computer as shown in (Figure 6). From the software commands, the speed of the longitudinal and vertical movements of the two beds can be controlled. From these two commands, this friction stir welding machine is semi-automated.

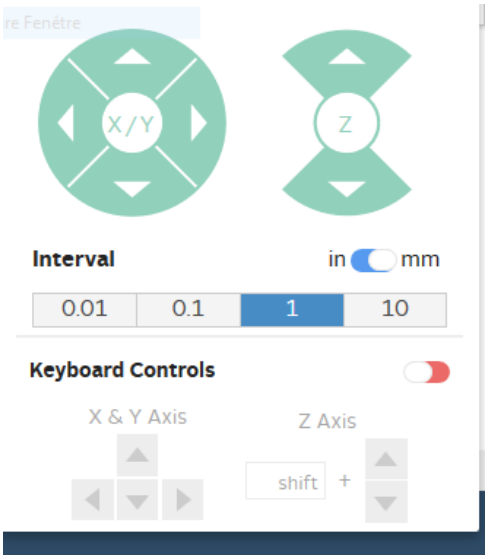

Figure 6: *Portion of a screenshot showed the software commands.*

Welding process

The FSW of lead alloy has been carried out successfully in the semi-automated friction stir welding machine (Figure 7). The material selected for the welding is lead alloy plates (Thickness=5 mm), due to its low melting point. FSW parameters considered in this experience are rotational speed of 2800 rpm (hand drilling machine), and weld speeds 10 mm/min (Horizontal moving bed). Other tests can be performed for other soft materials by changing just the welding conditions.

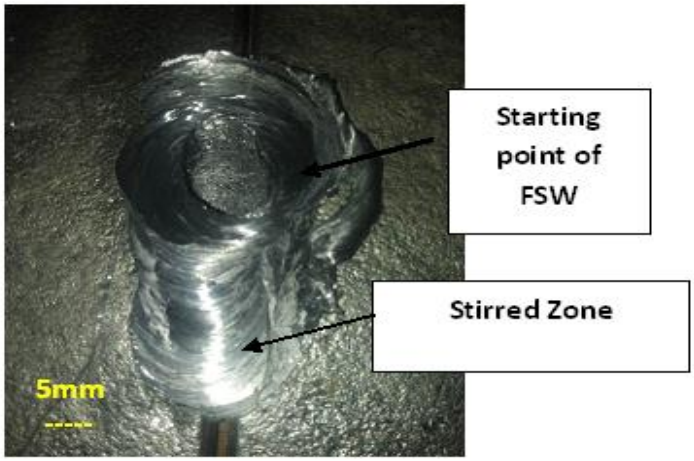

Figure 7: *Welded lead alloy plates by semi-automated FSW machine.*

Conclusion

A semi-automated FSW machine was fabricated by using hand drilling machine. This machine is used for welding soft materials. It is divided on two parts, mechanical part and electronic part. The two parts are connected between them for controlling the process of welding. A successful friction stir welding of lead plates is performed.

Acknowledgments

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