

An Innovative Fixture Design in Making Use of a Milling Machine to Perform the Function of Friction Stir Welding and Eliminate the Exit Hole

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ABSTRACT: The high cost and non-availability of friction stir welding machine motivated this research to design and fabricate a new fixture which services many purposes such using the milling machine to perform the friction stir welding process, withstand the forces which appear during the welding, prevent the distortion and vibration of the work pieces and reduce the exit hole problem which is one of the limitations of the friction stir welding method. In the present paper a new developed fixture was designed and fabricated taking in account the ability to vary the length, width and thickness of the work pieces. The fixture is designed without much complications, can be used for varied purposes, low cost and fit different milling machine tables. An additional plate is used to eliminate the exit hole. The fixture was successfully fastened on the milling machine table and the experiment was successfully done.

KEYWORDS: Friction stir welding, Fixture, Milling machine, Exit hole.

I. INTRODUCTION

The amendment in the machines to achieve specific tasks is considered very important in the industry. Sometimes the high cost and complexity of specialized machines make them less accessibility and usability. In this case using the modification machines are necessary to do some tasks with low cost and simple way. The high cost of friction stir welding machines encouraged the researchers to find an alternative solutions and use other machines to perform the task of welding especially for research purposes. One of these methods is to use the milling machine to achieve friction stir welding process. Special fixture is needed to use the milling machine in this case. Recently, many efforts are made to find the best fixture in this field. T. Minton and D.J. Mynors [1] showed that the conventional milling machines are capable of performing friction stir welding. Esther T. Akinlabi et al [2] demonstrated the design of support system and clamping for modifications done on milling machine to perform friction stir welding. The developed fixture allowed a good clamping and less vibration. P K Baghel and A N Siddiquee [3] invented a fixture which is suitable for robust vertical milling machine. The fixture prevented the deflection and movement of the work pieces. Q M Doos and B Abdulwahab [4] successfully welded aluminum pipes using friction stir welding method where a special fixture fixed on the conventional milling machine to weld the pipes in round motion. L Fratini et al [5] proposed new fixture for friction stir welding with titanium alloys. Shuja Ahmed et al [6] developed a new fixture of micro friction stir welding (μ FSW). Biswajit Parida et al [7] designed a new type of adjustable fixture to hold the work pieces and withstand the movement and vibration during the friction stir welding operation with the help of milling machine. In the present paper a new removable fixture is designed and fabricated to be fastened on the milling machine to perform the friction stir welding operations. The design is simple, cost effective and can be fastened on any milling machine bed. The fixture will help in solving the Exit Hole problem which is considered one of the prime limitations of the FSW process.

II. THE PROPOSED FIXTURE

There are many forces appear during the friction stir welding process. The main forces are shown in the figure (1). They are torque, transverse, axial and lateral forces. Due to presence of these forces during the friction stir welding process the main challenge is to withstand all these forces and this is one aim of the development of the fixture. When the tool arrives the end of the plates there are two possible cases. To stop the rotation and withdraw the tool from the work pieces and here a hole will appear or the tool can continue and exit out of the pieces leaving a tear out. In both cases the end should be cut forcibly with a loss of part of the material from the work pieces. The developed fixture is addressing in solving these problems.

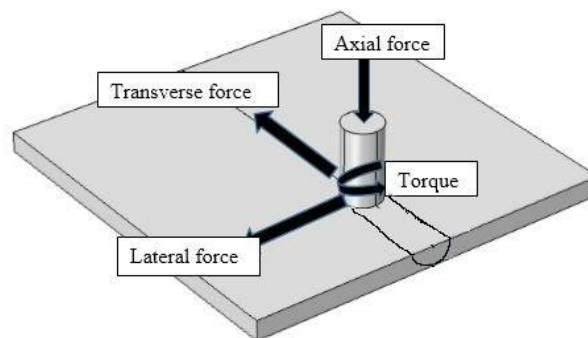


Fig. 1 Forces in friction stir welding process

The support system is made of various parts. To fabricate the system from one piece is too difficult taking in account the complexity and high cost. During the initial stages, many pieces were fabricated separately then some of them were joined together to form as a single component. The various parts are described briefly here.

A. End plates

Tow plates made of mild steel with 10 mm thickness are provided with slots to slide the bolts to suit any milling machine table dimensions. The main aim of the end plates is to fasten the total system on milling machine table. The plate and the dimensions details are shown in figure (2).

B. Backing plate

The backing plate was made of mild steel with 20 mm thickness as in figure (3). The upper face was provided at each end by four holes with 10 mm depth. On the bottom face at each end also four cubic with 10 mm depth were cut under the holes to accommodate the heads of bolts.

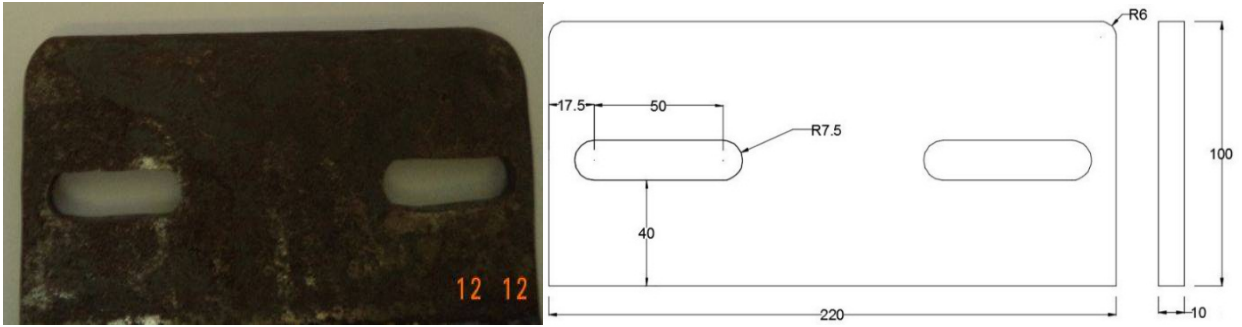
C. Lateral plates

The lateral plates were made of mild steel with 10 mm thickness. Three holes and one slot were provided at each plate as shown in figure (4). Here the number of lateral plates are two.

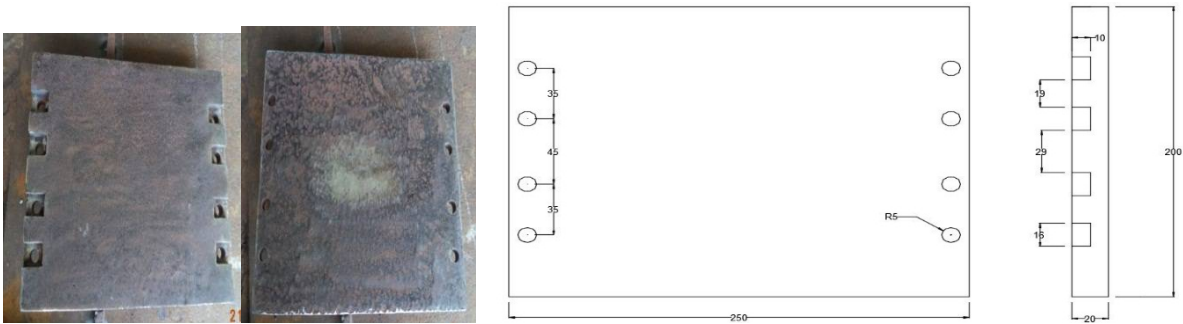
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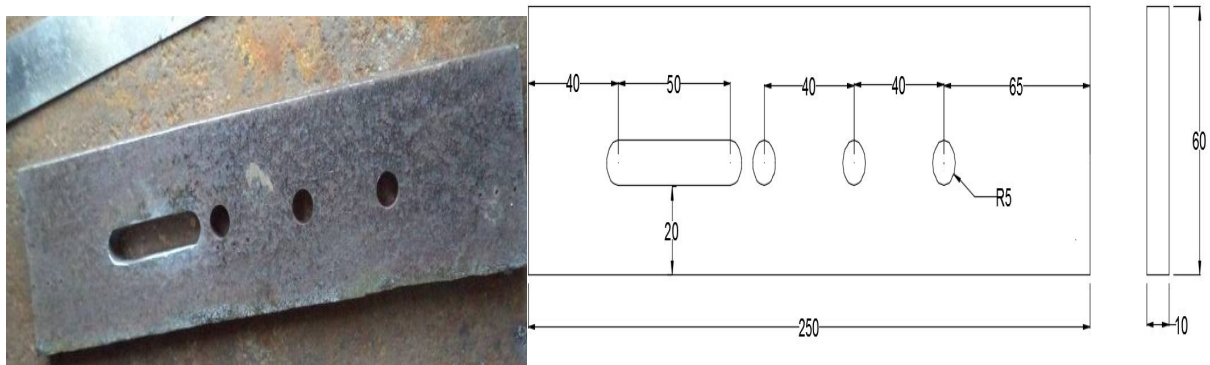
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(a) (b)
Fig. 2 End plate (a) photograph of plate; (b) dimensions details



(a) (b) (c)
Fig. 3 Backing plate (a) photograph of bottom face of plate; (b) photograph of upper face of plate; (c) dimensions details



(a) (b)
Fig. 4 Lateral plate (a) photograph of plate; (b) drawing details

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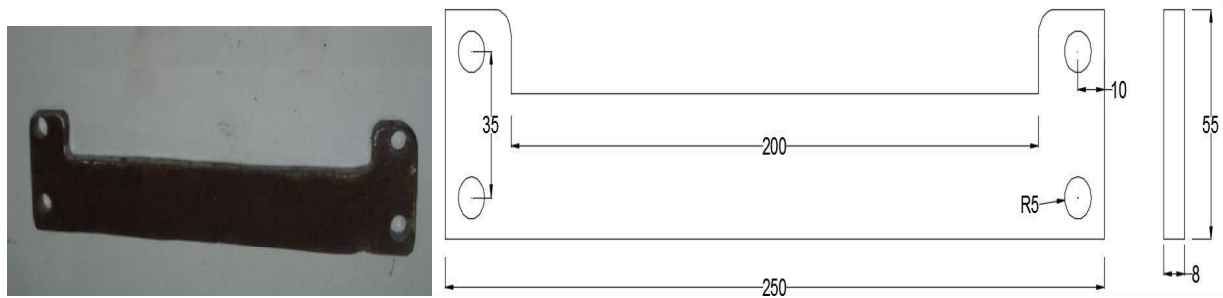
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D. Fasten plates (clamps)

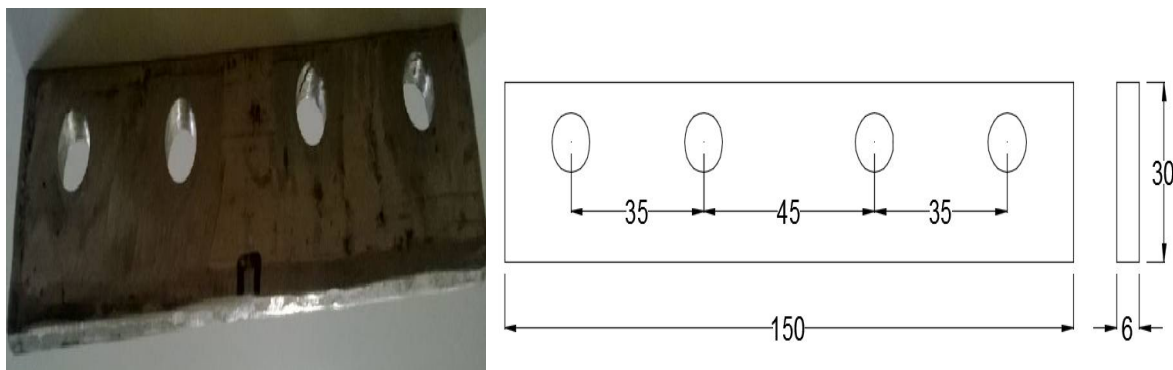
Tow plates made of mild steel flat with 8 mm thickness are used to prevent the axial movement and vibration of the work pieces. Each plate is provided with four holes as shown in figure (5).

E. Additional plates

Specific plate made of 5083 aluminum alloy with 6 mm thickness (same samples thickness) is provided with four holes which correspond with the holes in the backing plate (figure 6). The additional plate plays two important roles. Firstly, the fixed plate via four bolts will withstand the transvers force. Secondly, the main aim of this plate to eliminate the exit hole. This plate is preferred to make from the same material of sample plates (In this case it is designed to weld 5083 aluminum alloys). Some times and according to the standard length another additional plate can be used at the starting side. There is no specific details for this plate.



(a) (b)
Fig. 5 Fasten plate (a) photograph of plate; (b) drawing details



(a) (b)
Fig. 6 Additionalplate (a) photograph of plate; (b) drawing details

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After designing and fabricating of various parts the end plates, backing plate and lateral plates are joined together by arc welding to form one piece. Figure (7) shows 3D view of the various components of the system. Before fasten the total system on the milling machine table eight bolts are entered in the holes of the backing plate where the heads of the bolts are accommodated in the pockets at the bottom side of the backing plate. An additional plate is fixed at the end of the backing plate. The work pieces are placed on the backing plate adjacent to the additional plate. By applying the torque on the horizontal bolts, which entered through the holes in the lateral plates, will make the plates come close to each one and prevent the presence of the gap between the work pieces during the welding. Depending on the length of the work pieces a proper another additional plate may be inserted during the slots of the lateral plates to arrest the work pieces from the starting side. The clamps are placed over the work pieces through the bolts then by applying the torque on the nuts the work pieces will be secured between the backing plate and clamps. In this case the work pieces will be arrested from all directions i.e. the work pieces will be surrounded by the backing plate, clamps, additional plates, horizontal bolts. Then the fixture is fixed on the table via the end plates as shown in figure (8). The presence of the slots in the end plates make the ability to fasten the fixture on the table easily where the fixture can be move in the lateral direction to fit the tunnel of the table. Once the tool is arrived the additional plate then the tool is withdrawn. After the welding the contact area between the work pieces and the additional plate will depend on the shoulder diameter and the contact area can be trimmed easily. Different dimensions like thicknesses, width and length of the work pieces can be used.

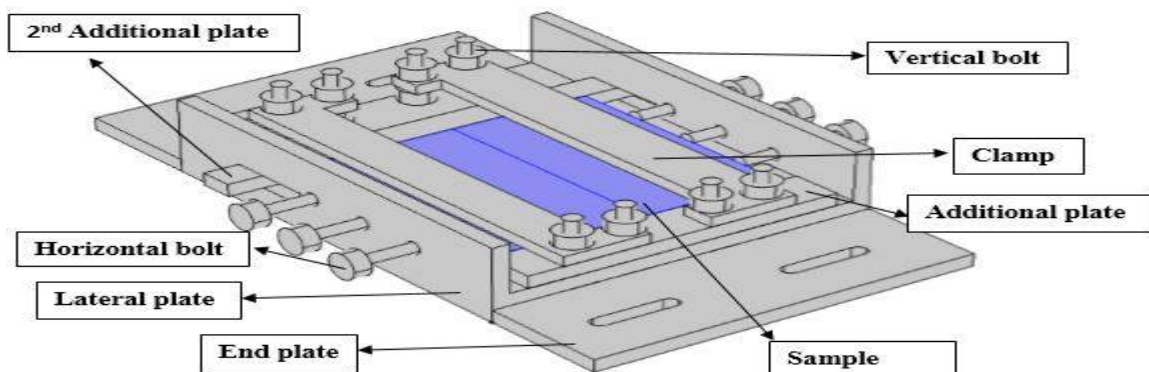


Fig. 7 3D view of the various components of the system

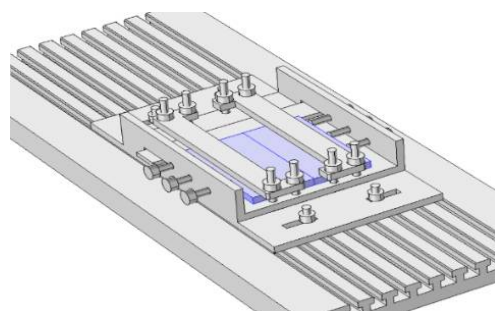


Fig. 8 3D view of the system on milling machine table

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III. TESTING OF THE FIXTURE

Figure (9) shows the experiment setup where the fixture was fastened on the milling machine table. Two samples of 5083 aluminum plates were fixed on the fixture with 6 mm thickness. Non consumable tool made of SS 310 with 18 mm shoulder diameter, 5.7 mm pin length and 6 mm pin diameter was selected for this operation. The rotational speed was 710 rpm and manual feed for the table.



Fig. 9 Experiment setup

IV. EXPERIMENTAL RESULTS

The fixture was successfully fastened on the milling machine table. The samples were successfully joined by friction stir welding process. During the operation no vibration was observed and after the welding there was no distortion in the samples.

V. CONCLUSIONS

The proposed fixture is highly useful especially for research purposes and many features can be gained:

- The present design is useful to use the milling machine to perform the friction stir welding process.
- The fixture is useful to weld all the connection line between the work pieces to eliminate the exit hole in the work pieces.
- The thickness, the length and the width of the work pieces can be varied.
- Improving the weld quality by withstanding the forces which appear during the welding process.
- The work pieces can be hold rigidly in the proposed fixture with the absence of the vibration and distortion during the welding process.
- The fixture is removable and suitable for different table dimensions of the milling machine.
- The design is simple and cost effective.
- The fixture was successfully fastened on the milling machine table and the experiment was successfully done.

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