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DESIGN AND DEVELOPMENT OF MILLING FIXTURE FOR FRICTION STIR WELDING

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Abstract

Friction-Stir Welding (FSW) is a solid-state joining process in which there is a relative motion between the tool and work piece, which produces the heat required that makes the material of the two edges to join by atomic diffusion. Friction-Stir Welding of Stainless Steel, Aluminium and various other alloys are done on retrofitted Vertical Milling Machines. For this Friction-Stir Welding operation to occur in a Milling Machine, a milling fixture is required on which the plates which are to be butt welded is to be bolted. In this paper, we developed a milling fixture and its clamping setup for a Vertical Milling Machine in which Friction-Stir Welding operations are to occur. The fixture was first designed using SOLIDWORKS Software keeping the accommodation of both backing plate and metal plate into consideration. The screw clamps are designed in such a way to hold the work pieces rigidly during Friction-Stir Welding operation. Taking into account the lateral and transverse movement of the tool and work piece, a new type of adjustable fixture was designed and fabricated. Later, the testing of the fixture is carried out by the use of ANSYS Software. The fixture is designed and analyzed for three different materials. The materials analyzed are Cast Iron (C45), Die Steel (D4) and Tool Steel and Hard Alloy (H20). After analyzing, the better material can be used for Friction-Stir Welding operations.

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Keywords: Friction-Stir Welding; SOLIDWORKS, ANSYS, Fixture.

1.0 Introduction

1.1 Fixture for Friction Stir Welding

Friction-Stir Welding (FSW) is a solid state welding process in which the materials are joined without melting. Invented, patented and developed at The Welding Institute (TWI), UK in 1991[1], it is successfully being applied to an increasing number of joining applications worldwide. In this process a rotating non consumable tool is made to rotate over the work piece and the welding process is completed. Friction-Stir Welding machines are really expensive so an alternate has been used. The advancement of using a Vertical Milling Machine as a Friction-Stir Welding machine has been adopted now-a-days. The precision of the tool and the position of the tool are in key

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issues in these criteria. When the tool is pressed in the work piece there is a pressure gap created in the work piece. In order to avoid such gaps during welding operations, clamps are used. By the usage of better clamps the weld can be more precise and accurate.

Pushp Kumar Baghel and Arshad Noor Siddiquee [2] developed and fabricated a fixture for Friction-Stir Welding. The fixture was designed in such a way to accommodate specific structures only. It can be used for multiple production of the same type of weld. There are no adjustments for varying lengths and thickness of the work piece. Biswajit Parida, Shiv Dayal Vishwakarma and Sukhomay Pal [3] developed a clamping system and an instrumented setup for a vertical milling machine for Friction-Stir Welding operations and measured the process forces. The strains were all analyzed using Wheatstone Bridge. They developed and fabricated a milling fixture for Friction-Stir Welding.Jawdat A. Al-Jarrah, Sallameh Swalha, DeyaA. Al Qahsi [4] studied the welding equality and analyzed the mechanical properties of Aluminium alloy joints prepared by Friction-Stir Welding. They have investigated the appearance and mechanical properties of the Friction-Stir Welded plates with different parameters like rate of heat input, rotational speed, grain size of stir zone, etc., Mokhtar Awang, Sajjad Raza Khan and Bilal Ghazanfar [5] have designed and fabricated an adjustable-angle fixture to incorporate tool tilting in a CNC milling machine with fixed spindle head. In particular milling machines the head is fixed, so the base can be tilted at a particular angle for Friction-Stir Welding to occur. Suleiman Alali and Niranjan Kumar Injeti [6] have designed and fabricated a fixture design for a milling machine to perform the function of Friction-Stir Welding and to eliminate the exit. They analyzed the need of a better exit hole in a fixture and designed the fixture allowing the easier exit of the work piece. Binxi Chen, Ke Chen and Wei Hao [7] developed the Friction-Stir Welding for small dimensioned Al3003 and pure Copper pipes. They studied that a distinctive temperature history due to heat accumulation was identified as an important feature for Friction-Stir Welding of small dimensioned pipes, thus leading to distinctive variations of surface conditions and other parameters. The work holding devices were manipulated to hold the distinct small elements. D. Trimble, G. E. O'Donnell and J. Monaghan [8] studied the characterization of tool shapes and rotational speed for increased speed during Friction-Stir Welding. They improvised a combination of tool force monitoring and post weld arrangement to determine effective welding parameters for the production of good quality weld. It was also analyzed at the highest possible welding speeds. X. Cao, M. Jahazi [9] analyzed the effects of welding speed on the quality of Friction-Stir Welded butt joints of a Magnesium alloy. The welding speed ranging from 5 to 30mm/s on a 2mm butt joint was analyzed on a Friction-Stir Welded AZ31B-H24 Magnesium alloy, and process parameters were determined. T. Saeid, A. Abdollah-Zadeh and F. Malek Ghaini [10] analyzed the Friction-Stir Welding on microstructure and mechanical properties of the weld on a duplex Stainless Steel. They used a single tool made of a WC-base material, to weld 2mm thick plates at a constant rotational speed of 600rpm. They analyzed that increasing the welding speed decreased the size of grains and hence improved the mean hardness value and tensile strength of the welded material. P. Cavaliere, G. Campanile, A. Squillace [11] studied the effect of welding parameters on mechanical and micro structural properties of AA6056 joints produced by Friction-Stir Welding. Their effects on the fixture due to the process parameters are also determined. R. Padmanaban, V. Ratna Kishore and V. Balusamy [12] studied the numerical simulation of temperature distribution and material flow during Friction-Stir Welding of dissimilar Aluminium alloys. They also studied the effect of temperature on the work holding device. They identified that Friction-Stir Welding is not only possible in welding of similar elements but also dissimilar alloys of various material combinations can be welded. Work plan for plant layout and process planning procedure for developing new plant by using new fixtures are discussed [18,19]. Some time metal matrix composites may be used for fabricating the fixture components.[20,21,22].

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2.0 Design and Analysis of the Fixture

2.1 Design using SOLIDWORKS

The fixture is basically considered upon the later designs and new innovations are made to Friction-Stir weld on both the directions. The fixture is built upon a single hard material and is cut at intrinsic shapes to attain a slot for the insertion of work piece. The holes for clamps are also cut in the fixture. The base of the fixture ix modified in such a way to accommodate the fixture on the work bed. The corners are filleted to reduce the deformation force caused at the corners. An extra element is added to sides of the top faces to avoid more deflection and to stabilize bending.

The design of the Fixture by using SOLIDWORKS software is shown in figure 1.

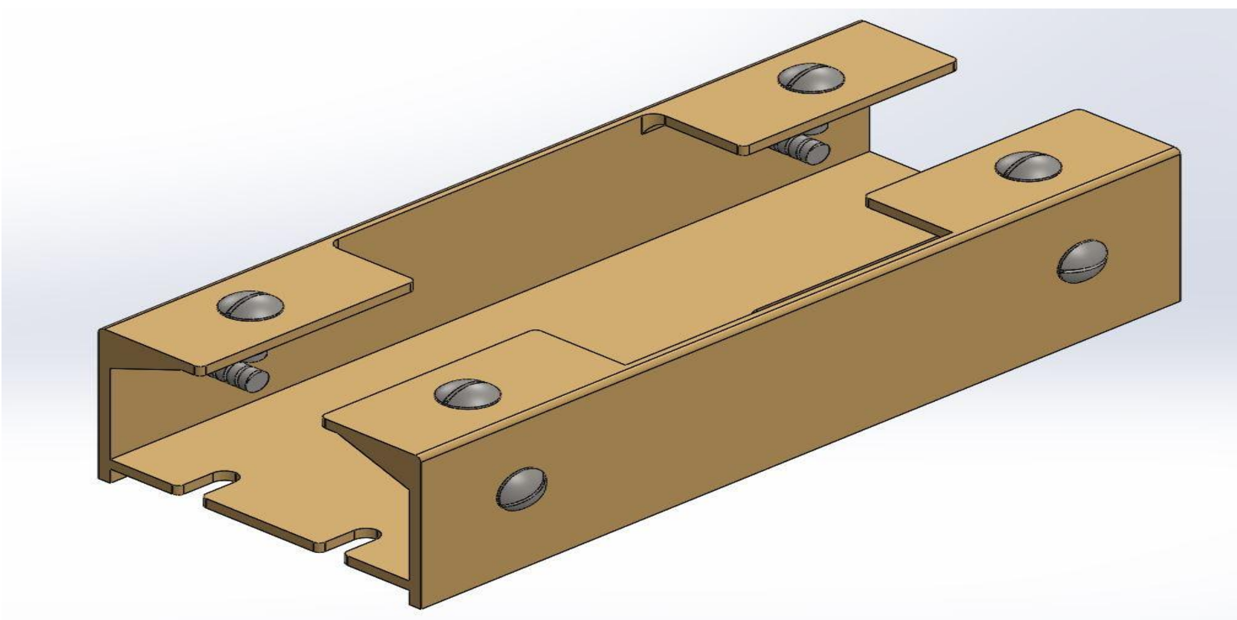

Fig. 1 Isometric view of the Fixture

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The various views of the Fixture depicting the exact location of clamps and key slots are

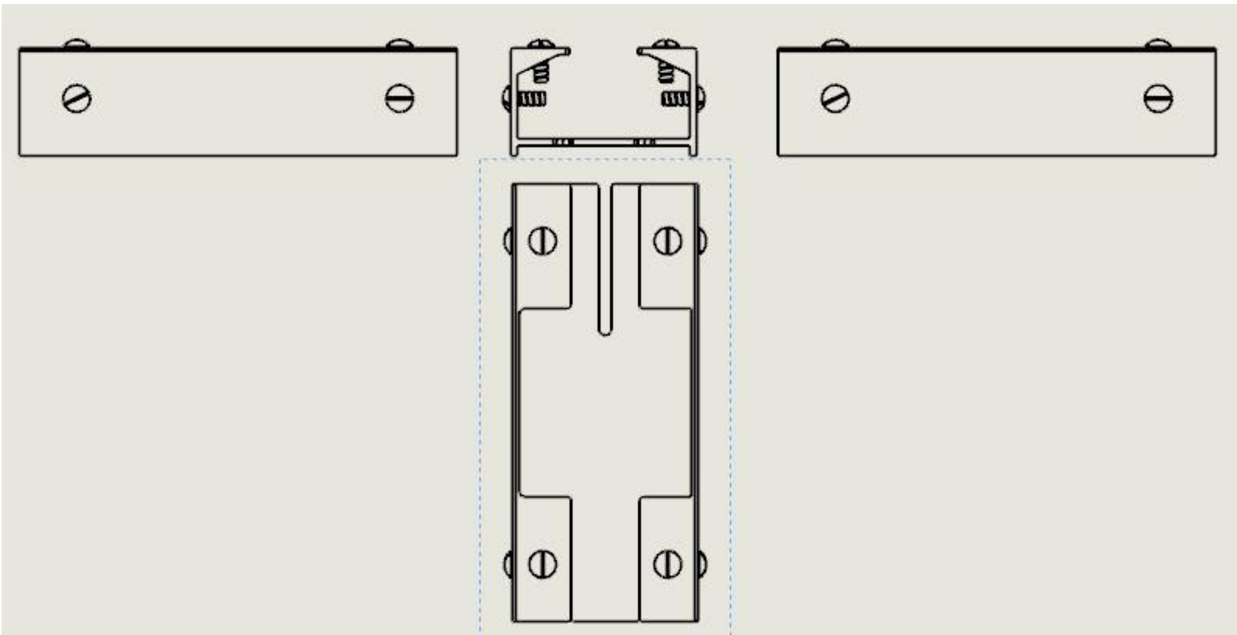

Fig. 2 Various views of the Fixture

2.2 Analysis of the fixture

The fixture is analyzed for three different materials. The materials that are analyzed are Cast Iron (C45), Die Steel (D4) and Tool Steel and Hard Alloy (H20). The properties of these materials are depicted in the table below:

	C45	**D4**	**H20**
Poisson Ratio	0.29	0.28	0.28
Density	7850 kg/m^3	7700 kg/m^3	7800 kg/m^3
Young's Modulus	210GPa	200GPa	180GPa
Tensile Strength	700 N/mm^2	670 N/mm^2	1110 N/mm^2

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The stress and deformation diagram obtained for C45 using ANSYS Software is

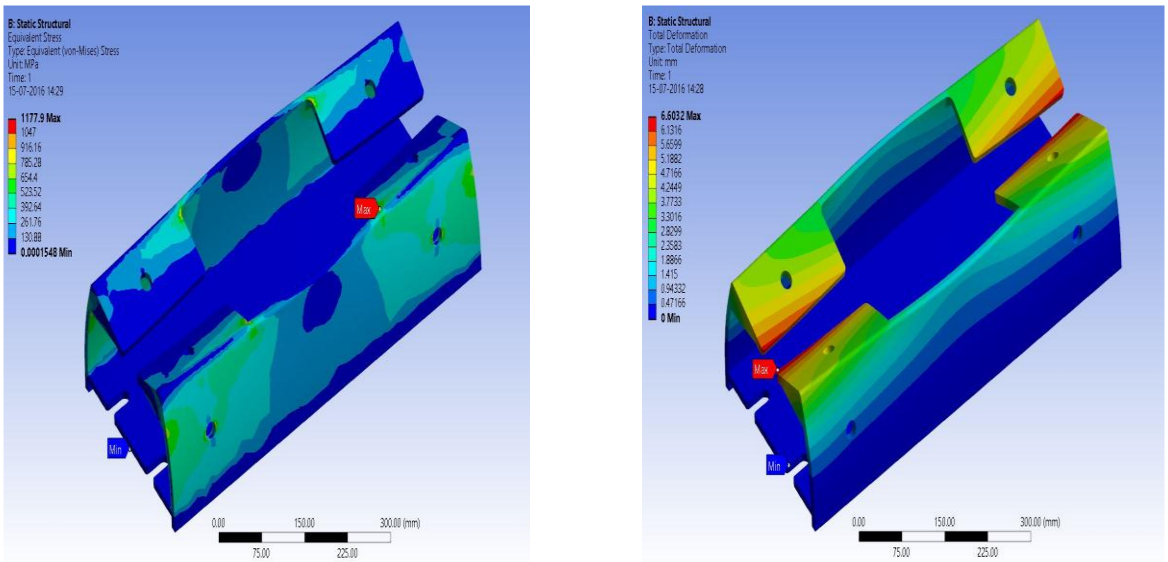

Fig. 3 Stress and Deformation Diagram for C45

The stress and deformation diagram obtained for D4 using ANSYS Software is

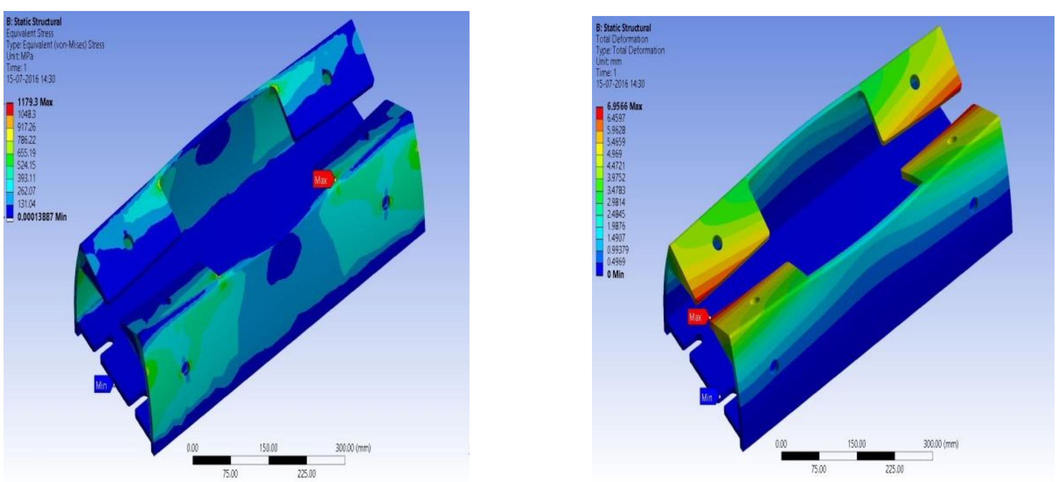

Fig. 4 Stress and Deformation Diagram for D4

The stress and deformation diagram obtained for H20 using ANSYS Software is

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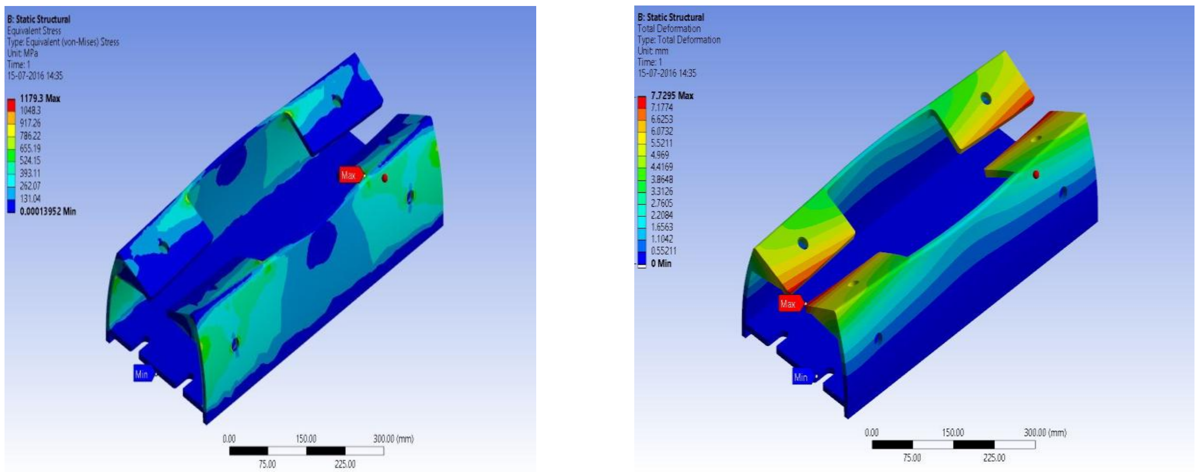

Fig. 5 Stress and Deformation Diagram for H20

3.0 Conclusion

From the figures 3,4and 5, it may be concluded that the stress concentration factor is very less in all areas and hence the deformation for all the three materials comes around 7mm maximum which is tolerable. The presence of wedge in the corners of the plate reduces the stress and hence improves the overall performance of the fixture. The refinement mesh has been incorporated to improve the overall meshing quality in and around the circle areas such that it can tolerate bi axial stresses. The value of stress comes around 1179.3N/mm^2 has the optimal solution for friction stir welding operations and hence C45 steel material can be used as alternate fixture material compared to D4 and H20 materials.

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