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DEVELOPMENT AND CONSTRUCTION OF A FIXTURE FOR ENHANCING FRICTION STIR WELDING OPERATIONS

Abhilash V[1], Prabakaran P[2], Dhilip Kumar D[4], Thamizhmurasu[4]

[1,2,3]Assistant Professor, Department of Mechanical Engineering, PERI Institute of Technology, Chennai.

[4]Department of Mechanical Engineering, PERI Institute of Technology, Chennai.

ABSTRACT

Friction Stir Welding being a solid-state process is free from defects generally occurs in fusion welding process. FSW of Stainless Steel is done on retrofitted vertical milling machine. For this welding operation a fixture is needed on which the plates which are to be butt welded is to be bolted. Fixture is required in various industries according to their application. This can be achieved by selecting the optimal location of fixturing elements such as locators and clamps.In this paper first fixture is designed using CREO software keeping certain things in view like groove of fixture to be such that it accommodates both backing plate and metal plate to be welded, then development of fixture is done using CREO drawing. We developed a clamping system and an instrumented setup for a vertical milling machine for friction stir welding (FSW) operations and measuring the process forces. Taking into account the gap formation (i.e., lateral movement) and transverse movement of the workpiece, a new type of adjustable fixture was designed to hold the workpiece being welded.

Keywords: Friction Stir Welding, Solid-State Joining, Weld Quality, Material Compatibility, Industrial Applications

1. Introduction

Friction stir welding (FSW) was first invented by The Welding Institute (TWI), UK in 1991 as a solid-state joining process. It is the process that involves plunging a portion of a specially shaped rotating tool between the abutting faces of the joint. The relative motion between the tool and the substrate generates frictional heat that creates a plasticized third-body region around the immersed portion of the tool. The contact of the shouldered region of the tool with the work pieces also generates significant frictional heat, as well as preventing plasticized material from being expelled. The tool is moved (relatively) along the joint line, forcing the plasticized material to coalesce behind the tool to form a solid-phase joint. At present, Friction Stir Welding has found various applications in a number of areas. Potential applications are space shuttle fuel tanks, aluminum decking for car ferries, manufacturing of compound aluminum extrusions and automotive structural components. Most of the applications are on aluminum alloys although several facilities have reported experiments on titanium alloys and steels. The process is not yet fully understood and further research is required to optimize this technology It is one of the emerging welding techniques and due to its advantages over fusion welding technique it has drawn attention of various researchers around the world. Apart from metallurgical and environmental benefits it has energy benefits as well, like only 2.5% of laser welding energy is needed for FSW.

FSW of Steel alloys requires a more careful design of both the fixture and the tooling with respect to FSW of aluminum alloys. As far as the fixture design is concerned , it is always regarded as the first problem to be overcome due to the high temperatures reached during the process; under such extreme conditions, the welded blanks are likely to remain stuck to the backplate compromising both the soundness of the joint and the integrity of the fixture itself. The fixture should be such that it should withstand the forces and rising temperature during welding process without distortion in shape. FSW is performed on a retrofitted vertical milling machine. To support the metal plates to be joined, the fixture is designed and fabricated using different machining processes. The main purpose of a fixture for friction stir welding is to hold the workpieces in position during welding. However, there is limited published information that details the fixture design requirements. The main reason for having appropriate clamps or fixtures is to prevent the specimens from moving while being welded. Obtaining good stability during the process is important since any deflection or major vibration would affect the quality of the weld. Certain features should be kept in mind while designing the fixture.

2. Experiment

A fixture's primary purpose is to create a secure mounting point for a workpiece, allowing for support during operation and increased accuracy, precision, reliability, and interchangeability in the finished parts. It also serves to reduce working time by allowing quick set-up, and by smoothing the transition from part to part. It frequently reduces the complexity of a process, allowing for unskilled workers to perform it and effectively transferring the skill of the tool maker to the unskilled worker. Fixtures also allow for a higher degree of operator safety by reducing the concentration and effort required to hold a piece steady.

Several machining operations require strong base plates. For example, a milling operation may require a tool steel plate with a 3/4 in. (19 mm) or 1 in. (25.4 mm) thickness. Here we used 15 mm plate of size 350X 250mm. Die is the main part which holds all the parts of the fixture including jaws, screw rods, clamps, etc. It is the very heavy part of the fixture and is made of mild steel. In this block two small projections are made for one end to arrest the workpiece movement from X axis direction. The dimensions of the die is 250X250X90 mm. There are two movable jaws in the fixture as it is designed for self-centering. And has two V shaped projection on each jaw to guide the jaw without twisting or tilting. They arrest the motion of the workpiece from Y axis. The clamps arrest the movement of the workpiece from the top so Z axis motion is arrested. Hence the workpiece is held firmly. The screws are responsible for the movement of the jaws. When the screws are rotated along its axis the jaws moves in a corresponding motion.

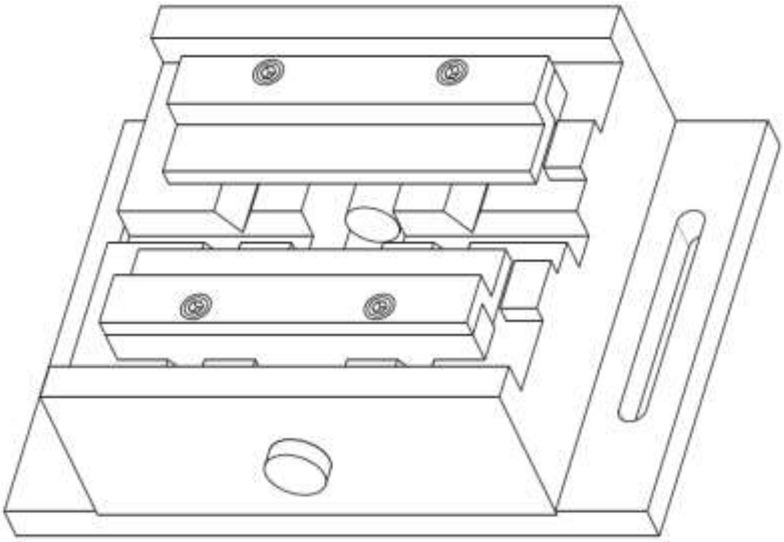
Fig 91.1 Fixture Assembly

3. Discussion

Friction stir welding is a solid-state joining process that uses a non-consumable tool to join two facing workpieces without melting the workpiece material. Heat is generated by friction between the rotating tool and the workpiece material, which leads to a softened region near the FSW tool. While the tool is traversed along the joint line, it mechanically intermixes the two pieces of metal, and forges the hot and softened metal by the mechanical pressure, which is applied by the tool, much like joining clay, or dough. It is primarily used on wrought or extruded aluminium and particularly for structures which need very high weld strength. FSW is also found in modern shipbuilding, trains, and aerospace applications.

Figure 91.2: FSW Machining

A rotating cylindrical tool with a profiled probe is fed into a butt joint between two clamped workpieces, until the shoulder, which has a larger diameter than the pin, touches the surface of the workpieces. The probe is slightly shorter than the weld depth required, with the tool shoulder riding atop the work surface. After a short dwell time, the tool is moved forward along the joint line at the pre-set welding speed. Frictional heat is generated between the wear-resistant tool and the work pieces. This heat, along with that generated by the mechanical mixing process and the adiabatic heat within the material, cause the stirred materials to soften without melting. As the tool is moved forward, a special profile on the probe forces plasticized material from the leading face to the rear, where the high forces assist in a forged consolidation of the weld. This process of the tool traversing along the weld line in a plasticized tubular shaft of metal results in severe solid-state deformation involving dynamic recrystallization of the base material.

Heat generation during friction-stir welding arises from two main sources. Friction at the surface of the tool and the deformation of the material around the tool. The heat generation is often assumed to occur predominantly under the shoulder, due to its greater surface area, and to be equal to the power required to overcome the contact forces between the tool and the workpiece. The contact condition under the shoulder can be described by sliding friction, using a friction coefficient μ and interfacial pressure P, or sticking friction, based on the interfacial shear strength at an appropriate temperature and strain rate. Mathematical approximations for the total heat generated by the tool shoulder Qtotal have been developed using both sliding and sticking friction models.

$$Q_{\text{total}} = \frac{2}{3}\pi P \mu \omega \left(R^3_{\text{shoulder}} - R^3_{\text{pin}} \right), \quad \text{(sliding)}$$

$$Q_{\text{total}} = \frac{2}{3}\pi \tau \omega \left(R^3_{\text{shoulder}} - R^3_{\text{pin}} \right), \quad \text{(sticking)}$$

Where ω is the angular velocity of the tool, Rshoulder is the radius of the tool shoulder, and Rpin is that of the pin. Several other equations have been proposed to account for factors such as the pin, but the general approach remains the same.

Conclusion

In this paper, the work of friction stir welding which is done on the conventional milling machine using a fixture which was designed. Anyhow arresting the workpiece in position for the first time was a great challenge. Hence, the friction stir welding is done manually with a great success. Still the both materials of work piece is not same and under goes thermal deformation only in the lower grade material (Al1100).

References

1. Design of Fixture by Pushp Kumar Baghel, Arshad Noor Siddiquee
2. Design of tool by M.Melendez, W.Tang, J.C Mc Clure
3. Studies and experimentation on FWS by KudzanayiChiteka
4. Manufacturing technology by M.Haslehurst
5. Design of Machine Elements by R. S. Khurumi
6. Hamilton, C. S. Dymek and A. Sommers, A thermal model of friction stir welding in aluminum alloys. International Journal of Machine Tools and Manufacture, 2008. 48(10): p. 1120-1130.
7. Wadeson, D.A., et al., Corrosion behaviour of friction stir welded AA7108 T79 aluminium alloy. Corrosion Science, 2006.
8. Zeng, W.M., H.L. Wu, and J. Zhang, Effect of Tool Wear on Microstructure, Mechanical Properties and Acoustic Emission of Friction Stir Welded 6061 Al alloy. Acta MetallurgicaSinica (English Letters), 2006.
9. Maggiolino, S. and C. Schmid, Corrosion resistance in FSW and in MIG welding techniques of AA6XXX. Journal of Materials Processing Technology, 2008.
10. Brian J. Dracup, W.J.A., Friction stir welding as a rivet replacement technology. 2003

11. Elangovan, K. and V. Balasubramanian, Influences of tool pin profile and welding speed on the formation of friction stir processing zone in AA2219 aluminium alloy.
12. Squillace, A., et al., Optimization of friction stir welds of aluminium alloys, in Intelligent Production Machines and Systems. 2006