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Design and Analysis of Friction Stir Welding Tools

K.Vara Prasad¹, K. Namcharaiah²

P.G. Student, Department of Mechanical Engineering, VNR College of Engineering, Ponnur, Guntur, India¹

Associate Professor, Department of Mechanical Engineering, VNR College of Engineering, Ponnur, Guntur, India²

ABSTRACT: Friction-stir welding (FSW) is a solid-state joining process (the metal is not melted) that uses a third body tool to join two facing surfaces. Heat is generated between the tool and material which leads to a very soft region near the FSW tool. It then mechanically intermixes the two pieces of metal at the place of the joint, then the softened metal (due to the elevated temperature) can be joined using mechanical pressure (which is applied by the tool), much like joining clay, or dough. In this project we have designed circular tool by using creo-2 and then applied static (tool rotational velocity 1000 rpm) and thermal (temperatures' and convection on plates and tool also) boundaries conditions. And calculated results like deformation stress and heat flux etc. Here we also designed 3 more tools hexagonal and tapered and truncated and applied same boundary condition with same material properties and calculated all results from all these results which tool can be used in the place of circular tool.

KEYWORDS: Friction-stir welding, deformation stress, heat flux, creo-2, ANSYS, results

I. INTRODUCTION

Friction-stir welding (FSW) is a solid-state joining process (the metal is not melted) that uses a third body tool to join two facing surfaces. Heat is generated between the tool and material which leads to a very soft region near the FSW tool. It then mechanically intermixes the two pieces of metal at the place of the joint, then the softened metal (due to the elevated temperature) can be joined using mechanical pressure (which is applied by the tool), much like joining clay, or dough. It is primarily used on aluminium and most often on extruded aluminium (non-heat treatable alloys), and on structures which need superior weld strength without a post weld heat treatment. It was invented and experimentally proven at The Welding Institute UK in December 1991. TWI holds patents on the process, the first being the most descriptive. A constantly rotated non-consumable cylindrical-shouldered tool with a profiled probe is transversely fed at a constant rate into a butt joint between two clamped pieces of butted material. The probe is slightly shorter than the weld depth required, with the tool shoulder riding atop the work surface. Frictional heat is generated between the wear-resistant welding components 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 pin is moved forward, a special profile on its leading face forces plasticised material to the rear where clamping force assists in a forged consolidation of the weld. This process of the tool traversing along the weld line in a plasticised tubular shaft of metal results in severe solid state deformation involving dynamic re-crystallization of the base material.

Paper is organized as follows. Section II describes related information about friction stir welding tools. Section III lists out various materials and manufacturing processes for friction stir welding tools whereas Section IV presents the experimental results and Section V presents conclusion.

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II. RELATED INFORMATION

The solid-state nature of the FSW process, combined with its unusual tool and asymmetric nature, results in a highly characteristic microstructure. The microstructure can be broken up into the following zones:

1. The stir zone (also nugget, dynamically recrystallised zone) is a region of heavily deformed material that roughly corresponds to the location of the pin during welding. The grains within the stir zone are roughly equiaxed and often an order of magnitude smaller than the grains in the parent material
2. The flow arm zone is on the upper surface of the weld and consists of material that is dragged by the shoulder from the retreating side of the weld, around the rear of the tool, and deposited on the advancing side.
3. The thermo-mechanically affected zone (TMAZ) occurs on either side of the stir zone. In this region the strain and temperature are lower and the effect of welding on the microstructure is correspondingly smaller.
4. The heat-affected zone (HAZ) is common to all welding processes. As indicated by the name, this region is subjected to a thermal cycle but is not deformed during welding. The temperatures are lower than those in the TMAZ but may still have a significant effect if the microstructure is thermally unstable.

The solid-state nature of FSW leads to several advantages over fusion welding methods as problems associated with cooling from the liquid phase are avoided. Issues such as porosity, solute redistribution, solidification cracking and liquation cracking do not arise during FSW.

- Good mechanical properties in the as-welded condition
- Improved safety due to the absence of toxic fumes or the spatter of molten material.
- No consumables — A threaded pin made of conventional tool steel, e.g., hardened H13, can weld over 1 km (0.62 mi) of aluminium, and no filler or gas shield is required for aluminium.
- Easily automated on simple milling machines — lower setup costs and less training.
- Can operate in all positions (horizontal, vertical, etc.), as there is no weld pool.
- Generally good weld appearance and minimal thickness under/over-matching, thus reducing the need for expensive machining after welding.

III. IMPORTANT WELDING PARAMETERS

There are few important welding parameters which determine the performance of the welding operation. We as part of this project try to analyse them in detail.

- The design of the tool is a critical factor as a good tool can improve both the quality of the weld and the maximum possible welding speed.
- There are two tool speeds to be considered in friction-stir welding; how fast the tool rotates and how quickly it traverses the interface. These two parameters have considerable importance and must be chosen with care.
- The plunge depth is defined as the depth of the lowest point of the shoulder below the surface of the welded plate and has been found to be a critical parameter for ensuring weld quality.
- Early work on the mode of material flow around the tool used inserts of a different alloy, which had a different contrast to the normal material when viewed through a microscope, in an effort to determine where material was moved as the tool passed.
- For any welding process it is, in general, desirable to increase the travel speed and minimise the heat input as this will increase productivity and possibly reduce the impact of welding on the mechanical properties of the weld. At the same time it is necessary to ensure that the temperature around the tool is sufficiently high to permit adequate material flow and prevent flaws or tool damage

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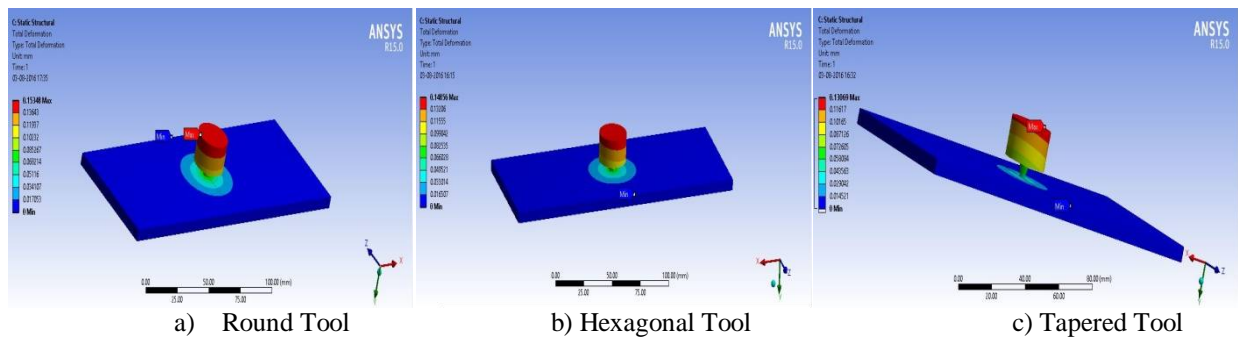
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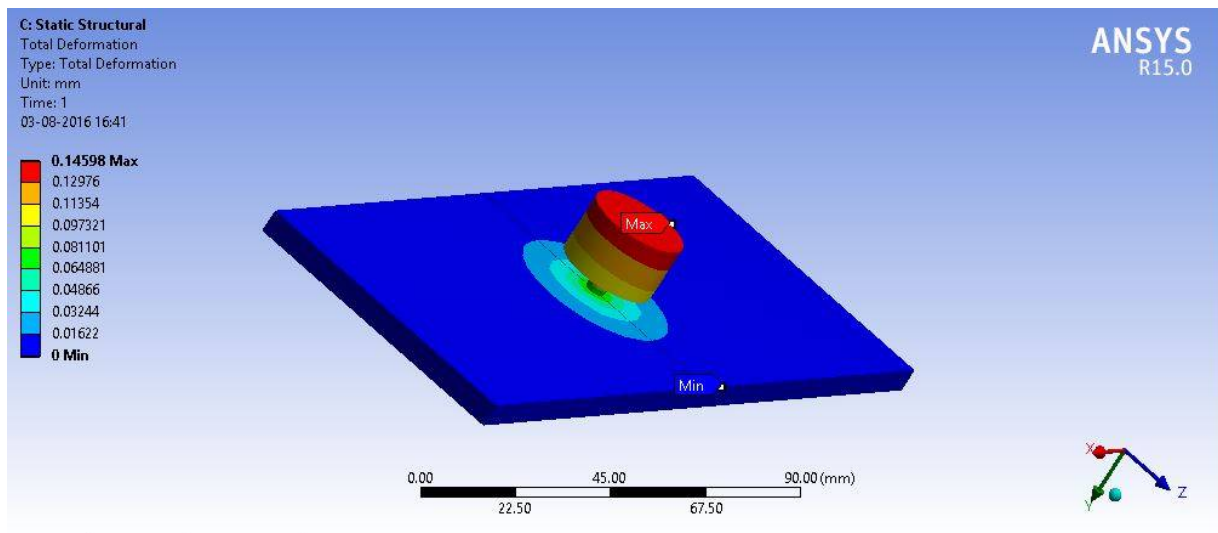
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IV. EXPERIMENTAL RESULTS

Figures show the results of static structural analysis results for four different tools engaged in Friction Stir Welding. They are a) Round tool b) Hexagonal tool c) Tapered tool d) Truncated tool



On detailed observation, we get to know the stress values for four different types of tools. On the basis of the stress values thus obtained, we derive conclusion and can decide the better tool for conduction of friction stir welding.



V. CONCLUSION

In our project we have designed 4 types of cutting tools Round, hexagonal and tapered and truncated for doing Friction Stir Welding of two dissimilar materials Aluminium alloy 6061 for plates and steel (tool) running at speed of 1000 rpm. And we conducted static analysis on it, in this project the round tool is considered as a existing tool and also we analysed other 3 tools with same boundary conditions and material. from the results when we were using circular tool it has been produces 462Mpa stress on the plate but the tapered tool produces 357.79Mpa only

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