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Recent Publications

Accepted

1. N. A. Jaafar, A. B. Abdullah and Z. Samad, "*Effect of punching die angular clearance on punched hole quality of S275 mild steel sheet metal*", The International Journal of Advanced Manufacturing Technology, In Press, 2018. (IF 2017 = 2.601 Q2). https://doi.org/10.1007/s00170-018-3040-4.

Active Grants

Title: Modeling of Twist Springback Pattern of Aluminum Alloy Strip with Non-Uniform Section.
FRGS (2014 – 2017)

New Research

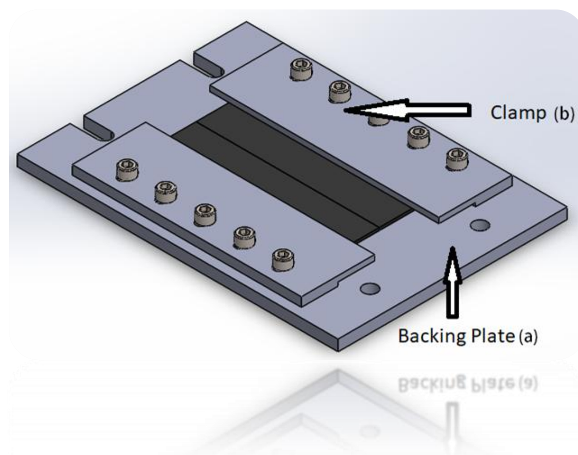
Friction Stir Welding (FSW) is the recent research topics explored by the group. It is known as one of the techniques in producing tailor blanks. FSW in a solid-state welding, where a non-consumable tool rotates at very high speed to generate heat and join two facing material without melting them. This technique gets tremendous attention by researcher as well as academician. There are many advantages and disadvantages of FSW. Based on the literatures, most of the present works were involve in optimization of the tool geometries, determination of efficient welding parameters and selection of most suitable welded material combinations whether similar or dissimilar metals. At the MFRL, our focus is on the post-forming behavior of the welded blank including formability and in achieving zero geometrical defects. This is the third techniques after forging and laser welding.

New Member

The Lab received another Master student as a new member, Adha Pahmi bin Fauzi. He is working on similar and dissimilar aluminum alloys friction stir welding. His focus is on the post-forming behavior of the welded blank such as springback pattern. His project is funded under Bridging Grant and Research University Grant by USM.

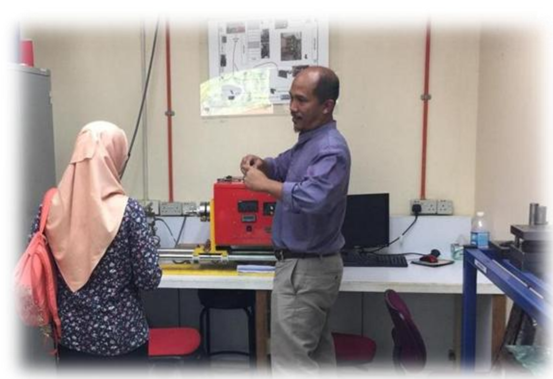
Name	Adha Pahmi bin Fauzi
Research Title	Experimental evaluation of Aluminum alloy tailor welded blank fabricated using friction stir welding.
Main Supervisor	Associate Professor Ir. Dr. Ahmad Baharuddin Bin Abdullah
Start	October 2018

(MSc)



Visitor from UM

On the 14th of December 2018, the Metal Forming Lab has received a visit by our counterpart from University of Malaysia (UM), Assoc. Prof. Dr. Farazila Yusof. Discussion was focusing on the possibility of research collaboration between USM and UM in laser welding and friction stir welding (FSW), as well as facilities sharing between these two parties. Note that, two of our post-graduate students are using laser welding machine station at the Centre of Advanced Manufacturing and Material Processing (AMMP), one of the top research centre in UM.



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Overview of Friction Stir Welding

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The transportation sector is one of the largest contributors of greenhouse gas emissions, accounting for over 26% of the global CO_2 emission levels and is one of the few industrial sectors where emissions are still growing (Chapman, 2007). Many countries in the world are introducing increasingly stringent regulations to control and reduce the level of greenhouse gas emissions from motor vehicles. As a result, automotive manufacturers are constantly seeking new ways to comply with these policies in developing energy efficient vehicles by exploring new drivetrain, materials and production technologies. One of the immediate solutions in creating energy efficient vehicles is to reduce the overall weight of vehicle bodies. This strategy, known as *lightweighting*, explores new materials, design and processes in producing components and structures which are significantly lighter, but fulfils the required performance requirements of the vehicle. One such technology is the use of Tailor welded blanks (TWBs), which are sheet metal blanks made up by joining smaller plates of different thicknesses and/or strengths. These TWBs can be used in sheet metal forming process of automobile structures such as in the production of the door or the bonnet of a car. TWBs have been successfully implemented in steel-based sheet metal productions, reducing waste and vehicle weights significantly. Normally, TWBs are produced using fusion welding processes such as laser beam butt welding and mash seam welding (Lee et al., 1996). Increasing use of aluminium in automotive body panels and structures invariably leads to its potential applicability in TWB technology. Incorporating TWB technology in aluminium for automotive has the potential to further increase the weight savings from the transition of steel-based structures to lighter metal alloys. However, fusion welding of light, non-ferrous alloys, such as aluminium is challenging. Fusion welding for non-ferrous materials such as aluminium has several weaknesses such as the formation of undesirable intermetallics, cracks, and porosities. In TWBs, a good weld is crack free and has high strength and reliability. The size and shape of the weld pool with low increase in hardness is desirable. Using FSW in producing non-ferrous TWB is an alternative solution. The technique has been documented by Kim et al. (2010) in the FSW of four automotive sheets of aluminium alloy 6111-T4, 5083-H18, 5083-O and DP590 steel sheets. Nevertheless, the utilisation of FSW in the production of aluminium-based TWB is relatively new and there are various issues which are yet to be addressed fully, especially for post-weld processes such as forming and bending.

Friction stir welding (FSW) is a solid-state joining process developed by The Welding Institute (TWI) Ltd in 1991 (Threadgill et al., 2009). It uses a non-consumable tool which is rotated and plunged into the interface of two workpieces. The rotation of the plunged tool causes friction which heats and softens the workpiece material. The softened material pair then gets mechanically mixed as the tool moves along the interface, creating a solid-state bond. It has shown success in the joining of non-ferrous alloys, especially for aluminium (Threadgill et al., 2009). Past studies have also explored the use of FSW to join dissimilar material combinations such as aluminium-steel (Watanabe et al., 2006), aluminium-copper (Sharma et al., 2017), aluminium-brass (Esmaeili et al., 2012), aluminium-titanium (Chen & Nakata, 2009), aluminium-magnesium (Buffa et al., 2015) and aluminium-plastic (Moshwan et al., 2014). The thickness of the material weld ranges from 2 mm to 25mm. Thin-sheet (less than 1mm) and dissimilar thicknesses FSW have been reported by Fratini et al., (2007), Leitao et al., (2009) and Mira-Aguiar et al., (2016). The major processing parameters in FSW includes the rotational speed of the tool (rpm) welding speed or transverse speed (mm/min) transverse speed, tool tilt angle, tool geometry (pin profile, tool shoulder diameter, pin diameter, D/d ratio of tool, pin length) and tool inclination angle. These parameters significantly influence the FSW process and determine the quality of the weld. Koilraj et al., (2012) found that the tool geometries, welding parameters, joint designs are among the most significant parameters affecting the material flow pattern and temperature distribution, thereby influencing the micro structural evolution of the material. It is reported that defect-free weld in dissimilar materials of AA5052 to AA2017 are obtained when the transverse speed and rotational speed are at 60 mm/min and 1000 rpm respectively. Further, the rotational speed or welding speed increases the tensile strength to a maximum value and then decreases due the occurrence of void defect. Also, in their studies on friction stir welding of AA8009, it was found that for high rotational speeds of 1200 rpm the tensile strength value was 60–70% of the base metal and for the lower rotational speed of 428 rpm it was found to be 90%. Key components of the FSW tool geometry are the tool shoulder and the pin (Casalino et al., 2014). While the shoulder is the main source of heat generated during the process, the primary constraint to material expulsion and the primary driver for material flow around the tool, the pin is the primary source for material deformation and the secondary source for heat generation in the nugget. Consequently, the geometry of both the shoulder and pin are important to the FSW process. FSW requires a proper contact between workpiece and shoulder, and it is achieved by maintaining an appropriate axial plunge load along with a shorter pin length of about 0.2–0.3 mm compared to the workpiece. The tool requires all the following characteristics: (a) as simple as shape as possible to reduce the cost; (b) sufficient stirring effect to produce sound welds for Al alloys. Due to its similar processing conditions to milling operations, FSW has been successfully conducted on modified conventional milling machines. The reconfiguration would mostly involve fabrication of a clamping and support system to hold the workpieces firmly in place and to reduce process vibrations. The design required for designing clamp is, (i) a rigid clamping is required to get sound weld and to avoid accident during friction stir welding, (ii) a backing plate is required, which will provide strong support sufficient enough to limit bending of substrate, (iii) horizontal and vertical plate movement should be restricted (Kamble et al., 2017). This approach has been verified by Hasan et al., (2017). This inexpensive milling machine adaptation allow for the conversion of conventional milling machine into a specialized Friction Stir Welding machine, suitable for research and development purposes.

Process optimization of FSW processes have been conducted by a number of researchers, such as by using Taguchi Methods (Ugrasen et al., 2018), Grey Based Taguchi Methods (Sahu & Pal, 2015) and Multi-Objective Optimization using surface response methodology (RSM) (Rajakumar et al., 2011). Among the process parameters investigated for optimization were rotational speeds, welding speed, number of passes, axial force, shoulder diameter, pin diameter and tool hardness.

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