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Research paper

Effects of Pin Diameter and Welding Position of Micro Friction Stir Spot Welding to the Mechanical Properties on Longitudinal Square Honeycomb Corrugated Panels

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Abstract

Weld aluminum material especially on thin plate is difficult because it cannot withstand the heat due to welding. Friction stir spot welding which is a solid state welding can overcome this damage because it does not require high temperatures. Then this technology is applied to the manufacture of lightweight structures square longitudinally corrugated honeycomb core sandwich panel product. This study is to determine how the pin diameter and welding position at straight and zig-zag position to the strength of the product. From the results, it is shown that diameter of the pin directly proportional to the strength of shear load. And in bending test, weld spot is an area that is weaker than the other area.

Keywords: *Micro Friction Stir Spot Weldin; Mechanical Propertie; Longitudinal Square Honeycomb Corrugated Panels*

1. Introduction

Product of lightweight structure is considered able to overcome the problems of weight and volume efficiency of a product, with a smaller density should be able to obtain the power structure that is not much different from the rigid bodies [1]. Honeycomb can be established as one of the best candidates among ultralight cellular materials for load-bearing and energy absorption applications [2].

Many researcher and scientists studied Honeycomb. Yuming Li et al studied and developed numerical modeling from the in-plane shear, torsion, in plane-shear coupled with torsion and transverse shear which were studied with skin effect: the honeycomb core's deformation was constrained by two fairly rigid skins. They concluded that a very good agreement has been achieved between numerical results issued from the H models and 3D FE modeling [3]. Another study on mechanical properties of periodic honeycomb structures with orthotropic Kagome cells was studied by Bin Niu and Bo Wang and they also investigated the wave propagation in this structure. Analytical study has been obtained the effective directional elastic stiffness, initial yield and elastic buckling strength of these honeycombs under in-plane compression and shear [4]. C. Combescure and R.S Elliott studied optimization and design of hierarchical honeycomb materials. They state that loss of strength (decreased critical load) was significant and may negate any advantages of the increased Young's modulus which was influenced considering nonlinear properties of material and their implications [5]. The manufacture and characterization of a PEEK-based zero Poisson's ratio honeycomb (SILICOMB) produced using Kirigami-inspired cutting and folding techniques were studied by R.M. Neville et al [6]. Method, structure, and material from honeycomb were many kinds of purpose.

In previous studies, welding technology still has problem [7] in this study welding technology was applied to produce a corrugated panel honeycomb, some welding parameters have been studied for example the speed of rotation pin [8], dweel time, tilt angle [8] of Micro Friction Stir Welding (μFSW) have been studied. This study is the development of the previous research to apply the welding method to produce honeycomb core sandwich panels. In welding activity on this product, the size of tools corresponding to size of core to get the best results of strength product should be determined, therefore, the research about size of pin diameter should be conducted.

Variation of size of pin diameter and welding positions was performed to determine the effect of both variables to the strength of the product. There is an optimum value of strength generated by the size of diameter pin at a certain size. The purpose of research is to study the influence of tools and position of Micro Friction Stir Spot Welding (μFSSW) to the lightweight structure longitudinal square corrugated honeycomb core sandwich panels.

2. Materials and Method

2.1 Materials

The shape of an elongated square specimen light structure sandwich panel corrugated honeycomb core is shown in Figure 1. The main materials for welding test specimen are A1100 aluminum plate with a thickness of 0.43 mm. The variation of pin diameter and welding positions was tested for 3 times. There were two kinds of testing which are bending test and shear tests, using Tensilon A&D 50 kN. The dimension of specimen is 200x105 mm. The variations of the size of a pin diameter of 2 mm, 2.5 mm and 3 mm and a variety of welding positions straight and the zig-zag were performed.

2.2 Weld Tool

The welding equipment is shown in Figure 2. This is the schematic μFSW welding equipment using a CNC machine that has been modified on the spindle.

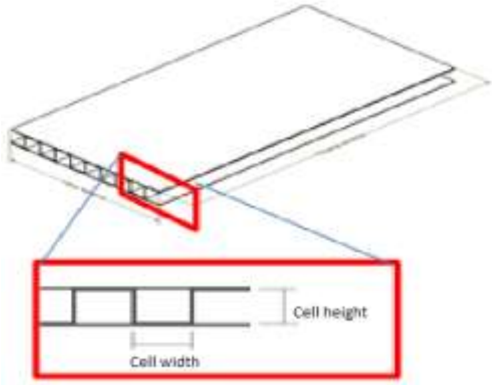


Figure 1: Geometry of core products

Large dimension of the honeycomb corrugated panel was levelled by three levels. Dimension of specimens was shown by Table 1.

Table 1: Material product

No	Part	Size plate (mm)
1	Top face and down face *for bending test*	200x110
2	Top face and down face for shear stress	200x140
3	Core	200x235

2.3 Pin Diameter

The variation of the pin diameter is 2 mm, 2.5 mm and 3 mm. The ratio of shoulder and pin is 1:2.

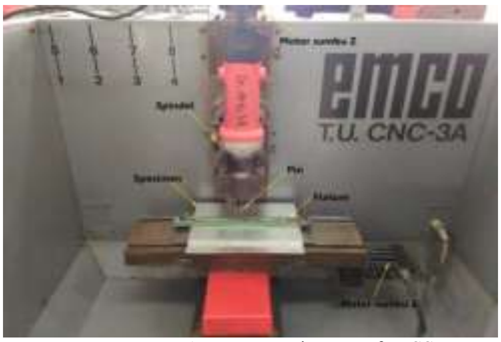
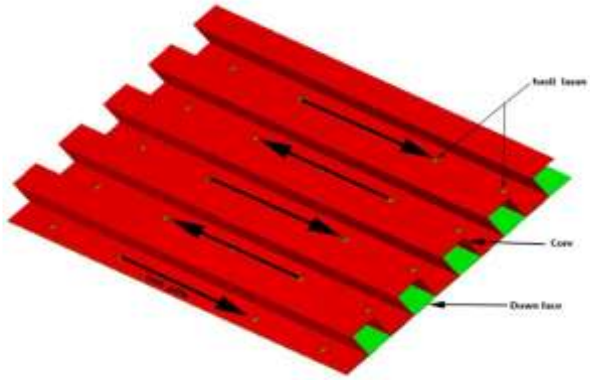


Figure 2: Equipment of μFSSW

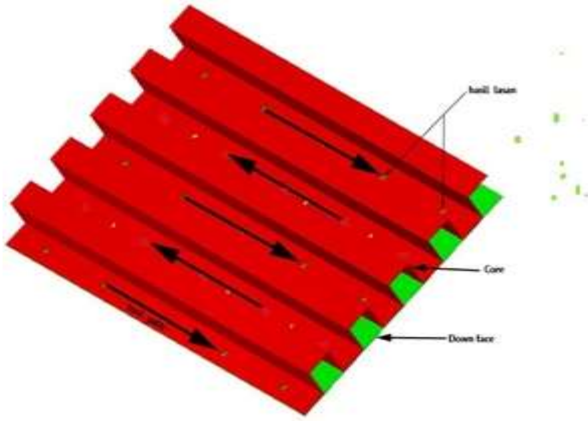
2.4 Welding Position

The variation in the position of the welding is performed with straight and zigzag position as shown in Figure 4.

Figure 3: Weld Tool of μFSSW



(a)

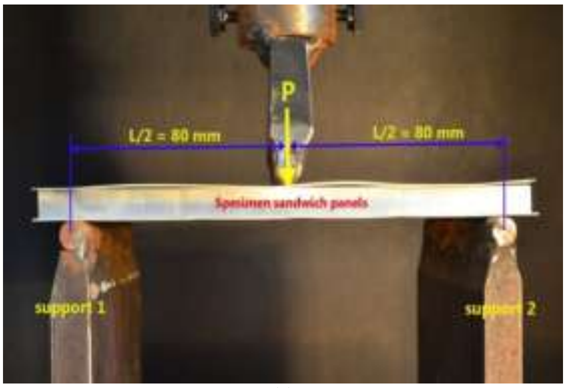


(b)

Figure 4: Welding position: (a) Straight, (b) Zig-zag

2.5 Testing

Bend testing process is conducted using Tensilon A & D machine with a capacity of 50 kN by modifying the jig from tensile to compress action with additional components, which are two pieces of support beams and compress jigs . Bending test used 3-point bending in accordance with ASTM C393 [9] as shown in Figure 5.a. For the shear test, the jig should be set using the special grip to perform shear stress. The shear test was conducted according to ASTM C273 [10] as shown in Figure 5.b.



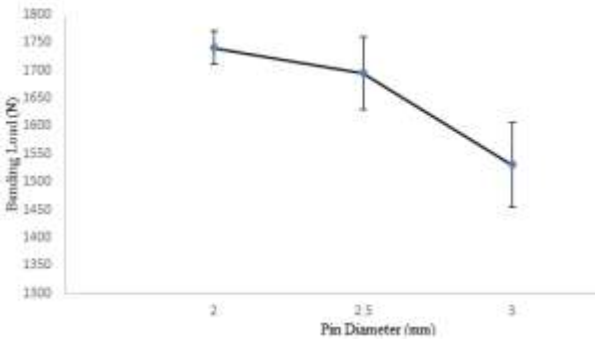
(a)

(b)
Figure 5: (a) 3-Point bending test, (b) Shear test

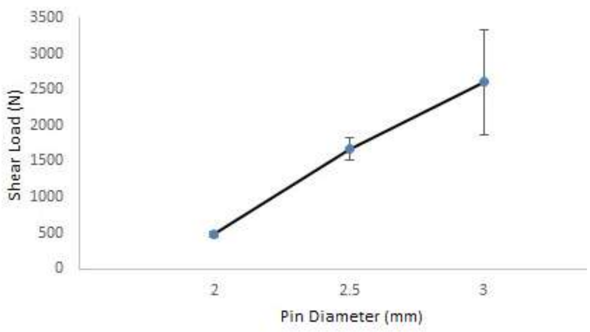
3. Result and Discussion

After the experiment, the relation between pin diameter and welding position to the bending load and shear load are shown in Figure 6 and 7. Figure 6.a. shows that by increasing the size of pin diameter the strength product of bending load decreases. However, in shear test shows that by increasing the pin diameter, the shear load will also increases as shown in Figure 6.b. In bending test, the welding activity make the core weaker in welding area than the other area and the smaller size of pin give the smaller destructive in core. However, the greater size of pin diameter make the greater welding area. It make the resistive area more wide, so the shear strength will be better.

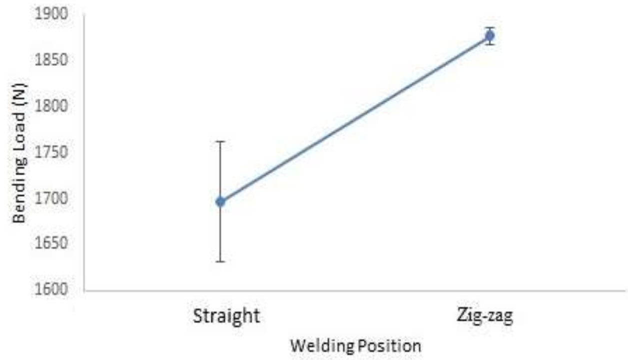
In variation of welding position, it can be concluded that zig-zag position shows best result in bending test as shown in Figure 7.a. However, in shear test, it cannot be concluded yet, because the value standard deviation is too big as shown in Figure 7.b.



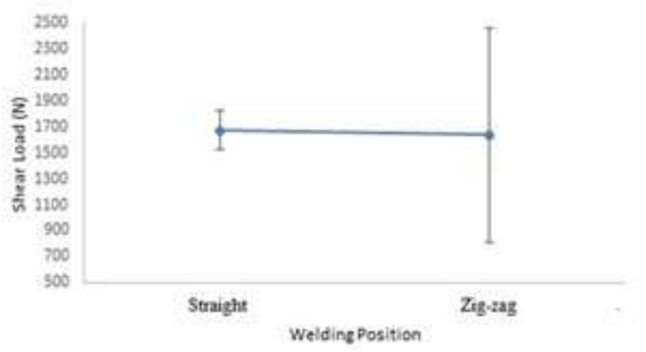
(a)



(b)
Figure 6: (a) Maximal bending load, (b) Shear load test, in variation of pin diameter



(a)



(b)
Figure 7: (a) maximal bending load, (b) shear load test in variation of welding position

In bending test, the welding activity makes the core weaker in welding area than the other area. So if the test is performed not in the welding area, the result will be better.

4. Conclusion

From the results of this paper, it can be concluded as follows:
Development of lightweight structures square longitudinally corrugated honeycomb core sandwich panel product has been conducted.
The size of pin diameter influences to the strength of product in shear stress. However, in 3-point bending stress, the result shows inversely.
The variation of welding position shows that zig-zag position can make better result in bending test. However, in shear stress it cannot be concluded yet, because the value standard deviation is too big.

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