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Evaluation of Mechanical Properties for Polyethylene Butt Welded Joint Formed by Friction Stir Welding

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Abstract: ***Friction stir welding is a solid state welding process suitable for producing joints, especially in lightweight materials, which are particularly interesting due to the weight saving potential. Thermoplastics have extensive applications in the present industry because they offer excellent physical and corrosion properties, high degree freedom of processing and design. The plunging of a specially designed non-consumable and rotating tool creates a connection between the sheets through frictional heat and plastic deformation. Minimum material loss is observed, and therefore a fully consolidated joint with flat surface is obtained. The aim of the present work is to investigate the mechanical properties of butt joints produced by friction stir welding (FSW) in high density polyethylene sheets of 7mm thickness. The determination of the welding parameters plays an important role for the weld strength. The tool rotational speed, tool plunge depth and dwell time were determined to be important in the joint formation and its strength. All the welding operations were done at the room temperature.***

Keywords: Friction Stir Welding, polymer, mechanical properties

1. Introduction

Friction Stir welding (FSW) was invented at The Welding Institute (TWI) of UK in 1991 as a Solid state joining technique, and was initially applied to aluminum alloys. Figure1 shows a typical schematic diagram of FSW. This technique has some advantages such as the solid-state process, ease of handling, joining of dissimilar materials and the materials that are difficult to fusion weld, a low distortion, excellent mechanical properties and little waste or pollution.

In this technique, a rotating tool was slowly inserted into the work piece until the shoulder contacted with the work piece. The tool rotation and traverse expedite material flow from the front to the back of the pin and welded joints were produced. The heating came from friction between the welding tool and the work piece as well as severe plastic deformation of the welded material. The process was suitable for joining plates, sheets; however, it can be employed for pipes and the hollow sections and positional welding. FSW aims for structural demanding applications to provide high performance benefits in industry. Although the FSW process was initially developed for Al-alloys, it also has a great potential for the welding of copper, titanium, steel, magnesium, metal matrix composites and different material combinations. Recently, some researchers have studied the application of FSW and FSSW to thermoplastics. The essence of the technology is that a rotating tool resembling the geometry of a milling tool is pushed in-between the plates to be welded, where the base material becomes molten under effect of the friction heat.

As a new welding method, the material to be welded do not need special preparation, even thick plates (>10mm) can be welded in a single step without any filler material.

In this study, FSW was performed to join high density polyethylene (HDPE) sheets in order to understand the influence of the welding parameters on welds. The purpose of this investigation was to improve the strength of the butt welds.

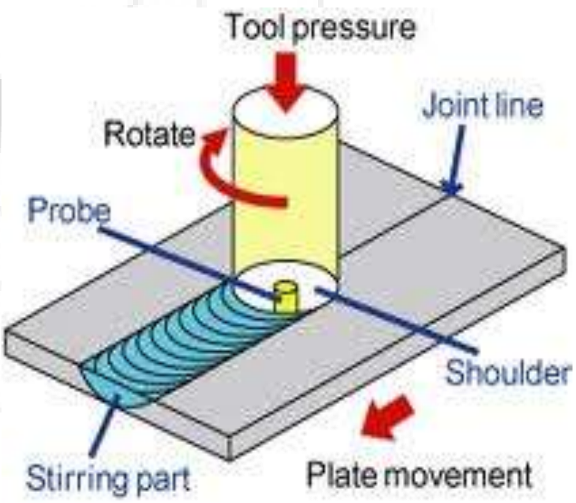

Figure 1: FSW Principle of operation

Benefits of friction stir welding

1) **Metallurgical benefits**: less distortion, high stability, fine microstructure
2) **Environmental benefits:** Shielding gas not required
3) **Energy benefits:** less energy required
4) **Cost benefits:** Low machine and tooling cost

2. Experimental Details

The material used in this experiment was a High density Polyethylene sheet (HDPE) cut to a suitable size of 150x70x6mm. The Mechanical and physical properties of this thermoplastic material are given in Table 1. The tool used in this experiment was a cylindrical profile high speed steel (HSS) having shoulder diameter of 12mm and pin diameter of 4.2mm.The work pieces are face milled in order to avoid any air gaps. Now, the work pieces are clamped in a butt configuration for FSW of HDPE sheets.

Figure 2: HSS Cylindrical profile tool

Tool Specifications

- HSS Tool Steel-10% Cobalt
- Length- 100mm
- Diameter-12mm

Table 1: Characteristics of HDPE Material.

Density (g/cm3)	Tensile Strength (MPa)	Flexural strength (GPa)	Melting point ^{o}C	Surface hardness
0.93-0.97	32	1.25	120-130	SD 68

Figure 3: Friction Stir Welding Equipment

The machine specification
X axis: mm
Y axis: mm
Z axis: mm
Spindle speed: 200-10000 rpm

Figure 4: Control panel of friction stir welding equipment

3. Results and Discussion

Mechanical Properties

Figure 5: Appearance of the welds

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The process parameters were investigated under multiple spindle speeds. Pin rotational speed was 550 rpm, 750rpm and 950 rpm. To ensure that shoulder applies enough pressure on work pieces, a tool-offset depth is required during the plunging step of the process. A plunge depth of 0.5mm and axial load of 28.83 kN was maintained throughout the experiments.

Table 2: Data obtained from tensile test

Specimen number	Rotational speed Rpm	Tensile strength N/mm^2
1	550	4.29
2	750	8.64
3	950	15.59
4	950	17.34
5	950	17.30
6	950	24.86
7	Unwelded	24.62

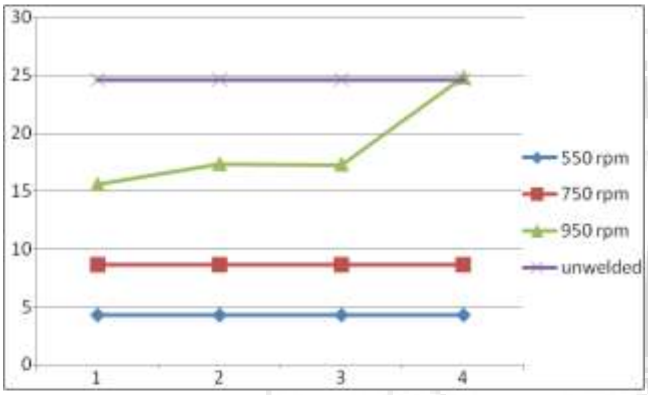

Figure 6: Tensile strength of welded and unwelded samples

We can see that the welded specimen no 4, welded at 950 rpm has a strength of 24.86 N/mm^2 which is more than the unwelded specimens tensile strength of 24.62 N/mm^2. Therefore we can conclude that a successful weld has occurred at 950rpm.Further Bending test was carried out on the specimen welded at 950rpm.The results were tabulated.

Table 3: Data obtained from bend test

Specimen number	Rotational speed Rpm	Load taken for bend kN
1	950	2.6
2	950	2.57
3	unwelded	3.39

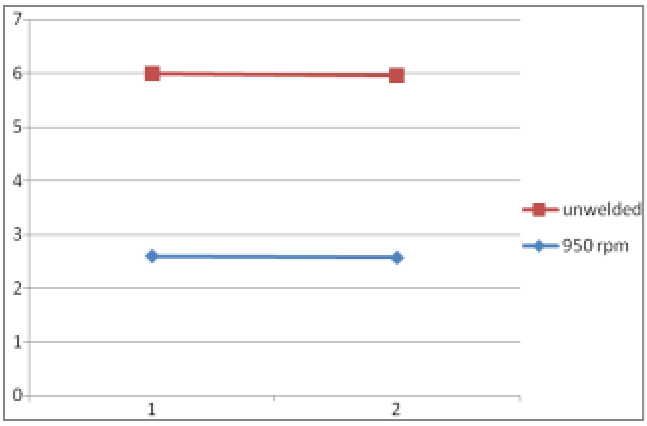

Figure 7: Load taken for bend in welded and unwelded samples

The tensile strength and the load for bend are compared in the graph below

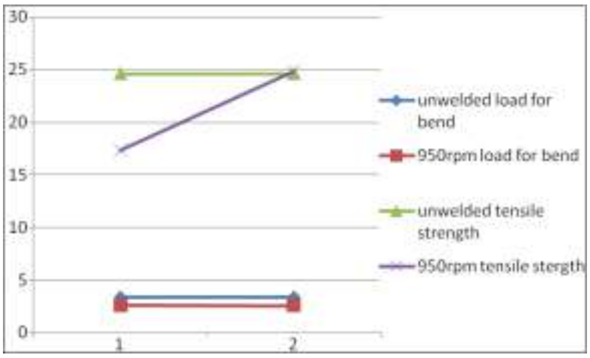

Figure 8: Tensile strength and Load taken for bend in welded and unwelded samples

4. Conclusion

The experiment results indicated that the maximum tensile strength of the joints, which is about 75% that of the base plate, was obtained with a tool rotation speed of 950 rpm. In general it was found that higher rotational speed resulted in higher tensile strength. This is due to the high local temperature achieved at higher spindle speeds leading to the formation of a large quantity of molten material leading to an efficient joint. The tool rotation speed plays an important role and contributes 70% to the overall welding parameter.

The dwell time was the most important parameter for weld strength followed by the tool rotation speed. Also from bend test we conclude that the bend results obtained from welded specimen is close as that of parental metal. The improvement in the weld strength from the initial welding parameters to the optimal welding parameter was about 40%.

References

[1] Amir Mostafapour and Ehsan Azarsa, A study on the role of processing parameters in joining polyethylene sheets via heat assisted friction stir welding: Investigating microstructure, tensile and flexural properties, International Journal of the Physical Sciences Vol. 7(4), pp. 647 - 654, 23 January, 2012.

[2] Erica Anna Squeo, Giuseppe Bruno, Alessandro Guglielmotti1, Fabrizio Quadrini1, friction stir welding of polyethylene sheets, the annals of “dunarea de jos” university of galati fascicle v, technologies in machine building, ISSN 1221- 4566, 2009.

[3] Z. Kiss, T. Czigány, Microscopic analysis of the morphology of seams in friction stir welded polypropylene, eXPRESS Polymer Letters Vol.6, No.1 (2012) 54–62.

[4] T. Czigány, Z. Kiss, friction stir welding of fiber reinforced polymer composites, 18th international conference on composite materials, Project ID: TÁMOP-4.2.1/B-09/1/KMR-2010-0002.

[5] Arvin Bagheri, Taher Azdast, Ali Doniavi, An experimental study on mechanical properties of friction stir welded ABS sheets, Materials and Design 43 (2013) 402–409.