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Studies on Producing Hybrid Material Sheets (Combination of Polyethylene and Polypropylene Sheets) via Friction Stir Welding Process: Evaluating Microstructure, Tensile and Flexural Properties for Potential Engineering Applications-A Review

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Abstract: ***Friction stir welding is a solid state welding process, where metal is not melted and uses a non- consumable cylindrical shouldered tool with profiled pin rotated and gradually plunged into the weld joint that are to be welded together. Friction stir welding is suitable for producing joints, especially in light weight 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 main aim of this study was to investigate the weldability of synthetic organic polymers (high density polyethylene and polypropylene) sheets via friction stir welding and effect of process parameters on microstructure and mechanical properties of welded sheets. Detail tool study will be carried out to make the process cost effective. The parameters under study were pin rotational speed and transverse speed of tool. Tensile and bend test were done in order to evaluate mechanical behavior of material. Also in the present investigation there is no addition of extra coating of material on tool but instead the surface is deformed under huge compressive load using friction stir welding equipment. All the welding operations were done at the room temperature.***

Keywords: Friction Stir welding, polyethylene, polypropylene, welding tool

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. Figure 1 shows a typical schematic diagram of FSW. A rotating tool including shoulder and pin, was slowly inserted into the work piece until the shoulder contacted with the work piece. Second, the rotating tool stayed few seconds before moving forward along the weld line .Third, the tool moved along the weld line and softened materials were moved with the rotational and translation of the tool from the front to the back of the pin. Finally, the solid state weld joint was produced in the stir region. The heating came from friction between the welding tool (shoulder and pin) and the work piece as well as severe plastic deformation of the welded materials. Synthetic polymers are human made polymers. They can be classified into four main categories: thermoplastics, thermosets, elastomers, and synthetic fibers. In recent years Synthetic organic polymers (High density Polyethylene & polypropylene) is extensively utilized in various applications such as high frequency radar cables, pipes, 3-D printer filaments, food storage containers, fuel tanks for vehicles, etc owing to its unique advantage of Low cost, Impact resistant, Moisture resistance, good chemical resistance and ease of processing. Food grades are also available for use in food industry. They can be readily processed by all thermoplastic methods. However intense use of High density polyethylene plastic in building a very competitive highly complex product over the conventional metals and alloys is due to the weight reduction it brings about in the component.

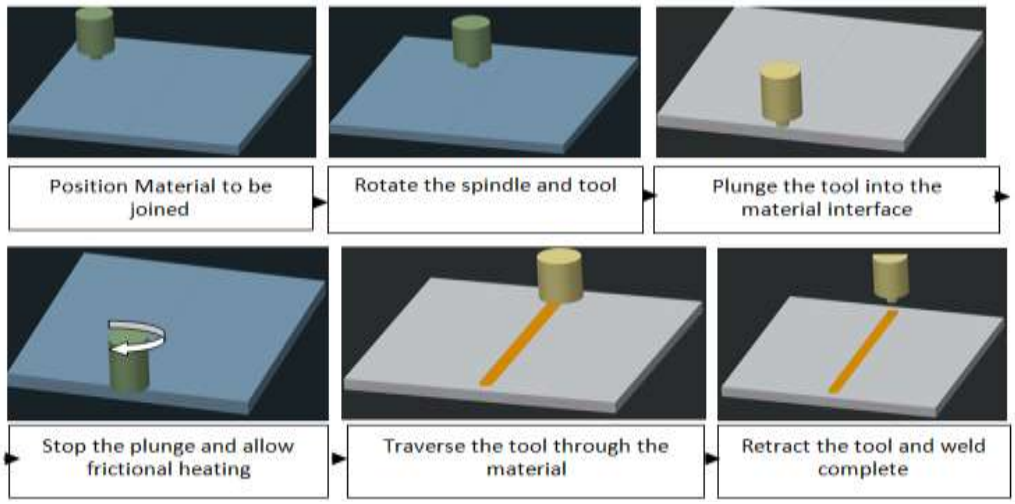

Figure 1: FSW principle of operation

2. Literature

Amir et al. [1] have investigated the role of processing parameters in joining HDPE via heat assisted friction stir welding followed by studies of microstructure and mechanical properties of welded plates.

Erica et al. [2] modified the FSW process by adding a heating step of the pin and samples to join. The joint quality was analyzed by means of tensile tests and thermal analysis.

Z. Kiss et al. [3] studied the super molecular structure of welded seams prepared by Friction Stir Welding of polypropylene sheet by optical and electron microscopy.

T. Czigany et al. [4] studied the joining of thermoplastic matrix composite sheets by Friction stir welding containing some kind of reinforcement. Also it shows the results of mechanical studies and seam micrographs obtained on chopped glass fiber reinforced polypropylene welded seams.

M.K. Bilici et al [5] the effect of tool geometry and properties on friction stir spot welding properties of polypropylene sheets. From the experiments the effect of tool geometry on friction stir spot weld formation and weld strength were determined.

Jicheng Gao , cheng Liu, Yifu Shen et al[6] the current state of FSW in plastic industry including tool improvement, welding methods, process parameters optimization, metal and polymer joining as well as composites fabrication, has been addressed.

Dr.Ebtisam F. Abdel-Gwad, Dr.Abu-Bakr M.Omar, Eng. Ahmed H.Radwan et al [7] Studied the combination effect of travel and rotational speeds of welding tool is investigated.Tensile, impact and fatigue tests are applied on the HDPE welded joints in order to evaluate their loadability.

Arvin et al. [8] studied the weld strength of acrylonitrile butadiene styrene (ABS) sheet joined by Friction stir welding.

Mustafa Kemal Bilici, Ahmet Irfan Yukler, Memduh Kurtulmus et al. [9] Studied the effect of important welding parameters and tool properties that are effective on static strength in friction stir spot welds of polymer sheets were studied.

Mustafa Kemal Bilici, Ahmet Irfan Yukler, Alim Kastan et al.[10] Studied the effect of tool geometry and welding parameters on the macrostructure, fracture mode and weld strength of the friction-stir spot welds of polypropylene sheets.

Parth Sas, Sushama Kadam, Yamini Chavhan, Minal Parate, Omkar Kotulkar, Vijayakumar S. Jatti et al.[11] Studied the welding parameters for different polymeric materials and are then analyzed.

Yahya Bozkurt et al. [12] studied the optimization of friction stir welding process parameters to achieve maximum tensile strength in polyethylene sheets.

Mustafa Kemal Bilici, Ahmet Irfan Yukler et al.[13] Studied the effect of welding parameters on friction stir spot welding of high density polyethylene sheets.

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

Table 2: Characteristics of polypropylene material

Density (g/cm3)	Tensile strength (MPa)	Flexural strength (GPa)	Melting point ^{o}C	Surface hardness
0.90-092	26	2	130-171	RR 85

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

3. Conclusion

The friction stir welding is very recent trends in the manufacturing technology of metal joining processes

especially for aluminum alloys .In this review, the current state of FSW of polymer material in improving tool, welding methods, optimizing process parameters had been addressed also the principle of FSW and vital factors that influence the quality of weld.

Although the FSW of polymer had been studied for nearly 20 years, it did not show substantive progress. However FSW had a great potential to produce a very high strength joint and a defect-free joint.

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