Ilkogretim Online - Elementary Education Online, 2018; Vol 17 (Issue 1): pp. 1444-1453
http://ilkogretim-online.org
doi: 10.17051/ilkonline.2018.01.39

Parametric Optimization Of Fsw Of Pp

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Abstract

Thermoplastics are higher in demand in the era of the advancing technology. Thermoplastic material is very useful in almost every field. Friction stir welding is a solid-stateprocess of joining the thermoplastic polymer. In this situation, attempts were made to joining the polypropylene plate of 6mm thickness with a conical threaded tool pin. Visual inspection was performed to check the surface quality of the welds. The results of the tensile testing show a better ductility of the welded joint with maximum tensile strength 19.41 MPa and joint efficiency 54.29 percent. Experiments were performed on varying tool rotational speed 270 to 545 rpm, feed rate 20 to 50 mm/min, and tilt angle ± 0˚ to 50˚ using L9 orthogonal array of Taguchi method. The current studyaimsat optimizing process parameters to arrive at higher tensile strength.

Key-words: Friction stir welding; polypropylene material; tool geometry; tensile testing.

Introduction

Friction stir welding (FSW) is a new process for joining thermoplastic polymeric material. This process is for joining the new technique of FSW was first successfully on aluminium alloy in 1991 at The welding Institute (TWI) in England. The FSW method produced friction wear resistant between the workpiece and tool and plastic deformation of the workpiece. This heat can also cause intensive moving of material structure to make new bonded molecules having a strong joint. FSW tool was imported role for shoulder and pin. This pin generates the heat required for the melting points and its main function is to create the material flow direction. The rotary motion of the tool leads to the intermixing of the two plates which were connected author and were joined by mechanical pressure. The incorporated motion of the tool pin with rotation speed and feed rate leads to movement in the material from leading side to trailsideOf the pin. When the molten material moved from the advancing side to retreating side pin is that part of the tool which is plunged into the workpiece during the welding process. In the FSW process, the material goes through critical plastic deformation at raised the temperature.Polypropylene has high tensile strength making hold tightly on to threaded opening. pp material is strong and usually withstand higher temperature and basically used in the food containers, lunch box, piping, rigid packaging, flexible packaging, textile industries, automotive sector, medical sector, customer goods, and industrial application and is also used for products need of incubated, such as dairies. Besides the rapid development of engineering plastic industry and pp wide uses, new welding methods are needed to lead strong, reliable, and low-cost joints. Welding technology is used not only in the production process but also in repairing and maintenance of the polymer parts.

During the era, 1910 polymer had led to the improvement on top with the lightweight alloys ofaluminium(1)Increasing demand for fuels and other chemicals has led to reducing in natural sourceswhich can lead to conservation such as various lightweight material and improved processing. an alloy of aluminium,magnesium, copper and thermoplastic polymer, etc are currently used in automobile,aerospace,shipbuilding, and railway industries. Thermoplastic polymers are beinglightweight with high specific strength and low manufacturing has drawnto the awareness of manufacturesto investigate these properties in prime industries(2).The first is was a comparative analysis between the various available techniques to join the thermoplastic.The material under the test was polypropylene (PP) (3). Welding trial of 9mm thickness of the PP sheet with a new variant of FSW was calledViblade welding.The effect of the tool rotational speed and feed rate was also studied. The weld jointefficiencywas50% of the base material strength. A groove tool is used in which the softpolymer was collected and back into a composite line(4). FSW tool is non-consumable in the combination of geometry and results into present theprocess of heat generation. FSW is also widely used in butt and lap configuration since its invention. TheFSW process was developed for aluminium but other materials such asmagnesium,copper,steel,titanium,thermoplastics, etc. were widely applied (5)(6). The diameter of the shoulder and pin to stay between the ratio of 3:1 or 4:1. The length of the pin stays 0.2 to 0.4 mmless than that of the thickness of the workpiece. The FSW tool usedits pin and shoulder bothin the shape ofconical overtime FSW uses different shaped tool pin including square,triangular, and cylindrical, etchave been improved the weld joint efficiency(7).While the tool rotation speed 1000 to 1200 rpm,feedrate 12 to 20 mm/min and tilt angle 1°to2°than optimum weld joint strength is 75%to the base materialin HDPE(8).FSW in aform of polymer material that forces the pin tool to flow with higher tool rotational speed andfeed rate polymer were in nugget flow zone that can be easily demolished to the macromolecular chain and can change thestructure building of polymer.Thus, the polymers are not much as metals joined by FSW. FSW commonpolymers welded are polypropylene(9).The thermoplastics material was different than those metal about the melting point,thermal conductivity, density,tensile strength, etc.As such the process ofparameters is tool rotational speed and feed rate higher than the heat will generate more because thepolymer material was melted more, in which the welded joint strength reduces(10).FSW has uniquedefects as compared to conventional welding methods.Root defect is seen on the weld surfaceduring welding the polymeric material with a conical threaded pin(11).When the tool pin length ishigher, however, the length of the tool is reduced due to frictional wear on the bottom backing plate this causesinsufficient welding of the workpiece.The peeling effect detected in many types of research, stay inwelding using conventional FSW tool (12).Flash defect is more common when welding inpolypropylene material(13). The Taguchi method is more power full method than analyzed the optimization ofprocess parameters.Taguchi method is experimental Design easy to apply for many engineering applications.The signal noise (s/n) ratio is used in this analysis which takes both the mean and variabilityof the experimental result (14).

Experimental procedure

In this experiment, the material is based on commercial-grade polypropylene (pp) sheet of 6mm thickness in which polypropylene is polymer synthesized from pp. A monomer is a dual process of plastic and fiber. The specimen size of 100mm×100mm×6mmwas shared from the sheet. Table 1. shows the physical properties of the pp of these materials respectively. The tool is used for welding manufactured from high chromium steel(H13) and dimension has been shown in the Fig.1 a-b. The diameter of the tool shoulder and pin is 18mm and 3mm respectively and the height of the pin is 5.8mm and left hand threaded, thread pitch 2 mm, threaded angle 29˚ and Hardness range (HRC) 38 to 48. A friction stir welding setup was established using a conventional vertical milling machine shown in Fig. 2. No extra setup is required for FSW except tool and fixture, to place a piece in proper position during welding.

The welding process of parameters are selected for the experiment has been shown in Table 2. The tool of the rotational speed and weld speed was different from a constant 1°,1.5°,2°.0.5mm plunged were applied to run the experiment to make sure the better plunging of the tool pin is in the workpiece. The coupons are to be welded closely on the bed with the help of fixture and no gap is to be maintained in the workpiece. The tool is fixed in the spindle and tool are fitted in collet was then transverse over the joint line to ensure that there was no discrepancy between joint line and the face of the tool pin.

The tensile test coupons are occurring the cut in Jigsaw machine according to ASTM D638 with a gauge length of 25 mm Tensometer tensile test machine is shown Fig. 3 a-c. Three specimens are cut from a one weld coupon as shown in Fig. 3 b. It is a welding specimen that has excess material peak it is removed from the emery paper. The presentation technique involved in this study were visual inspection and tensiletesting. Defects in surface welding can be seen from visual inspection. The tensile strength ofthe welded specimens was determined using a computer-controlled Tensometer tensile testing machine asshown in Fig. 3 c at 10 mm/min Passover speed.

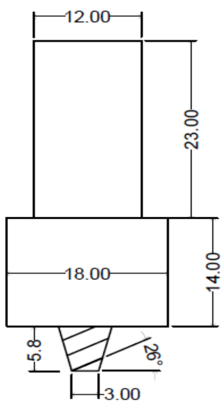
Table 1. Physical properties of PP

Density	Yield strength	Melting point	Tensile strength	Thermal conductivity

0.855 g/cm^3	12- 43 MPa	130-171 ˚C	33 MPa	0.22 W/MK

Table 2. Experimental process parameter

S. No.	Welding parameter	Level 1	Level 2	Level 3
1	Tool rotational speed (rpm)	270	380	545
2	Feed rate (mm/min)	20	31.5	50
3	Tilt angle (˚)	1	1.5	2



All the dimensions are in mm

(a) Tool dimensions **(b) Original tool**

Fig 1 Tool geometry (a) Tool dimensions (b) Original tool

Fig 2 FSW set-up

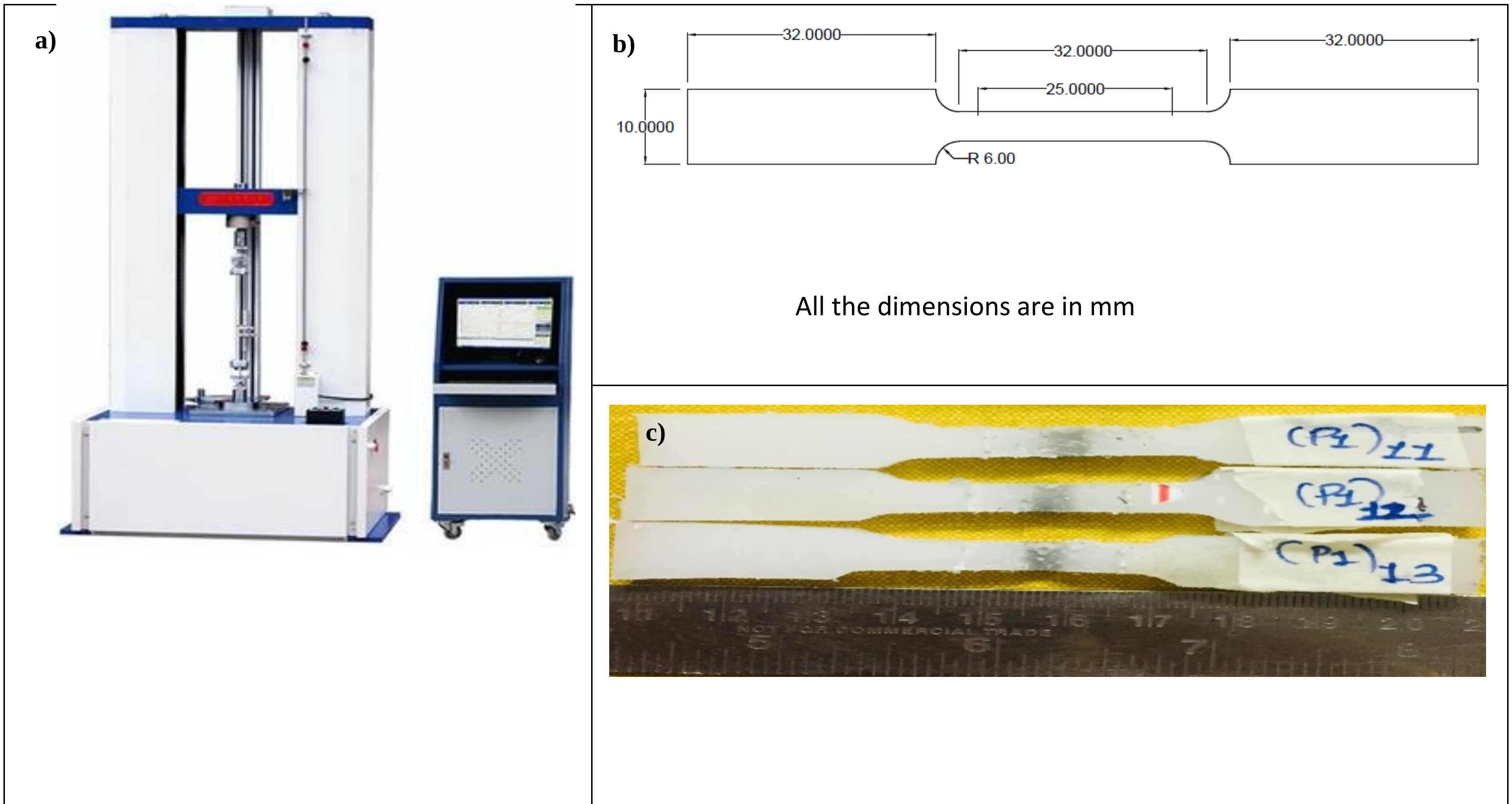


Fig 3. (a) Tensometer tensile testing machine; (b) tensile specimens from the welded sample; (c) tensile test specimens

Results and discussion

All the weld coupons are inspected and the welded surface represents on the weld coupons shown in Fig. 4. When the tool rotational speed is constant and the feed rate increases they do not have weld quality to be maintained. The reason for producing the flash on the weld surface is the time for rotational speed in which the soft material is removed. The black color was found on the welded coupons since the fiction is done between the backing plate and tool. The effect of the peeling is shown in Fig.4 (e-f). The peeling effect is caused due to higher axial load on the weld specimens.

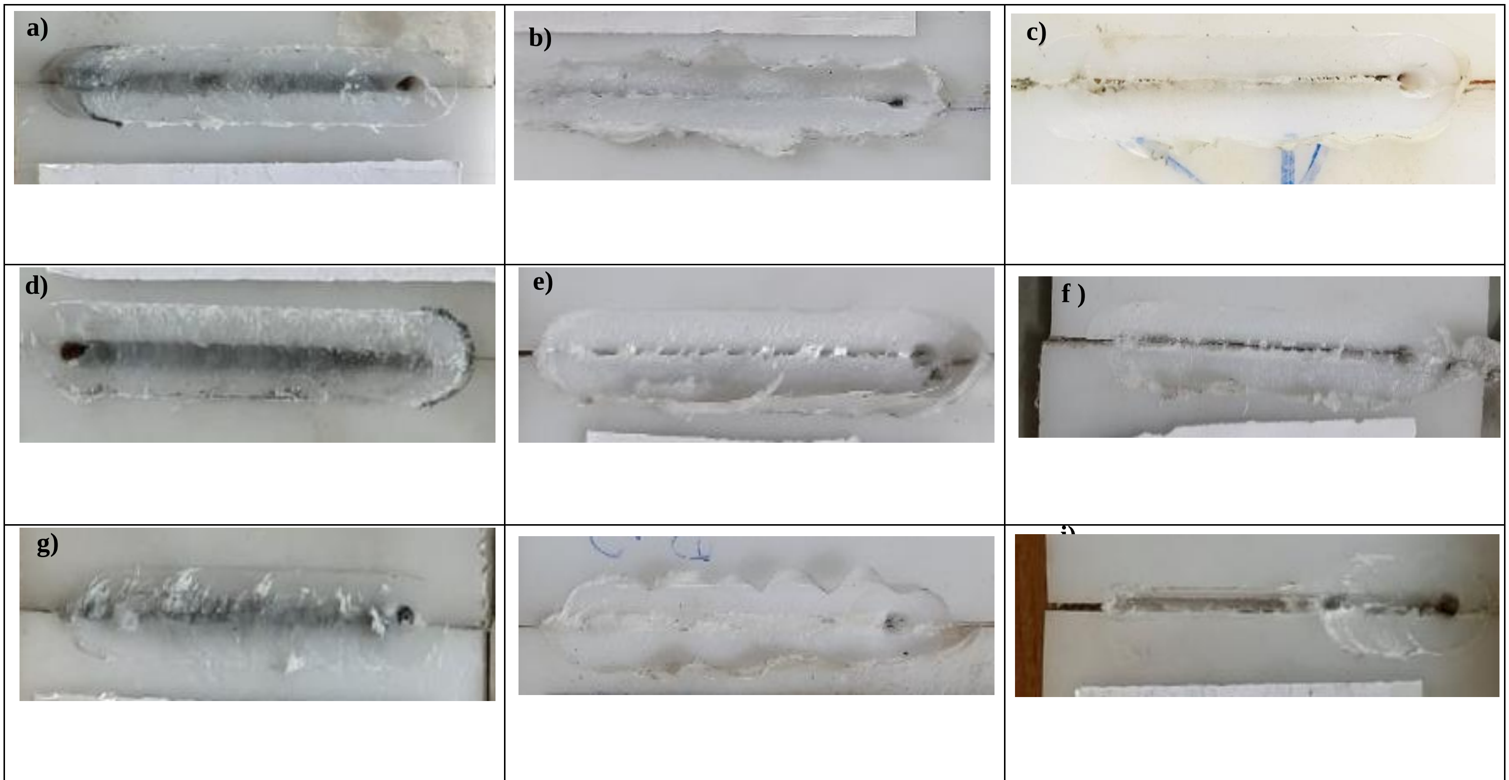


Fig. 4 (a) 270rpm/ 20mm/min/ 1° (b) 270rpm/ 31.5mm/min/ 1.5° (c) 270rpm/ 50mm/min/ 2° (d) 380rpm/ 20mm/min/ 1.5° (e) 380rpm/ 31.5 mm/min/ 2° (f) 380rpm/ 50mm/min/ 1° (g) 545rpm/ 20mm/min/ 2° (h) 545rpm/ 31.5mm/min/ 1° (i) 545rpm/ 50mm/min/ 1.5°

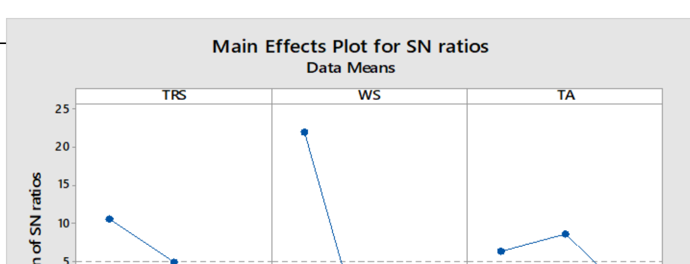
Table 3 indicates the average value of the three weld specimens of the weld coupons which evaluated the S/N ratio by the Taguchi method. Taguchi analysis is done on the tensile strength to ensure the optimum process variable. The main effect of the plot is to developed shown in Fig. 5. The optimal welding conditions obtained from Taguchi analysis are tool rotational speed 270rpm, feed rate 20mm/min and 1.5 of tool tilt angle to maximize the tensile strength. The maximum value of the tensile strength is 19.41MPa and welded joint efficiency is 54.29%. The effect of the tool rotational speed on the tensile strength has been shown in Fig.6.when the frictional heat is generated the tool of the rotational speed increases and simultaneously the tensile strengthdecreases. At the constant welding speed of 20mm/min. the tensile strength 380rpm is 0.89 MPa,and this value increased to 19.4 MPa in which the rotational speed of the tool is 270rpm.Since the rotational speed of the tool decreased to 545rpm then the tensile strength again decreases. If we further go beyond tool rotational speed 545rpm there will be probably no decrease in the tensile strength.

Table 3. Experiment results for tensile test and S/N ratio

S. No.	Tool rotational speed (rpm)	Feed rate (mm/min)	Tilt angle (°)	Tensile strength (MPa)	Joint efficiency (%)	S/N ratio
1	270	20	1	19.41	54.29	28.2484
2	270	31.5	1.5	0.89	2.5	1.4799
3	270	50	2	0.99	2.18	2.1087
4	380	20	1.5	12.25	34.18	24.2482
5	380	31.5	2	0.154	0.43	-13.7634
6	380	50	1	1.24	2.81	4.1060
7	545	20	2	3.26	13.53	13.0296
8	545	31.5	1	0.156	0.43	-13.6642
9	545	50	1.5	0.74	2.08	-0.1227

The effect of the feed rate on the tensile strength has been shown in Fig.7. When observed that increased in the feed rate and the tensile strength was decreased. The tensile strength was obtained from tool rotational speed is 270rpm, feed rate 20mm/min is 19.41MPa and 0.89MPa is tensile strength obtained from tool rotational speed 270rpm and feed rate 31.5mm/min. The decrease in the tensile strength of the joint is due to insufficient of heat which prevails due to increasing in the tool transverse speed, due to which the tensile strength more decreases to 0.89MPa, tool rotational speed is 270rpm, the feed rate is 50mm/min in 0.99MPa and 380rpm,50mm/minis 1.24MPa. From this, it is determined that as the feed rate increases, there is a decrease in the tensile strength.

The domination of the tool on the tilt angle of tensile strength on the weld is accompany shown in Fig.8. The tilt angle affects the horizontal flow of the weld material. The normal affected in the tilt angle can cause the tunnel and crack-like defects in the welded. The 1°tilt angle is better tensile strength then 19.41Mpa.



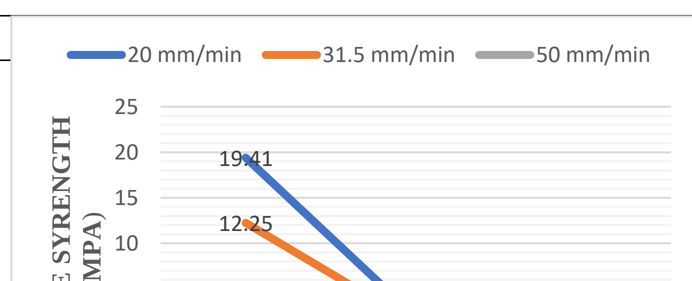


Fig. 5 Experiment results for tensile strength

Fig 6. Effect of tool rotational speed on tensile strength

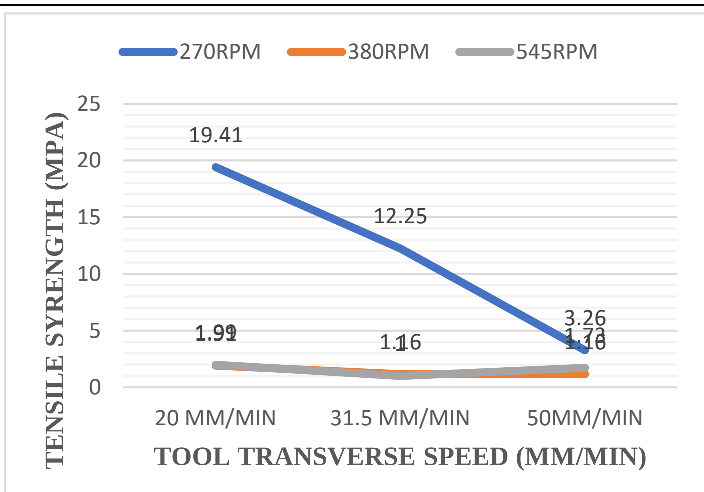


Fig 7. Effect of tool transverse speed on tensile strength

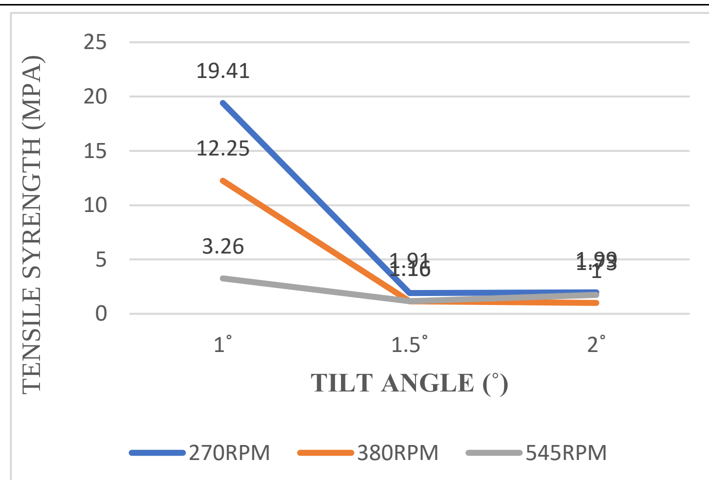


Fig 9. Effect of Tilt angle on tensile strength

Conclusion

The work present on the effect of a process for parameters by FSW process on pp material and their. These
are the following points that can conclude.

1. Inspect the defects across the weld by visual inspections.
2. The excessive flash defect is not only seen on weld coupons but also the heat is excess generated.
3. The maximum value of tensile strength is 19.41mpa. For the tool rotational speed is 270rpm,the feed rate is 20mm/min,1°of the tilt angle in which the joint welded efficiency is 54.29%. The analysis made from the Taguchi method was the optimum process of parameters was 270rpm,20mm/min, and 1.5°.
4. These are the two main factors of the tensile strength by the tool rotational speed and the feed rate.

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