Effect of Process Parameters on Pcbn Tool Wear Rate in Friction Stir Process of Aluminium 7075 Sic

Kailas Tambe, G. Krishna Mohan

Abstract: Friction state process (FSP) a variant of friction stir welding process (FSW), is used to friction process of Metal Matrix composites. Since Aluminium Alloy (AA) 7075 SiC is not been premeditated on FSP,effort has been made to explore the result of a range of process parameters on tool wear rate(TWR)in FSP by Taguchi method, research paper. The Process parameters that careful study of rotational speed, translational speed and tool pin diameter. Polycrystalline Cubic Boron Nitride (PCBN) tool of 6 mm, 7 mm and 8 mm diameters are used. The research is done by L_9 (3^4) orthogonal array. The eroded length of tool, volume measurements and the tool wear rate is calculated for a variety of combinations of factors and levels. The results of experiments systematically discussed and to achieve process parameters on tool wear rate is determined.

Keywords: FSP, AA 7075SiC, TWR, Taguchi method and FSW.

I. INTRODUCTION

FSP is current research in industry and academic Research and is an alternate process of friction stir welding. FSP generally use to manufacture automobile, aerospace and medical parts. The fundamental principle which is used in friction stir welding. The friction stir processing is differentiated FSW by means of parameters similar to tool rotation, tool travel (translational) speed and number of passes. The FSP characterized by ability to process both conductive and semi conductive materials which are having high surface accuracy regardless of material stiffness.

The FSP is preferable especially while processing of difficult-to-cut material because of low efficiency in nature and precision. Small volumetric material inference in FSP provides sustainable opportunity for manufacturing of small accurate parts for automobile and aeroplanes [2]. The benefit of FSP is to process with less consumption of material. The forces are extremely small due to tool and workpiece come closer in contact throughout the process, less friction forces on them. The other advantages of FSP include low setup cost, low speed ratio.

The drawback is formation of layer over heat affected zone upon the processed surface. The fact, it is impossible to take away all the molten part on the workpiece, thin layer of sediment, molten material deposit on the workpiece surface, which re-solidifies during cooling [3.4]. The effect on process parameters, particle dispersion and hardness in AA 7075 reinforced with TiB_2 micro particles and reported 50% add to the micro hardness compared with parent material [5].The hardness and wear resistance a variety of combination of travel speed, amount of passes and rotational speed for AA 7075 B_4C surface composite fabricated using FSP has been studied [1, 2].

This paper present study the effect of dissimilar process parameter with combinations on TWR in FSP of AA 7075 SiC alloy by Taguchi method, covering volumetric measurements, worn out length of the tool and tool wear rate are calculated. The influence depends on process parameters and behavior oftool and alloy material like AA7075 alloy are considered and discuss ornately.

II. TOOL WEAR RATE

The wear ratio, defined as the ratio of amount of tool wear to amount of removal of workpiece [7]. The method that is recognized to evaluate tool wear ratio by means of calibration of weight, length and total volume correspondingly. The common one by calculating volumetric wear ratio (ν), usually variations of weight are taken into measurement and then converted into volumes by material density.

The weight change is small make to measure it precisely in the method of FSP. Significant to measure and analyze material removal directly [1].

Tool Wear Rate (TWR) calculated [3].

$$TWR = V_W / t\, mm^3/min \qquad (1)$$

And

$$V_W = \frac{\pi D_W^2 L_W}{4}\, mm^3 \qquad (2)$$

Where,

V_W = Volume of tool wear

D_w= Diameter of the tool wear

L_w = Length of the tool wear

t = Machining time of the surface.

III. TAGUCHI METHODOLOGY

The main objective is to cram of TWR in FSP of surface texture on a complex to processing material order to do so. Taguchi's robust design method is used. Apart from significant the wear tendency of tool, the method also helps in optimizing the process parameters for FSP. The main paradigm of robust design method to choose levels of design factors to make product or process performance concentrated to uncontrollable variations such as manufacturing variations, deterioration and environmental

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A. Sarath Kumar, Asst. Professor, MED, MREC (A), Hyderabad,Telangana,India.

Research Scholar, MED, K L University, Guntur, AP, India

Dr. K. JayanendraBabu, Professor, MED, K L University, Guntur, AP, India.

variations. Following are the steps in Taguchi robust design methodology.

- Identify major function, side effects and failure modes.
- Recognize the testing parameters and then to summarize the quality loss as well as noise factors.
- Discover the quality characteristic which is about to observe and objective role to be minimized.
- Choice of control factors and its levels.
- Design of matrix experiment.
- Conducting the Matrix experiment.
- Analyze the data, decide optimum levels of control factors and forecast the performance under these levels.
- Conduct the confirmation experiment and future scope.

IV. EXPERIMENTAL SETUP

Fig 1: FSP Machine with tool set up

Fig 2:PCBN tool with conical pin

Make: HMT Machine used for conduct the experiments using PCBN Tool with 6 mm, 7 mm and 8 mm diameters are used to process on AA7075 SiC.Literature review suggests the PCBN tool has not yet been in use to process AA 7075 SiC material surface.

T W R chosen as output characteristic is observed and calculated as per equation (1) and (2) correspondingly. Since TWR ought to be as least as possible, output characteristic falls under the category of "smaller-the-better"(S-type) quality characteristic, evaluate the signal to noise (S/N) ratio. The principal function is to be optimized to enhance (S/N) ratio.

Signal to noise ratio is been calculate by

$$\eta = -10\ \log_{10}[\frac{1}{n}\ (y_i^2)] \qquad (3)$$

Where,

η = (S/N) ratio

y_i= Interpretation

n = number of interpretation

Process parameters between their levels are to be used in experimental process are listed in Table 1.

Table1: Process parameters and their levels

FACTORS	LEVELS		
	1	**2**	**3**
TOOL DIAMETER (mm)	6	7	8
ROTATIONAL SPEED, RPM	800	900	1000
TRANSLATIONAL SPEED, mm/min	20	25	30
TILT ANGLE, Degrees	0°	1°	2°

L_9 (3^4) orthogonal Array is selected for hauling out experimentation as it best suits the input requirements. Experimental plan is shown in Table 2.

Table 2: Experimental Design

EXP No.	FACTORS			
	ROTATIONAL SPEED, RPM	**TRANSLATIONAL SPEED, mm/min**	**TOOLPIN DIAMETER,mm**	**TILT ANGLE, Degrees**
1	800	20	6	0°
2	800	25	7	1°
3	800	30	8	2°
4	900	20	7	2°
5	900	25	8	0°
6	900	30	6	1°
7	1000	20	8	1°
8	1000	25	6	2°
9	1000	30	7	0°

V. RESULT AND DISCUSSION

Optimal parameters for surface is desired to shape on AA7075 SiC alloy using PCBN tool as in figure 1 is investigated by performing the nine investigations while experimental design represented in Table 2.

Each experiment shows wear length and wear diameter of the tool are noted from the friction stir process. The output characteristic TWR is calculated using formula shown in equations 1 & 2 respectively. Obtained results for nine experiments, along with S/N ratios are given in Table 3.

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Table 3 Experimental Results.

EXP No.	TWR (mm^3/min)	Signal/Noise Ratio (η) dB
1	0.001507	46.43773
2	0.002399	42.3994
3	0.003688	38.66418
4	0.002301	42.76167
5	0.003529	39.04697
6	0.00141	47.01562
7	0.003621	38.82343
8	0.001487	46.55378
9	0.002386	42.44659
TOTAL	0.022328	374.1494
AVERAGE	0.002481	42.68326

S/N Ratio obtained after each experiment, further analyzed, the objective function defined and the optimum set of process parameters are selected as shown in Table 4 and Figure 2.

Table 4: S/N ratio various levels of process parameters

	ROTATIONAL SPEED, RPM	TRANSLATIONAL SPEED, mm/min	TOOL PIN DIAMETER, mm	TILT ANGLE, Degrees
LEVEL 1	42.5	42.64	42.64	42.60
LEVEL 2	42.94	42.67	42.54	42.75
LEVEL 3	42.61	42.71	38.848	42.66

Fig 3: Tool Wear

The optimum mixture of process parameters rotational speed of 900 rpm, translational speed of 30 mm/min, tool pin diameter of 6 mm and tilt angle of 1°.

Theoretical S/N Ratio for optimum grouping is forecasted as 47.01562 dB.

The confirmation experiment carried out optimum settings of factors and levels to validate the experimentation. The TWR is too resolute with equations 1 & 2 shown in Table 5. S/N ratio value related to conformation experiment is calculated and is compared with the predicted one. Table 6 shows the predicted S/N ratio is in nearest proximity with actual one, thus validation of research study.

As shown in Table 7, the optimum grouping of factors as well as levels brought an improvement of 0.000137 mm^3/minute in TWR. The main function of maximizing the S/N ratio is accomplished i.e., from 46.43 to 47.92 to dB.

Table 5: Conformation experiment and its result

Rotational speed, rpm	Translational speed, mm/rev	Tool pin diameter, mm	Tilt angle, degrees	Twr (mm^3/min)
900	30	6	1°	0.01

Table 6: Predicted and Conformed S/N ratio

	S/N Ratio (η)
Predicted	47.01562
Conformed	47.265589

Table 7: Improvement

	Starting Condition	Optimum Condition	Improvement
TWR	0.001507	0.00137	0.000137
η	46.43773	47.92393	1.4862

VI. CONCLUSIONS

Taguchi's Robust Design methodology has been the effect of machining parameters similar to rotational speed, translational speed and tool pin diameter over TWR in friction stir process of AA 7075 SiC alloy using PCBN tool of 6 mm, 7 mm, and 8 mm diameter. This research study not only provides the best arrangement of process parameters, but also the wear trend of tool in different arrangement of process parameters.

(i) Theoptimal 'process parameters' for optimizing TWRbased on Taguchi's Robust Design Method for FSP of AA 7075 SiC alloy which includes rotational speed of 900 rpm, translational speed of 30 mm/min, tooltip diameter of 6 mm and tilt angle of 1°. The lowest tool wear is being attributed to the rotational speed of 800 rpm associated by medium translational speed of 20 mm/min and tilt angle of 0°.

(ii) A trend of mild tool wear is observed in experimentations of 1, 6 & 8 respectively wherever tool diameter is least in experimentation i.e., 6 mm is observed as the tool pin diameter decreases, tool wear reduces.

(iii) It is found that, tool wear is rising with increased tool diameter of 8 mm as shown in experimentations of 3, 5 & 7 respectively.

(iv) Conformation experiment displays the TWR indeed reduced i.e., 0.00137 mm^3/min with optimum arrangement of various factors and levels in FSP of AA7075 SiC alloy. The TWR achieved at the instance of beginning of experimentation is 0.001507 mm^3/min.Finally, an improvement in TWR of 0.000137 mm^3/min is accomplished by the usage of optimal parameters.

(v) The primary function of experimentation to maximize the S/N ratio is also obtained at the last stage of conformation experiment. The S/N ratio is improved by an amount of 0.696.

Concluded that with all these group of process parameters considered for study, diameter of tool pin which influences

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the TWR. However, the other parameters like contact tool workpiece, carbon precipitation which aims to be known their effect on TWR.

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Dr. Nagabhushana Ramesh N. completed his B.E in Mechanical Engineering (1986) and M.E in Production Engineering from Osmania University, Hyderabad, A.P, and India, (1994) Ph.D in Mechanical Engineering with specialization as Production Engineering in the field of Electro Discharge Sawing (Electro Discharge Machining) from Osmania University, Hyderabad, A.P, India (2007). TOTAL EXPERIENCE 30, Patent 01, International Science Index 01,Papers Published in International Journals: 18 No's National Journals: 01 No's, International Conferences: 21 No's, National Conferences: 16 No’s, Guided for Ph.D awarded:02 No's, Presently Guiding for the Ph.D:01 No's.

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