Parameter Optimization of Friction Stir Welding Process by using RSM on Dissimilar Welded AA6061-AA7075

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Abstract
In this study, the joining of dissimilar between AA6061 and AA7075 with thickness of 3 mm was perform by using a friction stir welding (FSW) method. Response surface methodology (RSM) was choose to optimize effective factors during FSW process. The result of process parameter on impact toughness of welded butt joint was studied. Rotational and transverse speed were the main process parameters which were taken into consideration. Three levels of the tool rotational and welding speed in the range of 900–1100 rpm and 90–110 mm/min were studied via a central composite design (CCD). The optimal process parameters were decided with reference to impact toughness of the joint. By using the optimum parameter, the projected optimum percentage of the impact toughness was confirmed by doing the experiment. The result indicated that the joint formed using the rotational speed is 1000 rpm and welding speed of 110 mm/min and 1100 rpm and 110 mm/min show the highest and lowest joint impact toughness is 5.404 J and 3.404 J, respectively. The joining impact toughness result is higher compare to the base metal. The Anova table has showed that the entire method are important to adequate the scientific model, where the residual blunder among investigational and theoretic is 3.02%. Microstructural observation has discovered the change of a recrystallization especially in SW region have significant effect on impact toughness and hardness test.

Keywords: friction stir welding, aa6061-aa7075, rotational speed

1.0 Introduction

In overall, joining of two or more things, generally metals or thermoplastics altogether permanently is considered as a fabrication process for welding and this method also can produce a single component. Development in technology of welding is continuously evolving in contemporary times. Variation of welding techniques has been found recently. Gas welding, (oxyacetylene torch and oxy-propane), arc welding (basic AC and DC welders, tungsten inert gas (TIG), and metal inert gas (MIG), plasma arc welding, laser welding, and electron beam welding are examples of welding type. Despite the fact, friction stir welding (FSW) is the up-to-date welding methods that was developed by The Welding Institute (TWI), UK in 1991 (Mahoney, Rhodes, Flintoff, Bingel, & Spurling, Sato, Kokawa, Enomoto, & Jogan, 1999). This welding method are capable of joining a variability of metals like aluminium, steel, magnesium, titanium, copper as well as other kinds of materials that unable to be welded by using the outdated welding methods.

FSW is a joining method which comprises solid state joining procedure that has used rapidly starting from its development in 1991 (Gibson et al., 2014; Mishra & Ma, 2005; Padhy, Wu, & Gao, 2017). Mostly this can be found in a wide assortment of venture like aerospace, car, marine and railroad (Gibson et al., 2014; Lohwasser & Chen, 2009; Mishra & Ma, 2005; Thomas & Nicholas, 1997; Wahid & SIDDIQUEE, 2018; Wang, Zhao, & Hao, 2017). Contrast with ordinary welding technique, FSW are the most proficient and viable welding strategy in 10 years back where its consider as less vitality and no spread gas utilized which make this procedure is more environmentally friendly. Furthermore, the joining procedure includes no filler metal and it can joint any aluminium material without fear of their compatibility of composition. Table 1 showed key advantage of FSW.

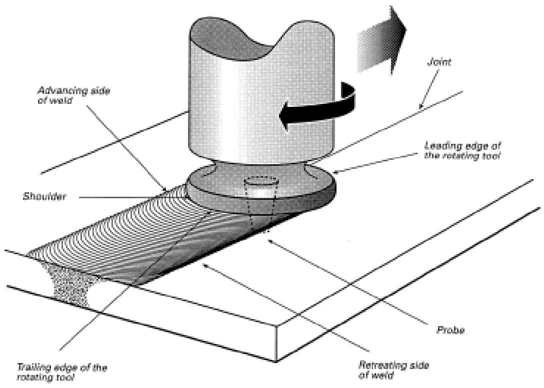

Figure 1 : Illustrated of friction stir welding Source: Thomas et al (1997)

Table 1 : Friction stir welding benefit

Metallurgical benefits	Environmental benefits	Energy benefits
Solid state process	Required no shielding gas	Improve in the using of material like joining different material and weight also being reduce
Low workpiece interference	Required no surface finishing	Need only a few percentage for laser welds
Good dimension stability	Grinding waste will eliminate	Fuel consumptions will decrease in light craft, automotive and ship applications
Keep the originality of alloy	Do not used solvents for degreasing	
Get the best metallurgical properties at weld line	Saving consumable material like arc rod.	

Nowadays, automotive industry trends towards reduced fuel consumption by reducing the vehicles weights, which more than 99% of a vehicle's Life Cycle Energy (Kawasaki et al., 2004), therefore there are increase used of aluminium. Compared to other joining process, FSW process offers various possible benefits for joining of aluminum alloys. FSW having numerous benefits and it has extended important attention in the automotive indusry (M.G. Dawes, 2000; Thomas & Nicholas, 1997) such as enhanced mechanical properties (tensile and fatigue), increased process robustness, absenceof consumables, reduced social issues (wellbeing and natural issues issues) and working cost favorable circumstances. In FSW, a round and hollow blend bar with a profiled stick is turned and dove in to joint. Frictional warmth at that point produced between the stick and the work piece. In car body design and improvement there are two important objectives that need to be considered which is car body light weighting and crashworthiness. This can reduce a car weight without improvement of crashworthiness such as link arm and upper and lower rail. Newly designs have also permitted the structural within vehicles to have certain energy absorption as a result the total energy absorption of vehicle through collision can improved.

The previous research by Umasankar Das et al. (Das & Toppo, 2018) examined the outcome of tool rotational on temperature and impact toughness dissimilar AA6101-T6 and AA6351. The result show, extreme impact toughness was detected at 1100 rpm rotational speed and decline with additional increase the rotational speed. A. Farzadi et al. (Farzadi, Bahmani, & Haghshenas, 2017) studied the optimization of welding parameter on for aluminium alloy 7075-T6 using the RSM method. His calculate the outcome of deviations in rotational and welding speed on the microstructure, hardness as well as tensile test. From the experiment result, the welding speediness has the most significant influence to the impact strength.

This study is to investigates the energy absorption of different aluminum alloy AA6061 and AA7075 joining, now are using in the automotive industry. By using the FSW technique, the proposed technique to find the optimal parameter of FSW is via Response Surface Method (RSM). There are limited scientific ways to discovery the optimal parameter for FSW. RSM has a sorted out style to locate the perfect structure of execution. Therefore, it tends to be exploited to detect the ideal parameter in the fabrication method. The effects of rotational and welding speed on calculation of energy absorption of welded joint have been investigated in this research by using RSM.

2.0 Methodology

2.1 Material and methods

This section discuss on technique that being used and will describe test and techniques that being performed and practiced respectively. All parameters utilized in this FSW trials depended on the literature review and its varies in rotational and welding speed. The FSW procedures were led by utilizing the conventional milling machine and this trial is directed by utilizing the Friction Stir Welding (FSW) of different aluminium alloys

AA6061-AA7075. The justification of the outcomes is showed as of the response optimizer with the projected scientific model. To perform this research systematically, some procedures have to be followed. Showed the flow chart of this study.

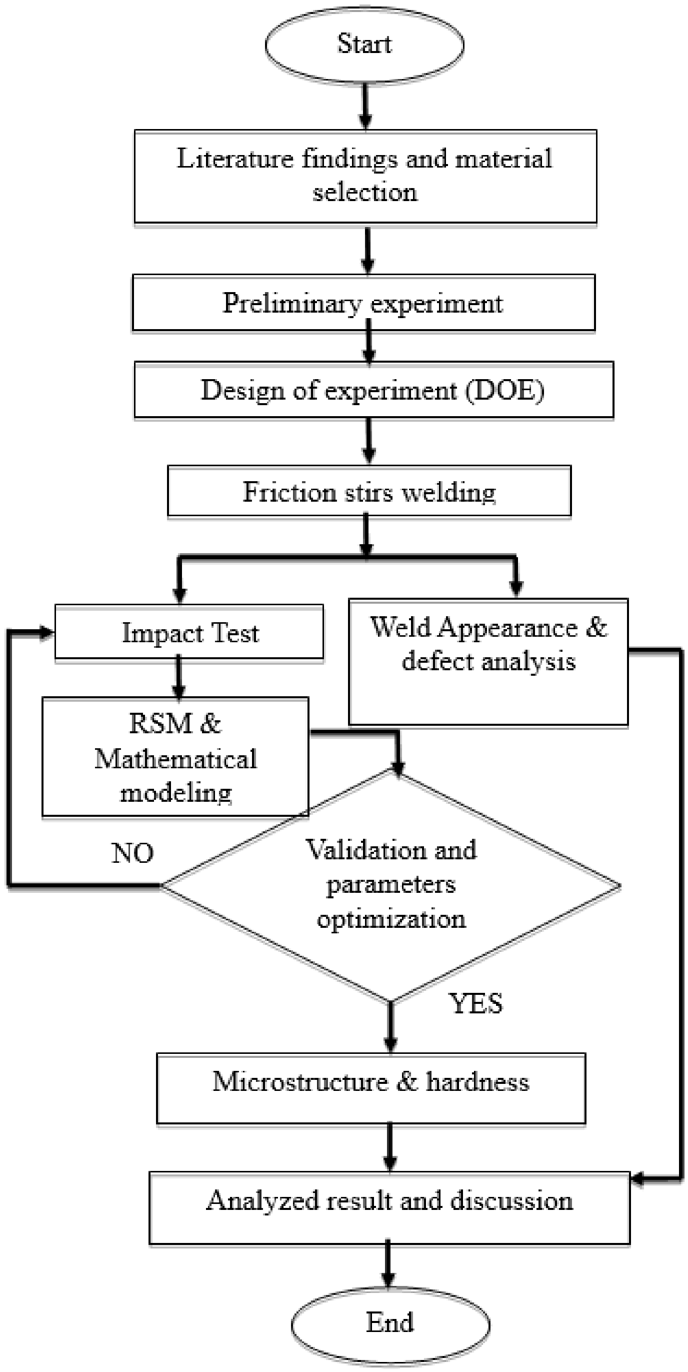

Figure 2: Research flow chart

Aluminium type AA6061 and AA7075 were chosen in this research as the main specimen. Table 2-3 to shows the composition properties, mechanical properties and physical properties of AA6061 and AA7075.

Table 2: Composition of aluminium alloy 6061 (composition %)

Element	Al	Zn	Mg	Cu	Mn	Si	Fe	Ti	Cr
Weight % age	Bal	0.25	1.2	0.4	0.15	0.8	0.7	0.15	0.35

Source : J.F. Guo et al (2014).

Table 3: Composition of aluminum alloy 7075 (composition %)

Element	Al	Zn	Mg	Cu	Mn	Si	Fe	Ti	Cr
Weight % age	Bal	6.1	2.9	2.0	0.3	0.4	0.5	0.2	0.28

Source : J.F. Guo et al (2014).

Table 4: Mechanical and physical properties for aluminum alloy 6061 and 7075

Based metal	Melting Point	Solidus Temperature	Thermal Conductivity (W/m-K)	Tensile Strength	Hardness Vickers (HV)	Impact Energy (Joule)
AA6061	652°C	582 °C	167	353	96	0.96
AA7075	635 °C	477 °C	130	572	175	N/A

Sources: Ambriez et al (2014)

In this study to keep off tool wear, H13 tool steel was used because of FSW device must tougher than soldered material (Mishra & Ma, 2005). In this study, taper cylindrical geometry being used as a tool and the dimension are showed in table 5.

Table 5: Tool pin dimensions

Dimension	Value
Hold diameter (mm)	22.50
Holder diameter (mm)	24.20
Shoulder diameter D (mm)	10.50
Shoulder length (mm)	4
Pin diameter d (mm)	3
Pin length, L (mm)	2.8
D/d ration of tool	3.5

FSW was done through utilizing traditional vertical milling machine model (VMM 3917). Rotational and welding speed use in this investigation is variable at 900 rpm, 1000 rpm and 1100 rpm and 900, 100 and 110 mm/min respectively before the conventional milling machine was set are shown in table 6. RSM with central composite design (CCD) were used. Two factors, namely rotational speed (rpm) and welding speed (mm/min) were investigated in three stages. The number of trials derives from the design of trial RSM where 13 experiments are considered as acceptable (in table 7)

Table 6: Welding parameter

Process parameters	Values
Rotational Speed(rpm)	900, 1000, 1100.
Welding Speed (mm/min)	90, 100, 110.
Title Sngle (^{O})	3

Table 7: The Tests and stages for different parameters, based on the CCD

Experiment No.	Rename experiment No.	Rotational Speed (rpm)	Welding Speed (mm/min)
1	A	900	100
2	B	900	110
3	C	900	100
4	D	900	110
5	E	900	90
6	F	1000	90
7	G	1100	90
8	H	1000	100
9	I	1100	110
10	J	1000	100
11	K	1000	100
12	L	1000	100

After FSW process was done, other mechanical tests were conducted to assess the joint quality, namely Impact Test and Vickers Hardness Test. Each specimen consists of three impact test samples are shown figure 3 and the average of value will be calculated.

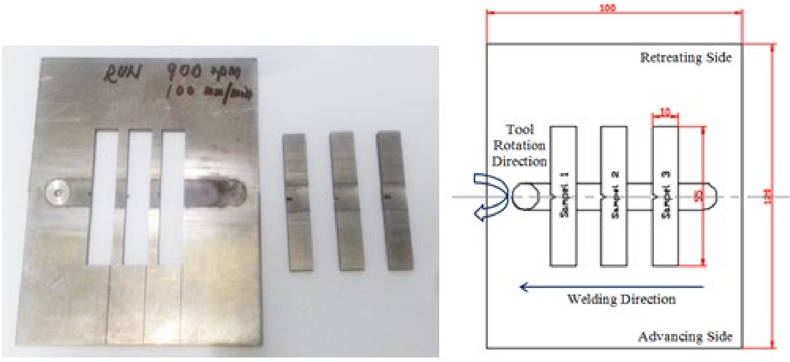

Figure 3: Each run of experiment will be consists 3 sample

The charpy test specimen follows as a specification of ASTM E23-16B standard, as the plate width is small, subsized specimens were ready as per previous study (Das & Toppo, 2018; Lakshminarayanan & Balasubramanian, 2010). Charpy impact specimens were set up to the measurements appeared in figure 4. To assess the effect toughness of the weld metal, the mark was set up at the weld metal (weld focus) just as in the HAZ. The samples are cut by utilizing wire cut Electrical Discharge Machining (EDM) machine for exactness wounding without altering the feature of that material.

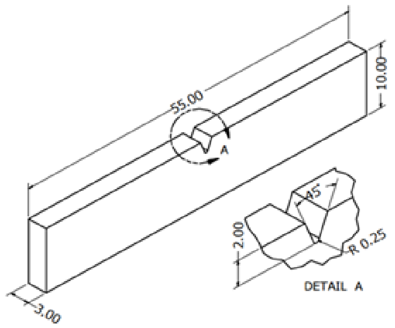

Figure 4: Dimension of sub size charpy test specimen (ASTM E23

To decide the energy absorbed in Joule, the effect trial was completed on the welded samples. In this test, the charpy tests was performed with impact velocity 5.308 m/sec as per the ASTM E-23-04 with room temperature via a pendulum-type impact testing machine (AIT 300 D) by an extreme size of 15 J and angle drop is 140^{o} are showed in figure 5.

Figure 5: Charpy test machine

The nonstop burden was utilized for a stay timespan of 10 seconds. Figure 6 demonstrated the Vickers hardness test machine, (MMT-X7).

Figure 6: Vickers hardness test machine

In this study, to create the relations among two welding parameters and one response, effect toughness RSM are being utilized. The scientific model was established to prove the connection among the process parameters and responses. With the input variables of rotational speed (RS) and welding speed (WS) by ignoring the blunder, the early order model can be write as below equation.

$$\gamma = \beta_0 + \beta_1(WS) + \beta_2(RS) + \beta_{11}(WS)^2 + \beta_{22}(RS)^2 + \beta_{12}(WS \times RS)$$

The full quadratic model was applied and statistically significant at 95% confidence level are using in this study. The exactness and correctness of the model were inspected using P value and correlation coefficient. Relation would be significant if the *P* value of the model fewer than the standard *P* value that is 0.05. Using RSM, model has been developed and the exactness of established models in forecasting the reaction requests to be confirmed and its led to find the exactness of the response optimizer. The outcome of joint parameters from the response optimizer are used. The minor fault shows the high accuracy of optimized combined parameters.

3.0 Result and discussion

This chapter will describe the outcomes attained from the experiments. The FSW between AA60661 and AA7075 has been conducted in order to find the optimum parameter. The outcome from impact test, hardness test and microstructure will be discussed accordingly. To verify the importance and suitability of the models, RSM analysis was used. The justification trial was carried out to create the developed scientific model and the robustness of the optimized parameter.

3.1 Impact toughness

Information of impact toughness is presented in table 8 where the outcomes was calculated based on median of three specimens. Every sample was engaged to discharge the outlier from the total trials.

Table 8: Experiment result of impact test

Exp. No	Sampel	Rotational speed (RPM)	Welding speed (MM/MIN)	Impact toughness (j)
1	A	900	90	3.600
2	B	900	110	5.096
3	C	1100	90	4.206
4	D	1100	110	3.401
5	E	1000	90	4.500
6	F	1000	110	5.404
7	G	900	100	4.434
8	H	1100	100	4.044
9	I	1000	100	4.944
10	J	1000	100	4.996
11	K	1000	100	4.912
12	L	1000	100	5.072
13	M	1000	100	5.069

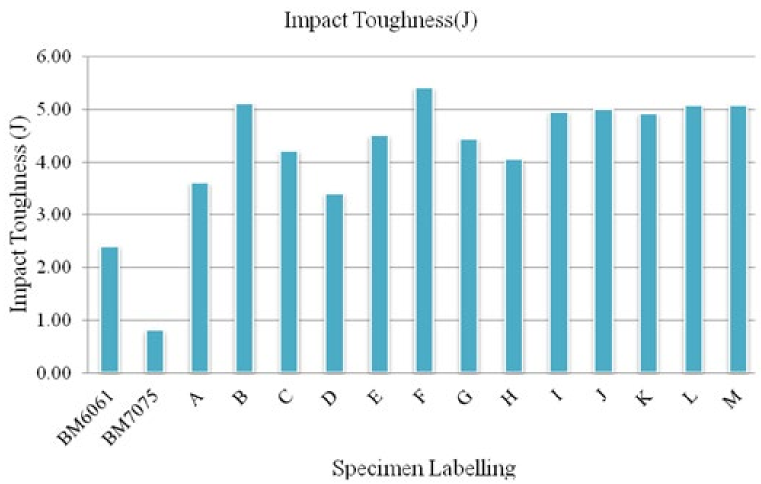

Figure 7: Comparison result of impact toughness with base metal

Base on the figure 7, present impact toughness results, for all specimens has shown the higher value than that of parent materials at the nugget zone fracture. This result is similar with the previous investigate by Von Strombeck et al. (A. von Strombeck, 1999). Impact toughness of parent metal for AA6061 and AA7075 is 2.4 J and 0.8 J, respectively. The result shows that the impact toughness of parent metal AA6061 is higher compared to the AA7075. After the impact test, it can be seen that the failure occurred at the weld nugget due to v-notch placed. From the failure looks like brittle fracture for AA7075 compare to AA6061. According to the figure 4.1, specimen D and F show the lowest and the highest impact toughness. The lowest impact toughness was 3.401 joule at 1100 rpm and 110 mm/min for sample D and the highest impact toughness was 5.404 joule at 1000 rpm and 110 mm/min for sample 6. In addition, the second lowest impact toughness was 3.600 Joule at 900 rpm and 90 mm/min for sample A. The lowest impact toughness is because of low friction pressure and time which does not supply adequate frictional temperature and time to design a comprehensive weld amongst the two different metals. After the rotational speed of the tool rises to 1000 rpm the effect toughness of the combined also increase. After increase in the rotational speed up to 1100 rpm, the effect toughness decrease. This decrease in the effect toughness, the grain modification at the weld zone because of high heat generation (Das & Toppo, 2018).

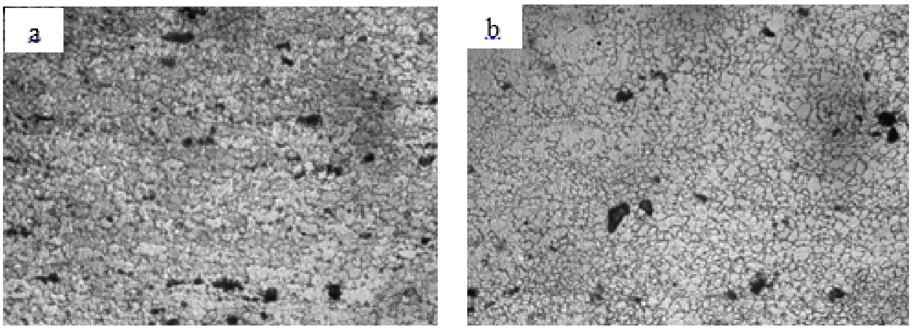

Figure 8: Mirocstructure at dissimilar rotational speed (a)1000 rpm (b)1100 rpm

For comparison purpose, the microstructure of stir zone at various rotational speed is presented in figure 8. As tool rotational speed increases the frictional heat also increases because of increased residing time of tool. The microstructure of the SZ experiences high temperature and severe plastic deformation, thus the microstructure of this zone is characterized by recrystallized grains, while the grain size at 1000 rpm is finer than that at 1100 rpm Fig. 4.3(a) and (b). The SZ grain size difference was also reported by Guo et al. (J. Guo et al., 2014) and Rozidgue et al. (Rodriguez et al., 2015) in dissimilar FSW of 6000 and 7000 series aluminium alloys. Arbegast, W.J et al. (Arbegast, 2008) reported that defects formation decreasing of mechanical properties. Resulting sample A and D show the low impact toughness due to produced flash and galling defect. For the sample A, flash imperfections are formed at the low rotation and welding speed due to insufficient heat input. Meanwhile, sample D at high rotational speed and welding speed produce flash and galling defects due to excess heat input. The defect formations are formed due to the additional or inadequate heat input were reported in previous FSW studies (Kim, Fujii, Tsumura, Komazaki, & Nakata, 2006). Flash may happen if improper parameter setting that causes thinning of the weld (Gibson et al., 2014). All sample fracture at the nugget zone (NZ). This is because nugget zone at sample is the v notch placed at the weld centreline.

3.2 Statistical analysis

Outcomes from impact test were analysed by using RSM with a quadratic model to create the relationships between response and parameters. The suitability of the models was assessed using analysis of variance through ANOVA. Error! Reference source not found. 2 showed the first ANOVA analysis of the impact test result from the experimental data. The outcome demonstrated that every one of the three models are important. Which the model term for the P worth is under 0.05 are critical model. The ANOVA reveal that the regression of the model is statistically significant with *P* value less than 0.05. The *P*-value of lack of fit is 0.341 (>0.05) and thus it is significant. The R^2 and R^2 adjusted values are 97.07% and 93.95% respectively indicate the regression precision. Due to the *P*-value are lower than 0.05 include the LOF therefore all process factor terms are significant. Subsequently, the model was admissible for satisfactory and further breaking down.

Table 9: The result of ANOVA test

Source	DF	Seq. SS	Adj. SS	Adj. MS	F	P
Regression	5	4.54756	4.54756	0.90951	46.31	0.000
Linear	2	0.78925	3.71396	1.85698	94.56	0.000
Square	2	2.43466	2.43466	1.21733	61.99	0.000
Interaction	1	1.32365	1.32365	1.32356	67.40	0.000
Residual Error	7	0.13747	0.13747	0.01964		
Lack-of-fit	3	0.11998	0.11998	0.03999	9.15	0.341
Pure error	4	0.01749	0.01749	0.00437		
Total	12	4.68503				
S = 0.741990		PRESS = 18.7484				
R^2 = 97.07%		R^2 (pred.) = 93.95%		R^2 (adj.) = 94.97%		

Base on the table 9, presents the association parameter of rotational and welding speed on effect strength. The augmentation of the rotational speed is expanded from 900 rpm to 1000 rpm with welding rate esteem likewise increments from 90 mm/min to 100 mm/min.The increment of the rotational speed is increased from 900 rpm to 1000 rpm with welding speed value also increases from 90 mm/min to 100 mm/min. This contributing towards high impact toughness but decreases with rotational and welding speed increases at 1100 rpm and 110 mm / min. Therefore to accomplish high sway durability welded joints, the rotational speed (950-1000 rpm) and the most elevated welding speed 110 must be picked. Rotational speed and welding speed are projected to effect on the impact toughness of the welded joint. The impact of the parameters is outlined in the fundamental impact plot (MEP) are appeared in figure 4.4. Figure showed, the rotational speed affected the impact toughness to extremely rise from 900 rpm to 1000 rpm and then declines up to 1100 rpm. The welding speed also displays a equivalent increment design.

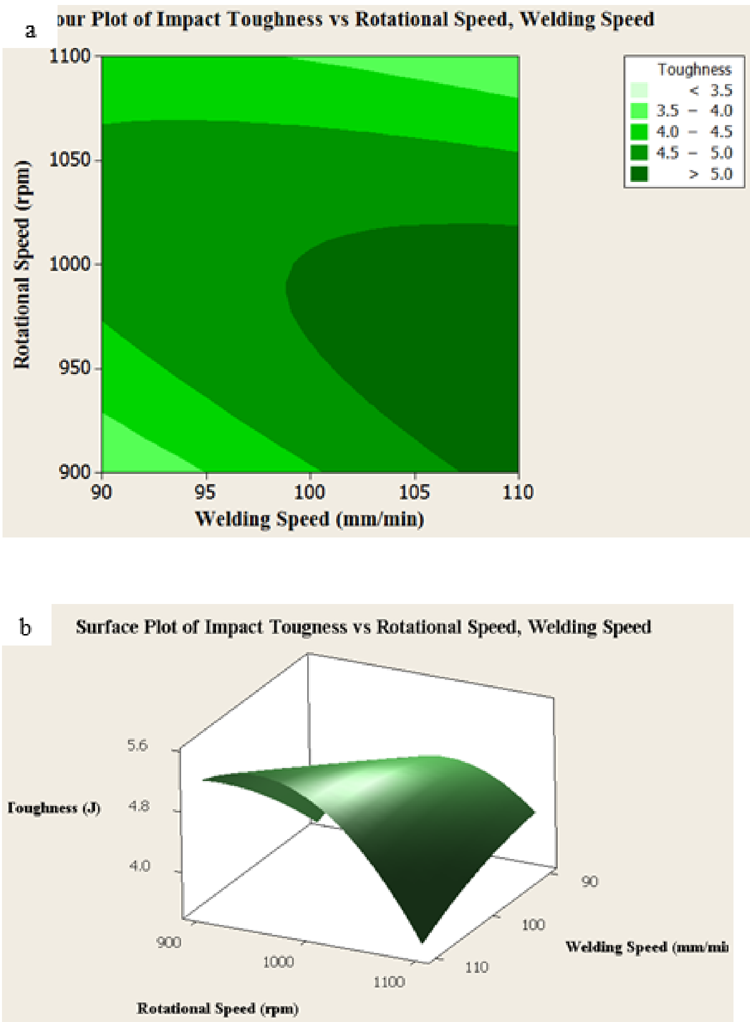

Figure 9: Effect of rotational speed and welding speed in (a) contour plot and (b) surface plot on impact toughness

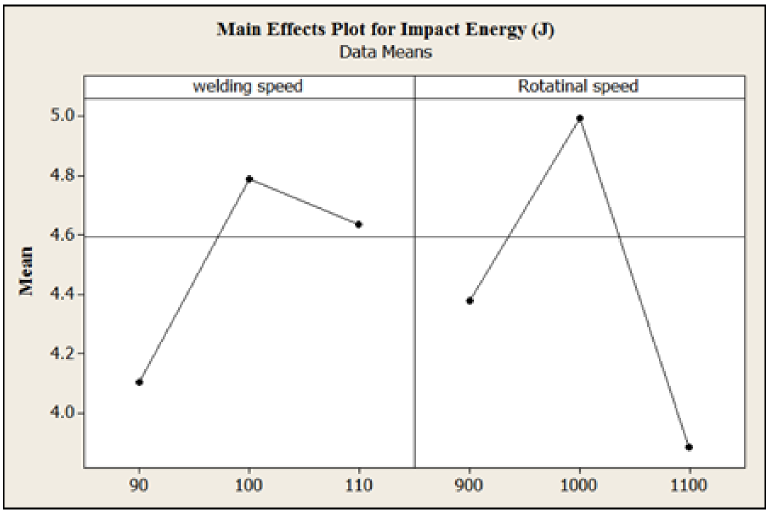

Figure 10: Main effect plot (MEP) for rotational speed and welding speed on impact toughness.

RSM has the ability to develop the logical model that spoke to the association between methodology parameters and the responses. The coefficient of relapse for every parameter was taken from the evaluated relapse coefficient, came about because of the investigation appeared in table 10 linear and square term for rotational speed and welding speed coefficients have p-values underneath than 0.05 however association coefficient for welding rate and welding velocity is more than 0.05s.

Table 10: Coefficients and their P values in coded condition

Term	Coefficient	SE Coefficient	T	P
Constant	-145.619	11.7037	-12.442	0.000
WS	0.818	0.1827	4.477	0.000
RS	0.219	0.0183	12.002	0.000
WS*WS	-0.001	0.0008	-1.282	0.241
RS*RS	-0.000	0.0000	-9.738	0.000
WS*RS	-0.001	0.0001	-8.210	0.000

The impact strength result from the examination was appeared differently in relation to the decided foreseen responses from the made model. The examination was made by figuring the percentage error and is displayed in Table 4.5. The dissemination of percentage error is diverse for every sample. The highest percentage error is 4.1 % for specimen 6, and the lowest percentage error is 0.34% for specimen 7. According to the confident level selected, errors lower than 5% is adequate. Figure demonstrates the scatter chart between the real and anticipated effect toughness values where the residuals in real and forecast are minimal, since the residuals will in general be near the askew line. It demonstrates that the model is agreeable in a normal response. Along this lines, the ultimate scientific model for foreseeing impact toughness can be stated as the accompanying exhibited in condition 4.2.

Table 11: Comparison between experimental and predicted result of impact toughness

Exp no.	Actual Impact Energy (J)	Predicted Impact Energy (J)	Error (%)
1	3.600	3.499	2.806
2	5.096	5.182	1.688
3	4.205	4.157	1.141
4	3.401	3.538	4.028
5	4.500	4.649	3.311
6	5.404	5.181	4.127
7	4.434	4.449	0.338
8	4.044	3.956	2.176
9	4.994	5.023	0.581
10	4.996	5.023	0.540
11	4.911	5.023	2.281
12	5.072	5.023	0.966
13	5.069	5.023	0.907

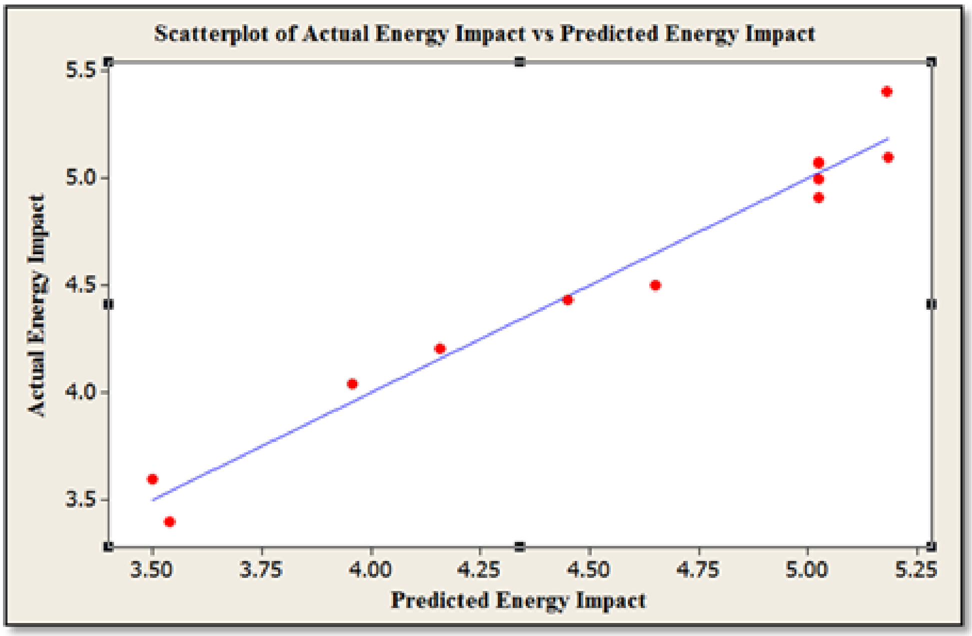

Figure 11: Scatter diagram of real and anticipated estimation of effect toughness

In the Central Composite Design technique, the objective of reactions canbe choosen which depends on the greatest, least or explicit values based on responses series. In this study, the aim maximum and minimum value is 15 Joule and 3.401 J. The value was taken from the maximum weight of pendulum and lower impact toughness value experiment demonstrate the ideal friction stir-welding parameters to accomplish most extreme effect of toughness. It is clear from the assume that the most elevated effect strength is accomplished at rotational speed of 1000 rpm and welding velocity of 110 mm/min.

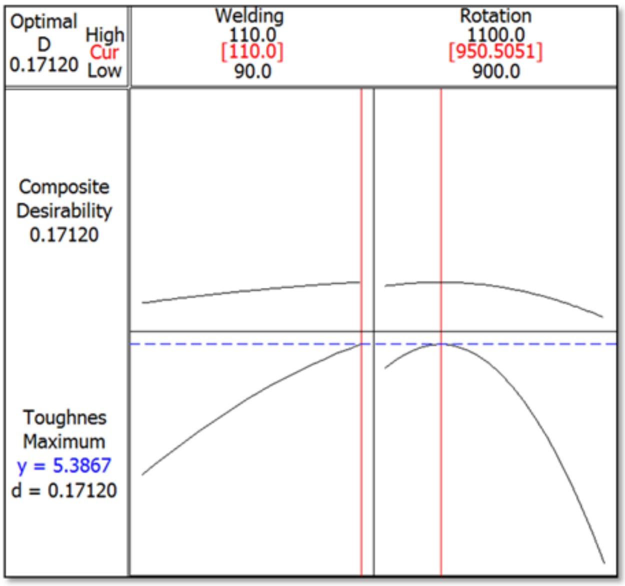

Figure 12: Optimization plot

This approval test was completed to affirm the precision of improved parameter and the scientific model with the picked focused on reactions. The optimize parameter used are 950 rpm for rotational speed and 110 mm/min for welding speed. Validation processes were carried out to access amount of relative error between the predicted and experimental result. The estimation of effect durability for expectation was determined from the numerical model dependent on enhanced parameter is 5.023 J. Contrasting the genuine and anticipated final product, the determined normal blunder is 3.02%, are appeared in table 12. The small error value showed the high accurateness of the projected model.

Table 12: Validation experiment result

Exp no.	Actual Impact Energy (J)	Predicted Impact Energy (J)	Error (%)
1	5.3687	5.120	4.86
2	5.3687	4.970	8.02
3	5.3687	5.456	1.60
4	5.3687	5.210	3.05
5	5.3687	5.300	1.30
13	5.3687	5.023	3.02

3.3 Micro hardness evaluation

Vickers hardness was done in this experiment to evaluate the hardness properties of the welded among AA6061 and AA7075 which display in figure 13. Vickers hardness dimensions were taken alongside the centre of the transverse welds. It can be observed that the base metal (BM), heat affected zone (HAZ), thermo-mechanically affected zone (TMAZ) and welding zone (SZ) place may be differentiated with the aid of studying the hardness value.

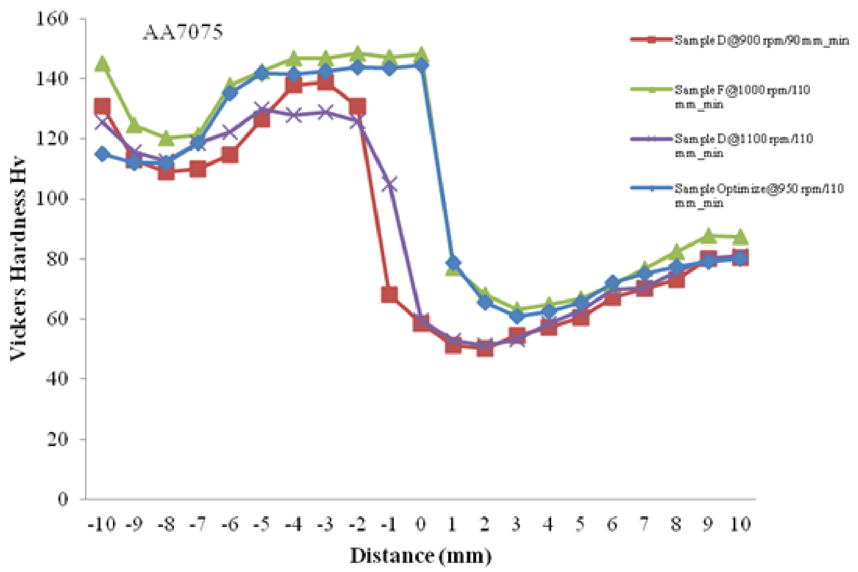

Figure 13: Shows the vickers hardness profile of the cross section of welded joints under different impact toughness value

Hardness peak had been observed in SZ location adjoining to the retreating side, in the meantime low hardness region were measured at SZ place adjoining to the advancing aspect it can be observed that AA7075 have a strong hardness value in SZ region compared to AA6061. Both AA6061 and AA7075, can also be identified the hardness value at HAZ region will decline from the hardness value of BM region due to the HAZ area is affected by the heat from the welding process or over aging, it will be alters the strength of the material (J. F. Guo et al., 2014). The thermal exposure causes the grain to grow.

In this study, all joints fractured at SZ region where the V-notch was allocated. Hardness test results showed the highest impact toughness specimen will give a high hardness value. While a low hardness value on the impact toughness depression. From the graph, at the SZ region the lowest and higher hardness value can be identified where the hardness value is 61.7 HV and 148.2 HV, respectively. The hardness value an apparent increase of the joints as the rotational speed was increase from 900 rpm to 1000 rpm. Higher hardness can be seen at rotational speed of 1000 rpm and welding speed 110 mm/min at the SZ region. The heat generated enough to plastics deformation of material and recrystallization of the grains. In addition, this SZ is directly stirred by the tool pin during FSW process. However, with further increases in the rotational speed up to 1100 rpm the hardness value decreases. The decrease hardness value at the SZ due to diverse affording to the percentage mix of the two materials (Kasman & Yenier, 2014). The hardness value at TMAZ was to some extent higher than the HAZ area for both AA6061 and AA7075 (Cavaliere, De Santis, Panella, & Squillace, 2009). In TMAZ region, the occurrence of plastic deformation but the temperature insufficient for recrystallization of grain. However, in HAZ region, the thermal cycles during the FSW process cause some microstructure changes with insufficient heat presence to cause plastics deformation. It is different for the tensile test performed on the different FSW studies. The links unsuccessful either through the HAZ or TMZA of the material with the lowest strength (J. Guo et al., 2014) (Amancio-Filho, Sheikhi, Dos Santos, & Bolfarini, 2008) (Da Silva et al., 2011) (Koilraj et al., 2012). In this study, show the hardness value on the SW area of AA7075 is better than the hardness of AA6061.

4.0 Conclusion

The fabrication of joining dissimilar aluminium alloy 6061 and 7075 with thickness 3 mm were successfully done by using friction stir welding. Modelling of FSW process between two factors rotational and welding speed, and the effect durability as response of friction stir-welded dissimilar aluminium alloy joint was created via CCD-RSM. Below are the conclusions: Friction stir welding of aluminium alloy turned into effectively welded with butt joint setup. Specimen F with rotational speed 1000 rpm and welding speed 110 mm/min produced highest impact toughness is 5.404 joule. As on alternative, specimen D with rotational pace 1100 rpm and 110 mm/min produced the lowest effect toughness is 3.404 joule. The impact tests, confirmed that the whole effect strength drastically expanded in the FSW welded joint, compare to the bottom metal. All the specimen the fracture become positioned on the stir zone (SZ) because of v-notch was allocated. The rotational velocity and welding speed has the extreme effect on the primarily based at the impact longevity outcomes. Both parameters added to the frictional warmth to the welding. The scientific model was formed in the direction of estimate the responses based on the process parameters. Base on the ANOVA analysis it shows that the all process factor among parameters were significant because of p-value are lower than 0.05. The ANOVA investigation was repetitive to evacuate the interface term and bringing about a high difference of the model; as the value of the coefficient of regression (R^2) and R^2 adjusted are more than 90%. The value of lack-of-fit (LOF) for the model is 0.341 higher than p-value, it is displays sufficient adequacies and acceptable. The optimal parameter was projected mostly to the highest impact toughness value. The optimal parameter for FSW between AA6061 and AA7075 is when the rotational speed is 950 rpm and welding speed is 110mm/min. The impact toughness of the FSW by using the optimum parameter is 5.023 J. It is slightly lower compare to the theoretical value which is 5.39 J. The error among the trial value and theoretical value is 3.02%. Because of frictional heating throughout the welding course, the hardness of the welded area is meaningfully relate to the microstructure changes. Entirely specimens displayed fairly equivalent movements but then diverse in hardness value, representing factor of rotational speed and welding speed has affected the specimen's Vickers hardness because of dissimilar of microstructure along the welded area. The hardness declines from base metal to the HAZ region.

The higher impact toughness value show the high hardness at the stir zone where the specimen was break during the impact test. On the other hand, the lowest impact toughness specimen shows the low hardness test at the same region. This significant due to thermal interaction caused the grain to raise. The grains converted rougher as they are positioned far away from the SZ. Bottom hardness values at the HAZ show fracture taking place at this area because of rougher and uneven grain dimensions thru small hardness.

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