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Comparative study on temperature during machining of Al6061 and Al7075 reinforced with Al_2O_3 using statistical analysis

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***Abstract*— The present paper focused on temperature measurement during machining of Al6061 by considering the Al_2O_3 as the reinforcement with an interval of 2% from 1% to 9% respectively. The experimental investigations were conducted using operational parameters such as feed rate, depth of cut, and spindle speed. However, in the case of 9% Al_2O_3, there is a temperature variation for spindle speed, with a progressive increase in temperature from 28.4°C to 35.4°C for 0.10 mm/sec to 0.20 mm/sec and 0.50mm to 1.25mm of feed rate and depth of cut for Al7075 combinations. Whereas, influence parameters in temperature was determine and the average temperature for the combinations considered. It is clearly shows that for the 0% Al_2O_3 the temperature was 32.46°C and for 9% Al_2O_3 the temperature was 28.91°C for Al6061.**

Index Terms: **Al7075, temperature, prediction, ANOVA, statistical analysis.**

INTRODUCTION

In the closing three decades, the development of advanced substances with foremost mechanical houses has underpinned fast development in manufacturing of new products. The ever increasing demand for excessive performance substances has spurred research into the improvement of advanced alloys and composites. Transport industries, particularly aerospace and greater recently automobile manufacturers have been interested especially in substances with excessive strength-to-weight ratios as these can provide large overall performance benefits.The materials have played and will continue to play a key role in enhancing human living throughout the world and enabling development of a nation [1-5]. Traditional monolithic materials have limitations in terms of achieving an appropriate combination of strength, stiffness, toughness, and density, among other properties. To address this shortcoming and meet the ever-increasing demands of modern-day technology, composites are the most promising substances of recent interest.Over the years, the concept of "sustainable development" for an advanced civilization in a fast growing global population is understood as a compressive approach that not only balances the environmental, social and financial considerations but also emphasizes their continual improvement and growth through scientific analysis. The advancement of advanced composites from the early 1940s to the composites utilised in the space shuttle orbiter has been phenomenal. This rise in the technology of reinforcements, matrices, and composite fabrication is due to the attention paid to the practical weight savings that can be realised by employing superior composites, which in turn can reduce cost and boost efficiency[6-9]. Composites are substances which made of two or more chemically awesome constituents, on a macro-scale, having a distinct interface setting apart them. One or greater discontinuous phases therefore, are embedded in a non-stop section to structure a composite. Generally, most of the composites consist of a bulk material (matrix), and a reinforcement of some kind, brought specifically to enlarge the electricity and stiffness of the matrix. This reinforcement is generally in fiber or particulate shape [10-12]. After extra over the quarter of a century of research, Metal Matrix Composites (MMCs) and extra specially Aluminum Matrix Composites (AMCs), are foundation to make a huge contribution to automotive, aerospace, and electronic applications.On one hand, this is the significance of developments in processing techniques, and on other hand, the outcome of advances in the sympathetic of the relationship among structure and mechanical characteristics. Nowadays MMCs have undergone a transition such that they are more promising in achieving good mechanical properties on conventional metals and alloys that are regarded as potential engineering materials for various aerospace, marine, and automotive applications. Our ever-growing technologies have been driving our industrial growth in the numerous fields like automobile, electronics, aerospace and marine[13-14].

EXPERIEMNTAL INVESTIGATIONS

The cutting temperature varies considerably with depth of cut and cutting speed and penetration rate respectively. The tool chip interface temperature is measured by a non-contact type thermocouple. The thermocouple has a ball which is used to contact on the cutting tool which measures the temperature increment in turning process. The increment in temperature is indicated on digital indicator (Fig.1).The tool's life is mostly determined by the cutting temperature. Heat is generated in zone "C," also known as the work tool contact zone, due to burnishing friction, and the heat in this zone increases over time as the wear land on the tool develops and increases. The cutting temperature varies considerably with depth of cut and cutting speed and penetration rate respectively. The tool chip interface temperature is measured by a non-contact type thermocouple. The thermocouple has a ball which is used to contact on the cutting tool which measures the temperature increment in turning process. The increment in temperature is indicated on digital indicator.

Fig 1 shows the arrangement made to measure the cutting temperature.

RESULTS AND ANALYSIS

In the current investigation, Al_2O_3 was varied from 0% to 9% with a 1% interval reinforced with Al7075 and Al6061 utilizing the Taguchi technique L15 design array. The experimental investigations were conducted using operational parameters such as feed rate, depth of cut, and spindle speed. However, in the case of 9% Al_2O_3, there is a temperature variation for spindle speed, with a progressive increase in temperature from 28.4°C to 35.4°C for 0.10 mm/sec to 0.20 mm/sec and 0.50mm to 1.25mm of feed rate and depth of cut for Al7075 combinations. Whereas, influence parameters in temperature was determine and the average temperature is give in Table 1. it is clearly shows that the for the 0% Al_2O_3 the temperature was 32.46°C and for 9% Al_2O_3 the temperature was 28.91°C for Al6061 (Fig. 2).

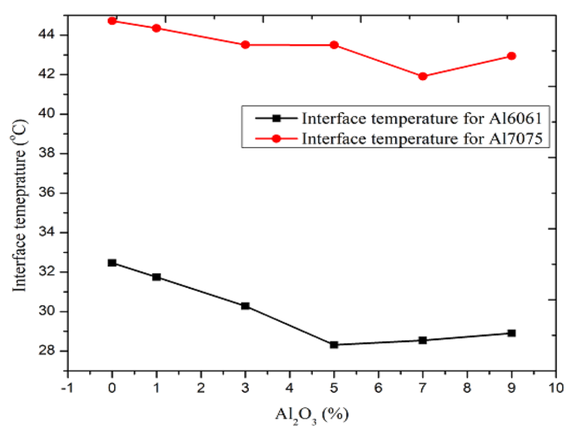


Fig. 2 Comparative study of interface temperature between Al6061 and Al7075 for different percentage of Al_2O_3

Multiple regression and ANOVA analysis for temperature on Al6061 and Al7075 reinforcement with Al_2O_3 for all combinations considered

Table 2 shows the results of multiple regression and ANOVA analysis of Al6061 without reinforcement of Al_2O_3 by considering four input variables with one output (temperature). It is clearly shows that the F-value of Al_2O_3, spindle speed, feed rate and combinations of feed rate and spindle speed are 64.18, 36.32, 11.14 and 5.16 respectively.

Table 1 Interface temperature for different percentage of Al_2O_3 with Al6061 and Al7075

Composition	Average Interface temperature For Al6061 (°C)	Average Interface temperature For Al7075 (°C)
0% Al_2O_3	32.46	44.72
1% Al_2O_3	31.75	44.35
3% Al_2O_3	30.28	43.51
5% Al_2O_3	28.32	43.50
7% Al_2O_3	28.54	41.91
9% Al_2O_3	28.91	42.94

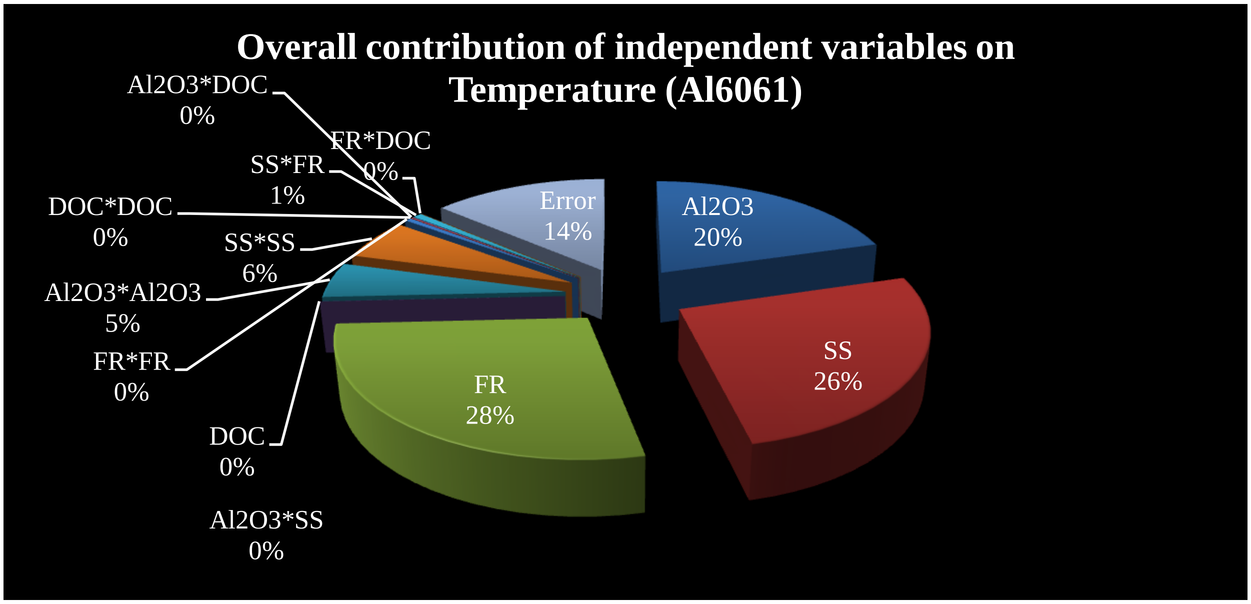
Table 2Overall ANOVA Analysis of temperature for Al6061

Source	DF	F-Value	P-Value	Contribution	Adj-R^2	R^2	Remarks
Regression	12	71.85	0.000	86.29%			Significant
Al_2O_3	1	64.18	0.000	20.45%			Significant
SS	1	36.32	0.000	26.04%			Significant
FR	1	11.14	0.001	27.72%			Significant
DOC	1	0.11	0.744	0.02%			Insignificant
Al_2O_3*Al_2O_3	1	49.51	0.000	4.95%	85.09%	86.29%	Significant
SS*SS	1	43.51	0.000	5.77%			Significant
FR*FR	1	4.92	0.028	0.49%			Significant
DOC*DOC	1	0.16	0.694	0.09%			Insignificant
Al_2O_3*SS	1	0.04	0.832	0.00%			Significant
Al_2O_3*DOC	1	0.70	0.405	0.07%			Insignificant
SS*FR	1	5.19	0.024	0.67%			Significant
FR*DOC	1	0.05	0.831	0.00%			Insignificant
Error	137			13.71%			
Total	149			100.00%			

Regression Equation

$$\text{Temperature for Al6061} = 19.82 - 1.143\, Al_2O_3 + 0.05513\, SS + 52.3\, FR - 0.60\, DOC + 0.0869\, Al_2O_3{*}Al_2O_3 - 0.000106\, SS{*}SS - 93.9\, FR{*}FR + 0.44\, DOC{*}DOC - 0.000068\, Al_2O_3{*}SS - 0.0732\, Al2O3{*}DOC + 0.0541\, SS{*}FR + 1.38\, FR{*}DOC \quad (1)$$

The multiple regression equation for temperature for Al6061is as shown in the equation 1.It depicts how independent variables affect the dependent variable of interface temperature. Table 2 reveals that Al_2O_3, spindle speed, and feed rate have a coefficient of determination of 86.29 percent and an F-value of greater. It means that all three parameters have a greater influence than the other parameters. The measured and anticipated values of the interface temperature for Al6061 are shown in Fig. 4.



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ig. 3 Pie chart of percentage contribution of the independent variables on temperature for Al6061

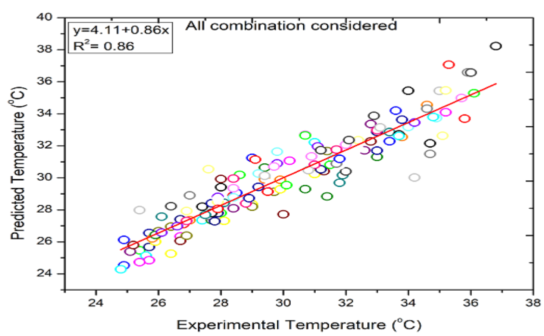

Fig. 4 Predicted and experimental values of temperature for all combinations of Al_2O_3

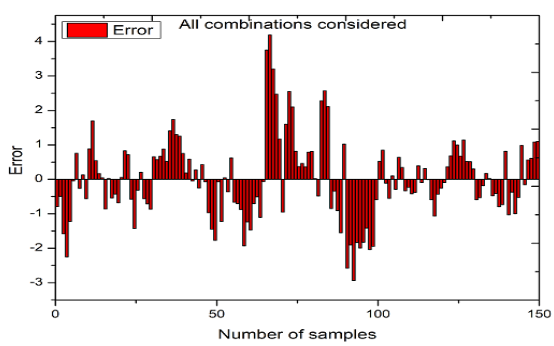

Fig. 5 Residual analysis of temperature for all combinations of Al_2O_3

Fig. 3 shows the percentage contribution of the operational parameters and for the present study Al_2O_3, spindle speed and feed rateis the major influence on interface temperature during turning process. Similarly the depth of cut is the least effect on interface temperature with a contribution ration of 0.02%. Fig. 5clearly depicts that the residual plots shows that the points are equally distributed on either side of the reference points.

Table 3 shows the results of multiple regression and ANOVA analysis of Al7075 with reinforcement of Al_2O_3 by considering four input variables with one output (temperature). It is clearly shows that the F-value of spindle speed, feed rate and combinations of spindle speed and spindle speed are 22.13, 19.61 and 30.65 respectively.

Table 3Overall ANOVA Analysis of temperature for Al7075

Source	DF	F-Value	P-Value	Contribution	Adj-R^2	R^2	Remarks
Regression	12	67.74	0.000	85.58%			Significant
Al_2O_3	1	0.11	0.746	2.22%			Insignificant
SS	1	22.13	0.000	21.75%			Significant
FR	1	19.61	0.000	54.48%			Significant

DOC	1	0.08	0.779	0.06%			Insignificant
Al_2O_3* Al_2O_3	1	1.23	0.269	0.13%	84.31%	85.58%	Insignificant
SS*SS	1	30.65	0.000	4.10%			Significant
FR*FR	1	8.68	0.004	0.91%			Significant
DOC*DOC	1	0.00	0.953	0.39%			Insignificant
Al_2O_3*SS	1	0.81	0.369	0.09%			Insignificant
Al_2O_3*DOC	1	0.06	0.803	0.01%			Insignificant
SS*FR	1	10.20	0.002	1.42%			Significant
FR*DOC	1	0.16	0.692	0.02%			Insignificant
Error	15			14.42%			
Total	24			100.00%			

Regression Equation

Temperature for Al7075 = 31.37 + 0.041 Al_2O_3 + 0.03779 SS + 61.0 FR – 0.45 DOC – 0.0120 Al_2O_3* Al_2O_3 – 0.000078 SS*SS – 109.6 FR*FR + 0.058 DOC*DOC – 0.000252 Al_2O_3*SS -0.0192 Al_2O_3*DOC + 0.0667 SS*FR + 2.26 FR*DOC (2)

The multiple regression equation for temperature for Al7075is as shown in the equation 2. It depicts how independent variables affect the dependent variable of interface temperature. Table 3 demonstrates that spindle speed, feed rate, and combinations of spindle speed and spindle speed have a coefficient of determination of 85.58 percent with an F-value of greater. It means that all three parameters have a greater influence than the other parameters. Fig. 7 shows the measured and the predicted values of the interface temperature for Al7075.

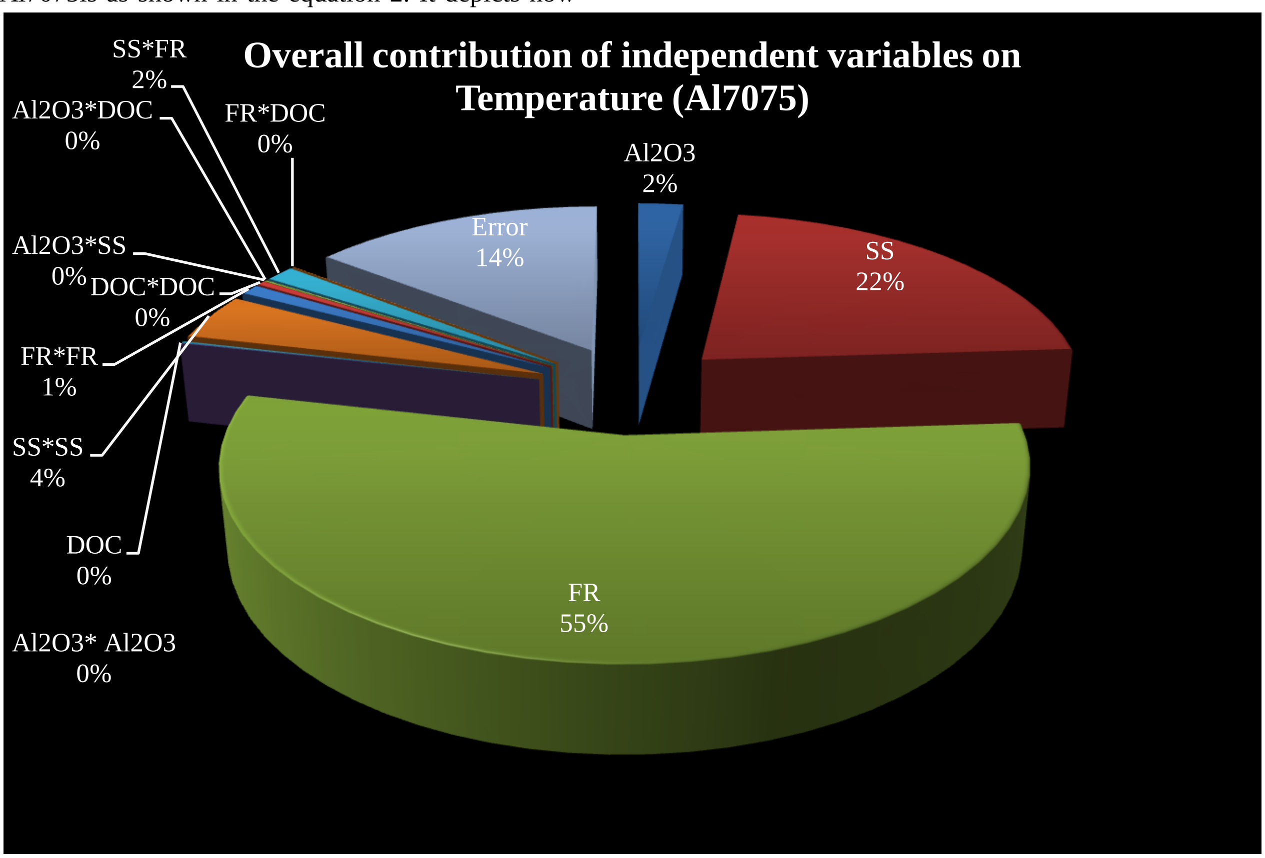

Fig. 6 Pie chart of percentage contribution of the independent variables on temperature for Al7075

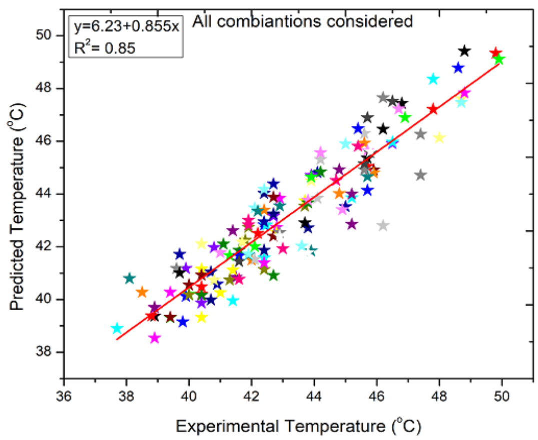

Fig. 7 Predicted and experimental values of temperature for all combinations of Al_2O_3

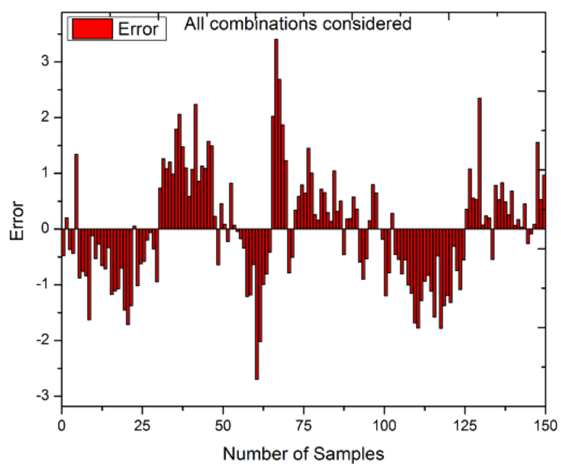

Fig. 8 Residual analysis of temperature for all combinations of Al_2O_3

Fig. 6 shows the percentage contribution of the operational parameters and for the present study feed rate, spindle speed and combinations of spindle speedis the major influence on interface temperature during turning process. Similarly the depth of cut is the least effect on interface temperature with a contribution ration of 0.06%. Fig. 8clearly depicts that the residual plots shows that the points are equally distributed on either side of the reference points.

CONCLUSIONS

Comparative study between Al6061 and Al7075 reinforced with Al_2O_3 was analyzed by considering depth of cut, spindle speed, feed rate and Al_2O_3. There was an fluctuation in temperature during the variation of spindle speed. Finally ANOVA analysis for al the combinations Cleary show that the Al2O3 (20.45 percent), spindle speed (26.04 percent), feed rate (27.72 percent), and depth of cut (0.02 percent) had an R2 value of 876.29 percent for Al7075. Similarly for Al6061Al2O3 (2.22 percent), spindle speed (21.75 percent), feed rate (54.08 percent), and depth (0.06 percent) had an R2 value of 85.58 percent. Experimental and statistical modeling were found to be in good agreement, and a comparison of experimental and statistical analysis was drawn.

REFERENCES

[1] Pramod R, Veeresh Kumar G B, Shuvakumar Gouda P S and Arun Tom Mathew. (2018). A study on the Al_2O_3 reinforced Al7075 Metal Matrix Composites wear behaviour using artificial neural networks. Material today: Proceedings 5: 11376-11385. https://doi.org/10.1016/j.matpr.2018.02.105.

[2] Kanaca E and Gunen Ali. (2016). Investigations on machinability of Al_2O_3 reinforced Al6061 metal matrix composites. Journal of natural and applied sciences 20 (3): 434-441. DOI:10.19113/sdufbed.72984.

[3] Veeresh Kumar G B, Rao C S P, Selvaraj N and Bhagyashekar M S. (2010). Studies on AL6061-SiC and Al7075-Al_2O_3 metal matrix composites. Journal of mineral and materials characterization and engineering. 9: 43-55.

[4] Suresh S, HarinathGowd G and Deva Kumar M L S. (2019). Mechanical and wear behavior of Al7075/Al_2O_3/SiC/mg metal matrix nano composite by liquid state process. Advanced composites and hybrid materials 2: 530-539. https://doi.org/10.1007/s42114-019-00101-y.

[5] Gnana Sundari K, Rishitosh Ranjan B and Surekha. (2019). Performance evaluation of Al7075 hybrid metal matrix composites during non-convectional machining process. International journal of scientific and technology research 8 (12): 3871-3877.

[6] Prakash M and Mohammed Iqbal U. (2018). Parametic optimization in turing of AA2014/Al_2O_3 nano composites for machinability assessment using sensors. IOP conference series: Materials science and engineering 402: 1-14.

https://doi.org/10.1088/1757-899X/402/1/012013.
[7] Mario C. Santos, Alisson R. Machodo and Marcos A S. Barrozo. (2018). Temperature in machining of aluminum alloys. Chapter 5. Intech open: 71-89. http://dx.doi.org/10.5772/intechopen.75943.
[8] Vinu N Ravindran and Jithin Babu R. (2015). Thermal analysis of machining Al7075-T6 using carbide tipped tool. International journal of innovation in engineering and technology 5(4): 160-166.
[9] EyupBagei and Babur Ozcelik. (2005). Analysis of temperature changes on the twist drill inder different drilling conditions based on Taguchi method during dry drilling of Al 7075-T651. International journal of advance manufacturing technology 25: 1061-1074. https://doi.org/10.1007/s00170-004-2569-6.
[10] Bhanodaya Reddy G, Venumurali J, Sankara Y and Sivaramudu G. (2017). Parametric optimization of lathe turning for Al7075 alloy using Taguchi: An experimental study. IOSR Journal of mechanical and civil engineering 14 (3): 39-45. DOI: 10.9790/1684-1403063945.
[11] Paulo Davim J, Maranhao C, Jackson M J, Cabral G and Gracio J. (2008). FEM analysis in high speed machining of aluminium alloy (Al7075-0) using polycrystalline diamond (PCD) and cemented carbide (K10) cutting tools. International journal of advance manufacturing technology 39: 1093-1100. DOI 10.1007/s00170-007-1299-y.
[12] Venkatesan K, Ramanujam R, Vignesh V. Shanbhag, Nithin N. Yalamoori and VekataSubba Reddy D. (2014). Preparation, characterization and machinability of Al7075-Al_2O_3 matrix composite using multi layer coated carbide insert. Procedia materials science 5: 1819-1828. https://doi.org/10.1016/j.mspro.2014.07.469.
[13] Shah P H and VishveshBadheka. (2016). An experimental investigation of temperature distribution and joint properties of Al7075-T651 friction stir welded aluminium alloys. Procedia technology 23: 543-550. https://doi.org/10.1016/j.protcy.2016.03.061.
[14] Jacob S, Shajin S and Gnanavel C. (2017). Thermal analysis on Al7075/Al_2O_3 metal matrix composites fabricated by stir casting process. IOP conference series: Materials science and engineering 183: 1-8. https://doi.org/10.1088/1757-899X/183/1/012010.