www.ijraset.com Volume 5 Issue II, February 2017
IC Value: 45.98 ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

A Comprehensive Study on the Process Parameters for Machining Aluminium 7075

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Abstract: This paper attempts to make a detail study on the machining parameters of Aluminium 7075 either in its pure form or in the form of composites. This grade of aluminium is known for its application in aerospace industry and hence reviewing about its machining parameters will lead to more development in the field of production. Surface roughness is a phenomenon which affects the product gradually and hence its influence on Al 7075 is important to deal with. The process parameters of speed, feed and depth of cut are the common interest in this study and their role in the various design of experiments techniques. From the discussions, it is revealed that feed rate is the most influencing parameter amongst all and hence this particular parameter could be very crucial in the scientific investigation pertaining to the use of Aluminium 7075.
Keywords: speed, feed, depth of cut, Taguchi, signal to noise ratio

I. INTRODUCTION

Aluminum7075 is suitable for a variety of specific applications such as aerospace applications, fire protection materials, filters, catalyst supports, gas burners, sensors and thermistors. Surface roughness plays vital role in many areas and is a factor of great importance in the evaluation of machining accuracy. Surface roughness has become the most significant technical requirement and it is an index of product quality. Roughness is often a good predictor of the performance of a mechanical component since irregularities in the surface may form cracks or corrosion. Although roughness is usually undesirable, it is difficult and expensive to control during manufacturing. Surface finish mainly depends on Cutting speed, Depth of cut and Feed. So, the main aim of the study is to find the optimum parameters (speed, feed, depth of cut) so that surface roughness is optimized. Modern machining industries is mainly focused on the attainment of high quality, in terms of dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining in terms of cost saving and increase the performance of the product with reduced environmental impact. There are various optimization techniques used like genetic algorithm, artificial neural network, grey relational analysis, utility concept, response surface methods, Taguchi technique etc. to find out optimum cutting condition.

II. LITERATURE REVIEW

Abolfazal Golshan et al. [1] have optimized the machining characteristics of Aluminum 7075 alloy during drilling process. The drilling parameters used for this process are cutting speed, feed rate and drill diameter while two output parameters are surface roughness and dimension error. A multi objective evolutionary based algorithm NAGA 2 was used to optimize the drilling parameters in the machining of Al 7075 alloy. Two linear polynomial models were developed for measuring surface roughness and dimension error. Surface roughness and dimension error was reduced from 3.5 µm to 3.24345 µm and 1.31 % to 1.15089 % respectively.

S.V. Alagarsamy . et al. [2] have utilized taguchi method to investigate the drilling parameters such as cutting speed, feed rate and material removal rate in drilling of Al 7075 alloy. Orthogonal arrays and signal- to- noise ratio with effect to ANOVA are used to inspect the effect of drilling parameters on the quality of drilled holes. The optimum conditions for material removal rate of Al 7075 are cutting speed of 100 rpm, Feed rate of 0.12 mm/rev and Depth of Cut of 3.5 mm. It is clear that Depth of Cut is the most significant factor influencing MRR followed by Feed rate and Cutting Speed is the least significant factor from response table for signal to noise ratio.

A.M. Khorasani et al [3] have done the milling operation on Al7075. The objective of this study is to discover the role of various parameters such as feed rate, cutting speed and depth of cut in tool life prediction in milling operation by using artificial neural network and Taguchi design of experiments. The accuracy error was found to be negligible (3.034%). It was found that the prediction correlates very well with the experimental results. Finally, the correlation for training and test was obtained 0.96966 and 0.94966 respectively and mean square error was calculated 3.1908% for test data.

S.Hari Vignesh and R.Karthikeyan [4] have developed mathematical model for correlating the higher order influences of various

Volume 5 Issue II, February 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

turning parameter on surface roughness. This study is attempt to develop a force, surface roughness and tool wear prediction model during finish machining of Al 7075 aluminium alloy to analyze the combination of machining parameter for better performance within selected range of machining parameter. Design of experiment with L27orthogonal array is used for conducting the experiment and Response surface methodology is used to develop mathematical model. Result shows that the cutting force are influenced principally by the depth of cut. On the other hand, both feed rate and depth of cut have less significance on surface roughness and tool wear.

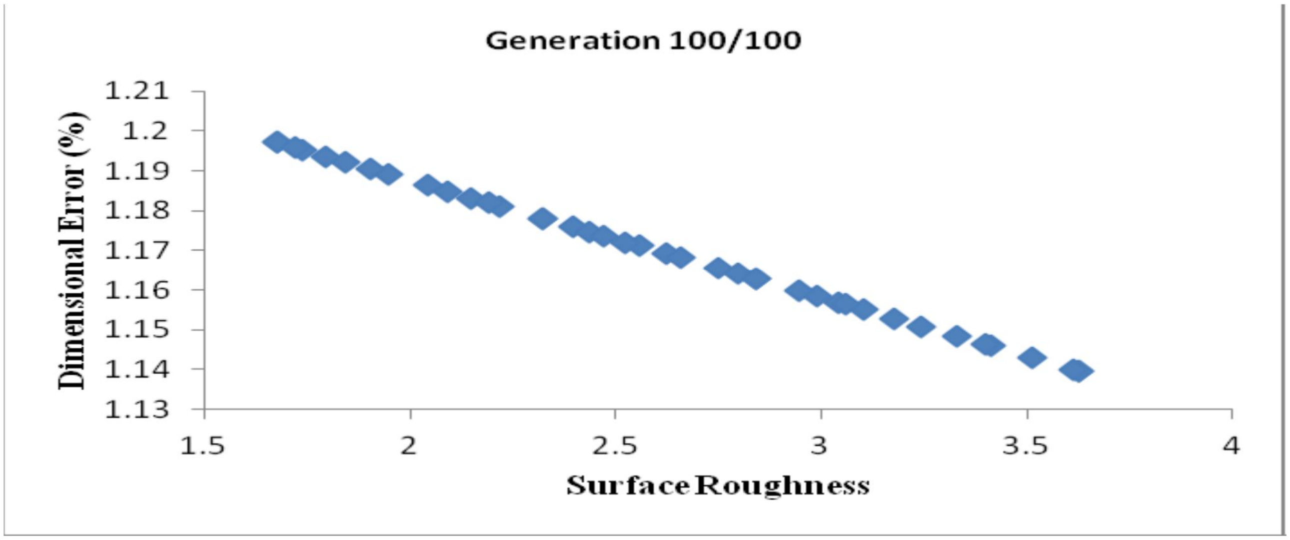

Fig 1. Pareto optimal set with use of NSGA-II [4]

Chand Badshah S B V J et al. [5] have used the grey relation to investigate the optimal combination of influential factors in the milling process of Al7075. Various combination of controlled parameters was identified. Taguchi grey relation analysis was used to measure and record the surface roughness, power consumption and cutting temperature. It is found that feed rate is the most influential factor on surface roughness. The increase of feed rate increases the surface roughness. Grey relation analysis shows that speed has greater impact over power when compared with other factors like feed rate and depth of cut. Depth of cut influences the temperature over speed and feed rate.
Dimitrios Vakondios et al [6] have examined the impact of various ball milling strategy selection on surface roughness of an Al7075-T6 alloy. In this paper, a number of experiments testing with different cutting conditions including axial and radial depth of cut and feed rate were performed and further analyzed using regression analysis and analysis of variance. The models were statistically validated and experimentally verified that can be used for the determination of the expected surface quality when ball end milling of Al7075-T6 is used, within the limits of the cutting parameters at the 95% confident level.
P. Munoz-.Escalona and P.G.Maropoulos [7] performed the face milling of Al7075. The networks of artificial neural network predicted the machining parameters. The Taguchi design of experiment was implied to reduce the time and cost of the experiments. The five inputs were cutting speed, feed per tooth, axial depth of cut, width and thickness of chip, while the selected output was surface roughness. It was inferred that a strong correlation persists between the chip thickness and the surface roughness subsequently followed by the cutting speed.
C.Harikrishana et al [8] have done their analysis on the surface quality improvement of Al7075/B_4C metal matrix composite in end milling operation. This study investigates the effect of feed rate, spindle speed, depth of cut and varied percentage (wt%) of B_4C in end milling of Al7075 alloy. Response Surface methodology is used to study the effect of these parameters and their interaction on surface roughness. In the order of their influence, feed rate and spindle speed influences the surface roughness most. The study also shows that depth of cut has least influence on surface roughness.
An optimization study by V.S. Kathavate and A.S. Adkine [9] of Al 7075 was done through Micro milling experiments with Taguchi robust technique in which spindle speed, Feed rate and depth of cut were used as controlled process variables. The results were analyzed using MINITAB 15 software for the responses. Regression analysis was done for MRR and surface roughness with Taguchi noise ratio to optimize all responses. ANOVA was done and multiobjective optimization was predicted. The optimal settings of process variables in micro milling of Al 7075 material are spindle speed of 2600 rpm, feed rate of 600 mm/min and depth

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of cut 0.07 mm that may help to achieve maximum MRR and minimum surface roughness. It was found that metal removing rate is adversely affected by feed rate while surface roughness is influenced by spindle speed. Finally, analysis of variance (ANOVA) suggests that feed rate contributes 65% of total process followed by spindle speed 18%, depth of cut 10% and rest are other parameters.

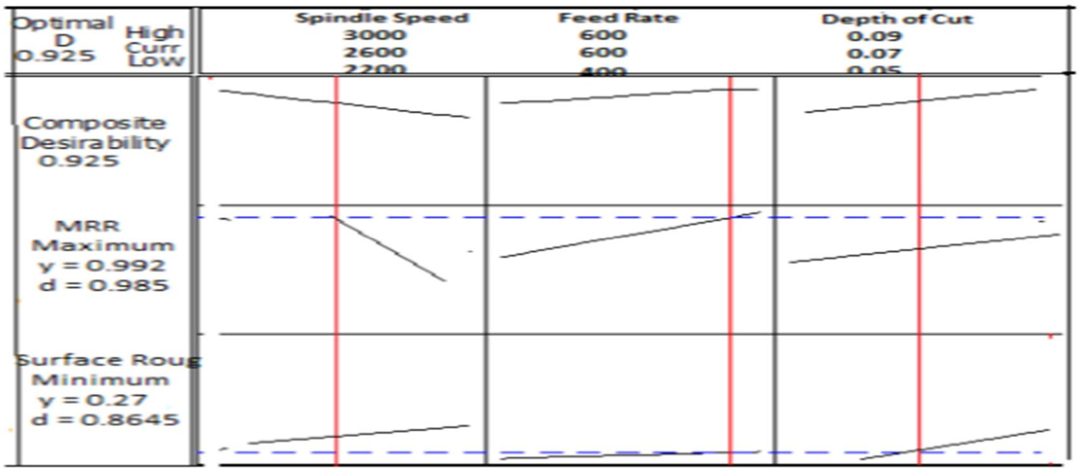

Fig 2. Optimization graph for surface responses MRR and Surface roughness [9]

A case study by J.Kechagias et al [10], was done to predict the surface roughness of slots during CNC milling of AL 7075 using 8mm slot mill cutter. In which three independent variables were used for process as feed rate, cutting speed and depth of cut with three different levels. A set of experiment using design of experiment and Neural Network modellling was used. Process performance is estimated using the statistical surface texture parameters Ra, and Rz; both measured in microns. Experimental results are used in order to train a feed forward back propagation neural network (FFBP-NN) and predict the surface texture parameters in finish slot milling of Al7075 alloy parts. The use of the FFBP-NN together with the performed experiments resulted in a successful way to model the process and predict the surface texture parameters when different cutting parameters apply.

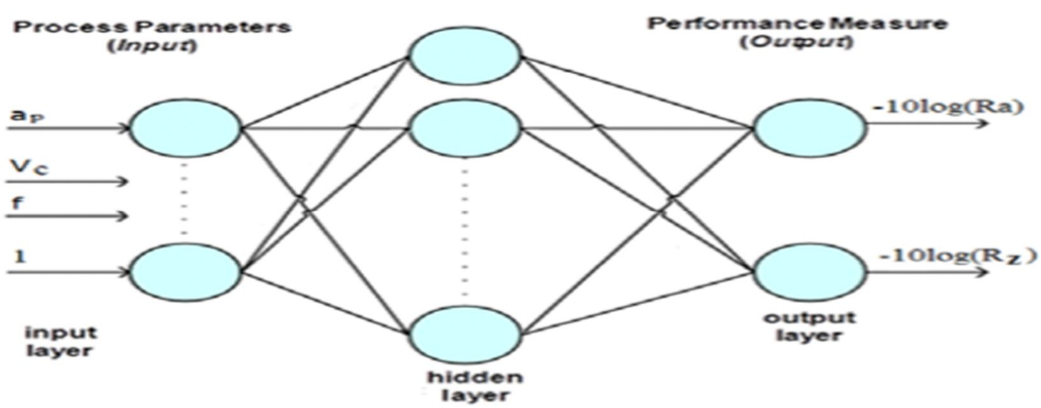

Fig 3. ANN Architecture (Feed forward with aback propagation learning) [10]

Ugur koklu [11] studied the optimization of the burr height and surface roughness influenced by the various process parameters with mechanical properties of Aluminum alloys as AL-2024, AL-7050 and AL-7075 in an experiment of dry drilling using Taguchi method with analysis of variance and signal to noise ratio to analyze the effect of drilling parameters. It is concluded that feed rate was the most influential controllable factor among input parameters which affects the burr height and cutting speed as the dominant parameter for minimizing the surface roughness significantly. The resulted optimal process parameters for both burr height and surface roughness were 20 m/min cutting speed, 0.05 mm/r feed rate and 8 mm drill diameter. Through the utilizing optimal conditions obtained with S/N ratio, the burr around the hole is minimized which contributes in the reduction of the overall manufacturing cost by reducing the number of processing requirement.

Ay Mustafa and Karagol Tanju [12] investigated an experiment on surface roughness, cutting temperature and cutting force in turning of Al 7075 alloy using diamond like carbon (DLC) coated cutting tools to analyze the effect of various process parameters on the cutting force, cutting force and temperature. Taguchi method with applied to optimize the various effects of all process parameters on the machining aluminum alloys. The feed with a proportion of 92.47% was the most effective factor in the formation of the roughness on the machined surfaces and also cutting speed and depth of cut.

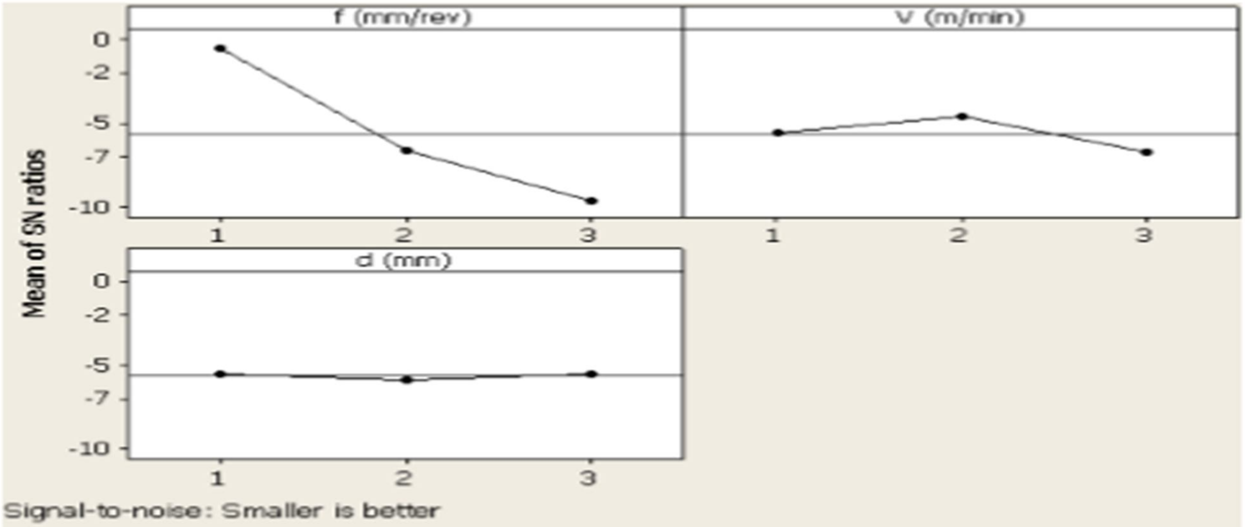

Fig 4. Control factors versus S/N ratios [12]

R.N. Nimase and P. M. Khodke [13] studied the Effect of machining parameters on the surface roughness of Al-7075 on milling operation using a 10mm mill tool with workpiece of 6mm thickness. Experiment based on an L8 orthogonal array of Taguchi method was employed to investigate the machining characteristics of Al-7075. From S/N ratio, optimal setting of machining parameters for low surface roughness was obtained at 2500 rpm, 240 mm/min and 2.0 mm for spindle speed, feed rate and depth of cut respectively. Also,confirmation test by using ANOVA shown that feed rate has more contribution of 46.36%, spindle speed has moderate contribution of 34.78% and depth of cut has less contribution.

Rizwan Anwar et al. [14] conducted a series of experiments for the optimization of surface roughness AL 7075-T in milling operation with various input process parameters and focused to enlist the optimal process input parameters to achieve better surface finish. Central Composite Design (CCD) technique in the Design Expert has been applied to carry out the analysis of experimented results. The results showed that at higher cutting speeds and low feed rates, lower values of surface roughness (Ra) has been achieved with additional depth of cut (DOC). By increasing the feed and cutting speeds, smaller Ra values has been achieved at lower values of depth of cut. By analysis of predicted and actual input parameters by contour plot, the minimum value of Ra was found to be 0.352 µm and an error of 3.29% was observed in the predicted and actual values of surface roughness.

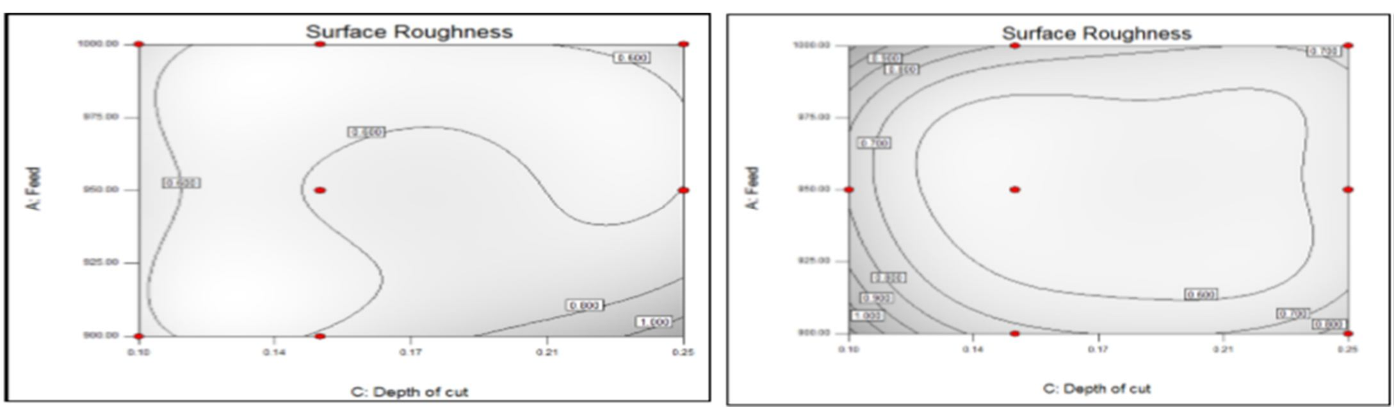

Fig 5. Feed and Depth of Cut at Cutting Speed of 4600 RPM & 5000 RPM [14]

in investigation was done to determine the surface roughness in the milling of aluminum alloy 7075 based open-cell silicon carbide (SiC). The machinability of both Al7075 and the open-cell SiC foam Al metal matrix composite was investigated during milling

Volume 5 Issue II, February 2017
ISSN: 2321-9653

using an uncoated carbide tool by Sener Karrabul and Halil Karakoc [15]. The examination was conducted using Taguchi L27 full-factorial orthogonal array and the machinability parameters was optimized by employing analysis of variance with artificial neural networks. The feed rate was the most effective control factor with a percentage contribution of 91.51 and 77.11 % influencing surface roughness for both the Al7075 and the open-cell SiC foam-reinforced composite, respectively. A good surface quality for the Al7075 alloy was obtained relative to the SiC foam composite under all milling conditions. The optimal machining combination for Ra was determined for both workpiece types at a machining speed of 170 m/min, an axial depth of cut of 0.8 mm and a feed per tooth of 0.08 mm/tooth.

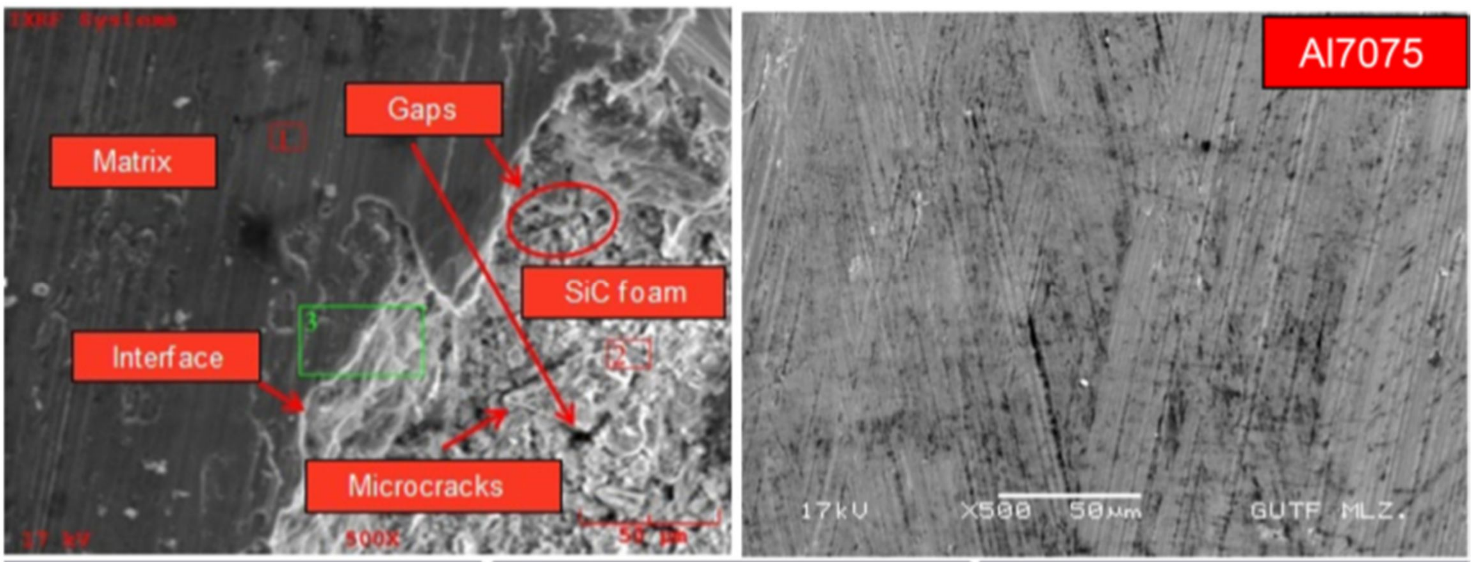

Fig 6. Microstructure of Machined MMC [15]

A.Etyemez [16] optimized the effects of tool path strategies for Al7075 by DLC coated end mill. Tool path, feed and cutting depth were the experimental variables taken at three levels. Taguchi evaluated by ANOVA shoes that the most effective factor is feed and the optimal cutting conditions is obtained at 500m/min feed and 0.25 mm cutting depth. Also, feed is observed with a value of 89.81% in formation of roughness.

Erol Kilicap [17] optimized the burr height in drilling of Al 7075 using the taguchi and response surface methodology. the three drilling parameters considered were cutting speed, feed rate and point of angle and were used without coolant. Design of experiments were performed and readings were tabulated. It has been found that taguchi is the most appropriate method to analyze surface roughness and feed rate is the most influencing parameter here. The optimal value obtained were 4 m/min for cutting speed, 0.1 mm/rev for feed rate and point angle 135°.Also, for achieving lower surface roughness, lower feed rate and cutting speed is preferred.

The surface measurement for the Turing of Aluminium metal matrix composite with the combination of Al7075/10/SiCp was studied by Ravinder Kumar and Santram Chauhan [18] using two techniques. The cutting speed, feed and approach angle were varied within a range and the experiments were conducted. A brief comparison was drawn between artificial neural network and response surface methodology to investigate the results. It is inferred that the surface roughness is primarily affected by interaction of cutting speed and feed rate. The best surface finish was attained at 0.05 mm/rev feed and 170m/min cutting height with an approach angle of 90 degrees.

A. Srinivasulu Reddy et al. [19] studied the influence of hole diameter and thrust force caused by drilling in Al 7075 by taking the process parameter in four levels. Mean strength to noise ratio was plotted for both dimensional accuracy and thrust force along with the results of ANOVA. The results revealed that cutting speed was the most influencing parameter for hole diameter and the most optimum condition was obtained at feed rate of0.15 mm/rev, cutting speed of 90 rpm and point angle at 90 degrees.

M. Subramanian et al. [20] modelled the surface roughness of Al7075 Using Response Surface Methodology by end milling. five parameters were introduced at five levels and design of experiments were performed with central composite design matrix. In the discussion of results, it was inferred that surface roughness increased with the increase in cutting feed rate and decrease in cutting speed. Also, it increased at a lower radial rake angle.

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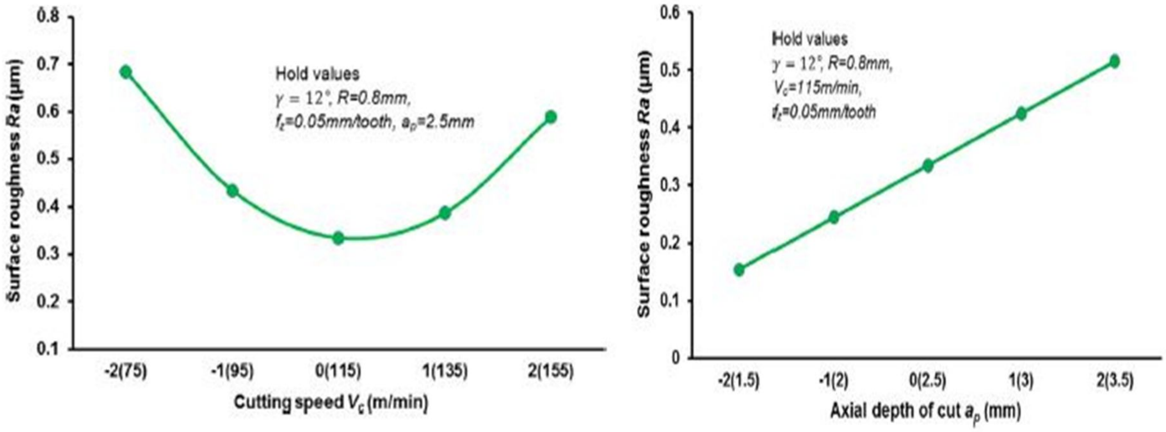

Fig 7. Direct effect of cutting speed and depth of cut on surface roughness [20]

Surasit Rawangwong et al. [21] performed face milling on Al7075 with carbide tool on the parameters of speed, feed and depth. These parameters were allocated with the variation of low and high. Factorial designs were performed and the results showed that speed and feed affected the surface roughness much while depth of cut was insignificant.it was also noted that the surface roughness was reduced at speed of 3800 rpm with the feed rate of 1000 mm/min.

Vamsi Inturi and V. Gopinath [22] experimented Response Surface Methodology with four parameters of speed, feed, depth and cutter diameter. The L16 orthogonal array was performed on MNITAB along with regression analysis. The surface roughness values vary between 0.27 to 1.02 microns and less roughness is obtained at 0.5 mm depth with a cutting speed of 88 m/min and feed rate of 300 mm/min.

K. Anand Babu and G. Vijaya Kumar [23] performed Taguchi-Fuzzy technique in drilling of Aluminium 7075 reinforced with 10%Silicon Carbide. Three parameters at three levels with different cutting environment and different tool material was used. Design of experiments with L27 orthogonal array and fuzzy if then rule was implied to analyze the data. The best results were obtained at a spindle speed of 500 feed at 0.2 mm/rev, point angle of 118 degrees with tool material of TiAlN-HSS and Cutting environment of Diesel.

Panagiotis Kyratsis et al. [24] performed the manufacturing process of drilling on Al7075 and used response surface methodology with the drilling parameters tool diameter, feed rate and cutting speed. The purpose was to determine the effect of thrust force on these parameters. It was observed that at higher values of tool diameter and feed rate, the thrust force increases but the increase of thrust force is more significant when cutting speed increases.

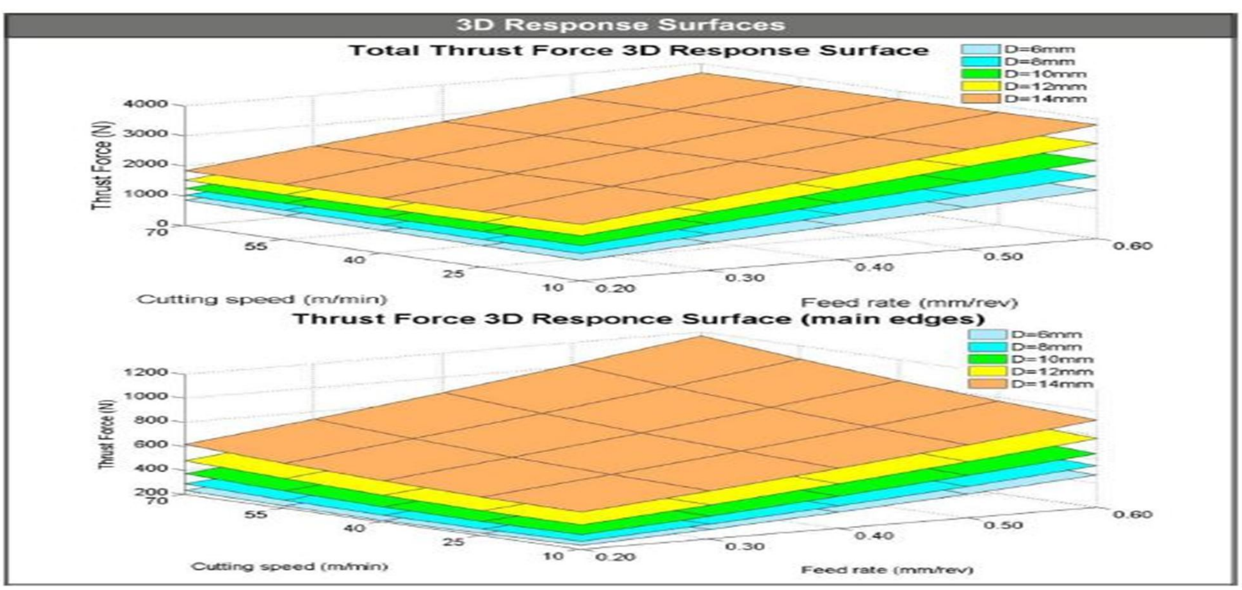

Fig 8. Response surfaces for the total thrust force and the thrust force due to the main cutting edges [24]

Volume 5 Issue II, February 2017
ISSN: 2321-9653

III. CONCLUSION

From the detailed review that has been done so far, it can be seen that three parameters play a vital role in the machining of Aluminium 7075. Amongst all the three, feed rate is the most influencing one. Other parameters like cutter diameter or tool material are insignificant to the contribution. MINITAB is the most common software used for deriving the results whereas Taguchi technique is the most preferred design of experiment technique due its simplicity and accurate results in an appropriate form. The figure of main effect plots shows the interrelationship between the parameters. Thus, researchers can utilize this study to further proceed in the optimization of Al7075.

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