Volume 1, Issue 1, 2016, pp. 12-18

website: www.ijoetr.com

International Journal of Emerging Trends in Research

A Critical Review on the Impact of Input Factors on Process Outcomes in Drilling of Aluminium Alloys

Vipin Gautam[1*], Ravi Pratap Singh[2], Ravinder Kataria[3], Dr. Jatinder Kumar[4]

[1]*M.Tech. Scholar, Department of Mechanical Engineering, NIT Kurukshetra (Haryana), India*
[2,3]*Research Scholar, Department of Mechanical Engineering, NIT Kurukshetra, (Haryana), India*
[3]*Assistant Professor, Department of Mechanical Engineering, NIT Kurukshetra, (Haryana), India*

* Corresponding author. E-mail: vgautam411@gmail.com (Vipin Gautam)

Abstract

This paper details a decisive review about the numerous investigations attempted by various researchers in drilling of aluminium alloys. Aluminium alloys are well known engineering materials possess vast range of industrial applications due to their advanced properties. The effects of different process factors on several machining characteristics such as; material removal rate, surface roughness, and cutting force have also been presented, and conferred in detail. The different types of aluminium alloys and their properties have also been discussed. It was exposed from the results that, surface roughness of the drilled hole significantly gets affected with the rate of feed and the cutting depth.

Keywords: Aluminium, drilling, process variables, MRR, review, surface roughness.

1. Introduction

Aluminium alloys are widely used as a main engineering material in various industries such as aircraft, aerospace, and automotive industries where weight is probably the most important factor. These materials are considered as easy to machining and possess superior machinability index (Gallab and Sklad, 1998; Nauari et al., 2003; Manna and Bhattacharya, 2006). Aluminium is a chemical element whose Latin name is alumen or alum (symbol Al) with an atomic number of 13. Aluminium is the third most abundant element on earth after oxygen (46.60%) and silicon (22.72%) (List et al., 2005; Dabade et al., 2007; Uday, Harshad and Suhas, 2010). An estimated 8% of the earth's crust consists of aluminium. Aluminium is too reactive chemically to occur in nature as the free metal. Instead, it is found combined in different minerals, mainly in silicates and alumino-silicates. The highest concentration of aluminium is found in bauxite.

Hamade and Ismail (2005) reported that aluminium alloys have a certain advantage for creating space equipment units. High values of specific strength and the specific rigidity of the material enabled the tanks, inter-tank and casing of the rocket to be manufactured with high longitudinal stability. The advantages of aluminium alloys also include their high performance under cryogen temperatures in contact with liquid oxygen, hydrogen, and helium. The so-called cryogen reinforcement happens in these alloys, i.e. the strength and flexibility increase parallel to the decreasing temperature. Engineers and manufacturers never cease to study the properties of aluminium, developing more and more new alloys for construction of aircraft and spaceships. 2xxx, 5xxx, 6xxx, and 7xxx series alloys are widely used in aviation. Reddy and Rao (2013) reviewed and conformed that aluminum is commonly used in a wide range of industries and constitutes about 40% of all metal-cutting operations.

Drilling is one of the most commonly used machining processes in the shaping of different advanced materials such as; ceramics, composites, etc (Singh and Singhal, 2015; Kataria et al. 2015; Singh et al. 2015). It has considerable economical importance because it is usually among the finishing steps in the fabrication of industrial mechanical parts. It has long been recognized that conditions during cutting, such as feed rate, cutting speed and depth of cut, should be selected to optimize the economics of machining operations. Drilling of aluminium alloys substantially differs from other materials due to its typical mechanical properties.

Drilling is a major and common process of hole making. Drilling is the cutting process in which a drill bit in a drill is used to cut or enlarge holes in solid materials, such as wood or metal. Different tools and methods are used for drilling depending on the type of material, the size of the hole, the number of holes, and the time to complete the operation. It is most commonly performed in material removal and is used as a preliminary step for many operations, such as reaming, tapping and boring. It is the cutting process in which a hole is originated or enlarged by means of a multipoint, fluted, end cutting tool. As the drill is rotated and advanced into the work piece, material is removed in the form of chips that move along the fluted shank of the drill. Figure 1 shows the basic geometry of drilling operation with chips removal.

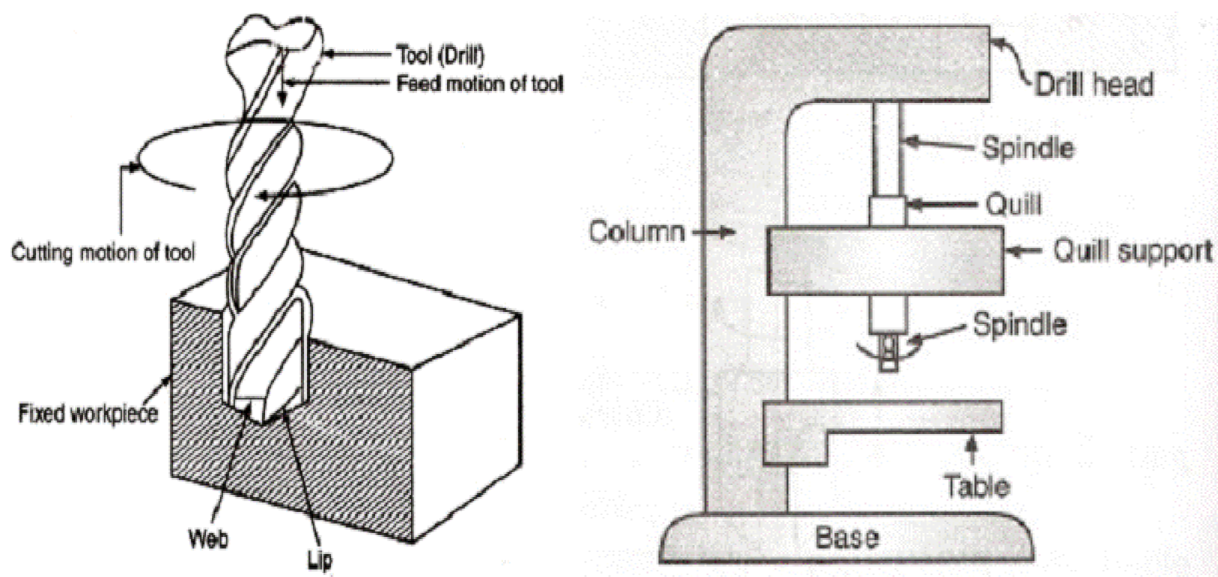

Figure 1 Basic diagram of drilling operation

Chen and Tsao (1999), and Zhao (1994) reported that amongst all traditional machining processes, drilling is one of the most important metal-cutting operations, comprising approximately 33% of all metal-cutting operations. In general, machining aluminium alloys required cutting fluids because the tendency of the chip to stick to the rake face of the cutting tool. Davim et al. (2006) presented an experimental study on drill of aluminium (AA1050) under dry, minimum quantity of lubricant and flood-lubricated conditions. The results of the experiment show it is possible to obtain similar performances to flood-lubricated conditions by using minimum quantity of lubricant. Various methods to design the experiments have also been explored by several investigators (Manna and Bhattacharya, 2006; Kilickap, Mesut and Ahmet, 2011; Navanth and Sharma, 2013).

In the present article a critical review about the several investigations carried out by various researchers in drilling of aluminium alloys has been presented.

2. Various Machining Characteristics on Drilling Process

The proper selection of input parameters well influences the machining response in drilling process. Drilling process of aluminium alloys has been well observed to be influenced by the several input parameters such as; spindle speed, feed rate, depth of cut, point angle, cutting time etc. The several process responses investigated by various researchers have been reviewed and highlighted below;

2.1 Surface Roughness (SR)

Navanth and Sharma (2013) experimentally investigated that a spindle speed of 300 rpm, point angle & helix angle of 1300/200 and a feed rate of 0.15 mm/rev is the optimal combination of drilling parameters that produced a high value of S/N ratios of hole roughness. Amran et al. (2014) from their experimental result found that to find the smooth surface in drilling process, it needs higher spindle speed with lower feed rate and smaller diameter.

Rajmohan, Kayaroganam and Palanikumar (2013) in their experiment used response surface methodology (RSM) and found that the optimum selected drilling process parameters settings are spindle speed of 1855 rpm, feed rate of 50 mm/min and 15% SiC which results in a surface roughness of 1.67 µm. Basavarajappa, Chandramohan, and Davim (2008) reported that the surface roughness values are always increasing with increase in the feed rate and decreases with increase in cutting speed. Reddy et al. (2014) reported that for achieving minimum surface roughness on the aluminium alloy always higher cutting speeds and standard point angles are preferred and for achieving minimum hole diametral error and lower burr height always at lower cutting speeds and standard point angles are preferred.

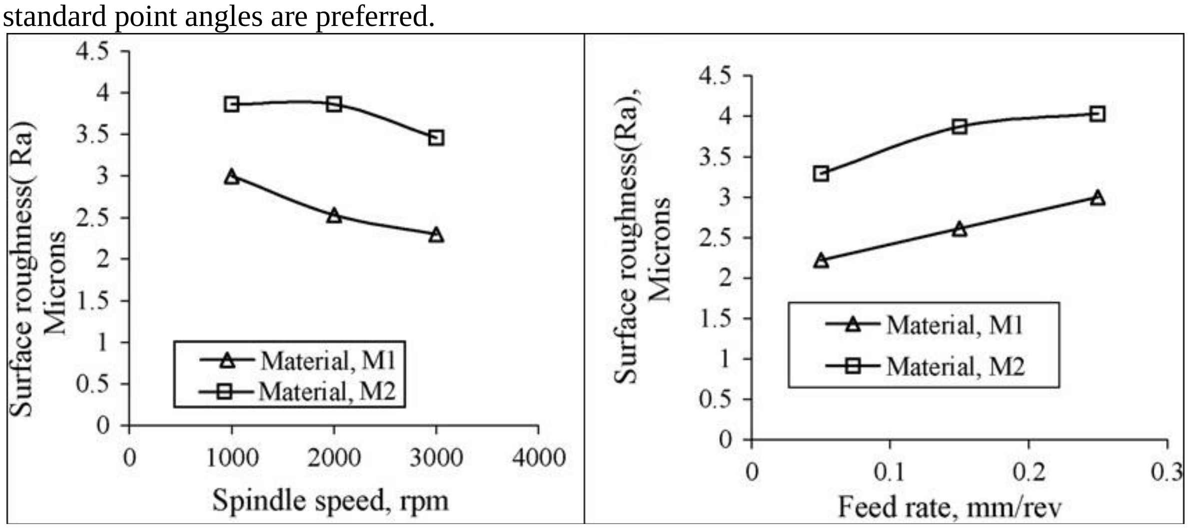

Figure 2 Mean effect plots for SR (Basavarajappa, Chandramohan, and Davim, 2008)

2.2 Material Removal Rate (MRR)

Dhavamani and Alwarsamy (2012) experimentally investigated the machining responses in drilling process by using Taguchi method with an L_{27} fractional factorial design for aluminium based composite.

Shivapragash et al. (2013) reported that optimum cutting parameters for maximization material removal rate is spindle speed set as low level (1000 rpm), feed rate set as maximum level (1.5 mm/min) and depth of cut set as middle level (6 mm).

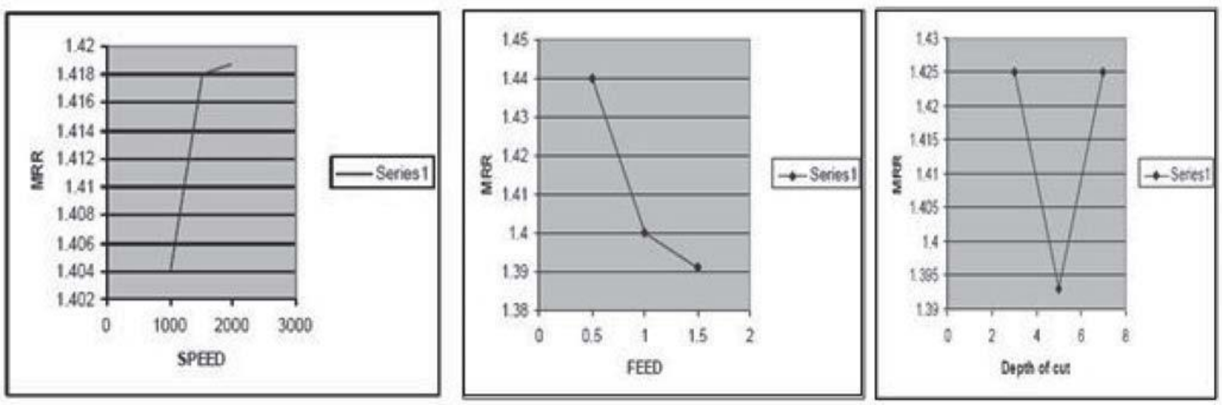

Figure 3 Effects of input parameters on MRR (Tyagi, Chaturvedi, and Vimal, 2012)

2.3 Cutting Force (CF)

Rajmohan and Palanikumar **(**2013) reported that optimum selected drilling process parameters settings are spindle speed of 1855 rpm, feed rate of 50 mm/min and 15% SiC which result in a minimum thrust force of 584 N. Ramulu, Rao, and Kao (2002) concluded that drilling forces were significantly influenced by tool materials. Since the degree of drilling force induced in the drilling process relates to the power requirement, which is correlated to production cost, low thrust force and torque are preferred.

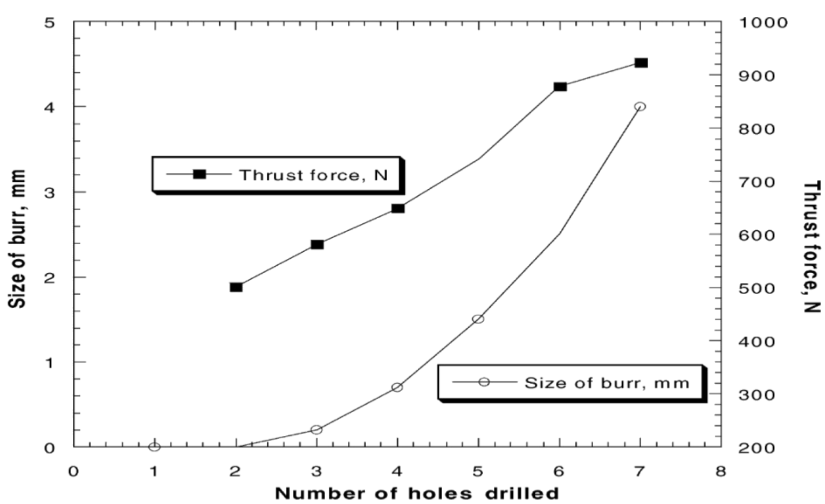

Figure 4 Thrust force and burr size produced with HSS drill while drilling (Al_2O_3)p/6061 (Ramulu, Rao, and Kao, 2002)

Rajmohan, Palanikumar, and Prakash (2013) experimentally investigated that The recommended levels of drilling parameters for minimizing thrust force, are: wt.% of SiC (15%), spindle (3000 rpm), and feed rate (50 mm/min). Basavarajappa et al. (2008) reported that thrust force increases for all the spindle speeds considered and for both the tool and workpiece materials.

3. CONCLUSION

The following conclusions can be drawn from the current research work;

1. Drilling process is observed as quite random process as it well affected with any slight variation in process variables.
2. The behavior of surface roughness was found to be increased as feed rate increases and spindle speed decreases, whereas thrust force was revealed to be enhanced as number of drilled holes incremented.
3. Material removal rate is found to well affect with the process variables such as; feed rate and depth of cut.
4. Aluminium and its alloys have been observed to possess better machinability while performing drilling operation.

References

Basavarajappa, S., Chandramohan, G., Davim, J. P., Prabu, M., Mukund K., Ashwin, M. and Kumar, M. P. (2008) ‘Drilling of hybrid aluminium matrix composites’, International Journal of Advanced Manufacturing Technology, Vol. 35, pp. 1244–1250.

Chen, W. C. and Tsao, C. C. (1999) ‘Cutting performance of different coated twist drills’, Journal of Material Processing Technology, Vol. 88, pp. 203–207.

Dabade, U. A., Joshi, S. S., Balasubramaniam, R. and Bhanuprasad, V. V. (2007) ‘Surface finish and integrity of machined surfaces on Al/SiCp composites’, Journal of Material Processing Technology, Vol. (192/193), pp. 166–174.

Dhavamani, C. and Alwarsamy, T. (2012) ‘Optimization of machining parameters for aluminium and silicon carbide composite using genetic algorithm’, Procedia Engineering, Vol. 38, pp.1994 – 2004.

Gallab, E. M. and Sklad, M. (1998) ‘Machining of Al/SiCp metal matrix composites’, Part I, Tool performance. Journal of Material Processing Technology.

Hamade, R.F. and Ismail, F. (2005) ‘A case for aggressive drilling of aluminum’, Journal of Materials Processing Technology, Vol. 166, pp. 86-97.

Kilickap, E., Mesut, H. and Ahmet, Y. (2011) ‘Optimization of drilling parameters on surface roughness in drilling of AlSI 1045 using response surface methodology and genetic algorithm’, International Journal of Advanced Manufacturing Technology, Vol. 52, pp. 79-88.

List, G., Nouri, M., Gehin, D., Gomez, S., Manaud, J. P., Petitcorps, Y. L. and Girot, F. (2005) ‘Wear behavior of cemented carbide tools in dry machining of aluminum alloys’, International Wear, Vol. 259, pp. 1177-1189.

Singh, R.P., Kumar, J., Kataria, R., Singhal, S. (2015) 'Investigation of the machinability of commercially pure titanium in ultrasonic machining using graph theory and matrix method', Journal of Engineering Research, Vol. 3, Issue 4, pp.75-94.

Kataria, R., & Kumar, J. (2014). A comparison of the different multiple response optimization techniques for turning operation of AISI O1 tool steel. *Journal of Engineering Research*, *2*(4), 1-24.

Kataria, R., Kumar, J., & Pabla, B. S. (2015). Experimental Investigation into the Hole Quality in Ultrasonic Machining of WC-Co Composite. *Materials and Manufacturing Processes*, *30*(7), 921-933.

Singh, R.P., and Singhal, S., (2015) Rotary ultrasonic machining of advanced materials: a review. International Journal for Technological Research in Engineering, 2(7), 777-785.

Manna, A. and Bhattacharyya, B. (2006) 'Taguchi method based optimization of cutting tool flank wear during turning of PRAl/ 20vol. % SiC-MMC', International Journal of Machining and Machinability of Materials, Vol. 4, pp. 488 - 499.

Navanth, A. and Sharma, T. K. (2013) 'A study of Taguchi method based optimization of drilling parameter in dry drilling of Al 2014 alloy at low speeds', International Journal of Engineering Sciences & Emerging Technologies, Vol. 6, No. 1, pp. 65-75.

Nouari, M., List, G., Girot, F. and Coupard, D. (2003) 'Experimental analysis and optimisation of tool wear in dry machining of aluminium alloys', Wear, Vol. 255, pp. 1359–1368.

Quiza, R. and Davim, J. P. (2010) 'Multi-objective optimisation of cutting parameters for drilling Aluminium AA1050', Artificial Intelligence in Manufacturing Research, Vol. 6, pp. 101-110.

Rajmohan, T. and Palanikumar , A. (2013) 'Application of the central composite design in optimization of machining parameters in drilling hybrid metal matrix composites', Measurement, Vol. 46, pp. 1470-1481.

Rajmohan, T., Palanikumar, K. and Prakash, S. (2013) 'Grey-fuzzy algorithm to optimise machining parameters in drilling of hybrid metal matrix composites', Composites: Part B, Vol. 50, pp. 297–308.

Ramulu, M., Rao, P. N. and Kao, H. (2002) 'Drilling of (Al2O3)p/6061 metal matrix composites', Journal of Materials Processing Technology, Vol. 124, pp. 244–254.

Reddy, I. S., Suresh, S., Raju, F. A. and Gurunadham, A. (2014) 'Determination of optimum parameters in CNC drilling of aluminium alloy Al6463 by Taguchi method', International Journal of Engineering Research & Technology, Vol. 3, No. 2, pp. 301-306.

Shivapragash, B., Chandrasekaran, K., Parthasarathy, C. and Samuel, M. (2013) 'Multiple response optimizations in drilling using Taguchi and grey relational analysis', International Journal of Modern Engineering Research, Vol. 3, No. 2, pp. 765-768.

Sreenivasulu, R. and Rao, C. S. (2013) ‘Application of grey based - Taguchi method to determine multiple performance characteristics in drilling of aluminium alloys – Review’, Research Journal of Engineering Sciences, Vol. 2, No. 3, pp. 45-51.

Tyagi, Y., Chaturvedi, V. and Vimal, J. (2012) ‘Parametric Optimization of Drilling Machining Process using Taguchi Design and ANOVA Approach’, Journal of Emerging Technology and Advanced Engineering, Vol. 2, No. 7, pp. 339-347.

Uday, A. D., Harshad, A. S. and Suhas, S. J. (2010) ‘Cutting forces and surface roughness in machining Al/SiCp composites of varying composition’, Machining Science and Technology, Vol. 10, pp. 258−279.

Zhao, H. (1994) ‘Predictive models for forces, power and hole oversize in drilling operations’, Ph.D. Thesis, University of Melbourne, Australia.