Materials Physics and Mechanics 47 (2021) 739-746
Research article

Received: June 16, 2021
Accepted: October 25, 2021

INVESTIGATION OF THE SURFACE ROUGHNESS OF ALUMINIUM COMPOSITE IN THE DRILLING PROCESS

Gundugandla Kishore[1], A. Parthiban[1]✉, A. Mohana Krishnan[2], B. Radha Krishnan[3]

[1]Department of Mechanical Engineering, Vels Institute of Science, Technology and Advanced Studies, Chennai, India

[2]Mechanical Engineering, K.Ramakrishnan College of Engineering, Trichy, India

[3]Mechanical Engineering, Nadar Saraswathi College of Engineering and Technology, Theni, India

✉ parmathi83@gmail.com

Abstract. This paper investigates the Surface roughness in the various Aluminium composite. The drilling experiment is performed on specimens Al7075 + 3% Al2O3, Al7075 + 3% Al2O3 + 1% Mica, Al7075 + 3% Al2O3 + 2% Mica, Al7075 + 3% Al2O3 + 3% Mica with high-speed steel twist drills of 5 mm diameter grade M2. ISO 234:1980 is the specification of the drills used in the current work. The drilling experiment takes place with a feed speed of 0.5 mm/rev. For the aluminum composite samples with coolant, the cutting speed is at different speeds of 10, 20, and 30 mm/min. The Surface Measuring Unit of the Stylus type is used to locate the Surface Roughness Ra of the drilled hole surface. The number of iterations completed is five times for the repeatability of effects with the same drilling parameters. The surface roughness had increased with the addition of reinforcement. The 2% mica addition showed a better surface finish than the 3% addition. Scanning Electron Microscopy investigated the Surface Morphological characteristics.
Keywords: drilling process, surface roughness, composite, measurement, aluminium

Acknowledgements. *No external funding was received for this study.*

Citation: Gundugandla Kishore, A. Parthiban, A. Mohana Krishnan, B. Radha Krishnan. Investigation of the surface roughness of aluminium composite in the drilling process // Materials Physics and Mechanics. 2021, V. 47. N. 5. P. 739-746. DOI: 10.18149/MPM.4752021_8.

1. Introduction

The drilling machine is commonly used for the manufacturing process in various industries. The materials are assembled by casting, shaping, and different manufacturing processes before the industries prepare the assembly. Also, activities are carried out to increase the output of the commodity. Aluminium is commonly soft material , but while adding reinforcement particles it became very hard and strong [5,6]. The existing results of Al-Alloy show the machining performance [7]. The spinning cutting edge, such as single or multiple wedge-shaped instruments to create holes, eliminates the metal bits. Drilling, milling, spinning, and turning are the four main phases of the traditional machining process. In traditional devices, rotation and feeding movements were applied concurrently using a drill on a clamped workpiece that exerts large forces. Drilling is an inexpensive and critical method in the final production process of mechanical parts. The plastic deformation and drill geometry

http://dx.doi.org/10.18149/MPM.4752021_8

of the workpiece material is complex throughout the drilling process. At the drill centre, the cutting velocity is close to zero. The rake angle and cutting speed all differ differently, based on the distance from the drill centre. The cutting edge with the fastest cutting speed is called the peripheral cutting velocity. Lopez de Lacalle et al. Mica Powder normally prefer to improve the polishing surface and stiffness [2]. The drilling method consists of two steps: drill point penetration into the workpiece, and the second is the drill hole movement. The material comes out of the workpiece through the shanks in the drill bit from the cutting velocity difference. The approach begins from a drill point, contacts the workpiece, and produces the penetration stage into the complete drilling stage [3]. The effect of cutting parameters on hole quality was explored, and the results indicated that while cutting tool material had a significant effect on surface roughness, it had a negligible effect on circularity [15]. Balout et al. [16] examined the influence of workpiece temperature on dust formation, cutting forces, and chip morphology during dry drilling of aluminium alloys 6061 and A356, magnesium alloy AZ91E, and brass 7030. They discovered that the temperature of the workpiece had a substantial effect on dust creation and emphasised that lowering the material temperature reduces dust generation and cutting forces. It has been stated that the surface roughness of the metal matrix composites increases with the increase in feed rate and decreases in spindle speed. The surface finish, which is a critical factor in the manufacturing and machining process, is influenced by the drill speed and feed parameters.

In different studies such as Taguchi techniques, more researchers often researched the different mechanisms of chip formations. The applications are primarily due to Composite mechanical and thermal properties, which leads to research as a significant element. Without burs, tool wear, cracks, and voids in the surface, the material removal process should be acceptable [16]. As this is a significant issue in an industrial setting, it is vital to be able to determine the rate of wear while drilling. This article discusses a study that was conducted to determine the mean surface roughness of an aluminium composite material at various drilling speeds.

2. Experimental methodology

Advanced properties of Aluminium metal matrix composites (AMMCs), such as higher strength, enhanced rigidity, decreased density, enhanced high-temperature characteristics, controlled temperature thresholds, enhanced temperature thresholds. In addition, these AMMCs are made more demanding by optimized electrical specifications, better abrasion and wear resistance, weight management, and better damping capabilities. Thanks to their excellent combination of properties, the most flexible materials for advanced structural, automotive, aerospace, aircraft, marine, defense, and other related fields are emerging.

Table 1. Sample preparation

S.NO	Samples
1	Al7075+3% Al2O3+1%Mica
2	Al7075+3% Al2O3+2%Mica
3	Al7075+3% Al2O3+3%Mica

Table 1 shows the composition of the aluminium composite prepared, the Al7075 is the matrix material and Al2O3 is the ceramic reinforcement which is constant to improve the properties, the addition of mica as reinforcement to study its impact on the machining parameters. The Al7075 matrix and reinforcement are preheated separately to 200°C to remove the moisture content, the Al7075 is heated to 650°C to a molten state and the stirrer is used to stir at 300 rpm. The alumina powder is then added at regular intervals according to the weight ratio. Further, the mica is added to the molten aluminium mixture and the stirring is done continuously. The molten aluminium is then fabricated into plates for the testing process. The Al7075 sample, mixed with Al2O3, MICA via the stir casting process for composite preparation is shown in Table 1. The Surface roughness is measured with 5 iterations as repeatability values for all the samples at different speeds and examined the wear surface in the SEM analysis.

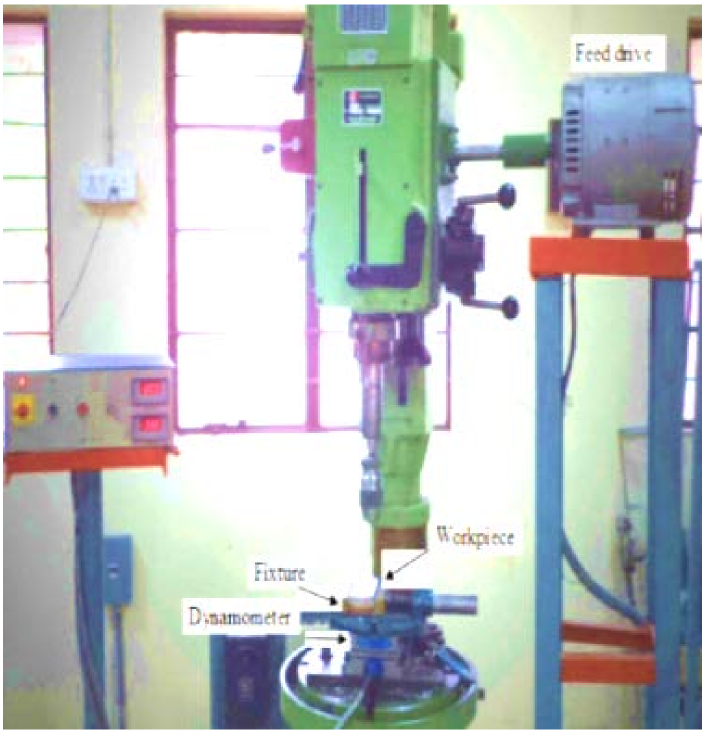

Fig. 1. Experimental setup for the drilling process

Surface Roughness. Surface roughness is one of the main factors in assessing machined surfaces' consistency in a machining process. The important performance measurements, such as surface integrity and surface roughness that assess the degree of performance resulting from specialized tools, are noted: material combination, corresponding speeds, feeds, and cutting depth. Due to the machined product's surface roughness, the mechanical characteristics of some items may be impacted. Touch causing wear, surface friction, heat transfer, the reflection of light, coating ability to spread, and fatigue resistance

SEM Analysis. The Samples were prepared with Al7075 + Al2O3 + Mica through the stir casting process. The prepared samples are drilled by high-speed steel with various input parameters like speed, feed rate, and cut depth. The SEM analysis was used to analyse the surface morphological characteristics of the drilled surface in samples. It can be used to analyse the surface defects and chemical bonding between the materials.

3. Result and Analysis:

The drilling experiment is performed on specimens Al7075 + 3% Al2O3, Al7075 + 3% Al2O3 + 1% Mica, Al7075 + 3% Al2O3 + 2% Mica, Al7075 + 3% Al2O3 + 3% Mica with high-speed steel twist drills of 5 mm diameter grade M2. ISO 234:1980 is the specification of the drills used in the current work. The drilling experiment is carried out at feed rates of 0.5 mm/rev, with varying cutting speeds of 10, 20, and 30 mm/min for aluminium composite samples of coolant at different stages. The Surface Measuring Unit of the Stylus type is used to locate the Surface Roughness Ra of the drilled hole surface. The number of iterations completed is five times for the repeatability of effects with the same drilling parameters. From the results, the average values are taken shown in table 2,3,4. The wearing of drills is being examined. While the surface roughness is directly related to the feed rate and cutting speed, the depth of cut is inversely proportional to both of these variables.

Table 2. Surface Roughness of feed rates of 0.5 mm/rev, speed of 10 mm/min

S.NO	Samples	Surface Roughness (μM)
1	Al7075+3% Al2O3+1%Mica	1.03
2	Al7075+3% Al2O3+2%Mica	1.101
3	Al7075+3% Al2O3+3%Mica	1.18

Table 3. Surface Roughness of feed rates of 0.5 mm/rev, speed of 30 mm/min

S.NO	Samples	Surface Roughness (μM)
1	Al7075+3% Al2O3+1%Mica	0.601
2	Al7075+3% Al2O3+2%Mica	0.63
3	Al7075+3% Al2O3+3%Mica	0.688

Table 4. Surface Roughness of feed rates of 0.5 mm/rev, speed of 20 mm/min

S.NO	Samples	Surface Roughness (μM)
1	Al7075+3% Al2O3+1%Mica	0.96
2	Al7075+3% Al2O3+2%Mica	1.02
3	Al7075+3% Al2O3+3%Mica	1.06

Scanning Electron Microscopy Analysis. SEM image reveals that the drilling procedure is carried out on sample B at a feed rate of 0.5 mm/rev and with a cutting speed of 20 m/min (Al7075 + 3 percent Al2O3 + 1 percent Mica), the wear caused by the drilling process is seen in Fig 2, and there is more debris caused during the drilling operation on the wear track, due to more feed rate, this wears debris or defects were caused. The Alumina and Mica reinforcements cause defects like plough and tear. The reinforcements produce adhesion wear during the rotational and push force provided by the drilling machine and come out of the surface, creating wear debris. The heat due to the friction, therefore, suggests that a larger component causes these flaws. With the drilling instrument, adhesion wear and abrasion of reinforced particles produce heat and, in turn, create maximum harm to the material's surface roughness.

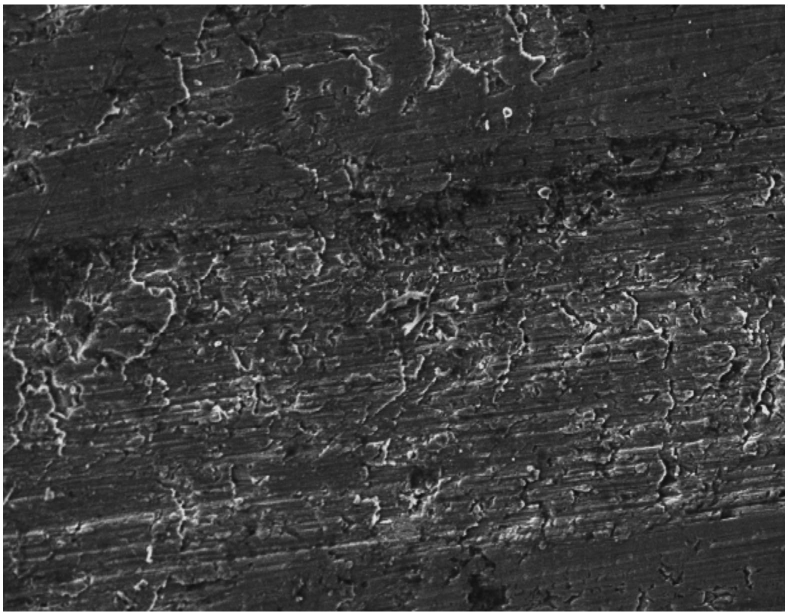

Fig. 2. SEM Analysis of Aluminium 7075 -3% Alumina – 1% mica at 20m/min and feed of 0.5 mm/rev

The SEM image reveals that the drilling procedure is carried out on sample C at a feed rate of 0.5 mm/rev and with a cutting speed of 20 m/min (Al7075 + 3 percent Al2O3 + 2 percent Mica), the wear caused by the drilling process is seen in Fig. 3, where the reinforcement particles can be seen. This is achieved at low speeds and low feeding rates. The track formation is very little noticeable because there are less friction and low-speed heat produced and wear and defects such as dirt, crater wear, and wear of adhesion compared to previous SEM photos. The harder the material the slower the drilling process to obtain reduced surface roughness.

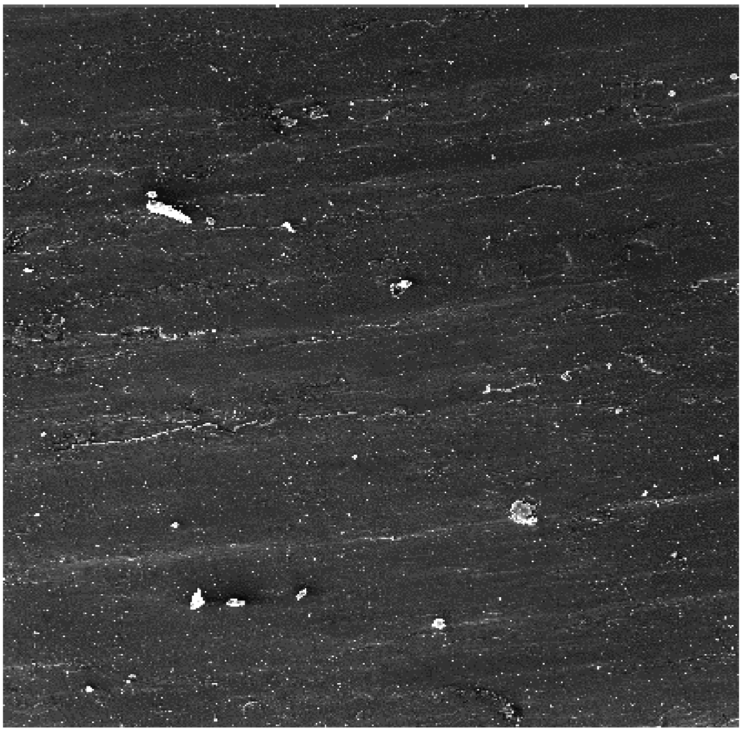

Fig. 3. SEM Analysis of Aluminium 7075 -3% Alumina – 2% mica at 20m/min and feed of 0.5 mm/rev

The SEM image below indicates that the drilling procedure is conducted at a feed rate of 0.5 mm/rev and on sample D with a cutting speed of 20 m/min (Al7075 + 3 percent Al2O3 + 3 percent Mica), the wear induced by the drilling process is shown in Fig. 4, the defects caused here are very large, and the tear is more on the surface allowing the roughness to decrease. We will observe from the picture that there are more surface reinforcements and more tracks, and greater surface ploughing. The scratches are depth, and more of the surface wear debris is caused by the greater amount of reinforcements in this shot. This track and defect effect is due to the high feed and speed pace, which lowers the specimen's surface. The torque will increase drastically on the aluminium composite during the feed rate and low spindle speed.

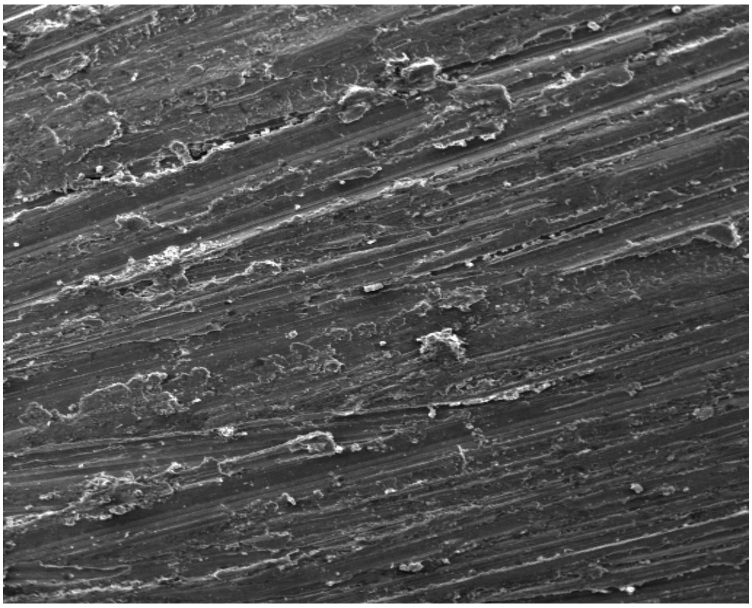

Fig. 4. SEM Analysis of Aluminium 7075 -3% Alumina – 3% mica at 20m/min and feed of 0.5 mm/rev

4. Conclusion

The drilling experiments have shown that surface roughness decreases due to the high speed and feeding of the drilling process. The 3% Alumina Aluminium 7075 alloy demonstrated greater surface roughness than the mica-reinforced Aluminium composites. The reinforcements are tougher materials than the aluminium alloy, which also reduces the drilled board's quality. With more flaws, the wear caused by the instrument and material interactions is strong. The temperature produced by friction between the tool-material interactions also includes the rise in surface wear and tear defects as a cause. Adhesion wear and abrasion wear with heat are created by instrument flank and material surface contact.

References

[1] Basavarajappa S, Chandramohan G, Prabu M, Mukund K, Ashwin M. Drilling of hybrid metal matrix composites-work piece surface integrity. *Int. J. Mach. Tools Manuf.* 2007;47(1): 92-96.
[2] Parthiban A, Krishnan AM, Krishnan BR, Vijayan V. Experimental Investigation of Mechanical and Wear Properties of AL7075/Al 2 O 3/MICA Hybrid Composite. *Journal of Inorganic and Organometallic Polymers and Materials*. 2021;31(3): 1026-1034.
[3] López de Lacalle LN, Lamikiz A, Sánchez JA, Cabanes I. Cutting conditions and tool optimization in the high-speed milling of aluminium alloys. *Proceedings of the Institution of*

Mechanical Engineers, Part B: Journal of Engineering Manufacture. 2001;215(9): 1257–1269.

[4] Prasath KA, Krishnan BR, Arun CK. Mechanical properties of woven fabric Basalt/jute fibre reinforced polymer hybrid composites. *Int. J. Mech. Eng*. 2013;2(4): 279-290.

[5] Krishnan BR, Ramesh M. Experimental evaluation of Al-Zn-Al2O3 composite on piston analysis by CAE tools. *Mechanics and Mechanical Engineering*. 2019;23(1): 212-217.

[6] Krishnan BR, Aravindh R, Barathkumar M, Gowtham K, Hariharan R. Prediction of Surface Roughness (AISI 4140 Steel) in Cylindrical Grinding Operation by RSM. *International Journal for Research and Development in Technology*. 2018;9(3): 702-704.

[7] Krishnan BR, Ramesh M. Optimization of machining process parameters in CNC turning process of IS2062 E250 Steel using coated carbide cutting tool. *Materials Today: Proceedings*. 2020;21: 346-350.

[8] Kumar NS, Kaleeswaran N, Krishnan BR. Review on optimization parametrs in Abrasive Jet Machining process. *International Journal of Recent Trends in Engineering and Research*. 2018;4(10); 2455-1457.

[9] Sanjeevi R, Kumar GA, Krishnan BR. Optimization of machining parameters in plane surface grinding process by response surface methodology. *Materials Today: Proceedings*. 2021;37: 85-87.

[10] Veluchamy B, Karthikeyan N, Krishnan BR, Sundaram CM. Surface roughness accuracy prediction in turning of Al7075 by adaptive neuro-fuzzy inference system. *Materials Today: Proceedings*. 2021;37: 1356-1358.

[11] Sanjeevi R, Nagaraja R, Krishnan BR. Vision-based surface roughness accuracy prediction in the CNC milling process (Al6061) using ANN. *Materials Science*. 2021;37: 245-247.

[12] Karthikeyan N, Krishnan BR, Vembathu Rajesh A, Vijayan V. Experimental analysis of Al-Cu-Si metal matrix composite by powder-metallurgy process. *Materials Today: Proceedings*. 2021;37: 2770-2774.

[13] Radhakrishnan B, Sathish T, Siva Subramanian TB, Tamizharasan, N, Varun Karthik E. Optimisation of Surface Roughness in CNC Milling Process Using RSM. In: *SSRG International Journal of Mechanical Engineering-(ICRTECITA-2017)-Special issue-March*. 2017. p.5-12.

[14] Vembathurajesh A, Sundaram CM, Krishnan BR, Nagarajan B, Rajan AV. Experimental investigation of Wear Characteristics of Aluminium Metal Matrix Composites reinforced with MoS2 and SiC Particles using Taguchi Method. *International Journal of Recent Trends in Engineering & Research*. 2020;7: 288-295.

[15] Yazman Ş, Köklü U, Urtekin L, Morkavuk S, Gemi L. Experimental study on the effects of cold chamber die casting parameters on high-speed drilling machinability of casted AZ91 alloy. *Journal of Manufacturing Processes*. 2020;57: 136-152.

[16] Ramesh M, Jafrey DD, Ravichandran M. Investigation on mechanical properties and wear behaviour of titanium diboride reinforced composites. *FME Transactions*. 2019;47(4): 873-879.

THE AUTHORS

Gundugandla Kishore
e-mail: kishorevelsuniv@gmail.com
ORCID: 0000-0003-4608-4097

Parthiban A
e-mail: parmathi83@gmail.com
ORCID: 0000-0002-9560-0265

MohanaKrishnan A
e-mail: amk3745@krce.ac.in
ORCID: 0000-0001-9673-425X

Radha Krishnan B
e-mail: radhakrishnancadcam@gmail.com
ORCID: 0000-0002-5070-5653