EXTENT OF SURFACE ROUGHNESS ANALYSIS FOR ALUMINIUM BASED METAL MATRIX COMPOSITES UNDER DIFFERENT LUBRICATION SYSTEM

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Abstract
The Surface roughness of the products fabricated by machining of Aluminium (Sic_p) reinforcement metal–matrix composites (Al/Sic_p MMC) is essentials as it impacts the execution of the finished part to great extent. Henceforth, estimation of quality can take into account the necessities of execution assessment. This paper presents the prediction model on surface roughness in machining of Al/Sic_p MMC by various till now. The objective is to explore the machinability of Al/Sic_p MMC using different tools. Therefore, to explore the surface roughness a number of a mathematical model for surface roughness has been developed by using regression analysis, FEM Simulator as a function of all parameters with an average error of 10% can be observed between the predicted and experimental values and validation experiment showed the reliable results. Big cavities, pit holes and discontinuous cavity found in the matrix materials depend upon the percentage of the reinforcement and type of the tool used.
Keyword: Aluminium Metal matrix composites and surface roughness

1. Introduction

Strength, ductility, good wear property with lower cost and better finish is really a challenge to the growing manufacturing of Aluminium based metal matrix composites (AlMMCs). A lot of application AlMMCs has been seen in the area of aerospace, defence, and common purpose devices hand tools and in the electronics industry as well. Composites may be classified as Metal Matrix Composites (MMC), Ceramics Matrix Composites (CMC), and Polymer Matrix Composites (PMC) [1].Composites are quite better than those the class of materials like Steel and cast iron as a Mechanical (Tensile, Impact etc.) and other properties (thermal conductivity, Design, Corrosion etc.).[2]

Numbers of issues were faced during machining of Metal Matrix composites like poor Surface Finish, hard machining, high tool wear due to high cutting forces between the tool and the workpiece, Frank, crater wear and erodes the rake face as well [3]. Aluminium Silicon carbide based MMC (AlSiCp) is one of the used material for the above said sectors and fabrication of AlSiCp is one task and machining of it is another task for obtaining the desired products[4], [5]. Machining may be turning, drilling, milling, grinding etc. The quality of the machined surface is characterized by the accuracy of its manufacture with respect to the dimensions specified by the designer. Each type of cutting tool leaves its own individual pattern which therefore can be identified. This pattern is known as a surface finish or surface roughness. Dry machining having no fluid which is not preferred everywhere because of lesser surface integrity.so, another technique to overcome this is Minimum Quantity Lubrication (MQL) or approximate dry machining where very less quantity of fluid is used and also not compromise with the surface quality. Application of nanofluid used in MQL has reduced the cutting temperature in the wide range of cutting speeds, feed, and depth of cut, also reduced the flank, crater, notch and adhesive wear of the tool and simultaneously improves the surface dimensionally as well.

The Surface roughness of machined AlSiCp MMC has been studied extensively by the many researchers. There are so many defects detected during machining like cavities in the surface due to pull out a particle, fracture of the SiC particle and voids around the SiC particle. No doubt load will distribute on the SiC particle to enhance the mechanical properties but also decrease the surface integrity with increasing the percentage of reinforcement. So the surface quality is reduced while increasing percentage of reinforcement.

Hardness of the composite improved by increasing the size of the particles, Dabade et al. [2010] worked on Al/SiC/30p composite and showed that the hardness of Al MMC was 120 VHN with fine reinforcement (65µm), and has a hardness of 100 VHN with reinforcement size (15µm) [6].

2. Literature Review

Surface Roughness (Ra) is a very vital parameter for any machined materials measured in micrometre (µm) and known by the distance between peak and centre line, Maximum peak height and the sum of the average of first four peaks and valleys. Two systems are basically employed for measuring roughness one is an averaging system (value form) and other is profiling system (graph form). Surface roughness measured by two methods one contacts and other is a non-contact method. Various equipment's for measuring surface roughness are profile meters, Bore inspect, Edge inspect and Coordinate measuring machine (CMM). Typically roughness value for casting process is in range of 0.6 to 50 µm (VDG instructor sheet K 100 obtainable from Verien Deutsher) depending upon the type of casting and for face milling its range is 0.4 to 25 µm relay upon the type of materials for casting. During machining the Surface roughness value varying generally with three parameters i.e Speed, Feed and Depth of cut[7]. To controlling these mentioned parameters can control the Surface roughness value. Applications of surface roughness effects several attributes like friction, wear, tear of the parts and other functions like holding the lubricant and coating etc. So nowadays, a number of researchers developed a mathematical model for predicting the Surface roughness value like Regression analysis, Taguchi method, artificial neural network (ANN), Fuzzy logic (FL) and evolutionary techniques etc [8].

For achieving better surface roughness, following sequence of the tools are recommended ploy crystalline diamond (PCD), Cubic boron nitride (CBN), Alumina, Silicon nitride and Tungsten carbide (WC)[9][10][11]. Surface roughness in end milling depends on the speed of the cutter, feed and depth of the cut, lubricant used and mechanical properties of the material. By controlling flank tool wear, cutting nose of the tool and dimensional accuracy for achieving the better surface roughness [12]. Surface roughness cannot be neglected, as per these characteristics for the design concern like Tensile strength, wear resistance, ductility, and fatigue strength of the machined part[13].

Various studies of predicting Surface roughness of the materials are followed in the next session. Sahin et al. [2002] examined the surface roughness (Ra) of the Al_2O_3 reinforcement in Aluminium MMC with different cutting tools and found that the value of Ra mainly depends on material and geometry of the tool and chip formation. With the increase in cutting speed, the temperature between the interference increased and this phenomenon can not cut/broken the particle but moved from the position due to the strong bonding between the particles and the Al alloy. The optimum value of Ra obtained at the speed of 160 m/min. in the machining of 10% by wt. of Al_2O_3 reinforcement in MMC with the particle size 16 µm and also observed that average roughness value increased with increasing speed and volume fraction of the reinforcement [14].

N. Suresh Kumar Reddy et al. [2005] studied the tool geometry (nose radius and rake angle) and cutting condition (speed, feed and depth of cut) during end milling and optimized the surface roughness values through genetic algorithm (GA) model[5].

N. Suresh Kumar Reddy et al. [2008] examined that during end milling of Al/SiC MMC using TiAlN coated tool cutter, the roughness value and cutting forces increased with increasing the feed rate while surface roughness decreases with increasing speed[15].

Basheer et al.[2008] investigating the roughness of machined AlSiC MMC with PCD tool and compared it with ANN model and concluded that at the lowest feed rate, smaller particle size and larger tool-nose radius provides best surface integrity[16].

M.F.F. Ab. Rashid and M.R. Abdul Lani [2010] worked on end milling of aluminium 6061 with four flute high-speed tool and concluded that ANN model was provided close results as compared to the multiple regression[17].

S. P. Dwivedi [2012] et al. studied the surface roughness of A356-SiC 5% composite fabricated by electromagnetic stir casting. During machining of A356 alloy 5 wt% SiC composites, tungsten carbide inserts were employed on CNC machine and found that increases the cutting speed decreases the surface roughness, whereas reverse in case of depth of cut and feed[18].

M. Chandrasekaran & D. Devarasiddappa [2012] developed the predicting model of surface roughness of end milling of Al-SiCp MMC using fuzzy logic (FL). Values of surface roughness depend upon feed, speed and least affected by the depth of cut. Surface roughness depends linearly with feed rate and inversely with speed so, for the better Surface finish, go for lower feed rate and high speed.

Ravi Kumar et al.[2014] worked on milling of Aluminium and highlighted the nearest result of surface roughness through ANN model. Predicted results are matched with ANN model by 92 percent and conclude that ANN is one of the best mathematical models for predicting the roughness value[19].

Okokpujie and Okonkwo [2015] worked on machining of aluminium under MQL environment and reported that axial depth has least effects on surface roughness as compared to other speed and feed and also concluded that a second order quadratic equation in the least square technique is provided quite better close results compared with the experiment[20].

Ojolo Sunday Joshua [2015] investigated the Cutting Parameters on Surface Roughness Prediction during End Milling of Aluminium 6061 under MQL (Minimum Quantity Lubrication) and concluded that MQL is better than Flooding/continue lubrication system and combination of input parameters are better choice as individuals, mostly affected by cutting feed followed by speed and lowest is the depth of cut. The best combination is speed and feed and the worst combination is speed and depth of cut[20], [21].

S.H. Tomadi et al. [2017] concluded that during end milling of AlSi/AlN metal matrix composites, uncoated carbide tool is better to perform then coated tool and surface roughness also depends on the size of the reinforcement: For smaller the size of the reinforcement having lower the value of roughness. For uncoated carbide tool, cutting speed: 320 m/min, feed rate: 0.4 mm/tooth, axial depth: 0.4 mm and 10% reinforcement provide the optimum results [22].

3. Variation in Surface roughness during wet machining

The fluid has to give a very strong impact during machining, no doubt fluid act as lubricant and purpose is to reduce the cutting zone temperature in the interference between workpiece and tool. But the choice of the fluid is a real challenge for the particular type of the machining and machining for what kind of the material is. Now a day different cooling systems are employed like flood coolant, minimum quantity lubrication (MQL), continuous cooling, interrupted cooling all are comes under the wet cooling system. The difference in above is all just for a system of supply, one has to continue supply other is discontinue supply and in MQL system, a small amount of fluid in mist form is applied during machining and known as Near Dry machining. Various factors affect the MQL system like cutting parameters (speed, feed and DOC), method of spray (internal/external spray), cutting fluid (vegetable/ water-soluble oil), type of cutting (continuous/intermitted), tool, fluid application etc. which directly or indirectly control the resulted parameters like Surface Roughness, cutting temperature, Chip control and tool life. Thus MQL provides a very strong application in the field of machining [23].

Used of lubricant reduced the value of surface roughness. S. Khandekar et.al [2012] worked on machining of AISI 4340 through uncoated carbide inserts under employ two different lubricants has been reduced the value of surface roughness by 58 % and 28 % as compared to the dry machining[24]. Mustafa Rifat et al. [2017] the surface quality was improved by 60% when CNC machined of Al6061-T6 alloy with MoS2 nanoparticle as a lubricant in MQL system[25].

Ojolo Sunday Joshua et al. [2015] the roughness value reduced when end milling of Aluminium 6061 under MQL compared to the dry conditions[20].

4. Effect of reinforcement on surface roughness

Surface roughness mainly depends upon the size of the particle and percentage of the reinforcements. It was explored that hard particle initially starts abrasive wear of the tool and make big and discontinue cavity formation in the surface of the materials if the depth of cut is more. In some cases, depth of cut has the least effect on surface roughness when the polycrystalline diamond tool (PCD) used, this was proved by Yuan and Lane [1993] [26]. Li and seah [2001] investigated the machining of Aluminium based MMC with different size and fraction of the reinforcement, the abrasive wear accelerates when the percentage of the reinforcement is higher than the critical value[27]. Pendse and Joshi [2004] postulated the relation of surface roughness with the feed, nose radius, cutting Speed and volume of reinforcement and stated that feed is the higher influencing factor then nose radius. Surface roughness decreased while increase feed, nose radius and reinforcement. For better surface roughness, lower the nose radius as shown in the fig.1 [28].

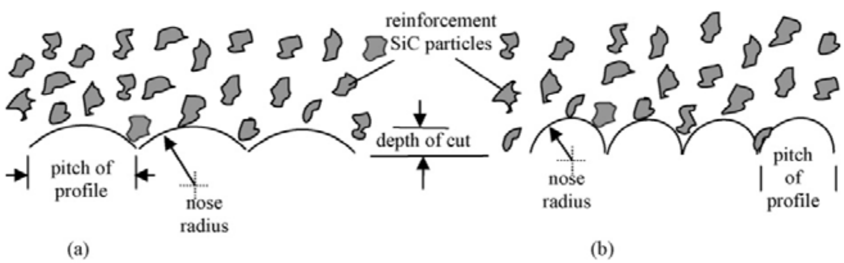

Fig.1 Effect of an embedded particle on Surface roughness (Pendse and Joshi, 2004) [28] (i) fig. 1a and fig. 1

5. Conclusions

From the literature review, the following conclusion may be adopted

1. A better surface integrity was achieved by selecting the proper combination of Speed, feed and Depth of cut during the machining of Aluminium based metal matrix composites.
2. Surface roughness was always better with higher speed, low feed and depth of cut again for any type of the machining [29], [30].
3. Surface roughness also depends upon the size of the reinforcement and percentage of the reinforcement[31], [32].
4. Used polycrystalline diamond tool (PCD) for obtaining better surface finish [33]–[35].

A lot of work was done in the field of predicting Surface roughness of Aluminium based metal matrix composites but still, a gap has been seen that what will be the effect of nano fluid used in MQL during machining of Aluminium based MMC.

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