Measurement 65 (2015) 166–180

Contents lists available at ScienceDirect

Measurement

journal homepage: www.elsevier.com/locate/measurement

Study on surface roughness measurement for turning of Al 7075/10/SiCp and Al 7075 hybrid composites by using response surface methodology (RSM) and artificial neural networking (ANN)

Ravinder Kumar *, Santram Chauhan

Department of Mechanical Engineering, NIT, Hamirpur 177005, India

ARTICLE INFO

Article history:
Received 28 November 2013
Received in revised form 22 October 2014
Accepted 9 January 2015
Available online 19 January 2015

Keywords:
Aluminum metal matrix composite
Density
Stir casting
Weight fraction
Machining
Average surface roughness (Ra)

ABSTRACT

This paper investigates the effect of cutting parameters (cutting speed, feed rate and approach angle) on roughness in turning of Al 7075 hard ceramic composite (10 wt.% SiC) and Al 7075 hybrid composite (7 wt.% SiC and 3 wt.% graphite) using polycrystalline diamond tool (PCD). The dry turning is conducted to examine the trend of roughness by using a SJ301 MITUTOYO roughness tester for both composites at cutting speed (80–170 m/min), feed rate (0.05–0.2 mm/rev) and approach angle (45–90°). It is inferred that surface roughness of the hybrid composite (7 wt.% SiC and 3 wt.% graphite) is lower than that of the hard ceramic composite (10 wt.% SiC) in all combinations of experiments. To recognize the mixing of reinforcement is examined using scanning electron microscope (SEM) and X-ray diffraction (XRD). Response surface methodology (RSM) and artificial neural networking (ANN) are applied to validate the results obtained during experimentation and to predict the behavior of the system under any condition within the operating range. It is apparent from the analysis that feed rate has significant contribution for both materials than speed and approach angle.

1. Introduction

Metal matrix composites (MMCs) offer various advantages in applications where high specific strength, stiffness and wear resistance are required. Aluminum reinforced with silicon carbide (SiC) particles is one of the combinations of MMC's, which has more significance in the areas of aerospace and automotive engineering components and other diverse industries [1]. Aluminum metal matrix composites, especially SiC particulate composites are increasingly being used for varieties engineering applications from automotive to aircraft components. It is possible to produce high quality MMC components to near net shape with many manufacturing techniques. Unfortunately, for reasons such as component design and dimensional tolerance requirements, the need for machining cannot be completely eliminated [2–4].

A widespread industrial application of these advanced materials will not be possible without the solution of the machining problems [5]. The poor reproducibility of physical properties of MMC specimens and components is an important hindrance for many possible applications. Most of the research on machining MMCs is concentrated mainly on the study of cutting tool wear and wear mechanism. Since it is well known that machining causes various geometrical and metallurgical defects in the surface region, one cannot draw conclusive decisions about the

* Corresponding author. Tel.: +91 9459095004.
E-mail address: ravindernitcad@gmail.com (R. Kumar).

http://dx.doi.org/10.1016/j.measurement.2015.01.003
0263-2241/

Table 1
Chemical composition of Al7075.

Chemical composition	Al	Cr	Cu	Fe	Mg	Zn	Si	Mn	Ti	Other
wt.%	89.79	0.08	1.35	0.3	2.21	5.67	0.4	.08	0.06	.06

machinability of any material by just looking at the tool wear and tool wear rates [6–8].

Characterization of surface topography is important in applications involving friction, lubrication, and wear [9]. In general, it has been found that friction increases with average roughness. Roughness parameters are, therefore, important in applications such as automobile brake linings, floor surfaces, and tires. The effect of roughness on lubrication has also been studied to determine its impact on issues regarding lubrication of sliding surfaces, compliant surfaces, and roller bearing fatigue. It is well known that the ability of a material to withstand severe conditions of stress, temperature and corrosion depends on the quality of the surface generated during machining which consequently determines the longevity and reliability of products made of these composites [10]. Krishnamurthy and Venkatesh [12] has been attempted to assess the factors influencing surface roughness and material removal rate in machining composite. Taguchi method was used to find the optimal cutting factors for surface roughness (Ra) and material removal rate (MRR). Three cutting factors, namely speed; feed and depth of cut were optimized with considerations of Ra and MRR. The experimental plan and analysis were based on the Taguchi L_{27} orthogonal array with three cutting factors using carbide tool (K20). The optimal parametric combination for K20 carbide insert was found to be feed, speed and depth of cut. The analysis of variance (ANOVA) result shows that feed the most significant process parameter on surface roughness followed by speed. Similarly Bhushan et al. [13] investigated the influence of cutting speed, depth of cut, and feed rate on surface roughness during machining of Al 7075 alloy and 10 wt.% SiC particulate metal-matrix composites. The experiments were conducted on a CNC turning machine using tungsten carbide and PCD inserts. Surface roughness of Al7075 with 10 wt.% SiC composite during machining by tungsten carbide tool was found to be lower in the feed range of 0.1–0.3 mm/rev and depth of cut range of 0.5–1.5 mm. The high hardness of the particles results in excellent abrasion resistance. However, this property lends poor machinability involving high tool wear and surface imperfections on the workpieces. For this reason, Anand Kumar et al. [14] investigates the feasibility and dry turning characteristics of in-situ Al–4.5%Cu/TiC metal matrix composites using uncoated ceramic inserts. The effect of machining parameters such as cutting speed, feed rate and depth of cut on the cutting force and surface roughness of the composites were investigated during the dry turning operations. Experimental results indicated that the cutting force increased with cutting speed up to 80 m/min then decreasing upto120 m/min. Built-up edge (BUE) and chip formation were also examined by scanning electron microscopes. The significant formation of BUE was observed in a lower amount at higher cutting speed and higher at lower cutting speed. The investigation revealed that, with the use of uncoated ceramic inserts, acceptable surface finish can be achieved during dry turning operation of the composites.

The surface finish is an important parameter in machining process. Surface roughness has received serious attention for many years [15]. It has formulated an important design feature in many situations such as parts subject to fatigue loads, precision fits, fastener holes and aesthetic requirements. In addition to tolerances, surface roughness impose one of the most critical constraints for selection of machines and cutting parameters in process planning. In the view of above machining problems, the main objective of the present work is to investigate the influence of different cutting parameters on the surface finish [16–19]. To the best of the authors' knowledge, little research has been carried out to determine the effects of cutting parameters on machining of hard ceramic composite and hybrid composite Al/SiC/Graphite particulate metal-matrix composite. Response surface methodology (RSM) is utilized for experimental planning and analysis during turning of Al–SiC–MMC. The results are analyzed to achieve optimal surface roughness and the issues of machining MMCs have been addressed from various aspects. In order to know surface

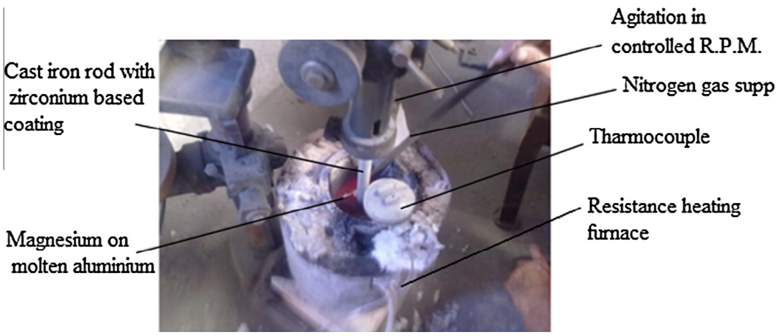

Fig. 1a. Photograph of set up for mixing of the SiC and Gr particle in aluminum.