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Optimization and experimental investigation on AA6082/WC metal matrix composites by abrasive flow machining process

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Abstract

Non-traditional finishing procedures have become increasingly important in recent years, and it is critical that these techniques can benefit from composite materials. One of the most recent methods of surface preparation is called as Abrasive Flow Machining (AFM). As a result of its advantages including light weight, good strength, and low cost, composite materials have displaced traditional materials. It is used to mill composite materials that have a high proportion of Tungsten Carbide (WC) content (Al 6082/WC composites with 30 to 70 % Tungsten Carbide content). Taguchi's philosophy can be employed to study the MRR, Surface roughness (Ra) and surface topography. Extrusion pressure is found to be the most important element in determining MRR and ΔRa. It is done using the Taguchi approach to improve the response parameters (MRR and ΔRa).

Introduction

An abrasive medium is extruded into a piece of work, resulting in smooth and completed surfaces [1]. A one-way system has the medium passing through the workpiece and out the opposite end. Passages in the workpiece and fixture allow the abrasive media to flow up and down in two cylinders [2], [3]. The material pushed into a hollow workpiece is used to mill the inside surface of the AFM process. The abrasive media is pushed downward by an upper cylinder-piston combination [4], [5]. Using an abrasive substance to extrude off the surface of a workpiece that is held in place by two fixtures, surface finishing is accomplished. Media is pushed upward by the bottom cylinder in the upward stroke. As a result, the finishing process occurs as the media is moving upward. Finishing composite materials with very low surface roughness is a challenge [6]. Because the workpiece is not directly chopped during the EDM process, this method is more convenient for milling composite materials. After the EDM procedure, the machining surface is often left with an outer layer. In order to resolve this problem, [7] investigated the surface of WC/Aluminum composites in the WEDM procedure. WEDM surface roughness was improved by [8], [9] using a low-cost, high-performance abrasive medium. A Si-based polymer is extensively mixed with abrasive particles to create the flexible medium [10]. Due to its modest cross-sectional area, melted Silicon was chosen as carrier. An all-inclusive method for material removal was proposed by [11] for various abrasive-based machining techniques. The hardened tool steel AISI D2 specimens were processed by [12], [13] first by electric discharge machining and then by AFM, and it was discovered that surface roughness of specimens damaged by EDM could be greatly improved by AFM. Brass and aluminium MRR trends are nearly identical, according to [14], [15]. Because aluminium is more susceptible to abrasion than brass, the quantity of substantial that can be removed from workpiece is greater [16], [17], [18]. Using the experimental study method of AFM, [19] were able to finish the complex-shaped slots created by wire EDM. The abrasive concentration, extrusion pressure, and time taken in machining were all studied using the Taguchi method. Authors also used a SEM to study the wire EDM slots that were then polished by AFM [20]. Authors looked at the most important input parameters and the parameters' ideal solutions. Taguchi approach is used by [21]to identify the factors that influence the quality of the finished surface in Magnetic Abrasive Finishing. The working gap, rotation speed, and grit size all have an impact on the quality of the finished product's surface [22]. After grit size and rotating speed, voltage and operating gap are cited as the most critical criteria for ΔRa. An excellent abrasion finish on composite materials is time-consuming to achieve. With more complex materials, abrasion treatments become even more important as a finishing operation. Vibrating cylindrical magnetic abrasive finishing systems were studied by [23], [24], [25] who looked at aspects including vibration frequency and rotating speed as well as grain size and flux density in the process of finishing aluminium workpieces. According to [26], the surface roughness of workpieces can be influenced by AFM input parameters using the Taguchi technique. Various parameters impacting the roughness of the surface have been optimized. The HLX-AFM procedure incorporates Taguchi's approach [27]. Optimizations have been made to a number of process parameters, and a major material removal technique has also been devised. Rotational–Magnetorheological Flow Abrasive Finishing was found by [28] to be capable of improving out-of-roundness of SS by 2.04 μm. The polishing media is rotated while being moved simultaneously up and down in this procedure. It has been decided to use response surface methodology in the design of the experiments. The findings of MMCs machined using an EDM method were published by [29]. The thickness of the recast layer has been examined using SEM micrographs. Using a rotational abrasive flow finishing technique, researchers were able to polish aluminium alloy and its MMCs [30]. Each variable like shear stress, % of viscous component, modulus of stress relaxation, and storage modulus, had an impact on the Ra and MRR, as shown in the results. An abrasive wear study was conducted by [31]on a lower-roughness surface sliding against a surface roughness. Polymer plasticity was studied using the slip line hypothesis. There are a number of factors that influence the abrasive wear rate as well as the coefficient of wear. They can be applied to ceramic-ceramics, ceramics-metals, and metal-metals sliding structures, respectively. The authors of [32], [33] investigated a magnetic abrasive finishing procedure with ultrasonic assistance. Measurements of normal force and torque have been made. Finishing torque and force have been influenced by supply voltage and finishing gap. Predicting torque and force in relation to voltage, cutting gap, and workpiece hardness is done using mathematical models. However, while aluminum-based MMCs are commonly employed in the aerospace and military sectors due to their abrasive natures and poor surface finishes, they also cause a lot of tool wear. For machining, polycrystalline diamond and cubic BN tools are employed. There were four main causes of tool wear: adhesion, chipping, fracturing, and abrasion, according to the results. For machining MMC, PCD tools are said to be best, then layered CBN and finally unlayered CBN.

Section snippets

Materials and methods

Hydraulic cylinders are made of EN8 material. Cylinders have an internal diameter of 90 mm. This tool has a 250 mm stroke. There has been a use of hydraulic oil 68 in this process. Fig. 1 depicts the experimental setup photograph. The components are being held in place by a nylon fixture. Slots may be easily carved into the work piece because of its machinability.

A nylon fixture has been used to hold the work piece in place. Transverse cross-sectional area is gradually lowered in the fixture,…

Experimentation

Pilot testing has utilized the one component at a time experimentation method. As work parts, AA6082/WC MMCs are employed. There are many variables that can be taken into consideration when determining processing factors like extrusion pressure and percentage of oil in average. The use of abrasion and liquid silicon as a finishing media for work