International Journal of Machine Tools & Manufacture 86 (2014) 44–61

Contents lists available at ScienceDirect

International Journal of Machine Tools & Manufacture

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

Developments in the non-traditional machining of particle reinforced metal matrix composites

A. Pramanik*

Department of Mechanical Engineering, Curtin University, Bentley, WA, Australia

ARTICLE INFO

Article history:
Received 31 March 2014
Received in revised form
1 July 2014
Accepted 2 July 2014
Available online 14 July 2014

Keywords:
Particle reinforced metal matrix composites
Non-traditional machining
Material removal rate
Surface finish
Machining mechanism

ABSTRACT

The non-traditional machining of particulate reinforced metal matrix composites is relatively new. However, researchers seem to pay more attention in this field recently as the traditional machining of particulate reinforced metal matrix composites is very complex. This research investigates different non-traditional machining, such as electro-discharge, laser beam, abrasive water jet, electro-chemical and electro-chemical discharge machining of this composite materials. The machining mechanism, material removal rate/machining speed and surface finish have been analysed for every machining process. This analysis clearly shows that vaporisation, melting, chemical dissolution and mechanical erosion are the main material removal mechanisms during non-traditional machining. The thermal degradation and the presence of reinforcement particles mainly damage the machined surface. The understanding of electro-discharge, laser beam and abrasive water jet machining is more developed than that of electro-chemical and electro-chemical discharge machining for particulate reinforced MMC.

© 2014 Elsevier Ltd. All rights reserved.

Contents

* Tel.: +61 8 9266 7981.
E-mail address: alokesh.pramanik@curtin.edu.au

http://dx.doi.org/10.1016/j.ijmachtools.2014.07.003
0890-6955/© 2014 Elsevier Ltd. All rights reserved.

1. Introduction

Machining processes remove unwanted material from a bulk workpiece and introduce the shape of the final product [61]. In traditional machining, the unwanted material is separated as chips by plastic deformation due to application of force by sharp cutting tools [62]. The use of traditional machinery to machine metal matrix composite causes serious tool wear due to the abrasive nature of reinforcing particles which shortens the tool life [40]. In addition, the worse surface finish due to tool–particle–machined surface interactions in conventional machining significantly hinders the use of MMCs [41]. Electronic-grade MMCs of high reinforcement content are nearly impossible to machine by conventional methods. Thus non-conventional techniques, including electro-discharge, laser-beam, electro-chemical and abrasive water jet machining, have also been applied to these materials [16]. However, research in machining of MMCs in traditional ways has been given higher importance over non-traditional machining for the last few decades. Thus, there is little advancement in the understanding of non-traditional machining of MMCs. There are some studies in the field of non-traditional machining of MMCs that produce interesting results as well. Different non-traditional machining methods of MMCs have their own advantages and drawbacks although these have higher potential over the tradition methods as the overall understanding on the suitability of these methods for MMC is relatively low. A clear understanding of these non-traditional methods for MMCs is necessary before being applied in the practical fields. This paper investigates the suitability of different non-traditional methods for machining MMCs by studying the machining mechanism, tool wear, surface finish, and machining speed based on information available in the literature. This will link all the understanding achieved by different researchers and, scientifically and systematically analyse those to give a detailed picture of machining MMC by non-traditional processes.

Every non-traditional machining below has been analysed based on the (a) material removal mechanism, (b) cutting speed/ material removal rate, (c) surface finish and dimensional accuracy and other parameters important for any specific method. All the parameters considered in this study are important scientifically, economically, and for assessing the latest developments, performance and efficiency of the considered non-traditional machining methods. The material removal mechanism describes the up to date understanding of the specified methods and reveals whether there are any underlying problems related to those methods. The cutting speed/material removal rate is very much related to how quickly a method can perform a given task. The cutting speed indicates the efficiency of the method as well as the suitability for any specific need. The surface finish and dimensional accuracy is a measure of performance of any method. If any method gives bad surface and dimensional accuracy compared to other methods at similar machining conditions, then the performance of the first method is worse than that of other methods. Thus, the method needs to be fixed and more research is required to improve it. Having said the above, this paper provides the contribution of many research works, advancement of the process understanding, the current state-of-the-art knowledge and trends in research to advance the technologies through discussions on several output parameters of the different methods.

2. Electrical discharge machining

Electrical discharge machining (EDM) is one of the most extensively used non-conventional material removal processes where electrical discharge is used to machine electrically conductive parts regardless of hardness [18]. The electric discharge generates high thermal energy which removes material by erosion [1]. EDM process takes place in a dielectric fluid where the tool is one electrode in the shape of the cavity to be produced and the workpiece to be machined is the other electrode. The tool is then feed toward the workpiece in a controlled path to produce the shape of electrode or its movement. The electrode and the workpiece do not make direct contact during the EDM process. Therefore, this process eliminates issues related to chatter and vibration. Electro-discharge machining (EDM) is a multipurpose process for machining intricate or complex types which has typical advantage in the manufacture of mould, die, automotive, aerospace and surgical components from materials that are difficult to machine by conventional methods. It is possible to drill a hole as small as 0.1 mm by EDM [18].

2.1. EDM mechanism of MMC

During EDM the tool is connected to the negative terminal of a pulsating DC power supply and the workpiece is connected to the positive terminal of the same source [35] where pulsating direct current supply occurs at the rate of approximately 20,000–30,000 Hz [18]. The tool is gradually brought close to the workpiece. When the distance between tool and workpiece reaches a certain value, the electricity starts to flow through the electrolyte from the tool to the workpiece and generates sparks. At this stage the thermal energy generates a channel of plasma between the tool and the workpiece where the temperature can be as high as 20,000 °C [18]. This temperature is high enough to melt and vaporise the workpiece material, and make tiny craters. It also causes tool wear. Thus the distance between tool and workpiece increases and the tool moves further to maintain a certain amount of gap facilitating electric spark. This process of melting and evaporating material from the workpiece surface is very dissimilar to that of conventional machining processes where chips are produced. When the plasma channel breaks down and turns off, the temperature reduces suddenly which allows dielectric fluid to circulate and implore the plasma channel, and flush the molten material from the pole surfaces in the form of microscopic debris. A typical material removal rate by this method is in the range of 10^{-6}–10^{-4} mm^3 per discharge [18]. The EDM process can be divided into two types, such as die-sinking and wire. The shape of the die is machined into workpiece by feeding the die into workpiece in the die-sinking EDM. On the other hand, in wire electro-discharge machining (WEDM) a thin wire is used as the tool electrode [1,7]. The size of the cut is always bigger than the size of the tool or wire in EDM. This is known as overcut, which is constrained by the minimum distance (between electrodes) necessary for spark. As the material removal in this process takes place through melting and vaporisation, a recast layer of workpiece material on the surface and a heat affected zone below the surface of the workpiece are generated [7].

Download English Version:

https://daneshyari.com/en/article/778841

Download Persian Version:

https://daneshyari.com/article/778841

Daneshyari.com