Chapter 8

An Investigation Into Non-Conventional Machining of Metal Matrix Composites

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ABSTRACT

One of the recently developing fields is that of non-traditional machining of particle reinforced metal matrix composites. The complexity associated with traditional machining of particle reinforced metal matrix composite is very high, and therefore, the researchers have begun to show more focus towards non-traditional machining. In the present work, the investigation has been carried out for non-traditional machining such as laser beam machining, electro-chemical machining, abrasive water jet machining, and electro-chemical discharge. Material removal rate, surface finish, and the mechanism of machining has been studied for each of the aforementioned processes. The main material removal mechanisms as has been identified are melting, mechanical erosion, vaporization, and chemical dissolution. The investigation reveals that the major reasons for the damage of the machined surface are the presence of reinforcement particles and thermal degradation.

INTRODUCTION

It is through the employment of machining processes that the final shape of the product is achieved through the removal of unwanted material from the main workpiece (Pramanik et al., 2009). The mechanism of material removal in case of traditional machining process involves the removal in the form of chips owing to the plastic deformation resulting because of the force being exerted by the sharp cutting tools (Pramanik et al., 2013). The tool life in machining of metal matrix composites (MMCs) is shortened because of the abrasive nature of the reinforcements (Pramanik et al., 2006). The surface finish is also worse due to the tool-particle-machined surface interactions. The aforementioned limitations put hindrance to the
use of MMCs (Pramanik et al., 2007). It becomes impossible for the conventional machining processes to machine MMCs with high percentage of reinforcing particles. Therefore, certain non conventional machining processes such as laser-beam, abrasive water jet, electro-discharge and electro-chemical have been developed for machining of such materials (Hihara et al., 2000). The last few decades have seen dominance of studies on traditional machining methods of MMCs over the non-traditional machining process such as electro-discharge machining (EDM), laser-beam, electro-chemical (ECM), abrasive water jet machining (AWJM) and photo-chemical machining (PCM). EDM process is one of the widely explored non-traditional machining process for particle reinforced metal matrix composites (PRMMCs) while PCM is the least explored of all. Thus it is obvious that a greater understanding is still required on machining of MMCs using non-traditional machining. A clear understanding of the different non-traditional methods used for machining of MMCs will aid in exploring the potential advantages of non-traditional methods over the traditional ones which then can then be applied in practical field. The present work therefore is an attempt to investigate the less explored non-traditional methods with focus on the mechanism of material removal, material removal rate, surface finish and the machining speed. The above parameters considered for the study will aid in assessing the recent developments, efficiency and the performance of the non-traditional methods. A better understanding on the mechanism of material removal rate leads to a proper visualization of the specific method and also the associated problems relating to the methods are revealed. The efficiency of machining process is reflected in its cutting speed which delineates the fact that how quickly the material removal takes place. The performance of a machining process is revealed by the level of surface finish and dimensional accuracy achieved. The performance of a machining process is considered worst if it gives rise to poor surface finish or poor dimensional accuracy. In the backdrop of the above discussion, the present work provides a brief overview of the non-traditional machining of MMCs by considering contributions from past researchers.

The rest of the chapter has been organized into: Laser beam machining, abrasive water jet machining, electro-chemical machining and electrochemical spark machining. The subsections in each of these sections describes in detail the material removal mechanism, major output response parameter and surface finish and dimensional accuracy for each of the aforementioned process. the chapter finally ends with the concluding remarks consisting of future directions.

**LASER BEAM MACHINING**

Laser beam machining (LBM) is considered to be one of the most employed non-traditional machining processes. It is one of the thermal energy based advanced machining processes. The workpiece material is melted and vaporized using laser beam (Dubey et al., 2008). The LBM process is suitable for producing geometrically complex shapes and small holes. The thermal and the optical properties of a material determine the effectiveness of the LBM process. For higher performance of LBM, a material is required to possess low thermal conductivity and diffusivity. Mechanical properties such as brittleness and hardness are insignificant properties responsible for the LBM effectiveness (Müller and Monaghan 2000). Laser beam is the main source of heat energy that is transferred through irradiation. The absence of cutting forces, material damage due to mechanical forces and tool wear makes LBM a suitable machining process for MMCs. LBM can be used for a number of machining operations on a single machine such as cutting, drilling, welding and grooving (Pham et al., 2007). The most common type of lasers used for machining are CO$_2$ and Nd:YAG lasers (Dubey et al., 2008). CO$_2$ lasers are generally used for