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The Effect of Process Parameters on Material Removal Rate and Dimensional Variation of Channel Width in Micro-milling of Aluminium Alloy 6063 T6

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Abstract

Micro milling is the process of manufacturing 3D complex structures with high accuracy, low cost and good surface finish. It has a wider scope in variety of applications such as micro fluidics for transportation of biological materials, micro heat exchangers for micro electromechanical systems (MEMS), etc.In this paper micro milling process is used under dry condition to produce micro-channels on Aluminium alloy 6063 T6 using Tungsten Carbide end mill cutter of 400 µm diameter. The effect of process parameters such as spindle speed, feed rate and depth of cut on material removal rate (MRR) and dimensional variation of channel width (W_{var}) is investigated. Design of experiment is done by Taguchi L16 orthogonal array. ANOVA is carried out to analyze the experimental results. The optimum conditions obtained from Taguchi method for optimizing MRR during micro milling of Aluminium alloy 6063 T6 are feed rate of 4.5 mm/min, depth of cut of 0.064 mm and spindle speed of 2500 rpm. Depth of cut is the most significant factor of about 63.10 % followed by feed rate of 33.30 % and the spindle speed is least significant factor about 1.16 % influencing MRR. Similarly the optimum conditions obtained from Taguchi method for optimizing W_{var} are spindle speed of 2000 rpm, depth of cut of 0.048 mm and feed rate of 1.8 mm/min. Spindle speed is the majorly contributing of about 53.05 % in obtaining optimal W_{var} ,depth of cut of 26.13 % and feed rate has very less contribution of 3.51 %.

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Keywords: Micro-channels; MRR in micro-milling; Dimensional variation; Taguchi method

1. Introduction

Fabrication of micro channels has been done by using non-conventional fabrication techniques (e.g. etching, electroplating, micro EDM, Wafer Bonding Technique etc). These processes have fewer material restrictions and the

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incapable to manufacture true three-dimensional features in comparison with other methods (1). Such processes are more expensive and inefficient compared to conventional one. Micro milling is the process of manufacturing 3D complex structures with high accuracy, low cost and good surface finish. It has a wider scope in variety of applications such as micro fluidics for transportation of biological materials, micro heat exchangers for micro electromechanical systems (MEMS), The micro-milling plays an important role in micro fabrication due to its advantages of flexibility, high efficiency and low energy consumption (2).

2. Experimental procedure

2.1 Selection of work piece material

A rectangular plate of Aluminium Alloy 6063 T6 is used as a work piece material for experimentation of size 68 mm in length 32 mm in width and height as 19 mm.

2.2 Selection of cutting tool material

Tool material used for micro milling operation is Tungsten Carbide flat end mill cutter of diameter 400 µm and shank diameter is 3 mm.

2.3 Selection of process parameters

Micro milling experiments are carried out by considering three parameters - Spindle Speed (rpm), Feed rate (mm/min) and Depth of cut (mm). Four levels low, medium, moderate and high are considered for each process parameter.

3. Methodology

3.1 Orthogonal Taguchi Array

Design of experiment is done by Taguchi method. The most appropriate orthogonal array (L16) is selected, where 4 levels and 3 factors of process parameters are selected and their effect on response variables is studied.

4. Experimentation

Micro milling experimentation is carried out on three axis Hyper 15 micromachining centre available at Walchand College of Engineering, Sangli. The working setup of micro milling and collet and modular fixture arrangement as shown in Fig. 1. (a) and (b) on which systematic experimentation is carried out as per the design of experiment. The micro-channels are manufactured under dry condition on aluminium alloy 6063 T6 by using two-flute flat end mill cutter of tungsten carbide having diameter 400 micron as shown in Fig. 2.

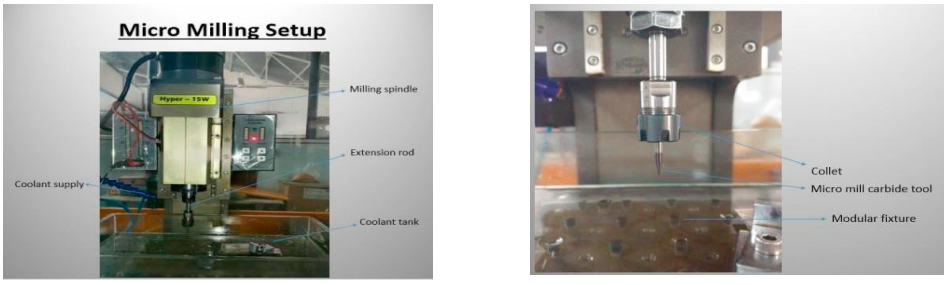

Fig .1. (a) Micro milling setup; (b).Collet and modular fixture arrangement