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Experimental Study in Micromilling of Inconel 718 by Fiber Laser Machining

Sachin C. Borse[a*], Prof. M.S. Kadam[b]

[a]*Research Scholar, Deogiri Institute of Engineering & Management Studies,Aurangabad431001, India*
[b]*Professor, Jawaharlal Nehru Engineering College, Aurangabad 431001, India*
[*]*Corresponding author. Tel.: +919420929365;.* E-mail address: *sachinborse1977@gmail.com, munjadaskadam@jnec.ac.in*

Abstract

In laser beam micro machining process, the quality of the micro milled component mainly depends on appropriate selection of process parameters. In laser milling technology, the material removal is done by a laser beam through the mechanism of layer by layer ablation. The process is affected by the laser characteristics and the properties of the work material but is mostly influenced by their interaction. The selection of the laser and its parameters significantly affects surface roughness as well as the material removal rate(MRR) of the micropart. In present research, an attempt has been done to study the effect of laser process parameters on the quality of the features obtained by laser machining. In Fiber laser micro milling operation on Inconel 718, scanning speed, frequency, power have most significant effect on all responses.

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Keywords: Micromilling, Inconel 718, Fiber Laser, RSM,

1. Introduction

The laser beams are widely used for cutting, drilling, marking, welding, sintering and heat treatment. The laser is also used to perform turning as well as milling operations but major application of laser beam is mainly in cutting of metallic and non-metallic sheets[1]. Laser milling is a new, very flexible process for micro-fabrication, suitable for machining difficult-to-machine materials, like ceramics, dielectrics, carbide and hardened steel with good productivity and surface[2].Stainless steel is an important engineering material that is difficult to be cut by oxy-fuel methods because of the high melting point and low viscosity of the formed oxides. The laser cutting quality depends mainly on the laser power, pulse frequency, cutting speed and focus position [3].Infrared laser micromachining is a

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tool for rapidly producing microfluidic structures in PMMA. In combination with a simple bonding method, it is possible to produce working microsystems, where the time between changing the design and testing the finished structure is less than two hours. This makes the laser set-up a highly flexible and inexpensive tool for rapid prototyping in microfluidics[4].The capability of the laser milling process to produce microgeometries is limited by the scale of the feature. The bigger the dimensions of the cavity, the smaller the dimensional error. The diameter dimension error decreases more than the depth error when the scale of the cavity machined is increased. The geometry of the feature to machine affects the process performance [5].The dimensions of the cavity subjected to micromilling was 8mm* 8mm.

Nomenclature

RSM	Response Surface Methodology
GA	Genetic Algorithm
R_a	Surface Roughness value
CCD	Central Composite Design
MRR	Metal Removal Rate
LBM	Laser Beam Machining
PMMA	Polymethyl Methacrylate

2. Experimental Work

With a properly designed experiment, it should be possible to determine, with a much reduced number of experiments, the effect of changing any one variable with the same accuracy as if only one factor has been varied at a time, and interaction effects between the factors. The discussion on interaction effects between the factors is very crucial and can reveal how the process can be controlled in order to achieve the desirable process outputs. One useful class of such designs, which are economical in the number of experiments required, is the CCD. CCD is one type of RSM, which is a collection of experimental design techniques and regression methods. Multiple linear regression technique was employed to develop the model for the response, i.e. surface roughness. A CCD with 20 trials was selected. This is a second order design and can handle linear, quadratic and interaction terms in the process modelling. Experiment is conducted on Bradma fiber laser beam machine manufactured by Forbes & Company Ltd Aurangabad and the experiment is also conducted in Forbes & Company Ltd Aurangabad. Machine is having different input parameter such as scanning speed, frequency, Power, different scanning strategies, spot overlap. Machine specifications are given in table 1.

Table 1 Machine Specification

Specification	Description
Laser Type	Fiber
Wavelength	1064 nm
Scanning Speed	0- 7000 (mm/s)
Average Power	0-20 W
Frequency	20 Hz – 200 KHz
Focus Diameter	100µm