Chapter 9
Laser Trepan Drilling of Monel k-500 Superalloy in Low Power Laser Beam Machining

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ABSTRACT

In the field of micro processing of materials, laser has great importance as a source of heat and for its ability to deliver a coherent beam. The use of 50-watt average power for through-hole is impossible to achieve good quality drilling of the metal sheet upto 2 mm thickness. But the use of unique parameter sawing angle and constant focal point distance plays a significant role on hole diameter and circularity in laser trepan drilling. In the present research study, laser trepan drilling is investigated through multi diode pulsed fiber laser beam machining. Experimental analysis based on central composite design (CCD) of response surface methodology (RSM) has been fulfilled to find out the mathematical model.

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A study of the effect of sawing angle with other process parameters such as cutting speed, power, duty cycle, and pulse frequency on overcut bottom diameter and circularity at bottom for a monel k-500 has been conducted. Experimental validation of the proposed model shows that desired hole quality can be obtained by optimization of controllable of suitable process parameters.

INTRODUCTION

The earliest machining process for making different types of hole is drilling. Non-traditional drilling techniques like electro discharge machining (EDM), electro chemical machining (ECM), ultrasonic machining (USM), plasma arc machining (PAM), laser beam machining (LBM) and abrasive jet machining (AJM) etc. have come into the arena of drilling methods as a result of the development of materials and requirement of high precise holes with higher drilling rate (Dahotre et al. 2007; Jain 2005; Liu et al. 2012; Biffi et al. 2011). The laser beam drilling is more acceptable than other non-conventional drilling techniques due to the fact laser beam drilling has better techniques for higher production rate over the wide range of materials of conductive and non-conductive by nature (Meijer 2004). Their advantages are precession of operation, high speed processing and low cost. Laser drilling has involvement of high temperature processing of materials with solid phase heating, melting and evaporation. For reduction in the oxidation reactions in the cutting section use of assist gas is made in metallic material processing. An extensive heating in the cutting section via high temperature exothermic reaction is caused by oxidation reactions cutting section is devoid of cutting asperities like sidewall burning, overcut, dross attachment, taperness and thermal erosion. The defects portions along the cut section are minimized when cutting parameters are selected approximately in laser cutting or drilling process with proper control. The quality assessment of the final product requires important aspects like laser cutting process and assessment of the cutting parameters on kerf size and geometry. Improvement of process control and achieving of quality of the final product can be optimized through optimization of studies on laser drilling (Gautam et al. 2018; Mishra et al. 2013; Majumdar et al. 2013).

LASER ABLATION WITH NANO SECOND LASER

Material ejection and generation of nano particles are caused by photo thermal process in ns laser ablation. Rate of energy deposition being slow it combines with electronic and vibrational mode of the work-piece to hit the target material. Thermal penetration depth gives the estimated depth of effective laser energy absorption at low laser value (Roy et al. 2015). Thermal evaporation dominates the ablation process in the regime of thermal penetration. Direct heating of laser radiation causes ionization of vapor plume when the laser value comes near the threshold value. As the laser intensity goes to be higher than the gas ionization threshold optical break down process helps the ionization phenomenon to occur. The laser irradiant being greater than 10^9 w/cm^2 and surface temperature being equal to thermo dynamic critical point phase explosion phenomenon happens to change the matter from an overheated liquid droplet. Creation of plasma with high temperature and pressure occurs at the end of the laser pulse, leading