ANALYSIS OF FIBER LASER MARKING CHARACTERISTICS FOR PRODUCING MARKS OF VARIOUS GEOMETRICAL SHAPES

Thesis submitted

by

MOHIT PANDEY

DOCTOR OF PHILOSOPHY (ENGINEERING)

DEPARTMENT OF PRODUCTION ENGINEERING
FACULTY COUNCIL OF ENGINEERING & TECHNOLOGY
JADAVPUR UNIVERSITY
KOLKATA-700032
INDIA

2024

AN ABSTRACT

The thesis is structured in well-organized manner so that chapter 1 outlines an overview of laser marking processes, material removal mechanism, present needs, and applications. Apart from that, it also highlights the review of past research with existing research gap and outline the present research objectives. chapter 2 provides the details of fiber laser marking set up used for experimentation. It also shows the marking strategy and the methods employed for generation of complex geometrical shapes such as square, triangle, circle, ellipse, hexagon, pentagon or a combination of these geometrical shapes. chapter 3 presents process parameter selection and experimentation for fiber laser marking on stainless steel 304. Basic study was conducted in order to analyze the influences of process variables on the responses of fiber laser marking on stainless steel 304. The process variables set that has been obtained using one factor at a time method can be utilized for the marking of other complex geometrical shapes such as square, equilateral triangle, pentagon, hexagon and a combination of this geometrical shapes. chapter 4 highlights the mathematical modelling based on response surface methodology. The development of empirical formula and ANOVA test for the responses points out the correctness of the developed model. Apart from that, the single objectives as well as multi objective optimization of responses have been performed to find the optimal set of process variables for achieving optimum value of the responses. chapter 5 provides the study of marking quality characteristics on Ti6Al4V with the aid of the fiber laser system. Influences of process variables on line and surface marking is helpful in the generation of better-quality line marked surface which can be used for the generation of better-quality geometric shapes on the surface of Ti6Al4V. Chapter 6 focus on the comparative studies regarding the influences of process variables on laser part marking on black, red and white PMMA materials which had a wide range of applications in engineering fields. The effects of different process variables on the responses provides exposure of process parameter settings for good quality laser marked surface. Apart from that, UV-VIS-NIR spectrophotometer has been conducted in order to ascertain the change in optical properties occurred during laser marking operations. Chapter 7 contains the general conclusions based upon various experimental results and future scope of work which can be carried out by other researchers in order to extend the work in the areas of laser marking.

The author has made an attempt to justify the uniqueness of the present work by exploring image quality characteristics of SS604, Ti6Al4V, and PMMA materials with fiber laser marking set up. The analysis conducted provides that suitable parametric combination which could be for the generation of complex geometric shapes on those engineering materials as a part of product branding. Therefore, the author believes that the present research work will provide a lot of possibilities to the researcher and scientists who are working in the areas of fiber laser marking and also provides guidance for the generation of any complex geometric shapes for the industries applications.