Influence of Laser Cutting Parameters on the Cutting Quality of Inconel 718

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ABSTRACT- This study focuses on the most important laser cutting factors that influence the cutting surface quality of Inconel 178. The RSM method was used in this experiment to obtain the optimal parameters. The average of surface roughness and hardness tests was determined using a Mitutoyo surface roughness tester and a Microhardness Tester (MHT). Cutting speed, laser power, and focal length had the greatest influence on the cutting area and surface roughness. The cutting area and surface roughness were most affected by cutting speed, laser power, and focal length. The highest power level of 2000 W and the shortest focal length of 0.30 mm had the lowest surface roughness. The striation pattern was improved, and the cutting lines were straightened at cutting speeds of 300 m/min. At a focal length of 0.30 mm, the cutting-edge surface had the least amount of roughness. These findings prove that the cutting speed, laser power and focal length influence the quality of the cutting area of Inconel 178.

1. INTRODUCTION

Inconel is a member of the family of austenitic nickel-chromium-based superalloys. Inconel 718 is one of the austenitic nickel-chromium-based superalloys that is used in the oil and gas sectors. Due to its low heat conductivity, having built-up edges when machined, nickel alloy is a material that is difficult to cut and has poor machinability. Nickel alloy is also a material that has a high affinity. Due to the limited heat conductivity of the Inconel 718 material, the temperature in the cutting zone was drastically reduced during the machining process. As a result, the surface roughness was reduced.

Previous research on the machining of nickel alloy demonstrated that as cutting speed increases, the interface parameter becomes far more significant than as laser power increases. Previous researchers concentrated on the cutting process of high carbon steel. Very few researchers had focus on cutting Inconel 718 using laser cutting. Therefore, it is essential to conduct an analysis of the machinability of this material using the laser cutting process. This study investigates the effect of laser cutting parameters on the cutting quality of Inconel 718.

2. METHODOLOGY

In this work, Inconel 718 is used to investigate the effect of laser cutting parameters. The chemical composition of this materials are C(0.03%), Mn(0.08%), Fe(18.36%), S(0.001%), Si(0.07%), Cu(0.12%), Ni(53.54%), Cr(18.31%), Al(0.57%), Ti(0.88%), Co(0.20%), Mo(2.86%), Ta(0.004%). The Box-Behnken response surface method is used in this study to identify the optimum parameters. A laser cutting machine (HV2-R Series) is used to cut the material. The surface roughness tester is used to determine the quality of the cut. Every single technique of cutting procedure has been measured on each process surface, with each step surface having parameter fixed points. In this investigation, the measurement was made nine times at nine distinct locations with a straight movement of the stylus tip in a parallel manner at varied cutting intervals for all cutting scenarios. The Rockwell Hardness (HRB) test is used to determine the mechanical properties of the cutting edge. The microstructures of the various manufacturing variants were analysed using optical and scanning electron microscopy (SEM). This procedure is carried out to determine how the manufacturing variants affected the final product. The specimens were undergoing grinding and polishing process and then the etching was done in a solution that contained 50 millilitres of nitric acid, 75 millilitres of hydrochloric acid, 35 millilitres of H_20_2 and 90 millilitres of distilled water.

3. RESULT AND DISCUSION

Table 1 shows the laser cutting parameters. Cutting speed, laser power, and focal length each had a significant impact on the quality of the cutting area, while cutting speed had the most significant impact that reflect to the cutting quality.

The influence of the laser and the cutting speed on the cutting surface characteristics of the parts is seen in Figure 1. The striation flow pattern consists of two distinct zones. A smooth-cutting area with finer striations was found from the top of the cut edge to a certain penetration depth. Based on the analysis, it displays the laser-cut sample, which has a pore at the bottom. Pores are uncut regions between layers of construction and bonding defects [1]. These pores are detrimental to the mechanical performance of the material because they act as stress concentrators, creating fatigue and surface discontinuities [2]. Due to the high laser power, laser cutting may cause porosity and lack of fusion. In most cases, controlling laser power, cutting speed, and focal length reduces porosity of the Inconel material [3].

Table 1 Laser cutting parameters

Number of tests	Laser Power (W))	Focal Length (mm)	Cutting Speed (m/min)
1	1750	0.30	300
2	1750	0.60	200
3	1750	0.45	250
4	2000	0.45	200
5	2000	0.45	300
6	1750	0.45	250
7	1500	0.45	200
8	1750	0.45	250
9	1500	0.45	300
10	2000	0.60	250
11	1500	0.30	250
12	1750	0.60	300
13	1750	0.65	250
14	1500	0.30	250
15	1750	0.30	200

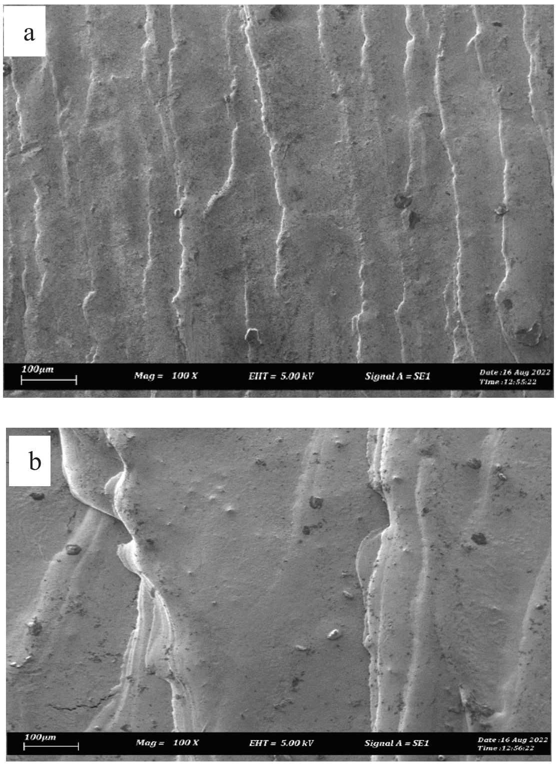

Figure 1 Effect cuttting parameters (a) 200m/min (b) 300m/min

When the cutting speed was increased, the surface roughness was reduced. It was noticeable when the laser power was increased to higher levels. On the other hand, increasing the cutting speed while operating at a low power level caused the surface roughness to increase. This could be attributed to the undercut, incomplete cutting edge that resulted from the beam not penetrating the material fully, not reaching a high enough temperature, and not completely melting the material in the cutting groove [4]. The relationship between cutting speed and focal length revealed that increasing the cutting speed resulted in a decrease in the roughness of the cutting surface when used in conjunction with a focal length of 4 millimetres (cutting edge). On the other hand, the surface roughness was increased when the focal length was 8 mm. As a result, variations in laser parameters are brought on by shifts in cutting speed, which have a direct bearing on variations in the cutting surface roughness.

4. CONCLUSION

The cutting surface roughness demonstrated that at low cutting speeds, an excessive increase in cutting laser power resulted in an increase in cutting-edge roughness. This was due to an increase in the amount of cutting-edge roughness. There were no traces of sticky particles at the bottom of the cutting edge when the cutting rate was increased from fifty to one hundred metres per minute. Furthermore, the pattern of the cutting lines was rather straight, and their thickness was greatly reduced, bringing the cutting circumstances very close to optimal cutting conditions. Changes in the focal length of the laser during the cutting process were found to be less effective than changes in the cutting speed in terms of changing the shape of the striation pattern and the thickness of the cutting lines. When the laser power was increased, the amount of melt volume increased proportionally. As a result, the surface roughness on the lower part of the cutting edge became more uneven.

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