Influence of defocus on diameters of micro holes on super alloy by millisecond pulse laser percussion at high energy

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Abstract

Micro holes with various diameters were formed on GH2132 super alloy using a millisecond pulse Nd:YAG laser with different defocus at a high energy of 100 J. The microstructure of the micro hole was analyzed using optical microscope. The results indicate that with the defocus varying from -3 to +3, the diameter of the holes first decreases and then increases. The diameter obtained with-3 defocus is about 580 μm and the diameter obtained with +3 defocus is 230 μm and the one with -1 defocus is 167 μm which is the smallest one.

Keywords

Laser drilling, micro hole, millisecond pulse laser, percussion, super alloy.

1. Introduction

For recently several decades, laser drilling has been widely studied [1-3]. It is an important approach to drill holes in various kinds of materials especially hard materials and precision materials. It possesses several advantages over conventional techniques including non-contact, low heat input into the material, high accuracy, consistency, being ease to automate and being able to drill very small holes [4-5]. Laser drilling has showed dramatical applications in industries, especially in aerospace fields and precision manufacturing filed.

Laser used in drilling includes short pulse laser and long pulse laser. In both kinds of laser, the drilling process is usually performed with single or multiple percussion pulses, during which, the laser parameters have important influence on the structure of the holes. Many researches in literatures have studied the effects of laser parameters on drilling process and holes characteristic of short pulse laser [6-8]. However, laser drilling using long pulse, especially millisecond pulse laser, whcih shows much more application in industry, was seldom studied.The present paper deal with the characterization of micro holes on super alloy obtained by percussion of millisecond pulse laser. Influence of defocus on the holes characteristics was studied.

2. Experimental details

2.1 Drilling and Characterization of micro holes

The tests was carried out using a pulsed Nd:YAG laser (LASAG FLS 352A, DEMAG, German) which is equipped on a five-axis machine tool (power LT80, DEMAG, German). The output wavelength of laser is 1064 nm; the pulse duration can range from 0.1-3ms; the pulse frequency is 0.1-500Hz; the maximum energy is 50J with the maximum mean power of 170w. The diameter of the nozzle is 6mm and the laser focus is 3mm below.

The drilling test was performed on a pie shaped GH2132 super alloy with the thickness of 0.2mm and the radius of 15 mm, whose chemical copmosition was listed in table 1. During drilling process, the distance between two micro holes was kept 2mm, so that the holes would not affect each other. The primary parameters were adopted, namely 30Hz, 1000us, 4000 beam expanding, 4 bar oxygen as

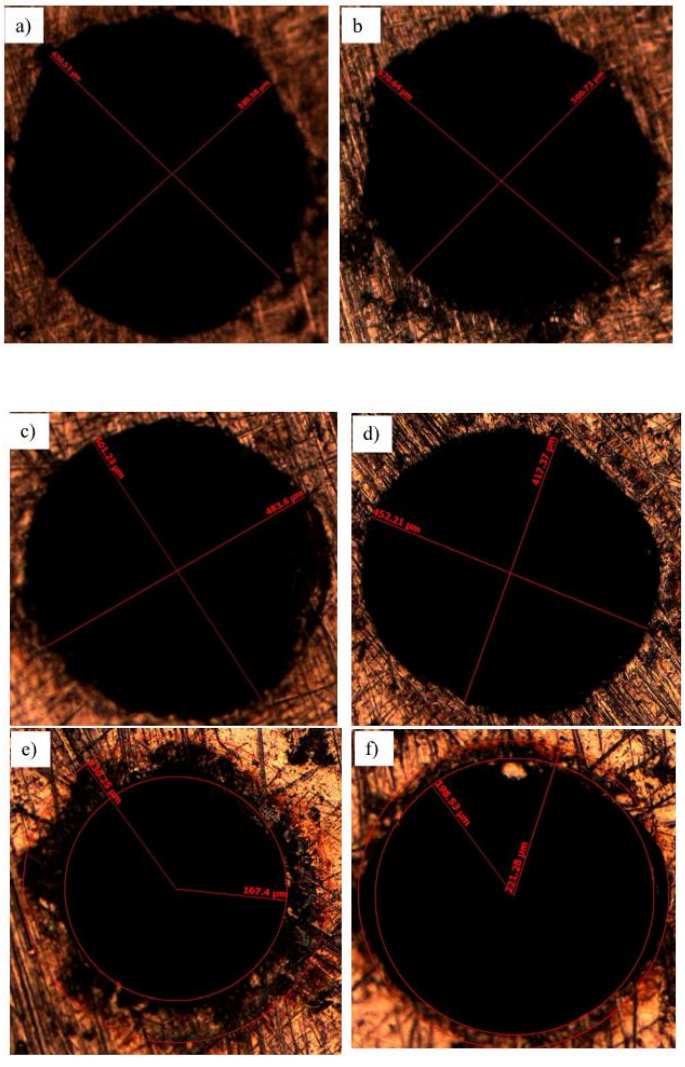
auxiliary gas and the average power was 65w. In order to investigate the influence of defocus on the diameter of the micro holes, different defocus namely from minus -3mm to plus +3mm were used. The surface morphologies of the micro holes obtained with different defocus were observed by optical microscopes.

Table 1. Chemical composition of GH2132 super alloy

Element	C	Cr	Ni	Mo	Ti	V	B	Mn	Al	Si	P	S	Fe
Content	≤0.08	13.5 -16.0	24.0 -27.0	1.00 -1.50	1.75 -2.30	0.10 -0.15	0.001 -0.01	1.0- 2.0	≤0.40	≤1.00	≤0.030	≤0.020	Remains

3. Results and discussion

Figure 2 show the morphologies of the micro holes obtained with different defocus. The corresponding diameters of the holes are listed in Table 2. It can been that with the defocus varying form -3 to +3, the diamater of the doles gradually decreases and then increases. When the defocus is 1mm, the hole is the smallest. The changing of holes diameters is resulted from the diameter of the laser focus which varies according to the defocus. When the defocus varies from -3 to 0, the diameter of the laser focus on the sample surface also varies from big to small. When the defocus varies from 0 to +3, the diameter of the laser on the sample surface varies from small to big. Therefore, the diameter of the holes first decreases and then increases. But the minimun hole is obtained with 1mm defocus, not 0 defocus. The result here shows some difference with that reported in literature[9], it may because that a different and higher energy is used here.



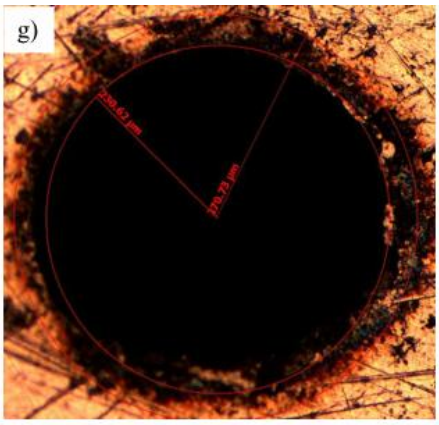


Figure 2 OM image of laser drilled holes with different defocus (a),(b) ,(c) ,(d) ,(e) ,(f) and (g) is for defocus of -3.-2.-1,0,1,2 and 3μm, respectively

Table 2. Diameters of the holes with various defocus(μm)

Defocus	-3	-2	-1	0	1	2	3
Maximum Diameters	630	570	501	452	167	198	230
Minimum Diameters	580	500	483	417			

4. Conclusions

Micro holes with various diameters were formed on GH2132 super alloy using a millisecond pulse Nd:YAG laser with different defocus at a high energy of 100 J. The results indicate that with the defocus varying from -3 to +3, the diameter of the holes first decreases and then increases. The diameter obtained with-3 defocus is 580μm, the diameter obtained with +3 defocus is 230μm and the one with +1 defocus is 167μm, which is the smallest one. The corresponding author is Yunlong Wang, Tel/fax:86-511-88790191, E-mail:wangyunlong@ujs.edu.cn.

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