Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(7):239-245

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Study on the plate surface quality of laser cutting YAG

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ABSTRACT

With different thickness, different grades of stainless steel cutting experiments, the process parameters based on single factor test method the laser power, cutting speed, pulse width, repetition frequency, from coke, auxiliary gas pressure on the influence law of cutting quality. Based on two-factor test method for systematic analysis of the laser power, pulse width and repetition frequency of the incised the influence degree of the average width, show that laser power influence the most significant, pulse width is more significant.

Keywords: Laser cutting; Stainless steel plate; The surface quality

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INTRODUCTION

As an important application of laser, laser processing is an effective means to improve the traditional industry production capacity in industrial pproduction. The most typical is the laser cutting technology, because of its high cutting precision, speed, flexibility, wide application range, low noise advantages, can effectively make up for the defects of traditional method of cutting tool wear the deformation of the workpiece, cutting, types of material consumption, low machining efficiency. Since the apprearance of 1960s,it was quickly applied to industry, agriculture, health and other various fields of soh the continuous development of the laser properties and working principle of the in-depth exploration of analysis and laser equipment update, the application process more controllable, application results continue to improve, to bring huge economic benefits to the society.

Laser processing technology as the important application of laser in industrial production is the effective measure to improve the ability of traditional processing industry production, one of the most typical is the laser cutting technology, the proportion of its application has more than 70% of the laser processing industry, the application of industries including automobile manufacturing, aerospace manufacturing, chemical equipment manufacturing, electrical and electronic products manufacturing, oil and metallurgical equipment manufacturing industry, biological medicine equipment manufacturing, etc.; Cutting objects are mainly slotted sieve tube, CVD diamond film, PCR biochip liquid storage pool, cold rolled steel, precision gears, substrate mica sheet, endovascular stents, LCD glass substrate, etc.; the ability of cutting materials is very extensive, including all kinds of steel, alloy and high hardness, high melting point of non-metallic materials.

Laser cutting is the most mature technology in laser application, with the development of automobile industry, the accurate cutting and favorable welding performance are required increase and need to further improve the cutting quality problems. Laser cutting quality, cutting surface quality indicators include (1) the kerf width and cutting surface roughness; (2) the cutting section of corrugated, tilt angle and the cutting surface roughness; (3) cutting slag thickness surface; (4) the width of the heat affected zone.

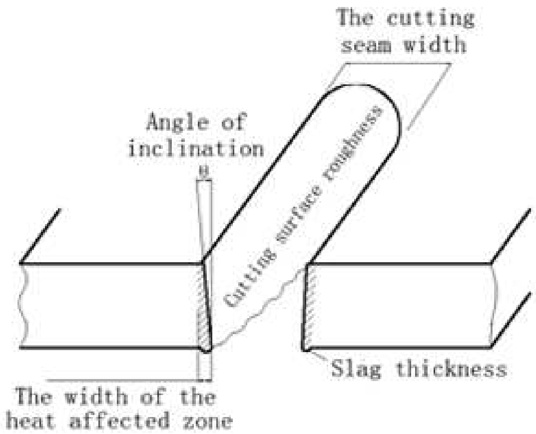


Figure 1 laser cutting quality evaluation index

According to the laser cutting of the domestic and foreign research present situation, research on the cutting thin plate YAG pulse laser is fewer, and the existing research results only based on the single factor test simple, influencing factors are involved is not complete, lack of in-depth analysis of the system, the research contents of this paper are as follows:

(1) the laser power, the single factor test method the cutting speed, the cutting quality of influence width, repetitive frequency, defocus, assistant gas pressure based pulse;(2) the laser power, double factors test method of pulse width, repetitive frequency on the cutting width influence research based on.

EXPERIMENTAL SECTION

Laser cutting processing equipment take JHM-1GXY-500B Wuhan Chutian Laser Group Limited production of YAG multifunctional laser processing machine as shown in Figure 2, the main technical parameters: rated power 500W (above the optical fiber transmission 200W); the maximum output power of 550W; the max single pulse energy of 100J, 0-100J continuously adjustable (optical fiber transmission 25J); pulse frequency 1-500Hz, continuously adjustable (1Hz); pulse width 0.1-20ms, continuously adjustable (step 0.1ms); pulse current is 0-600A; focal spot diameter of 0.3-2mm; the maximum cutting speed 1200mm/mim.

Figure 2 YAG laser processing machine

Measuring equipment used in this study include:
(1) VME400T 3D imaging probe from Zhitai precision instruments Shenyang branch production measure instrument, as shown in figure 3. The main technical parameters are as follows: the measurement of stroke: X axis 400mm, Y axis 300mm, axis Z 200mm; X/Y axis linear precision (3+L/200) um; X/Y/Z three axis optical encoder resolution 1um; repetitive 2um; optical magnification 0.7-4.5X, image magnification 28-180X.

(2) the MM-30C inverted microscope from Shanghai second Schleswig optical instruments Co. Ltd., as shown in figure 4. The main technical parameters are as follows: the optical magnification: 100 * /200 * /400 * /500 * /1000 *; fretting hand wheel lattice coarse micro coaxial focusing mechanism value: 0.002mm; mechanical moving stage size: 242mm x 200mm, mobile range: 30mm * 30MM; round rotatable table size: the largest diameter of phi 130mm, minimum aperture is less than 12mm in diameter.

Figure 3 3D optical imaging probe

Figure 4 inverted microscope

Compound instrument
The material type which were adopted in this experiment:
(1) Cr18Ni9 plate, thickness of 1mm, 0.6 mm;
(2) 1Cr17Mn6Ni5N sheet, thickness are respectively 0.9mm, 1.05mm, 1.25mm, 1.7mm.
Chemical composition sheet is shown in Table 1, table 2

Table 1 Chemical composition of stainless steel Cr18Ni9

C	Si	Mn	Cr	P	S	Ni
0.15	1.00	2.00	17.-19.	0.035	0.030	8.-11.

Table 2 Chemical composition of 1Cr17Mn6Ni5N (%)

Elements	C	Si	Mn	Cr	N	P	S	Ni	半铜	高铜
GB/T20878	≤0.15	≤0.75	5.5～7.5	13.5～15	≤0.25	≤0.06	≤0.03	3.5～5.5	0.8	1.5

RESULTS AND DISCUSSION

Figure 5 shows the power of the laser is the most important parameter of laser cutting quality, the change of the power directly result in the change of input to the material surface power density change, resulting in significant effects on kerf width. Under different laser power and current, laser cutting seam width variation. With the increasing power and current, the cutting seam width increase obviously. Do not use the oversize power and current, The higher laser power, the bigger power density, the greater the molten material, the high pressure steam liquid material was taken away, the more the seam width, surface quality is poor. The smaller the laser power, power density is smaller, which is often do not have enough energy to melt and cut the metal.

Figure 6 shows the cutting speed is an important factor which affecting the laser cutting efficiency and cutting quality, for the existence of optimal cutting speed range of a certain thickness of some material of workpiece, workpiece within the upper and lower the cutting seam width tended to be stable, small range. At this rate, material to the surface of the material to spontaneous combustion; accumulation of excessive heat, heat affected zone becomes larger, the surface quality becomes poor; if over this speed, which will also lead to the exclusion of hot melt material ablation incision surface quality of the rough surface.

Figure 7 shows the width pulse laser is directly related to the effect of time in each cycle of laser in material, at the same time its changes can cause changes in the laser frequency range, so it has a great effect on cutting quality.

Figure 8 shows that for the pulse repetition,frequency laser directly affect the cutting quality and the cutting time. In the middle of a certain frequency range, incision ripple frequency with increase of the laser frequency increases so as to obtain high quality cut low roughness, but lower than the range of materials, due to overheating and over burning, causing the kerf width increases, ripple frequency is low, the incision high roughness, lower quality, higher than the range of frequencies, lead material cutting impermeable and bottom dross phenomenon.

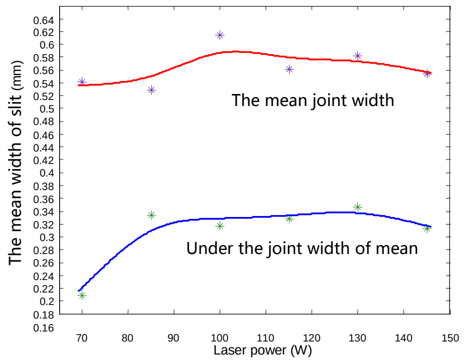


Fig.5

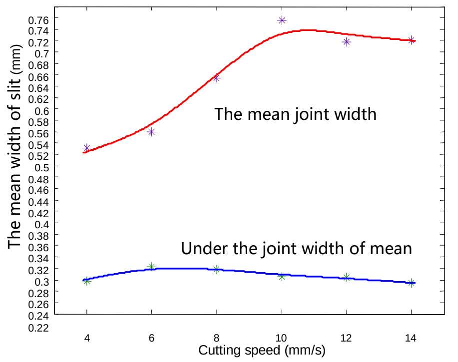


Fig.6

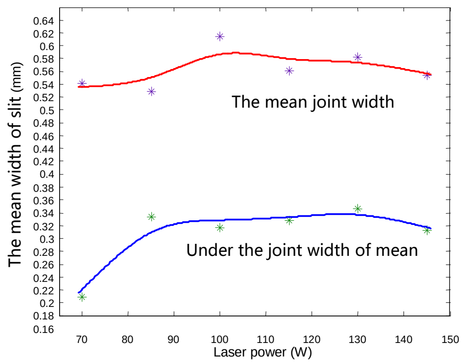


Fig.7

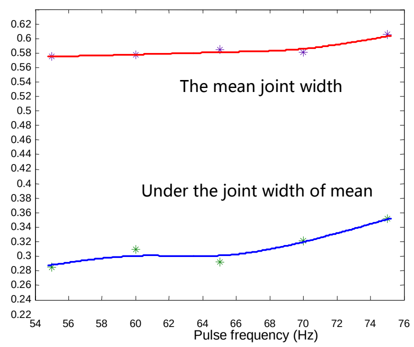


Fig.8

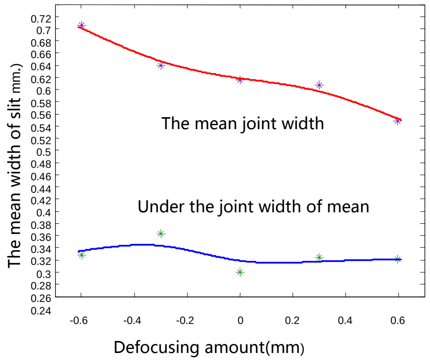


Fig.9

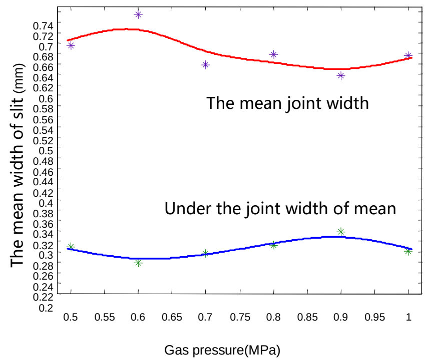
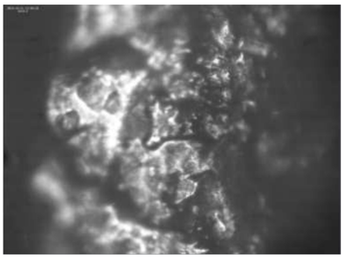


Fig.10

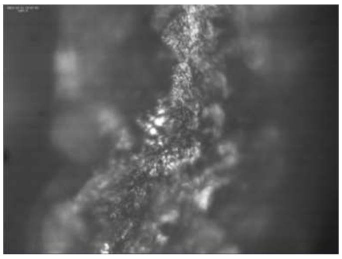
Figure 9 shows using the laser cutting, the selected focal volume will have a great effect on cutting quality. Because the defocus changes can change position on the surface of the material and radiation focus spot radius size, thus affecting the concentration of laser energy, resulting in cutting quality changes.

As the focal point is of the highest power density, in most cases, the focus position just in the surface of the workpiece when cutting, or slightly below the surface, when the focus is in the best position,the cutting gapis minimum and the efficiency is highest.

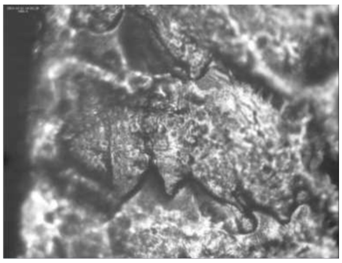
Figure 10 shows during the laser cutting process, auxiliary gas acts to cool the cutting area, blowing slag, heat effect, so the reasonable selection of species and pressure assisted gas can effectively improve the cutting quality. Due to oxygen and material reaction can be cut with a lot of reaction heat for the laser, can improve the cutting speed. But for the stainless steel sheet metal inert gas can be obtained without oxidation trimming, directly used in welding, strict control of laser heat input measures, good corrosion resistance effectively maintain the stainless steel, this paper tests using nitrogen gas as auxiliary. After the determination of the auxiliary gas, gas pressure is also an important factor, when the gas pressure is high speed cutting thin plate when higher need, in order to prevent the incision on the back of slag, hot slag hanging onto the workpiece will damage the cutting edge; when the thickness of the material increase or cut slower when the gas pressure should be reduced.



(a) 85W，Ra=6.180μm

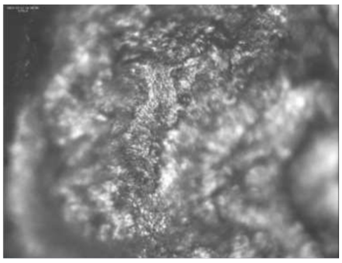


b）115W，Ra=6.35μm

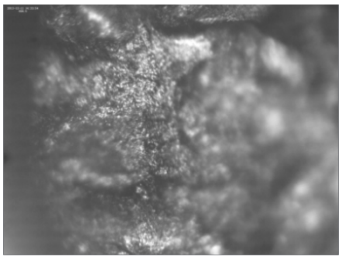


（c）145W，Ra=7.188μm

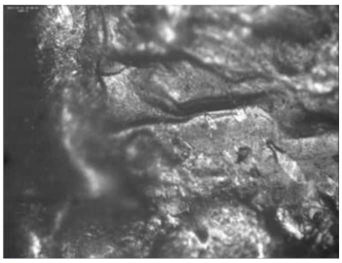
Figure 11 1Cr17Mn6Ni5N cutting surface morphology（Thickness: 0.9mm cutting speed: 6mm/s pulse width: 0.7ms frequency: 50Hz defocusing amount: 0mm: N2: 0.8MPa gas pressure）



（a）0.6MPa，Ra=7.523μm



（b）0.8MPa，Ra=6.091μm



（c）1.0MPa，Ra=8.345μm

Figure 12 1Cr17Mn6Ni5N cutting surface morphology (Thickness: 1.7mm laser power: 140W cutting speed: 6mm/s pulse width: 0.7ms frequency: 50Hz defocusing amount: 0mm assisted gas: N2）

Figure 11 shows when use the inverted microscope magnified 200 times, observed under different power 1Cr17Mn6Ni5N cutting seam surface morphology and the surface roughness value of the corresponding. Along with the power of 85 w to 145 w, 1Cr17Mn6Ni5N slitting surface roughness value showed a trend of increase, when the power is 85 w slitting surface quality is best.

Figure 12 shows 1Cr17Mn6Ni5N cutting seam surface morphology under different air pressure and the corresponding surface roughness value, when the pressure increased from 0.6 MPa to 0.6 MPa, 1Cr17Mn6Ni5N slitting surface roughness values increase with the decrease of the first, and the pressure of 0.8 MPa slitting surface quality is the best.

Acknowledgements

Supported by The scientific research project of Education Department of Jilin province(（NO.2O11219）.Thank professor zhan-guo li changchun university, Dr Shi Yaochen and Jacques: master's gracious assistance.

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