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CIRCULARITY VS TAPER IN MICRO-DRILLING WITH PULSED ND:YAG

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Abstract: *The evolution of the drilling has brought us the micro-drilling by pulsed laser, but this in comparison with the conventional one presents problems with the circularity and the taper. The present study observed how the increase in peak power affects the circularity and taper of micro holes. Combinations of the parameters used to obtain holes in 1 mm thick AISI 316L steel plates were made using a pulsed Nd:YAG laser comparing these parameters in each combination. The increase of the peak power reduces the taper of the micro-holes, but this caused a loss of circularity at the exit of the holes some arriving at forms near squares.*

Keywords: *Nd:YAG, Circularity, Taper, AISI 316L, Micro-drilling.*

1. INTRODUCTION

The drilling process is one of the earliest recorded machining operations, although such a process has evolved greatly over the millennia, it fails to overcome inherent physical barriers of the conventional process, such as the very high rotations required to achieve micro hard cutting speeds, difficult drilling of hardened alloys and super alloys, drilling on non-planar surfaces or out of the normal direction.

According to Arrizubieta cited by Salgado Junior, 2016, laser drilling does not see such barriers for drilling holes with diameters ranging from 5 μm to 1 mm with aspect ratios of 1:200. Usually the operation is performed with a single pulse or a short pulse sequence, with a time band of 0.01 ms to 100 ms, and peak powers that reach 50 kW.

Pulsed laser drilling has progressed remarkably over the years to become an essential tool for the generation of micro-holes in many components used in industry (Thawari, Sarin Sundar, Sundararajan, Joshi, 2005). Nd:YAG (neodymium doped aluminium yttrium and Nd:Y3Al5O12) is a crystal that is used as a solid state lasers. The triple-ionized neodymium dopant, Nd (III), typically replaces a small fraction (1%) of yttrium ions in the host crystalline structure of yttrium-aluminium garnet (YAG), since the two ions are of similar size. It is the neodymium ion, which provides the property of laser emission in the crystal, in the same way as the red chromium ion in ruby lasers (Koechner, 1988).

2. EXPERIMENTAL PROCEDURE

A pulsed Nd:YAG laser with a maximum power of 7 kW guided by optical fiber was used, with a camera installed near the head for proper positioning of the laser and a gas nozzle for the expulsion of the material. The head has vertical displacement and manual angulation adjustments.

A stereoscope with integrated image capture system and acquisition of dimensions to obtain the input and output diameters, and area of the holes. The specimens were supported on a table that has a spindle for horizontal displacement of the same. The metal used in the study was stainless steel AISI 316L in the form of 1mm thick plates. Test specimens were made in dimension 22 mm per 100 mm. In the specimens we draw auxiliary lines for positioning of the laser because it did not have control of displacement by numerical control. The auxiliary lines were spaced 2 mm in the rolling direction and 5 mm in the transverse direction of the lamination.

For each combination 10 shots were fired, these specimens were taken to the stereoscope where they had their outputs photographed, then they were cut by electro erosion for observation and measurement of the taper.

The taper was calculated from the angle formed between the entrance diametrical line and the profile of the hole, taking as a hole of low taper the one with angle closer to 90 degrees.

3. RESULTS AND DISCUSSION

The angle α was obtained through the input and output diameters giving an approximation as seen in Figure 1.

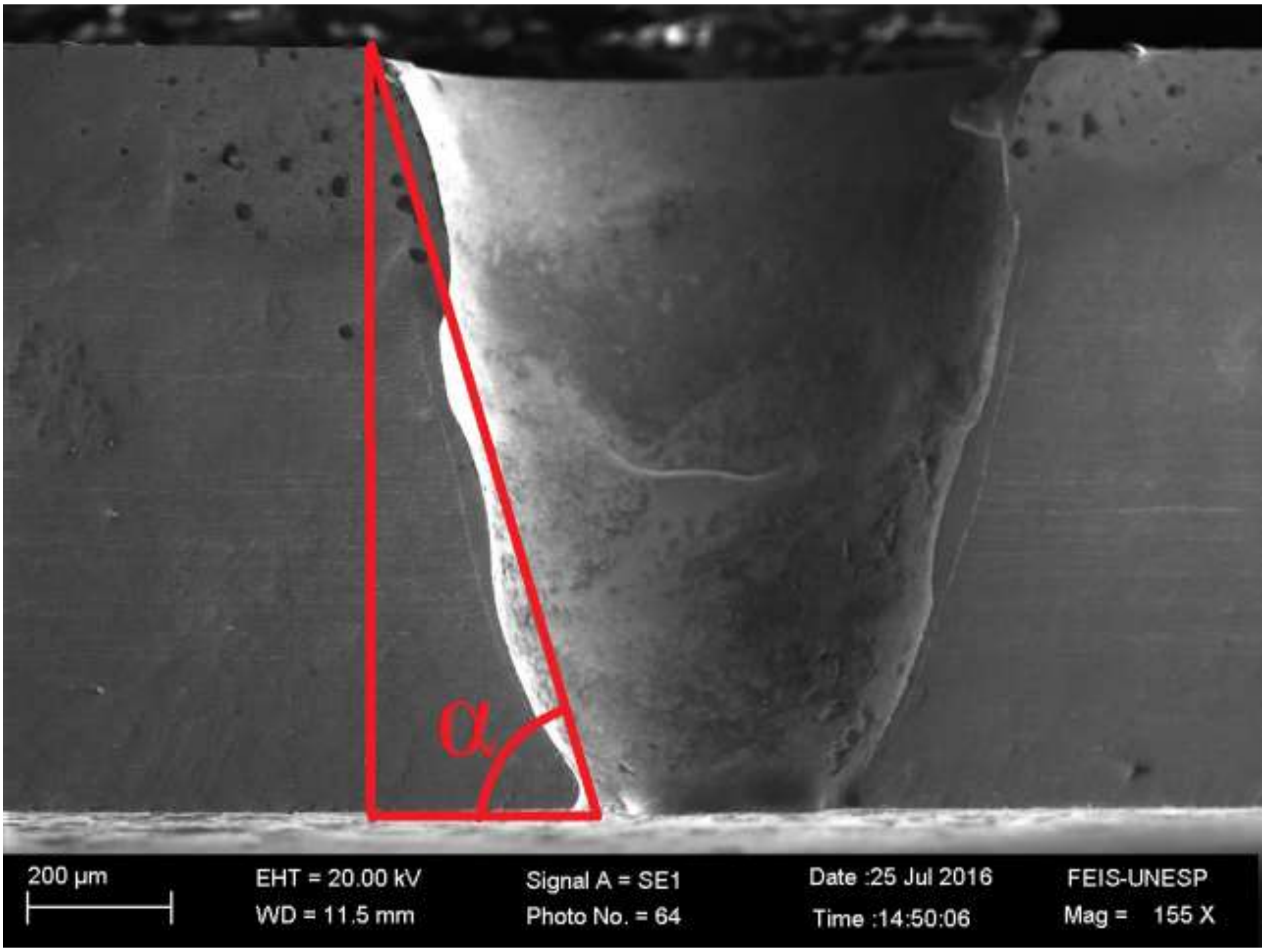

Figure 1: Schematic representation of obtained angle

We can see in Figure 2 that the increase in peak power reduces taper because there is an increase in the outlet diameter, the abbreviations ug and wg respectively indicate the use of shielding gas and without the use of shielding gas.

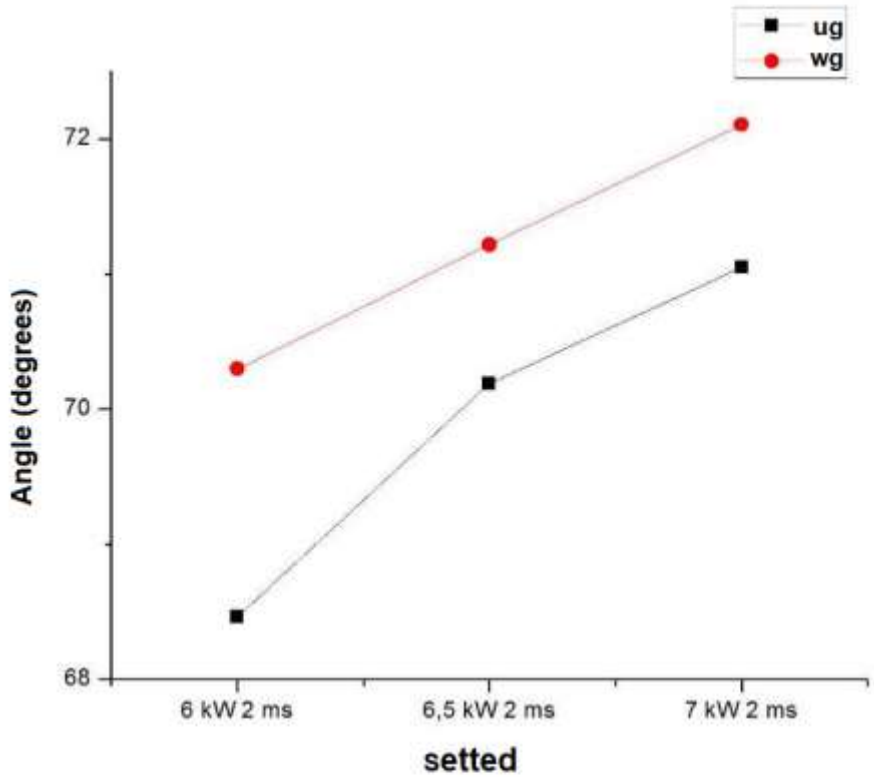

Figure 2: Taper vs peak power (the author himself)

In Figure 3 we see that the increase in power causes the loss of circularity, even approaching square shapes.

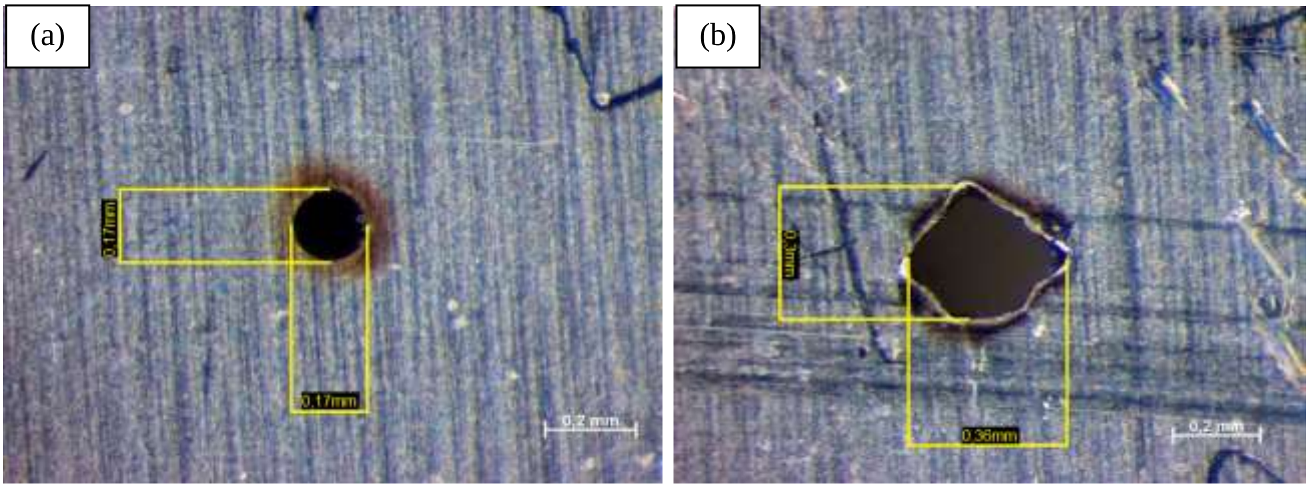

Figure 3: Loss of circularity. (a) 6kW 2ms; (b) 7kW 2ms. (the author himself)

4. CONCLUSIONS

Research has shown that we can not reconcile low taper with good roundness, peak powers beyond that necessary for total plate drilling cause the output of the hole is no longer circular, but leaves us with low values in the angle between the diametrical line entry and drilling of the hole, ie greater taper. However this increase causes the angle to increase leaving the taper becoming smaller, this choice must be made according to the needs of use.

What is clear and that with the equipment and material used in the process and the current knowledge we can not obtain microconfigurations with little conical circular exits, thus needing larger studies in the area.

5. REFERENCES

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