Some Technical Methods to Study the Roughness of some Surfaces, Generated into Metallic Targets by Laser Micro Piercing in Determined Conditions

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ABSTRACT

Dimensional machining realized by laser beam and/or another concentrated energy sources in metallic targets, is based on melting, vaporisation and expulsion of some quantities of metal as a function of radiation parameters and material nature.

In some cases as: drawing plates used for the synthetic wires, fine fuel filters or fuel injectors, for the internal surface of the hole, is prefered more roughness in comparison of the holes, realized by classic piercing.

For instance, to realize some textures of simple synthetic fibres or in combination with natural fibres we want to have not a smooth surface, but a rough one because in this way, the texture will be more resistant in the places exposed at different efforts.

Concerning the fuel injectors we prefer the same: a rough surface, in order to ensure a better pulverized jet of the fuel. In the same time, when the hole is machined with a concentrated energy: L.B.M, E.B.M. a.s.o. the injector has a longer life.

It is not very easy to study the roughness resulted by L.B.M. in a less than 0.2 mm diameter hole.

To avoid errors of investigation, authors have experienced on pieces of carbide and alloyed steel which were bored on separate adjacent plans, and in this way, the bored surfaces were not affected by a cutting operation after boring, for such small diameters.

1. INTRODUCTION

Advances in the fields of communications, medical devices, optics, electron-optics, computers and others have created a need for holes that are straighter, more accurate, better defined, and in many cases, much smaller in diameter than a human hair (=25.4 $\mu$m).
To do such operation is today possible by using non-traditional machining process like: LBM – Laser Beam Machining, IBM – Ion Beam Machining, EBM – Electron Beam Machining and EDM - Electrical Discharge Machining, to mention the more used techniques for the present.

The improvements in ultraviolet light lasers have made them a very competitive tool for micro-drilling and other micro-machining applications. New equipment offers a combination of high peak power, high repetition rates and beam quality that make it suitable for drilling holes as small as ten micrometers diameter in stainless steel, in carbon steels, as well in titanium, ceramics, silicon and many other hard materials, up to about 1 mm thick.

2. ABOUT MICRO-DRILLING DEVELOPMENT

For all operation of micro-drilling, is very important to obtain the best quality of drilled holes.

The diode laser produces a pulse that is much shorter, 15 ns, compared to milliseconds, for the older style lasers.

Using such systems, we generate less heat in the drill part. Because of the high power intensity created by the short pulse, much of the material is removed in a photo-ablative state, rather than a thermal melting state. So, the recast layer is much smaller and the holes surface has a better quality.

Some automotive companies and their suppliers are more and more interested in the use of laser drilling for fuel injection components. The same interest is represented by the holes, machined in the nozzles, used in the manufacture of fibers.

With CO₂ laser cutting or wire-electrical discharge machining, we could create holes of any desired shape or size.

We note that by EDM we could operate only conductive materials, laser drill can be used to drill materials ranged from soft plastics to sintered carbide, even diamonds.

For all mentioned utilizations, authors were interested in the quality of drilling.

3. EXPERIMENTAL WORK

For very thin holes, even if the material thickness is reduced, it is very hard to examine the roughness of the drilled surface. To have a “better view” for the machined surfaces, authors proposed pieces of two or more parts which were pressed together and then machined-pierced on the adjacent zone as seen in figure 1.

In this way was possible to observe - with the optical microscope – the resulted surface after machining and also to measure the roughness.
Of course, there could be “a lot” of systems, to ensure the necessary pressure of the pieces during machining. Other solutions are presented in the figure 2 and figure 3.

Because the machining by Laser-Beam, Electron-Beam or Ion-Beam is based on melting and vaporization of the material we meet situations in which not all materials was evacuated from the machined hole and that could be very dangerous, by creating obstructions, or other damages.

It is very important to have a correct image of what happened during machining and also to have the possibility of comparing the influence of parameters of machining to arrive at the best quality.

In the same time we could better establish the best type of the used energy i.e. Laser Beam, Ion Beam, Electron Beam, Electrical Discharge, Ultrasounds, a.s.o.
Drilled surface roughness parameters were investigated using a Surtronic 3+ unit manufactured by Rank Taylor Hobson (figure 4).

Data obtained from roughness measurement unit were analyzed using Talyprof software (figure 5). As parameter for characterizing roughness it was chosen the arithmetic mean deviation of profile (Ra) which represents the arithmetic mean of the absolute values of the profile deviations from the mean line within the limits of the base profile. The results were collected on sheets of results (table 1) and the variance of Ra parameters versus beam parameters was plotted (figure 6).
<table>
<thead>
<tr>
<th>Results sheet</th>
<th>Pulse Power (1÷60) [W]</th>
<th>Pulse duration (1÷110) [µs]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 30 40 50 60</td>
<td>10 30 50 80 110</td>
</tr>
<tr>
<td>Diameter [µm]</td>
<td>D1= 20</td>
<td>1.692 1.815 1.876 1.915 3.212</td>
</tr>
<tr>
<td></td>
<td>D2=25</td>
<td>1.675 2.047 3.072 3.944 4.027</td>
</tr>
<tr>
<td></td>
<td>D3=30</td>
<td>2.763 3.055 3.746 5.148 6.787</td>
</tr>
</tbody>
</table>

Table 1. Ra values for different process parameters

![Figure 6. Variance of surface roughness parameter Ra versus Pulse Power [W] and pulse duration [µs].](image)

4. CONCLUSIONS

By comparing samples obtained by laser drilling for different materials it was observed that there are not major differences if the hole is circular or it has other profiles (figure 7).

![Figure 7. Laser cutting of random shape profiles](image)
The investigation method with two or more parts proposed in this paper is suitable for different materials processed by laser as ceramics steel or composites.

If necessary for some defined cases the method could be applied also with transversal sectioned parts.

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REFERENCES