Experimental Investigation And OP Timization of Femto Second Laser Micro Machining of Aluminium Co Mposite

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Abstract

Micromachining is a main concept in aeronautical engineering. The goal of the work is to find the optimized control of the femto second laser micro machining machine which we have used in this work. Aluminium composite, which is the lightest metal is used as the specimen. Concentric pattern holes are made in the specimen. The changeable parameters for experiment are Scanning speed, Repetition rate and Laser power. 0.008mm dia holes are made. The optimized method is concentrated in the greater depth achieved and surface roughness achieved so to find it we have used Universal tribometer to take the picture and analyze it using the software Gwyddion.

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1. INTRODUCTION

Femtosecond laser micromachining is a cutting -edge technology that uses ultrafast femtosec ond 10^{-15} lasers to create high-precision featu res in materials at a microscopic scale. This tec hnology has gained widespread interest and u se in many industries, including microelectroni cs, medical devices, photonics, and microfluidic s.

The term "femtosecond" refers to the duration of the laser pulse, which is typically around 10^{-15} seconds. This ultrafast pulse allows for precis e material removal with minimal heat affected zones and minimal collateral damage to the su rrounding area. This is because the high-intens ity laser energy is absorbed by the material in a very short amount of time, which causes it to vaporize and create a small crater or hole.

Femtosecond laser micromachining has severa l advantages over traditional micromachining t echniques such as mechanical drilling, milling, or chemical etching. For example, the laser's hi gh precision allows for the creation of complex 3D structures with sub-micron resolution, whic h is not possible with traditional techniques. A dditionally, femtosecond laser micromachining can be used to machine transparent materials such as glass or polymers, which are difficult to process with traditional methods.

The process of femtosecond laser micromachi ning involves several steps. First, the laser bea m is focused onto the material surface using a lens system. The laser beam typically has a wav elength in the Near-Infrared (NIR) or visible ra nge, which allows it to be focused to a spot siz e of a few microns in diameter. The laser energ y is then absorbed by the material, which caus es it to vaporize and create a small crater or ho le.

The parameters of the laser beam, such as its energy, pulse duration, and repetition rate, are carefully controlled to achieve the desired mat erial removal rate and precision. For example, i ncreasing the laser energy or decreasing the p ulse can increase the material removal rate, bu t may also increase the heat affected zone and collateral damage. Conversely, decreasing the l aser energy or increasing the pulse duration ca n decrease the material removal rate,

but may also decrease the heat affected zone and collateral damage.

Femtosecond laser micromachining is its ability to create high-precision features with sub-micron resolution. This precision is due to the laser's ultrafast pulse duration, which allows for precise material removal without damaging the surrounding area. Femtosecond laser micromachining is its ability to machine transparent materials. This is because the laser's ultrafast pulse duration allows it to create micro channels or holes in the material without damaging the surrounding area. This is particularly useful in applications such as microfluidics, where transparent materials such as glass or polymers are often used.

2. MATERIAL

Aluminium composite 6061 is precipitation-hardened aluminium alloy that contains magnesium and silicon as its major alloying elements. It is a heat-treatable alloy that can be strengthened by aging after solution heat treatment. The alloy has a nominal composition of 97.9% aluminum, 0.6% silicon, 1.0% magnesium, 0.28% iron, 0.2% copper, 0.25% chromium, and 0.15% zinc. It is widely used material in various industries due to its excellent properties such as high strength, good corrosion resistance, and excellent machinability The alloy is available in various forms such as plates, sheets, bars, and extrusions.

3. METHODOLOGY

Taguchi L9 array is used for conducting experiments in Femtosecond laser micromachining. The L9 design is often used in quality engineering and product design to study the effect of multiple factors on a response variable. The design consists of nine experimental runs, with each run testing a different combination of levels of the four factors being studied. The levels are typically chosen to represent high and low values for each factor.

4. EXPERIMENTAL WORK

To optimize the femto second laser micro machining we use the aluminium composite as the sample and we used some changeable parameters. They are Scanning speed (mm/s) (250 - 750), Repetition rate (KHz) (1 - 50) and Laser power (%) (80 - 90). We have used concentric hole pattern to drill holes in the sample in the diameter of (0.008) mm. We drilled 3 holes per sample with different parameters. Figure 1 represe nts the femto second laser micro machining center. FIG 1 shows the femto second laser micro machining in NIT.

FIGURE 1

5. RESULT

We have made a L_9 series of the parameter as the input values to the machine. To study about the drilled holes, we use WHITE LIGHT INTERFEROMETER to capture the picture and analyze it using GYWDDION software. So, we found the depth and surface roughness at the holes. So, at lower scanning speed we could achieve more material removal, but the surface roughness is not good in that parameter it is good in high scanning speed, high repetition rate and at high power.

6. CONCLUSION

At lower scanning speed we can achieve more material removal, but the roughness will not be good and multiple passes can increase the depth of material removal, but they may also lead to increased heat-affected zones and decreased machining resolution. So, the optimized parameter is high scanning speed high repetition rate and more laser power. The time taken for machining is also less compared to other and minimum recast layer formation, so the peak and valley depth values are low.

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