Experimental Research on the Technical Parameters of Laser Engraving

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Abstract. The process route for obtaining the processing parameter data through the engraving test first and then using these data for laser engraving was formulated. Through laser engraving experiments on a variety of materials such as wood, bamboo, paper, plastic, leather goods, PCB, acrylic, glass, paint layer, etc., we studied the changes of laser engraving with laser intensity, engraving speed, and black and white contrast. The physical process of laser engraving is analyzed, and the laser engraving of different materials is successfully carried out using the optimized parameters obtained by the experiment. And through the experiment to obtain the appropriate engraving technical parameters, technical parameters include laser intensity, engraving speed, black and white contrast, etc. The experimental results show that different engraving materials have basically different laser intensity, engraving speed, and black and white contrast. The combination of low intensity and slow speed engraving can delay the laser loss. The slower the speed of most materials, the better the effect. Carrying out laser engraving on materials with high ignition points, the effect of low-speed engraving is better. Laser 3D engraving technology is an emerging and promising laser processing technology. This article has reference value for further research on laser 3D engraving.

1. Introduction
As a representative laser application technology and a new important field of material processing, laser engraving has been widely used [1-2]. Laser processing technology has become one of the key technologies in developing emerging industries and transforming traditional manufacturing industries [3-5]. As a new manufacturing technology, laser processing plays an important role in many aspects [6-7]. Laser engraving is one of the most important application fields in laser processing technology.

In recent years, with the cross-fusion of information technology, computer technology and automation technology in the field of laser engraving, the application of laser engraving has been greatly expanded. Literature [8-10] carried out corresponding research on laser engraving machine, and achieved some results. Due to the unique advantages of the laser, the relative movement between the laser beam and the workpiece during laser engraving can form uneven shapes on the workpiece. At present, laser engraving machines are mainly used for engraving, cutting lines, trademarks, and seals of industrial products, including the engraving of binary images. Laser engraving is an advanced technology that can complete fine markings on objects, and can engrave very exquisite, non-wearable characters, symbols and patterns.

Since laser engraving is a non-contact forming process, it is impossible to guarantee machining allowance through mechanical feed like traditional machine tools. On the contrary, it can only be achieved by adjusting the technical parameters of the system. Therefore, before laser 3D engraving, an
engraving test should be performed on the engraving material to obtain the data of engraving technical parameters [11-13]. Through engraving experiments and studying the laser engraving mechanism of the engraved material, we can understand and master the behavioral characteristics of the laser processing process, which is conducive to obtaining accurate engraving speed and engraving depth, and ensuring high engraving quality [14]. It can also provide parameter data for actual carving and establish a process database.

This paper conducts laser engraving experiments on a variety of materials, and obtains the most suitable engraving technical parameters through experiments. The technical parameters of engraving include laser intensity, engraving speed, black and white contrast, etc.

2. Laser Engraving Hardware Description
Laser engraving machine is an integrated system integrating laser technology, numerical control technology and computer technology. This article uses a lighter Naliya brand small laser engraving machine to carry out the experimental test tasks; the laser engraving machine has a power of 8000mw and a gross weight of about 1Kg. The scope of application is wide, and the engraving materials include plastic, paper, wood, leather, paint, glass, etc. The engraving area is larger, the speed is faster, and the accuracy is higher. The working engraving accuracy can reach 0.075mm, and the smallest engraving font is 0.8mm. It adopts imported laser head, supports continuous software adjustment, and controls the size of laser intensity to achieve multiple uses.

The triangular pulley system is adopted, the pulley and the track are 90 degrees without gap, and the triangular pulley layout is used to make the machine run smoothly without jitter and improve stability. Using double stepping motors, the motor can withstand temperature up to 80 degrees, withstand voltage of 500V AC 1 minute, support long-term operation with low noise, and accurate step distance. Using high-precision, high stability, high-precision temperature compensation chip.

3. Carving Experiment and Result Analysis
This article carried out laser engraving experiments on a variety of materials. The materials for laser engraving experiments include: wood, bamboo, paper, plastic, leather, PCB, acrylic, glass and paint layer. Through laser engraving experiments on these materials, find out the most suitable laser engraving technical parameters corresponding to these materials.

3.1. Results of Carving Experiment

3.1.1. Wood

![Figure 1. Picture carved on wood.](image)
3.1.2. Bamboo

![Bamboo Text](image1)

**Figure 2.** Text carved on bamboo

![Bamboo Cartoon](image2)

**Figure 3.** Cartoon picture carved on bamboo

3.1.3. Paper

![Paper Text](image3)

**Figure 4.** Text carved on paper shell

![Paper Picture](image4)

**Figure 5.** Picture carved on paper shell

3.1.4. Plastic

![Plastic Picture](image5)

(a) and (b)

**Figure 6.** Picture carved on plastic.

3.1.5. Leather

![Leather Text](image6)

**Figure 7.** Text carved on leather.
3.1.6. PCB

Figure 8. Text carved on PCB.

3.1.7. Acrylic

Figure 9. Text carved on acrylic.

3.1.8. Metal plating

Figure 10. Text of different parameters engraving on metal plating.

3.1.9. Glass

Figure 11. Text carved on glass.
3.2. Analysis of Experimental Results

The above experimental results show that different engraving materials have basically different laser intensity, engraving speed, and black and white contrast. Engraving with low intensity and slow speed can delay laser loss. The slower the speed of most materials, the better the effect. For engraving materials with high ignition point, lower the speed for engraving first, and then increase the intensity if not ideal.

Glass, white plastic, and transparent plastic need to be painted with a whiteboard marker or other easy-to-erasable colored pens before carving.

According to the above experimental results, the best parameter table of the engraving material is summarized as shown in Table 1.

Table 1. Engraving material parameter table

| Carving material | Laser intensity | Engraving speed | Black and white contrast |
|------------------|-----------------|-----------------|-------------------------|
| Wood             | 4               | 8               | 200                     |
| Bamboo           | 5               | 8               | 200                     |
| Paper            | 3               | 6               | 200                     |
| Plastic          | 3               | 6               | 220                     |
| Leather          | 4               | 8               | 200                     |
| PCB              | 4               | 8               | 200                     |
| Acrylic          | 4               | 8               | 200                     |
| Metal plating    | 35              | 35              | 140                     |
| Glass            | 15              | 20              | 200                     |

In the table, the laser intensity range is 0~36, 0 means the weakest, 36 means the strongest; the engraving speed range is 0~60, 0 means the fastest, 60 means the slowest; the black and white contrast range is 0~255, 0 means the most White, 255 means the darkest.

4. Conclusion

This paper systematically studies the laser three-dimensional engraving process, and formulates a process route that first obtains processing parameter data through engraving experiments, and then uses these data for laser engraving. Through laser engraving experiments on wood, bamboo, paper, plastic, leather goods, PCB, acrylic, glass, paint layer and other materials, the law of laser engraving changes with laser intensity, engraving speed, black and white contrast is studied. The physical process of laser engraving was analyzed, and the optimized parameters obtained from the experiment were used to successfully carry out laser engraving of different materials. Appropriate technical parameters of engraving are obtained through experiments. The technical parameters include laser intensity, engraving speed, black and white contrast, etc. Experimental results show that different engraving materials have basically different laser intensity, engraving speed, and black and white contrast. Engraving with low intensity and slow speed can delay laser loss. The slower the speed of most materials, the better the effect. For engraving materials with high ignition point, you can first reduce the speed of engraving, if not ideal, then increase the intensity.

In this paper, through experimental research and exploration of laser engraving technology, the most suitable engraving technical parameters for various materials are obtained, and certain practical experience and theoretical results have been obtained. Through the engraving experiment, not only can we grasp the influence law of each process parameter on the engraving depth and engraving quality, but also provide parameter data for actual engraving and establish a process database based on this. By adjusting the process parameters of the system, studying the laser engraving mechanism of materials,
and correctly grasping the behavioral characteristics of the laser processing process, it is helpful to obtain precise engraving depth while ensuring high engraving quality.

Laser 3D engraving technology is a new and promising laser processing technology. The research of laser 3D engraving is still in its infancy. Due to the limitations of equipment, funds, personnel and time, the depth of some work is far from enough. The 21st century is the age of optoelectronics. As a new laser processing technology, it has broad application prospects. This article has important significance and reference value for further research on laser 3D engraving.

5. Acknowledgments
This work is supported by the Open Project Program of Laser Precision Machining Engineering Technology Research Center of Fujian Province (Grant No. 2018JKA003) and the School-level Incubation Project of Xiamen University Tan Kah Kee College (Grant No. 2017L02).

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