Laser perforator

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ABSTRACT

Laser equipment for the perforation of documents and securities is presented. This laser perforator (LP) differs by extendend precision of perforation, high processing velocity, perfected automatic control. LP's operation is based on the preliminary theoretical and experimental research of laser irradiation and paper or/and organic tissue interaction. The results of CO_2-laser irradiation action upon different materials and samples of documents allowed to determine system requirements to LP.

Developed LP is destined for perforation of paper documents with jackets with total thickness from 0,5 to 4 mm. Processing document, LP makes more than 100 conical perforation holes that improve protection rate of document. LP guarantees perforation time less than 3 sec, document's blank positioning precision ±0,2 mm, laser beam positioning precision ±0,01 mm. Due to the system parameters optimization it became possible to eliminate a singeing of hole edge, that improved perforation quality.

Developed LP consists of laser-module, technological module, laser cooling module and automatic control system. Laser module includes continuous Q-switched CO_2-laser, scanner, power supply, controller, chopper. Technological module has X-Y-table, conveyer for blanks of documents, pneumatic block. Automatic control system, which includes two videocameras, illuminators, controller, PC, gives a possibility to control holes disposition in a matrix and to identify perforated number.

Key words: $C0_2$-laser, laser perforation, controller, paper processing, securities protection rate.

1. INTRODUCTION

Recently the creation of equipment for perforation of documents and securities being rather complete problem is developed by two ways: as mechanical perforator and laser perforator. Method of mechanical perforation of thick blank packages has several disadvantages: e. g. die-cutting causes expansion of the holes edges.

Consequently the alternative method of laser perforation was developed. Circumventing some problems it has several advantages: (1) the possibility of perforation of a wide range of documents produced from different materials; (2) absence of mechanical contact between tool and document; (3) high perforation precision; (4) high productivity; (5) automatic control possibility.

However, the development of document's processing laser equipment clashes with some problems, particularly the problem of perforating hole edge singeing.

Therefore, the development of laser perforator for documents and securities high quality processing is very actual task.

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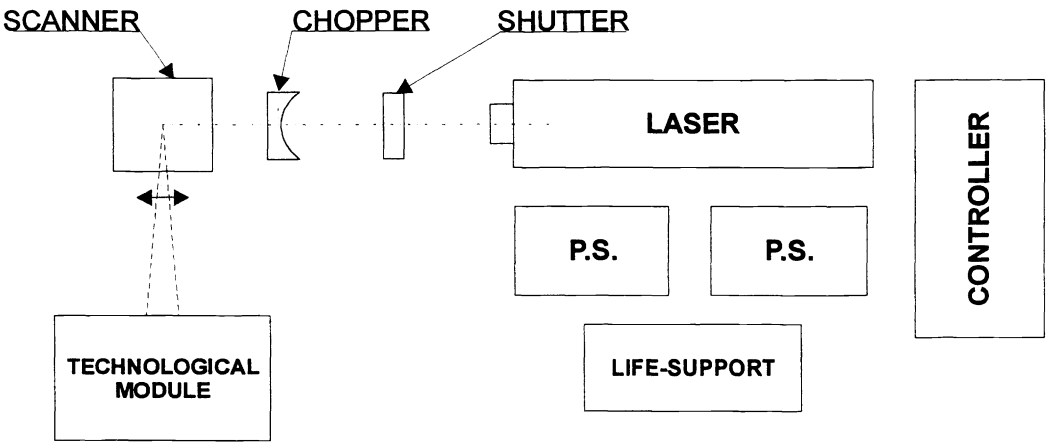

Fig. 2. Block-scheme of laser perforator LP.

Laser module includes continuous Q-switched CO_2-laser, scanner HPM10G3 for laser beam deflection, power supply, controller, chopper for radiation beam modulation and shutter for radiation chopping. The chopper with pneumatic actuator is destined to reduce the time duration for single hole processing to 5ms-6ms. Synchronism of the chopper and deflection mirrors of the scanner operating is provided with the feedback inductive detector.

Technological module has X-Y-table, conveyer for blanks of documents, pneumatic block.

Automatic control system, which includes two videocameras, illuminators, controller, PC, gives a possibility to control holes disposition in a matrix and to identify perforated number.

Life-support system includes laser cooling system.

Perforating number consists of 8 symbols, one symbol is performed in a matrix of 4x6 or 5x6 points (Fig.3).

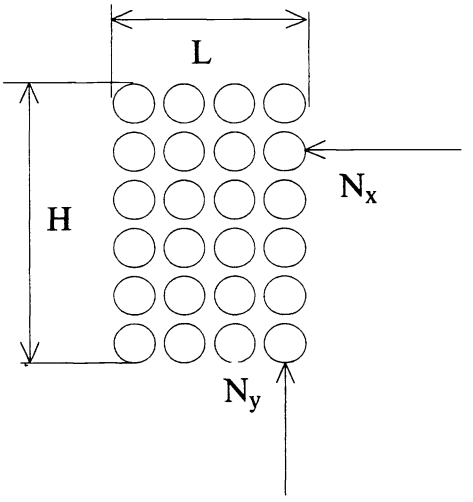

Fig. 3. Perforation matrix HxL.

Input hole diameter attains 0,7mm-0,9mm. Conicity of the holes in perforating document lies in a range of 0,5-0,8 and may be varied. Fig.4 shows the fragment of the sample of perforated document by mechanical perforator (Fig.4a) and the samples of the laser perforated by LP paper and document (Fig.4b,c). It is evident that laser perforation is preferable due to the higher quality concerning a uniformity of holes and a form of edges. This fact confirmed a higher securities protection rate, provided by LP laser perforation.

2. PRELIMINARY EXPERIMENTS

Our previous research efforts were focused on studying the dependence of perforated holes quality on the laser setup and operation parameters. The experiments on CO_2-laser irradiation action upon paper packages and organic material jackets gave the following results.

In the experiments with continuous CO_2-laser the mechanical chopper was applied. An influence of radiation power and pulse duration on parameters and form of holes in paper was studied. Pulse duration varied within 8ms-17.5ms and laser power varied from 80W to 300W. Performed perforation had such obvious drawbacks as singeing of hole edge and color halo around hole in paper as a result of a large amount of combustion products. We have designed the special clamping device to press document's pages to an even bearing within perforation zone (Fig. 1).

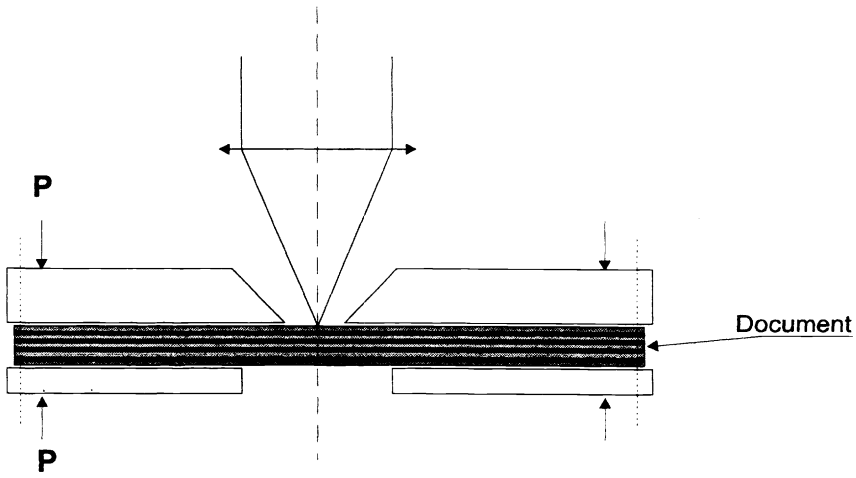

Fig. 1. Clamping device for perforating document pressing.

This attachment allowed to create vapour dynamic channel to avoid a penetration of material destruction products between the sheets of document. By such way it became possible to eliminate a singeing. But there appeared a secondary effect of glueing of the sheets caused by IR radiation action upon pressed paper and jacket material. This limitation in using the continuous CO_2 -laser couldn't be avoided by technological methods.

Further, our research efforts were concentrated at the second series of experiments with pulse transverse dicharge multimode CO_2 -laser with following parameters: pulse duration 150ns, pulse frequency 0,5Hz-10Hz, average pulse power 0,249 J, pulse peak power P_p=1,66 MW, laser fluence $W_p=P_p/S=5{,}3\cdot10^7 W/cm^2$.

We have investigated an action upon fine paper with thickness δ=0,06mm, copying paper δ=0,03mm and document jackets δ=0,5mm, processed on back side of jacket from organic film (film thickness δ=0,25mm). Under the laser beam action there appeared an explosive effect. The hole was perforated by the shock wave force. Small particles of paper (paper dust) were excavated on operated side, the back side hole form looked like punched one.

As a result of the performed experiments it was shown that for the aim of high quality perforation optimal processing mode would be developed. One hole processing time (pulse duration) in combining with laser fluence must not lead to the explosive effect on the one hand, and must not cause a tissue combustion on another hand.

2. LP EQUIPMENT DESCRIPTION

To overcome specified problems the technology and equipment for laser perforation (LP) was developed. LP has module structure and consists of laser module, technological module, life-support system and automatic control system (Fig.2).

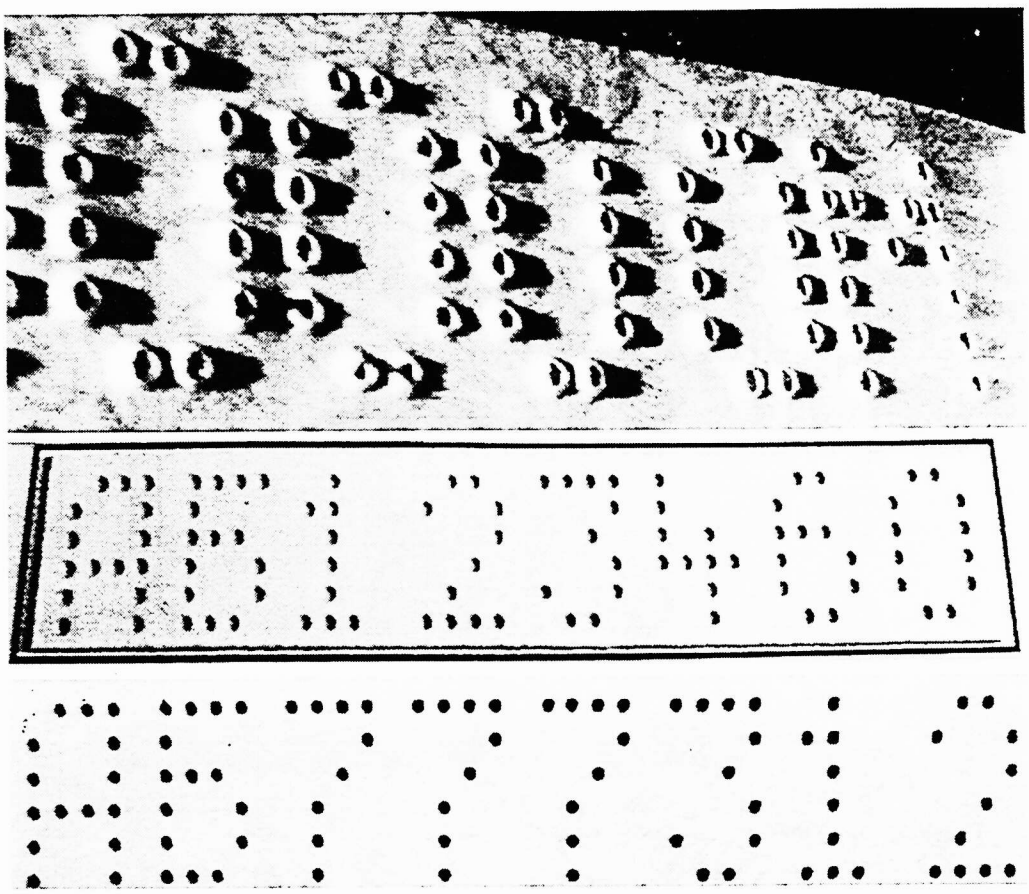

Fig. 4. Photographs of the perforations (fragments): mechanically perforated document (a); laser perforated paper sheet (b); laser perforated document (c).

The main technical specifications of described LP are putting below (Tabl.1).

Table 1.

Specifications		
N	**Parameter**	**Value**
1	Laser wavelength, μm	10,6
2	Average laser power, W	155
3	Scanner input laser beam diameter, mm	≤ 7
4	Peak power in Q-switched mode, kW	2
5	Modulation frequency, kHz	113,5
6	Scanner focal length, mm	≥200
7	Deflection velocity, m/s	≥1,6
8	Perforation field, mm	≥15x70
9	Laser beam positioning precision (in perforation field), mm	±0,01
10	Document perforation time, s	≤3
11	Table vertical motion, mm	150
12	Operation readiness after switching, min	≤ 20

13	Document positioning precision,	mm	±0,2
14	Power consumption,	kW	6
15	Size, mm: - laser and technological module - control module - life-support system		 2750 x 900x 1320 1000 x 600 x 1780 570 x 550 x 1280
16	Weight,	kg	≤ 2000

4. CONCLUSION

We have developed the technology of laser perforation free of some essential drawbacks of mechanical perforation and proposed the equipment for documents and securities laser perforation with perfect quality and increasing securities protection rate.

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