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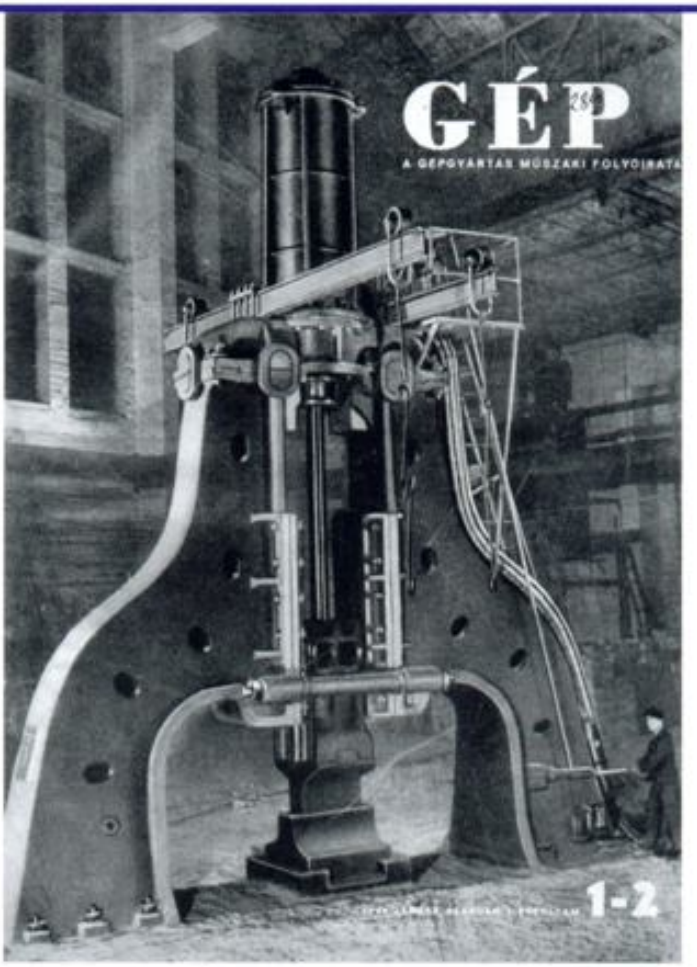

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ÜVEGEK HELYI GYENGÍTÉSE ÉS JELÖLÉSE LÉZERSUGÁRRAL

WEAKENING AND MARKING OF GLASS WITH LASER BEAM

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ABSTRACT

The article reviews the weakening method of cross section of vial neck using CO_2 laser beam and presents the way of finding its technological parameters. Through weakening of cross section the breaking force has to be between 30-80 N. The method is suitable for marking other glass products (e.g. phial of perfume) too.

Keywords: laser technology, reproducibility, marking of glass products, bending stress.

1 INTRODUCTION

For the purpose of dosage, the various liquid medicines and chemicals are filled into vials and then the vials are sealed. Before their use, the vials shall be broken at their neck to have access to their content. Formerly, the neck of vials was weakened by means of a rasper in order to facilitate the break concentrated at a specified point. The vial could be broken by bending stress. In parallel with the technical progress, part of the vials are already scratched at their neck by means of a diamond disk, thus ensuring the reliable and accurate breaking.

Similar problem arises in identification and the marking of glass products. At present, it is solved by gluing tags bearing the appropriate text. By using laser, both tasks can be solved.

2 WEAKENING OF THE NECK OF VIALS USING LASER BEAM

Cutting of glass using laser beam is not raked among the simple tasks of production technology. In order to support them, let us quote a professional opinion as follows: "The laser beam as a light beam is reflected. To cut glass is much more difficult than black traprock by means of laser beam". Requirements set to breaking according to the standard ISO 9187-1:2006(E) became stricter to the extent that, when using the device shown in *Figure 1* for breaking, both the minimum value (F_{min}) and the maximum value (F_{max}) of breaking force are specified. It is possible to fulfil these limits only by controlling the cutting parameters.

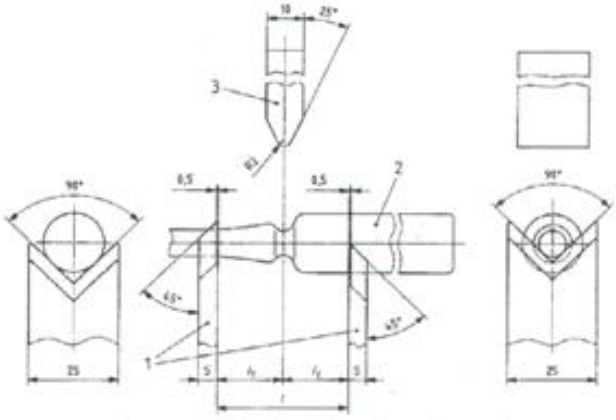

Figure 1 Sketch of breaking the vial

Prior to solving the task, let us briefly overview the peculiarities and application possibilities of laser technology. In 2004, more than 38000 laser based materials processing equipment were sold in the world, from which approximately 18300 units used CO_2 laser and 12200 units used solid-state laser [1].

The laser beam generators produce optical radiation of special characteristics within the ranges of near ultraviolet (*NUV*) and far ultraviolet (*FUV*) as well as within the ranges of near infrared (*NIR*) and far infrared (*FIR*), *Figure 2 and 3*.

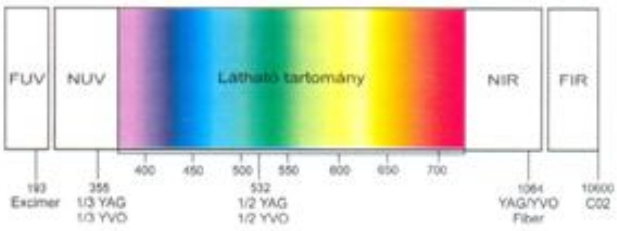

Figure 2
Spectral division of optical radiations and the wavelength ranges (expressed in nm) of laser radiation emitted by marking laser devices used in the industry

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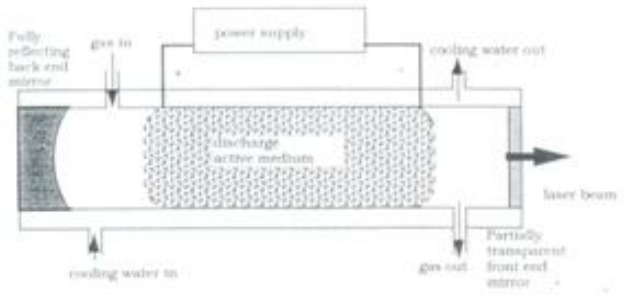

Figure 3
Basic construction of slow flow (SF) laser [2]

We started the development of glass cutting technology with the application of CO_2 laser machine. As a first step, the peculiarities of the CO_2 laser source had to dealt with.

The advantages of the laser beam cutting (marking) can be summarized as follows:

The individual materials absorb the laser radiation of various wavelength to a different extent, therefore, it shall be examined what type of laser beam generators could be or shall be used in each and every application. The marking possibilities are primarily defined by the material to be marked. The advantages of the laser beam marking technology over the traditional technologies are:

- the mechanical characteristics of the workpiece do not influence the marking technology, thus the process is *flexible*,
- excellent marking quality and repeatability, the process is *precise*,
- high speed, the process is quick,
- the processing is contactless, without wear and with minimum stress on the workpiece,
- due to the process control computer and interfaces, easy integration into production lines thus ensuring the possibility of rapid conversion,
- the wide range of materials can be processed,
- the laser beam may come up on places difficult to access where other technologies fail [3].

We aim at defining marking parameters that fulfil the above conditions. For the purpose of weakening the wall of vials, we used an engraving operation in which the material at the focus boils under the effect of laser beam and is evaporated from the surface.

Thus, a crater-like pit is generated at the surface. This operation, similarly to the mechanical engraving causes a palpable pit on the surface. The breaking forces of vials acting at the middle of 36 mm span (18/18) are indicated in the *Table 1*. For marking of the neck of vials, a 30W MACSA K-1030 PLUS type laser beam generator (CO_2 galvo head, pulse mode) was used. The spot diameter of the laser beam depends on the lens used. The focal length of lens used for testing was 200 mm that focused the laser beam to a diameter of 350 µm. The maximum power density of the focused laser beam was 245 W/mm^2. The area

	breaking force [N]	
In case of force acting at the middle of a 36 mm span (18/18)	minimum	maximum
F	30	80

Table 1 The breaking forces of vials

which could be marked by means of the lens was 100x100 mm. The wavelength of CO_2 laser source was 10600 nm. From among the laser processing parameters, it is the marking length (line) or the number of point shootings that are the decisive values [3]. There were two methods of marking to weaken the neck of glass vials. One of them is that the vial is rotated meanwhile lines in length of several micrometers are etched by means of laser beam into its wall. In the other method, the glass wall is weakened by point shooting in spot size of laser beam according to the time of revolution, *Figure 4*. With reduced time of revolution i.e. increased rotational speed, the length of marking lines and the number of shots, respectively, is reduced. In both cases, care shall be taken to prevent the laser beam from cutting too deep lines into the wall of glass.

Figure 4
Weakening of glass wall with point-shooting

The glass vials were fixed in a fastening and rotating equipment in such way that the neck of the glass vial is located in the marking area of the laser beam generator, *Figure 5*.

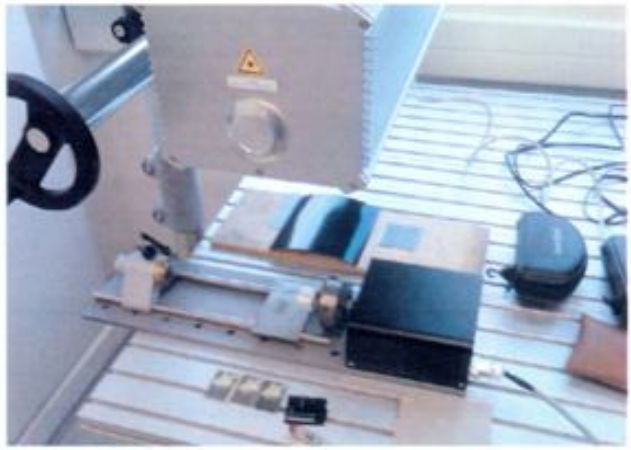

Figure 5 Laser marking of glass vials

A driving motor rotated the vials at a constant speed while the laser beam generator applied several shot pulses on the neck of vial. At first, the rotational direction was changed back and forth, however, a difference in the measurement was detected. It turned out that, irrespective of the speed of the marking laser, the length of the marked ditches was influenced by the relative velocity resulting from the rotation.

The laser parameters listed below had to be optimized depending on the time of revolution :

- the power density of the laser beam, 90 [%],
- the sweeping speed of the laser beam, 30 [mm/s],
- the pulse frequency, 10 [kHz],
- the marking length, h [μm] and
- the number of dot shots during a specified time.

The break of vials was tested by means of an equipment type Instron, *Figure 6*.

Figure 6 Break test of the vials

In case of white vials the dot form, while in case of brown ones the line-like marking proved to be advantageous. The break test results of the brown vials are shown on *Figure 7*.

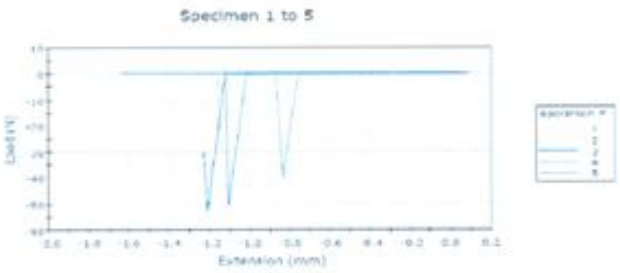

Figure 7 Break test results of vials

Based on the results, it can be shown that:

- by using laser beam, it is possible to weaken the neck of vials so as the value of breaking force falls within a specified interval;
- in case of laser beam generators of various capacity, it is necessary to define the marking parameters previously (our marking results relate to 30 W CO_2 laser source, but we made researches with 10W CO_2 laser source as well);
- the cutting technology is free of pollution as compared to that using cutting disk;
- the system can be automated.

3 APPLYING TEXT ON GLASS USING LASER BEAM

At present, laser marking technology can excellently be used on raw materials of paper, leather, wood, plastic, textile and metal. However, this technology is not popularized on glass surface as yet. The reason is, that it is not a simple matter to apply proper marking on the surface of glass; it requires much testing [4]. On production lines manufacturing and packaging perfumes *Figure 8*, acceptable surfaces were obtained by using technologic parameters as follows:

Figure 8 Inscription on a vial

- power density 30W (using CO_2 laser source), 100%,
- repetition frequency 100 kHz,
- depending on the band speed of production line, the number of characters and their size, the number of text rows, the marking speed was changed between 500 and 2500 mm/s.

ÖSSZEFOGLALÓ

A cikk ismerteti az üvegampullák nyakrészének CO_2 lézerrel történő keresztmetszet-gyengítési eljárását és bemutatja a technológiai paraméterek meghatározását. A keresztmetszet-csökkentés következtében az ampullák törőerejének 30–80 N közötti intervallumba kell esnie. A módszer alkalmas más üvegipari termékek (pl. parfümös üvegek) jelölésére is.

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