

ECONOMIC ASPECTS OF BOOKBINDING LASER SCRIBING

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ABSTRACT:

The paper deals with optimal adjustment of parameters of laser beam for bookbinding scribing. Engraving belongs among non-conventional methods of laser scribing that are based mainly on the physical or the physico-chemical principle of cutting operation without the application of force on the machined material. Commercial CO₂ laser Mercury L-30 by firm LaserPro, USA was used for scribing. The experiment was done in firm MECHANIKA PV. Five basic types of covering materials were selected for the laser scribing of text. The specimens were inspected and their characteristics were investigated. Further, economic comparison of laser technologies and gold stamping on manual press was performed.

Keywords: CO₂ laser, bookbinding laser scribing, economic evaluation

1 INTRODUCTION

Engraving belongs among non-conventional methods of laser scribing that are based mainly on the physical or the physico-chemical principle of cutting operation without the application of force on the machined material. The firm MECHANIKA PV deals among others with the laser scribing problems. Consequently, they offered cooperation in solving these problems. The firm wants to use this technology for bookbinding. This study deals with optimal setting of parameters of laser beam for bookbinding scribing.

2. EXPERIMENT

2.1 CO₂ laser MERCURY L-30

Commercial CO₂ laser Mercury L-30 by firm LaserPro, USA was used for experiment. It is possible to change power and feed rate of laser system. Ray of laser could be focused on mark diameter $d = 185 \mu\text{m}$. The maximum value of density of energy flow is $q = 1,1 \text{ GWm}^{-2}$. The maximum value of power is 30W and maximum value of feed is 1066 mm/s. Shape of laser trajectory is designed by the help of software Corel Draw. Wide spectrum of different materials (ceramic, quartz, plastic, rubber, wood and certain composite structures) can be scribed and machined by laser MERCURY L-30. This laser type is used mainly for commercial engraving.

2.2 Covering materials used for experiments

Five basic types of covering materials were selected for the experiments. These specimens were scribed by laser. Each material differed from others by its colour, surface and structure. See table 1.

Table 1. Covering materials used for experiments

N.	Material title	Colour	Surface	Description
1	BALADEK	dark-blue	roughened of slight grooves	leather imitation
2	BALADEK	vinous	smooth without visible defects	leather imitation
3	IMPERIAL	green	visible cross and lengthwise fibrous structure	natural buckram
4	IMPERIAL	red	visible cross and lengthwise fibrous structure	natural buckram
5	COVERING PAPER	blue	rough, visible relief	properties like hard paper
6	NATURAL	white-grey	markedly visible structure fibrous	tow-cloth

2.3 The laser scribing of experimental covering material

Experimental text was scribed with parameters combination of laser system – maximum feed 100% (1066 mm/s) and power was being changed – see table 2.

Table 2. Settings for material number 1

Feed f [%]	Feed f [mm/s]	Power P [%]	Power P [W]
100	1066	10	3
100	1066	7	2,1
100	1066	20	6
100	1066	40	12
100	1066	60	18
100	1066	80	24

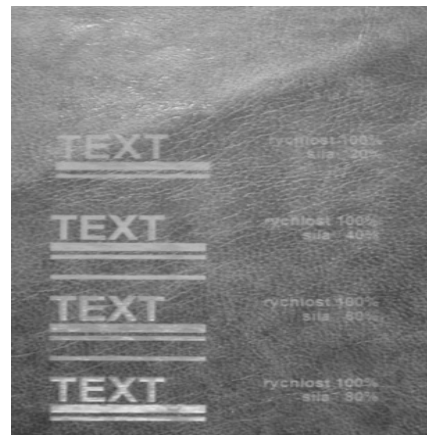


Figure 1. BALADEK (dark blue)

Due to space limit particular results and evaluation are described only for material number 1.

Feed 100%, power 7%

Value of laser power was too small therefore material did not evaporate and practically did not melt even.

Feed 100%, power 10%

The power increase about 3% caused melting of material surface layer only therefore colour of scribing is always black.

Feed 100%, power 20%

Twenty percent of power was sufficient for material evaporation. Yellowish text with dark blue touch of surface layer was created on the surface. Yellowish colour is caused by inner surface layer.

Feed 100%, power 40%

Here, we can see very clear and sharp edge of single letters. Top layer was evaporated absolutely. Due this fact the surface colour of material does not influence resulting colour of text. The laser power appears to be optimal.

Feed 100%, power 60%

At this power laser evaporated not only total surface layer material, but also partly inner surface layer. It is not desired effect. The basic layer of material comes out into text colour.

Feed 100%, power 80%

The high power of laser was reason for burning-up of almost all material. This effect is perceptible also from second side of material. The contour of burned out text is created here.

Figure 2. BALADEK (vinous)

Figure 3. IMPERIAL

Figure 4. IMPERIAL (red)

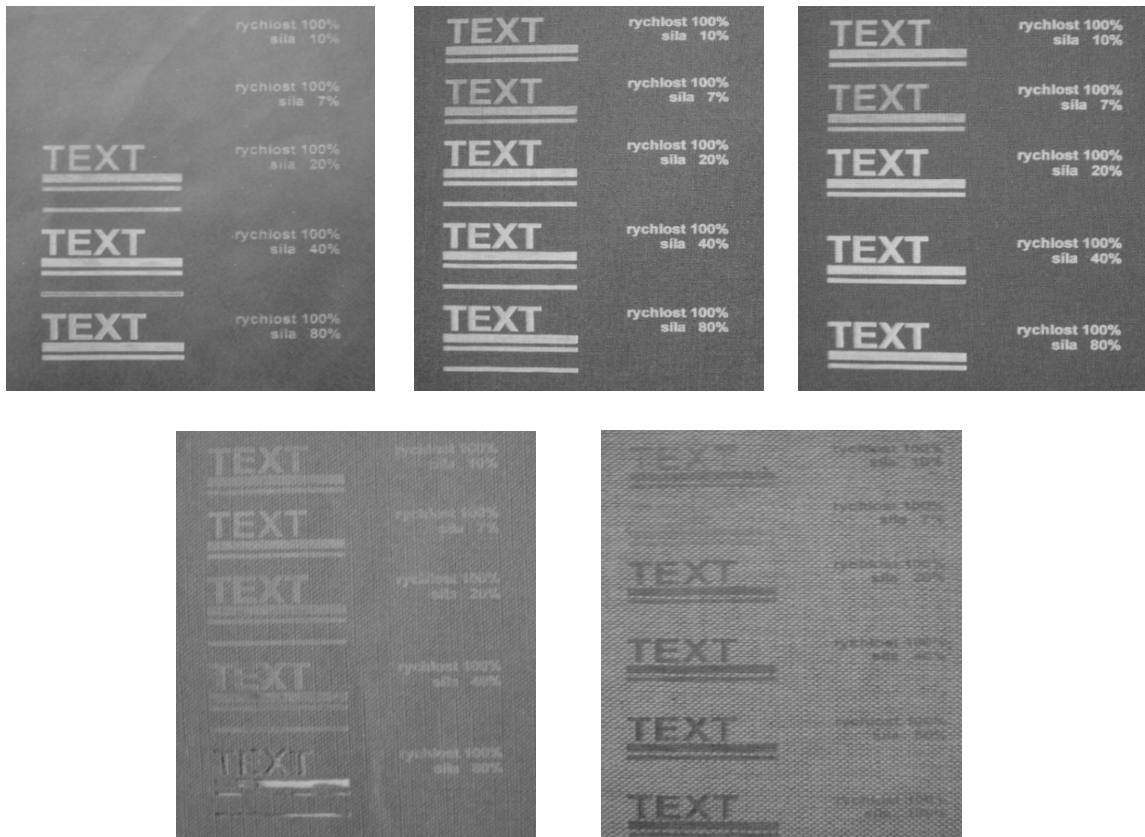


Figure 5. COVERING PAPER

Figure 6. NATURAL

2.4 Optimal parameters combination of laser system

Value of input characteristics are stated as a percents from maximal power ($p_{\max}=30W$) and maximal feed ($f_{\max}=1066mm/s$).

Table 3. Optimal parameters combination of laser system for used materials

N.	Material title	Optimal feed	Optimal power	Annotation
1	BALADEK	100%	40-50%	Narrow interval of power is caused especially by properties of material surface layer
2	BALADEK	100%	40-80%	Power range mainly depends on required text colour
3	IMPERIAL	100%	20-80%	Text is even legible with power value under 20%
4	IMPERIAL	100%	20-80%	Text parameters are same as for the previous material
5	COVERING PAPER	100%	5-20%	Suitable for lower power value. The material began burn at power over 40%
6	NATURAL	100%	40-50%	Suitable for higher power - over 40%

2.5 Economic evaluation of laser scribing usage

The laser technology is usually used in cases where conventional method of machining cannot be used. The fast changes of working cycle can be applied using advantages of the laser system. It is possible to achieve high level of productivity with rapid symbol changes in program Corel Draw.

2.5.1 Advantages of usage of laser system:

- good working conditions for machine operator

- silent running
- higher safety of work than conventional machining
- reduction of man power and production place
- cutting operation without the application of force on the machined material
- nearly maintenance-free

2.5.2 Disadvantages of usage of laser system:

- too high actual price of laser system
- necessity of the evaporated material exhaust
- difficult reparation in case of laser machine failure
- colour of the text is affected only by the character of some layers of used material

2.5.3 Economic comparison of laser technologies and manual gold stamping of a thesis title part

From our experimental results it is possible to state that the laser scribing of title part of thesis took about 4 minutes - attributable costs are about 0,5 EU.

It was also observed that the scribing time with common technology of manual gold stamping would take about 60 minutes - attributable costs are about 5EU.

3. CONCLUSION

From table 3 is evident that it is not necessary to use lower feed than maximal for bookbinding laser scribing. Laser is capable to create desired text on the material surface even by low power value. Hence, it is not necessary to decrease laser feed from the point of view of productivity. It is necessary to know suitable output parameters, setting of specific laser system and properties of machined materials for obtaining good results of scribing by laser.

Furthermore, it was observed that the laser power and properties of particular material layers have biggest influence on properties and appearance of scribing text. The optimal setting of laser power in the interval 40-50% from maximal power of the laser machine was possible to use for almost all covering materials. Only covering paper was different because its properties are rather similar to normal paper than textile or imitation of leather.

The influence of the covering material colour was last factor which was evaluated. It was observed that the colour does not influence properties and appearance of scribing text. It is obvious that technologies utilizing laser beam are multiply faster than gold stamping on manual press. Long adjustment and composing of single letters into desired text string have biggest participation on long work time on gold stamping press, however the laser scribing work time is significantly shorter due to usage of Corel Draw software.

At the conclusion, it is possible to state that increasing of quality of scribing and machined surface, increasing of productivity and economic profit are main priority targets of laser scribing and machining.

4. REFERENCES

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