Exploring the various parameters of CO_2 laser in the cutting of paper

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Introduction

Postpress remains one of the last stages in graphic production that still resists digitisation. The processes that take place in it are either manual or are done on specialised machines that are not so sophisticated and flexible. The handling of the post-press itself is of such a nature that it can be automated and even integrated into the in-line process of graphic production, but it isn't easy to fully digitise.

By analysing the trends in the printing industry, it can be seen that the sales of conventional solutions for finishing machines are in constant decline in the last decade. Only devices designed for digital printing resist the demand reduction, so it is not surprising that many large manufacturers of graphic finishing machines adapt their machines to the requirements of digital printing, smaller runs and ink-jet and toner prints. The growth of the production of packaging and labels must undoubtedly be in the focus of development of post-press machines because the packaging sector will take over 50% of the total printing in the coming period.

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A fundamental principle of CO_2 laser paper cutting

The word laser comes from the acronym "light amplification by stimulated emission of radiation" (Gould, 1959). The laser emits monochromatic coherent light whose energy affects the surface it hits. CO2 laser (carbon dioxide) is a gas laser that emits infrared light with a wavelength of 9.6 and 10.6 microns (µm). It is highly efficient and suitable for both industrial and medical use.

To use the techniques of laser cutting, optimally is necessary to know the principle of cutting material. The mechanism of paper cutting by laser is based on the evaporation of the substrate. Laser cutting mechanism involves heating the material to the temperature of evaporation, or the temperature at which chemical degradation of the material occurs. The physical change that a material undergoes is the conversion of the material directly from a solid to a gaseous state (Piili, 2013). The temperature that will be reached depends on the material that receives the laser beam and whose molecules are excited by it If the material evaporates at 150 ° C for the material to degrade, the laser should excite the molecules to move at a speed that will raise the temperature to the point of evaporation. Consequently, the temperature of the laser depends on the substrate that receives the laser beam. The largest part of the laser power is used for breaking chemical bonds in the material.

Influential parameters

Laser power is defined as the total amount of energy emitted in one unit of time. The unit in which the laser power is expressed is Watt (W). The maximum laser power intensity is expressed in watts per unit area (usually W cm^{-2} or W mm^{-2}). When cutting non-metals, maximum intensity is required to achieve high temperatures when cutting the substrate, which results in good cutting quality combined with high cutting speeds.

Some studies investigated how grammage affects the cutting speed when cutting with a CO_2 laser. Federle and Keller (1992) experimented with paper materials for offset printing, grammage from 80 to 170 g/m^2, at a laser power of 600 W. It was concluded that grammage and cutting speed are not linearly dependent. They also concluded that the grammage has no effect on the quality of laser cutting, nor on the kerf.

The influence of material thickness on successful laser cutting was investigated. The cutting of several different paper materials with a constant laser power of 550 W was examined. Maximum cutting speeds for different material thicknesses were found. It was concluded that cutting speed increases with decreasing material thickness. The less material needs to evaporate, the cutting is faster (Malmberg et al., 2006).

Bulk is the thickness of a sheet of paper and is the opposite property of paper density. High bulk is a type of paper with a greater thickness than other papers with the same grammage. This property of the paper is essential if the paper is required to be stiff. Malmberg et al. (2006) examined the effect of bulk on laser cutting speed. CTMP and pine pulp cuts were performed at a constant laser power of 90 W and 550 W. It was concluded that as the bulk increases, the cutting speed increases. High bulk papers have lower density, so there is less material required to evaporate when cutting, resulting in faster laser cutting (Malmberg et al., 2006).

Natural fibres have a hollow cross-section. The amount of water in the paper has a significant effect on laser cutting.

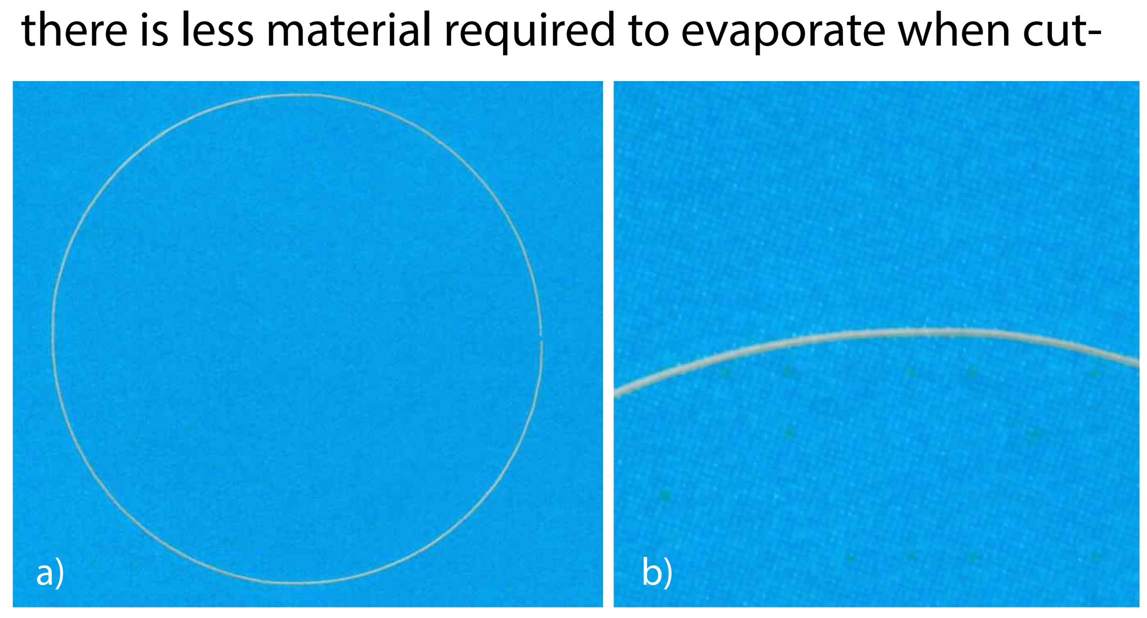

Figure 2

a) Optimal laser power for kiss-cut of printed self-adhesive paper b) detail

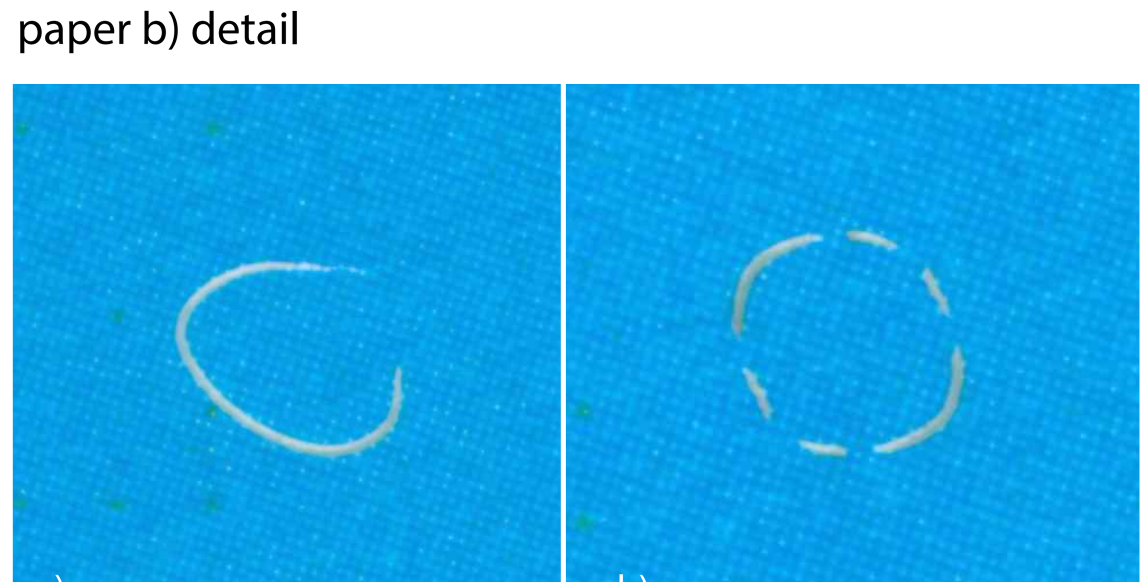

Figure 3

Influence of cutting speed and power on laser precision:
a) high power and cutting speed
b) lower power and cutting speed

Conclusion

The need to find a solution in post-press that will match the advantages of digital printing is a very demanding task. Through the development of modern technologies, the graphic product kept its digital form further and further from one phase to next. Keeping the product in digital form for as long as possible meant speeding up the work process, reducing errors and increasing the possibility of correcting any shortcomings. First, digitalisation appeared in the process of prepress, layout, while the other phases remained analogous. Then slowly digitalisation moved step by step until it reached the printing process. In the printing process, the print finally turns into an analogue form, and its further processing also continues analogue. This is where the problems that plagued graphic artists for centuries arise. Although the automation of the finishing process is at a high level, the machines used still process the product with the help of mechanical tools. This is in no way conducive to the philosophy of today's business in the printing industry as we have seen the gradual progress of digital technology through the process of prepress to the printing itself, so it will undoubtedly continue in the process of post-press.

The use of laser cutting systems is no longer science fiction. The development of lasers has made it possible to cut even sensitive materials such as paper without any traces of cutting like burning or combustion. The ability to influence different parameters of the laser such as its speed, power, frequency and resolution allows it to adapt to a vast range of different materials from paper, cardboard to films and foils. Different materials react differently to the laser beam, so it is necessary to increase the number of experiments that will show the influence of the laser beam and its parameters on different substrates. In addition to cutting, the laser can be used for various surface treatment such as engraving, especially for cardboard, but also cover materials.

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