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Cutting with laser in postpress

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Introduction

Use of laser technology in processing and cutting material has shown many advantages over conventional techniques. Speed of operation, accuracy, precision, suitability for the environment, and good hygienic conditions distinguish laser technology. Laser cutting technology has opened up new opportunities in the packaging market compared to conventional packaging manufacturing techniques. The advantages are reflected in the diversity of packaging shapes, sizes and complexity, with fewer design limitations, as well as opportunities to improve the quality of packaging production. The quality of laser-cut products is reflected in the cut edges that are clean, glued, and do not contain material fibers that come out of the cutting edge. The profitability of this technology for small runs has contributed to the growth of smaller crafts and special workshops. Laser cutting is computer controlled, fast direct method, easy to use, and the line drawing representing the path of the cut can be changed one after the other by software, which is an advantage. Also, the speed of the process is largely influenced by the fact that this technology does not require tool replacement - a laser beam is a universal tool that moves along a software-defined path. Laser devices must be equipped with systems for vacuuming fumes that arise in the evaporation material process. Depending on the material being processed, different fumes can be expected in the immediate nearby during the cutting process, so it is necessary to ensure good ventilation.

Paper as laser cutting material

Paper materials have a smooth, flat and uniform surface, however microscopic images show that paper materials have a complex structure consisting of a network formed by interwoven fibers originating from wood. The paper contains filler particles (clay/kaolin, calcium carbonate or other minerals) (Piili, 2013). Also, paper is a composite material consisting of cellulose, hemicellulose and lignin (Hosoya, Kawamoto and Saka, 2007). Some paper materials are coated with a thin layer of mineral pigments (usually clay/kaolin, calcium carbonate or other minerals or a mixture of the pigments mentioned above) or a thin layer of plastic (Piili, 2013). Some paper materials contain layers of different paper materials, for example, a middle layer of mechanical pulp and a bottom layer of chemical pulp (Piili, 2013).

Fibers are usually much longer (the average fiber length is 1 mm) than thick (average fiber thickness is 100-200 microns). Due to these dimensions, the wood fiber network looks like a 2D network (Niskanen, 1998). When the air between the fibers is considered, the fibers form a 3D network (Niskanen, 1998). Such a 3D structure of wood fibers strongly affects the optical properties of paper materials. Paper materials contain different optical barriers: pores of different shapes and sizes, mineral pigments, long fibers, etc. (Piili, 2013).

Light can perform transmission, scattering, reflection, diffraction, and absorption when it interacts with paper materials and their components (Niskanen, 1998; Pauler, 2002).

All these characteristics of paper change the way it reacts to the laser. Increased moisture in paper will increase the laser strength needed to cut through the paper (Malmberg, Immonen and Kujanpää, 2006). One of the requirements for paper substrates is that they have the sufficient tensile strength to pass through the processing process and usage without tearing (Riley, 2012). In addition to the breaking point, an important characteristic is the elongation at which the breaking occurs, and the tests are performed on dry and wet papers (Riley, 2012). The tensile strength test is standardised according to the ISO (International Organization of Standardization) ISO 2758:2003 (ISO 2758 2003).

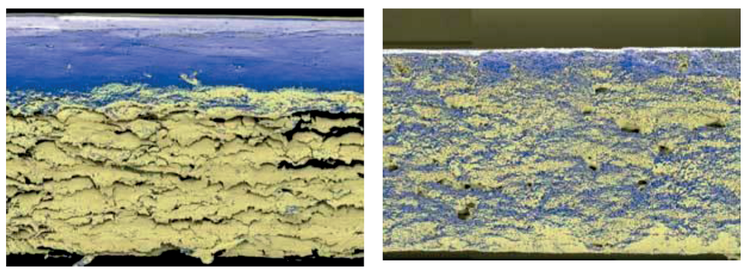
By definition, tensile strength represents the force required to break a material (Kirwan, 2005). Under the action of this force, the material exhibits elastic properties up to a certain level. Force applied to the paper strip is proportional to the deformation or elongation caused by the applied force (Kirwan, 2005).

The influence of cutting on paper

We can expect the paper to suffer a specific degree of degradation using laser or conventional cutting. Paper material is subject to degradation if it is exposed to external influences. The result of degradation can be a decrease in paper strength and a change in structure (Stepanov, 2015). A question arises about which type of cutting degrades the paper and which experimental method can answer that question. Indeed, changes in aesthetics and performance after cutting are essential for the further use of paper.

It has been observed that paper materials change colour during or after laser treatment, primarily newsprint, copy paper, and some cardboard.

SEM analysis showed the difference in cutting edges between conventional and laser cutting. However, new research is needed to show how these edges affect the material's tensile strength. For example, will edges obtained mechanically result in lower tensile strength, or will the laser adversely affect the tensile strength due to the way the beam changes the chemical composition at the point of interaction with the material?



a) b)

Figure 1

a) SEM micrograph of an edge that was cut by a mechanical blade and b) an edge that was cut by a laser (Malmberg & Kujanpää, 2006)

Conclusion

Cutting paper materials with a laser beam can be combined with digital printing machines. The advantage of digital printing is the ability to produce small runs with a quick change of the printed image. The advantage of this way of cutting is that there is no change of tools when changing jobs, while the image that needs to be cut is changed in the program (Boyle, 1999).
Authors Malmberg and others (Malmberg, Immonen and Kujanpää, 2006) list situations in which it is recommended to use a laser for cutting paper materials:

- when working with small editions below 1000 pieces,
- when it is necessary to achieve a high degree of cutting accuracy, as well as cutting of complex geometric shapes,
- when making samples or series of samples,
- if expensive material is used for the processing of which a high degree of manufacturing accuracy is necessary,
- in production where different types of products are made and when a high speed of delivery is required.

Laser cutting of materials can provide a unique solution to manufacturing requirements. The use of lasers is ideal for applications that require cutting complex profiles and edges with high accuracy. Laser can cut materials of different thicknesses, cutting the same part in large quantities (mass production) or cutting very soft and hard materials (Eltawahni, Benyounis and Olabi, 2016). Laser processing of paper materials opens up new possibilities for improving the appearance of graphic products. Laser technology made it possible to make the appearance of these products unique and original.

REFERENCES

Boyle, E. (1999) 'Lasers are on the cutting edge, digitally speaking', Paper, film & foil converter, (4), pp. 14–15.
Eltawahni, HA, Benyounis, KY and Olabi, AG (2016) High Power CO 2 Laser Cutting for Advanced Materials – Review, Reference Module in Materials Science and Materials Engineering. Elsevier Ltd. doi : 10.1016/B978-0-12-803581-8.04019-4.
Hosoya, T., Kawamoto, H. and Saka, S. (2007) 'Cellulose-hemicellulose and cellulose-lignin interactions in wood pyrolysis at gasification temperature', Journal of Analytical and Applied Pyrolysis, 80(1), pp. 118–125. doi : 10.1016/j.jaap.2007.01.006.
Kirwan, MJ (2005) Paper and Paperboard Packaging Technology. Blackwell Publishing Ltd.
Malmberg, H., Immonen, M. and Kujanpää, V. (2006) 'Laser cutting of paper', in Proceedings of Challenges´06 Symposium, p. 32.
Niskanen, K. (1998) Tap on section to go there . Helsinki [etc.] : Fapet Oy [etc.].
Pauler, N. (2002) Paper Optics . Lorentzen and Wettre .
Piili, H. (2013) CHARACTERIZATION OF LASER BEAM AND PAPER MATERIAL INTERACTION
Riley, A. (2012) 'Paper and paperboard packaging', in Fundamentals, Materials and Processes . Woodhead Publishing Limited, pp. 178–239. doi : https://doi.org/10.1533/9780857095701.2.178.
Stepanov, A., Saukkonen, E., Piili, H. and Salminen, A. (2015) 'Effect of Moisture Content of Paper Material on Laser Cutting', Physics Procedia . Elsevier BV, 78(August), pp. 120–127. doi : 10.1016/j.phpro.2015.11.024.

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