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LASER TECHNOLOGY AND POSSIBILITY OF ITS APPLICATIONS

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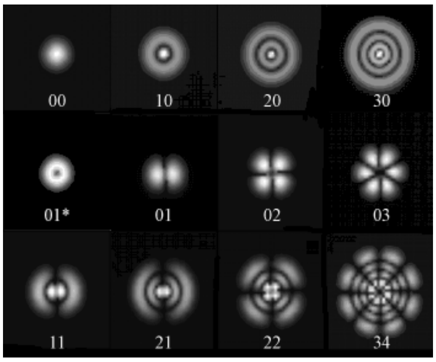
ABSTRACT
The paper deals with possibilities of using the laser in technologies. It evaluates the influence of design and technological conditions on output parameters of cutting process, and also presents relative laser workability of some polymers. This paper gives mathematical model for determination laser cutting quality functions based on results of the experimental research. Finite element analyses of the transient nonlinear heat and mass transfer were simulated using of the two-dimensional model. The temperature distribution was derived. The parametric analyses of the thermal fields were realized by the finite element method.
Keywords: Laser Machining, Technological Conditions, Simulation

1. INTRODUCTION

1.1. The Lasing process
The term „laser“ tells us that a simplified description of the lasing process could be „opposite of absorption”. At the heart of the lasing phenomenon is the ability of photons to stimulate the emission of other photons, each having the same wavelength and direction of travel as the original.
According to quantum theory, atoms and molecules have discrete energy levels, and can change from one level to another in discontinuous jumps. Under normal conditions, most atoms or molecules remain quiescent at their lowest energy level, or ground state. But if these particles are exited into higher energy states-by an intensive flash of light, an electrical charge, or other means-they will, in dropping back to the normal ground state, emit incoherent light in the process. In a laser cavity, such emitted photons are trapped between highly polished and parallel mirrors. Whenever a photon passes close to another excited particle of the same wavelength, the second particle will also be stimulated to emit a photon that is identical in wavelength, phase, too, become part of the growing wave between mirrors. Lasing begins when enough photons are present, and if one of the mirrors is partially transparent, a highly disciplined, intense, and now, coherent beam is emitted.

1.2. Transverse Beam Modes
The photons oscillating from one end of the resonator to the other constitute electromagnetic energy which forms an intense electromagnetic field. The shape of this field is critically dependent not only on the photon wavelength, but also on the mirror alignment, curvature, and spacing, and on the bore diameter of the laser tube. This field can assume many different cross-sectional shapes, termed *transverse electromagnetic modes (TEM*), but only certain modes, or mixtures of them, are useful for

processing materials. The TEM_{00} mode is ideal for most cutting, drilling, and welding applications because it produces a beam that can be focussed to a minimum spot size for very high power density. It is a Gaussian mode, with most of the energy in the centre.



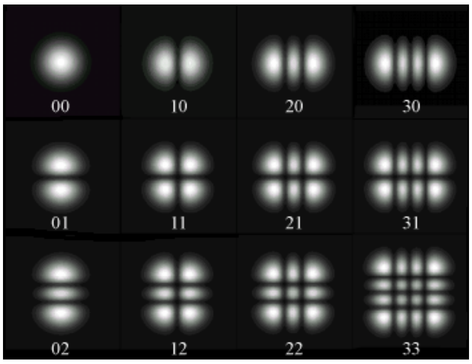


Figure 1,2. Selected Mode TEM

The TEM_{01} mode cross section shows a “hollow” centre, with most of the energy concentrated near the periphery of the focussed area. This mode distributes the beam energy efficiently for other heat-treating and drilling applications. TEM_{01} also has its particular uses. But not the difference between the cross-sectional representation of the widely used TEM_{00} mode and that of mode called TEM_{11}.It is evident that the distribution of power across the TEM_{00} beam (shown at the in figure 3 as a single Gaussian curve), results in a more efficient tool for cutting than does the more fragmented power distribution of the divided TEM_{11} beam (shown at the right in figure 3 as two curves).

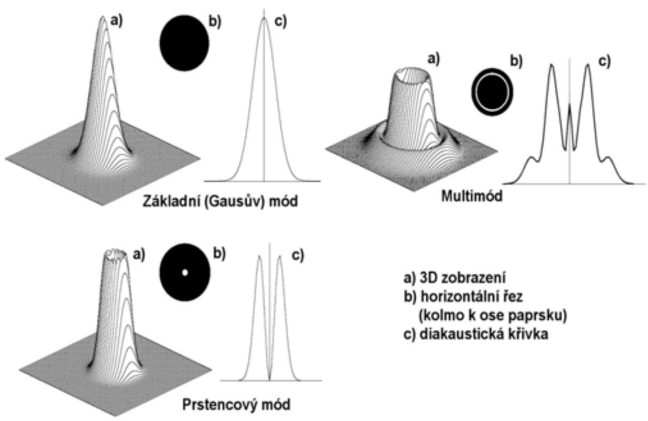


Figure 3. Analogy of Beam Modes to tool

2. THE EXPERIMENT

The sidewall from PMMA is by degrees cooled after passing through of the laser light in the specific cut. At the same time the thermal flow is distributed from the cut plane to the internal dimension of the wall.

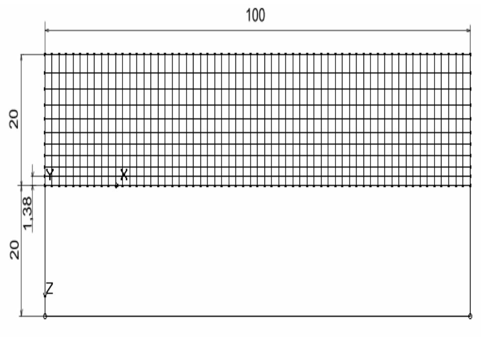
The thermal process is described by Fourier-Kirchhoff differential equation:

$$\frac{\partial T}{\partial t} = \alpha \nabla^2 T, \qquad \alpha = \lambda / \rho c \qquad (1)$$

Where λ is thermal conductivity, ρ is density, c is heat capacity.

The thermal conductivity of thermoplastic materials is (100-1000) times less then metals. That fact cause that plastics keep high differences of temperatures between external and internal layers.

The physical characteristics of the thermoplastic materials are changed very expressively in this temperature interval. Values λ,ρ,c were entered as the function of the temperature through medium of the thermal curves.The heat flow values were entered as the variable parameters. Progressive ignition and extinction of the heat flow simulates the ray laser movement. The maximal temperature was regulated on the already alluded cracking temperature by the repeated change of the heat field value and following thermal field calculation.
The results are presented in the following pictures.



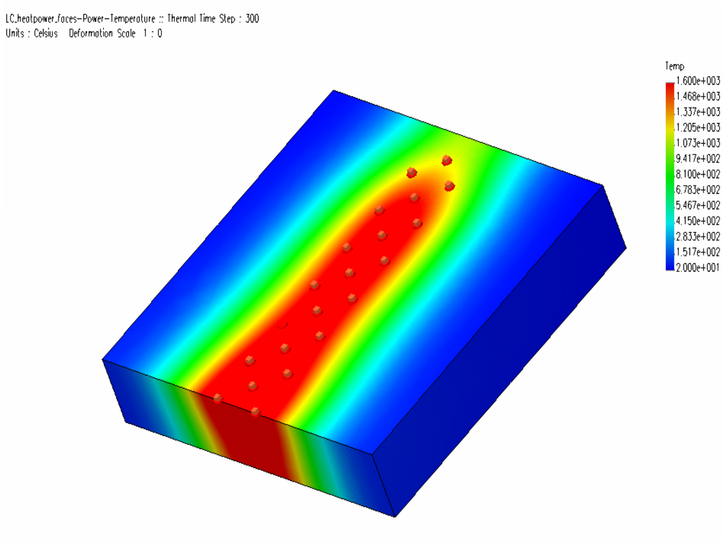


Figure 4. The dimension of the specimen (mm) and finite element mesh. *Figure 5. The thermal field for polymers materia*

Defining and determining of laser workability is a big problem. More workplace for laser cutting determines possessiveness that 15 input variables, further on by time and space variable physically - mechanical and chemical properties of machined material, scoria and the fact, that during the cutting plasma arises. According to our experience it is the most advantageous to define the laser workability with the help of isometric h-v of P-v diagrams. They are describes dependence between depth of cut (h) on laser cutting speed for some metals for range of power (P). Dependencies of laser cutting speed on power for some materials are shown in Fig. 6
Relative laser workability has been defined. It is characterized with the depth of the depth of the cut related to the unit width of the cut and unit output.
The results of the experiments so show very good relative workability of materials and composites whose particles do not tend so separate during the process. If technological conditions (moving speed of the laser head, the beam output, mode parameters of the optics) are optimized, a good quality of the cut can be reached for both metals and plastics.
In case of polymers (plastics and rubber), the surface modification is completely different. During exposition of polymeric material (PP, PS, PE, PC, PVC, PA) samples to concentrated energy, the surface layer degrades and the strength of the samples derogate. On the other hand, PMMA and metal are influenced in a different way. When the output (and therefore heat) increases, the metal material surface is heated above modification temperature. It causes structural transformations in surface layer. The result is a hardened surface layer of the metal and improved strength of samples.
The effect of the laser beam upon PMMA is of interest, too. Due to the layer structure modifications, the surface hardness rises, flaws and creases are healed and as the result of this the sample strength increases. Due to the activity of high concentrate energy and at the same the high temperature, PMMA depolymerize and it rise an amount of radicals at the end of the polymer strings. Thanks to existing of radicals and minor amount of monomer, it raises a net structure here and so the layer strength increases. The strength of the machined layer depends on the time of interaction, too. Longer time of the laser beam contact to material imports better material strength and hardness. This phenomenon is typical for plastics and it can be useful in special tools manufacturing.

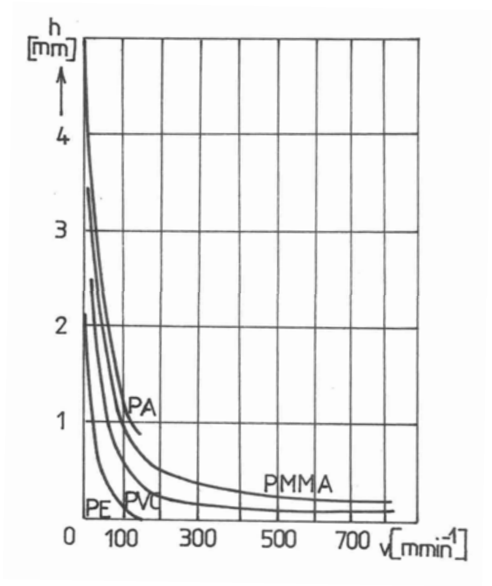


Figure 6. Results of laser cutting for some polymers

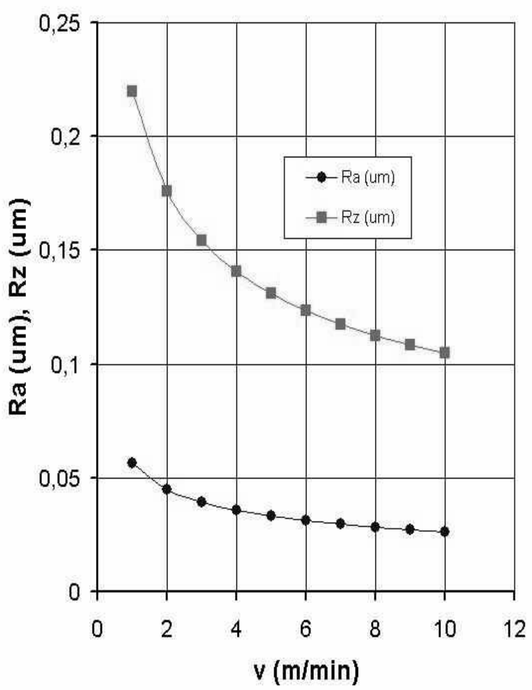


Figure 7. Effect of the feet rate on the roughness'

3. CONCLUSION

Laser beam is the tool of the future. It can cut without affecting the surrounding material. Its energy is clean, reliable and docile it's ready to be tamed and handled to give an unequalled quality to the process. Quality of cut depends from working parameters of laser cutting process (laser power, feed rate, material thickness.)

The results of the experiments so show very good relative workability of materials and composites whose particles do not tend so separate during the process. If technological conditions (moving speed of the laser head, the beam output, mode parameters of the optics) are optimized, a good quality of the cut can be reached for both metals and plastics.

The model LASER interaction with thermoplastic material is possible. The result area of the high temperature respectively its gradients are narrow after passing of through the LASER ray. The width of the thermal influence area is only a minimal depends on the cutting speed. The high temperature gradients induce both short time transient thermal stress values and residual tension at the cut proximity.

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5. ACKNOWLEDGMENT

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