10th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2006, Barcelona-Lloret de Mar, Spain, 11-15 September, 2006

LASER CUTTING OF METALS AND POLYMER MATERIALS

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ABSTRACT
The paper deals with possibilities using the laser in technology. It evaluates the influence of design and technological conditions on output parameters of cutting process, and also presents relative laser workability of some metals and polymers.

Keywords: Laser Machining, Technological Condition, Polymers

1. INTRODUCTION
One of the new technological applications of current technology is laser. Laser beam appears to be the most universal tool, which can be widely used in many areas of the industry. It can be applied for machining, such as cutting, carving, graving and drilling, but also for surface melting, alloying, hardening and etching. Another use is plastics polymerization or dimensions measuring. For each of these applications it is necessary to choose the right irradiation intensity and the time of the concentrated energy performance.

Laser, one of the greatest inventions in modern physics, is a quantum amplifier of electromagnetic wave motion based on mutual interactions of mass and radiation. This short definition determines laser for the field of material cutting and heat treatment. During laser year laser has spread in almost all fields of science, engineering and art. The development in field of the laser technology has led to increase of investments for technological lasers used in manufacture when comparing with investments for purchase of laser for research. This way technological laser has come to the production. At present it is assumed that in the field of material processing work about 25 000 lasers in the world. For material processing from constructional and kinematic point of view suits the best CO2 laser with fixed laser system and moveable cutting optics numerically controlled in two or three axes. For machining of polymers the sufficient output is up to 1 000 W, for metals the appliance with the cutting output up to 2 500 W.

Laser technological workplace determined of cutting consist of heavy-duty CO2 laser with the output up to 2 500 W (technological laser in UTB Zlín has continual output 400 W), heavy-current part o laser and light - current adjustable part. The outgoing laser beam is rectified by collimator and enters into closed space of the machine, where is rectified by the system of mirrors on cutting optics.

Computer in two axes controls the worktable motion (see Fig. 1). Products of combustion are evacuated from the workspace of laser appliance by compressor into air through separator. The appliance control enables design and graphical representation of formed workpieces in CAD system and continual cutting according the control program. The appliances are equipped also with numerically controlled copy device.

Laser machining is based on the use of photon erosion. The cause of melting, evaporation and chip flow is monochromatic and coherent radiation with very low divergence and high output concentrated on a small area, it means with high density of energy (up to $10^7 – 10^9$ J.mm^{-3}). The temperature highly exceeds boiling point of material ($10^5 – 10^6$ K) while cutting, which causes vigorous evaporation of material and entraining of melted layer. In the case, when active gas is used for blowing, additional oxidation of workpieces material occurs, which produces additional heat and makes the machining more intensive. Separation and transport of chips take in the average $10^{-3} – 10^{-4}$ s.

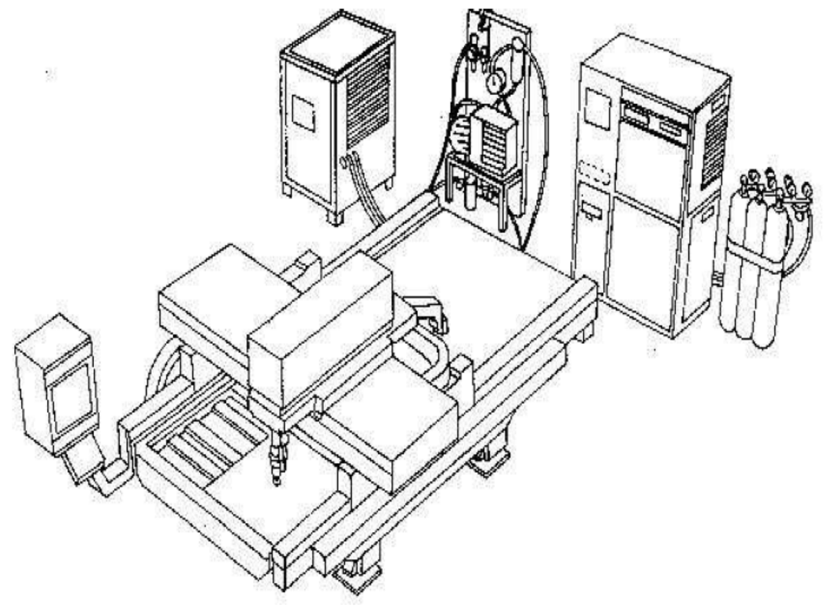

Figure 1. Arrangement of technological workplace for laser cutting

The workplace in UTB Zlín is able to monitor the effect of technological conditions on the output parameters of laser cutting. At present, the work on completing this equipment continues. In the design and production areas we have implemented and tested device for cutting samples during rotation, which can bring some effect when put into practice, and a device for laser cutting materials in different angles, which enables to measure reflectance of the laser beam during angular cutting.

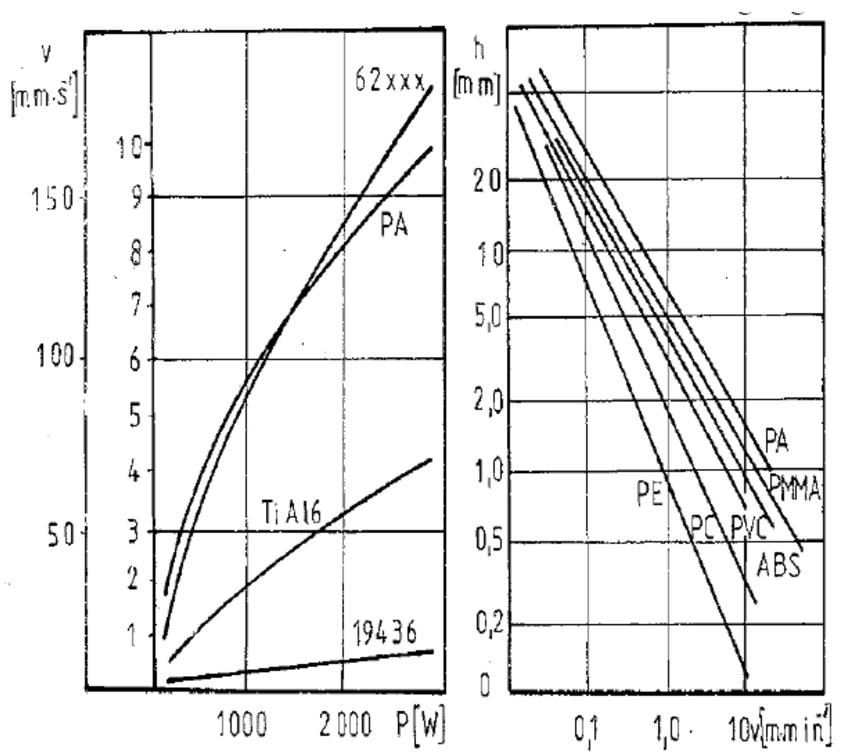

Figure 2. Results of laser cutting for some metals and polymers

Defining and determining of laser workability is a big problem. More 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. These diagrams are shown in Fig. 3. 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. 2 and Fig. 3. 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 laser workability of wood is also very good and the last but not the least the workability of titan, titan alloy, heat resisting materials, Nimonics etc. Especially advantageous are the combinations of laser with conventional machines and robotization of this technological process. The efficiency of this modern technology is significantly improved.

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.

Nowadays, we can see ever increasing use of non-metals materials especially polymeric materials. Processing temperatures of these materials are much lower than in case of metals so temperature degradation of these materials is indispensable. Thermal and thermal and thermaloxidation stability of these materials is a crucial factor for manufacturing considerations. It is practically impossible to process these materials without special knowledge of their stability in desired manufacturing process. Devaluation of final products caused by degradation processes which take place in processing.

Heat incidence could effect polymers in two ways. At first polymer softs eventually melts. Kinetic energy of polymeric chains is increasing so intermolecular forces are exceeded. It results in compliance or flow of polymer, polymer is easy workable. Some structure changes could also take place.

Certain high molecular substances fall into low molecular products eventually to monomer units without noticeable chemical destruction (depolymerization). Others eliminate some low molecular by-products with destruction. In both cases polymer degradation occurs so thin degenerated surface layer could take place on the laser machined parts.

It is notable that materials difficult for mechanical (conventional) machining have relatively good laser workability. The increase of alloying additions leads to the decrease of thermal conductivity and heat removal from the place of laser beam contact with the material. It leads to more intensive evaporation.

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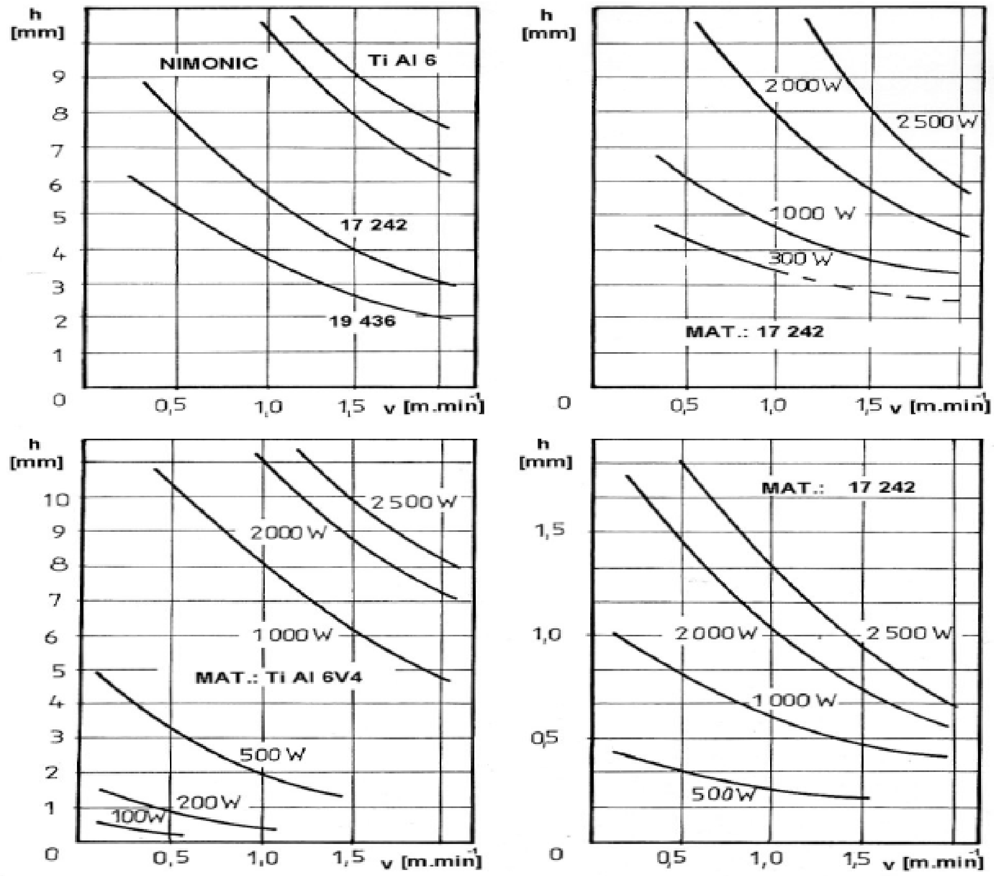

Figure 3 Laser machinability of the difficult-to-machining materials

2. CONCLUSION

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.

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This work has been supported in part by the Ministry of Education of the Czech Republic under grant No. MSM 708352102 Design, Analysis of Processes and Tools for Manufacturing of Polymers.