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LASER PROCESSING

Part of “high technologies” in the industrial production of a country is the most important criterion for assessing its prospects and the most convincing argument for determining its place among other global players. To this one of the “highest” and most significant today are laser technologies, which have recently been increasingly used in industry, so the development of modern production is increasing with the introduction of science-intensive technologies. The use of laser processing of materials allows ensuring the high quality of the obtained products, the specified productivity of the processes, environmental cleanliness, as well as the saving of human and material resources. As a result of the use of a laser beam for processing materials, it becomes possible to make fundamental changes in the technology of manufacturing products [1, c.3].

The era of lasers began in the second half of the 20th century. The quantum generator (or laser in more familiar language) was discovered at that time. It is a source of monochromatic coherent light and is an amazing optical device that avalanche-likely generates photons with the same energy, direction of movement and polarization, that is, it emits a narrowly focused light beam of high power.

Physicists and engineers appreciated this discovery and already in 1962, almost immediately after testing the first laboratory quantum generator, commercial lasers from Spectra Physics (USA) were developed and offered to the market. It was the time of a real revolution in laser technology, as a result of which many modifications and types of lasers have been created and are now successfully used: from the smallest, a few microns in size, to the giant Nova at the Lawrence Livermore National Laboratory in the USA, 137 m long and with a total power of 1014 W.

Thanks to its unique properties (firstly, high radiation power – up to 10^8-10^9 W/cm^2 in continuous mode and up to 10^{16} -10^{17} W/cm^2 in pulsed mode), the laser has become a highly effective tool that allows you to instantly heat (burn) and cool the material at a local processing area without subjecting the entire workpiece to thermal deformation. In addition, the laser beam is easily controlled, that is, it organically fits into any automated systems

Thanks to these advantages, laser technology has penetrated literally into all scientific and industrial fields, firstly, into metalworking. Since the 70th of the XX century, the laser has been successfully used for welding, cutting, surfacing, marking, and hardening of metals. According to statistics of recent years, the world industry uses about 40,000 laser complexes with a total cost of up to $1.5 billion. At the same time, laser technologies have become priority directions in communication and information processing systems, in optoelectronics, biology and medicine, in measurement systems, and in scientific research.

The reason for the active introduction of lasers into all spheres of modern civilization is that this technology is truly “high”, one that largely determines the overall level of technological development. In the near future, further expansion of the scope of application of laser technologies in mechanical engineering (laser processing of materials), photochemistry, micro- and nanotechnology, telecommunications, optical processing and information recording, medical diagnostics, surgery, and environmental monitoring is expected [2, c.54].

Lasers are classified into: 1) Solid-state lasers on luminescent solid media (dielectric crystals and glasses); 2) Semiconductor or diode lasers have an amplification medium based on semiconductors; 3) Lasers based on dyes – a type of lasers that uses a solution of fluorescent dyes with the formation of broad spectra of organic dyes as an active medium; 4) Gas lasers – lasers whose active medium is a mixture of gases and steam; 5) Gas dynamic lasers – gas lasers with thermal rolling, in which population inversion is created between excited vibrational-rotational levels of hetero nuclear molecules by adiabatic expansion of a gas mixture moving at high speed (more often N_2+CO_2+He or N_2+CO_2+H_2O, the working substance is CO_2); 6) Excimer lasers are a type of gas lasers that work on energy transitions of excimer molecules (dimers of noble gases, as well as their monohalides), which can exist only for a while in an excited state; 7) Chemical lasers – a type of lasers, the source of energy for which are chemical reactions between the components of the working environment (mixtures of gases); 8) Free electron lasers – lasers whose active medium is a stream of free electrons that oscillate in an external electromagnetic field (due to which radiation is produced) and propagate with relativistic speed in the direction of radiation; 8) Fiber lasers – the active medium and possibly the resonator of which are elements of an optical fiber; 9) Other types of lasers, the development of the principles of which is currently a priority research task (X-ray lasers, gamma lasers, etc.) [2, c.56].

Types of laser processing include: 1) laser cutting of metals; 2) laser oxygen cutting; 3) laser cutting of materials in pulse or continuous mode; 4) laser welding; 5) marking and engraving; 6) micro- and nanoprocessing [2, c.60].

Laser equipment used for cutting is classified by radiation sources and output power, which in turn determines the material being processed. As a rule, modern equipment for laser metal cutting consists of:

– a laser with cooling and power systems;
– coordinate table for fastening the workpiece;
– computer system of table control;
– technological gas supply device;
– ventilation system [2, c.63].

One of the main processes of obtaining workpiece or parts in mechanical engineering is metal cutting. Traditionally, mechanical methods are used, the main disadvantages of which are low productivity, low stability of the cutting tool, as well as the difficulty, and sometimes the complete impossibility, of multi-shaped cutting along circular and curvilinear contours. Methods based on physicochemical action on the material (gas, gas-electric, plasma cutting) are also not without significant drawbacks, the main ones being low accuracy, significant thermal impact.

High-precision electroerosion cutting allows you to produce parts of any geometry, but its disadvantages are low productivity and high technological complexity. Due to high accuracy and complex contour opening, today laser technologies are in many cases the best alternative to the methods presented above. Laser cutting is based on local heating, melting, and vaporization of the material by a focused laser beam. It is possible to carry out both through cutting and applying lines, obtaining grooves, etc. The use of lasers for cutting metals and non-metals has the following advantages compared to the above traditional methods, namely:

– A wide range of processed materials: carbon and alloy steels, including corrosion-resistant ones; aluminum, titanium, copper, and their alloys; non-metallic materials – ceramics, graphite, wood, plywood, thick cardboard, sandpaper, rubber, glass, various types of plastics, minerals, leather and other materials.

– The possibility of obtaining thin cuts, including curved ones – with sharp corners, thin bridges, transitions without radius.

– Insignificant dimensions of the zone of thermal influence. The mechanical properties of the metal in the laser cutting zone practically do not change, and scale formation is reduced to a minimum.

– Chemical purity of the cutting process.

– The possibility of automating the process and obtaining high productivity.

– The possibility of cutting according to a complex profile in two and three dimensions, including volumetric cutting using high-tech fiber optic systems. The geometric shape of the parts and the level of complexity of the contour of the product, which are designed for laser cutting, are actually not limited.

– High indicators of accuracy and quality of the received products. The use of a laser is especially justified in those cases when it is necessary to manufacture complex parts in small series and a large nomenclature.

The most effective is laser cutting of materials of this thickness: steel – from 0.2 mm to 30 mm; aluminum alloys – from 0.2 mm to 20 mm; copper alloys – from 0.2 mm to 15 mm; non-metallic materials – up to 50 mm. Compared to many types of equipment used in production, the cost of laser cutting equipment is still quite high, although recently there has been a tendency to decrease it. Laser cutting, which takes place in the evaporation mode, is carried out under conditions of high intensity of laser radiation (1010 ... 1012 W/m^2), which is implemented in the mode of short laser pulses of nanosecond and picosecond duration. In this case, the radiation power density exceeds the volumetric evaporation flux density. The destruction products in the channel of the cut are mainly in the vapor-gas phase and are removed from the channel due to the energy and pressure of the vapors. This mechanism requires high energy consumption and is carried out only for fairly thin metal. In order to significantly reduce energy consumption, increase the thickness of the processed metal and cutting speed, that is, to intensify the process and expand its technological capabilities, an auxiliary gas is used, which is supplied to the cutting zone. Such cutting is called gas laser cutting. By its nature, this technology is combined (hybrid) [3].

Therefore, laser technologies are at the very beginning of their evolution and continue to improve due to the introduction of new economic and high-power lasers, light guides, delivery schemes to the workpiece and other innovations. Specialists distinguish the following areas of development of laser processing:

– expansion of the types of processed materials (special alloys and non-metallic materials), in particular materials that work in extreme operating conditions, stable in chemically aggressive and radiation-laden environments;

– increase in the range of thickness of materials;

– improvement of technological quality of processed materials and created products;

– development, creation and bringing to the level of industrial serial application of a new type of processes [2, c.65].

REFERENCES

1. Афанасьєва О.В. Лазерна поверхнева обробка матеріалів: монографія / Афанасьєва О.В., Лалазарова Н.О., Федоренко Є.П. – Харків: ФОП Панов А.М., 2020. – 100 с.

2. Інтегровані технології обробки матеріалів [Текст]: підручник / Е.С. Геворкян, Л.А. Тимофеєва, В.П. Нерубацький та ін. – Харків: УкрДУЗТ, 2016. – 238 с.

3. Пупань Л.І. Лазерні технології у машинобудуванні: навч. посібник для студентів спеціальності «Прикладна механіка» денної, заочної та дистанційної форм навчання / Л.І. Пупань. – Харків: НТУ «ХПІ», 2020. – 109 с.