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FACTORS AFFECTING THE ACCURACY OF LASER CUTTING PARTS

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Keywords: quality, accuracy, processing modes, laser cutting, laser power, laser beam diameter, error, focusing processing modes workpiece parameters.

Abstract. The article deals with the problem of ensuring the required quality of parts during laser cutting. The main factors and parameters affecting the accuracy and quality of parts obtained by laser cutting are considered. Technological methods are presented to ensure the required quality of processing with optimal performance.

ФАКТОРЫ, ВЛИЯЮЩИЕ НА ТОЧНОСТЬ ОБРАБОТКИ ДЕТАЛЕЙ ЛАЗЕРНОЙ РЕЗКОЙ

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Ключевые слова: качество, точность, лазерная резка, мощность лазера, диаметр лазерного луча, погрешность, фокусировка режимы обработки, параметры заготовки.

Аннотация. В статье рассмотрена проблема обеспечения требуемого качества деталей при обработке методом лазерной резки. Рассмотрены основные факторы и параметры, влияющие на точность и качество деталей, получаемых при обработке лазерной резкой. Представлены технологические приемы, позволяющие обеспечить требуемое качество обработки с оптимальной производительностью.

The use of laser cutting complexes for cutting materials of relatively small thickness (up to 20 mm for steel) is one of the most productive and promising areas, which is widely used in such industries as the electrical industry, instrumentation, shipbuilding and many others. Also effective is the use of laser cutting technology in pilot production or at the stage of development of new products, when it is especially important to reduce the time of development of products.

The main directions of the development of laser technology are to increase its efficiency and achieve high indicators of cut quality [5]. Despite the large amount of work devoted to laser cutting, there are still no sufficiently reliable methods for predicting cutting results. This is explained not only by the complexity of the processes occurring during cutting, but also by a large number of factors unrelated to the processing modes, but significantly affecting the final result.

In connection with the above, it is relevant to review the factors that affect the quality of manufacturing parts by laser cutting.

The quality of manufacturing parts by laser cutting is determined by the following indicators: accuracy, roughness, non-perpendicularity (wedge-shaped), length of the heat-affected zone, cutting width, lagging of the cutting line, the amount of burr (sagging on the lower edge of the cut metal), radius of melting of the upper edge [3].

These indicators depend mainly on the energy and optical parameters of the installation, machine parameters, processing modes and parameters of the workpiece.

The main energy parameters of the laser include:

– power density;
– laser power;

The main optical parameters of the installation include:
– the diameter of the beam at the exit from the laser resonator;
– the divergence of the laser beam;
– mode composition of radiation;
– the shape of the power density distribution over the beam cross section;
– degree of radiation polarization.

Machine parameters are defined by:
– the error of mechanical components;
– the error of the control system;
– the error of the optical system;
– the error of the electric drive.

Processing modes include:
– cutting speed;
– type of gas;
– focus position;
– gas pressure.

The parameters of the blank can include:
– the thickness of the workpiece;
– material;
– the condition of the workpiece surface;
– the geometry of the workpiece.

Let's consider the influence of the above parameters on the accuracy and quality when processing parts by laser cutting.

Depending on the type of material, different laser power is required to achieve the optimal result. The laser power is an interrelated value with the cutting speed. In some cases, a convenient value that characterizes the quality of the process is a complex parameter, which is the ratio of the radiation power to the cutting speed P/v_p or P/h (where h is the cutting depth of the metal).

The basic laws of laser cutting are qualitatively described by the Swift - Hook - Geek theory. So, with high efficiency of laser cutting, this theory gives a simple relationship for energy balance:

$$h v_p b(c\rho T_{пл} + L_{пл}) = \eta P\ ,$$

where P - total laser power, η - the efficiency of the process, $L_{пл}$ - specific energy of metal melting.

If we assume that in laser cutting, the cutting width is equal to the diameter of the laser beam, then it follows from the formula that v_p is directly proportional to P at $h = const$ [3].

An important factor that determines both the nature of the metal cutting process and the dimensional characteristics of the cuts is the power density in the zone where laser radiation affects the material. This parameter is a complex variable and depends not only on the laser radiation power, but will it get focus, mode structure of the beam, its divergence, beam diameter at the exit of the cavity, and other factors.

The optical parameters of the setup and the focusing system are largely interrelated, since they determine the diameter of the focusing spot, which in turn determines, together with the power, the power density of laser radiation. When choosing focusing systems, it is necessary to solve problems related to the mode structure and geometry of the focused beam, the choice of the focusing lens, and the localization of the beam focus relative to the surface of the processed material.

The mode structure is determined by the choice of the beam shape, which depends on the type of laser, the resonator circuit, the pumping mode, and the use of intracavity diaphragms. A spot of minimal size with a diameter of the order of the wavelength can be obtained by focusing beams in which the power density distribution over the cross section obeys the Gauss law.

The focal position of the laser beam also significantly affects the cutting process. It is necessary to set the optimal focal length for each specific processing process, as it affects the shape of the resulting cut and the scale sticking.

It is also required to determine the focusing lens suitable for the task at hand, since the spot diameter and focusing depth depend on the focal length of the lens. To reduce the difference between the cut width at the top and bottom (slope), it is necessary to minimize the spot diameter. Decreasing the focal length of the lens results in less slope when cutting thin sheets.

A significant influence on the machining accuracy have preset settings, such as thickness and grade of material, as its surface, the geometry of the loop.

Shiny material surfaces, such as pure aluminum, lead to strong reflections of the laser beam and poor cutting results. A layer of scale, paint and plastic coatings on the surface of the sheet also impairs the cutting results. Rough and matte surfaces ensure high cutting speeds. The thin oil layer often present on the sheets often improves the cutting quality.

Some structural elements of parts (thin bridges, sharp corners, small holes, etc.) cause a number of difficulties during laser cutting. They must be processed with a reduction in power and cutting speed, as well as the pulse repetition rate.

When processing sharp and right angles, "loops" (Fig. 1) or small radii of rounding (0.1-0.2mm) are added. If the part is saturated with structural elements, technological stops are used to remove heat. Particular attention is paid to the processing sequence of the elements: for better heat dissipation, smaller elements should be processed first, then larger ones. To prevent the cutting head from colliding with the raised part after cutting, technological "jumpers" are used.

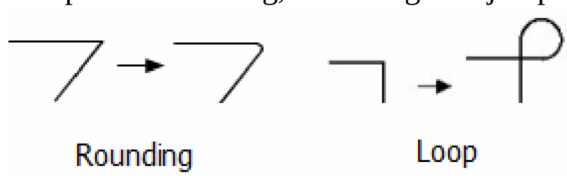

Fig. 1 Technological elements during laser cutting of a part

In addition to these parameters, the accuracy and quality of the surface of the parts after laser cutting is affected by the presence of vibrations of the workpiece during the cutting process. This is especially true for thin sheet materials (up to 1mm thick). Therefore, if you need to manufacture parts with high accuracy requirements (10-12 quality), you need additional technological equipment to secure the workpiece during its processing.

Based on the above, it can be seen that laser cutting is a complex process, which is influenced by a large number of factors. Therefore, only careful study and correct collection of all process parameters allow you to obtain parts of the required quality with optimal performance.

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