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Laser Thermal Hardening

TuychiyevAbdumalikTursunovich
Assistant of Andijan Mechanical Engineering Institute
abdumaliktuychiyev1961@gmail.com
tel. +998 90 544 67 14

Annotation. This article is about the most advanced types of laser technology in Mechanical Engineering and their application. This article is covered about several types and the principles of performance are explained.

Keywords. machinery, laser, technology, modern cutting machines, digital techniques.

Introduction

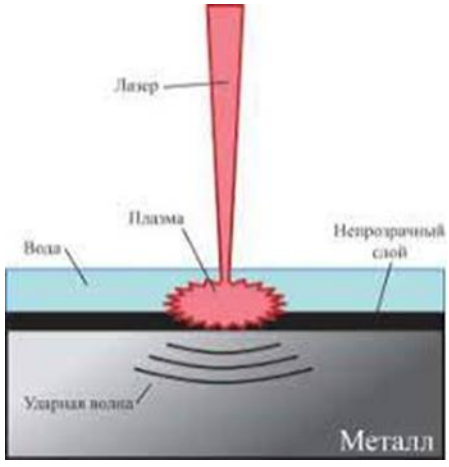
The development of industry is inextricably linked with the creation of new materials with high technical and economic indicators. One of the most important tasks of mechanical engineering is to improve the mechanical characteristics of metal parts operating under wear conditions. An effective solution to this problem lies in the introduction of modern technological methods to ensure the optimal condition of the surface layer of the material

Currently, it is impossible to imagine the manufacture of parts without finishing hardening treatment. With its help, you can increase the strength characteristics of any metal. Depending on the composition and purpose of the workpiece, it can be subjected to various types of hardening treatment such as: annealing, quenching, aging and chemical-thermal treatment, as well as surface hardening by laser. In our article, we will talk about laser hardening of the surface of titanium alloys.

Material and Materials.

Titanium products are most often used in aviation and rocket engineering. For example, the most labor-intensive is the production of monowheels, which are a disk with blades for air intake, as well as the manufacture of individual blades. Everyone knows that residual stresses after cutting the blades can bend the blades, rendering the product unusable. And since titanium is not a cheap metal, such a marriage will cause serious damage to the enterprise.

To remove residual stresses, heat treatment of finished products and laser gluing are used to increase the strength of the surface. To relieve stress, titanium products are most often annealed. Vacuum annealing is widely used, which reduces the hydrogen content in titanium alloys, which leads to a decrease in the tendency to slow destruction and corrosive cracking. To relieve small internal stresses, incomplete annealing is used at 550–650oC deg. Titanium alloys have low wear resistance and, when used in friction units, are necessarily subjected to either chemical-thermal treatment or laser riveting (Figure 1).



Drawing.1.Laser incline

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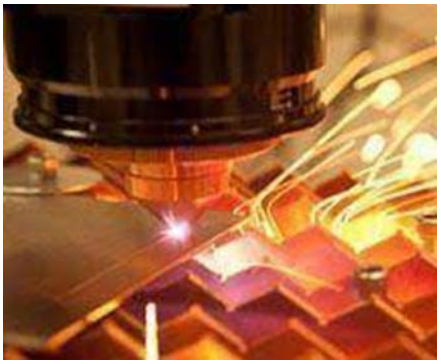
Results

In the most traditional case, the riveting is obtained in the process of cold forging, when a massive striker methodically strikes the hardened metal surface, deforming it in places. This method of metal hardening has been known for several hundred years. The continuation of this technology, when it became possible to process details of complex shape, is the "bombardment" of the metal surface with metal balls. With such processing with a special shot, with a high feed rate, the surface acquires the necessary mechanical characteristics and even becomes significantly less susceptible to corrosion. These are reliable installations that have been used for more than a decade, their productivity is sufficient to carry out hardening on an industrial scale. However, there is also a more advanced surface hardening technology using a similar method — using a powerful solid-state laser as a bombardment source. This technology is somewhat similar to plasma spraying, but only partially. The radiation from such a laser has outstanding indicators in terms of pulse energy and the frequency of "bombing". The very first experiments on strengthening the metal surface with a laser were carried out in the 90s. But with the method of hardening with steel balls, lasers were able to compete recently, when really powerful laser energy sources became available. In industry, a laser for surface hardening was first used in the manufacture of turbine blades for aviation equipment. These are thin-walled parts of complex shape, so a more "delicate" laser hardening has become preferable for them than standard hardening with balls. Currently, laser hardening is already used not only in aviation, but also in advanced automotive (for processing chassis parts, gearboxes) and medical industries (strengthening knee and hip implants). Laser hardening uses pulses with high intensity — up to 10 * 10 W / cm2, which allows you to create a powerful shock wave directed at the material being strengthened. In detail, this process looks like this: two layers are applied to the hardened surface before processing, one of which absorbs laser radiation — this is the lower layer adjacent to the metal, and the second layer is transparent, it is on the surface. A special paint is used as an absorbing layer, and water is usually used as a transparent layer on top. The laser beam directed at these layers passes unhindered through the water and begins to intensively evaporate the second, lower layer of paint. However, at this time, the water layer begins to prevent the sharp formation of gas from the evaporating lower layer. Accordingly, the energy from the resulting gas interacts in the opposite direction from the water layer, i.e. in the direction of the metal, strengthening it in this way. Because the whole process described above takes place extremely quickly, then the hardening effect is very noticeable, and the hardening depth can reach 1 mm (when hardening with metal balls, the depth of 0.4 mm was considered the limit) (Figure 2.)



Drawing.2.Laser hardening of the metal surface

Discussion

As a result of many experiments and research on this topic, there has been a tendency that one "superbug" with an energy of 50 J or more, which will process 0.5 cm2 at a time, it is more expedient to replace several beams covering only 1.5 mm2, but working much more intensively. This way allows you to repeatedly reduce the cost of the design, make it more productive in the conditions of existing production. If one large laser fails, the installation will become inoperable, and the breakdown of a small laser in a system of dozens of the same will not particularly affect the system's performance (Figure. 3).

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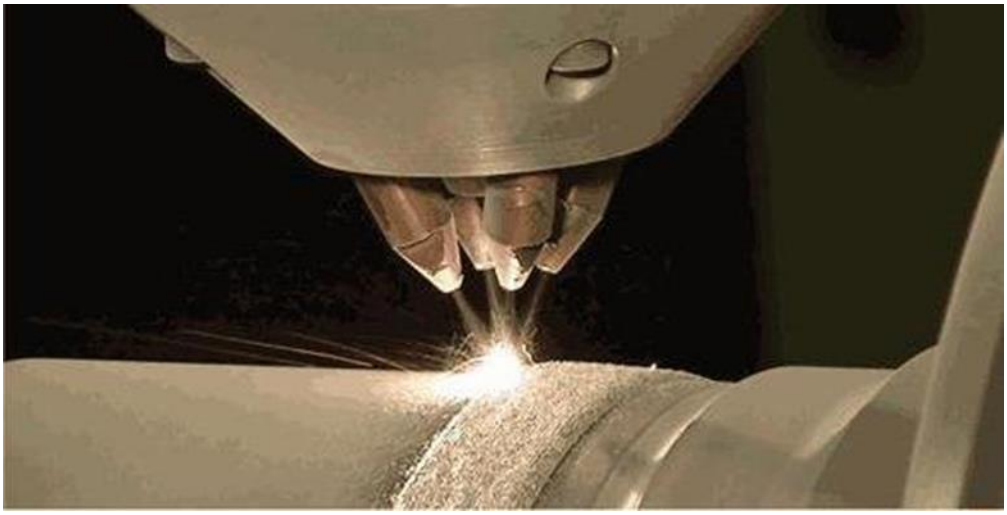

Drawing. 3. Treatment with 4 laser beams

The advantages of laser hardening are a reduction in the volume of additional processing and the possibility of processing inhomogeneous three-dimensional workpieces. Due to the insignificant thermal effect, the deformation remains at a limited level, the costs of additional processing are reduced or do not arise at all.

Conclusions.

It is obvious that laser surface hardening significantly improves the strength characteristics of metal alloys. This article provides an overview of the method. Currently, laser hardening is used in the structure of the processing of chassis parts, as well as gearboxes, etc. In the following articles, it is planned to conduct a number of studies of the surface layer of various grades of titanium, as well as at various parameters. Investigation of strength characteristics for each of the modes selected experimentally.

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