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Comparison Metal Water Jet Cutting with Laser and Plasma Cutting

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Abstract

The main objective of this paper is to select the best technology for cutting metal. In this article i will briefly discuss the different ways of cutting metal, such as water jet cutting, as well as laser and plasma cutting. These techniques and their comparisons are illustrated in a table to highlight the differences between them. Further comments are then provided on the key aspects of this comparative method, leading to the appropriate conclusions, which responds to the seemingly simple question: Which technology is best suited to cutting metal?

Keywords: abrasive water jet cutting; laser cutting; plasma cutting; economy of metal cutting

1. Introduction

Nowadays, we used many different materials for the production which generally have to be respectively formed by a more or less complicated cutting operations. In this article, I will focus attention on three ways of shaping the workpiece materials, namely: water jet cutting, laser and plasma cutting. These methods will be compared only in terms of cutting metals, which significantly reduces the scope of discussion and at the same time doing their precision. In the literature I have not found a good comparison of these three techniques cutting simultaneously. They were the only preliminary statement without much description [9,10], or comparing only two techniques [7,8,12].

In this paper I would like to move a following problem, which of these three technique is best suited for cutting metals. This is only a seemingly easy question that I will try to answer in this article. My objective is to find the treatment that will be the most versatile, relatively inexpensive and environmentally friendly. First present a brief description of each of the cutting methods. Summary table in the form of positive and negative qualities which I

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selected. The table will be used to compare methods of cutting in 5 categories. In this article I would like to focus on the comparison of versatility these techniques, environmental friendliness, and whether there are restrictions on the thickness of the cutting material. In addition, I will examine how these three techniques affect the workpiece material, for example comparing quality of the cut surface. At the end of my paper I compose ease of software machine and selection of cutting tools.

2. Water jet cutting

Water jet is the method consisting of cutting the material (or a water jet can relate to cleaning it) by the use of thin water jets under high pressure with added abrasive slurry used to cut the target material by means of erosion. [22] The technique with using high pressure water for cutting materials was first time patented in 1968 by researcher in USA, but fast development of water jet cut method was starting in early ‘80s. [18] Today is a rapidly developing technology, that is used in industry for processing variety of engineering materials. It is an emerging technology, which has many advantages over the other non-conventional cutting technics. [20] Often, in order to improve the performance of the process additive is used in the form of abrasive grains of garnet, which allows cutting of very hard materials. The correct name of this technology is so cutting hydro-abrasive treatment (abrasive water jet). The figure 1(a) shows the abrasive water jet cutting system.

Cutting process can be described briefly as follows. The water fed by a pump under pressure, after passing through the water causes the suction nozzle to the abrasive mixing chamber. Then a mixture of water and abrasive is directed to the mixing nozzle in order to form and stabilize. [15] The result is a stream of hydro-abrasive, which has enough power to cut through even the toughest materials.

Water jet we can applied in many areas of modern industry, such as automotive industry, aerospace industry, construction engineering, environmental technology, chemical process engineering, and industrial maintenance. [1] Typical water jet cutting machines have a working space from few square feet to hundreds of square feet. In this moment the high pressure water pumps are available from 276 MPa up to 689 MPa. [2]

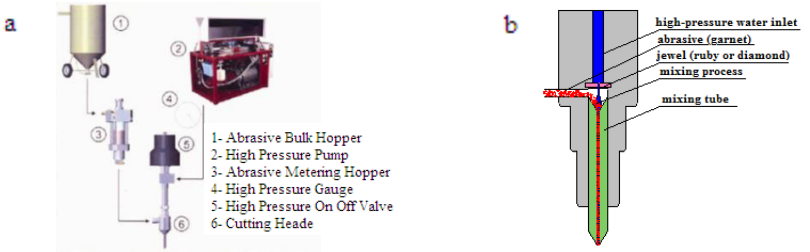

Fig.1. (a) abrasive water jet cutting system [6]; (b) the principle of operation of the abrasive water jet nozzle.

3. Laser cutting

Laser cutting is a technology, which enables a laser to cut of various materials using the high-point of the cutting jet by the introduction of energy and technical gas of high purity. Laser radiation is characteristic, and thus practically unattainable by other methods. Gets plenty of power here in the choice, but a very narrow area of the spectrum. Its characteristics include consistent in time and space radiation, and the most polarized beam with low divergence. [3] Depending on the cutting device is carried out in three ways: by burning, melting or sublimation.

Creation of the laser beam generally involves stimulating a lasing material by electrical discharges or lamps within a closed container. The beam is reflected internally through a partial mirror, until it achieves sufficient energy to escape as monochromatic coherent light. Generally, the narrowest part of the focused is less than 0.32 mm in diameter. Of course, taking into account the thickness of the material, the width of the gap as small as 0.10 mm are possible.

4. Plasma cutting

Plasma cutting is basically a process that is used to cut generally steel and sometimes other metals of different thicknesses. This process consists of metal melting, and then disposing of the cut metal from the slot. This is done by means of a concentrated plasma arc, having a large kinetic energy. [11] In fact, plasma cutting uses a high temperature that prevails in the core plasma arc and high speed plasma stream. The electric arc is formed between the tungsten electrode and the cut object. Principles of its formation is as follows: by passing the gas stream in the compressed form of the arc for the phenomenon is a result of ionization and high power density is possible to produce a stream of plasma. The most commonly used gas plasma cutting is air and also in high-power devices used argon, nitrogen, hydrogen, carbon dioxide. [11], [13] Plasma arcs are extremely hot and are in the range of 25 000 ° C. Due to the high temperature plasma cutting edge of a destructive influence on the confluence. This method we can usually cut from 50 mm to 150 mm thick. This is a large range of metal cutting.

Fig. 2. (a) the principle of operation of the laser nozzle; (b) the principle of operation of the plasma nozzle.

5. Comparison of water jet, laser and plasma cutting

From the table it can be concluded that the best solution is abrasive water jet cutting, as in many categories is better than other methods. However, this is not the end of obvious. First, there are compared in table 1 the all parameters, and besides, it is often the case that we are only at certain properties and only those selected represent real value for us. Below I compared three different methods for metal cutting in areas that I think are crucial. Each of the six categories, which compares the begin of a new paragraph, preceded by an additional way of describing the selected issue comparisons.

Table. 1. Comparison of cutting methods. Marked in blue the best solution [5],[7],[9].

method of cutting	abrasive water jet	laser beam	plasma beam
speed	slow	fast	fast
material thickness	thick and thin	thin and medium	medium and thick
size details	small and large	small and large	large
shapes	complicated	complicated	simple
materials suitable for intersection	most of solid	homogeneous with no reflective bodies	metals and conductive materials
materials covered with rust	very good	good	average
composites	yes	no	no
material hardening	no	yes	yes
thermal deformation	lack	yes, small area	yes, wider area
hazardous vapors	no	yes	yes
multilayer cutting	possible	impossible	impossible
precision cutting	high	higher	good
burr formation	minimal	yes	yes
operating costs	topmost	lower	lower

Versatility of technique cuts, that means economy cuts.

Water jet cutting as compared to laser and plasma technology is primarily a more versatility. We cut here virtually any type of material, are not so restricted as in the case of a laser to homogeneous materials which do not reflect light, or as in the case of the plasma to the conductive material. For example, a perfect choice for cutting stone of varying thickness, shape and properties. [21] Due to the small cutting force ceramic does not break, when cutting of complicated shapes. [19] Here, there are quite a lot (in terms of waterjet technology) limitations on cutting speed, but keep in mind that this technology does not release harmful gases, UV radiation and other hazardous substances harmful to the machine operator. Technology same water jet cutting is so safe that we can use it to cutting food. Strength cutting head is relatively large, and the price of water - the basic cutting agent low. Texture of cut material here does not affect the quality of the processing, as is the case with the laser, where it may lead to distortion of the beam. You may also cut highly reflective materials such as aluminium and copper, and the cutting of holes does not make too much trouble here as in the case of plasma cutting.

Environmentally friendly treatment.

Ecology in a world of dwindling resources is a very important subject, therefore I would like to a more mention here about waterjet technology, which is the most environmentally friendly. Water is a chemical compound that occurs widely on Earth. Other necessary feedstock for cutting water are garnets. These are a group of silicate minerals. Garnets possess very similar physical properties and crystal forms but different chemical compositions. [4] It occurs quite frequently in the environment. In abrasive water jet technology water taking part in the cutting process can be used repeatedly, and abrasive, which is usually in the form of natural material garnet can be recycled after use. As mentioned above, do not emit here also no hazardous fumes [14] as is the cutting beam or plasma. An additional advantage of ecological and economical here is very small cutting gap without raising additional material consumption. If conditions allow the waste can be used to further the machining process, because it is not thermally deformed.

Unlimited thickness of the cut material

One of the greatest advantages of hydro-abrasive machining, compared to the technique of laser cutting of materials is the possibility of limited practical geometry of the machine. It is mainly about cutting materials over 30 mm, where the waterjet works very well, and lasers are starting to have the first problem. When we continue this thought and move on to more than 100 mm cut material, it turns out that the hydro-abrasive machines are already unbeatable compared to laser technology, and it is not yet the end of their ability. Please note that, as usual, the thickness of the cut material is associated with a relatively longer duration of cutting, which should also be taken into account because it is not the fastest cutting techniques. Compared to laser plasma seems to be more universal, because it can be used to cut materials in the range from 0.5 mm to about 160 mm. [12] However, as the thickness of the material also increases the wear of the electrode.

No thermal deformation of the cut material

Another important advantage of water jet machining is the lack of any thermal deformation of the material being cut, and thus no melted edges. [8] The temperature in the vicinity of the treatment increases in small areas as compared to other methods, and the process further location in the water, will accelerate the removal of heat from the treatment zone. [2] As a result, the amount of heat generated at the cutting does not affect in any way the shaped material. For these reasons we can declare that the structure was preserved, because no significant change in the existing structure. [16]

The quality of the cut surface

The structure of the cut surface in waterjet machining has a very high quality. The edges are rounded here, and additionally are not formed burrs. This results in a lack of need for a finishing process, which can significantly shorten the duration of the production of parts, and allows you to reduce the number of machines. [17] Water jet machining this is a way to cut without heat Interactions. The lack of high-temperature cut material is not distorted

area at near cut, so you do not need to use excess material that must then delete. It is the preferred method when the materials being cut are sensitive to the high temperatures generated by other methods. [10] Little downside hydro-abrasive technique is less precise cuts and relatively large compared to the noise in the laser cutting. However, the worst falls here plasma technology, which is both highly inaccurate and loudest.

Easy programming of the machine

Both the water jet machining, laser and plasma cutting can be easily attached the starting material. In water jet cutting the cut object is laid directly on a special grid, which prevent to the object from falling into the tank with water. In the absence of forces which could move the workpiece is used specific weights or fixtures. All compared treatment techniques are easy to program, which practically consists of the appropriate cutting path planning. There is no a problem choice of tools. With the right software it is possible to determine the shape of the cutting time.

6. Conclusion

The problem discussed in this article was which techniques (out of water jet, laser and plasma) is best suited for the cutting of metals. In trying to answer this question, I divided the three techniques into categories and selected the method with the best outcome. I displayed the results in a table in which the colour blue illustrates the most effective solution in each category. After analysing the results, I found that the most efficient way of cutting metal was by using the technique of water jet technology. This is supported by the following proposals: The first that water jet cutting is the most versatile method for the separation of materials, and that this technique can cut through almost any material such as steel, stone, ceramics, aluminium, glass, wood, plastics, laminates, etc. There is no limit related to current conductivity and reflection of light. The second is that this method of cutting is an environmentally friendly process that does not produce any harmful fumes. The only materials used are water and the abrasive. The third is that the water jet technique can cut thick as well as thin materials which is not the case with other methods which are only successful when cutting to a certain thickness. The fourth is that compared to laser and plasma cutting, water jet cutting material is a method by which there are no thermal deformation of the cut material. The fifth is that the structure of the cut surface's hydro-abrasive technique is of a very high quality in that the edges are rounded and the burr is virtually non-existent.

The last comment is that the abrasive water jet is not the quickest way to cut, and a long time spent cutting increases the cost of cutting. From these findings it is clear that the water jet technique is the most suitable of those compared for cutting metals. This statement is consistent with the authors and their literature which is cited within and has been used as research for this article. In the next article I would like to attempt to expand my studies of technique comparison to include other materials such as marble, stone and ceramics.

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