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NEW HIGHLY EFFICIENT METHODS OF MACHINING METALS

The requirements to quality and reliability of mechanical parts are constantly increased. New highly efficient methods of machining metals are used for increasing the firmness of details to the wear, resistance to corrosion to the action of aggressive substances and improvement of other operating indexes. These machining methods have already found wide application in a modern engineering, such as the electrophysical and electrochemical machining methods. This article deals with such new highly efficient machining methods of metals as electrical discharge, ultrasonic, beam and electrochemical machining methods.

Main advantages of these methods are:

− possibility of machining of difficult form parts with playback of instrument form;

− a capacity to treat of materials of any hardness and viscosity;

− possibility of machining of the curvilinear and spiral holes, producing of the very small holes, narrow and deep slots;

− absence of distortions of materials structures;

− possibility to use of instruments, which made of less durable materials than workpiece;

− an increasing of the labour productivity and simplification of equipment during treatment of especially difficult parts.

All types of electrophysical and electrochemical machining methods can be divided into such categories: electrical discharge, electrochemical, ultrasonic, electron beam and combined.

In all these methods of machining removal of assumption is made due to electric or chemical erosion. The general disadvantage of these machining methods is a substantial increasing of energy intensity of processes. It is considered that a technique-economic effect from application of physical and chemical machining methods is that time of machining of the shaped surfaces diminishes in 2-3 times, and difficult surfaces − in 5-10 times comparatively with cutting [1].

Electrical discharge machining. There are such electrical discharge methods of machining as electro-erosive, electro-pin and abrasive-erosive.

Electrical discharge machining (EDM), also known as spark machining, spark eroding, burning, die sinking, wire burning or wire erosion, is a manufacturing process whereby a desired shape is obtained by using electrical discharges (sparks). Material is removed from the workpiece by a series of rapidly recurring current discharges between two electrodes, separated by a dielectric liquid and subject to an electric voltage [4].

Electrical discharge machining is based on the use of the phenomenon of electric erosion that takes place on results the action of impulsive electric digits between an electrode-instrument and by an electrode-billet. There are two types of electrical discharge machining: electro-spark and electro-impulsive.

Electro-impulsive machining is based on the use of impulsive arc digits of large duration (0.1-100μs), large energy (to a few dozens of joules). For reduction of wear of electrode instrument machining in a difference from electro-spark comes true at reverse polarity, i.e., a workpiece is a cathode, and instrument − an anode. Industrial oil, transformer oil and diesel fuel are used as working liquids. Force rolling of working liquid is used for increasing of efficiency of process and reduction of wear of electrode-instrument.

Electro-pin machining is based on mechanical destruction or change forms of metallic surfaces, that is executed simultaneously with heating or melting of these surfaces by an electric current. The feature of this method of machining is the large productivity of process at low quality of machining. Electro-pin machining can be executed in air and liquid environments. A method is used mainly for machining of large size parts, for example, for cleaning out of casting surfaces and welding seams.

Abrasive Electrical Discharge Machining (AEDM), is a hybrid process, in which free abrasive grains are mixed in the dielectric fluid. It is characterized by the mutual assistance of mechanical interaction (abrasion) and thermal interaction (electrical spark erosion). Abrasive Electrical Discharge Machining is executed on a current-carrying copula by means of polishing wheels. Electrolyte is fed between a workpiece-anode and polishing wheel-cathode, a wheel gets rotary motion, and a workpiece − reciprocating. Abrasive Electrical Discharge Machining is widely applied at the flat and round polishing of hard alloys, high-speed cutting, construction and heatproof steel; polishing of profile slots, spherical surfaces; sharpening of cutting instruments [1].

Ultrasonic machining methods. Ultrasonic machining is a subtraction manufacturing process that removes material from the surface of a part through high frequency, low amplitude vibrations of a tool against the material surface in the presence of fine abrasive particles. Ultrasonic vibration machining is typically used on brittle materials as well as materials with a high hardness due to the microcracking mechanics.

There are such ultrasonic methods of machining as size ultrasonic machining and imposition of ultrasonic vibrations on a cutting tool. The ultrasonic methods of machining are based on the use of energy of ultrasonic vibrations frequency from 18 to 44 kHz with intensity more than 10 W/cm^2. The source of ultrasonic is magnetostriction and piezoceramic transformers that work from an ultrasonic generator.

There are such varieties of ultrasonic machining as:

− a free abrasive machining, that is used for the removal of small nicks-and-burrs (less than 0.1 mm) and polishing of small details (by mass 10-20g);

− machining of details made from hard fragile materials by means of abrasive slurry;

− cleaning and greasing of working surface abrasive wheel during the finishing polishing;

− use of ultrasonic vibrations of small amplitude of cutting edge and abrasive cutting tools for intensification of cutting of badly machining materials;

− use of force ultrasonic vibrations of tools for a plastic deformation during surface-strengthening machining [6, p.552].

Beam machining methods. There are such beam methods of machining as laser and electron-beam.

Material is melted and evaporated under the action of energy of beam streams or high-energy streams during use of beam machining methods.

An electron-beam machining (EBM) is a process where high-velocity electrons concentrated into a narrow beam are directed toward the work piece, creating heat and vaporizing the material. EBM can be used for very accurate cutting or boring of a wide variety of metals. An electron-beam machining (EBM) is based on removal of substance under the action of the focused electrons – evaporation or sublimation of substance from a point, an electronic beam acts on which. An electron-beam processing makes possible to process electroconductive and isolating materials with any physical properties [5, p.854].

Laser beam machining (LBM) of materials is done by means of light beam that emanates by an optical quantum generator (a laser). Laser beam machining is applied during cutting sheets of metal made of titanic alloys, non-rusting steels and compositions, and also for welding these materials. This process uses thermal energy to remove material from metallic or nonmetallic surfaces. The laser is focused onto the surface to be worked and the thermal energy of the laser is transferred to the surface, heating and melting or vaporizing the material. Laser beam machining is best suited for brittle materials with low conductivity, but can be used on most materials [2, p.609].

Electrochemical machining methods (ECM). An electropolishing is a machining at small closeness of current and stationary electrolyte. A workpiece is connected to the anode, and a cathode is the metal-plate made from lead, copper or steel. Electropolishing is used before realization of galvanic processes, for the removal of the tempered layer after cutting.

Electrochemical machining is done at small intervals between electrodes and intensive movement of electrolyte. ECM can cut small or odd-shaped angles, intricate contours or cavities in hard and exotic metals, such as titanium aluminides, Inconel, Waspaloy, and highnickel, cobalt, and rhenium alloys [8]. Both external and internal geometries can be machined. ECM is often characterized as "reverse electroplating", in that it removes material instead of adding it. A high current is passed between an electrode and the part, through an electrolytic material removal process having a negatively charged electrode (cathode), a conductive fluid (electrolyte), and a conductive workpiece (anode); however, in ECM there is no tool wear [7, p.198].

This type of machining is used for implementation of such operations:

– calibration, contour machining, removal of nicks-and-burrs, rounding of edges and marking that is done at stationary electrodes;

– copying, broaching, calibration and sharpening that is done at gradual motion of electrode;

– machining of flat and shaped surfaces, circular cutting, that is done at the rotation of cathode;

– machining of the external and internal surfaces, machining of direct and spiral ditches that is done at the rotation of anode;

– cutting by rod and cutting by a tubular-contour method, that is done at difficult motion of electrodes.

Combined machining methods are based on parallel or sequential application of several physical and chemical methods or in conjunction with cutting [3, p.425].

REFERENCES

1. Чучман Ю.І. Технологія машинобудування для електромеханіків / Ю.І. Чучман. – Львів : Видавництво Національного університету “Львівська політехніка”, 2001. – 348 с.

2. Dubey, Avanish. Laser beam machining – A review / Avanish Dubey // International Journal of Machine Tools and Manufacture. – Volume 48. – Issue 6. – 2008. – pp. 609-628.

3. Hassan Abdel-Gawad El-Hofy. Fundamentals of Machining Processes : Conventional and Nonconventional Processes, Second Edition / Hassan Abdel-Gawad El-Hofy. – CRC Press, 2014. – 496 p.

4. Jameson, E. C. Electrical Discharge Machining / *E.C. Jameson* // Society of Manufacturing Engineers : Dearborn, MI, 2001. – 329 p.

5. Kalpakjian, Serope; Schmid, Steven. Manufacturing Engineering and Technology (2nd ed.) / Kalpakjian, Serope; Schmid, Steven. – Pearson Prentice Hall, 2006. – pp. 854–855.

6. Kalpakjian, Serope. Manufacturing Processes for Engineering Materials / Kalpakjian, Serope. – Upper Saddle River, NJ 07458 : Pearson Education, Inc., 2008. – pp. 552–553.

7. Todd, H. Robert. Manufacturing Processes Reference Guide (1st ed.) / Todd, H. Robert; Allen, K. Dell; Alting, Leo. – Industrial Press Inc., 1994. – pp. 198–199.

8. Valenti, Michael. Making the Cu /Valenti, Michael//Mechanical Engineering, American Society of Mechanical Engineers, 2001. – http://www.memagazine.org/backissues/membersonly/nov01/features/makcut/makcut.html