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Applications of laser beam machining pdf

Laser Beam Processing (LBM) is one of the most popular uncons convention processing processes used in advanced processing. From: Modern Processing Technology, 2020Bijoy Bhattacharyya, Biswanath Doloi, Modern Processing Technology, 2020Laser beam processing (LBM) is an excellent material processing technique for machine with a wide range of advanced materials, especially difficult-machine advanced ceramics and composites. LBM can be used to process these materials in complex shapes and sizes that are even more difficult to reach surfaces. Laser beam processing can replace traditional machining for a variety of industrial applications due to the following various advantages. (a) LBM can produce a better finished processing surface and thus eliminate use after final processing;(b)Laser beam can be moved to a remote place for processing hazardous materials such as nuclear fuel rods, etc.(c)LBM. (c) LBM can remove substances from selective areas of the work piece by focusing on the beam;(d)Solvent/chemical is not used during the process, so it is a clean machining process;(e)LBM has adaptable to automation for high efficiency and high-speed machining;(f)LBM is contactless type processing and there is no physical tool. Thus, no processing force or wear of the tool is realized. Machine components do not have mechanically induced material damage and vibration,(g)Complex profiles with high precision can be easily cut with laser,(h)Laser beam processing does not depend on mechanical properties (hardness, fragility, etc.), it depends more on heat and optical properties of the material to be processed to some extent. Therefore, the material can be processed to any degree of fragility or stiffness. Low thermal diffusivity and conductivity materials are particularly suitable for laser processing,(i)Laser beam processing is independent of the electrical conductive nature of the work part. It can process a wide range of materials, from plastic to diamond. (j) The processing of materials with laser is very fast, so the area affected by very small heat (HAZ),(k)Large aspect ratio micro features can be produced together with acceptable accuracy and dimensions,(l)In LBM, less material can be removed from the selected parts of the material. Thus, it reduces material waste,(m)Laser beam processing is a highly flexible processing system coupled with a multi-axis job positioning system or robot. Thus, LBM can be adapted with automation and(n)Provides a wide range of material processing techniques such as laser beam processing, drilling, cutting, groove, scribble, marking, cleaning and turning. Since laser beam microprocessing is a thermal type material removal process, there are also some limitations as below. (i) This requires a high initial investment cost,(ii)The maintenance cost of the LBM system is high and requires skilled operators to carry out various operations,(iii)Efficiency is low compared Introduction to lbm machine laser beam power related to electrical energy. However, the development and research issues of various industrial lasers can improve the efficiency of converting electrical energy into beam energy and (iv)Highly reflective and transparent materials in processing state cannot be processed by laser beam, etc.(v)They have limited applications for thicker materials but are highly applicable for thin-section materials. (vi) Metal removal rate is very low. Bijoy Bhattacharyya, Biswanath Doloi, Modern Processing Technology, 2020Laser Thing is one of the most unpoptent conventional processing processes used in advanced processing. The LBM process was discussed in detail in the previous chapter 4. Laser beam processing is a heat source with different advantages as it can operate any material regardless of its mechanical properties as well as its electrical conductivity. However, melting, evaporation and work part produce some negative effects on processed products, as the material uses heat energy for a period of time ablation. Some of the main disadvantages of LBM are thermal damage, heat-affected area (HAZ), re-cast layer, cracking and melting of molten metal, or re-accumulating, banding effect and dross and splash formation. LBM cannot be processed effectively due to its low ablation rate, as well as high reflective material as well as transparent material. Laser beam processing can help with vibration to improve the performance of the LBM process and overcome the limitations set out above. The use of LBM in the microprocessing range is becoming more acceptable due to its various advantages. Researchers are investigating converting LBM in a way that limitations can drastically reduce. Accordingly, vibration of the work part can prevent surface oxidation and recast layer formation by disabling the agglomeration of nanoparticles. In addition, nanoparticals of the material are more sensitive to heat energy than bulk materials due to the high distribution of nanomanins surface atom [105]. Ultrasonic vibration is an effective way to release local energy concentration because high frequency repetitive motion has a consequence for equal normalizing spatially concentrated energy. Figure 6.55 represents the concept of this process. The surface properties of a processed surface can be improved to compare ultrasonic vibration assisted laser microprocessing without the help of vibration [106, 107].Fig. 6.55. (a) the concept of laser ablation processes with conventional method and (b) ultrasonic assisted method [106]. Femtosecond lasers are increasingly used for micron and sub-micron processing applications thanks to better machining quality and processing capacity than other lasers [108]. However, significant limitations of femtosecond laser processing are the machined surface and adjacent side wall the fields are usually covered with re-solidified and restored nanoparticles material as a result of high-energy laser beam interactions with the work piece material. An attempt was made to improve the LBM process by introducing low frequency lens vibration in order of amplitude and 500 Hz in the range of 0-16.5 μm. Copper substrate vibration-assisted femtosecond laser micro-drilling lens has significantly improved the vibration effectiveness of a lens [109, 110]. Vibration femtosecond laser is placed on the normal lens lens movement to increase the blowing effect during the processing process. Experimental system installation diagram shown in Figure 6.56 [111].Figure 6.56. Schematic diagram of vibration-assisted femtosecond laser micro-drilling system [111]. The surface surface and aspect ratio of the processed structures have been improved. This is due to the exciting effect caused by the vibration of the lens, which changes the focused beam point. The state of focus and defocus that occurs at the same time in the processing zone. Due to local force convection, this effect increases the heat transfer of ablated particles. In addition, these increased cooling particles help to reduce the chances of joining wall surfaces and simultaneous particle agglomeration. The wall surface becomes much cleaner than the traditional laser micro-drilling. Aspect ratio is also increased by 154% with the help of lens lens vibration compared to no vibration during micro drilling using lbm.Q. Feng... Z.J. Pei, Processing Technology for Composite Materials, 2012In laser beam processing (LBM) is a laser that focuses optical energy on the surface of the energy source work piece. Highly focused, high-density energy melts and evaporates parts of the work piece in a controlled way. It is widely used in sheet cutting and drilling holes. UV-A LBM is a combination of LBM and ultrasonic vibration. Vibration is applied in the direction of feeding laser generator or work part. One of the biggest advantages of laser drilling on conventional drilling is that there is no contact between the tool and the work piece, eliminating the delamination caused by the thrust and vibration of the drill bit. Puncturing of small diameter holes can be up to 0.025 mm. For large holes with a diameter of 0.5 mm, the laser beam is controlled to cut the outline of the hole. Laser cutting for composite materials is complex because composite material components often have very different thermal conductivity, heat capacities and evaporation temperature (Hocheng and Tsao, 2005). Experiments on venting Al-Cu-based composites reinforced with SiC particles were carried out by UV-A LBM with ultrasonic vibration applied in the direction of feeding (Liu et al., 2005; Xu et al., 2009).

Experimental results showed that with ultrasonic vibration, there is quality of processed holes increased the efficiency of processing, reduced the dimensions of the heat-affected area, and increased the depth of the machined hole. Bijoy Bhattacharyya, Biswanath Doloi, Modern Processing Technology, 2020Micro laser beam processing (LBM) is one of the most popular, versatile, contact as well as wear fewer methods of material removal. Laser irradiation provides superior flexibility, probability and high-grade automation that makes this process easily applicable to nonconduous materials such as different ceramics, metals and polymers. In addition, today's semiconducondut industries also rely on laser micromachining to manufacture solar batteries. The flexibility to change the pulse period from micro to femto second, change and frequency in the wavelength, has provided the production of laser microprocessing with a higher aspect ratio than micro parts. In addition, processing techniques such as drilling, cutting, surface teksture, laser are used for welding purposes outside of application. However, harmful thermal effects such as quiet, changes in the microstructure of the main material and deterioration of surface quality can be reduced to some extent during microprocessing by careful control of different association parameter settings and the application of shorter pulses. Bijoy Bhattacharyya, Electrochemical Micromachining for Nanofabrication, MEMS and Nanotechnology, 2015Microprocessing laser beam processing (LBM), highly consistent beam of electromagnetic radiation with wavelength focused on a small point that can be performed for co2 laser changing from 157 nm to a fluorine excimer laser and produces high density power causing rapid heating, melting of molten metals, melting, evaporation and. Laser microprocessing is characterized by a short pulse length from millisecond range for microsourcing to pico- and even femtosecond range for ablation of metals. Figure 1.12 shows various micro-LBM units. The nenidium-doped yttrium aluminum garnet (Nd:YAG) can develop high-precision micro holes in hard materials such as laser metal and diamonds, while excimer lasers are mostly used for ceramics and composites. CO2 laser is capable of drilling micro holes in very thin material with high production speed. Microelectronic and other particulate sensitive surfaces are effectively cleaned with 350 mJ/cm2 248-nm excimer laser pulse. The Excimer laser is also capable of producing thin surface structure on small parts. Q-switch Nd:YAG and excimer laser molds are used for surface configuration and is used for modeling and die to produce cosmetically attractive surfaces in plastic consumer products. However, the formation of a solidified layer and a HAZ is inevitable. Micro holes and medium precision slits with various sections, but with a low aspect ratio ranging from 1 to 2, are the main products. Femtosecond processing performance as high power generator is available among the current laser microprocessing methods is considered the highest [16]. Excimer and femtosecond lasers are preferred to prevent solidified layer and HAZ on machine surface. Figure 1.12. Micro-LBM.N various units. Roy, ... Q. Mitra, Microprobe production and Precision Engineering, 2017 This section discussed an overview of Nano's second pulse laser beam processing. Laser material interaction and short pulse laser beam processing material removal are given illustration. Pulsed laser ablation challenges are discussed. These challenges have been shown to be corrected in the form of laser processing in different environments, especially underwater. Examples of developments in the sunk state of laser material composition. Laser beam microprocessing of the Inconel 625 superalloy in the sunk state has been experimentally examined here. The central composite design-based DOE technique is used here to make experimentscra. The effect of the height of a water column together with other controllable process parameters, i.e. lamp current, pulse frequency, pulse width and cutting speed is successfully investigated with notch width, cutting depth and HAZ width. According to the ANOVA results during the experimental study conducted in the selected range, the height of the water column is seen to have a major impact on all processing responses. The lamp current used here as a function of average power is the most effective process variable, while pulse width is the least affecting factor for all processing responses. HAZ width, kerf width and depth of cut are reduced by increasing the water height. Bijoy Bhattacharyya, Electrochemical Micromachining for Nanofabrication, COMPARED to other microprocessing processes such as MEMS and Nanotechnology, 20151.Micro-EDM, micro-USM (Ultrasonic processing), micro-LBM (laser beam processing) and tool-based microprocessing, EMM's initial installation and operation costs are less.2.EMM is a relatively less polluting microprocessing process in the context of the production of sound, smoke and other harmful radiation. Reduces the cost of protective and preventive sub-systems.3.EMM mostly uses eco-friendly electrolytes, minimizing the total disposal cost of the electrolyte used. Wit Grzesik, Advanced Processing Processes of Metallic Materials (Second Edition), 2017This section provides comprehensive information on the manufacture of nano products and elements of micro-electromeatic systems using various techniques and processes. Taking into account well-established techniques such as nanomachining (ultra-sensitive) and afm, new trends in improving nanoprocesses, laser beam processing, electron beam processing processes have been generally examined. Background of typical machining processes such as turning, milling and grinding, as well as nanoprocessing processes including different construction materials (metallic and non-metallic), The physical mechanisms responsible for the transition from fragile to ductility regimen processing are explained. In addition, a special focus is given on the effective applications of new structures, control systems and nanomachining techniques. In addition, the focus was directed at the selection of special tool systems, fixing systems and machining conditions, applied to nanotools. All nanomachining techniques discussed are supported by new research studies, original research and practical examples. In addition, measurement scaling up to nanolevels is highlighted and a range of suitable measuring devices and measurement systems are offered. Some trends in nanoproure, which are considered tip-based nanoproures, have been discussed. Xichun Luo, ... Saeed Z. Chavoshi, Hybrid Processing, 2018Machining is a type of traditional manufacturing approach with tools and work controlled movements to remove raw material replacement material to achieve desired dimensions, shapes and surface coating to meet the functional requirement of the final product. The ability to produce a variety of part geometries and geometric properties (e.g., screw threads, threaded teeth, flat surfaces) is the most versatile and accurate of all manufacturing processes. The Industrial Revolution and the growth of the world's manufacturing-based economies can be largely traced back to the development of various processing operations [1]. Processing operations are divided into two groups. A group is mechanical machining in which cutting tools or abrasive wheels are used to cut the material to leave the desired part shape. Typical mechanical machining processes include turning, milling, drilling, grinding, etc. Non-traditional processing, on the other hand, means processing processes that clean excess material with a variety of techniques, including mechanical, thermal, electrical or chemical energy, or combinations there. They do not use a solid cutting tool or grinding wheel in the traditional sense. Ultrasonic processing (USM) and water jet cutting (WJC) are two typical non-traditional mechanical processing processes. In the USM, abrasives in a snable are driven at high speed with a low amplitude, a vibrating instrument at approximately 0.075 mm and a high frequency instrument of approximately 20,000 Hz. However, the action of abrasives performs cutting, impinging against the work surface. WJC uses thin, high pressure and high-speed water flow to the work surface, causing the work to be cut off. Electrochemical processing (ECM) removes metals from the electrical conductive work piece with anodic dissolution, where the shape of the work part is obtained by a rapidly flowing electrolyte close to operation, but by a separated electrode tool. Non-traditional thermal energy process includes electrical discharge processing (EDM), electron beam processing (CPA) and laser beam (LBM). EDM cleans the metal with a series of discrete electrical discharges (sparks) that cause localized temperatures high enough to melt or vaporize the metal just near the discharge. CPA uses high-speed electron current focused on the work part surface to remove material by melting and evaporation. LBM uses a laser light energy to remove material with evaporation and ablation. Chemical processing (CHM) is a non-traditional process in which material occurs through contact with a strong chemical echant. Includes chemical milling, chemical discharge, chemical engraving and photochemical processing (PCM) etc. Figure 1.1 shows the classiation of major processing processes. Figure 1.1. Classification of processing processes. Thanks to advances in precision machine tool and key machine parts design, computer numerical control and tool manufacturing, the capacity of machining technology has been significantly improved. Today, high precision and ultra-precise machining operations can achieve very high accuracy between 10 and 100 nm and a material lifting speed above 10−4 mm3/s. They offer quality and reliability for traditional products, but they also offer completely new products, especially where mechatronics, miniaturization and high performance are important [2]. Driven by the growing need for higher production, integration and performance, processing technologies are clearly moving toward the economic production of high-precision three-dimensional (3D) products. The wide range of applications of high strength and heat resistant materials such as titanium and nickel based alloys, hardened steels, advanced engineering ceramics and lightweight composites are seen in the aerospace, automotive, nuclear and medical equipment industries. These advanced materials are generally classified as machine-difficult materials due to their high strength and low thermal conductivity, which lead to a poorly machined surface surface and a short tool life by adopting traditional mechanical machining processes, making cutting forces and cutting temperature too high. Currently, highly precise 3D complex parts are made through a variety of separate high precision machining operations. Therefore, a long process chain and lead time will cause, as shown in Figure 1.2. To solve this problem, multifunctional machines/machining centers have been developed by key machine manufacturers such as Mazak (, DMG Mori (and Okuma (. To achieve higher machining accuracy and efficiency, these machines integrate multiple traditional mechanical machining processes such as milling, turning, drilling, grinding and engraving into a single machine. The main advantage of these machines is that they can perform different traditional machining operations in a single machine installation. These machines are especially useful for production complex parts increasing accuracy due to reduced repositioning error. In addition, installation and interoperation reduce queue and transit times, significantly reducing both production and loading times. This helps significantly reduce production time, as shown in Figure 1.2. Comparison of traditional machining processes and multifunctional machining processes. However, these multifunctional machines or machining centers only integrate traditional mechanical machining, which is not always the best option for handling some tight machine advanced engineering materials such as ceramics or hard steels. It can also avoid the traditional deficiencies of mechanical machining, such as burr production and short tool life. On the other hand, non-traditional machining operations such as EDM, ECM, USM, CPA and LBM can provide better and more consistent work piece quality and higher efficiency in processing machine materials that are more difficult than traditional mechanical machining. The unification of traditional mechanical machining processes with non-traditional machining processes can help to take advantage of one process and compensate for the shortcomings of the other process. This results in hybrid processing technology. Bijoy Bhattacharyya, Biswanath Doloi, Modern Machining Technology, 2020Modern machining works demand very specific surface features with complex shapes, tight tolerances and the least surface damage and many extreme uses with the thinnest and more precise dimensions. Conventional shaping and sintering techniques are often not able to meet these demands. Conventional machining is limited to production of complex shapes and sizes on hard and brittle materials. Unconical processing processes such as electrical discharge processing and electro-chemical processing, which can produce varieties in complex ways, are only suitable for electrical conductive materials. Since laser beam processing is a thermal process, heat-affected damage occurs and is an expensive process and is not economical for the thicker work part with the large removal of the material. USM is a non-thermal, non-chemical and non-electrical processing process that does not change the chemical composition, material microstructure and physical properties of the work part after processing. The USM process machine can be used for precise macro and micro properties, round and single-shaped holes, blind spaces and cascading holes, etc. Multiple features can be drilled simultaneously and often significantly reduce total machining time. Ultrasonic processing often uses tool material such as tungsten carb, monel and stainless steel to provide efficient energy transmission to abrasive particles and minimize tool wear. Because high-dimensional accuracy, good surface surface and complex shape on the machined surface can be achieved with USM, the need for USM is very high in modern industries. For machining engineering materials that exhibit very attractive features for modern industries. Interest properties high hardness, high heat resistance, chemical ineration, special electrical conductivity, high strength-weight ratio and longer life expectancy, USM is a viable alternative processing process. Alumina based ceramics are used in sealing rings, medical prostheses, laser tubes, electronic surfaces, ballistic armor, thermocouple tubes, electric insulsions, grinding environment, yarn guides and wear component, etc. USM is a mechanical material removal process that can be used for the processing of such hard and brittle materials. Ultrasonic processing process machine can be employed for sensitive micro properties, circular and non-circular micro holes and blind micro cavities. Glass in ultrasonic processing, Suitable for processing hard and brittle materials including sapphires, ferrite, PCD, Piezo-ceramic, Quartz, CVD Silicon Carp and Bio-Ceramics, etc. High accuracy and good surface coating, lack of heat generation during processing, ability to drill circular and non-circular holes on very hard materials, lack of thermal effect on mechanical work piece and thermal effects on the processing of electrical conductor and nonconducilar materials are some of the advantages of USM. Unlike other non-traditional processes such as laser beam processing and electro-discharge processing, etc., ultrasonic processing process creates a low level of work surface with no thermal damage and residue stress, which is important for the survival of fragile materials that serve. The newest and most exciting class of advanced engineering materials can be processed by USM, such as alumina, zircon, silicon carb, silicon nitride, boron carb and boron nitride, etc. Ultrasonic processing has tremendous need and has great potential application in the field of advanced production. Rotary ultrasonic processing (RUM) is extremely necessary for meso (millimeter) range as well as micro-intermittent machining applications to further increase material removal rate and reduce hole inerrency such as conicity, overcut, circularity error, etc. For deeper drilling with high precision, the RUM abrasive bonded vehicle is very effective rather than supplying fixed USM abrasive slurr. To avoid erosion of machined hole walls due to loose abrasive particles and abrasive stenosis in the sediment during washing at the fixed USM, RUM can be used to achieve near-size tolerant, where water cooler is provided for clean and sustainable processing. Sometimes to overestule the lack of fixed USM, RUM is a suitable option for industrial applications for various machining operations such as hard and fragile, types of conductive and noncondutor materials, drilling, milling, grinding, isstured, etc. Application.