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OVERVIEW ON MICRO MACHINING

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Abstract —
In recent years, advanced materials with distinctive metallurgic properties like super alloys, composites and ceramics has been developed to satisfy the strain of maximum applications. whereas these materials square measure more durable, tougher, less heat sensitive and bit more resistant to corrosion and fatigue, they're additionally troublesome to machine.
Micro systems can be used in wide applications in biomedical electronics, optics, micro-mechanics, microfluidics, dies, moulds etc. element components employed in these systems have feature dimensions in micrometers and part volumes less than 1 mm3. Manufacture of these parts with high accuracy could be a challenge.

This paper summarizes a few the micro machining technologies such as micro-electrical discharge machining, electro chemical micro machining, micro-laser assisted machining, and abrasive slurry jet Micro-machining micro ultrasonic machining, and micro electron beam machining. Literature identifies that micro machining greatly influences machining of hardmaterials.

Micromachining great benefits in machining of hard materials in non-conventional machining as well as in conventional machining like micro-mechanical milling, chemical etching, and micro-detonation of striking arc machining.

The present overviews and analysis varied needs of micromachining and the effective utilization in the micro machining domain for further strengthening

Keywords-- Advanced material, Micromachining, applications, Types, Analysis.

Introduction

In the previous few decades, the necessity of advanced materials increased due to their unique metallurgic properties such as Superalloys, Composites, Ceramics. These properties have been developed to satisfy the demand of maximum applications such as in aerospace, automotive and bio-medical industries etc. These advanced materials are more durable, tougher, less heat sensitive and more resistant to corrosion and fatigue.

These materials are difficult to machine. Thus, micromachining is very important aspects of the developed machining process.

Among the difficult to machine materials, super alloy is high-performance alloy, it has the excellent mechanical

B. Mechanics ofMicro-machining:

A. Properties and Application ofMaterials:

strength and resistant to creep at high temperature, good surface stability, and corrosion and oxidization resistance. a super alloy's base alloying element is sometimes nickel, cobalt, or nickel-iron. Typical applications are in the aerospace, industrial gas {turbine| turbine} and marine turbine industries, e.g. for turbine blades for hot sections of jet engines, and bi-metallic engine valves for use in diesel and automotive applications [1].

Composites materials are materials made from 2 or more constituents materials with significantly different physical or chemical properties, that once combined, produce a material with characteristics different from the individual components. These materials are stronger, lighter or less costly in comparison to traditional materials. Composite materials are generally used for buildings, bridges, and structures such as boat hulls, swimming pool panels, automobile bodies, shower stalls, bathtubs, storage tanks, imitation granite, and cultured marble sinks and countertops. the foremost advanced examples perform routinely on satellite in demanding environments. Some examples of composites are Composite building materials such as ascements, concrete, reinforced plastics such as a fiber-reinforced polymer, Metal Composites, Ceramic Composites [2].

Ceramic materials are inorganic, non- metallic materials made up of compounds of a metal and a non-metal. Ceramic materials may be crystalline or partially crystalline. they're formed by the action of heat and subsequent cooling. Clay was one of the earliest materials used to produce ceramics, as pottery, however, many alternative ceramic materials are now used in domestic, industrial and building product.tend to be robust, stiff, brittle, chemically inert, and n-conductors of heat and electricity, but their properties vary widely. for example, porcelain is widely used to make electrical insulators, however, some ceramic compounds are superconductors. Mechanical properties are important in structural and building materials also as textile fabrics.

They include the many properties used to describe the strength of materials such as: elasticity, tensile strength, compressive strength, shear strength, fracture toughness & ductility (low in brittle materials), and indentation hardness. Examples of ceramics materials are barium titanate, Bi SrCa copper oxide, B nitride, Lead zirconatetitanate (PZT), silicon carbide (SiC) etc[3].

Mechanics of Micro-machining Material removal processes exhibit significantly completely different behavior and characteristics at the micro/mesoscale than at the conventional macro-scale. These differences are primarily the consequence of the relative scaling between the principal constituents of the cutting operations performed. Micro-cutting operations are frequently used to produce features with reduced sizes and tolerances that necessitate the use of tools such as small diameter endmills that themselves have features, e.g., the cutting edge radius, that are comparable in size to the cutting parameters, viz., the feedrate, owing to current limitations in tool manufacture. As a consequence, the mechanisms of chip formation may have significant ploughing as well as shearing effects, which will influence cutting forces, vibrations, process stability and part surface finish in ways quite different than in conventional, macro-machining.

A second significant factor in micro-machining is the need to consider the inhomogeneity of the material at the scale of micro-machining since the characteristic grain size, except for single crystal materials, is on the order or even larger than the chip thickness/cut cross section and frequently on the order of the tool diameter, e.g., in drilling or end milling.

Even for single crystal materials, the crystallographic orientation plays a significant role in cutting performance at the micro-scale. The first section of this chapter presents results pertaining to the size effect, energy considerations and basic cutting mechanics considerations in micro/meso-scale machining. The modeling methods presented range from continuum mechanics and molecular dynamics approaches mechanisticmodelling.[3]

C. Brief Overview ofProcesses:

Machining is any process within which a cutter is employed to remove small chips of material from the workpiece. To perform the operation, relative motion is required between the tool and the work. This relative motion is achieved in most machining operation by means that of a primary motion, known as "cutting speed" and a secondary motion known as "feed". the shape of the tool and its penetration into the work surface, combined with these motions, manufacture the desired shape of the resulting work surface.

In conventional machining, removal of material from a workpiece in the form of a chip via brute force of a sharp cutter. However, the material removal rate is extremely low. an attempt has been made to machine the material with MMM, CE, and MDSAM. when these processes enforced, they increase the fabric removal rate comparably and meet the most effective suitable required production.

In micro detonation of striking arc machining (MDSAM), the ceramics is removed by the micro-detonation plasma jet which us ejecting from the nozzle of the micro-detonation generator. The micro-detonation plasma jet has the characteristics of high temperature and high force.[4]

1. Micro-Electro-Discharge :

micro-Electro-discharge machining (micro-EDM) Micro EDM is a thermo-electric process for machining electrically conducting materials notwithstanding their mechanical properties. Being a non-contact process, micro- EDM is one of the most effective alternative ways that can be used for machining high aspect ratio 3D micro structures.

2. Tool based Mechanicalmicromachining:

Tool based mechanical micromachining technology is gaining importance in Micro-Electromechanical system device fabrication due to its ability to machine 3D microfeatures on different engineering materials.[4]

Non-conventional manufacturing processes is defined as a bunch of processes that remove excess material by various techniques involving mechanical, thermal, electrical or chemical energy or combinations of these energies but do not use a sharp cutting tools because it has to be used for traditional manufacturing processes. but uses of micro machining have the great revolution in the manufacturing field. These micromachining are MEDM, EMM, MLAM, MUM, AJMM, andMEBM.

Micro-EDM is the application of EDM in micro-field. The low energy range is changing into important when the EDM process is used in micro-field. Micro-electrical discharge machining is one of non-conventional manufacturing techniques which are believed to have a strong research and application capability and importance. one of the main problems regarding electrical discharge machining generally could be a tool wear. Discharges occurring between electrodes affect each surfaces the work piece as well as the tool electrode. There have been developed several strategies to beat this impact of machining. the other idea that might minimize tool wear is an application of a new material for tool electrode. Also, different materials are utilized in forms of coatings for electrodes that reduces material removal rate from the tool electrode [6].

ECM machining process is applied to the micromachining range of applications for manufacturing of ultra-precision shapes; it is called electrochemical micromachining. EMM is an efficient technique of producing variety of components for the aerospace, automotive, defense, electronic and biomedical industries. a more robust understanding of the high-rate dissolution is urgently needed for EMM to become widely used manufacturing process in the micro-manufacturing domain.

ECM machining process is applied to the micromachining vary of applications for manufacturing of ultra-precision shapes; it is called electrochemical micromachining. The tool wear decreased so much because of an interrupted cutting or milling[6].

Laser assisted micro machining is an important and quite recent development in the evolution of ductile mode machining technology. Unlike a traditional laser assisted machining process, in a LAM process the laser and the tool are coupled together where the laser beam passes through the diamond tool and is delivered to the tool-work piece interface [7].

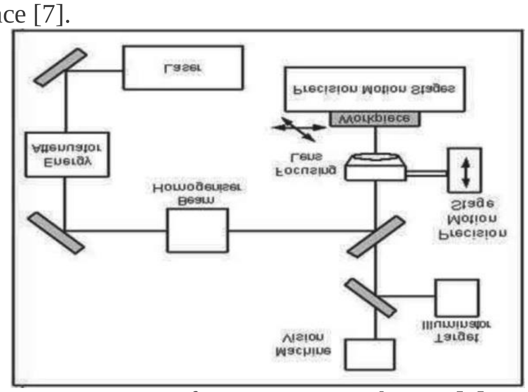

Fig.1 setup of Laser Micromachining [7]

Abrasive jet micro-machining (AJMM) utilizes compressed air to accelerate a jet of small erodent particles to high speeds. The particles impact the surface of a target, removing material by mechanical erosion. Various types of eroded micro-features, such as micro-channels, micro- holes, and stepped planar areas, can be created on the target surface by controlling the jet trajectory and scan speed, and through the use of an erosion resistant mask [9].

II. Historical Aspects

A study of Structural and Mechanical Properties of Al/B4C Composites made-up by Wet Attrition milling and Hot Extrusion, scientist concluded that the Al matrix composites reinforced by different volume fractions of B4C particles and also monolithic Al were prepared by wet attrition milling followed by hot forward extrusion processes. The microstructure of the composites was investigated by SEM. Also, the mechanical properties of the produced composite samples were measured and compared with the monolithic Al. super alloys and the tool wear is attributed to high chip contact length, higher temperatures, high adhesion and diffusion in dry cutting as compared to wet cutting. On the literature of Development of micro milling tool made of single crystalline diamond for ceramic cutting, over that so as to machine micro aspheric molds and dies made of ceramics, micro milling tools made of single crystalline diamond (SCD) tools were developed by using laser fabrication. The molds of tungsten carbide were cut in the ductile mode with the milling tool developed.

On the basis of review for Comparison of tool wear mechanisms and surface integrity for dry and wet micro drilling of nickel-base super alloys, it has been concluded that Adhesion, diffusion and chipping are the main tool-wear mechanisms in micro drilling nickel based mostly Carbon nano fiber assisted micro electrical discharge machining of reaction-bonded silicon carbide, Electro discharge behavior, Material removal rate, electrode wear magnitude relation, Spark gap, Surface roughness, has been reported. It concluded that Adding carbon nano fibers into the dielectric fluid can significantly improve the electro discharge frequency, and successively, improve the fabric removal rate and spark gap, The EWR drops significantly with the rise of carbon nano fiber concentration, especially under the time-controlling conditions, Increasing carbon nano fiber concentration is useful to stop tool tip concavity formation, and in turn, improves form accuracy of micro cavity, without carbon nano fiber addition, the RB-SiC material was removed by spilling of enormous flakes, causing massive surface craters. With fiber addition, however, the crater size might be dramatically reduced; Surface finish will be improved by adding carbon nano fibers in the dielectric fluid. all-time low surface roughness was achieved at a fiber concentration ~~of~~ 0.02 0.1 g/L [6]Further study of carbon fibres electrodes in micro electrical discharge machining the scientist found that the planned tests were also used to verify the newly designed experimental setup. during the trials certain issues occurred. generally a deflection of the fiber once tangency was noticeable. The values of voltage threshold for detecting short circuits should be carefully chosen.

Comparative study on discharge conditions in micro- hole electrical discharge machining of tungsten carbide (WC-Co) material concluded that Micro-EDM process for micro-hole of tungsten carbide (WC-Co) was newly designed. Electro-optical characteristics were evaluated on the discharge conditions with the R C value. ~~The~~ voltage drop on the resistance increased with increasing resistance, which reduced the voltage between the electrode and work piece [7].

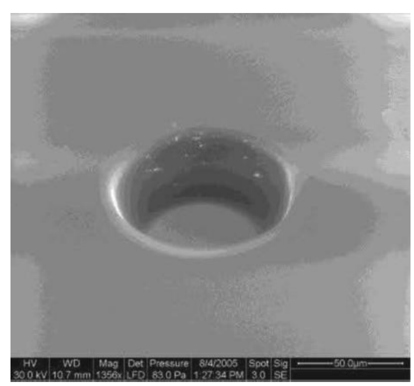

Fig. 2 hole produced by EDM [6]

The back movement of the electrode which occurred frequently in certain trials consumed time that can be used for the proper machining. This also influences the calculated value of linear tool wear which have taken into

account the total time of experiment. It was impossible to estimate or measure the back-movementtime.

D. Review

After reviewing of electrochemical micromachining the Voltage on Machining Rate and Overcut, Effect of Pulse on time on Machining Rate and Overcut, Effect of Electrolyte Concentration on Machining Rate and Overcut has been observed. It has been concluded that the machining rate and overcut are significantly influenced by the electrolyte type, the acidified electrolyte is found to produce higher machining rate and lower overcut compared to sodium nitrate electrolyte, the dissolution rate is higher for acidified sodium nitrate compared to sodium nitrate electrolyte at higher pulse on time i.e., 15-17.5ms

On the study of Experimental study on electrochemical micromachining has been concluded that Process parameters, such as micro-tool feed rate, electrolyte flow, pulse period and pulse on–off ratio have been successfully maintained at the desired values during all sets of experiments, Process parameters like applied machining voltage, electrolyte concentration and frequency have significant effect on UR and accuracy. UR increases with the increase of electrolyte concentration, applied machining voltage and frequency, but the increment of unit removal deteriorates the accuracy of the product, and It is observed from the experimental analysis that at higher frequency, medium concentrated electrolyte and average machining voltage, i.e. 55 Hz, 20 g/l and 3V, respectively, the desired accuracy can be achieved with highest possible amount of material removal[14].

Influences of different contaminations on the electro-erosive and the electrochemical micro-machining the researcher found that the contaminations cause a reduction in gap space and above all a change of the electric field in the gap.

The work times of the electric fields are different in this respect, i.e. for the micro-EDM it is the electrostatic field during the ignition phase (pulse pause), and for the µ PECMM it is the electric flow field during the removal phase (pulse duration)[6].

On the study survey of Characterization of a hybrid laser-assisted mechanical micromachining (LAMM) process for a difficult-to-machine material, has been reported that Effect of laser variables and cutting parameters on forces, Factors affecting the depth of cut, Measurement of groove depth, Effect of laser variables and cutting parameters on surface roughness and concluded that The main effects of depth of cut, width of cut and laser power on the cutting force are statistically significant at a risk level (a) of5%.

The two-way interaction effects of depth of cut and laser power, depth of cut and tool width, tool width and laser power, cutting speed and laser power, and laser location and cutting speed on the cutting force are also statistically significant, All two-way interaction effects except thedepth of cut and cutting speed, and laser location and laser power, are statistically significant on thrust force, and Laser induced thermal softening improves the accuracy of the groove depth by reducing the stage deflection[9].

On the basis of Prediction of machined surface evolution in the abrasive jet micro-machining of metals researcher made the conclusion that the angular dependencies of the erosion of aluminium 6061-T6, 316L stainless steel and Ti–6Al–4V were measured by machining channels using an abrasive jet of 50 mm aluminium oxide powder. As expected for ductile materials, the maximum erosion rate occurred between impact angles of 20°–30° [11].

After reviewing of Surface finishing of intricate metal mould structures by large-area electron beam irradiation conclusion has been such as Large-area electron beam irradiation has been shown to be an excellent method for polishing engineered surface microstructures of high aspect ratios. Since this is a noncontact method protrusion can be smoothed without damaging engineered surface microstructures and intended form of such structures can be enhanced [13].

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II. SUMMARY

The present study has been done to study the area of micromachining where micromachining has been applicable. The purpose of the present study, therefore, is to put forward an overview of the published work for the current scenario in the underlying mechanism involves in the micromachining for difficult to machine materials and the create a platform for the future research.

1) Micromachining finds the wide applications in industrial sector, machining of hard materials, mouldings, automotive, bio-medical industries, aerospace, electronics, agriculture, welding,etc.
2) Micromachining provide a significant effect to improve the productivity of the product and reduce the cost andtime.
3) Micromachining improve the MRR, andprovide required surfaceroughness.
4) With the help of MEDM, EMM tool life significantly increased. Specially in EMM comes the great revolution because of in this process has the higher MRR compare to others and tool remains as it is because in this process there is no contact between the tool and thework.
5) In MUM and MLAM caused no deformation ofthe work piecemicrostructure.
6) Research effort on the EMM and micro electron beam (MEBM) on super alloy materials remains relatively few.
7) Published research reported that the non-conventional micro machining and conventional micro machining on advanced materials made the great influence in the manufacturingsector.

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