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ULTRASONIC MACHINING PROCESSES-REVIEW PAPER

Kanwal Jeet Singh
Department of Mechanical Engineering
Giani Zail Singh P.T.U Campus, Bathinda
India
kanwalbti@gmail.com

I.P.S Ahuja
Department of Mechanical Engineering
Punjabi University, Patiala
India
ahujaips@yahoo.co.in

Abstract – The objective of the present study is to review of the ultrasonic machining process. Generally ultrasonic machining is based on the different- different parameters which are used to increase the output result like material removal rate, tool wear rate, surface roughness, micro hardness etc. Different parameters produce different output result. The present study gives an idea about which parameters put an effect on output parameters. It also gives an idea about which work material is suitable for machining with different parameters. Ultrasonic machining (USM) is a mechanical material removal process used to erode holes and cavities in hard or brittle work pieces by using shaped tools, high-frequency mechanical motion, and an abrasive slurry. Unlike other non-traditional processes such as laser beam, and electrical discharge machining, ultrasonic machining does not thermally damage the work piece or appear to introduce significant levels of residual stress, which is important for the survival of materials in service. The fundamental principles of stationary ultrasonic machining, the material removal mechanisms involved and the effect of operating parameters on material removal rate, tool wear rate, and work piece surface finish of titanium and its alloys are reviewed, for application in manufacturing industry.

Keywords – Ultrasonic machining, Review of USM.

I. INTRODUCTION

Ultrasonic machining (USM) is of particular interest for the machining of non-conductive, brittle work piece materials such as engineering ceramics. Because the process is non-chemical and non-thermal, materials are not altered either chemically or metallurgical. The process is able to effectively machine all materials harder than HRC 40, whether or not the material is an electrical conductor or an insulator. Holes as small as 76µmin diameter can be machined, however, the depth to diameter ratio is limited to about 3:1 USM has been variously termed ultrasonic drilling; ultrasonic abrasive machining; ultrasonic cutting; ultrasonic dimensional machining and slurry drilling.. Since its invention, USM has developed into a process that is relied upon to solve some of the manufacturing community's toughest problems. The USM process begins with the conversion of low frequency electrical energy to a high-frequency electrical signal, which is then fed to a transducer. The transducer converts high-frequency electrical energy into mechanical vibrations, which are then transmitted through an energy-focusing device, i.e. horn/tool assembly.

This causes the tool to vibrate along its longitudinal axis at high frequency (usually ≥20 kHz). The tool vibrates with a total excursion of only a few hundredths of a millimeter in a direction parallel to the axis of tool feed. For efficient material removal to take place, the tool and tool holder must be designed with consideration given to mass and shape so that resonance can be achieved within frequency range capability of the USM machine. Typical power ratings range from 50 to 3000W and can reach 4 kW in some machines. A controlled static load is applied to the tool and abrasive slurry (composing a mixture of abrasive material; e.g. silicon carbide, boron carbide, alumina, etc. suspended in oil or water) is pumped around the cutting zone. The vibration of the tool causes the abrasive particles held in slurry between the tool and the work piece, to impact the work piece surface causing material removal by micro chipping. Fig. 1 shows the basic elements of an USM set up using either a magnetostrictive or piezoelectric transducer with brazed and screwed tooling. Variations on this basic configuration include:

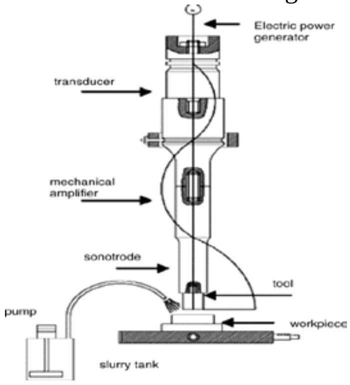

Fig.1. Basis element of USM

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A variation of USM, known as rotary ultrasonic machining (RUM), involves the use of rotating diamond-plated tools on drilling, milling, and threading operations. The construction of RUM machines is nearly identical to USM machines except for the addition of a 0.37–0.56kW (1/2–3/4 HP) rotary spindle motor capable of rotating up to 5000 rpm. The ultrasonic power required for the RUM process is considerably less than that used for USM; RUM machines typically are rated at 300W or less. Machining performance in the rotary mode is found to be much superior to the conventional mode. Recently the feasibility to machine ceramic matrix composites (CMC) using RUM has been investigated, which results into better MRR, and hole quality (in terms of chipping dimensions).

- USM combined with electrical discharge machining EDM) and abrasive flow machining (AFM). Nowadays ultrasonic vibrations are used successfully to enhance machining capability of micro-EDM to handle titanium alloys. It has been found in micro-hole machining of titanium plate, micro-ultrasonic vibration lapping enhance the precision of micro-holes drilled by micro electro-discharge machining.
- Ultrasonic assisted conventional/non-conventional machining. USM assisted turning is claimed to reduce machining time, work piece residual stresses and strain hardening, and improve work piece surface quality and tool life compared to conventional turning.
- There are also non-machining ultrasonic applications such as cleaning, plastic/metal welding, chemical processing, coating and metal forming.

II. BASIC ELEMENTS OF AN ULTRASONIC MACHINE TOOL

The machines for USM range from small, tabletop-sized units to large-capacity machine tools. In addition to the part size capacity of a USM machine, suitability for a particular application is also determined by the power rating. Fig. 2 shows compact 500W USM machine for small, light-weight work piece.

The material removal rate is directly related to power ability of the USM machine. All USM machines share common subsystems regardless of the physical size or power. The most important of these subsystems are the power supply, transducer, tool holder, tool and abrasives.

III. ULTRASONIC POWER SUPPLY

The power supply for USM is more accurately characterized as a high power sine-wave generator that offers the user control over both the frequency and power of the generated signal. It converts low-frequency (60Hz) electrical power to high-frequency (approximately 20kHz). This electrical signal is supplied to the transducer for conversion in to mechanical motion.

ULTRASONIC TRANSDUCER

In the case of USM transducer, electrical energy is converted in to mechanical motion. With a conventional generator system, the tool and horn are set up and mechanically tuned by adjusting their dimensions to achieve resonance. Recently however, resonance following generators has become available which automatically adjust the output high frequency to match the exact resonance of the horn/tool assembly. They can also accommodate any small error in set up and tool wear, giving minimum acoustic energy loss and very small heat generation. The power supply depends on the size of transducer.

Two types of transducers used for USM are based on two different principle of operation, piezoelectric and magnetostrictive. Piezoelectric transducers used for USM generate mechanical motion through the piezoelectric effect by which certain materials, such as quartz or lead zirconate titanate. Piezoelectric transducers, by nature, exhibit extremely high electromechanical conversion efficiency (up to 96%), which eliminates the need for the water-cooling of the transducer. These transducers are available with power capabilities up to 900W. Magnetostrictive transducers are usually constructed from a laminated stack of nickel or nickel alloy sheets. These types of transducers are rugged but have electromechanical conversion efficiencies ranging from only 20 to 35% .

IV. TOOL HOLDER

The function of tool holder is to attach and hold the tool to the transducer. Additionally, the tool holder also transmits the sonic energy to the tool, and in some applications, also amplifies the length of the stroke at the tool. Tool holders are attached to the transducer by means of a large, loose-fitting screw. Half hard copper washers are used between the transducer and tool holder to dampen and cushion the interface, which further reduces the chances of unwanted ultrasonic welding. Fig. 3 shows the amplifying tool holders, and mechanically attached tools used for USM.

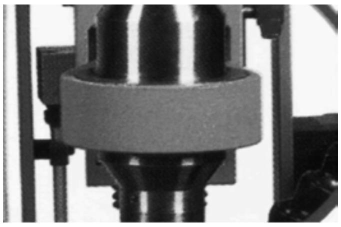

Fig.2 Amplitude coupling for compact 500 W machine.

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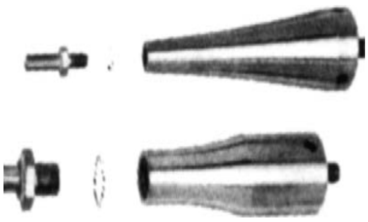

Fig.3 Amplifying tool holder and mechanically attached tools used for USM.

V. TOOL AND ABRASIVES

To minimize tool wear, tools should be constructed from relatively ductile materials such as stainless steel, brass and mild steel. Depending upon the abrasive used, the work piece material, work piece/tool wear ratio can range from 1:1 to 100:1. The tool is normally held against the work piece by a static load exerted via a counter weight/static weight, spring, pneumatic/hydraulic or solenoid feed system. For optimum results, the system should maintain a uniform working force while machining and be sufficiently sensitive to overcome the resistance due to the cutting action. Static load values of about 0.1–30N are typically used.

The force is particularly critical when drilling small holes less than 0.5mm diameter as bending of the tool can occur under too high a load. The transport medium for the abrasive should possess low viscosity with a density approaching that of the abrasive, good wetting properties and, preferably, high thermal conductivity and specific heat for efficient cooling, water meets most of these requirements. The abrasive material is mixed with water to form the slurry.

The most common abrasive concentration is 50% by weight; however this can vary from 30–60%. Thinner mixtures are used to promote efficient low when drilling deep holes or when forming complex cavities. Once abrasive has been selected and mixed with water, it is stored in a reservoir at the USM machine and pumped to the tool–work piece interface by re-circulating pumps at rate up to 26.5 L/min.

VI. MATERIAL REMOVAL MECHANISUM

Extensive work on the mechanism of material removal reported. Most of work is on machining mechanism of hard and brittle material. These mechanisms are detailed in Fig. 4 and comprise:

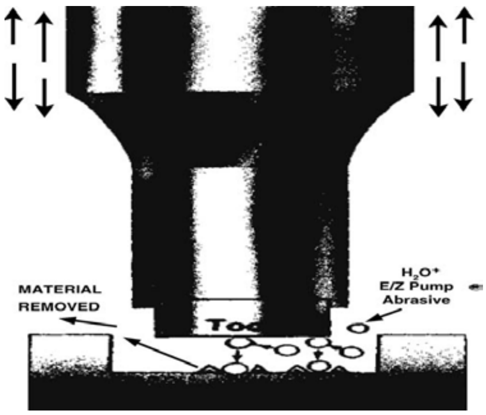

Fig.4 USM material removal mechanism

- material abrasion by direct hammering of the abrasive particles against the work piece surface.
- micro chipping by impact of the free moving abrasive particles
- cavitations effect from the abrasive slurry
- chemical action associated with the fluid employed

Cavitations erosion and chemical effects were of secondary significance with the majority of work piece material acting essentially to weaken the work piece surface, assist the circulation of the abrasive and the removal of debris. The individual or combined effect of the above mechanisms result in a work piece material removal by shear by fracture (for hard or work hardened material) and displacement of material at the surface, without removal, by plastic deformation which will occur simultaneously at the transient surface With porous materials like graphite as opposed to hardened steels and ceramics, cavitations erosion is a significant contributor to material removal.

Authors (Year)	Material Used	DOE/Technique	No. of Experiment	Methodology	Results/ Implications
Pei and Ferreira (1998)	Work Piece Ceramic Material (Magnesia Stabilized Zirconia)	• Rotary Ultrasonic Machining, Vibration Frequency 50Hz to 20kHz, Rotational Speed 3000 rpm, Grit Concentration 20% by volume, Abrasive Grit Size 270/320, Coolant Water.	• Pilot Exp: 8 • Process Exp:8	• Predict MRR from the process Parameters • Interaction between single abrasive particle and the workpiece to estimate to volume of material Removal. • Effects of the abrasive particle on the surface.	• MRR increases as tool rotation speed increases. • MRR increases as abrasive particles decreases. • MRR increases as diameter of abrasive decreases. • MRR increases as static force increases.
Thoe et al. (1999)	Work piece Ceramic coated Nickel alloy	• DC servo head and spark tee Dual Voltage 30A. Frequency 150W, 23 kHz, carrying medium dielectric fluid (BP 180 Hydrocarbon oil), Boron Carbide abrasive grit 220 size.	• Pilot Exp: 12 • Process Exp:18	• Performance of the combined EDM & USM processes. • Effect of combined USM/EDM operation on hole Quality. • Effect on the bonding layer between ceramic coating and nickel metal.	• Deployment of EDM along with USM increases MRR. • Electrode Flushing depth of cut increases. • Intermediate metallic layer is not eroded during machining. •
Jianxin and Taichiu (2000)	Alumina based ceramic composite (Monolithic Al_2O_3)	• EDM used wire DWC 90G transistor pulse current 30A. • USM used 240 W power, frequency 16-25 kHz, and abrasive B_4C size 80, 120, 240. • Diamond Saw use diamond blade, feed rate 05 mm/min, speed 6m/s.	• Pilot Exp: 0 • Process Exp: 12	• EDM is thermal process which removes material between two electrode and workpiece. • USM is abrasive machining process which removes material by erosion between tool and workpiece. • Diamond Saw cutting use conventional cutting.	• EDM of Al2O3/ TiC/Mo/Ni ceramic material have poor surface finish produce crack. • USM and Diamond saw cut surface in better quality. •
Ghahramani and Eang (2001)	(Monolithic Al_2O_3)	• USM machining frequency 19.5 kHz - 20.5 kHz, • Abrasive slurry Al_2O_3 with water carrying medium 280 grit size	• Pilot Exp: 0 • Process Exp: 7	• USM is used on Monolithic Al_2O_3. Workpiece, tool provide line load across the thickness of model. • Stresses are measured by high stress gradients.	• In between USM tool and workpiece, abrasive particles initiate impact on striking location at that point tensile stresses are developed. • Stresses tendency in brittle material to migrate more rapidly. • The impact force of abrasive particles, lateral cracks propagate parallel to surface of work piece •
Wang et al. (2002)	Titanium Alloy (Ti-6Al - 4V)	• Silicon Carbide Abrasive in Kerosene Working Fluid, size 300, concentration 5%, 10%, 20% and 30%	• Pilot Exp: 0 • Process Exp: 20	• MEDM produced spark and material will removed by evaporation of metal • MUSM produced ultrasonic vibration and material will removed by erosion and grinding processes.	• Micro electric discharge machining and Micro ultrasonic lapping have good quality to produce micro hole. • Rotating tool of micro ultrasonic lapping (RUSL) also work as a grinder that's why the quality of micro hole is improved.

Storck et al. (2002)	Aluminum alloy	• Ultrasonic vibrator with steel horn and work piece aluminium metal	• Theoretical Modal	• Ultrasonic Vibrator was pushed torn over the track by slider driven by pneumatic cylinder.	• Theoretical approach based on Coulomb's friction law. • Super position of harmonic movement either perpendicular or parallel to macroscopic motion microscopic friction reduced.
Ya et al. (2002)	Plain Glass	• Rotary UMS frequency 20 kHz, speed 2000 rpm, abrasive aluminium oxide with water	• Process Exp: 7	• USM is connected with CNC, USM gives ultrasonic vibration and CNC gives High rpm. • Abrasive slurry is introduced in between tool and workpiece.	• Part programming of USM and CNC is generate. So factor affecting the MRR are static load, grit size, and concentration, mechanical properties of material of tool, rotational speed and feed rate of the workpiece.
Hocheng and Kuo (2002)	Molding steel SKD61	• USM tool is copper, abrasive aluminium oxide, grit size 220, water carrying medium, frequency 20.69 kHz, amplitude 3.9µm, and concentration 40%.	• Pilot Exp: 0 • Process Exp: 1	• USM polishing is done on molding steel and copper tool is used. • The tool is moving close loop and zigzag path. • Analyze the result of ultrasonic polishing effect.	• After EDM, USM polishing is used and surface finish is improved. • The static load of ultrasonic machining increases, the quality of smoother surface is improved •
Japitana et al. (2004)	Aluminum alloy (A5052) (overhanging groove)	• USM frequency 19 kHz, Amplitude 36µm, Rolling angle 10O, Feed rate 800 mm/min, depth of cut 0.1mm	• Process Exp: 1 • Work piece (80x80x40 cm)	• Developed software as the new machining method. • Two type of overhanging groove been cut, Straight and curved groove. • Cutting process is done by part programming software and control 6-axis of machining.	• Part programming Software is used for ultrasonic cutting of overhanging groove • Surface finish improves greatly. • Efficiency of ultrasonic cutting with CAM software is confirmed theoretically as well as experimental.
Ma et al. (2004)	Aluminum (52 S)	• USM tool material carbide, Frequency 18.76 kHz, amplitude 4µm, abrasive B4C with water medium	• Process Exp 1 • Work piece dimension (29.5 dia, 350 length) mm	• The vibrator is resonated at about 19 kHz by exciting two piezoelectric plates. •	• Ultrasonic elliptical vibration cutting on machining accuracy is turning is analyzed theoretically. • Ultrasonic cutting and ordinary cutting shows that both processes improve the machining accuracy.
Zeng et al. (2005)	Silicon Carbide	• RUM Diomanol core drill outer dia.9.6mm and inner dia 7.8mm, diamond abrasive, grit size 100/120.	• Process Exp 5 • Work piece dimension 98x56x56 mm	• Rotary ultrasonic machining (RUM) power supply between 50 Hz-20 kHz. • RUM tool rotate and Diamond dust slurry pass from the centre of tool. •	• Attritions wear and bond facture defects are generated on SiC. • Tool wear at end face is maximum. • Tool wear at two stage, 1st attritions wear dominates, 2nd bond fracture dominates.
Choi et al. (2007)	Plane Glass	• USM at frequency 20 kHz, low amplitude 2-50µm, SiC abrasive, Water and Hydrofluoric acid. Tool diameter 1.5 mm	• Pilot Exp 0 • Process Exp 2 • Work piece dimension 10x50x50 mm	• Ultrasonic machining is done with 1.5 mm tool diameter, slurry SiC and water. • USM is done with 1.5mm diameter tool, slurry SiC,	• HF fluid gives 200% more MRR as compare to ordinary USM. • Surface roughness and MRR improved up to 40% at micro drilling and 200% at

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			•	water and Low concentration of HF fluid.	macro drilling. • Low concentration: HF (5% by weight) fluid is recommended.
Singh and Khamba (2007)	Titanium 15 & Titanium 31	• USM at frequency 20kHz, tool material SS, HSS, HCS, WC, DI and Ti, Slurry Concentration 15%, 20% & 25%, power rate 30%, 60% & 90%, Grit size 220, 320 & 500, Abrasive B4C, SiC & Al2O3.	• Pilot Exp: 0 • Process Exp:18	• USM is done with six different metal tools. • Concentration is 15%, 20% & 25% with abrasive B4C, SiC & Al2O3. • Taguchi method is used for DoE. •	• Maximum MRR contribution 28%, type of tool with 24.6%, type of slurry contribution 13.3%, remaining parameters are in-significant. • Optimized results obtained for 90% power rate with carbide slurry.
Curodeau et al. (2008)	Thermoplastic P20 (32 HRC hardness)	• USM frequency 30 kHz, amplitude 10µm, abrasive 20% SiC in Oil Carrying medium, tooling material 100% Acetal	• Pilot Exp: 0 • Process Exp:5	• Test the hammering mode to remove a thin layer of tool steel material. • Test the non-contact µ-polishing to improve the surface finish.	• 22-µm uniform surface removed. • µ-polishing operation successfully improved a wire EDM. • UAµM efficiently used to µ machining a tool surface with a thermoplastic tool.
Singh and Khamba (2008)	Titanium 15 & Titanium 31	• USM at frequency 20 kHz, tool material SS, HSS, HCS, WC, DI and Ti, Slurry Concentration 15%, 20% & 25%, power rate 30%, 60% & 90%, Grit size 220, 320 & 500, Abrasive B4C, SiC & Al2O3.	• Pilot Exp: 0 • Process Exp:18	• USM is done with six different metal tools. • Concentration is 15%, 20% & 25% with abrasive B4C, SiC & Al2O3. • Taguchi method is used for DoE. •	• Titanium is well machinable with 60% power rate and SiC abrasive of grit size 220. • Best results obtained with SS tool and SiC slurry. • The verification experiments revealed that 34.46% improvement in MRR of Titanium 15 and Titanium 31.
Lil et al. (2011)	Silicon carbide SiC	• Predicted parameters. • Frequency, amplitude, abrasive, grit size, carrying medium. •	• Theoretical Process.	• Establishing the mathematical model for improving the efficiency of ultrasonic machining.	• Improvement in the processing efficiency of SiC monocrystal. • Obtain parameter optimization which satisfies the processing constraints.
Kang et al. (2012)	Aluminum Alloy (A5238)	• USM frequency 29.585 kHz Amplitude 3.1µm, abrasive SiC, Grit size 220, water Carrying Medium. • LBM f-Theta focal length 256mm, wavelength 1070mm, pulse width 200ns.	• Pilot Exp: 0 • Process Exp: with USM :.5 • Process Exp: with LBM: 5	• USM is done with taking parameters on Al alloy work piece. • LBM is done on same Al alloy workpiece. • Then comparison the results of both machining on same work piece.	• Surface finish of USM process is more as compare to LBM. • MRR rate is 25.69% more in LBM as compare to USM. • Surface oxidation effect is more in LBM process. • For Large cutting or long length cutting LBM is recommended.

Nath et al. (2012)	SiC (50x50x 3) ZrO_2 (50x40x 7) Al_2O_3 (50x50x. 5) All in mm	• USM tool Stainless steel, Dia 3.16,1.7mm, Slurry SiC, B4C, Grit size 75/106µm, Frequency 25 kHz, Amplitude 40-80 µm, • Static Load 0282 kg	• Pilot Exp: 0 • Process Exp: 3 • One operation on each workpiece	• Material of SiC, ZrO2 & Al2O3 drilling is done with two dia tool 3.16 &1.7mm • In the experiment two type of slurry used. • The compression the result of experiment and analysis which parameters are best for better results • •	• Both entrance chipping and the wall integrity of USM hole are due to the redial and lateral crack. • At top surface of the polished workpiece maximum crack are propagate, the sticking of abrasive particle also damage the tool of USM. •
Liu et al. (2012)	Carbon fiber reinforce d plastic (CFRP) (65x45x 8.5) mm^3	• Rotary ultrasonic machining, the diamond abrasive are used. Coolent is used without abrasive, frequency 18.6 kHz,	• Pilot Exp: 0 • Process Exp: 16	• Rotary ultrasonic machining the diamond abrasives are fixed on RUSM tool. • RUSM tool rotate as well as vibrate at frequency 18.6 kHz and produced ah hole 10.095mm.	• The elliptical separating cutting mechanism can reduce the average cutting forces. • The elliptical separating cutting mechanism can increase material removal rate. • RUSM can reduce the tool wear and prolong the tool life. • RUSM can improve the precision of hole. •
Cong et al. (2012)	Carbon fiber reinforce d plastic (CFRP)	• RUSM frequency 20 kHz, power rate 20%, 40%, 60% & 80%. • Tool rotation speed 1000, 2000, 3000, 4000 & 5000, feed rate 0.1, 0.3, 0.5 & 0.7.	• Pilot Exp: 0 • Process Exp: 18	• RUSM machining is combine process that combine material removal mechanisms of diamond grinding and ultrasonic machining. • RUSM experiment is performed of different spindle speed, feed rate and ultrasonic power. • Study the power consumption in RUSM.	• Tool rotation speed decreases as ultrasonic power supply increases. • Different CRPF, power consumption and of coolant pump and air compressor kept unchanged. • Power consumption of coolant pump is higher than 65% of entire RUSM system power consumption.
Lu et al. (2013)	BK 7 Glass 20x20x5 mm^3	• RUSM (Rotary Ultrasonic machining) at 20-50 kHz, rpm 20000, amplitude 2-5 µm, • Coolant is water.	• Pilot Exp: 0 • Process Exp: 18	• RUSM with diamond abrasive particle on tool is used in grinding. • RUSM and Conventional Grinding indentation test is performed. • The analysis the test under microscope 500x magnification. •	• MRR in RUSM is 6-10 times higher than that of conventional grinding. • The affected zone of the incipient cracks promote the energy dissipation, when the abrasives engaged into the hard substrate of the material, hereby resulting in a higher residual stress on the final surface produced in the formal RUM process.
Tabatabaei et al. (2013)	Aluminum (65 J)	• UAM (Ultrasonic Assist machining) at natural frequency 228.5 Hz, chip	• Pilot Exp: 0 • Process Exp: 1	• UAM power supply 1000V, with frequency 20 kHz. Amplitude 10µm, • Material is removed by	• MRR of UAM is improved. • Surface finish in UAM is more as compare to conventional machining.

		thickness 6mm, stiffness 2..628 N/m, ultrasonic frequency 20 kHz,		chipping process. • Lathe machine is used to rpm.	• Tool Stability and life is more as compare to conventional machining.
Beak et al. (2013)	Soda lime glass	• Ultrasonic Frequency 20 kHz, Amplitude 20µm, tool WC Abrasive Aluminium oxide, concentration 30, feed rate 10µm/s	• Pilot Exp: 0 • Process Exp: 1	• USM is done on selected parameters on workpiece soda lime glass. • Hard wax is used to operation with USM. • Both the process with hard wax and without wax result is analysis.	• With hard wax the crack formation is less as compared to without hard wax. • Surface finish with wax is more as compared to without wax. • MRR is less in with hard wax as compare to without hard wax.
Cong et al. (2014)	Carbon fiber reinforced plastic (CFRP)	• RUSM frequency 20 kHz, power rate 20%, 40%, 60% & 80%. • Tool rotation speed 1000, 2000, 3000, 4000 & 5000, feed rate 0.1, 0.3, 0.5 & 0.7.	• Pilot Exp: 0 • Process Exp: 18	• Analyze the CFRP material removal mechanism. • Establish a relation between cutting force and abrasive grain indentation depth. • Obtain the CFRP mechanical properties using composite micromechanical analysis. •	• Experimental investigation conducted to estimate the fracture volume factor and verify that is constant over the process. • The model has been used to study influences of input variables on cutting force. • Cutting force is related to parameters in RUM of CFRP.
Patil et al. (2014)	Ti_6Al_4V	• Cutting tool KENNA Metal (DNMG 150608 KC 9225), • Cutting speed 10, 20, 30 m/min, feed rate 0.1 mm, Vibration frequency 20 kHz, amplitude 20 µm, Coolant Dry.	• Pilot Exp: 0 • Process Exp: 8	• Made a modal simulation and find stress analysis of tool. • Analyze the strain effect, shear friction, cutting temperature, cutting force.	• As the cutting speed increases, the UAT reduces 17-18%. • The simulation shows that a reduction in TWCR (tool-work contact ratio) in UAT and the transient process conditions during UAT, leads to a considerable (45–50%) reduction in the cutting forces

VII. CONCLUSION

The Ultrasonic machining is best machining process for the brittle material. For the machining of glass, ceramic, CFRP, Alloy Steel, Titanium Alloy and many other brittle and hard material ultrasonic machining is the best machining process. There are so many parameters which are used for machining and gives better output results and these also modify in future work. For the machining of glass Silicon Carbide abrasive slurry gives the better results, for increase the surface finish Aluminum Oxide is the best input parameter.

Hydro florid acid low concentration increases the MRR 200%. It is possible to ultrasonically drill holes in titanium without causing excessive surface integrity damage; specifically cracking using ultrasonic assisted drilling. Higher surface finish is attained when machining on titanium alloy is undertaken by USM and it is not always necessary that if work piece with higher toughness value is machined, it will have less MRR rather it is combination effect of material composition (hardness of work piece) relative to the tool and work piece. In otherwords selection of operating parameter levels is critical in order to achieve acceptable productivity.

USM is assumed to be stress and damage free process, so for contour machining it is recommended as it can automatically adjust the output high frequency to match exact resonant frequency of the tool assembly. This also accommodates any small errors in set up and tool wear, giving minimum acoustic energy loss and very small heat generation.

As regards to tool material it should have high wear resistance, good elastic and fatigue strength properties, and have optimum values of toughness and hardness based upon the specific application.

During operation in USM slurry is splashed out from sump tank because of high vibrations of tool, so, proper care should be made for fixing the slurry concentration and slurry flow rate as it will have a serious effect on tool life and MRR.

No major fatigue problems were encountered with the high speed steel tool, any chipping/fracture generally being due to tool/hole misalignment during fabrication. Ultrasonic drilling caused no deformation of the work piece microstructure.

The hardness of slurry material should me more than the work piece, in general larger abrasive grit sizes and higher slurry concentrations results in to higher MRR.

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