Trends On Nonconventional Maching Processes: A Review

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Abstract- *The so-called non-conventional machining methods can no longer be called "non-traditional", since they found a extensive range of applications. In addition, these electro-physical and electro-chemical material removal methods time and again do participate with the more conventional machining techniques. Those non-conventional machining methods allow the machining of compound shapes, not at least because of the use of highly developed CNC-technology. The cutability of material often suggests the use of these techniques. e.g. when hard steel alloys and special composite materials are disturbed. Confirmation is given of the growing inexpensive importance and the enlarged scope of applications covered by these non-conventional manufacturing methods. This is illustrated by a number of specific examples.*

Keywords- Electric Discharge Machine, Electrochemical Machine, Abrasive Jet Machining.

I. INTRODUCTION

The title non-conventional material removal methods became partially demoded: electro-chemical and electro-physical material removal processes are indeed more and more deployed in the metal working industry today. The various techniques may be conveniently classified according to the appearance of the applied energy (fig. 1). These non-conventional machining techniques may come into the picture as possible alternative machining methods for s number of reasons, the main ones being:

1. Machinability of workpiece material.
2. Workpiece shape complexity
3. Automation of data communication.
4. Surface integrity and precision requirements.
5. Miniaturization requirements. [1]

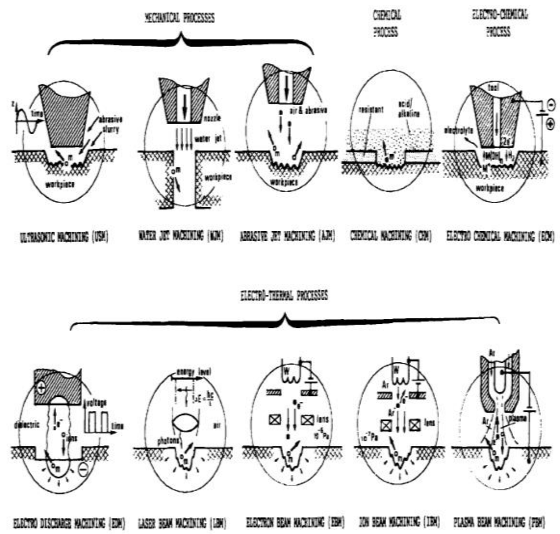

fig.1:Models Shoving Various Non-Conventional

Machining Methods.

Electrochemical machining (ECM)-

Electrochemical machining (ECM) is an anodic electrochemicaldissolution process. Figure 2 illustrates its principles and basic equipment. A D.C. voltage (usually about 10 to 25 volts) is applied across the interelectrode gap between a pre-shaped cathode tool and an anode workpiece. The electrolyte (e.g. $NaN0_3$aqueous solution) flows at high speed (10 to 60 *mls)* through the gap (about 0.1 to 0.6 mm). With currentdensity of 20 to 200 cm^2, the anode workpiece isdissolved according to Faraday's law. The dissolvedmaterial (usually metal hydroxide) and other by-productsgenerated in the process such as cathodic gas are transported from the gap by the electrolyte flow. The final shape of the workpiece is approximately negative mirror image of the tool electrode, as the latter does not alter during the ECM process. The first process resembling ECM was patented by Gusseff in 1929. Significant advances during the 1950s and 1960s developed ECM into a major technology in theaircraft and aerospace industries. ECM has many advantages over traditional machining such as its applicability regardless of material hardness, no tool wear, high material removal rate, smooth and bright surface, and production of components of complex geometry. ECM is an effective method for producing a wide variety of parts for the aerospace, automotive, defense, and medical industries: for example turbineblades, engine castings, bearing cages, gears, dies and molds, artillery projectiles, and surgical implants. Moreover with recent advances in machining accuracy and precision, the electronics industry has begun to useECM for micro-machining components. ECM with apulsed D.C. voltage offers an enhanced accuracy control. The combination of ECM with other machining process has been shown to yield performance superiorto that achieved by individual processes. ECM and itspulse system are finding new applications in finishing mold and dies for many industrial components. Through its integration with many other enabling technologies, ECM is finding wider application and increasingacceptance in a variety of other industries.

Despite these advances, research is still needed on some aspects of electrochemical machining. Current areas needing attention include tool design, process monitoring and control, electrolyte processing, disposal of machiningproducts and accuracy. Thecomplexity of ECM process makes it difficult totheoretically predict and on-line monitor the interelectrode gap size which greatly affects the ECM performance. Lack of efficient methods of process control hinders the integration of ECM equipment within the modem manufacturing environment. Tool design is often a costly empirical procedure, rather than an exactscience.

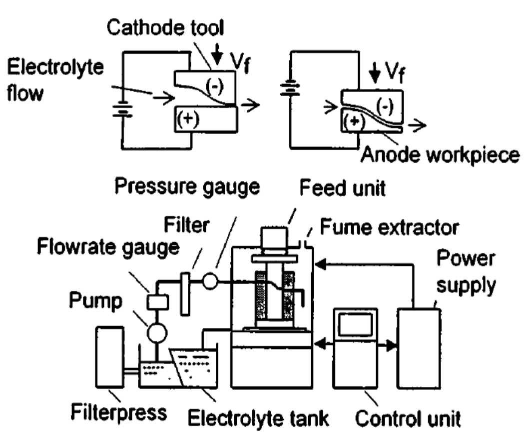

Fig 2 : ECM principle and equipment

Significant experience and expert knowledge are required to successfully operate the process. Additionally, ECM generates a large quantity of waste, mainly metal hydroxide sludge. The processing and disposal of thesludge, which may include heavy metals from the work piece material&' are complex and costly. The new and emerging enablingtechnologies for sensing, monitoring and control, tool design software, sludge reduction, processing and disposal need to be integrated with ECM to make the process more accurate, efficient, automatic, reliable and environmentally acceptable.[2]

ULTRASONIC MACHINING AND APPLICATIONS-

Ultrasonic machining (USM) is a non-conventional mechanical material removal processgenerally associated with low material removal rates; however its application is not limitedby the electrical or chemical characteristics of the workpiece materials. It is used formachining both conductive and non-metallic materials; preferably those with low ductility and hardness above 40 HRC, e.g. inorganic glasses, silicon nitride,nickel/titanium alloys, etc. Holes as small as 76 mm in diameter can be machined, however, the depth to diameter ratio is limited to about 3:1.The history of ultrasonic machining (USM) began with a paper by R. W. Wood andA. L. Loomis in 1927 and the first patent was granted to L. Balamuth in 1945. USM has been variously termed ultrasonic drilling; ultrasonic cutting, ultrasonicdimensional machining; ultrasonic abrasive machining and slurry drilling. However fromthe early 1950s it was commonly known either as ultrasonic impact grinding or USM.In USM, high frequency electrical energy is converted into mechanical vibrations viaa transducer/booster combination which are then transmitted through an energy focusingdevice, i.e. horn/tool assembly. This causes the tool to vibrate alongits longitudinal axis at high frequency (usually $ 20 kHz) with an amplitude of 5–50 mm. Typical power ratings range from 50–3000 W and can reach 4 kW insome machines. A controlled static load is applied to the tool and an abrasive slurry(comprising a mixture of abrasive material; e.g. silicon carbide, boron carbide, etc. suspendedin water or oil) is pumped around the cutting zone. The vibration of the tool causesthe abrasive particles held in the slurry between the tool and the workpiece, to impact theworkpiece surface causing material removal by micro chipping. Fig. 3 shows the basicelements of an USM set up using either a magnetostrictive or piezoelectric transducerwith brazed and screwed tooling.[3]

Variations on this basic configuration include:–

- Rotary ultrasonic machining (RUM). Here the tool is excited and simultaneously rotatedso reducing out-of-roundness to about 1/3 the values obtained in conventional USM. Typical rotational speeds are < 300 rpm, but with diamond impregnated tools, rotational speeds can be as high as 5000 rpm.
- USM combined with electrical discharge machining (EDM).
- Ultrasonic assisted conventional/non-conventional machining. USM assisted turning is claimed to

reduce machining time, workpiece residual stresses and strain hardening, and improve workpiece 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.

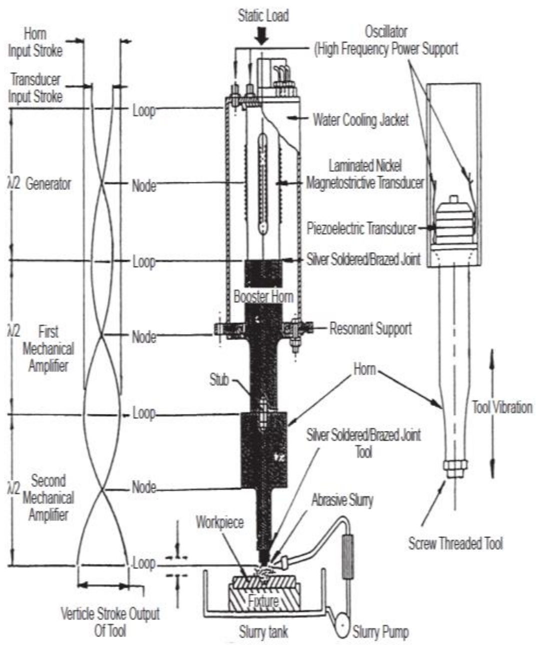

Fig. 3: Basic elements of USM head

AN OVERVIEW OF THE EDM PROCESS-

The elements of EDM are two electrodes, a cathode and anode, separated by a liquid dielectric. During operation, an applied voltage of :200 V across a typical gap of 40 um causes the dielectric to break down. The voltage *U* fans to about 25 V and the current *I* rises to a constant value set by the operator. A plasma channel, surrounded by a vapor bubble,grows during this "on-time" *t* or pulse which is usually less than 100 us. Unlike a gas, the surrounding, dense liquid dielectric restricts the plasma growth, concentrating the inputenergy *UIt*in a very small volume. Energy densities of up to 3 J/mm3 result, causing local plasma temperatures to reach as high as 40 000 K. Dynamic plasma pressures rise to as much as 3 kbar due mainly to inertial (density) effects.Viscosity effects are thought to be responsible for the plasma shape of Fig. 4. [4]

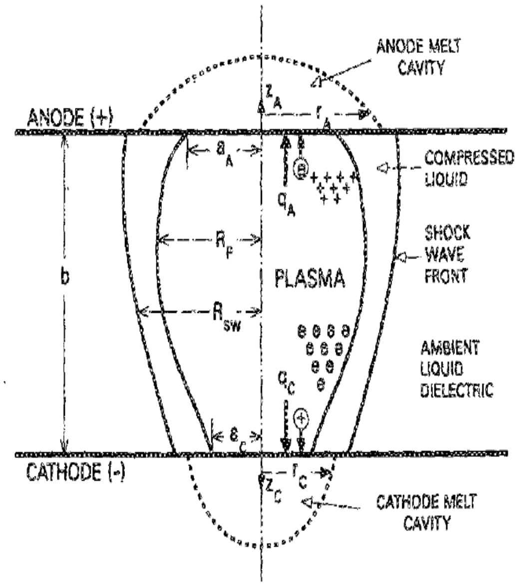

FIG. 4: A schematic diagram of EDM process showing the circle heat sources, plasma configuration, and melt cavities after a certain on-time.

Abrasive jet micro-machining (AJM)-

Abrasive jet micro-machining (AJM) utilizes a jet of abrasive media to erode features such as channels and holes in glass and other materials, usually through a polymeric or metal mask. The small scale of these features, for example channel widths and depths less than 100 _m, has increased the accuracy and repeatability requirements well beyond that associated with traditional abrasive jet machining. One of the major difficulties with the AJM process is the handling of the very fine abrasive media required to manufacturefeatures with the desired resolution. Typical applications use blocky-shaped aluminum oxide particles with average dimensions between 10 and 25 m. Close packing in such fine powdersis promoted by their irregular shape and electrostatic charge.

Powder flowability and compactibility are greatly influenced by particle size, size distribution, moisture content, and surface texture. Interparticle adhesion is further enhanced by moisturethat adsorbs readily onto these hygroscopic surfaces. Consequently,the relative humidity of storage air can have a major influence on the adhesion forces at the interfaces of particles. Furthermore, it is well known that the movement of powdersleads quickly to stratification and the creation of gradients of particle size and/or shape. Such problems result in alteration of the powder mass flowrate during the course of AJMexperiments. Powder feed control of two micro-blasting systems is considered in the present work. Briefly, system *I* is a pressurized powder feed system and system *II* is similar to conventional fluidized bed powder spray systems used in powder coating.[5]

III. CONCLUSION

USM is a non-thermal process which does not rely on a conductive workpiece and is preferable for machining workpieces with low ductility and hardness above 40 HRC.USM is believed to be a stress and damage free process.Recent developments and future directions of ECM are presented in this paper. The advantages of this process are being increasingly recognized not only in itstraditional base of the aircraft and aerospace industries,but also in many application fields where controlledsurface finishing, grinding, abrading and micro-machining are required.

REFERENCES

[1] [R. Snoeys; F. Staelens; W. Dekeyser "Current Trends In Non-Conventional Material Removal Processes". *Annals of TheCirp Vol. 35/2/1986*.
[2] K.P. Rajurkar, D.Zhu, J.A. Mcgeough, J. Kozak, A. De Silva. New Developments In Electro-Chemical Machining. *Annals Of The Clrp Vol. 48/2/1999*
[3] T. B. Thoe, D. K. AspinwallAnd M. L. H. Wise. Review On Ultrasonic Machining. Int. J. Mach. Tools Manufact. Vol. 38, No. 4, Pp. 239–255.
[4] Philip T. Eubank, Mukund R. Patel, And Maria A. Barrufet.Theoretical Models Of The Electrical Discharge Machining Process. J. App\. Phys., Vol. 66, No.9, 1 November 1989.
[5] A. Ghobeity , H. Getu , T. Krajac , J.K. Spelt , M. Papini. Process Repeatability In Abrasive Jet Micro-Machining. Journal Of Materials Processing Technology 190 (2007) 51–60.