A

Seminar report

On

Ultrasonic Machining

Submitted in partial fulfillment of the requirement for the award of degree
Of Mechanical

SUBMITTED TO: **SUBMITTED BY:**

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Preface

I have made this report file on the topic **Ultrasonic Machining;** I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.
My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to …………..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

Student Name

INTRODUCTION

- In ultrasonic machining (USM), also called ultrasonic grinding, high-frequency vibrations delivered to a tool tip, embedded in abrasive slurry, by a booster or sonotrode, create accurate cavities of virtually any shape; that are, “negatives” of the tool.
- Since this method is non-thermal, non-electrical, and non-chemical, it produces virtually stress-free shapes even in hard and brittle work-pieces. Ultrasonic drilling is most effective for hard and brittle materials; soft materials absorb too much sound energy and make the process less efficient.
- Almost any hard and brittle material, including aluminum oxides, silicon, silicon carbide, silicon nitride, glass, quartz, sapphire, ferrite, fiber optics, etc., can be ultrasonically machined.
- The tool does not exert any pressure on the work-piece (drilling without drills), and is often made from a softer material than the work-piece, say from brass, cold-rolled steel, or stainless steel and wears only slightly.
- The roots of ultrasonic technology can be traced back to research on the piezoelectric effect conducted by Pierre Curie around 1880. He found that asymmetrical crystals such as quartz and Rochelle salt (potassium sodium titrate) generate an electric charge when mechanical pressure is applied. Conversely, mechanical vibrations are obtained by applying electrical oscillations to the same crystals. Ultrasonic waves are sound waves of frequency higher than 20,000 Hz.

PRINCIPLE

- The machining zone (between the tool and the work piece) is flooded with hard abrasive particles generally in the form of water based slurry.
- As the tool vibrates over the work piece, abrasive particles acts as indenter and indent both work and tool material .
- Abrasive particles , as they indent , the work material would remove the material from both tool and work piece.
- In Ultrasonic machining material removal is due to crack initiation, propagation and brittle fracture of material.

Material Removal Models in USM

The following are the Material Removal Models used in USM

1. Throwing of abrasive grains.

2. Hammering of abrasive grains.

3. Cavitations in the fluid medium arising out of ultrasonic vibration of tool.

4. Chemical erosion due to micro –agitations.

Effect of Slurry, Tool and Work Material

- MRR increases with slurry concentration.
- Slurry saturation occurs at 30 to 40% abrasive/water mixture.
- Material Removal rate drops with increasing viscosity.
- The pressure with which the slurry is fed into the cutting zone affects MRR .

- In some cases MRR can be increased even ten times by supplying the slurry at increased pressure.
- The shape of the tool affects the MRR. Narrower rectangular tool gives more MRR compared to square cross section.
- Conical tool gives twice MRR compared to cylindrical tool.
- The brittle behavior of material is important in determining the MRR.
- Brittle material can be cut at higher rates than ductile materials.

TRANSDUCER

- The high frequency electrical signal is transmitted to traducer which converts it into high frequency low amplitude vibration.
- Essentially transducer converts electrical energy to mechanical vibration. There are two types of transducer used

1. Piezo electric transducer

2. Magneto-stricitve transducer.

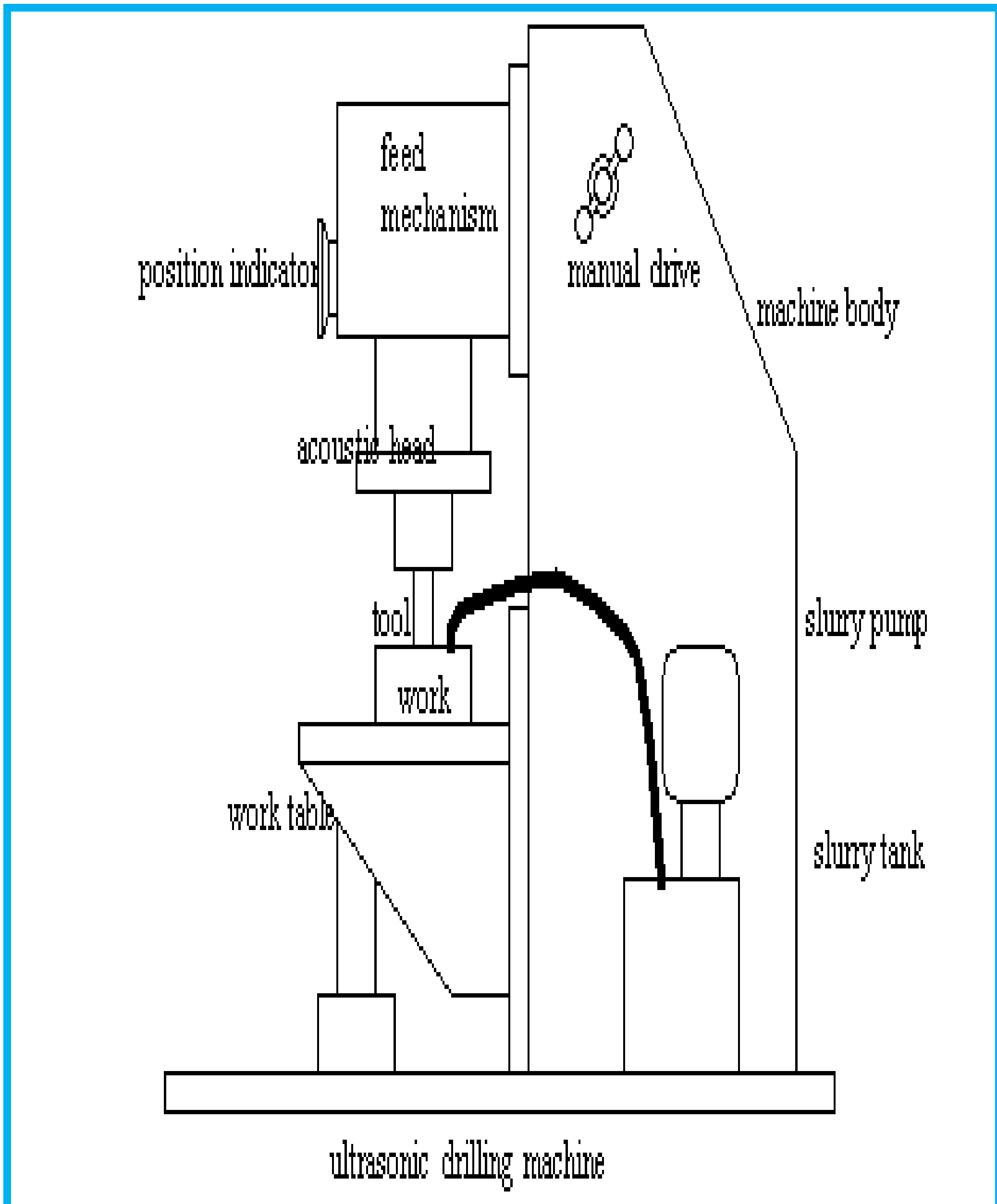
MAGNETOSTRICTIVE TRANSDUCER

- These transducer are made of nickel , nickel alloy sheets.
- Their conversion efficiency is about 20-30%.
- Such transducers are available up to 2000 Watts.
- The maximum change in length can be achieved is about 25 microns.

USM system components

1. Power supply
2. Transducer
3. Tool holder
4. Tool

5. Abrasive slurry



1. Transducer

- Piezoelectric transducers utilize crystals like quartz whose dimensions alter when being subjected to electrostatic fields.
- The charge is directionally proportional to the applied voltage.
- To obtain high amplitude vibrations the length of the crystal must be matched to the frequency of the generator which produces resonant conditions.

2. Abrasive

- Abrasive Slurry

  - common types of abrasive

  - Boron carbide (B_4C) good in general, but expensive

  - Silicon carbide (SiC) glass, germanium, ceramics

  - Corundum (Al_2O_3)

  - Diamond (used for rubies , etc)

  - Boron silicon-carbide (10% more abrasive than B_4C)

- Liquid

  - Water most common

  - Benzene

  - Glycerol

  - Oils

  - High viscosity decreases MRR

3. Tool Holder/Acoustic head

- The shape of the tool holder is cylindrical or conical, or a modified cone which helps in magnifying the tool tip vibrations.
- Its function is to increase the tool vibration amplitude and to match the vibrator to the acoustic load. Therefore it must be constructed of a material with good acoustic properties and be highly resistant to fatigue cracking.
- Monel and titanium have good acoustic properties and are often used together with stainless steel, which is cheaper.

4. Tool

- Tool material should be tough and ductile. Low carbon steels and stainless steels give good performance.
- Tools are usually 25 mm long ; its size is equal to the hole size minus twice the size of abrasives.
- Mass of tool should be minimum possible so that it does not absorb the ultrasonic energy.
- It is important to realize that finishing or polishing operations on the tools are sometimes necessary because their surface finish will be reproduced in the workpiece.
- Tool and toolholder are often attached by silver brazing.

APPLICATIONS

- Machining of cavities in electrically non-conductive ceramics
- Used to machine fragile components in which otherwise the scrap rate is high
- Used for multistep processing for fabricating silicon nitride (Si_3N_4) turbine blades
- Large number of holes of small diameter could be machined. 930 holes with 0.32mm has been reported (Benedict, 1973) using hypodermic needles
- Used for machining hard, brittle metallic alloys, semiconductors, glass, ceramics, carbides etc.
- Used for machining round, square, irregular shaped holes and surface impressions.
- Used in machining of dies for wire drawing, punching and blanking operations
- USM can perform machining operations like drilling, grinding and milling operations on all materials which can be treated suitably with abrasives.
- USM has been used for piercing of dies and for parting off and blanking operations.
- USM enables a dentist to drill a hole of any shape on teeth without any pain
- Ferrites and steel parts , precision mineral stones can be machined using USM
- USM can be used to cut industrial diamonds
- USM is used for grinding Quartz, Glass, ceramics
- Cutting holes with curved or spiral centre lines and cutting threads in glass and mineral or metallo-ceramics.

ADVANTAGES

- It can be used machine hard, brittle, fragile and non conductive material
- No heat is generated in work, therefore no significant changes in physical structure of work material
- Non-metal (because of the poor electrical conductivity) that cannot be machined by EDM and ECM can very well be machined by USM.
- It is burr less and distortion less processes.
- It can be adopted in conjunction with other new technologies like EDM,ECG,ECM.

DISADVANTAGES

- Low Metal removal rate.
- It is difficult to drill deep holes, as slurry movement is restricted.
- Tool wear rate is high due to abrasive particles. Tools made from brass, tungsten carbide, MS or tool steel will wear from the action of abrasive grit with a ratio that ranges from 1:1 to 200:1.
- USM can be used only when the hardness of work is more than 45HRC.

REFERENCES

- www.google.com
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