

Research Background

In EDM, material is removed by evaporation due to the heat of the arc plasma. Bubbles are generated, which stay between the electrodes.

The presence of the bubbles hinders the flow of dielectric fluid between the electrodes and causes the occurrence of short circuits, concentrated discharges, abnormal discharges and suppresses the removal process of debris

➔ **Decrease of processing efficiency and accuracy**

As a solution to the problem, electric discharge machining with ultrasonic vibration applied to the tool electrode has been proposed and its effect has been confirmed. **However, direct observation of bubble behavior in ultrasonic vibration applied EDM has not been realized so far.**

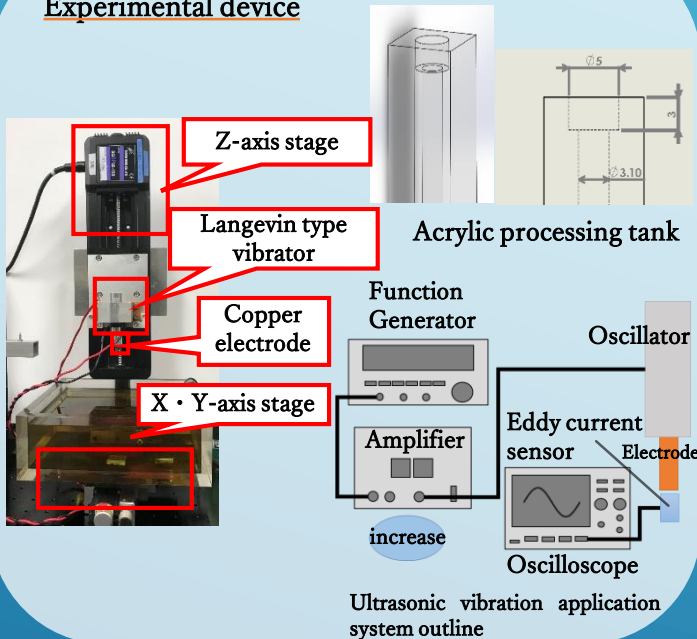


It is necessary to observe the bubble behavior directly to understand the exact phenomenon.

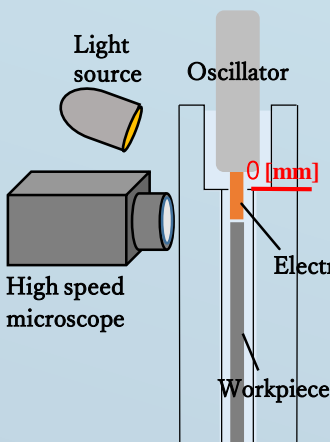
Purpose of the research

Observation of the bubble behavior in the discharge gap during ultrasonic vibration processing.

Experimental device



Experimental method



Discharge condition

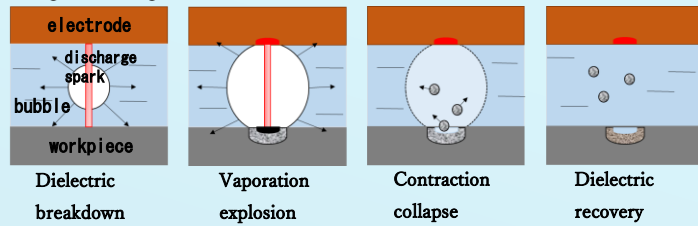
Electrode	Cu ϕ 3 (+)
Workpiece	SUS304 ϕ 3 (-)
Power supply voltage [v]	100
Discharge current [A]	4
Pulse [μ s]	5
Reference voltage [v]	60
Frequency [kHz]	44
Amplitude [μ m]	2

Camera shooting condition

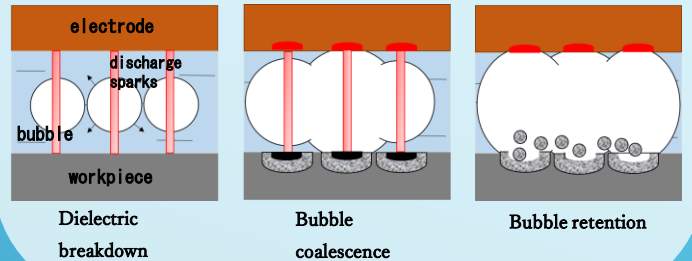
Exposure time [s]	1/3000
Frame rate [fps]	1000
Resolution [px]	640 \times 480

Process of bubble formation

Single discharge

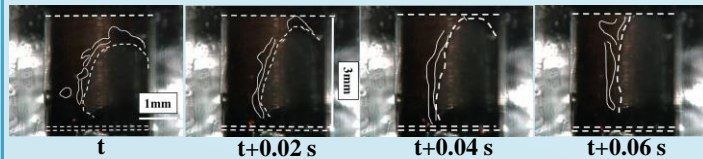


Continuous discharge



Effect of ultrasonic vibration

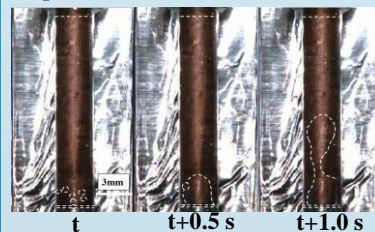
Depth: 3 mm; No ultrasonic vibration applied



- Processing debris does not only exist between the electrodes but also at the bubble boundaries.
- In the upper part of the bubble, when the bubble escapes, the cutting waste also escapes.

Air bubbles play a major role in the discharge of cuttings.

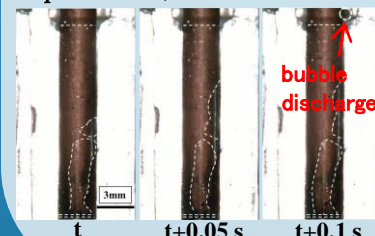
Depth: 15 mm; No ultrasonic vibration applied



- Adjacent bubbles form one large bubble and stay.

➔ **Expansion of bubble occupied part**

Depth: 15 mm; Ultrasonic vibration applied



- Air bubbles were discharged by ultrasonic vibration.
- The united bubbles do not collapse by the cavitation effect.
- It is expected that air bubbles have been exhausted by the pumping effect.

Conclusion

- In the side gap, air bubbles affect the discharge of debris.
- When the processing hole is deep, the air bubbles merge and become one large air bubble, expanding the air bubble occupied part and increasing the concentration of cutting waste.
- Promotion of air bubble discharge by applying ultrasonic vibration.