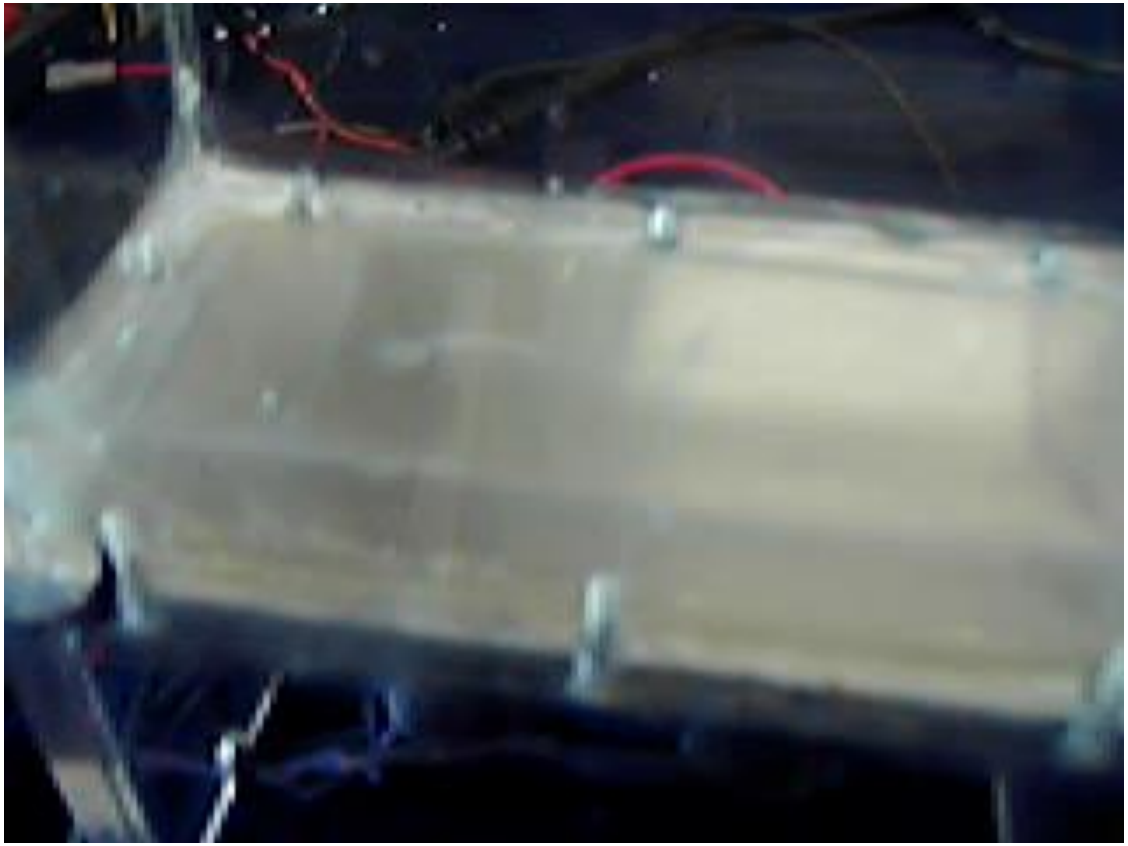
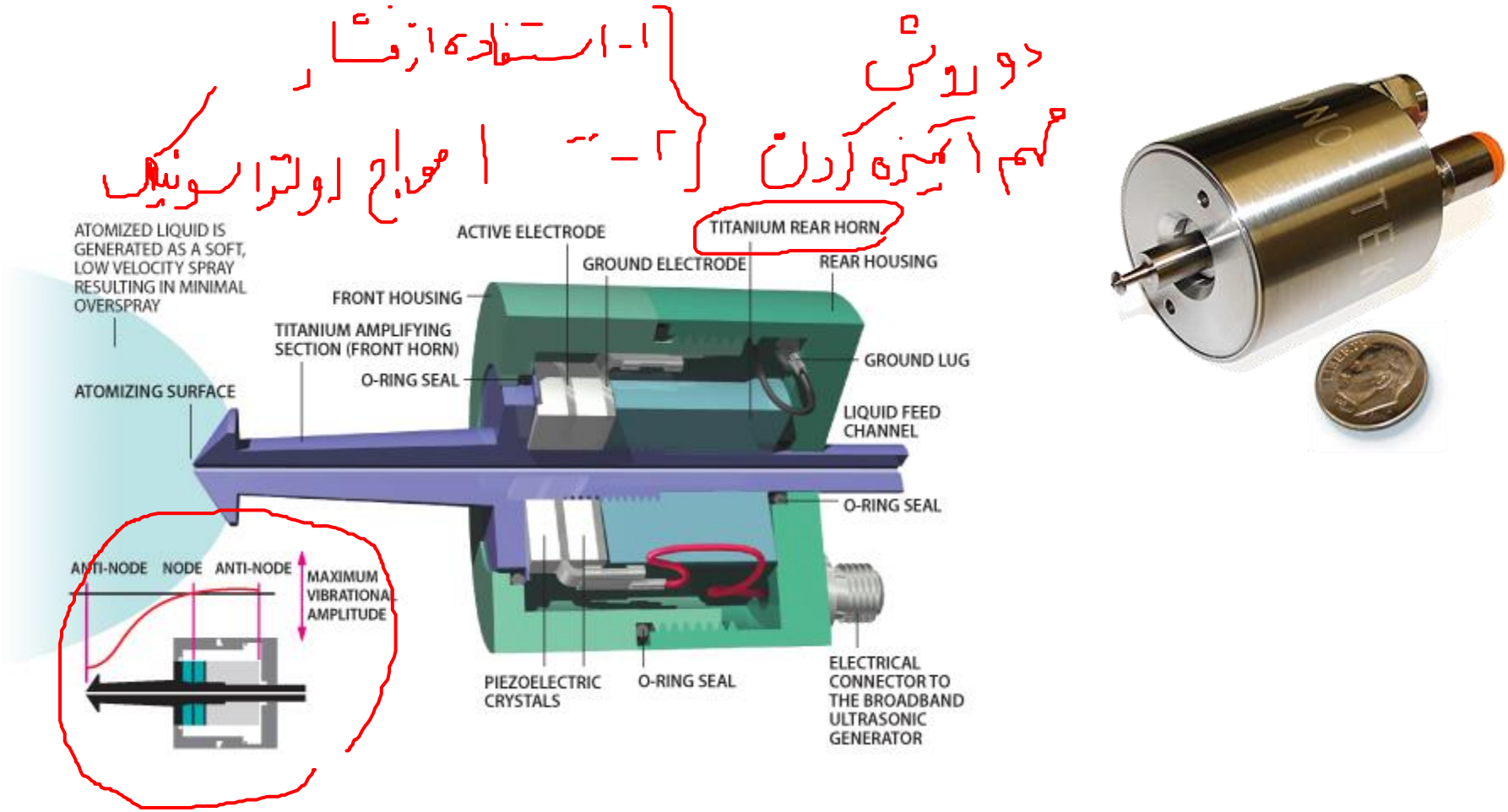
کاربردهای اولتراسونیک در حوزه توان بالا

Ultrasonic Cleaning tank

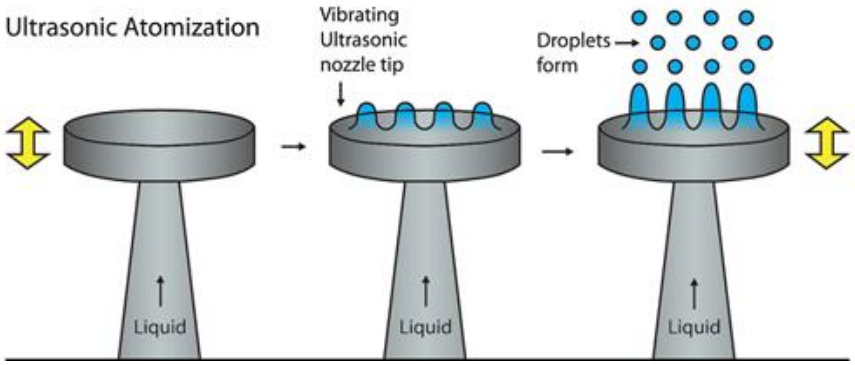
Ultrasonic Cleaning tank



Ultrasonic Atomiser



Mechanism

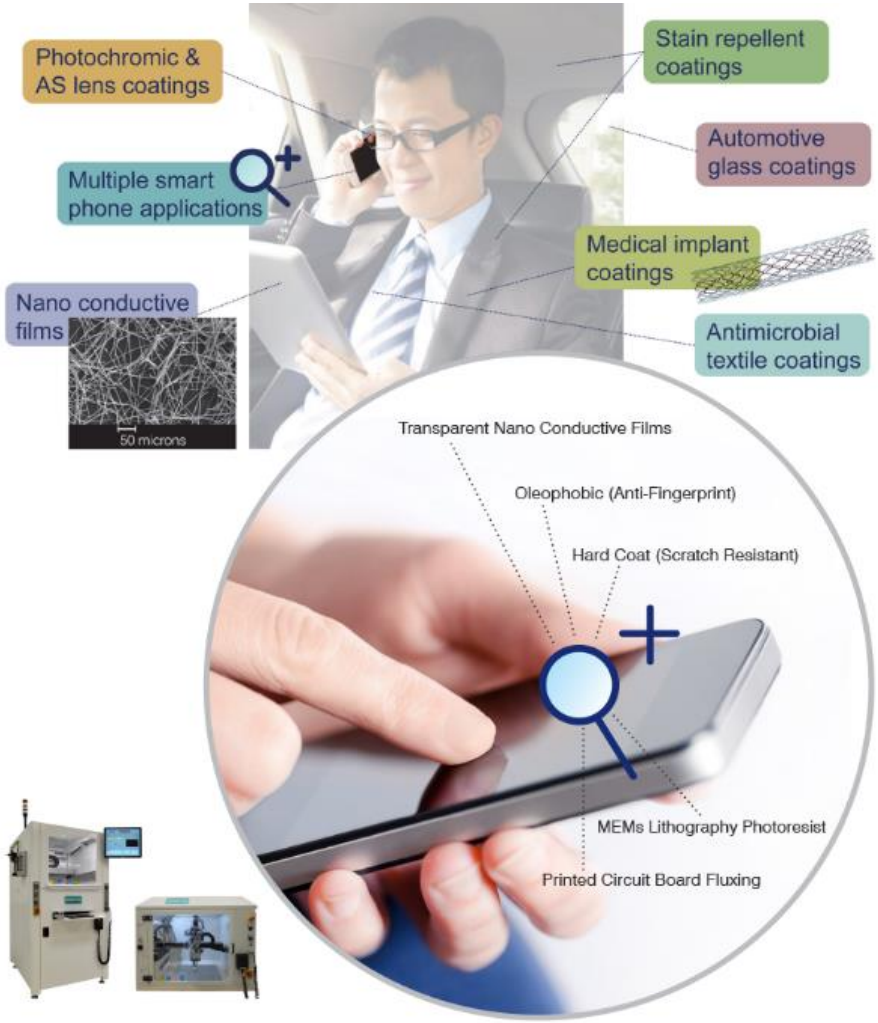


Advantages

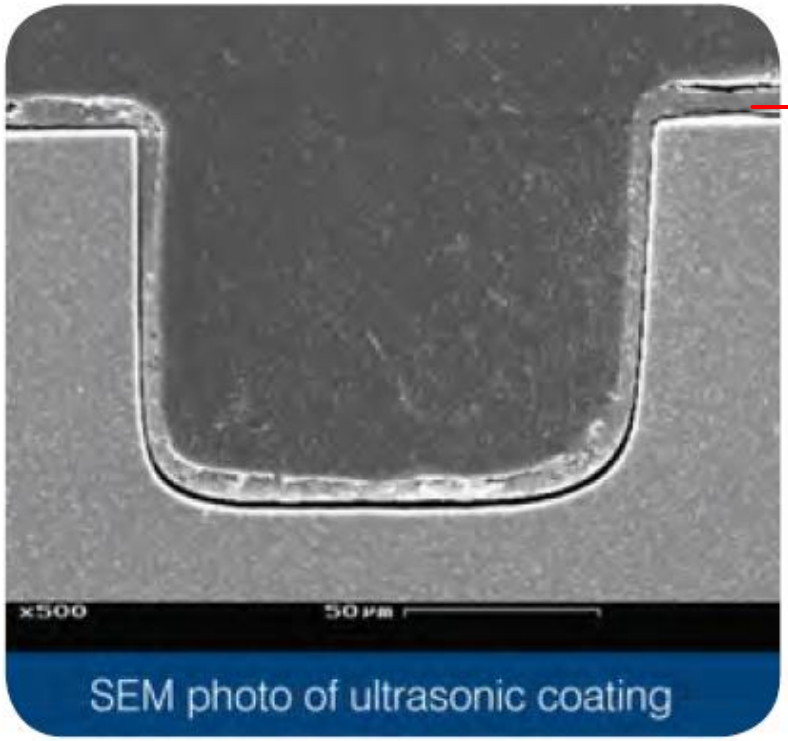
- Spray patterns are easily shaped for precise coating applications
- Highly controllable spray produces reliable, consistent results
- Ultra-low flow rate capabilities, intermittent or continuous
- No moving parts to wear out
- Non-clogging
- Drops sizes as small as 13 microns, depending upon nozzle frequency
- reduce downtime in critical manufacturing processes

Different Designs

Applications



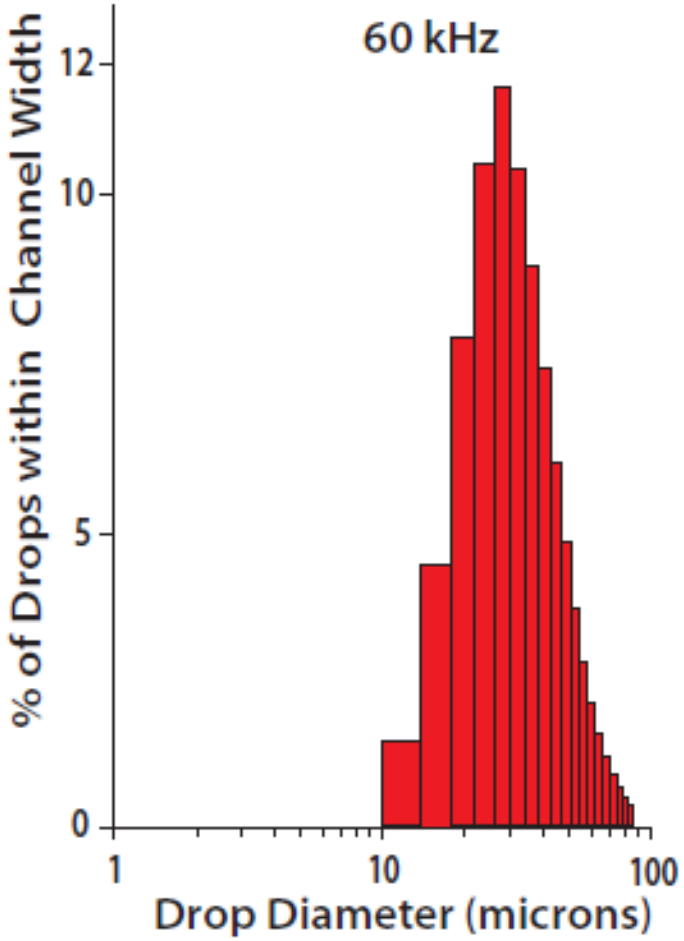
Applications



Uniform coating thickness of deep well topographies

Frequency impact

$$d_h = 0.73 \sqrt[3]{\frac{T}{\rho f_a^2}}$$



- Emulsification and homogenisation are common

unit operations in the pharmaceutical, cosmetic, food, chemical (paint, lubricants and fuels) and other industries.

oil (yellow) and water (red) before emulsification

oil (yellow) and water (red) after emulsification

https://www.dideo.ir/v/yt/hGDe829IliQ/ultrasonic-emulsification

Working principle of Ultrasonic Emulsification

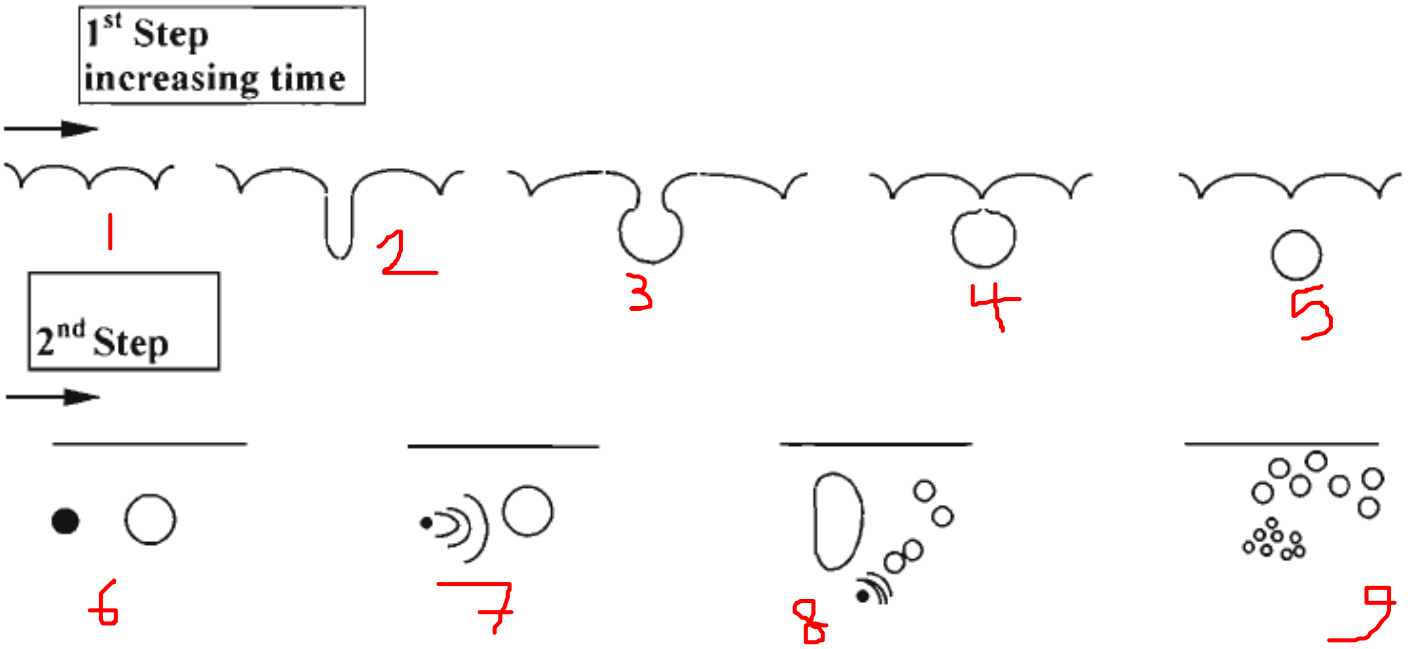
1.

instable waves form at the oil-water interface, which results in the eruption of rather large oil droplets (approx. 50–100 m) into the water phase.

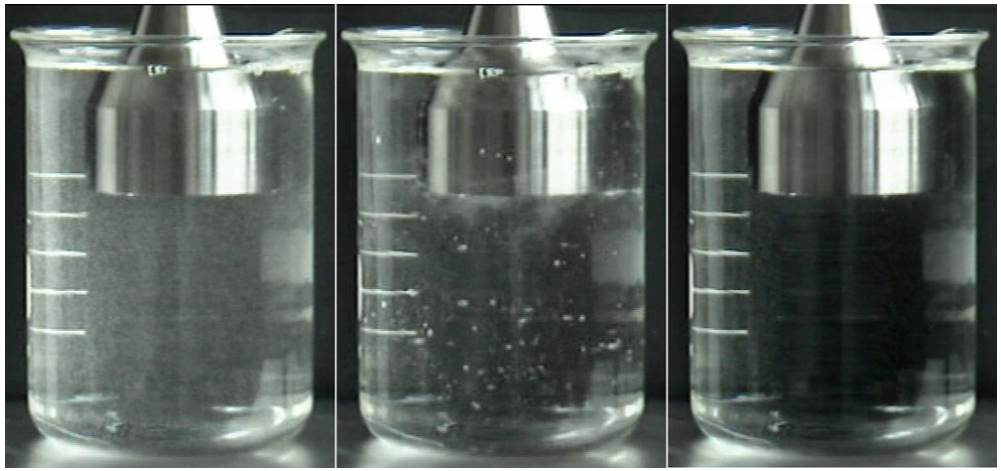
2.

the shock waves of cavitation events in the close vicinity of the coarse oil droplets will cause their disruption into much finer droplets

Ultrasonic Emulsification mechanism



Liquid degassing

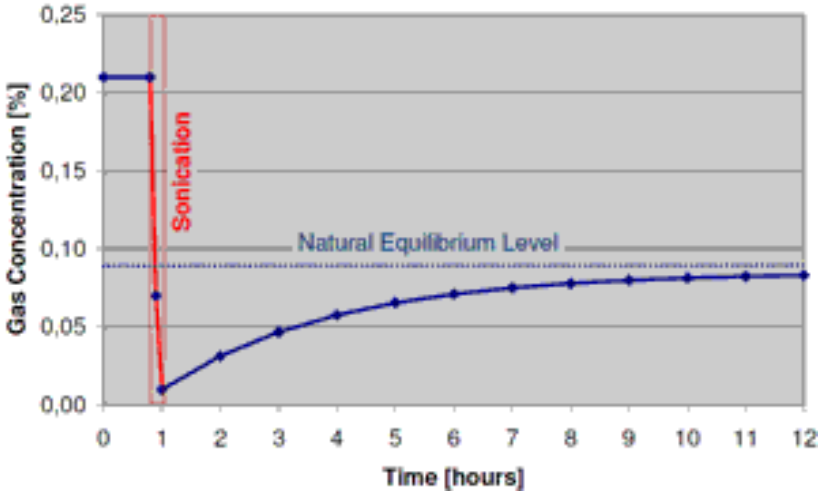


Water

Oil

Mechanism of Ultrasonic Liquid degassing

When the cavitation bubble collapses, the gas does not immediately re-dissolve. If the cavitation bubble contains enough gas molecules to form a larger than critical sized nucleus, the gas bubble will grow and rise. If it is less than critical size, it will slowly re-dissolve. Thus, for rapid degassing, the energy input must be high enough to create a large number of nuclei.



https://www.dideo.ir/v/yt/Wifs4zDvZVE/ultrasonic-degassing

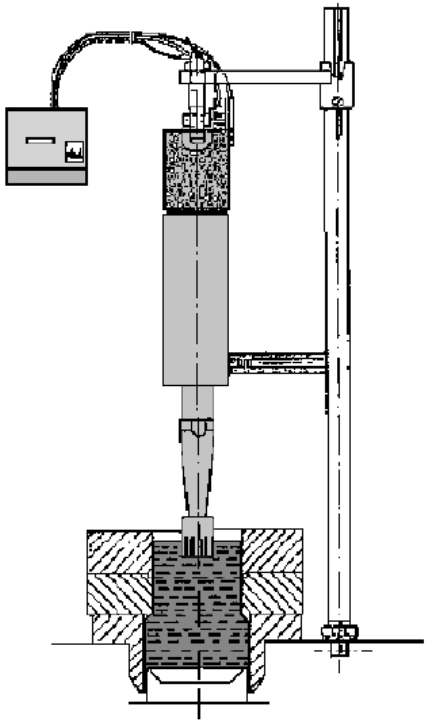
ultrasonic melt degassing

hydrogen could be efficiently removed from A1- and Mg-based melts only when the ultrasonic treatment is accompanied by developing cavitation.

https://www.dideo.ir/v/yt/XKnHjby8m6E/ultrasonic-continuous-casting%2C-direct-chill

Ultrasonic Solidification

Ultrasonic vibrations transmitted into a solidifying aluminum create special conditions influencing the crystallization process. The effects are both in the melt and at the crystallization front.



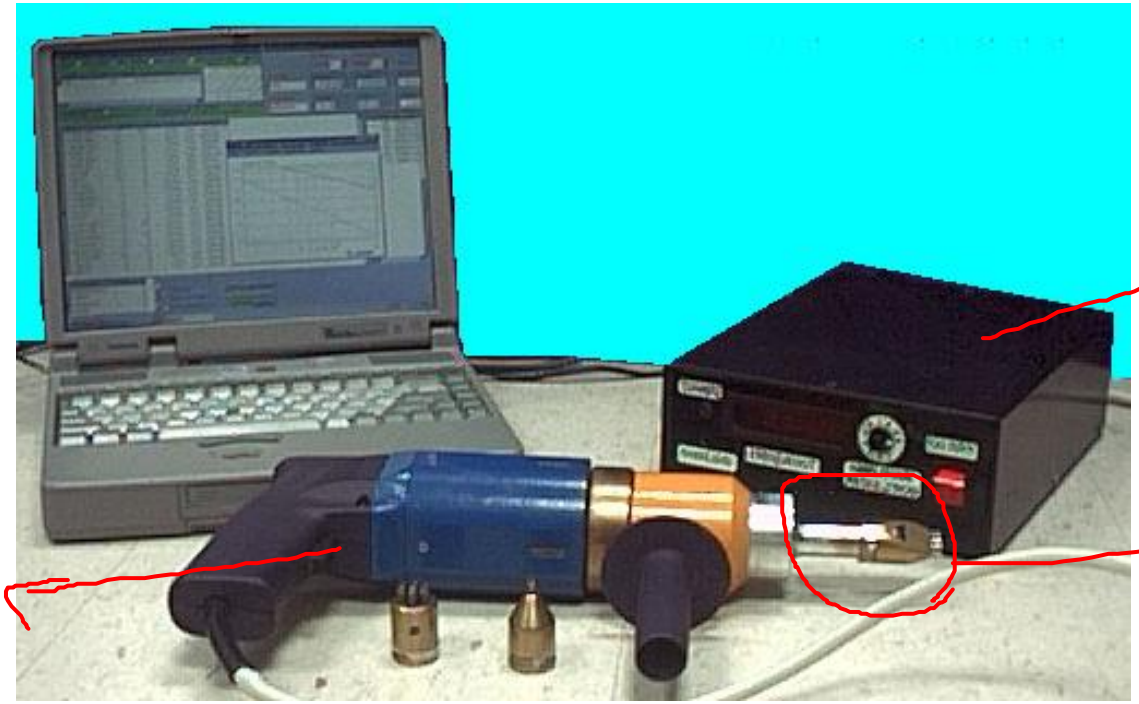
Ultrasonic Solidification

as a consequence of ultrasound the number of nucleation centers increases due to cavitation phenomenon in the melt. Increased number of nucleation centers leads to the increase of nuclei and therefore grains in the solid phase.

Ultrasonic metallurgy

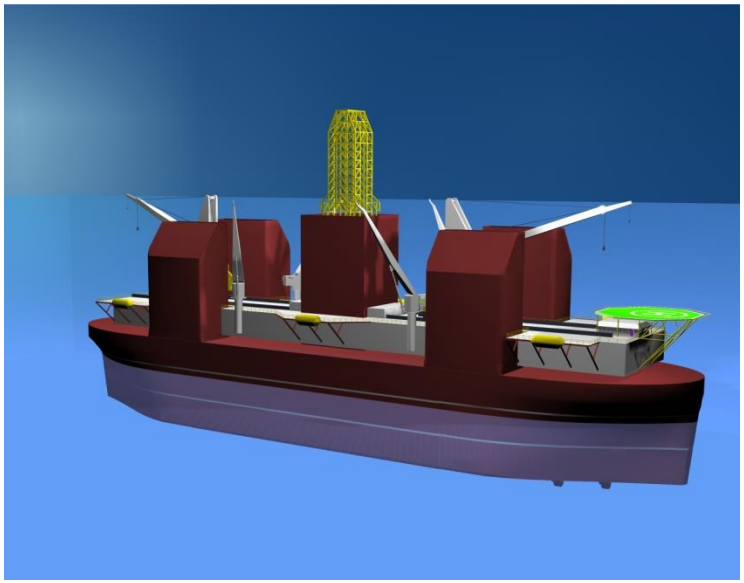
- Grain refinement, with significantly improved and 3D uniformly distributed micro-crystallization.
- Disintegration, elimination, wetting and dissolving of non-metallic and metallic inclusions, making smooth intermetallic transitional area.
- Alloys mixing with nano-particles, increasing density of the alloys, varying percentages of alloys ingredients.
- Improving chemical, mechanical and physical properties and corrosion resistance e.g. in Al-Li alloys and other aerospace alloys.

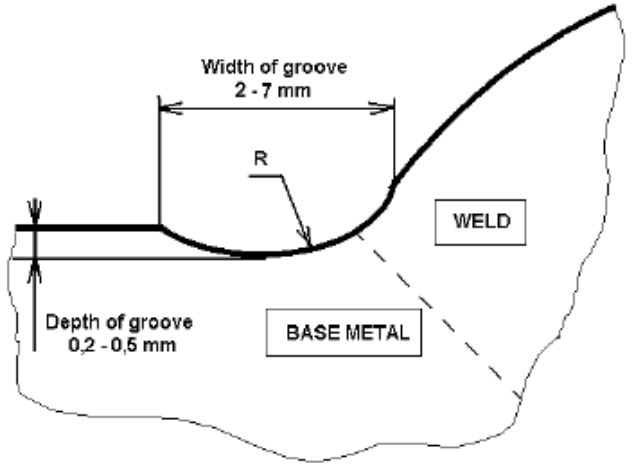
- **Ultrasonic Peening**
  - **Increase Fatigue Life of Welded Elements**
  - **removal of harmful tensile residual stresses**



Ultrasonic Peening

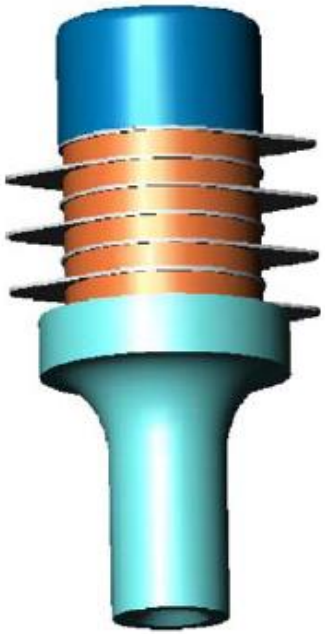
- **Applications**
  - **Offshore Industry for stress relieving**
  - **eliminating of distortions caused by welding and other technological processes**

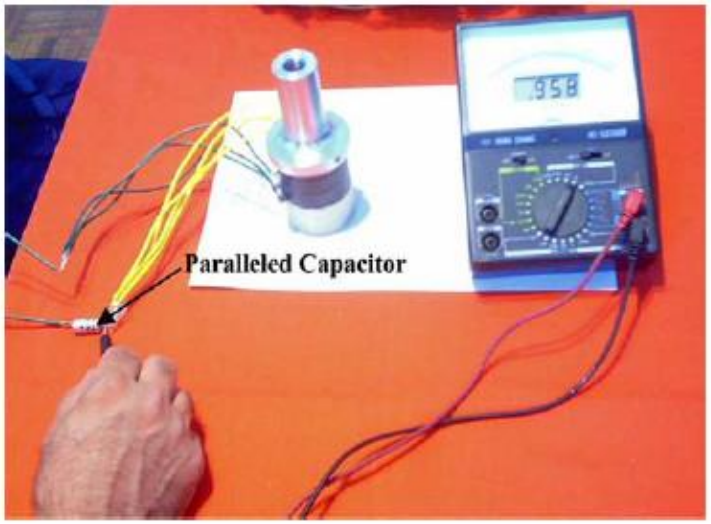




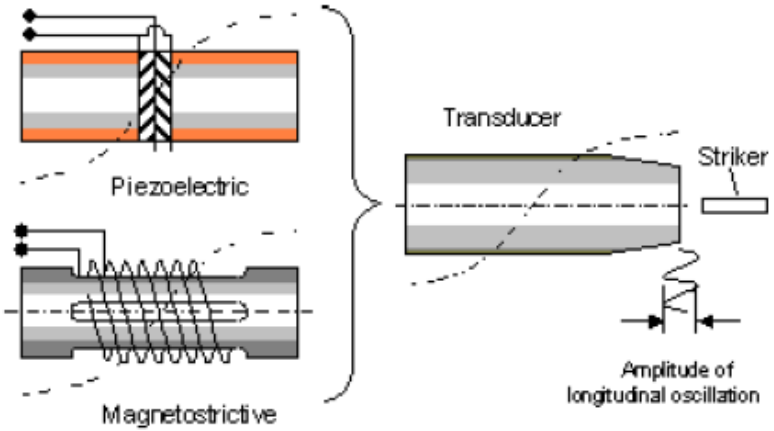
Profile of weld toe improved by Ultrasonic Peening

Transducer Design





Transducer Design



Transducer Head

Samples

Before Ultrasonic peening

After Ultrasonic peening

Samples

Application of UP for rehabilitation of welded elements of a large grinding mill

Ultrasonic Peening Equipment

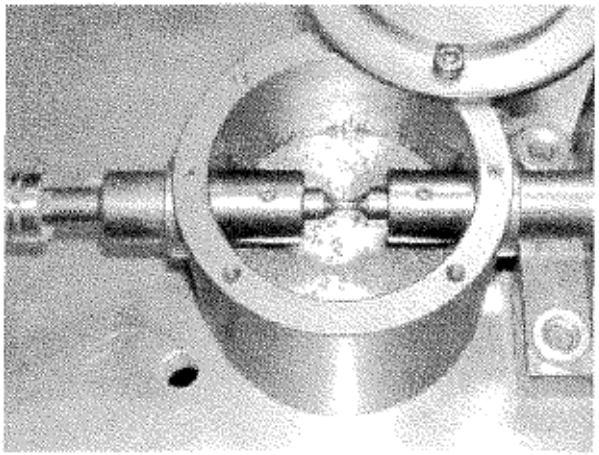
https://www.dideo.ir/v/yt/jqlNih9angU/what-is-ultrasonic-peening%3F-an-overview-of-uit

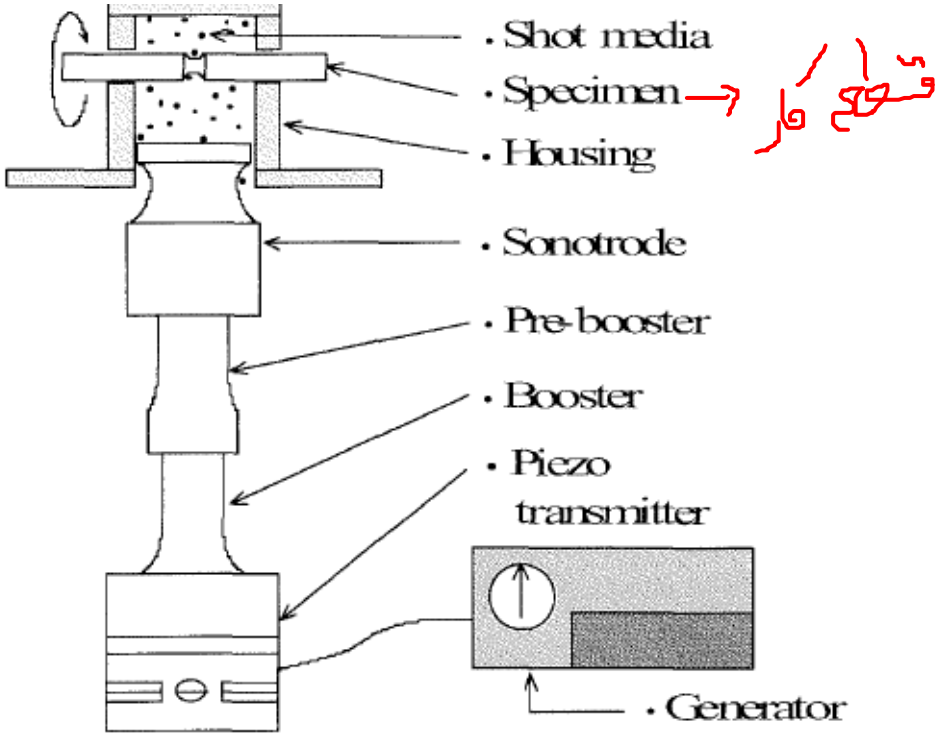
Ultrasonic Shot Peening

Small stainless steel balls in a specially designed ultrasonic chamber will be mechanically stimulated to impact parts placed in the chamber. The part is randomly and uniformly impacted in 3-dimensions by the steel balls with sufficient force to create a wide range of stresses

1. Formation of a white layer up to 10 microns in depth with exceptional corrosion resistance, abrasion resistance, and lubricity.
2. Plastic deformation of the surface.
3. Elimination of tensile stress and the introduction of favorable compression stress up to 12 millimeters in depth.
4. Altering the surface finish resulting in a smoother surface and eliminating defects.
5. Improvement in endurance and corrosion resistance. Up to 250% and 400% respectively.

Ultrasonic Shot peening





https://www.dideoi.r/v/yt/7Dyfje9divQ/introducing-stressonic%C2%AE-technology-for-ultrasonic

Ultrasonic Shot peening

Ultrasonic assisted extrusion

Advantages:

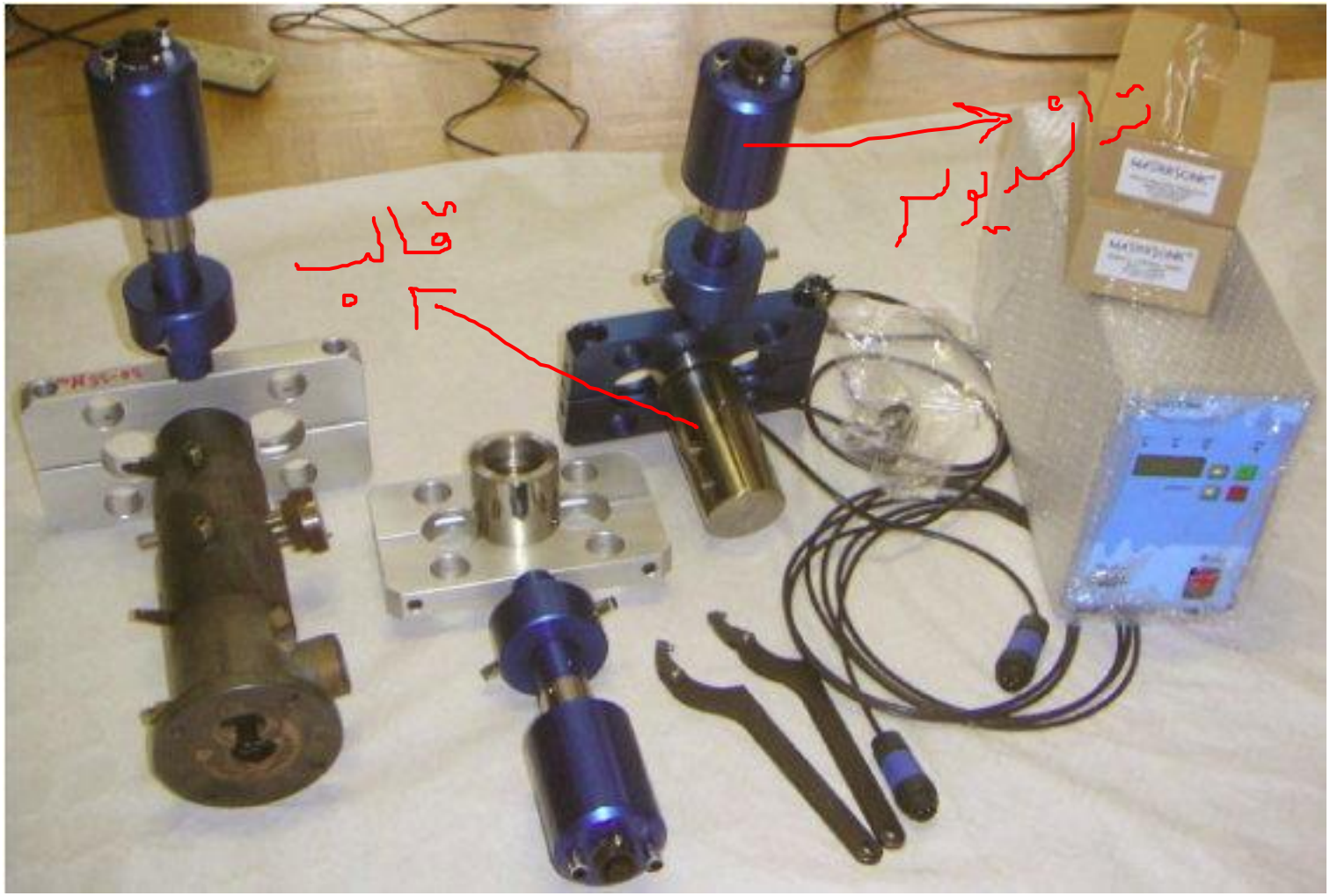
Friction reduction between the tool and the extruded or drawn material, leading to:

- Improved Material Flow
- Reduced Pressure
- Faster Extrusion or Drawing
- Less breakage in a drawing process improves production yield.
- Improved surface quality of extruded or drawn material.

- **Ultrasonic softening**

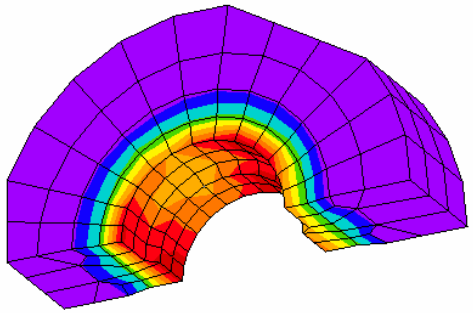
Ultrasonic assisted extrusion

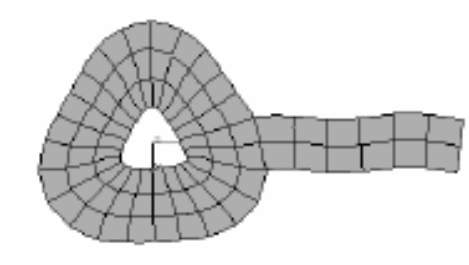
Transducer for extrusion

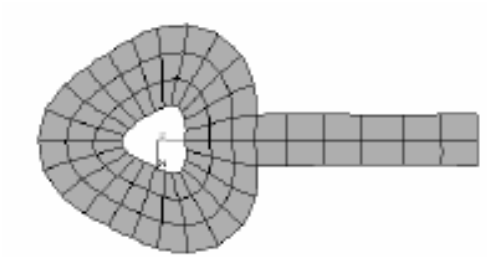


Difficulties of die vibrating

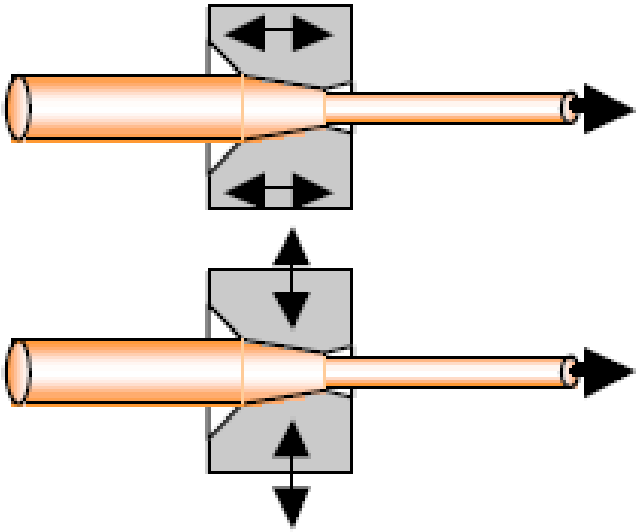
When applying process (such as tube drawing), the most effective and practical approach is to use radial vibrations.

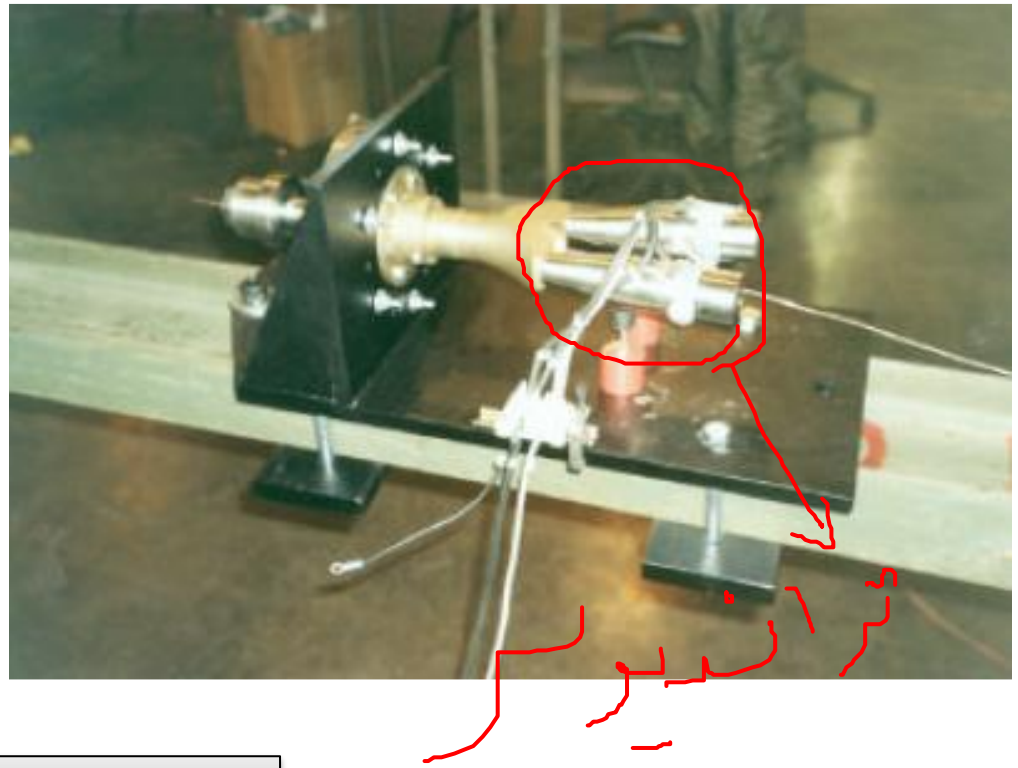






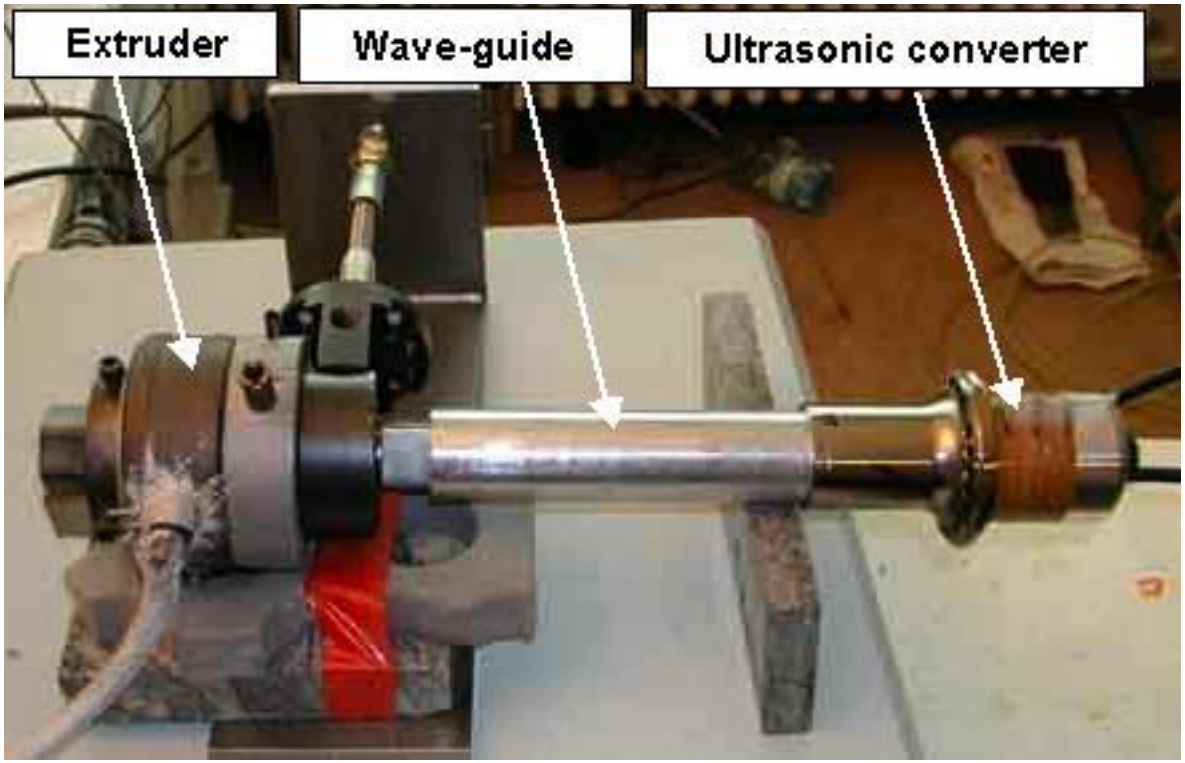
Ultrasonic assisted extrusion and wire drawing





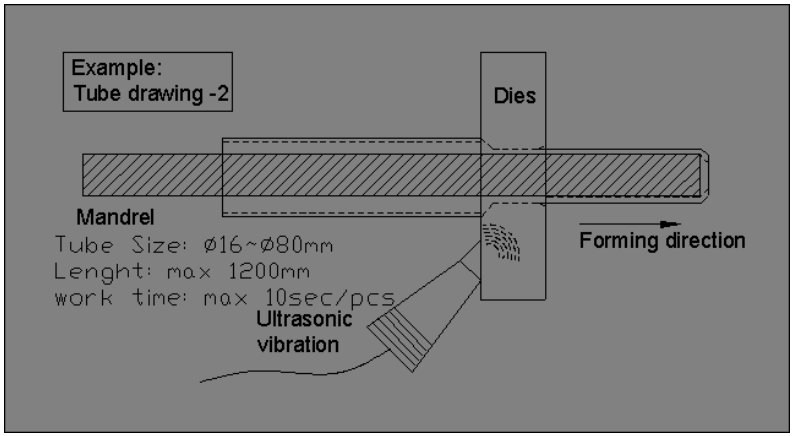
Wire drawing

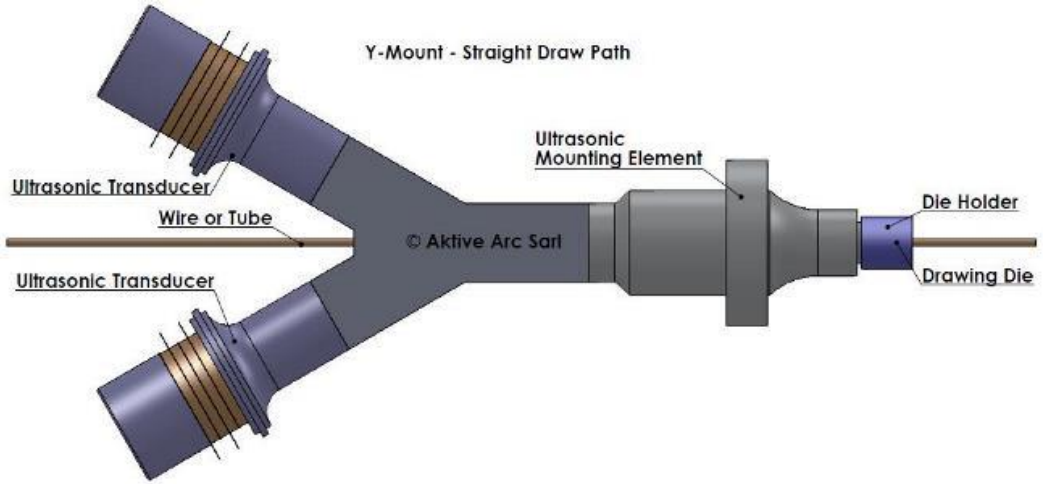
Ultrasonic assisted extrusion



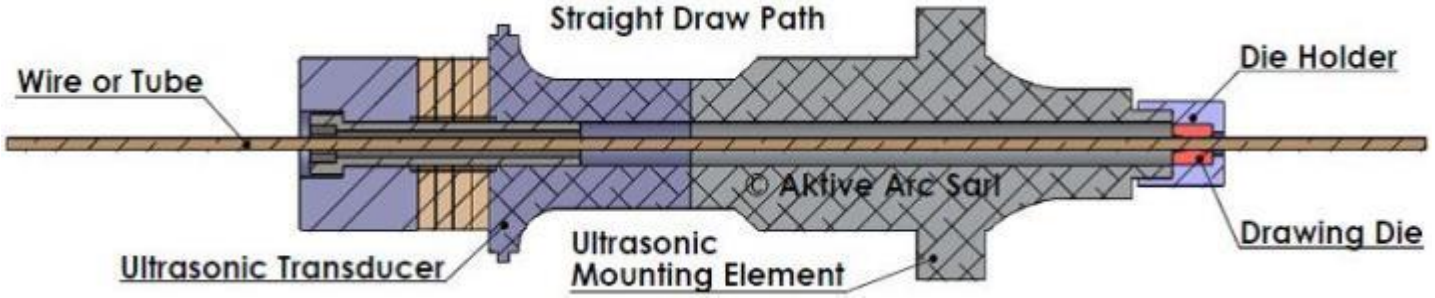
Ultrasonically agitated plastic extruder for composite plastics

Ultrasonic assisted wire drawing



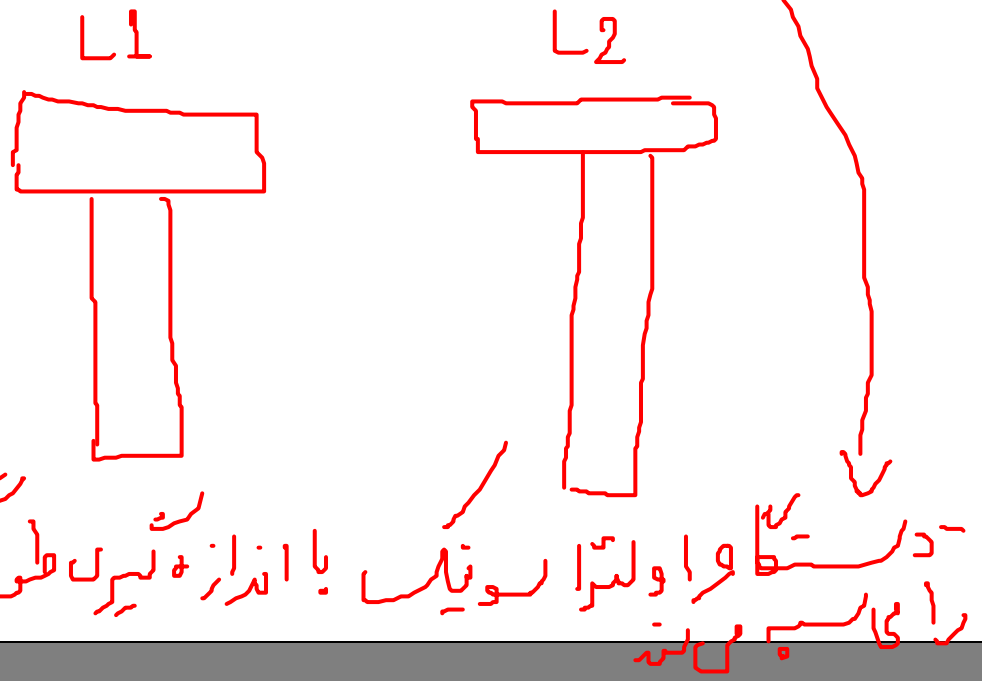


Ultrasonic assisted wire drawing



Complex vibration testing

- Leakage & sealing test
- Bolts torque measurement



Accelerated Leakage & Sealing Test in a Liquid ULTRASONIC BATH

- An ultrasonic chamber filled with water (or some other liquid) may be used for leak testing, sealing, and corrosion resistance tests on watchcases, high-tech components, or Microsystems.

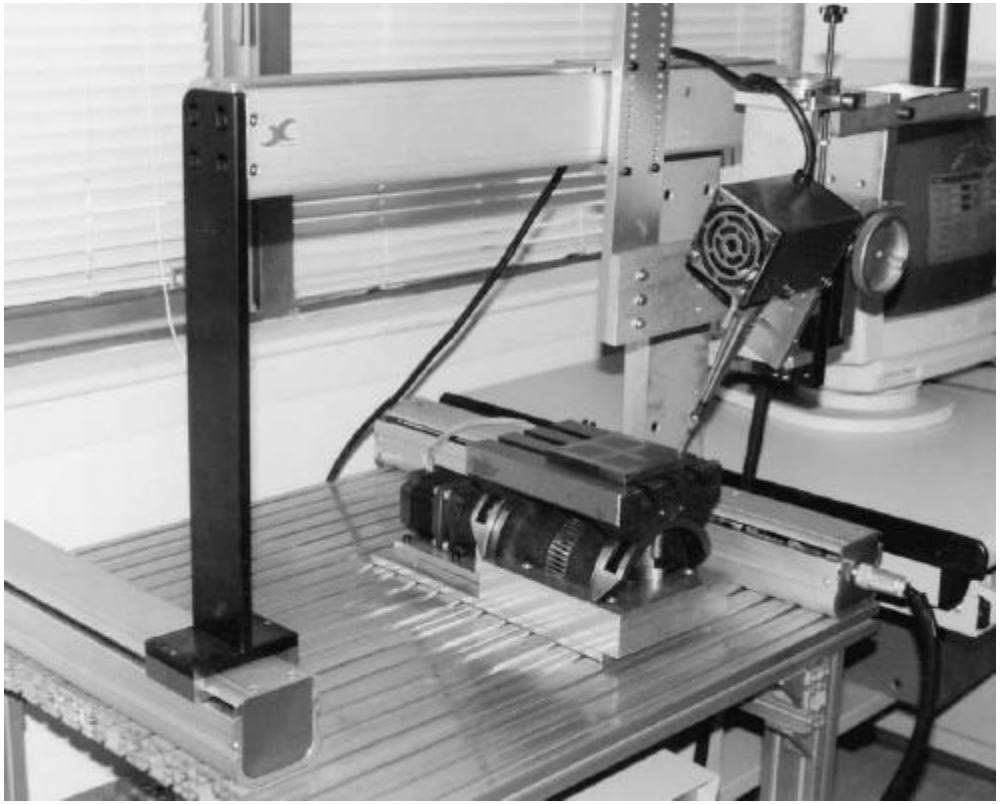
ultrasonic surface etching

- **A process like Ultrasonic machining that polishes the surface of materials with abrasives**

- **Application : polishing of steel molds after EDM (molds of injection molding)**

- **Material removal mechanism:**
  - **Hammering**
  - **Cavitations**

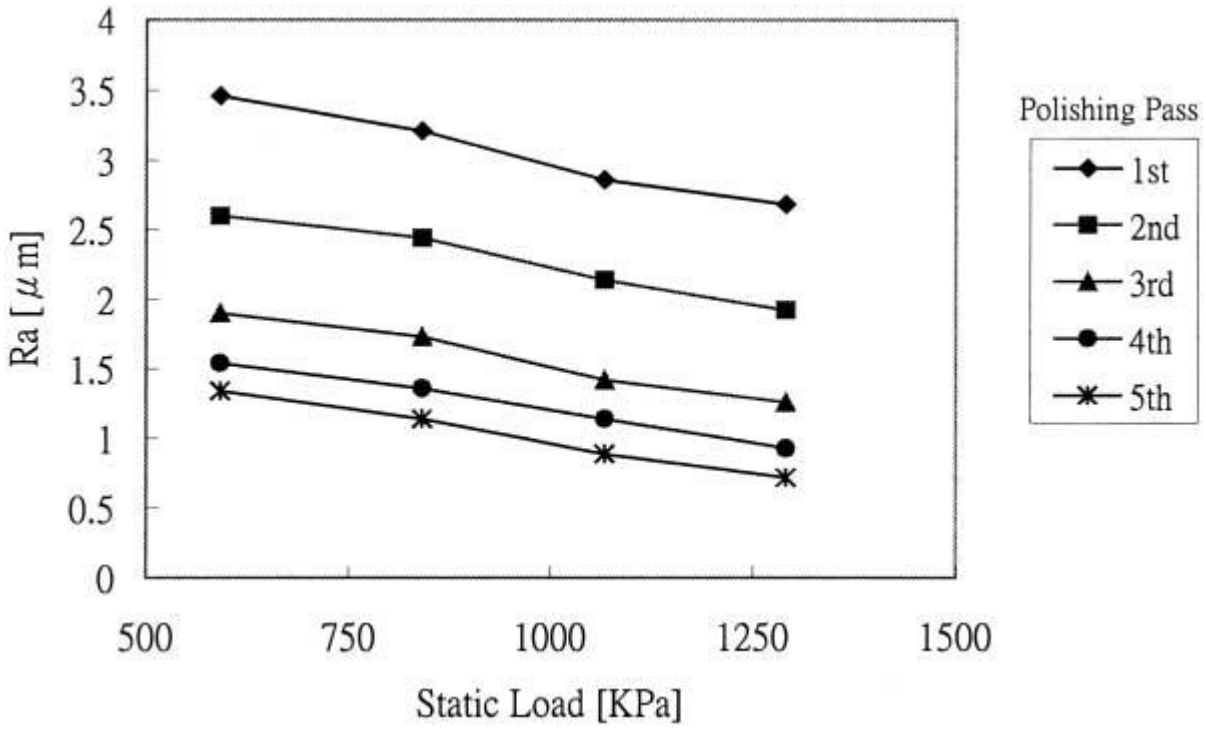
ultrasonic surface etching



Machine

Effect of static load

There is a linear relation between the acquired surface finish and the static load. The larger the static load is, the smoother the surface will be produced.



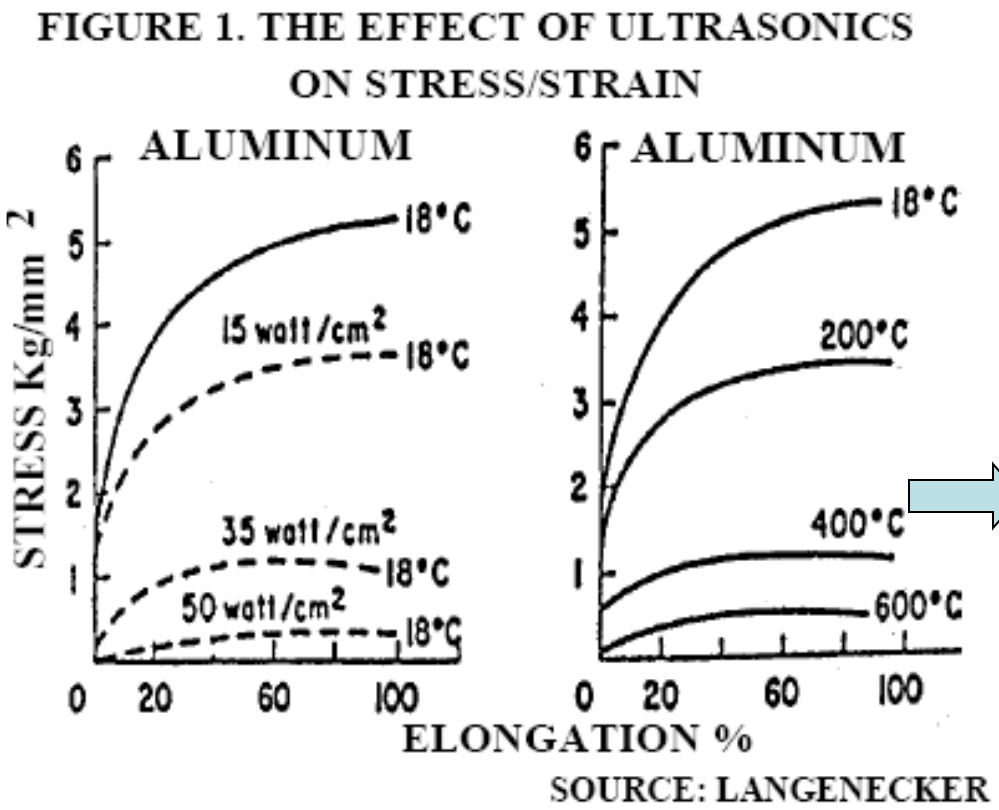
Mesh sizes

the surface roughness cannot be improved when the large 100 mesh abrasive grits are used:

The vertical (perpendicular to surface) magnitude of the tool vibration is identified around 60 μm. The average size of the 100 mesh abrasive particle is around 149 μm. Under this situation, the abrasive particles have little chance entering the opening between the tool and the work surface during ultrasonic polishing

Ultrasonic softening

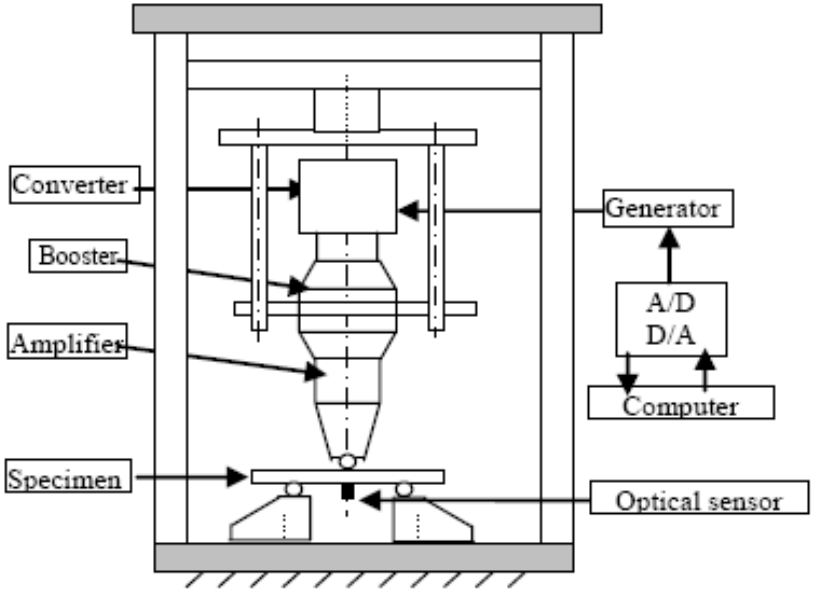
- Material deformed at higher temperatures recrystallizes dynamically and has an annealed grain structure. Ultrasonically deformed material is not recrystallizsed and has a work hardened grain structure



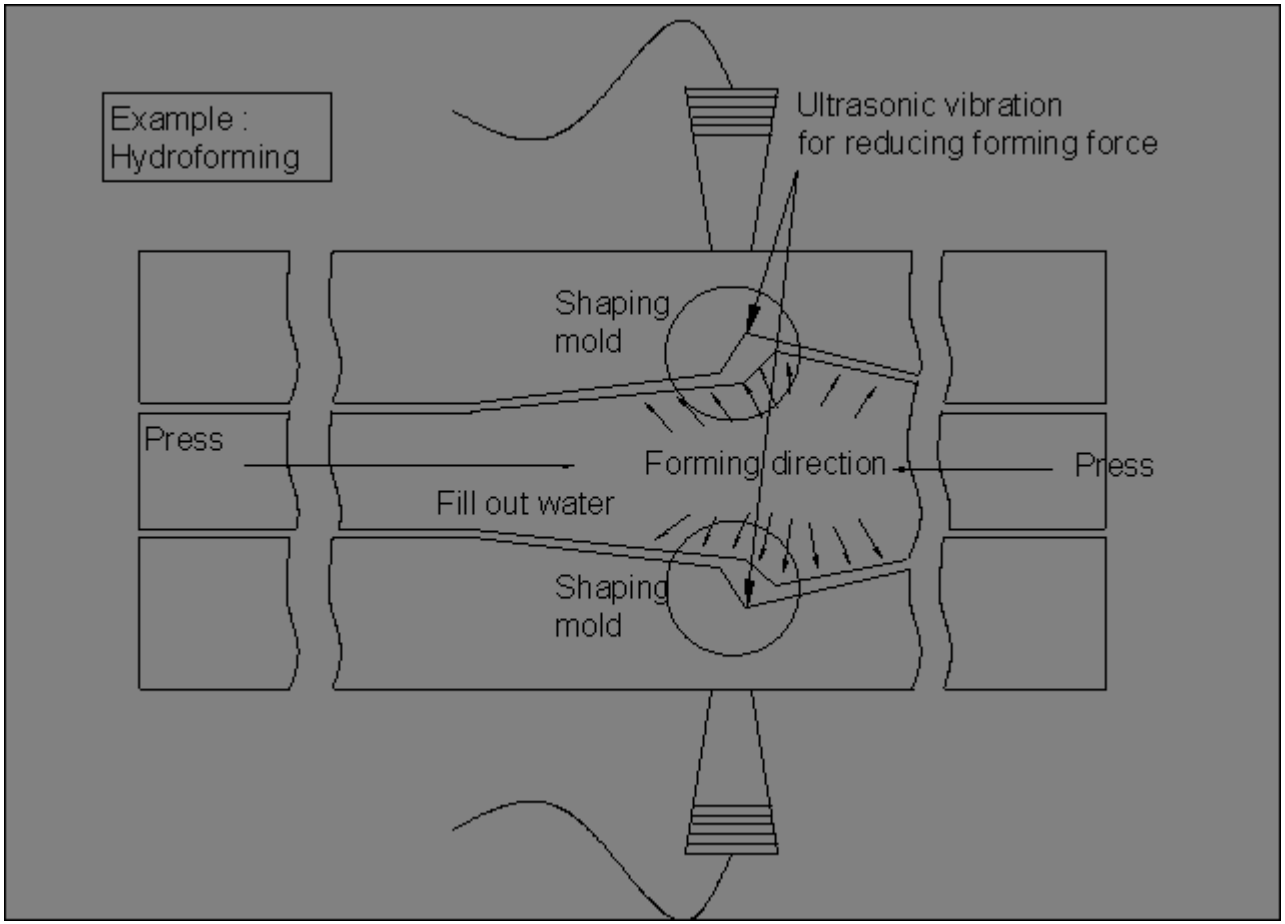
With Ultrasound

Without Ultrasound

Ultrasonic Bending



Ultrasonic Assisted hydro forming



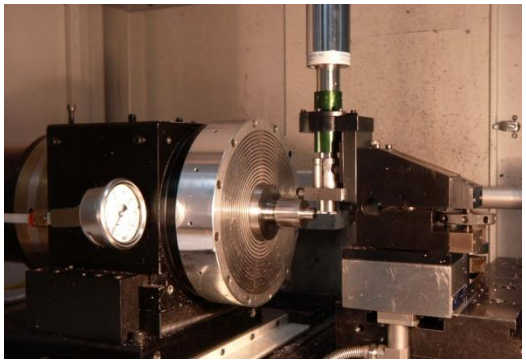
Ultrasonic assisted machining

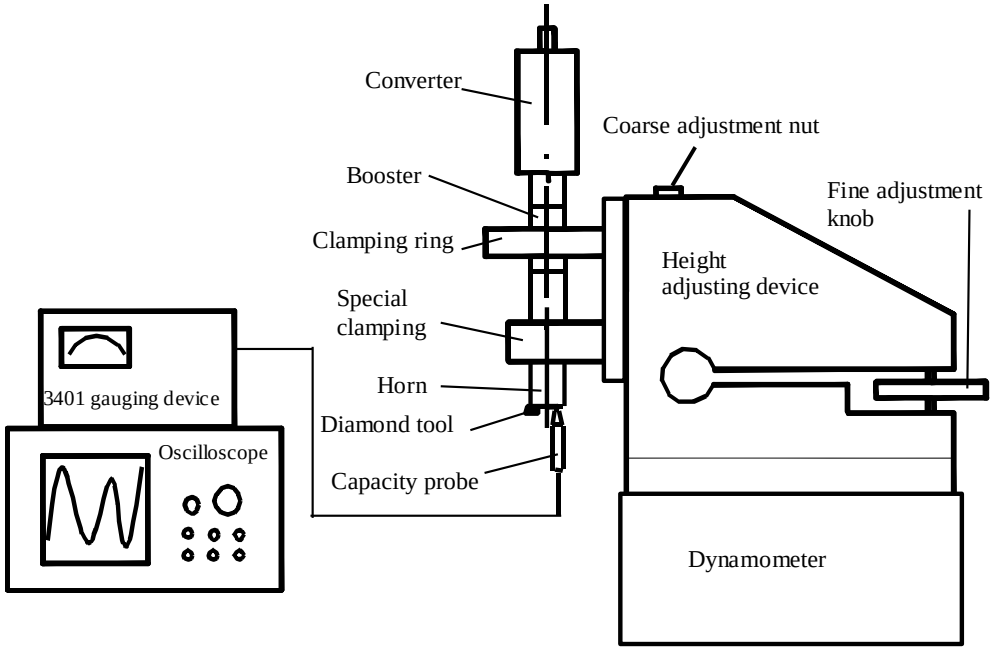
Description

Ultrasonic assisted turning (UAT) is an advanced method developed for machining tough and brittle materials such as supper-alloys, ceramics and glass.

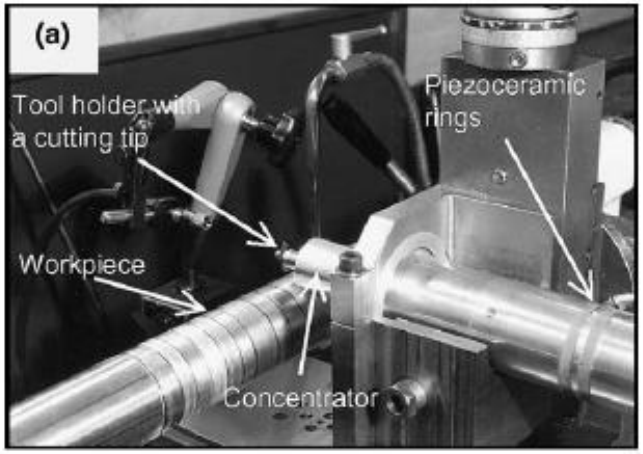
Ultrasonic vibration is principally applied in one or two directions. Machining assisted by two directional ultrasonic vibration referred to elliptical ultrasonic vibration leads to the added advantage of further force reduction and better machining accuracy.

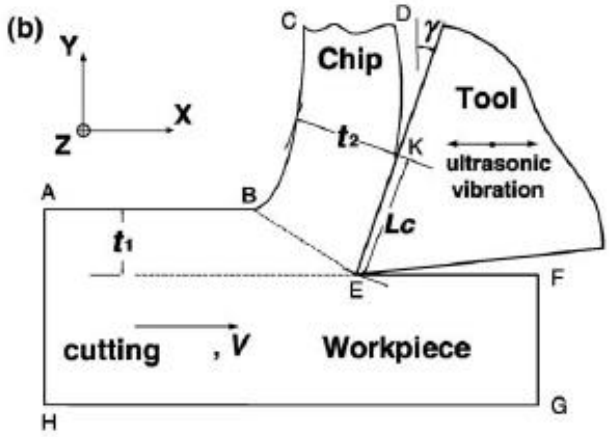
Ultrasonic assisted machining

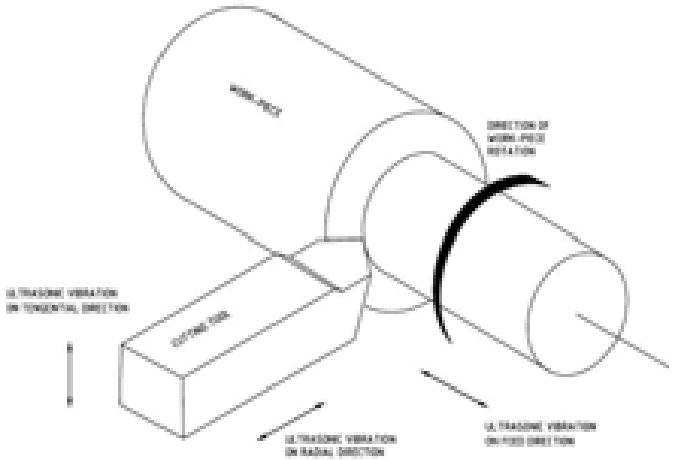




Vibration Directions







Principal vibration directions during ultrasonically assisted turning

Inconel alloys

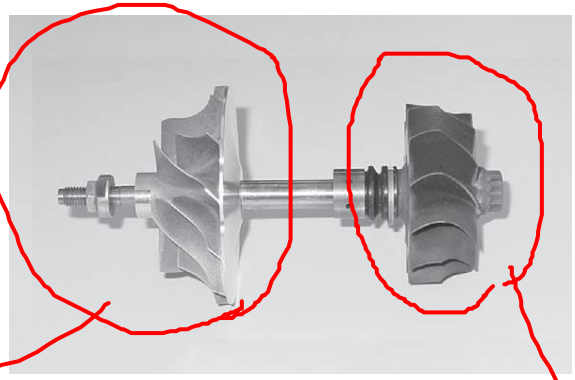
- Inconel refers to a family of austenitic nickel-chromium-based super alloys
- Inconel alloys are oxidation and corrosion resistant materials well suited for service in extreme environments. When heated, Inconel forms a thick and stable oxide layer protecting the surface from further attack

Inconel alloys

Inconel	Element (% by mass)														
	Nickel	Chromium	Iron	Molybdenum	Niobium	Cobalt	Manganese	Copper	Aluminium	Titanium	Silicon	Carbon	Sulfur	Phosphorus	Boron
600 [3]	72.0	14.0-17.0	6.0-10.0				1.0	0.5			0.5	0.15	0.015		
617 [4]	44.2-56.0	20.0-24.0	3.0	8.0-10.0		10.0-15.0	0.5	0.5	0.8-1.5	0.6	0.5	0.15	0.015	0.015	0.006
625 [5]	58.0	20.0-23.0	5.0	8.0-10.0	3.15-4.15	1.0	0.5		0.4	0.4	0.5	0.1	0.015	0.015	
718 [6]	50.0-55.0	17.0-21.0	balance	2.8-3.3	4.75-5.5	1.0	0.35	0.2-0.8	0.65-1.15	0.3	0.35	0.08	0.015	0.015	0.006

Inconel is a difficult metal to shape and machine using traditional techniques due to rapid work hardening .

Applications

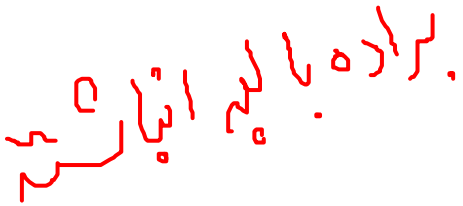


Engine turbocharger

Turbine blade

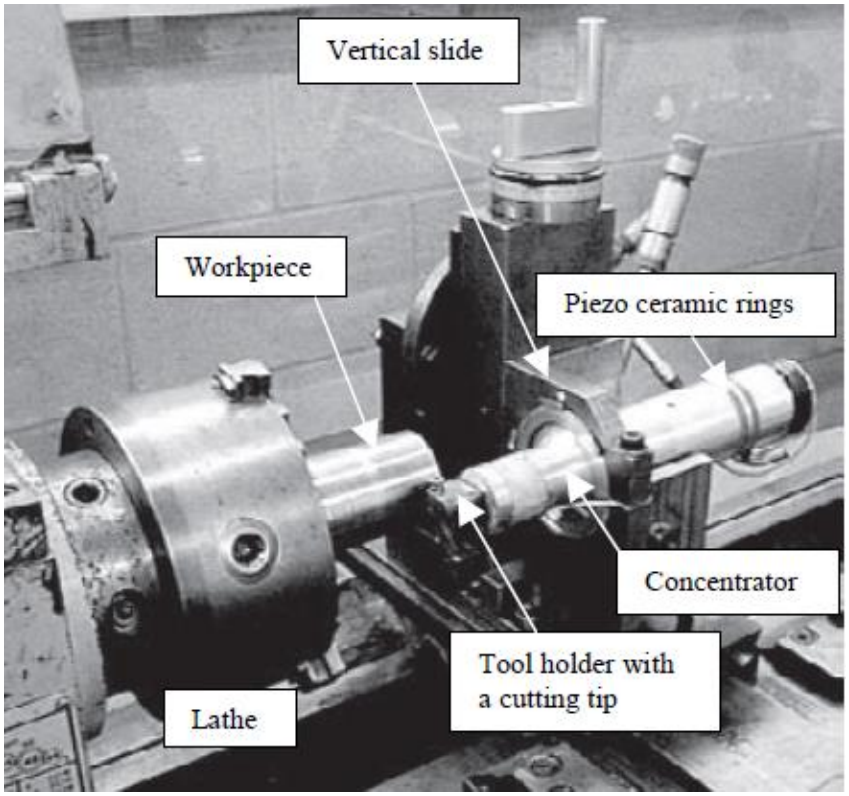
Ultrasonic assisted machining

- With the application of ultrasonic vibration, the rake face is separated from the cutting area and cooled down by air/lubricant, which lowers the temperature below the critical value.
- workpiece material in micrometer size is likely to stick to the cutting edge which is very similar to the Built-up-edge (BUE). These sticked material on the cutting edge engraves grooves on the machined surface and the back surface of the chip. When the ultrasonic vibration is employed, the cutting temperature is significantly reduced. This helps to reduce the chance of work material to stick on the cutting edge.

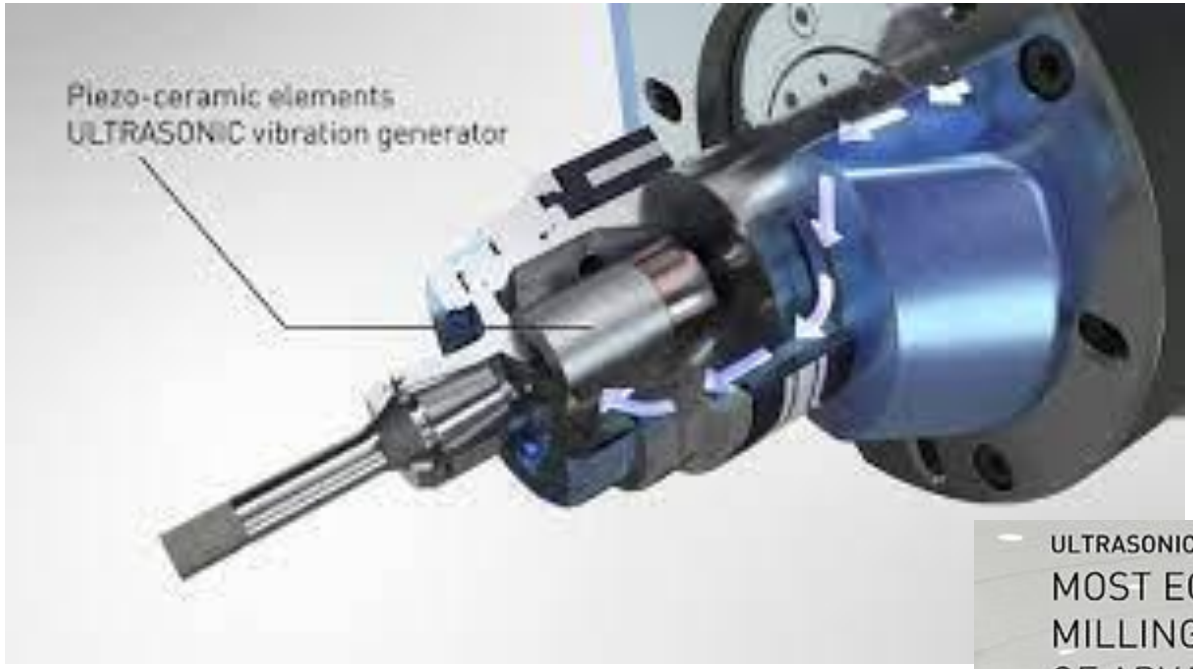


Ultrasonic assisted machining

- Tool wear
  - ultrasonic vibration assisted cutting has a longer tool life (250 and 160 times longer at 50, 100 rpm, respectively)



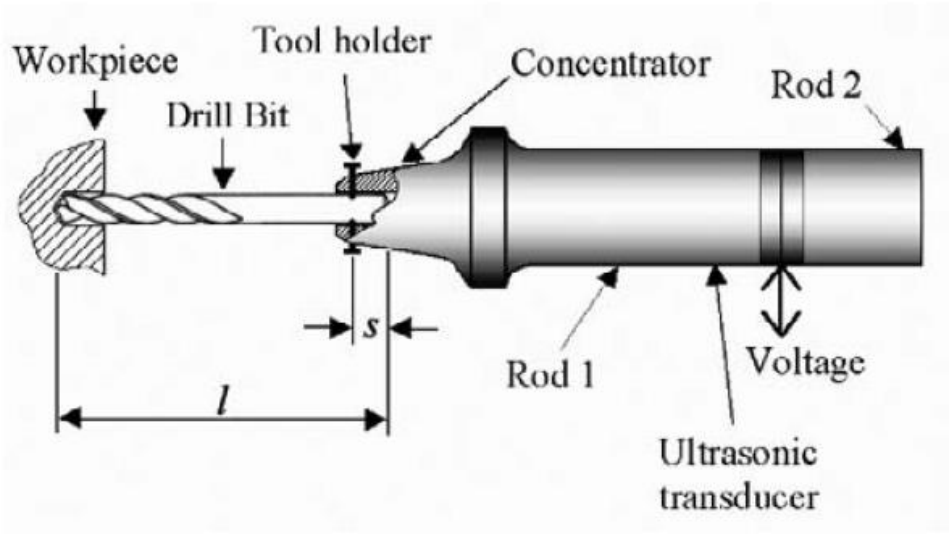
Ultrasonically assisted milling



https://www.dideo.ir/v/yt/lWdu9Uo4g-0/ultrasonic-by-dmg-mori

Ultrasonically assisted drilling

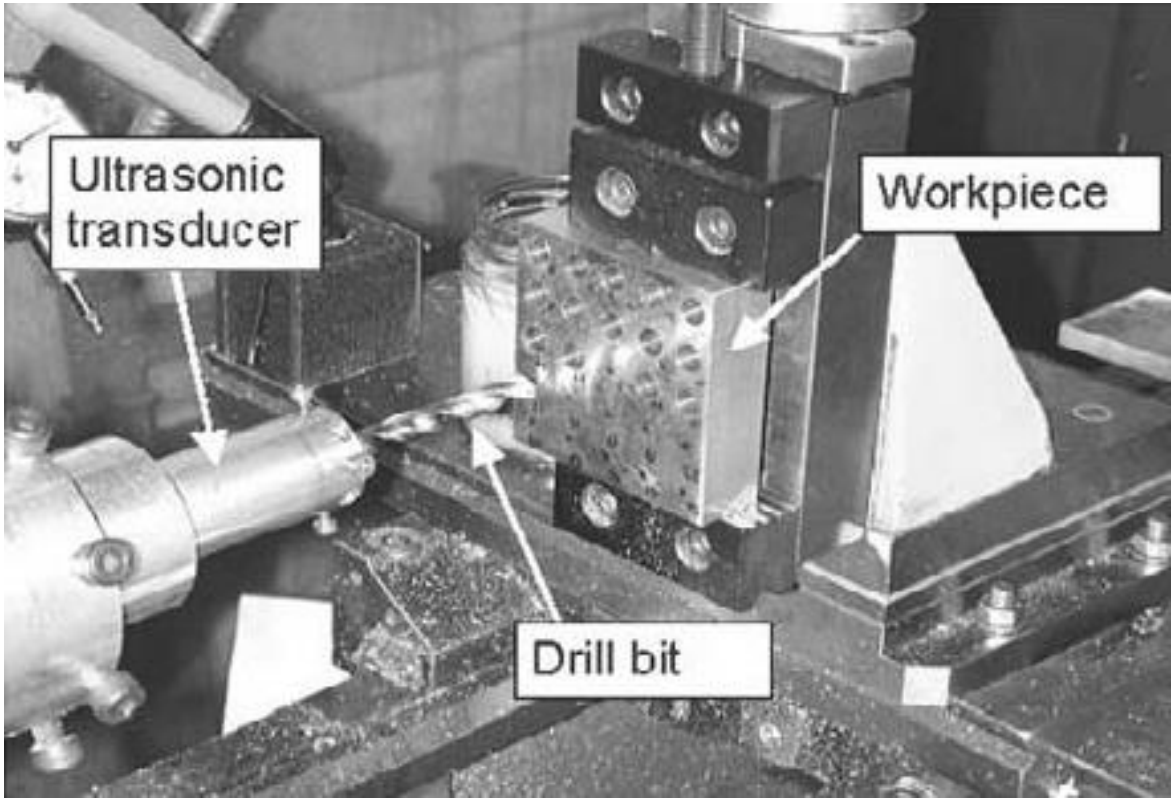
- Ultrasonically assisted drilling takes place when ultrasonic vibration is superimposed on to the relative cutting motion between a drill bit and the workpiece being drilled.



Properties

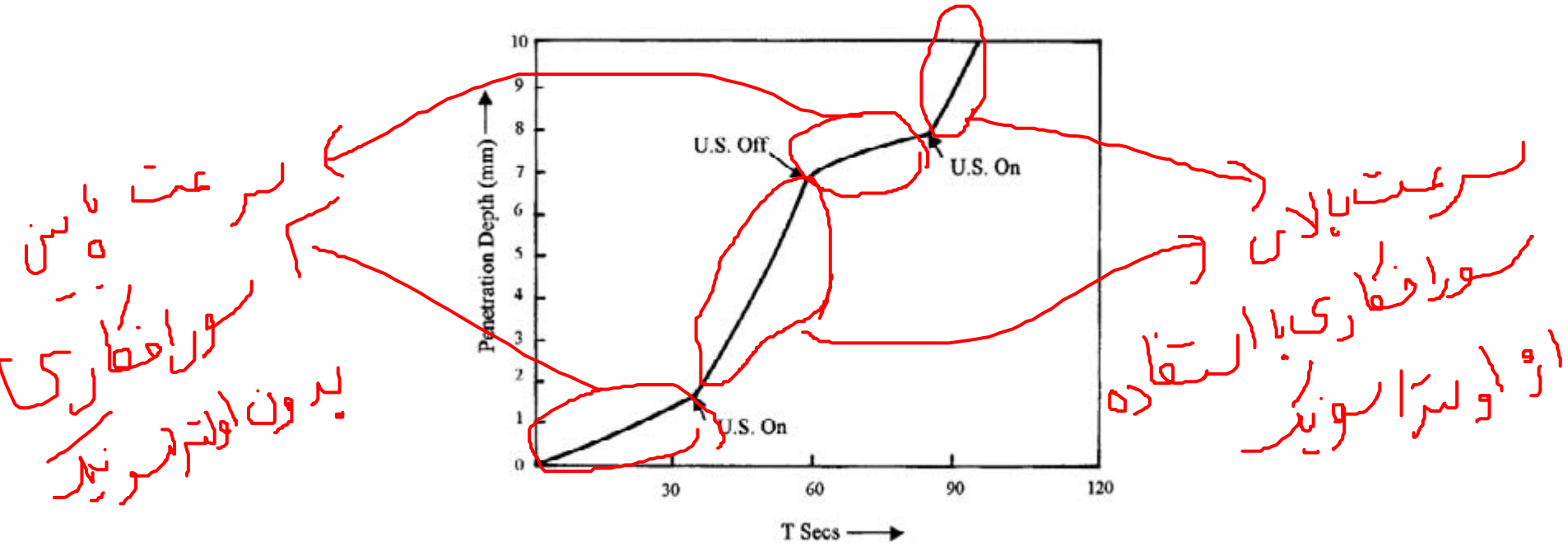
- Main benefits
  - A reduction in the cutting forces
  - an increase in the penetration speed
  - elimination of burrs

Experimental Setup

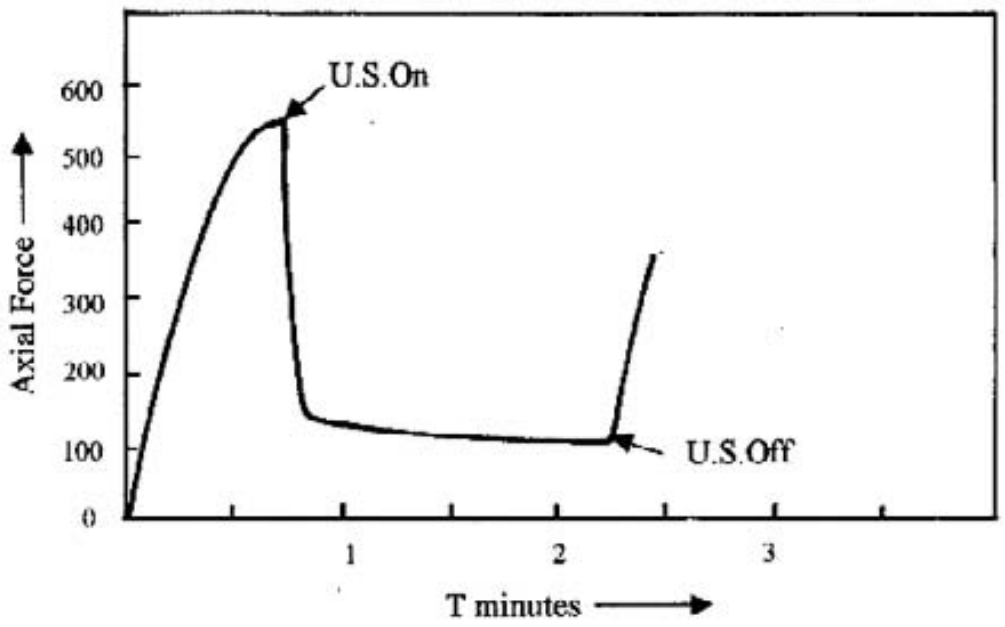


Effect of ultrasonic on penetration rate

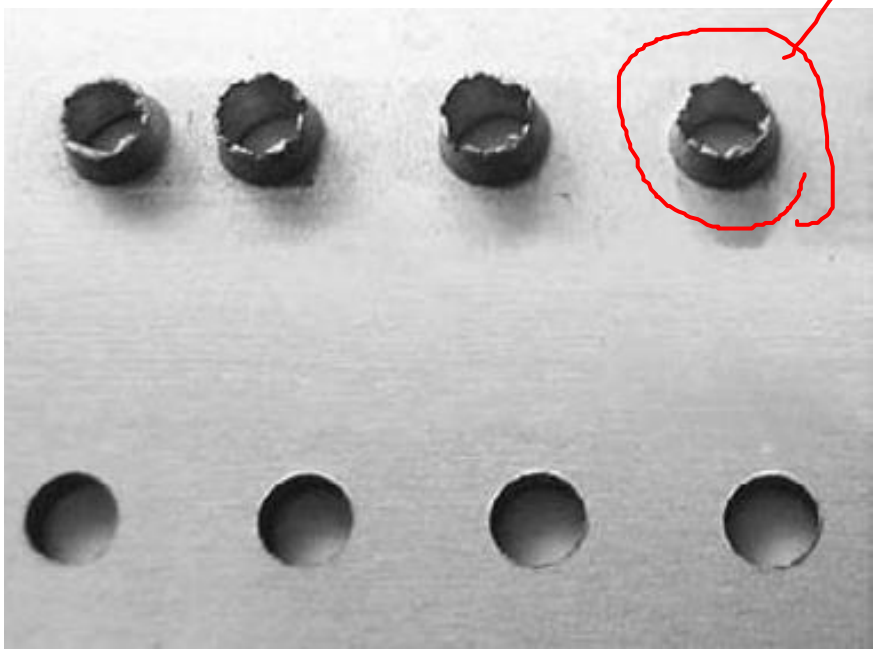
- In some cases, the penetration rate was increased by a factor of four depending on the rotational speed.



Effect of ultrasonic on axial force



Effect of ultrasonic on hole quality



Without US

With US

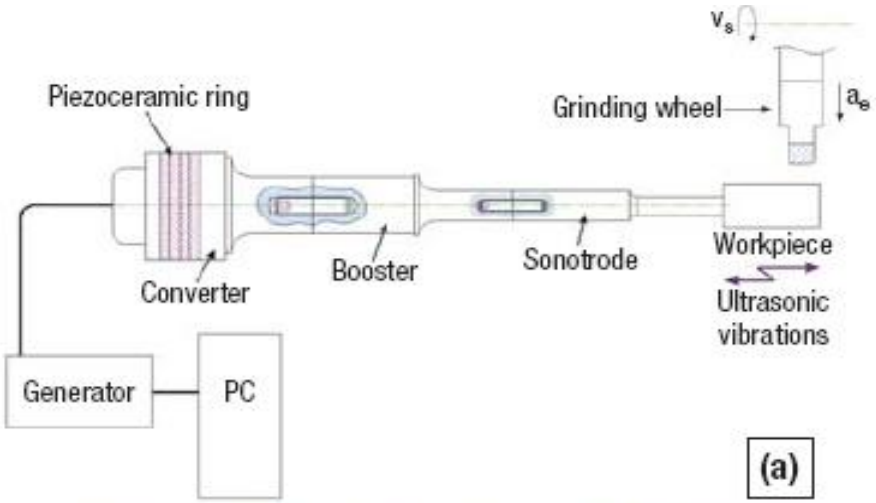
drilling an aluminum plate

Ultrasonic assisted grinding (UAG)

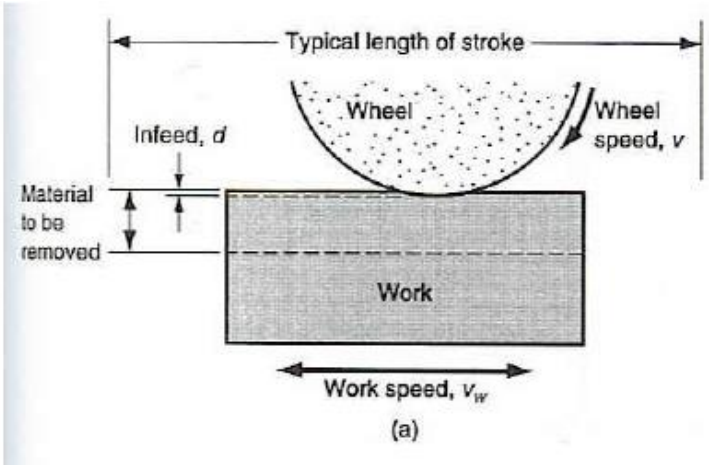
- By optimizing the chip-forming process during grinding, energy consumption or energy conversion are reduced and the thermal effect and deformation of the workpiece are also reduced.

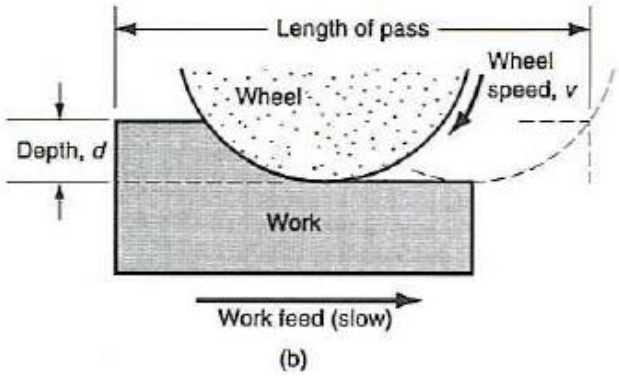
- The principle of this technique consists of adding high-frequency (16-40 kHz) vibrations with amplitudes (2-30 μm) in the feed direction or transverse to the feed direction to the tool or the work piece.

Ultrasonic assisted grinding-Setup of experiments



Grinding Processes



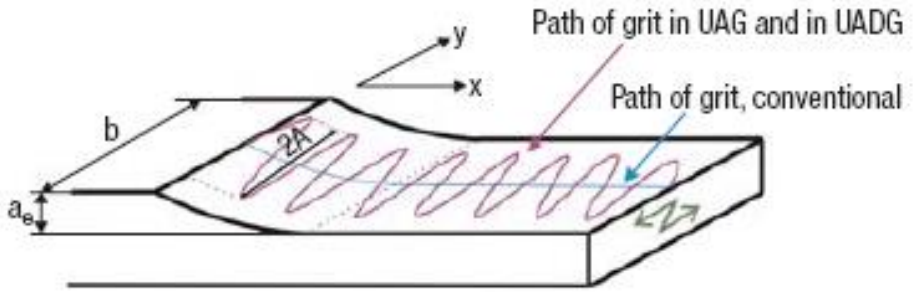


Conventional Grinding

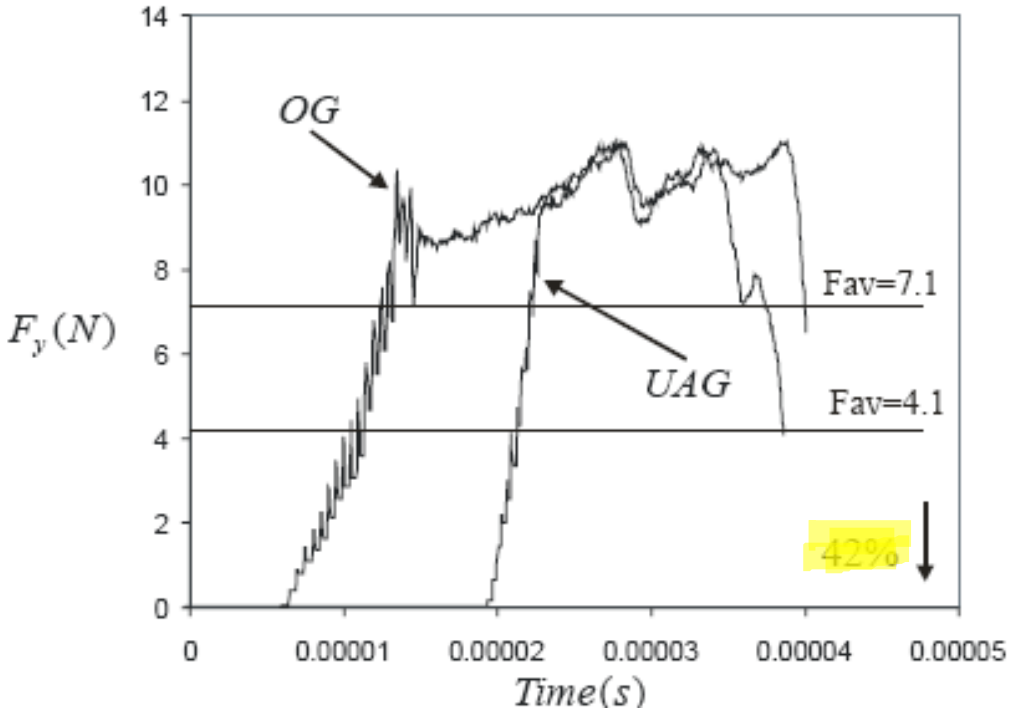
Creep feed grinding

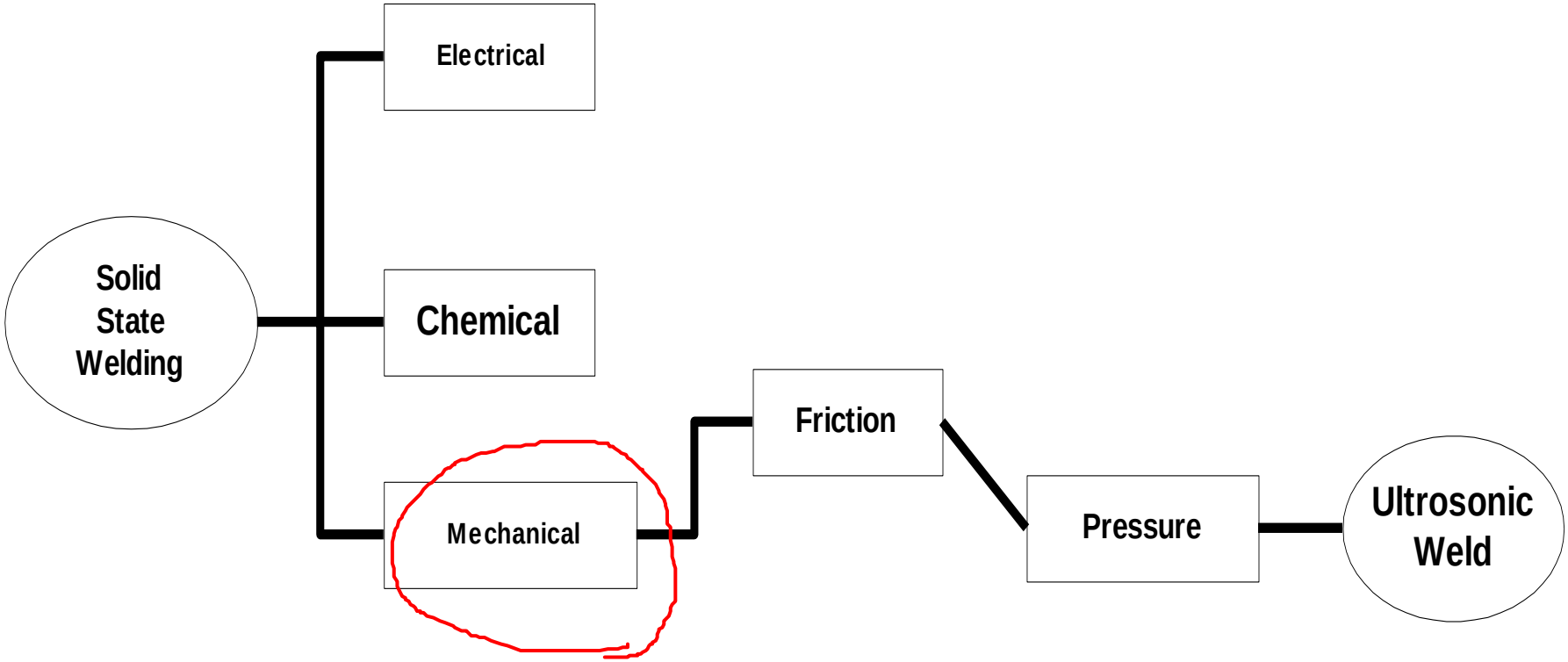
Mechanism of UAG

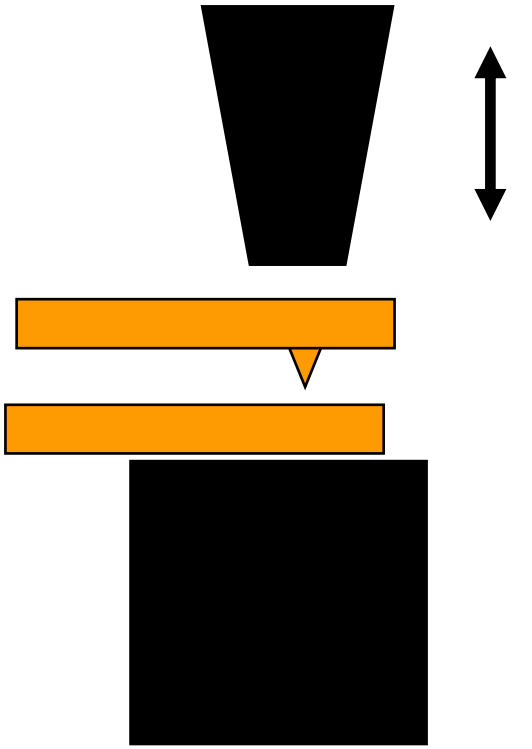
- The oscillating movement of the work piece (ultrasonic vibrations) transverse to the feed direction leads to wave-shaped (sinusoidal) movements of the abrasive grits on the surface of the work piece.



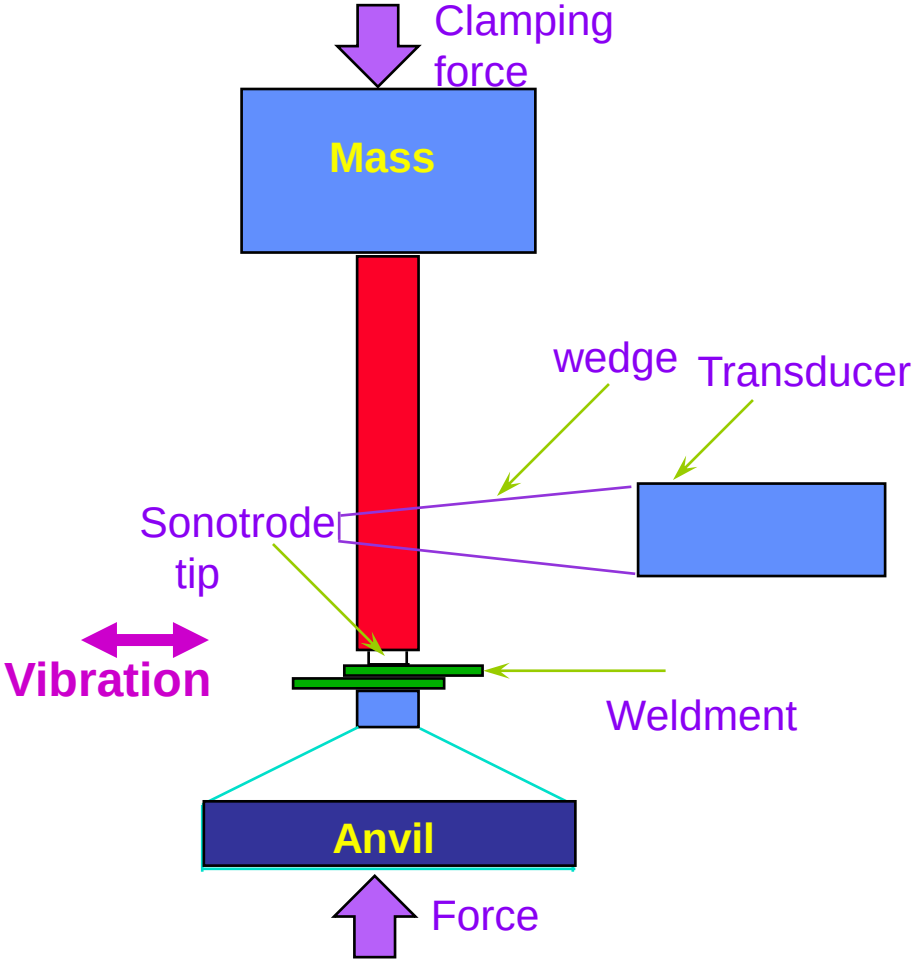
Force Reduction




Solid State Welding
Electrical
Chemical
Mechanical
Friction
Pressure
Ultrosonic Weld



جوشکاری پلاستیک ها



جوشکاری فلزات

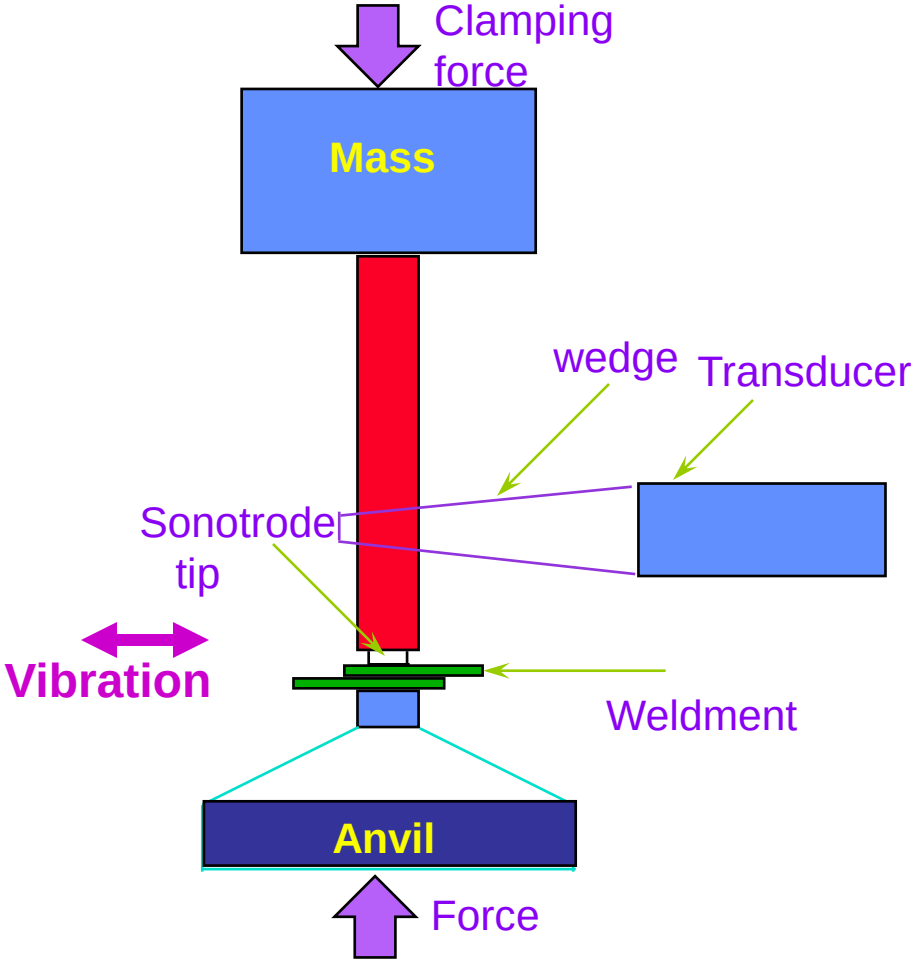
Definition of Ultrasonic Welding

Ultrasonic welding occurs by the introduction of oscillating shear forces at the interface between two metals while they are held together under moderate clamping force. The resulting internal stresses cause elastoplastic deformation at the interface.

Ultrasonic Welding Process (metals)

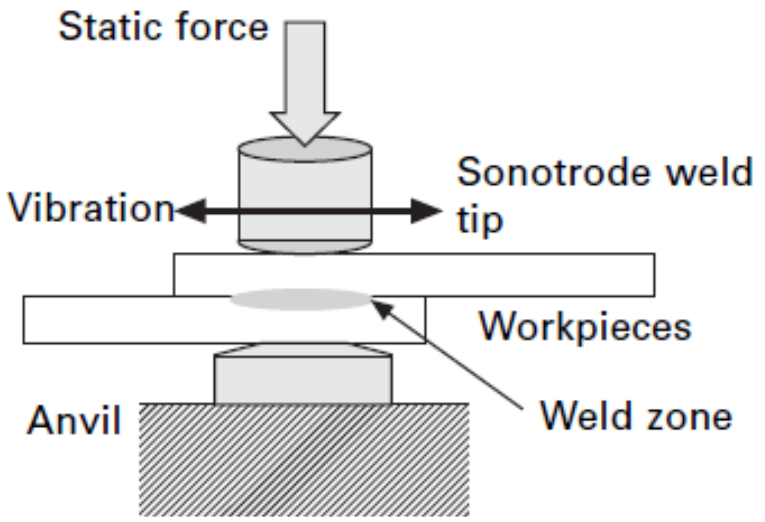
Process Description:

- Components of ultrasonic welding system include:
  - Transducer
  - Sonotrode
  - Anvil

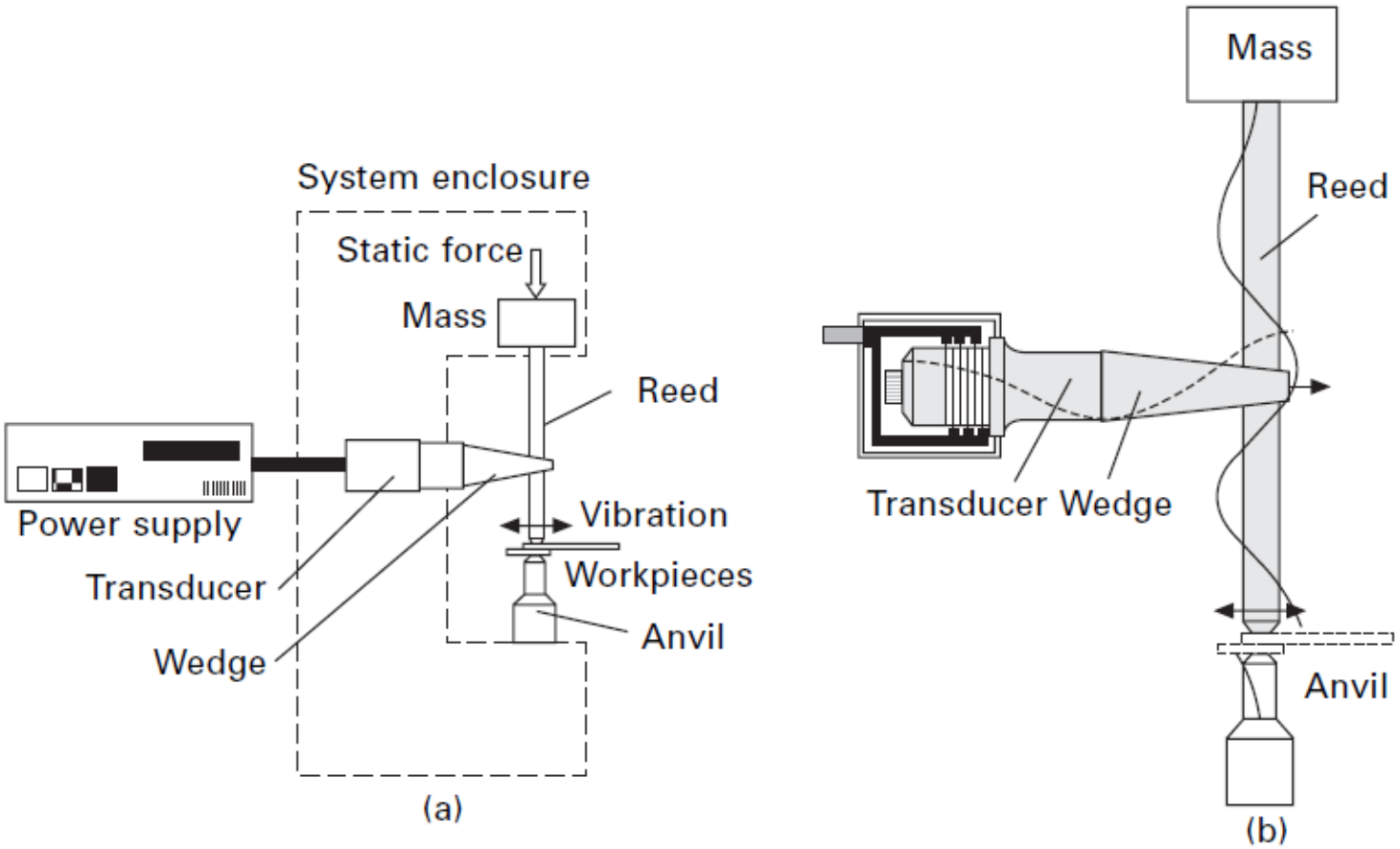


Ultrasonic Welding Mechanism

- A static clamping force is applied perpendicular to the interface between the work pieces.
- The contacting sonotrode oscillates parallel to the interface.
- Combined effect of static and oscillating force produces deformation which promotes welding.



Ultrasonic Welding Equipment



Ultrasonic Welding Equipment

Ultrasonic Welding Interfacial Interaction

- Localized temperature rises resulting from interfacial slip and plastic deformation.
- Temperature is also influenced by power, clamping force, and thermal properties of the material.
- Localized Plastic Deformation
- Metallurgical phenomena such as recrystallizing, phase transformation, etc..... can occur.

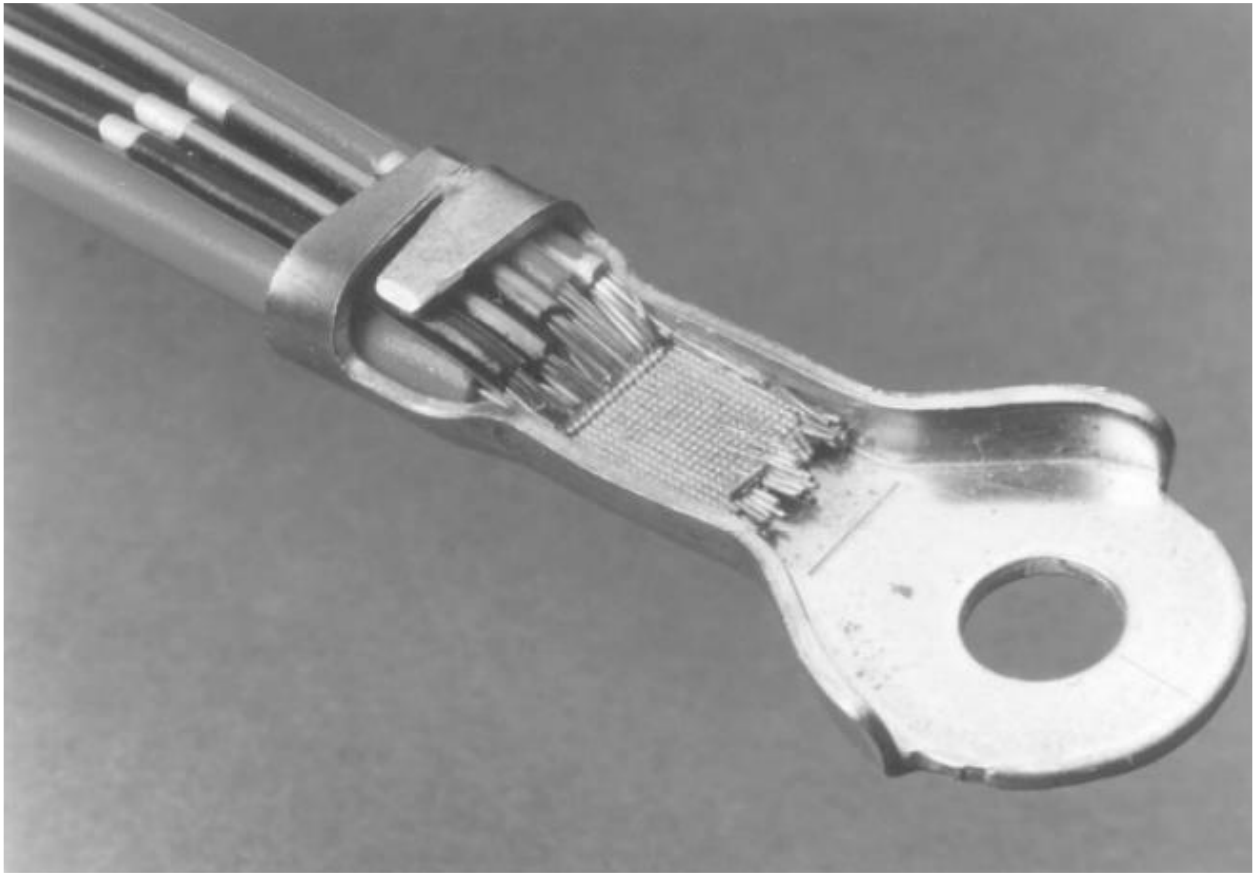
Advantages of Ultrasonic Welding

- No heat is applied and no melting occurs.
- Permits welding of thin to thick sections.
- Welding can be made through some surface coatings.
- Pressures used are lower, welding times are shorter, and the thickness of deformed regions are thinner than for cold welding.

Limitations of Ultrasonic Welding

- The thickness of the component adjacent to the sonotrode tip must not exceed relatively thin gages because of power limitations of the equipment.
- Process is limited to lap joints.
- Butt welds can not be made because there is no means of supporting the workpieces and applying clamping force.

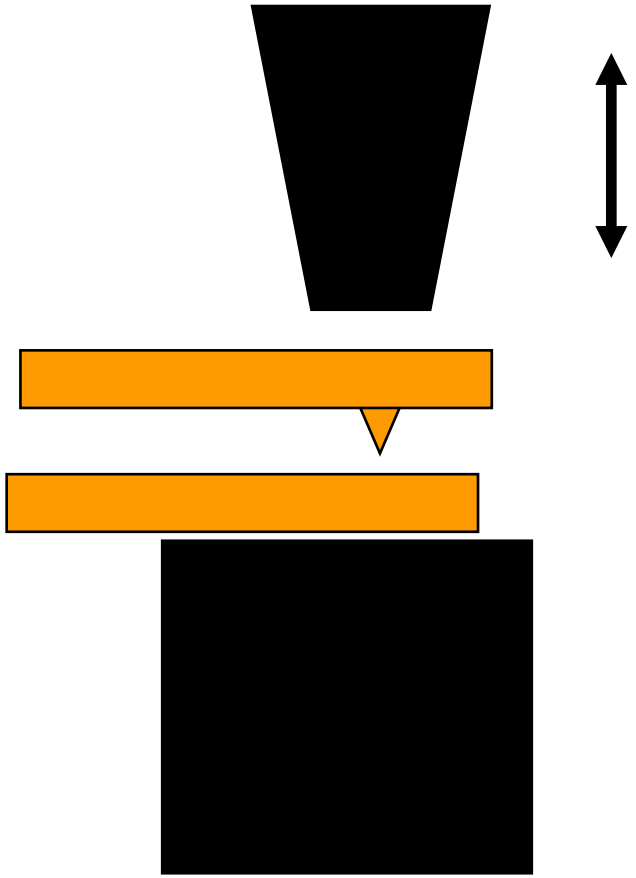
Applications



Multiple wire to single terminal (source: Telsonic)

Ultrasonic Welding of Plastics

- Advantages
  - Fast
  - Can spot or seam weld
- Limitations
  - Equipment complex, many variables
  - Only use on small parts
  - Cannot weld all plastics

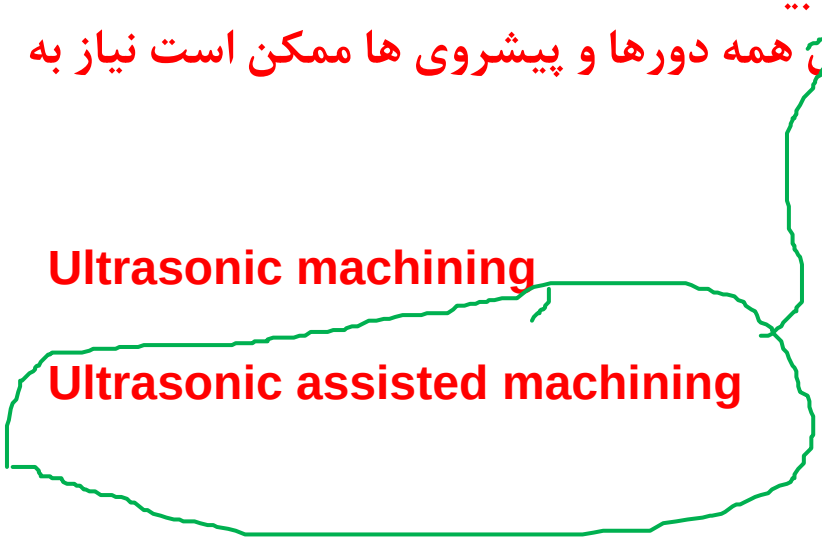


Applications of Ultrasonic Welding

- Assembling of electronic components such as diodes and semiconductors with substrates.
- Electrical connections to current carrying devices including motors, field coils, and capacitors.
- Encapsulation and packaging.
- Plastic parts

معایب استفاده از کمک امواج در فرایندهای تولیدی

۱-به علت وجود نوسانات ممکن است باعث کاهش عمر قطعات دستگاه شود.
۲-هزینه تجهیزات نسبتا گران است.
۳-تعمیرات و نگهداری دستگاهها گران بوده و نیاز به تخصص جهت انجام تعمیرات می باشد.
۴-رفتار پیزوالکتریک بسیار متاثر از شرایط دمایی است و عمر پیزوالکتریک کوتاه بوده و در صورت کارکرد مداوم ممکن است خیلی زود از کار بیفتد.
۵-برای رسیدن به شرایط بهینه اولتراسونیک برای همه دورها و پیشروی ها ممکن است نیاز به ترانسدیوسری با طراحی متفاوت باشد.



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