Power Ultrasound in Medical Applications

Welding of fabric, dispersion of liquids and powders, ultrasound assisted cutting, Scaler, Phaco, Therapy

Power ultrasound in medical applications

Power ultrasound is involved in various medical applications. Examples for applications where ultrasound is indirectly involved are the manufacturing of medical equipment, surgical masks, plastic parts or the packaging of pharmaceuticals. Moreover, ultrasound is directly applied for the dispersion of powders and liquids in medical inhalers. Another huge field of application are ultrasonic surgical instruments (e.g., phaco emulsification, bone cutting, ultrasonic scalers) and cavitation-based processes like cell disruption. Depending on the field of application within medical applications the ultrasound systems can be grouped depending on frequency and sound intensity as depicted in figure 1.

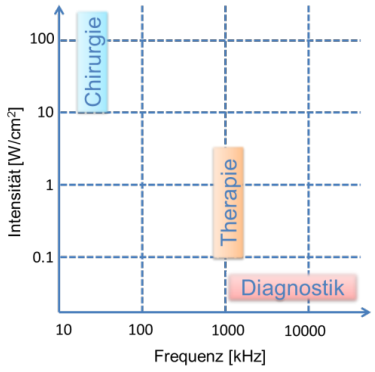


figure 1: Overview of fields of application and their dependency of frequency and sound intensity

Ultrasonic Welding

Many medical products like breathing masks, plastic adapters and plastic parts are manufactured by ultrasonic welding. Ultrasonic welding can replace the usage of adhesives to accelerate the manufacturing process and improve the environmental friendliness. Ultrasonic welding can be used to join many different materials like thermoplasts or fabric.

figure 2: Personal protection equipment like breathing masks manufactured by ultrasonic welding

Ultrasonic cutting

Power ultrasound is also applied for numerous cutting process in the fabrication of medical products. Advantages of ultrasonic cutting are that chips and dust can be avoided to realize clean cuts. Furthermore, due to the µm-cutting-movements of the ultrasonic cutting tool, macroscopic movements or high rotation speeds of the blade can be prevented allowing precise cuts with low feed forces. Ultrasonic cutting is also well suited for many compound materials. Due to the ultrasound vibration of the cutting blade, cutting and sealing can be achieved in only one process step.

Ultrasonic knives and cutting tools are also applied in surgery for cutting and processing tissue and bones. Due to the ultrasound vibrations of the blade, tissue can be cut precisely, and blood vessels can be sealed at the same time.

Dispersion of liquids and powders

Ultrasonic vibrations and sound fields can be used to generate fine aerosols with a clearly defined droplet size. The technique is especially applied for medical inhalers. Furthermore, ultrasound can be applied to disperse powders and liquids with a higher viscosity for manifold applications.

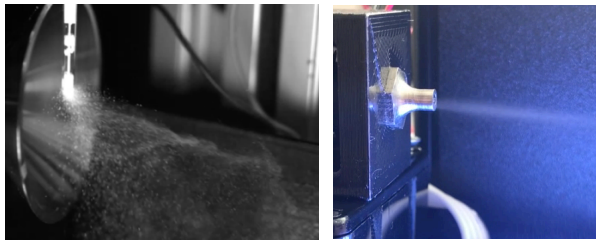


figure 3: Contactless dispersion of powder (left) and fine dispersion of water at 250 kHz (right) by ultrasound systems

Besides the widespread bolted-Langevin-transducers (BLT-transducers) nowadays membrane-transducers are often used for atomizing applications. Figure 4 shows such a transducer atomizing a semi-viscous liquid for a combustion process and an high speed camera image of the generated spray.

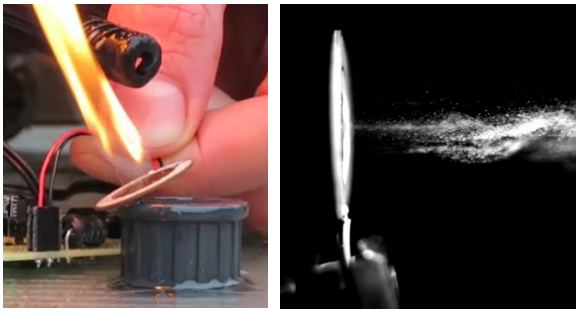


figure 4 membrane transducer (100 kHz) atomizing petroleum (left) and high-speed image of the spray (right)

Ultrasound Therapy

Ultrasound therapy transducers are applied to transfer ultrasound waves through the skin of patients at frequencies around 1 MHz and a power of a few W/cm^2. This technique is for example applied to cure tensions in muscles.

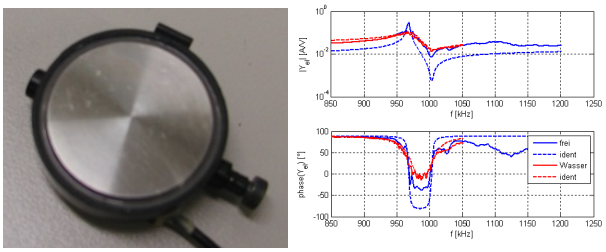


figure 5 Prototype transducer for ultrasound therapy (1 MHz) and frequency response measured in air and water

Power Ultrasound Equipment

Most ultrasound systems that are utilized for the described applications consist of an ultrasound generator that creates the driving signals, an ultrasound transducer to convert electrical signals into mechanical vibrations, and the tool or Sonotrode as interface to the process. Especially in medical applications all these components must be designed and manufactured carefully. Furthermore, the equipment must be tested extensively to guarantee a safe operation.

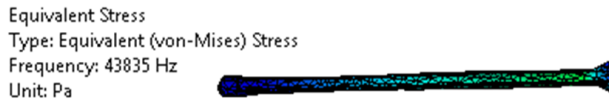


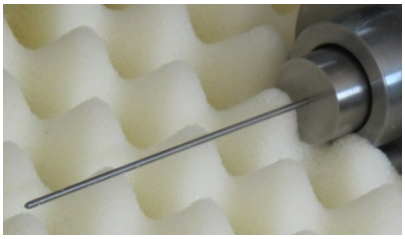
figure 6 Finite-Element-Simulation (FEM) of the stress distribution in a thin hollow medical ultrasound resonator

Provided services by ATHENA

The ATHENA Technologie Beratung GmbH supports their customers as independent partner for the development and testing of ultrasound equipment.

Examples for our comprehensive services in this field are

- Development and design of ultrasound transducers, sonotrodes and tools
- Analysis and optimization of existent ultrasound equipment using laser measurements, FEM simulations and signal analysis
- Development of control units and ultrasound generators
- Analysis and optimization of ultrasound generators, for example by signal analysis
- Feasibility studies for the application of ultrasound in medical applications
- Verification of engineering standards for medical equipment



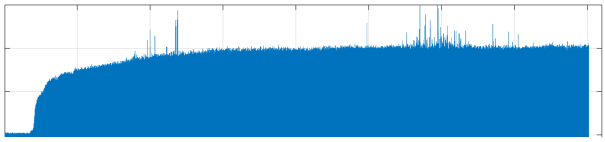


figure 7 measurement of the vibration amplitude of an 40 kHz ultrasound handpiece immersed in water during the measurement with a maximal velocity amplitude ≥ 10 m/s).

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