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ACOUSTIC-STRUCTURE INTERACTION MODELING OF PIEZOELECTRIC TRANSDUCERS IN FLUID MEDIUM

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Introduction:

The use of high-intensity ultrasound to improve mass transfer efficiency in fluids under supercritical conditions, is presently a novel technique for the extraction of natural products. An extraction system to prove such technique was developed at semi-industrial stage by using extensional piezoelectric transducer. To scale up the extraction system, a new transducer with a plate radiator has to be designed to get higher power capacity. Additional requirements for the new type of transducer are high quality factor, high efficiency and stable performance under power operation. The application of ultrasound improves up to 90% the mass transfer.

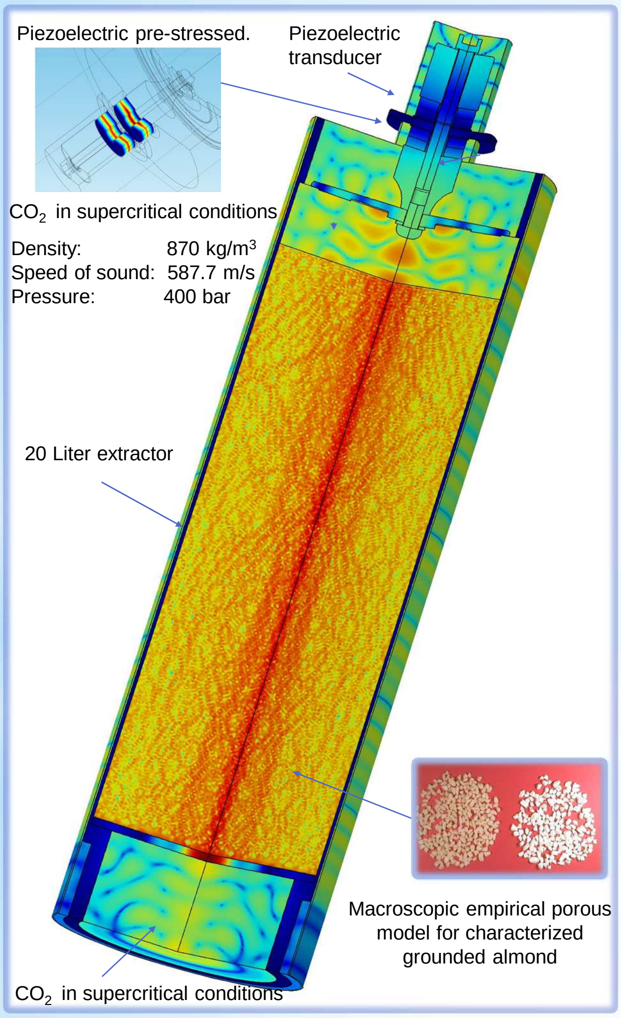

Fig. 1.- Ultrasonic Extractor 20l. Sound Pressure Level distribution.

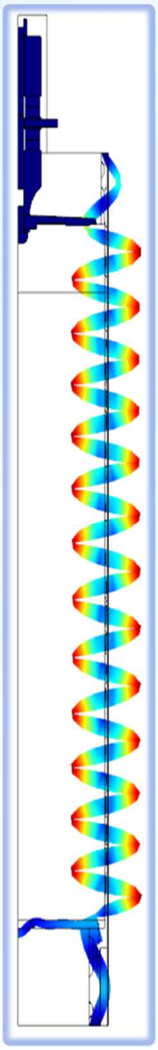

Fig. 2. A container structural mode shape (21963 Hz).

Computational Methods:

The analysis of the physical coupled between the piezoelectricity and mechanical structural of the transducer and the fluid medium with grounded material inside (linear elastic with attenuation model and equivalent Biot model for porous media) will provide a precise knowledge about the dynamic response of the transducer at an applied electric excitation on the piezoelectric terminals *(Fig 3)*. *Figure* 5 show the applied boundary conditions.

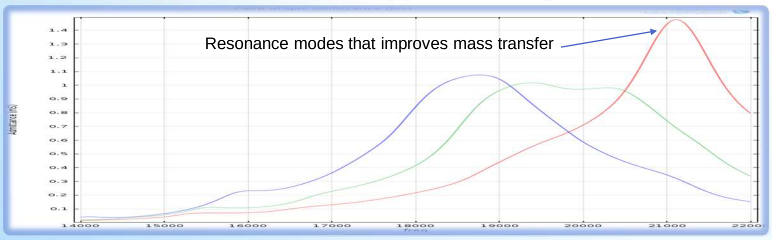

Fig. 3. Electric admittance of the transducer. Parametric model of the vibrator length influence

Characterized parameters for porous model:

Drained density, permeabitlity, porosity, Biot-Willis coefficient and tortuosity factor.

Fluid properties: density, compressibility and dynamic viscosity.

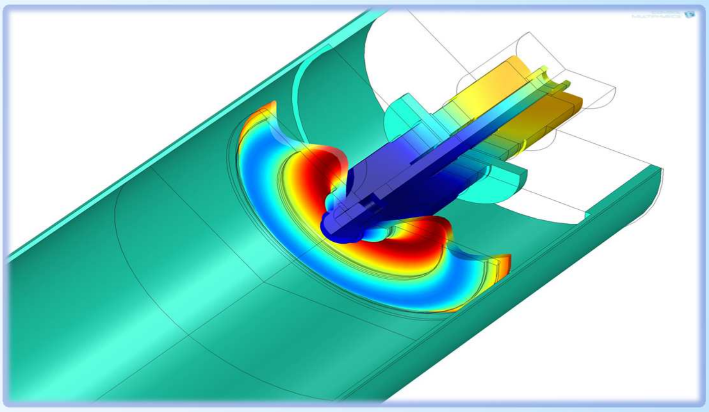

Fig 4.- Piezoelectric Transducer (21430 Hz). Axisymmetric bending mode of the radiator (3 nodal circle).

Results:

The numerical model shows the transducer response and distribution of pressure, acoustic intensity and sound pressure levels (SPL) in the fluid medium and on the sample to be treated (ground almond + CO_2-SC.) inside the container-extractor *(Fig* 1).

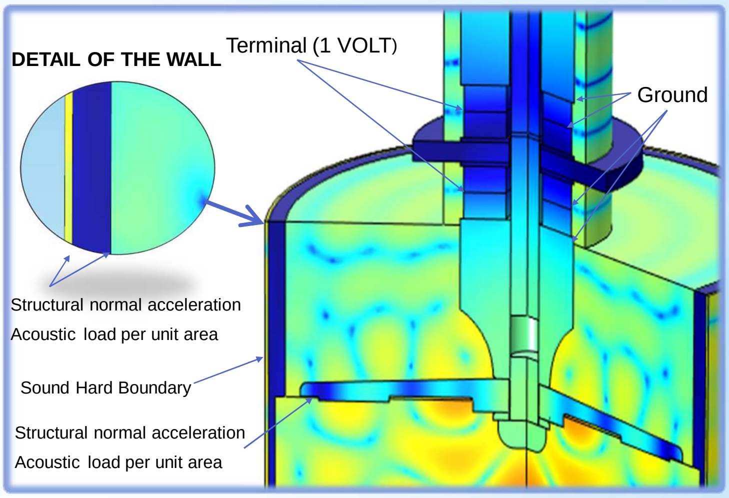

Fig. 5.- Boundary Conditions

Conclusions:

By modeling the interaction of the acoustic field with the piezoelectric vibrating structure, it has been possible to design and develop a new unit of the piezoelectric transducer with a circular stepped radiator taking into account the effect of the fluid load. Figure 3 shows the electric impedance of the ultrasonic device. It has been designed specifically to optimize its performance in the process of supercritical fluid extraction. The transducer geometry studied for this application has shows high amplitude of displacement of the vibrating plate radiator, giving rise to a good radiation emission to the medium in the container. The developed models also help to modify the geometry of the transducer to separate unwanted vibration modes close to the tuned resonance mode. The influence of the vibration modes of the container (where the transducer is placed) has been also accounted in order to investigate the existence of potential interactions with the tuned mode *(Fig* 2).

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