Simulation Studies on the Design of a Helmholtz Resonator Type Underwater Acoustic Sensor

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Abstract

A Helmholtz resonator type acoustic sensor has been designed using analytical method and finite element modeling software, COMSOL Multiphysics®. The acoustic sensor is an aluminium double frustum, hour glass, shaped with the resonator at the bottom and an acoustic horn above to amplify the incoming acoustic signal. The horn provides a broad amplification of the incoming acoustic signal while the resonator provides narrow band amplification. The Helmholtz resonator is designed for a resonant frequency of 10 kHz operation underwater based on the geometrical parameters of the base, neck diameter and height of the structure. The design parameters were optimized by the analytical and FEM modeling studies. This structure has been modeled using COMSOL Multiphysics®, with the suitable boundary conditions for underwater applications. The resonance frequency and the acoustic pressure distribution at the resonance of resonator cavity were studied for the influence of each geometrical parameter. The simulated and calculated values of the resonant frequency are nearly matching, while the difference is attributed to the end correction factor which has to be included for the neck length in the analytical studies. Also, the acoustic pressure variation along and within the structure showed that the acoustic pressure increases towards the base, for the first mode of resonance. Further investigations revealed that the base angle of the resonator influences the acoustic pressure distribution within the resonator cavity. In MEMS fabrication of such a device using Silicon wafer, this angle corresponds to 54.7 degrees due to anisotropic etching characteristic which depends on the orientation (plane) of silicon wafer. The effect of the material, such as aluminium, silicon, glass, etc. used to fabricate this structure has also been studied. It is seen that the acoustic impedance of the material influences the amplitude of acoustic pressure at resonance and it increases with the acoustic impedance. Dimensional dependence of the horn will be further studied. The effect of aluminium nitride coating to reduce oxidation of aluminium immersed in sea water will also be investigated.

Figures used in the abstract

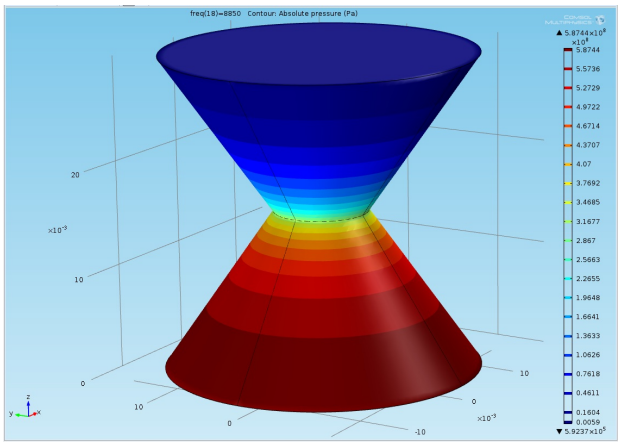

Figure 1: Acoustic Pressure distribution inside the cavity at resonance

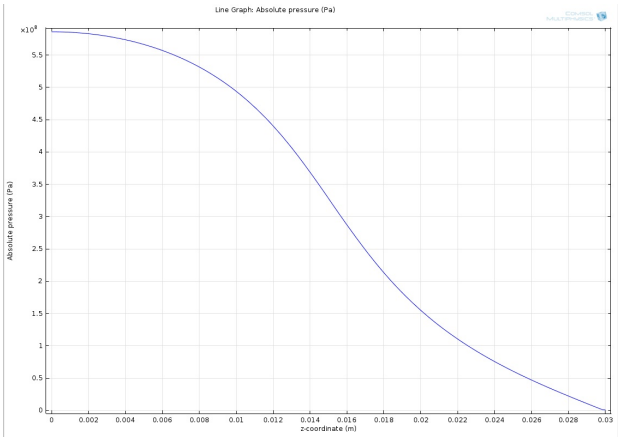

Figure 2: Variation of acoustic pressure along the axis of structure