COMSOL CONFERENCE INDIA 2012

Acoustical Design of Digital Stethoscope for Improved Performance

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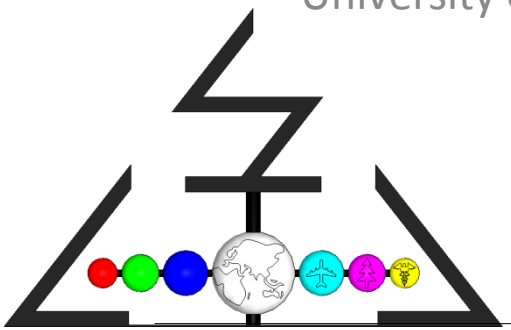
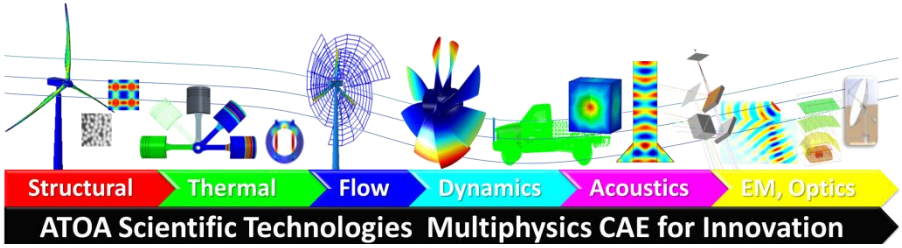
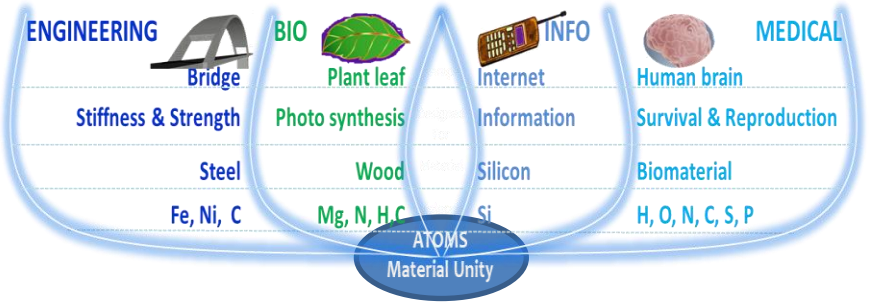


ATOA Scientific Technologies (ATOAST)

- Engineering Simulation Solution Provider for First Time Right Design.
- Bridge Atom to Application to Proliferate Simulation (Multiphysics, Multiscale & multimaterial) for cost effective Innovation.
- ATOAST's Technical Vision is Driven by Material Unity
- ATOAST Global with HQ's in Bangalore
- India's First COMSOL Certified Consultant
- ATOAST JYOTHI Foundation empowers our social mission.





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Stethoscope

- Stethoscopes are used for auscultation of heart, lung and murmurs for over two centuries.
- New development in digital stethoscope convert acoustical energy into other forms (electromagnetic, electrostatic) and back to acoustical energy.
- Our objective is to improve the basic acoustics for use in telehealth environment.

Telehealthcare

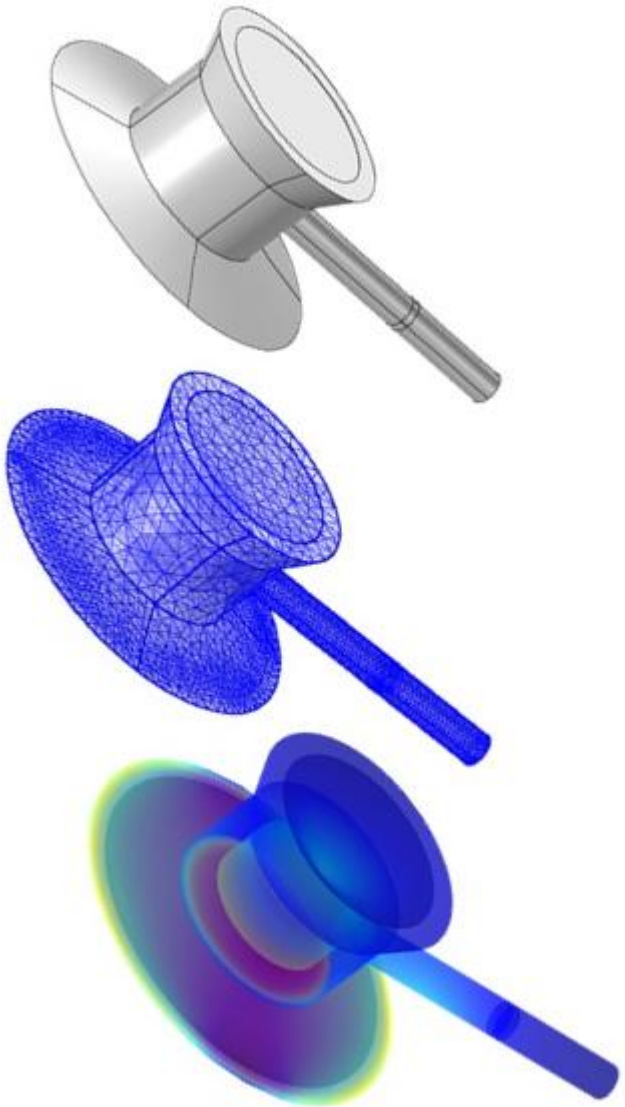
- There's a huge, unmet healthcare need in India.
- Unprecedented growth in mobile communication
- Telemedicine is a good for Affordable Solution
  - Low cost + Digital+ Communication
  - WHO eHealth /mhealth
  - Quality healthcare for all

mHealth
New horizons for health through mobile technologies

- Digital healthcare devices
- Telecommunication
- Rural/Developing
- Urban/Developed
- Affordable, Quality healthcare

Acoustical Design

- Performance improvement
- Sound propagation
- Noise effects
- Material of construction
- Geometry



Governing Equation

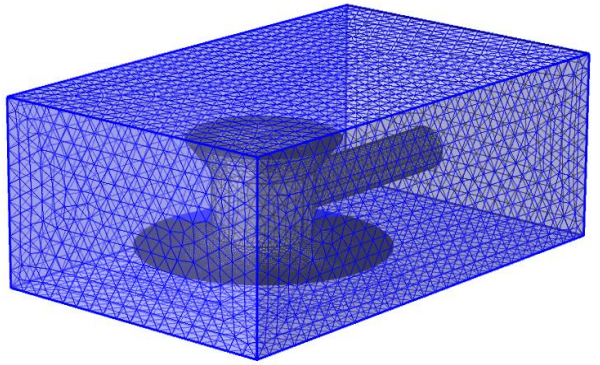
- The acoustic wave propagation in the stethoscope is governed by the wave propagation equation.
- The frequency domain pressure acoustics interface in COMSOL was used for this investigation.
- Sound waves in a lossless medium are governed by the inhomogeneous Helmholtz equation.

$$\frac{1}{\rho_0 c_s^2}\frac{\partial^2 p}{\partial t^2} + \nabla.\left(-\frac{1}{\rho_0}(\nabla p - \mathrm{q})\right) = Q$$

Where,
ρ_0 in kg/m^{3,}
refers to the density
c_s in m/s
is the speed of sound,
p in (N/m^2),
is the differential Pressure
Q in 1/s^2
is the source

DoE Design and Simulation

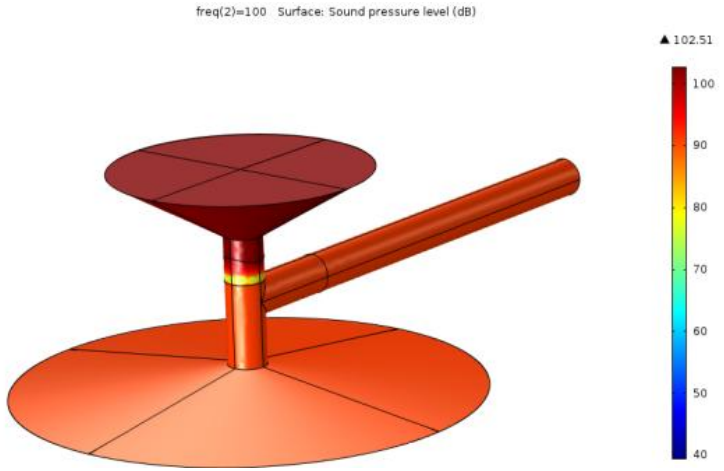
- Parametric CAD model and FEA mesh
- The air column inside the stethoscope, Aluminum or stainless steel casing and the surrounding air were modeled as separate domains.
- The model was equipped to investigate the effects of geometry, construction material, and environment variables on the acoustic performance for optimization.
- The frequency response of the stethoscope from 10 to 2000 Hz was investigated.



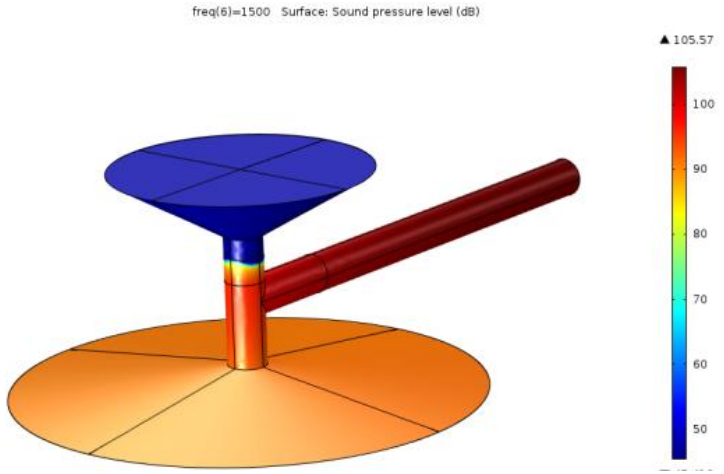
Material	Density (kg/m2)	Speed of sound (m/s)
Aluminum	2700	6420
Brass	8480	390
Stainless Steel	7850	6100

Results and Discussion

- Sound Pressure level of the air column
- Propagation pattern varies with frequency
- Significant for auscultation and signal processing.



Sound Pressure at 100 Hz

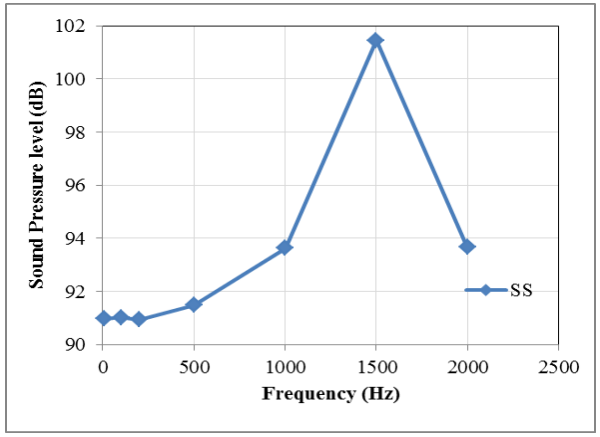


Sound Pressure level at 1500 Hz.

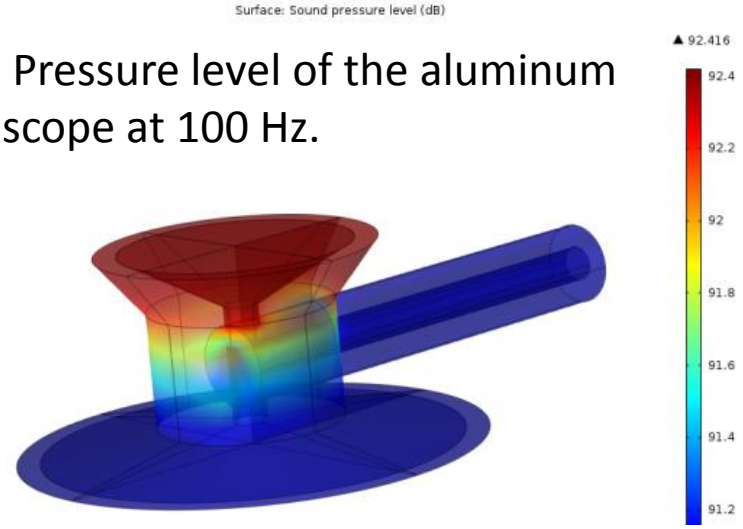
Results and Discussion

- Sound propagation performance of the stethoscope with the air column and Al casing
- Contributes to the efficiency of the sound propagation

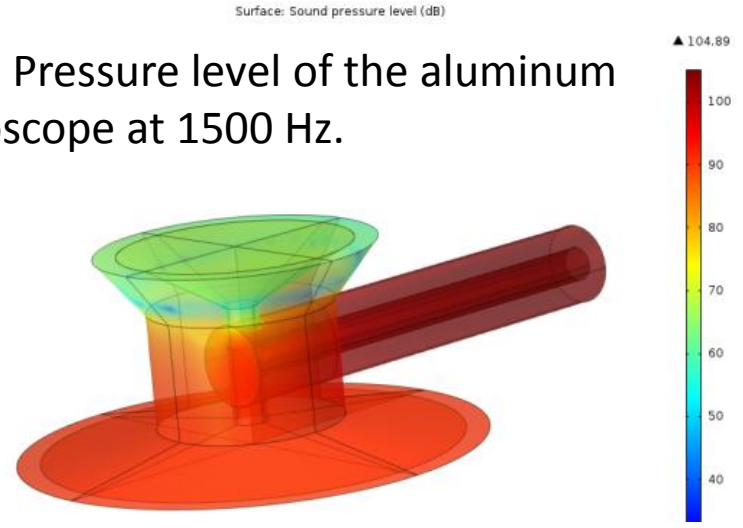
Frequency response



Sound Pressure level of the aluminum stethoscope at 100 Hz.

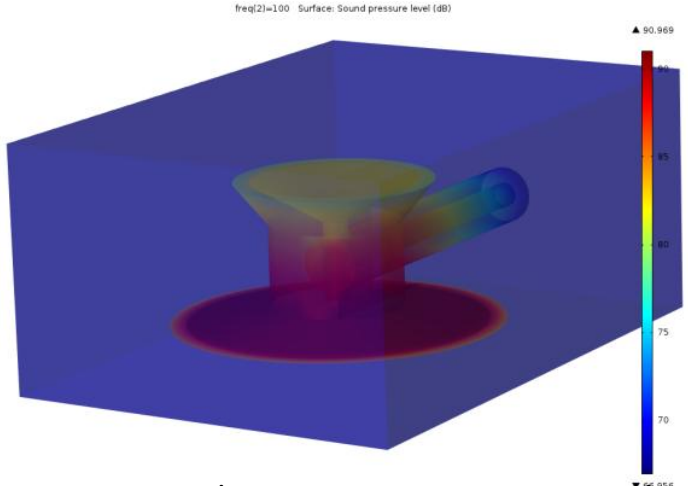


Sound Pressure level of the aluminum stethoscope at 1500 Hz.

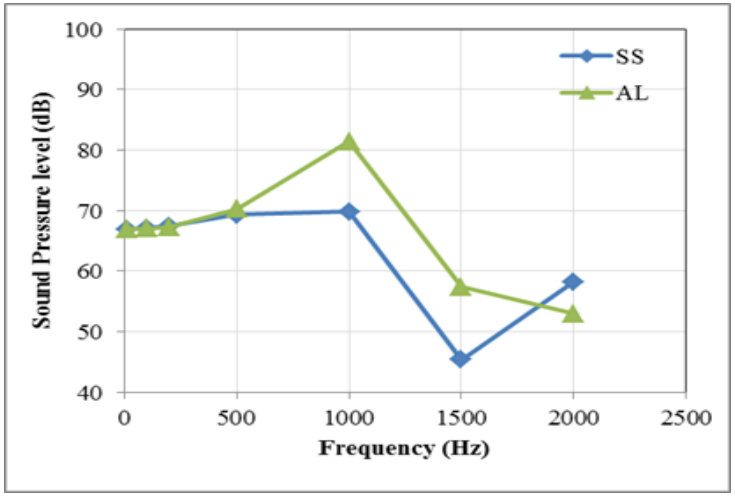


Results and Discussion

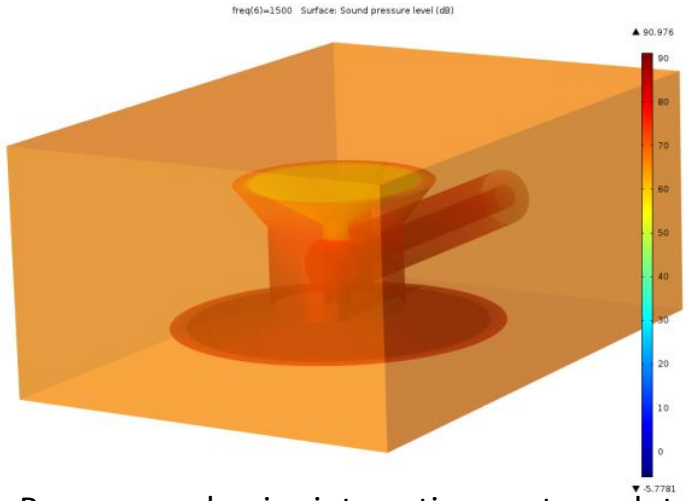
- Auscultation Pressure + Noise Input
- Interaction effects as function of frequency on the transmission.
- SS vs AL



Pressure and noise interaction contour plots of stainless steel stethoscope at 100 Hz.



Sound Pr level at the for SS and AL Stethoscopes



Pressure and noise interaction contour plots of stainless steel stethoscope at 1500 Hz

Conclusion

- Parametric COMSOL model is useful in estimating the performance of the stethoscope.
- Geometry, Frequency, noise, material construction performance investigated.
- Results will be used to improve the performance for use in telehealth environment.
- Multiphysics coupling and FSI will be used in the future for product design and finalization.