Theoretical Study on Standing Wave Thermoacoustic Engine

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Background

Performance of thermoacoustic engine is governed by various design parameters like type of resonator, stack geometry, frequency, type of working gas etc. and various operating parameters like heat input, charging pressure etc. Hence, to arrive at an optimum configuration of the engine a theoretical model is required.

In this work, system dimensions like length of resonator, stack, hot and cold heat exchangers are fixed with helium-argon mixture as a working gas and parallel plate type stack. Two plate spacings, corresponding to Helium-Argon mixture and Nitrogen gas, is used for carrying out analysis with Working gases used : Helium, Argon, Nitrogen, Carbon dioxide and Helium-argon mixture.

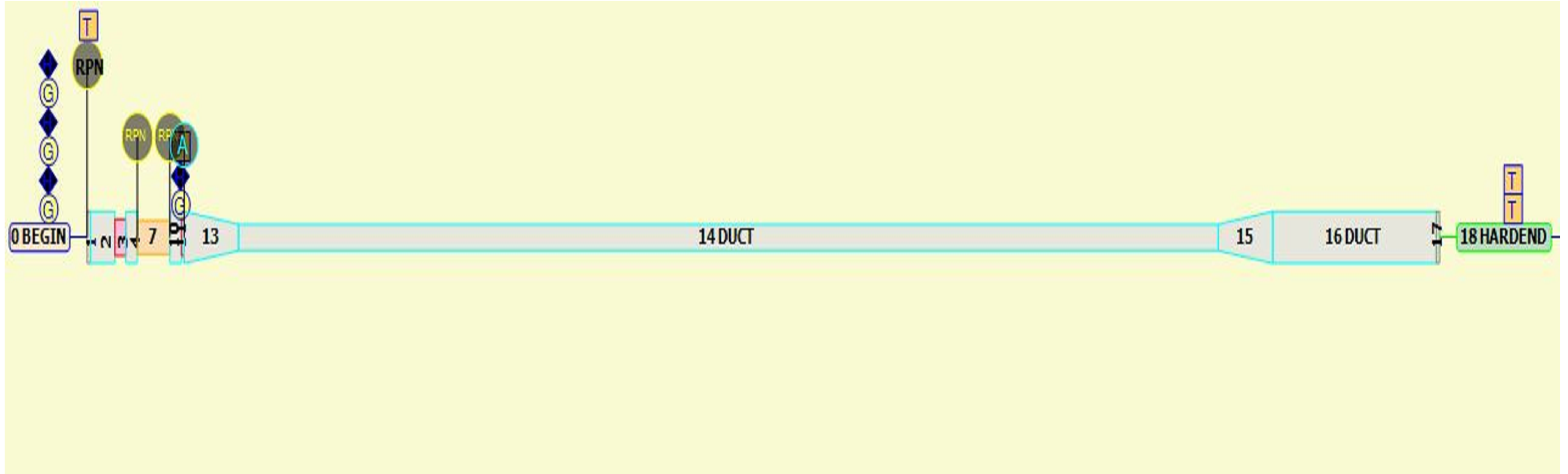
Objective

To study the effect of charging pressure on performance of thermoacoustic engine with two different plate spacings in terms of resonating frequency, onset temperature, pressure amplitude, acoustic power and efficiency.

Conclusion

- Pressure Amplitude linearly increases with increase of charging pressure for all gases that are used in the study. The highest pressure amplitude is exhibited by Argon driven system while the lowest is by CO_2 driven system.
- Acoustic Power and efficiency follows the similar trend of slight reduction with charging pressure for all the sampled gases.
- Argon has the highest Onset temperature while Helium has the lowest Onset temperature. This implies that it is easier to start oscillations in a Helium run system.
- Lowest acoustic power and efficiency is by use of CO_2 while He loses its "edge" once the pressure increases.

Schematic



Model Description

- Numerical simulation is carried out for a standing wave type half wavelength thermoacoustic engine using DeltaEC.
- The heat input is of 2000 W and the cold heat exchanger temperature of 303K, both of which are held constant. The overall length of the device is about 2200 mm.
- Stainless steel stack of parallel plate geometry is used for this analysis. The length of the stack is kept 60 mm.

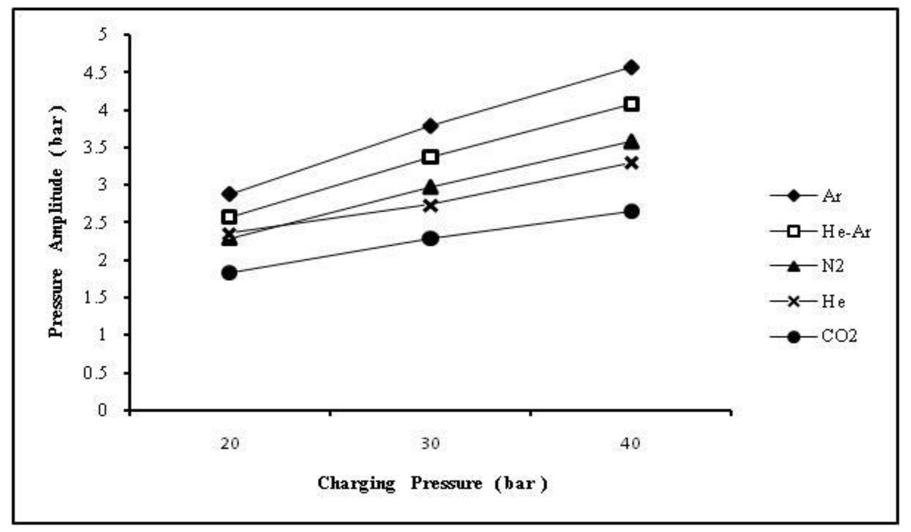
Methodology

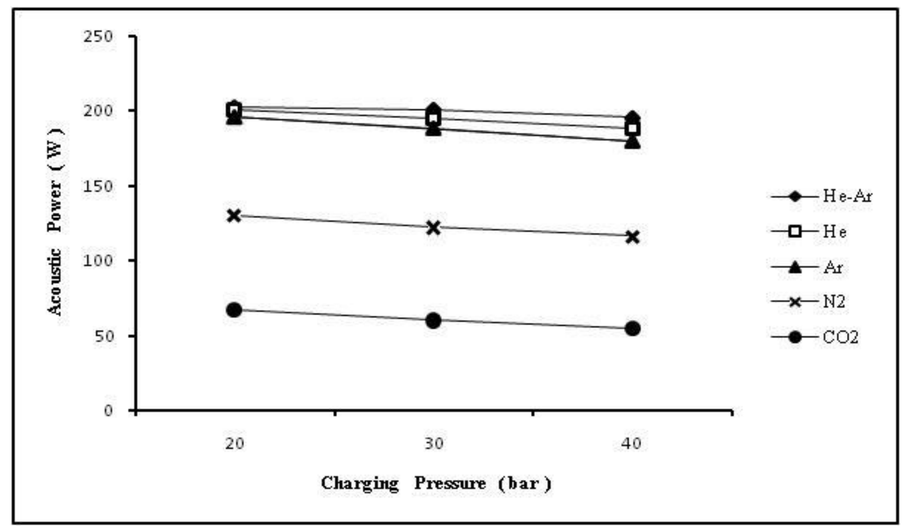
- The plate spacing at 20 bar pressure for N_2 and He-Ar mixture were computed corresponding to maximum relative Carnot efficiency and used for the present analysis. The same for N_2 was found to be 0.46 mm and that for He-Ar mixture was found to be 0.58 mm using numerical simulation.
- Charging pressure was varied from 20 to 40 bar with these two plates spacing varying. This analysis is carried out with He, Ar, CO_2 and N_2 and a He-Ar mixture with 70% Helium.
- The effect on the performance of the system in terms of pressure amplitude, acoustic power, efficiency and onset temperature were plotted and studied.

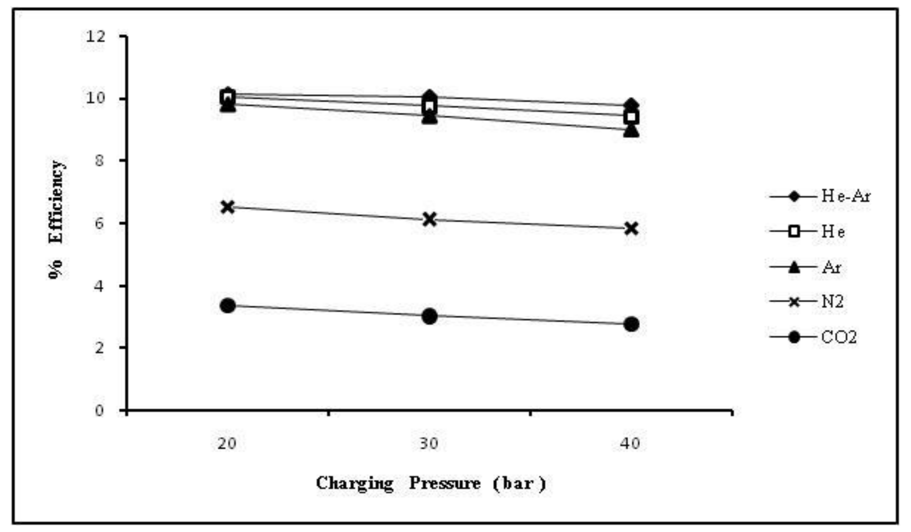
Results

PRESSURE AMPLITUDE (bar) — ACOUSTIC POWER (W) — % EFFICIENCY — ONSET TEMPERATURE (K)

PLATE SPACING = 0.46 mm







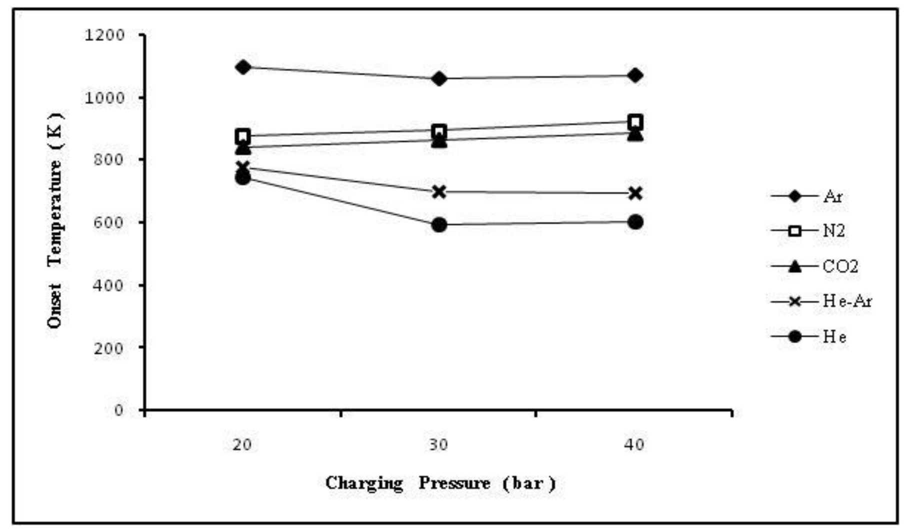
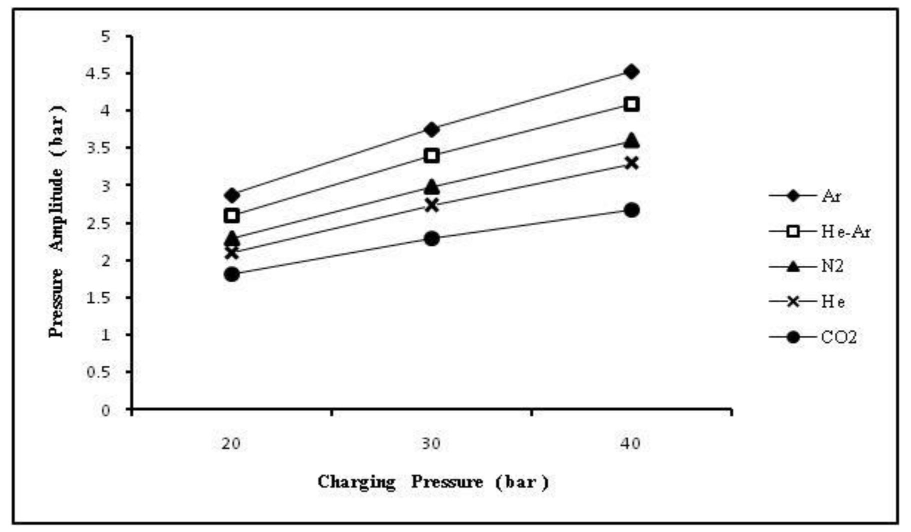
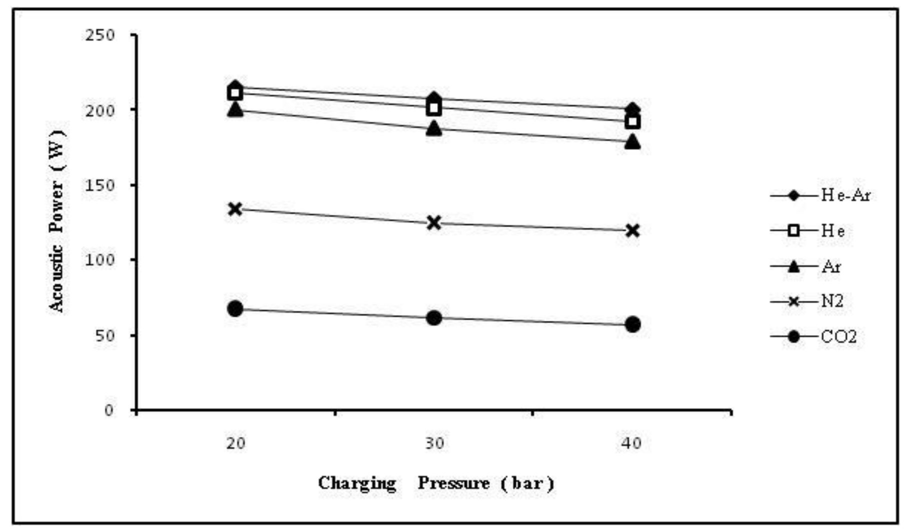
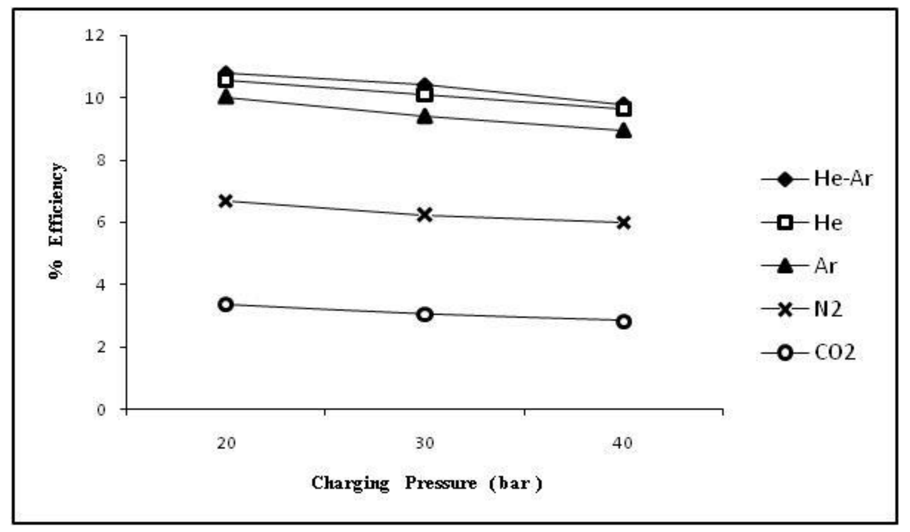
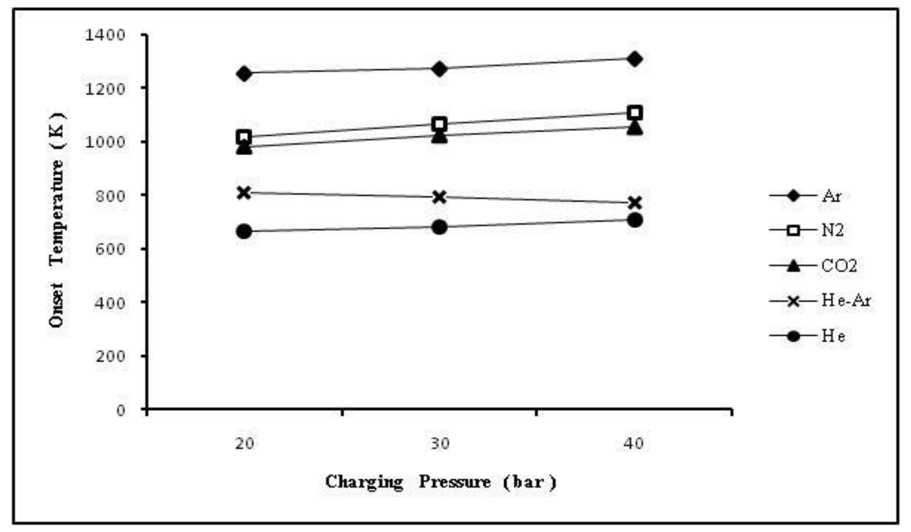


PLATE SPACING = 0.58 mm









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