CONCENTRATION-DRIVEN ACOUSTIC INSTABILITY IN AEROSOLS

A. Offner[1] and G. Z. Ramon[1]

[1]Technion – Israel Institute of Technology, Haifa, Israel

offner@campus.technion.ac.il

A temperature gradient imposed on a dense aerosol may trigger an acoustic instability which, in turn, may accelerate the coalescence and agglomeration of droplets. Thermoacoustic instability, i.e. a critical temperature gradient imposed on a solid-gas interface initiating spontaneous self-sustained oscillations, has been intensively studied in the context of undesired acoustic waves produced in combustion chambers. Recent work[1,2] demonstrated how modifying the working fluid to contain water vapour dramatically decreases the temperature gradient required for triggering this instability. In this process a thin film of liquid covers the solid such that a liquid-gas interface is formed, from which water evaporates and condensates according to the local equilibrium with the surrounding gas. In the present work we speculate on the feasibility of a similar process, only here we consider a uniform, three-dimensional structure of droplet in contact with the gas rather than a thin film.

In the considered configuration, the liquid-gas interface is discontinuous such that the gas is not constantly in contact with its source/sink. Unlike a thin film interface, droplets are free to move with the surrounding oscillating gas, with their entrainment factor largely determined by the droplet diameter[3]. A minimum droplet size of $\sim 1\ \mu\mathrm{m}$ is required, below which droplets are practically fully entrained and the instability is unlikely to occur.

As a first approximation, the droplets formation is thought of as only slightly deviating from a close packing of spheres, hence $d/L = 1 - \varepsilon$ with d and L the droplet diameter and distance between neighbouring droplets, respectively, and $\varepsilon \ll 1$. A linear stability analysis is performed, seeking the critical temperature gradient and the resonant frequency that would trigger the instability. The results demonstrate the possibility of a relatively low temperature gradient initiating acoustic oscillations in a dense aerosol.

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REFERENCES:

1. Meir A., Offner A. and Ramon G. Z. ‘Low-temperature energy conversion using a phase-change acoustic heat engine’ *Applied Energy*, **2018**, *231*, 372-379.
2. Offner A., Yang R., Felman D., Elkayam N., Agnon Y. and Ramon G. Z. ‘Acoustic oscillations driven by boundary mass exchange’ *Journal of Fluid Mechanics*, **2019**, 866, 316-349.
3. Sujith R. I., Waldherr G. A., Jagoda J. I. and Zinn B. T. ‘A Theoretical investigation of the behavior of droplets in axial acoustic fields’ *Journal of Vibration and Acoustics*, **1999**, 121, 286-294.