The Rijke's tube : modelling issues and experiments

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Abstract: The Rijke tube (e.g. Epperlein et al (2015)) can serve as a prototypical experiment for research and study of thermoacoustic phenomena in which heat transfer and acoustics are dynamically coupled (there is a critical heater power beyond which the tube begins to hum loud). This experiment is an illustration of the phenomenon of thermoacoustic instabilities, which typically occur whenever heat is released into gas in underdamped acoustic cavities. The heat release can be due to combustion or solid/gas heat transfer. Under specific conditions the coupling between the acoustic and heat release dynamics in the cavity becomes unstable. This instability takes the form of a sustained limit cycle resulting in audible powerful pressure oscillations. Thermoacoustic instability most often arise in combustors of gas turbines and aero engines where the resulting powerful pressure waves are undesirable due to the danger of structural damage as well as performance degradation. The advantage of the Rijke tube as an experimental device is that it generates acoustic instabilities without a combustion process. It is also a useful benchmark to test and analyze a multi-physics system in the context of system analysis and control design.

A priori the modelling is based on first principles with mass, energy and momentum equations (e.g. de Andrade et al (2016), de Andrade et al (2018)) resulting in a set of nonlinear partial differential equations (PDE's). Then after some hypotheses, the model may be reduced to a wave-like equation. Yet the reduction approach may appear rather obscure with several aspects. Besides other modelling approaches are possible (see e.g. Bonciolini et al (2017), Noiray and Schuermans (2013)) and compatible with what is observed.

In this talk we shall be presenting different aspects about the modeling of the Rilke's tube, that aims to emphasize the key features of the dynamics of the system, as well as the experimental set-up that has been designed and is now operational. The link between the observations (and typically the frequency of the produced sound) and the modeling will be discussed.

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