COMBUSTION DYNAMICS IN A RIJKE TUBE (PULSED COMBUSTOR)

Learning Objectives

1. Familiarization with the characteristics of resonant systems, frequencies and mode shapes
2. Introduction to acoustic waves and combustion dynamics
3. Exposure to the use of piezoelectric pressure transducers, photomultiplier tubes and rotameters
4. Exposure to frequency analysis (power spectra)
Lab Info

- **Location**
  - ESM G2

- **When**
  - the next two weeks (only one week for each group)
  - there will also be a 2nd lecture next week

- **Safety**
  - all experiments with combustion are potentially hazardous… follow all the precautions outline in the lab manual regarding igniting and operating the combustor

Pulsed Combustors, Combustion Dynamics

- Can produce pressurized outputs (thrust) without external machinery (e.g., compressors)
- Cause of spectacular failures in rockets (and gas turbines)
Rijke Tube

- Open ended pipe with internal, compact heat source
- Acoustic modes of a pipe

\[ p(t) = \bar{p} + p'(t) \]
\[ p'(x,t) = A(x)\sin \omega t \]

\[ \phi = 90^\circ \]

Velocity (+ up)

Pressure Standing Wave

Fundamental

\[ \lambda = 2L \]
\[ f = a / 2L \]

p-node

v-node

AE2610
Piezoelectric Pressure Transducers

- Piezoelectric crystal releases or absorbs charge based on strain
- Allow fluid pressure to “push” on crystal mounted to solid base (via diaphragm); stress \(\Rightarrow\) strain
- Current source
- Also sensitive to vibrations and temperature

Chemiluminescence and PMT

- Chemiluminescence
  - chemical reaction produces a molecule (usually a radical) in an electronically excited state which can decay by emitting a photon (light)
  - \(\text{CH} + \text{O}_2 \Rightarrow \text{OH}^* + \text{CO}\)
  - \(\text{C}_2\text{H} + \text{O} \Rightarrow \text{CH}^* + \text{OH}\)
- PMT – Photomultiplier tube
Experiment

- You will acquire acoustic pressure and PMT data at different burner heights
- You will make observations of flame behavior in resonance and out

Lab Info

- Location
  - ESM G2
- When
  - the next two weeks (only one week for each group)
  - there will also be a 2nd lecture next week
- Safety
  - all experiments with combustion are potentially hazardous… follow all the precautions outline in the lab manual regarding igniting and operating the combustor