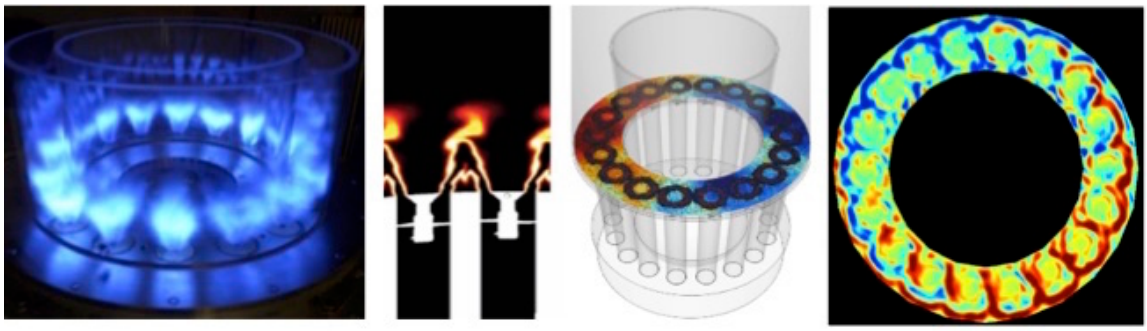
ANNULIGhT



Annular instabilities and transient phenomena in gas turbine combustors

Preliminary program for summer school on thermoacoustics

September 24th – 28th

Cambridge University Engineering Department

Lecturers:

Prof Tim Lieuwen (Georgia Tech)

Prof Wolfgang Polifke (TU Munchen)

Prof Aimee Morgans (Imperial College London)

24 September 2018 Monday Morning

Lecturer: Prof. Dr. Tim Lieuwen

Overview / background on gas turbine combustion technology fundamentals

- Working principle of gas turbines, combustion architectures
- operational limits, emissions, premixed vs. non-premixed flames.

Disturbances in combustors

- canonical disturbance modes
- Vortical disturbances (flow instabilities in shear flows; wakes, jets, etc.)
- Entropy disturbances and fuel system dynamics

24 and 25 September Monday afternoon, Tuesday morning

Lecturer: Prof. Dr. Wolfgang Polifke

Thermoacoustic combustion instability- basic concepts

- acoustic-flow-flame interactions in feedback, Rayleigh criterion
- importance of phase / time lag
- dispersion relation of n-tau model for small n (see McManus & Poinsot, 1994),

Flame transfer functions (basic treatment)

- impulse vs. frequency response; n-tau and distributed delays
- the physics of the FTF: (convective) delays-- front kinematics, vortices, equivalence ratio, droplet evaporation

Basic acoustics

- wave equation, propagation of characteristic waves
- boundary conditions, impedance /admittance,
- scattering at "duct singularities" (area change, flame)
- (thermo-)acoustic eigenmodes,

Overview of modelling / simulation approaches

- characteristic waves, Galerkin, FE, state space phasor diagrams (for eigenmodes, flame dynamics with time lags, ...)

hands on :

- work with phasor diagrams to understand
  1) eigenmodes, effect of non-ideal reflection on phases, eigenfrequencies of duct- area change- duct, thermoacoustic eigenmodes- and-frequencies.

2) dynamics of flames as distributed delays (low-pass behaviour, excess gain, phase jumps,

- State space *toy model* of Rijke tube

25 and 26 September Tuesday afternoon, Wednesday morning

Lecturer: Prof. Dr. Tim Lieuwen

Flame dynamics

- Premixed limit
- Partially premixed flames
- non-premixed flames
- Spray flame dynamics

hands on*: t.b.d.*

26 September 2018 Wednesday Afternoon

Lecturer: Prof. Dr. Aimee Morgans

- (in)stability vs. resonance / combustion instability vs. combustion noise
- more on characteristic-based modelling of acoustics (mean flow, damping, annular geometries ...)
- flame describing functions as weakly nonlinear extension of flame transfer functions
- Determining linear stability of thermoacoustic systems
  (minimum determinant, Bode diagrams, shooting method)

hands on :

- Matlab code for determining purely acoustic modes of tube using determinant method
- Matlab code for determining thermoacoustic stability of Rijke tube using Bode diagram method

27 September 2018 Thursday Morning and Afternoon

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