Systems and methods for suppressing thermo-acoustic instabilities in a Combustor

IITM Technology Available for Licensing

PROBLEM STATEMENT

- **Turbulent flows like gas turbine combustors** can **experience thermoacoustic instability due to large amplitude periodic oscillations**.
- This instability can **cause extensive damage** to **combustor parts**, leading to fatigue failure, loss of system performance, and mission failure.
- **Smart control strategies** have been developed to mitigate this instability, including acoustic dampers, liners, staged fuel injection, and microjet injections.
- **Passive control involves modifying combustor geometry**, altering fuel injection mechanisms, installing baffles, **Helmholtz resonators, and applying acoustic liners.**
- **Active control strategies supply energy** to the thermoacoustic system through **dynamic actuators, divided into active closed-loop and open-loop control.**

TECHNOLOGY CATEGORY/ MARKET

Technology: Suppressing thermo-acoustic instabilities in a Combustor
Category: Aerospace & Defense Technologies
Industry: Aerospace
Application: Aero engine gas turbines
Market: The global market size was reached **USD 3.3 billion in 2023** and is projected to expand at **9.2% CAGR from 2024 to 2032**

INTELLECTUAL PROPERTY

IITM IDF Ref. 1946
Patent No: IN 547498

TRL (Technology Readiness Level)

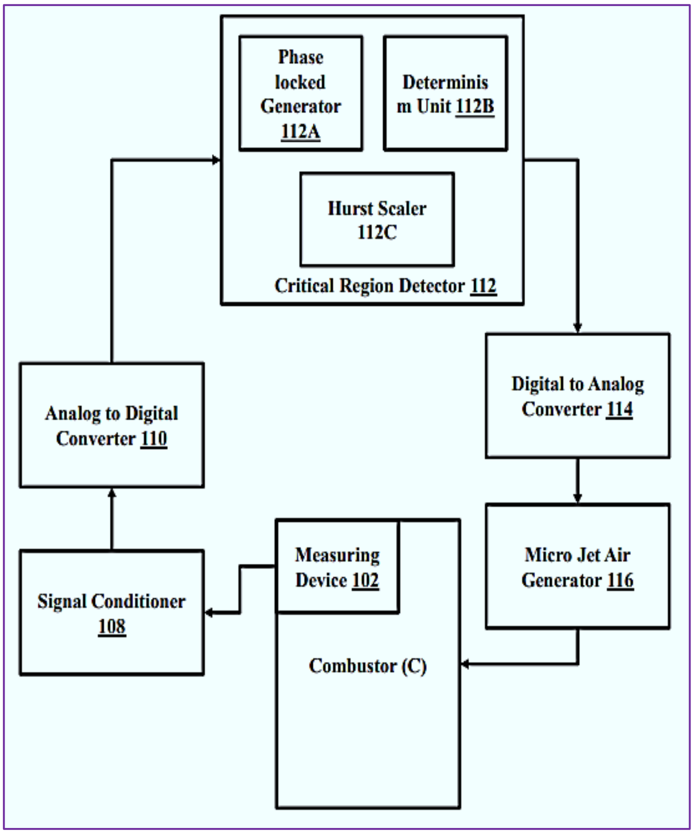
TRL- 4, Experimentally validated in Lab;

Research Lab

Prof. Sujith RI,
Dept. of Aerospace Engineering

TECHNOLOGY

System for suppressing thermo-acoustic instabilities in a combustor



- **Generating first and second signals for combustor's turbulent velocity and acoustic pressure fluctuations.**
- **Determining phase locked values for signal synchronization.**
- **Measuring parameters for recurring turbulent velocity fluctuations at each combustor location.**
- **Determining Hurst exponent values based on first signal.**
- **Identifying critical region for phase locked values, recurring fluctuations, and Hurst exponent values.**
- **Injecting micro-jets to suppress thermo-acoustic instabilities.**

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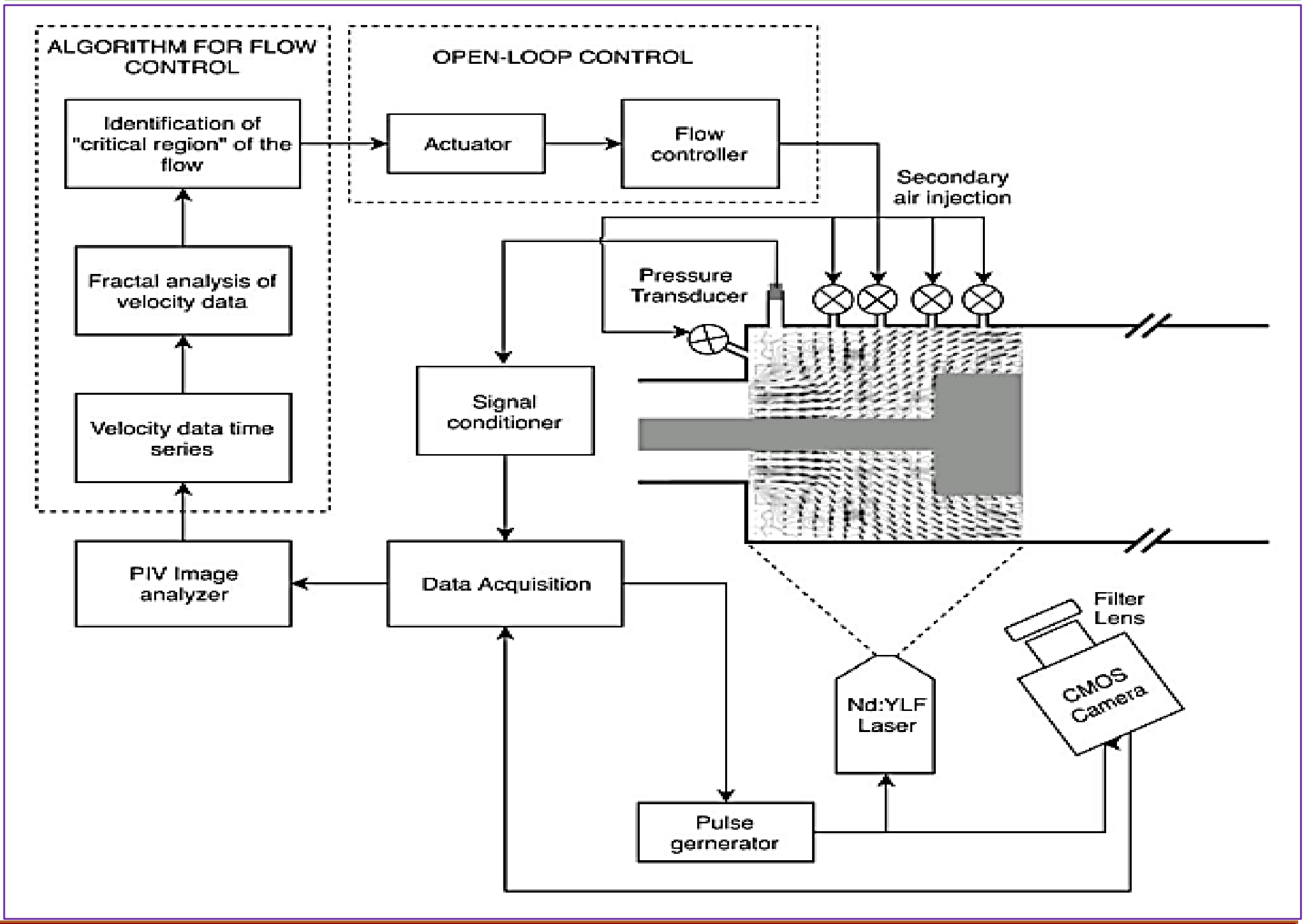
Method of optimizing the open-loop or smart passive control strategy in a turbulent combustor



Key Features / Value Proposition

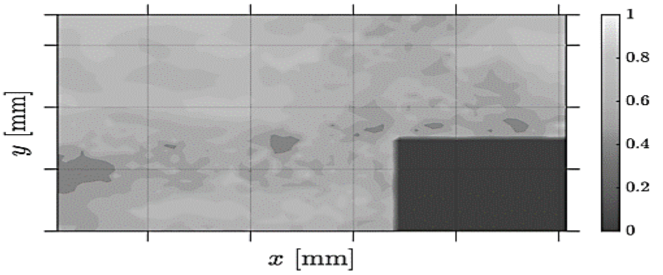
Detecting Combustion Instabilities

- Determining phase locked values across the combustor to indicate synchronization of turbulent velocity and acoustic pressure.
- Using Hilbert transform to determine phase difference of first and second signals.
- The phase locked value corresponds to a correlation between turbulent velocity and acoustic pressure.
- Measures recurring fluctuations in turbulent velocity including recurrence rate, determinism, entropy, trapping time, and average diagonal length.
- Measures a Euclidian distance between state points of the phase space trajectory at every combustor location.
- Hurst exponent values indicate scaling behavior of the first signal corresponding to turbulent velocity.
- Detects a critical region of the combustor at a region in the combustor.

Advancement

- Hurst exponent value is close to zero for periodic signals and greater than 0.5 for noisy and fractal signals.

The below diagram shows a distribution of *H* when the state of thermoacoustic instability is controlled by targeting the critical region using secondary air



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