800 1222·2022 ANNI

UNIVERSITÀ DEGLI STUDI DI PADOVA

Development of measurement techniques based on image analysis for multiphase flows

Giulio Tribbiani - 38th Cycle

Supervisor: Prof. Gianluca Rossi

Meeting - 13th September 2023

Baker Hughes

Co- Supervised by:

- **Ing. Francesco Azzini**
- **Ing. Martina Mengoni**

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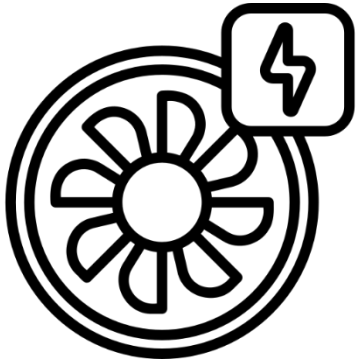
Introduction



GAS TURBINE

Renewable Energy is still not able to fully replace carbon fuels

Environmental Impact of combustion engine based Power Plants has to reduced

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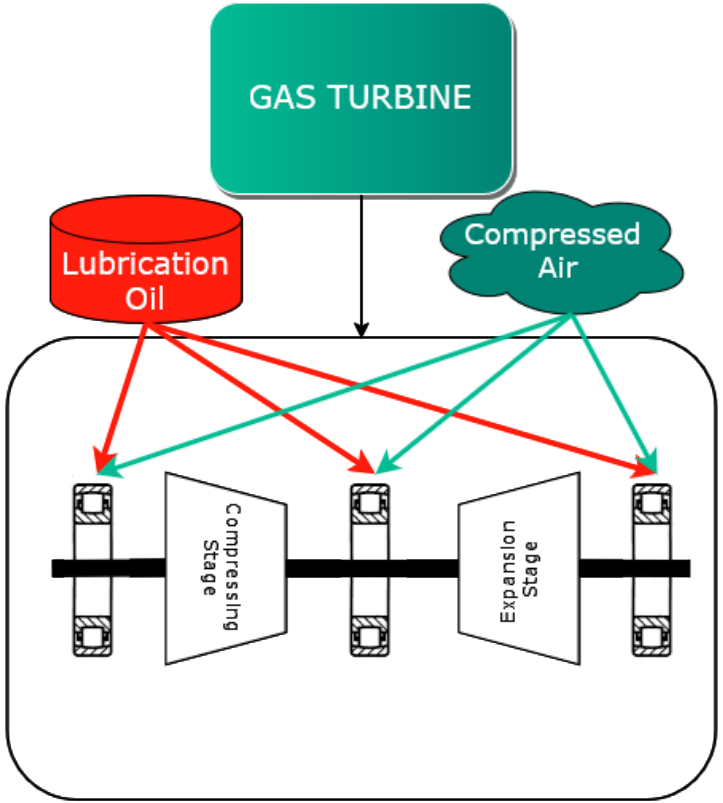
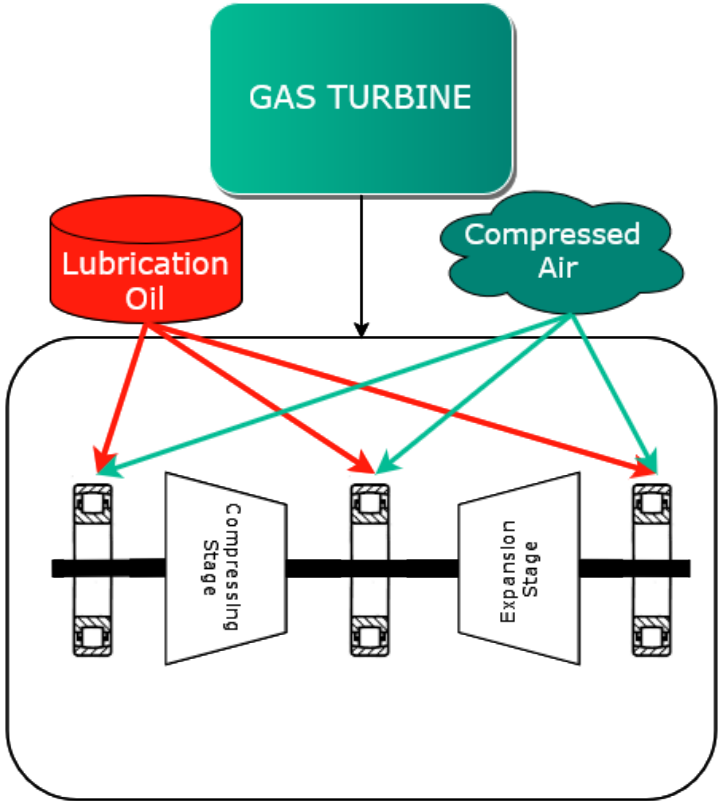
Introduction



A lubrication system is needed to allow a smooth operation of the Gas Turbine

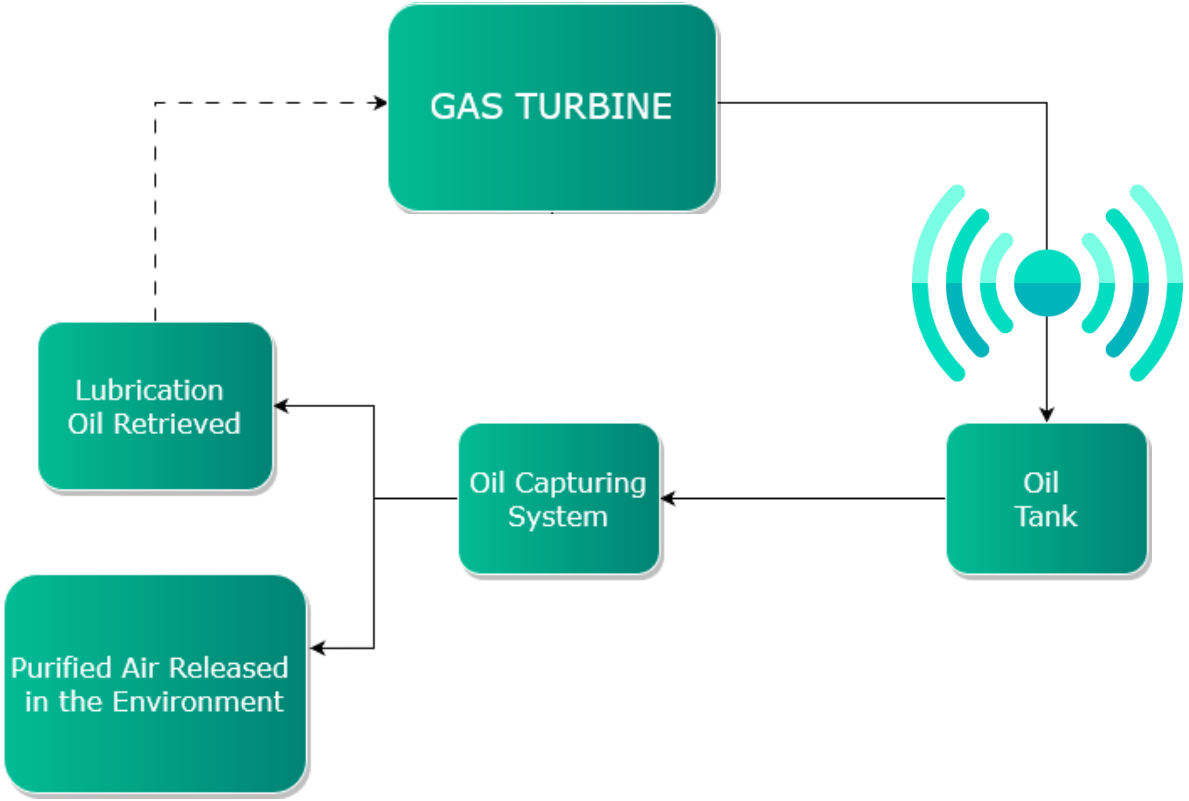
Compressed Air is injected to prevent oil leakege outside the bearings

Introduction



MULTIPHASE FLOW (mixture of air and oil) circulating in the lubrication system of the turbine

Introduction



The right Oil-Air Ratio is needed for the Oil Capturing System to work properly

MASS FLOW RATE SENSOR FOR BOTH PHASES

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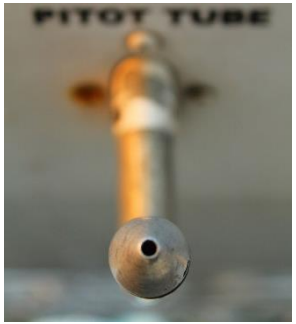
Technology Scouting and Limitations

Conventional Mass-Flow Rate sensors

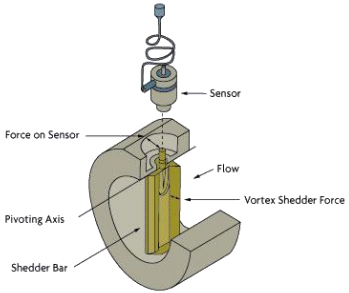
Non-Conventional Mass-Flow Rate sensors

Technology Scouting and Limitations

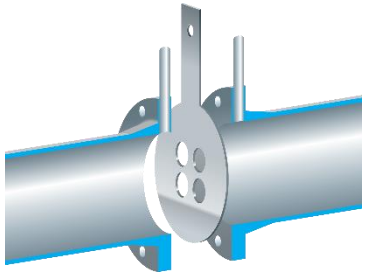
Conventional Mass-Flow Rate sensors



Pitot Tube

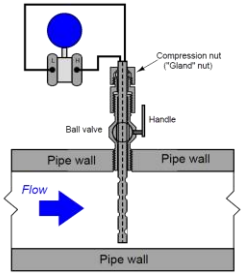


Vortex Shadding



Orifice Plate

Coriolis Effect



Drag Disk

Turbine

Non-Conventional Mass-Flow Rate sensors

Technology Scouting and Limitations

Conventional Mass-Flow Rate sensors

Non-Conventional Mass-Flow Rate sensors

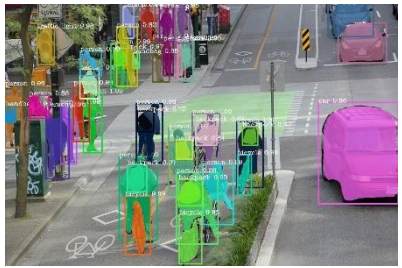
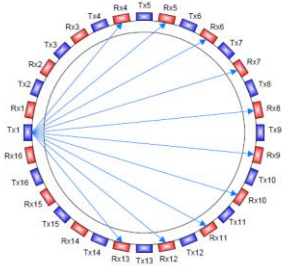
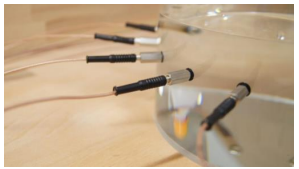


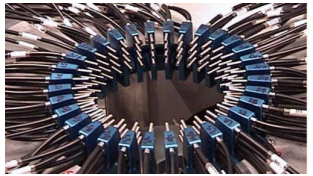
Image Analysis



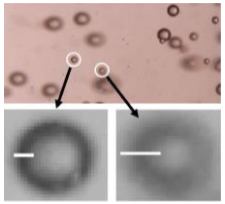
Tomographies



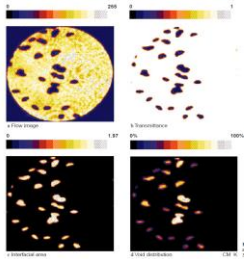
Electrical Impedance



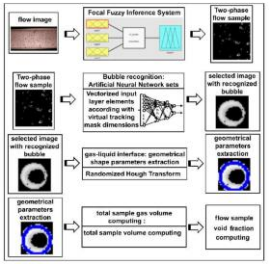
Optical



Bubble Detection



Light Attenuation



Neural Networks

Ultrasonic

Gamma Rays

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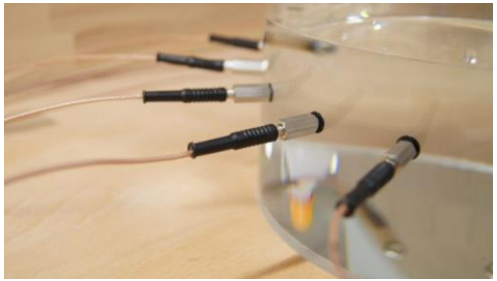
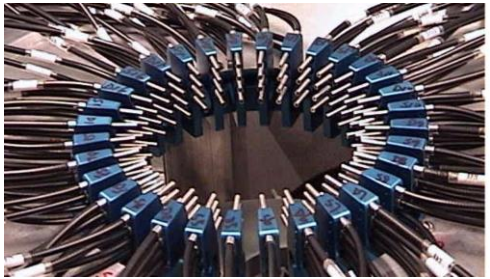
Promising Approaches

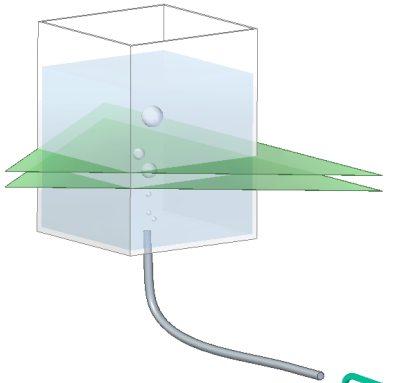
Electrical Impedance Tomography



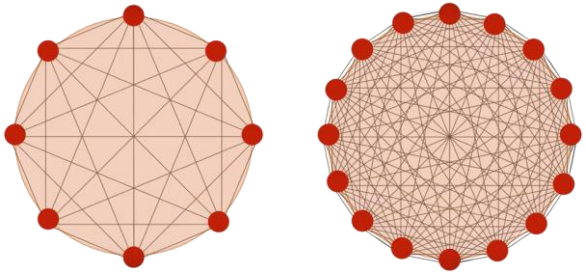
Optical Tomography

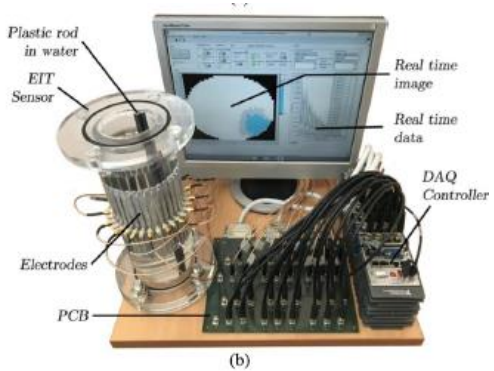


Laser Sheets
(light attenuation)



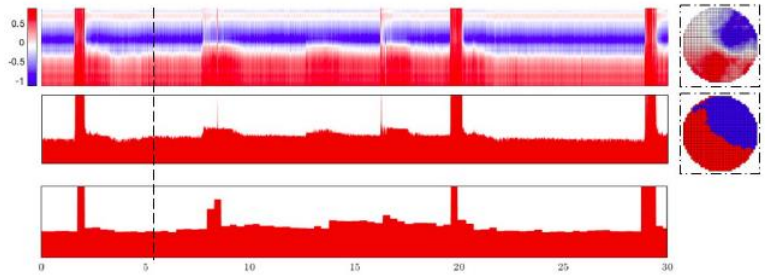
Electrical Impedance Tomography





An AC signal of few mA is created between the two electrodes. Like any other tomography, the attenuation of this signal will be proportional to the electrical impedance in the linear path.

$$I_x = I_0 e^{-(\mu x)}$$



Optical Tomography

Laser Sheets (light attenuation)

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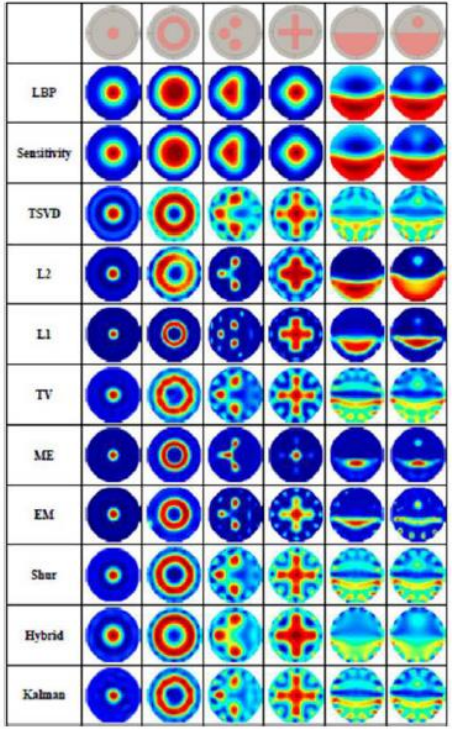
Electrical Impedance Tomography

Algorithms to solve the **Ill-posed Inversion Problem :**

- Linearization Methods
- Jacobian Matrix based methods (Linear Back-Projection, Single Value Decomposition, Tikhonov Regularization)
- Iterative Methods (Landweber Algorithm)



Optical Tomography

Laser Sheets (light attenuation)

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Optical Tomography

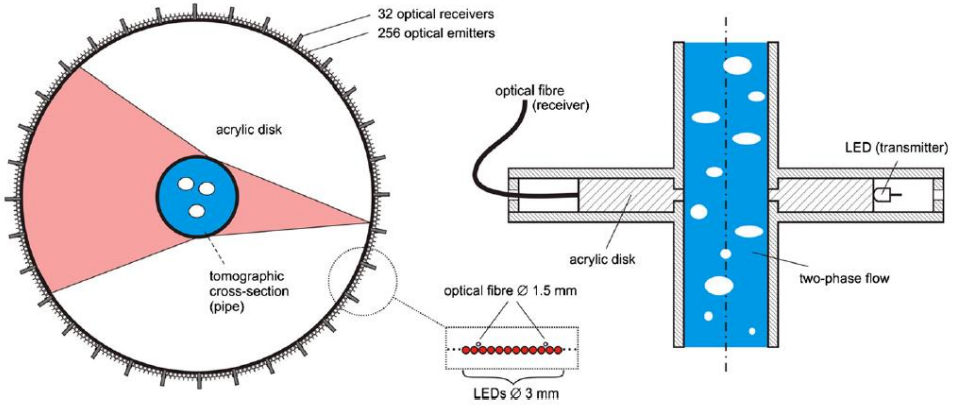
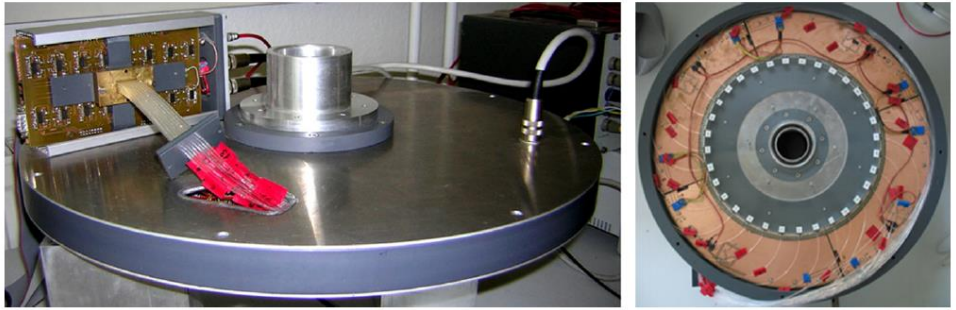


Figure 1. Basic design of the optical tomograph. Left: horizontal view; right: sectional view.



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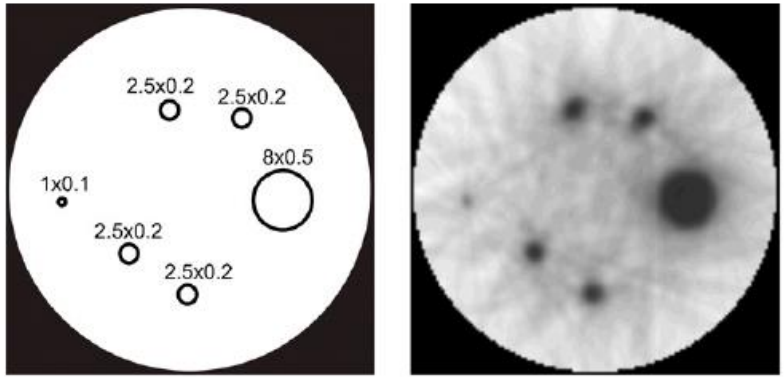
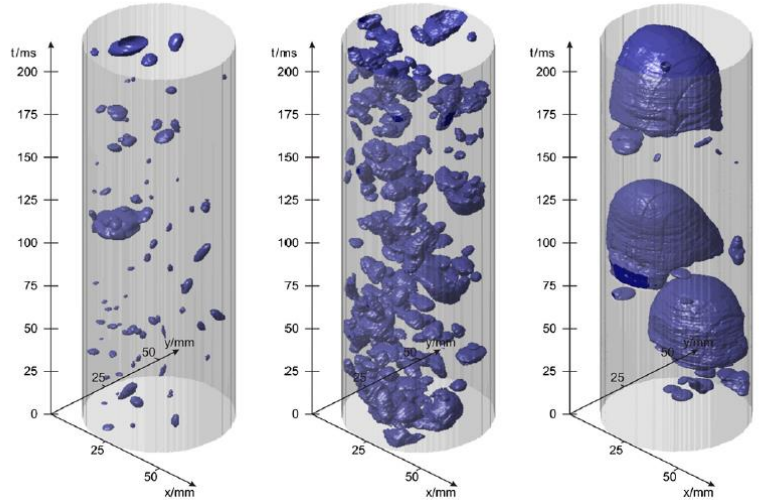
Electrical Impedance Tomography

Laser Sheets (light attenuation)

Optical Tomography





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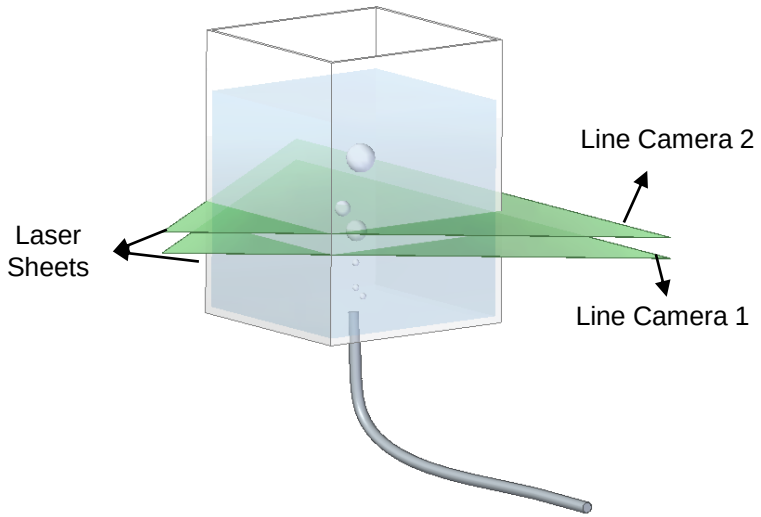
Electrical Impedance Tomography

Optical Tomography

Laser Sheets (light attenuation)



An innovative method proposed to measure the flow rate of air bubbles inside the dispersion fluid

Thanks for the attention