Experimental Quantification and Prediction of Micro-Turbojet Engine Performance Degradation Imposed by Inlet Distortions

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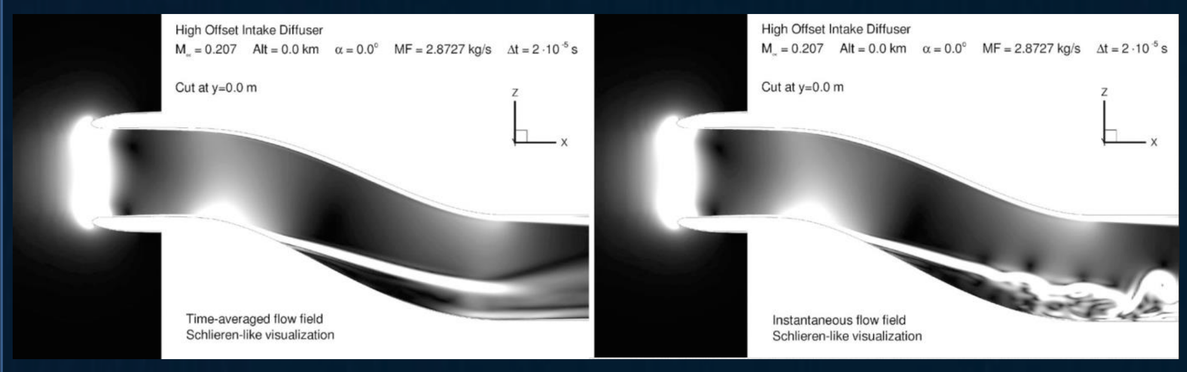
MOTIVATION

The performance of a jet engine greatly depends on its air delivery system. The type and geometry of the inlet and the inlet duct determine the pressure loss and distortion of the air supplied to the engine, which in turn affects the thrust and fuel consumption. The engine compressor is particularly vulnerable to flow distortions as it is designed for uniform flows and, when subjected to distortions, suffers from performance degradation which could potentially lead to rotating stall and surge

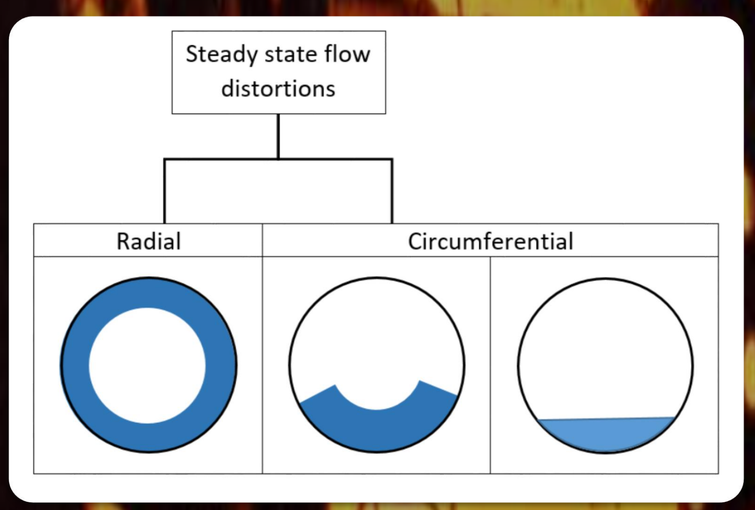
There is a need for development of robust quantification and prediction tool for micro gas turbine engine performance degradation due to various inlet distortions via detailed experimental measurements.

Beyond the direct contribution of developing new experimental tool, the outcomes of the present research have the potential to be applied towards designing novel inlet geometries and better predicting the micro gas turbine engine performance limitations within a given platform.

TYPICAL INLET DISTORTION



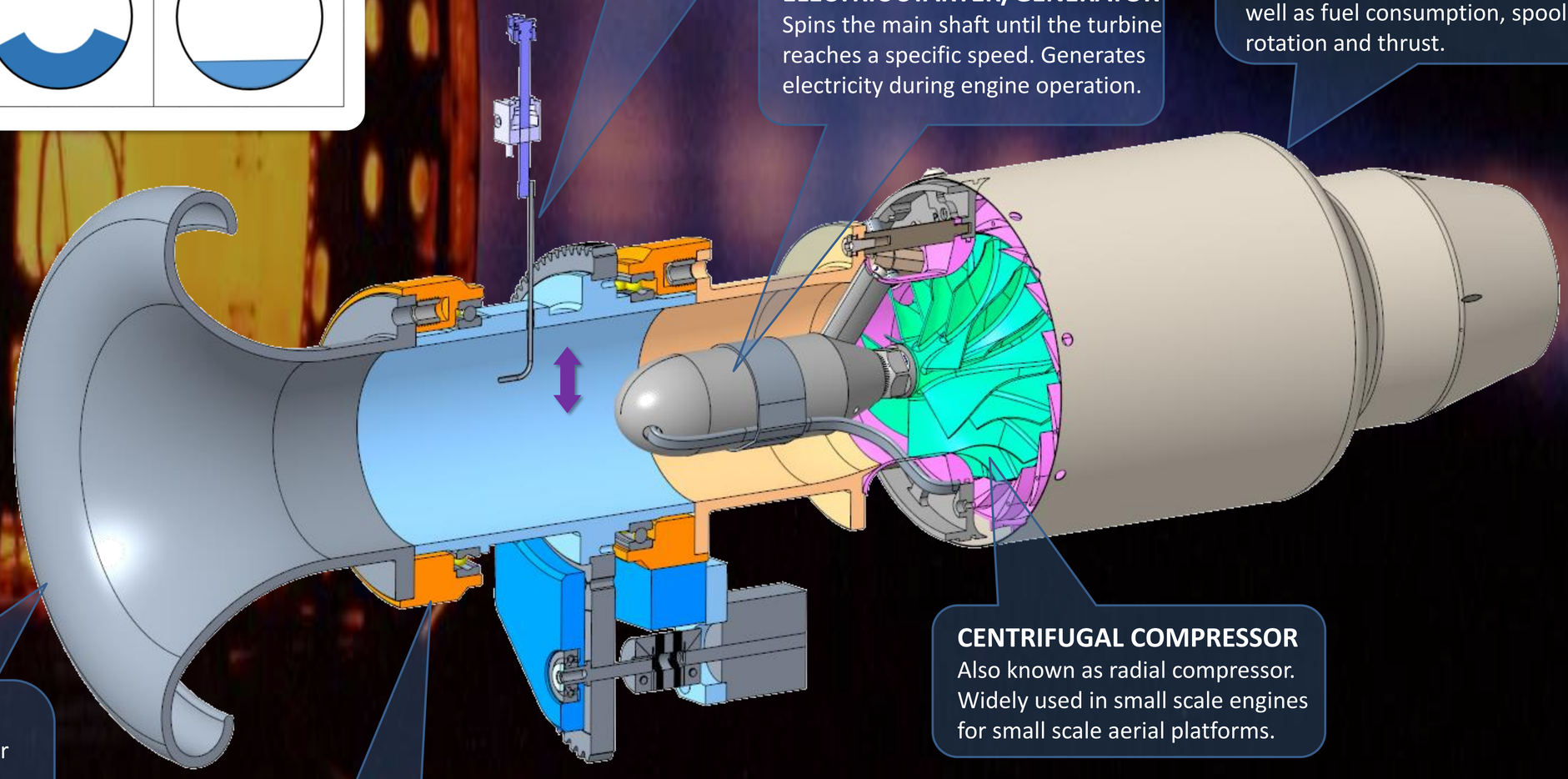
Comparison of diffuser flow solutions (time-averaged and instantaneous flow field. Schlieren-like visualization) with different physical time steps applied. Image source Ref [1].



PRESSURE SENSOR
A 360-degree rotatable and radially controlled total pressure sensor allows to determine the total pressure distribution of the air supplied to the engine.

ELECTRIC STARTER/GENERATOR
Spins the main shaft until the turbine reaches a specific speed. Generates electricity during engine operation.

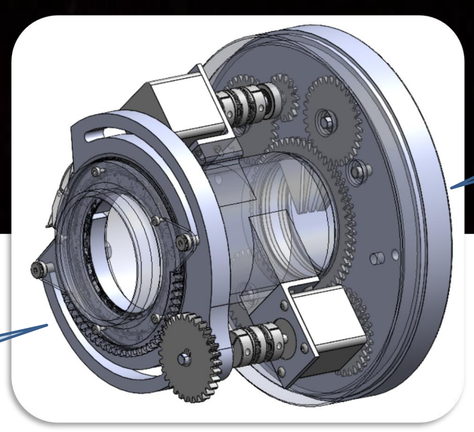
MICRO-TURBOJET ENGINE
Micro-turbojet engine, which is capable of producing nominal thrust of 230 N and is instrumented to measure temperatures and pressure at various engine stations, as well as fuel consumption, spool speed of rotation and thrust.



BELL-MOUTH INTAKE
Provides smooth entry of air flow, minimize downstream boundary layer growth, reduces flow nonuniformities and produce an even velocity profile at the engine entry.

MODULAR JOINT
Allows interchangeability between various modules of flow distortion.

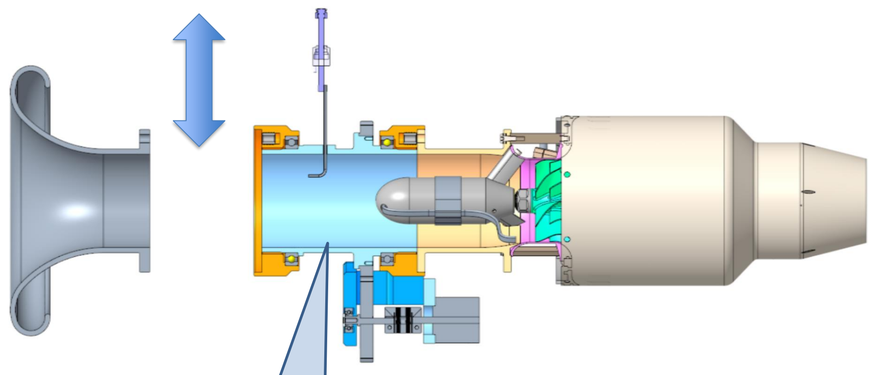
CENTRIFUGAL COMPRESSOR
Also known as radial compressor. Widely used in small scale engines for small scale aerial platforms.



CIRCUMFERENTIAL DISTORTION MODULE

RADIAL DISTORTION MODULE

MODULAR FLOW DISTORTION GENERATOR (MFDG)



PRESSURE SENSING MODULE

RESEARCH GOAL

- The Modular Flow Distorting Generator (MFDG) shall be a tool to allow test aided design of inlets and their integration with engines for the industry
- Independent generation of radial and circumferential distortions, allows research of wide range of inlet distortions and the impact on engine performance
- The MFDG allows versatility of research on various distortions
- The facility shall pioneer Micro-Turbojet engine and inlet distortions research in Israel

FUTURE WORK

- Implementation of the design
- Experimental research

MFDG MAIN COMPONENTS

1. Bell-mouth intake
2. Radial distortion module
3. Circumferential distortion module
4. Pressure sensing module

REFERENCES

1. Berens T.M., Delot A.L., Chevalier M., Van Muijden J., *Numerical Simulations for High Offset Intake Diffuser Flows*. In Proceedings of the 52nd Aerospace Sciences Meeting, National Harbor, MD, USA, 13 January 2014