

A New Research Facility for Testing Heat Exchangers for Efficient Thermal Management Next Generation Jet Engines GT2024-139079

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Motivation

The European aviation sector has committed to achieving climate neutrality by the year 2050. The Clean Aviation Open Fan for Environmental Low Impact of Aviation (OFELIA) initiative represents a significant stride toward realizing this objective. OFELIA aims to establish the advantages of an open fan architecture (figure 1) in terms of operational efficiency, specifically tailored to meet the evolving requirements of the upcoming generation of Short & Medium Range aircraft.

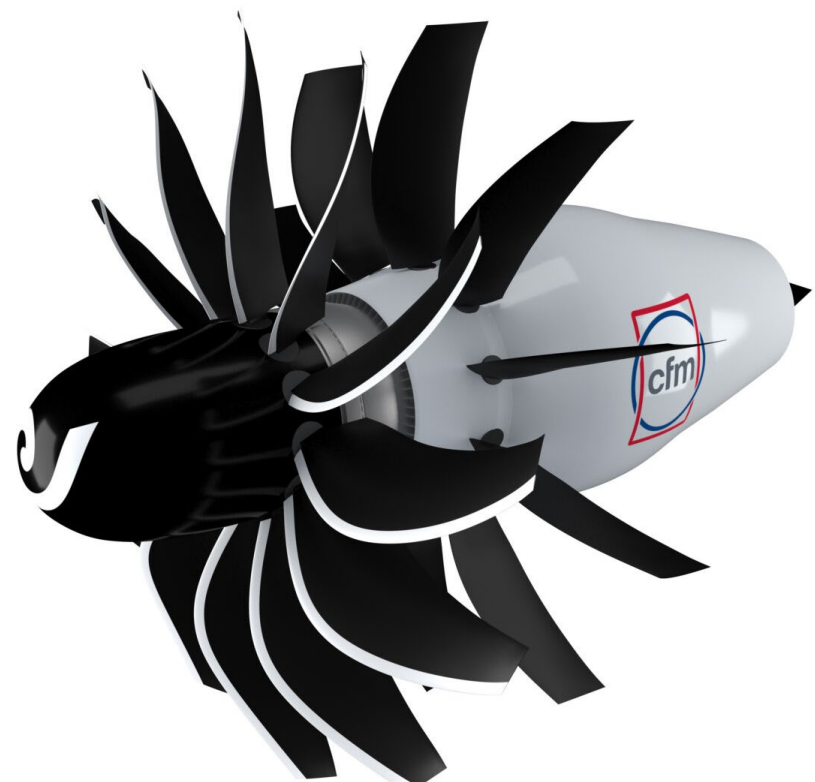


Fig. 1

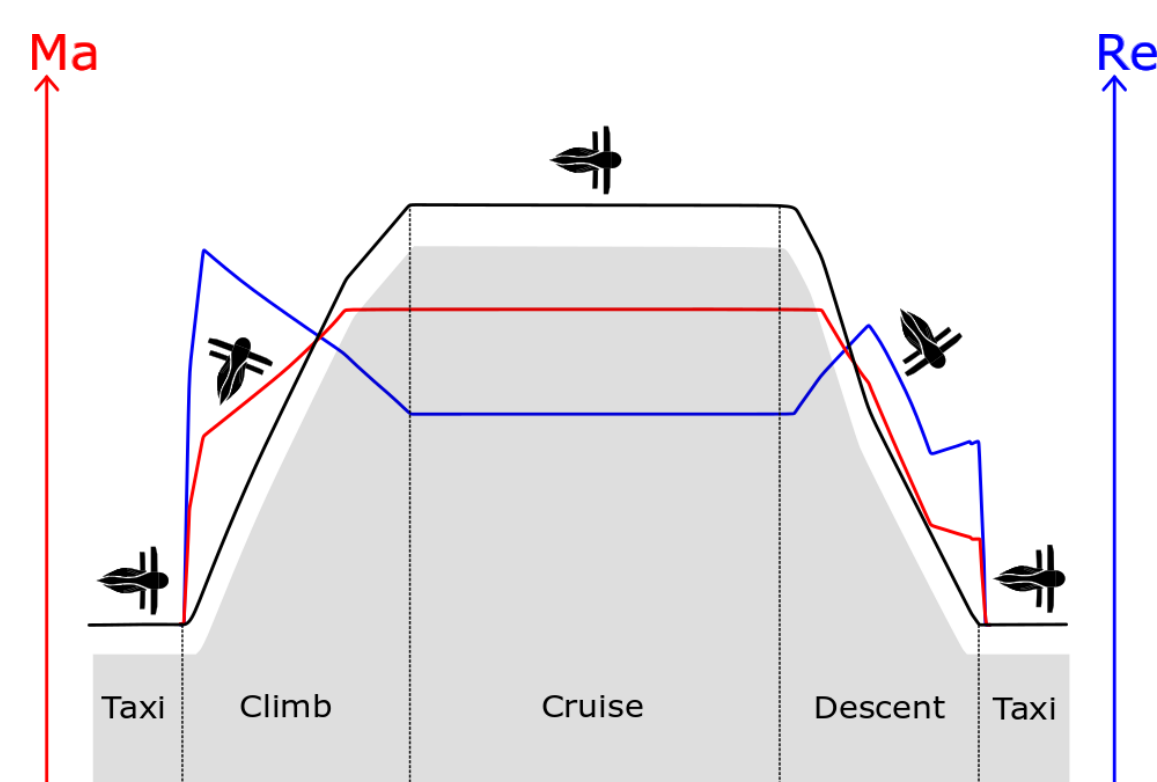


Fig. 2

Such alternate engine designs require optimized thermal management systems, incl. efficient heat exchanger (HX) designs to achieve the ambitious performance targets. TUD has upgraded its existing wind-tunnel facility to test HXs under engine relevant operational conditions (Re, Ma; figure 2). This new facility can accommodate both conventional and advanced manufactured HXs.

Test Rig

To replicate various flight phases in the test rig, the air pressure is adjusted to alter the Reynolds number independently of the Mach number (figure 3). The HX is subjected to a flow of high temperature oil, and the dissipation of heat is achieved through controlled flow of air (figure 4).

Test Rig - Air Side

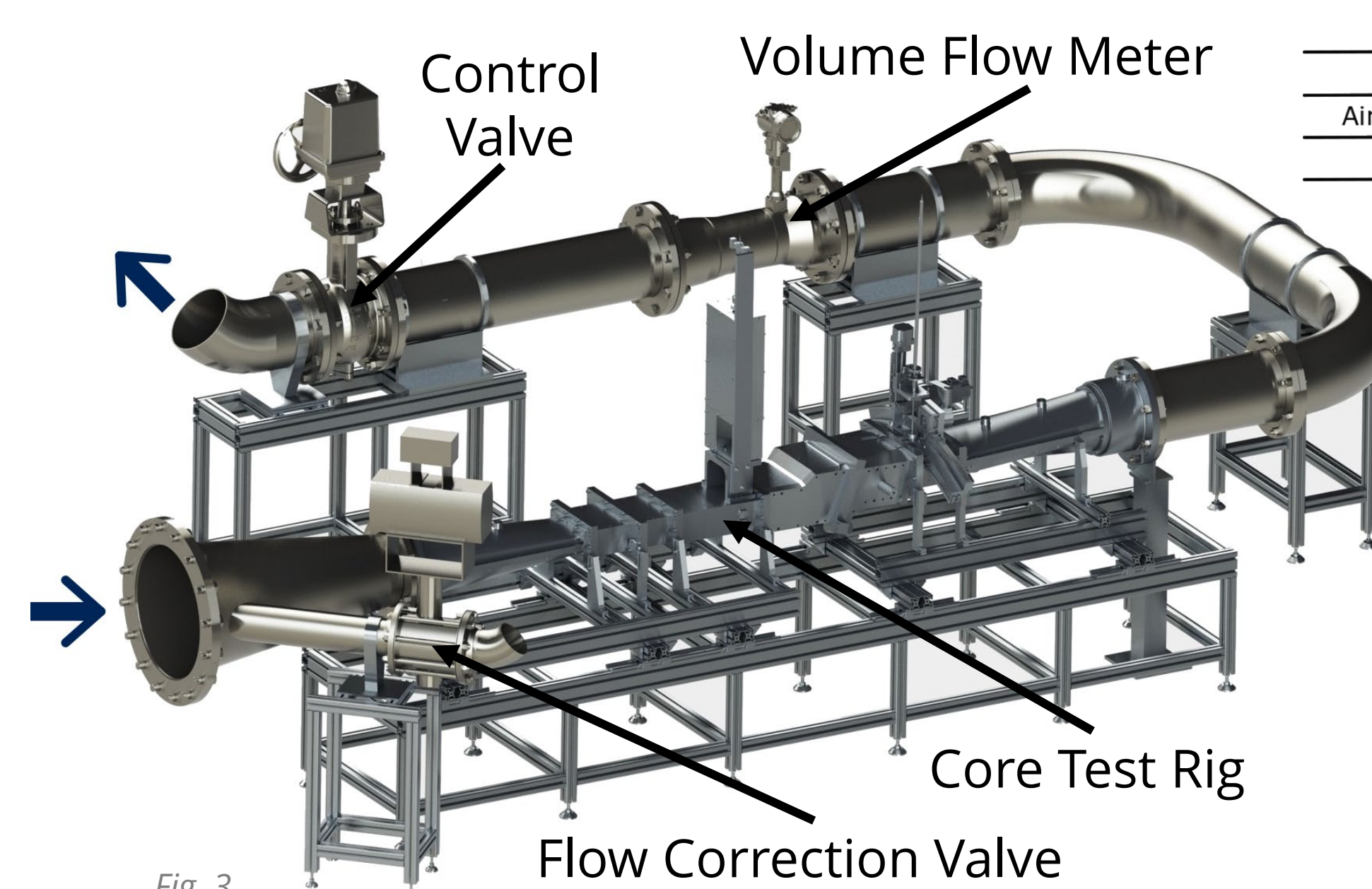


Fig. 3

- Oil Side

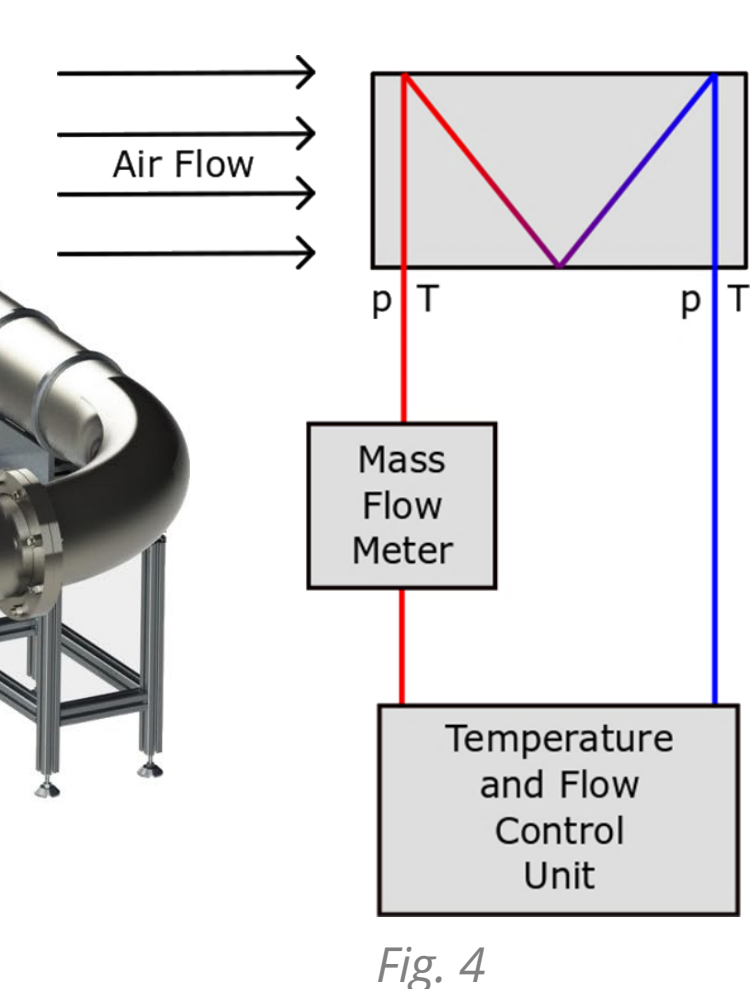


Fig. 4

$$Re = \frac{\rho v L}{\eta}$$

$$Ma = \frac{v}{a}$$

- Quantification values:

$$\Delta p_t = p_{t,In} - p_{t,Out}$$

$$Q = \dot{m}_{air} \cdot c_p \cdot (T_{Out} - T_{In})$$

I. Inlet Screen

- Control inlet conditions
- Pressure and velocity distribution

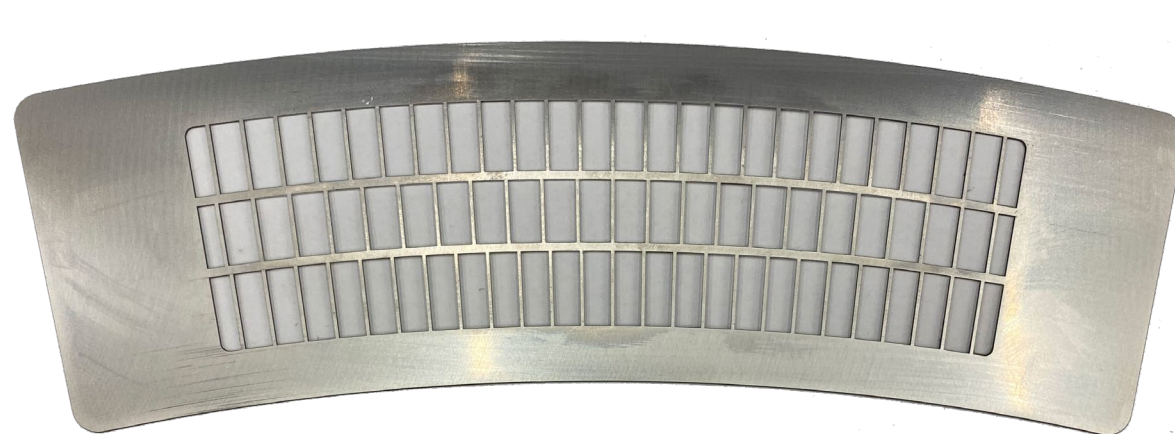


Fig. 5

II. Inlet Condition Measurement

- Boundary Layer Probes
 - Total Pressure Probe including Thermocouple (TC)
 - Radial traverse system for Five Hole Probe including TC
- ➔ 1D temperature and velocity profile



Fig. 6

III. Outlet Condition Measurement

- Boundary Layer Probes
 - Total Pressure and Temperature Rakes
 - Radial & circumferential traverse system for Five Hole Probe including TC
- ➔ 2D temperature and velocity profile

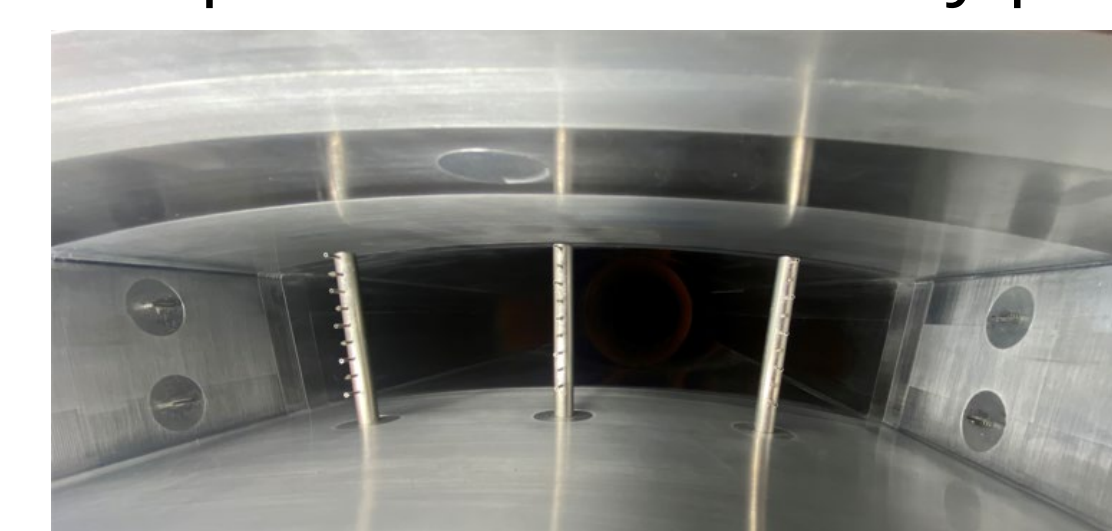


Fig. 7

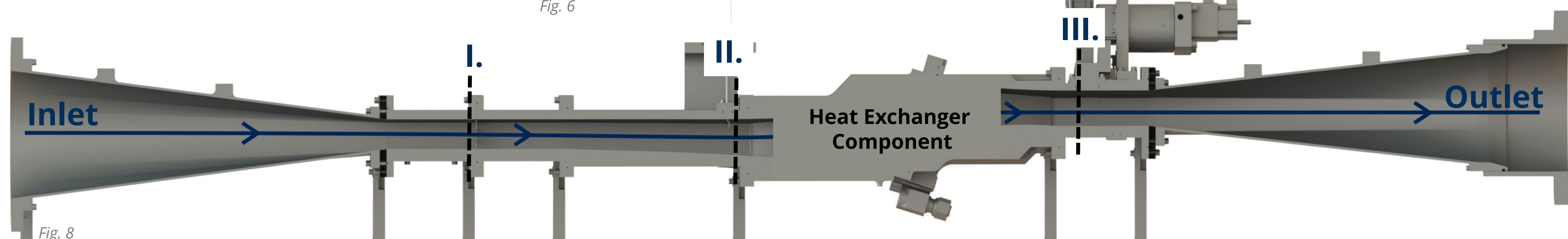


Fig. 8

Conclusion

Thermal management is an absolutely crucial aspect of next-generation engines, and the HX assumes a pivotal role as a fundamental component. This poster describes an exciting test rig that tests and validates additively manufactured HXs. A notable feature of this experimental setup is its capability to set the Re independently of the Ma by introducing controlled overpressure.

Figures:
 Fig. 1 Advancing open fan architectures [1]
 Fig. 2 Operating conditions of an engine during different flight phases
 Fig. 3 Test rig - air side
 Fig. 4 Test rig - oil side
 Fig. 5 Inlet Screen
 Fig. 6 Measuring arrangement of the HX inlet conditions
 Fig. 7 Measuring arrangement of the HX outlet conditions
 Fig. 8 Cross section of the core test rig
Source:
 [1] CFM, „RISE“, <https://www.cfmaeroengines.com/rise/>