UNIVERSITY OF NOTRE DAME

The 9th International Supercritical CO2 Energy Technologies Symposium
March 2 - 5, 2026, Pittsburgh, PA
Paper #084

ND POWER & PROPULSION

Lessons Learned from the Operation of 10MW sCO2 Compressor Test Facility at the University of Notre Dame

Jeongseek Kang, Alex Vorobiev, William Stewart, Jeffrey Clark, & Scott C. Morris

1

Acknowledgement

U.S. DEPARTMENT of ENERGY

ND POWER & PROPULSION

ECHOGEN power systems

CINCINNATI

2

BACKGROUND & RESEARCH QUESTIONS

❑ A PTES Cycle Example

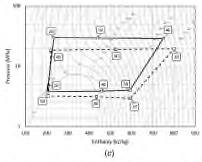
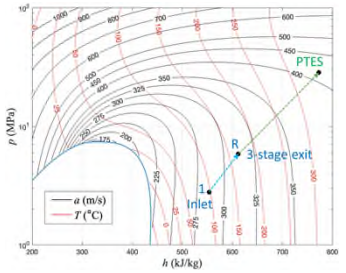


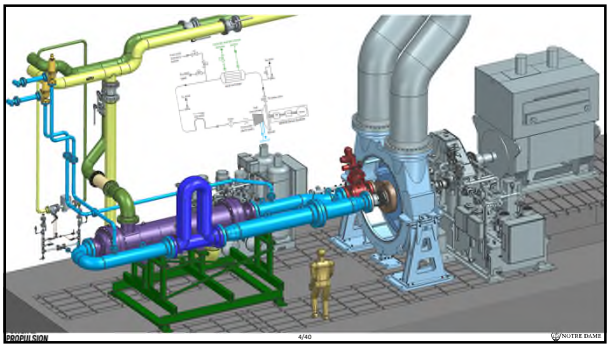
Fig. 1 Simplified process flow diagrams of PTES charging and generating cycles. HTR1 and HTR2 refer to two sections of the high temperature thermal reservoir, which is split to accommodate the variable c_p of CO_2 across the temperature range of the HTR: (a) charging, (b) generating, and (c) generating.

(Reference : Held et al., 2025, ASME J. Eng. Gas Turbines Power, 091014)

❑ 3-Stage Axial Compressor for a PTES Cycle



3

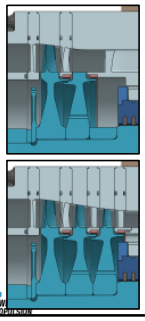


4

10MW CO_2 COMPRESSOR TEST FACILITY @ NOTRE DAME POWER & PROPULSION

5

PREVIOUS Research / RESEARCH QUESTIONS



10MW-class sCO2 Axial Compressor Test Facility

* Kang, J., Vorobiev, A. Cameron, J. D., Morris, S. C., Wackerly, R., Sedlacko, K. P., Miller, J. D., and Held, T. J., 2021, "10MW-class sCO2 Compressor Test Facility at the University of Notre Dame," The 4th European sCO2 Conference for Energy Systems, March 22-26, 2021-sCO2.eu-144.

High efficiency demonstration of a single CO2 axial compressor

* Kang, J., Vorobiev, A., Sutton, J. B, Stewart, W. S., Cameron, J. D., Morris, S. C., Turner, M. G., Sedlacko, K. P., Miller, J. D., and Held, T. J., 2024, "Experimental Demonstration of an Advanced CO2 Axial Compressor for CO2-based Power Cycles and Energy Storage Systems," The 8th International Supercritical CO2 Power Cycles Symposium, Paper # 44, San Antonio, TX.

Performance scaling and real gas effect of CO2 axial compressor

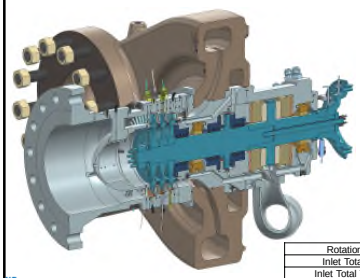
* Kang, J., Vorobiev, A., Cameron, J. D., Morris, S. C., Turner, M. G., Sedlacko, K. P., Miller, J. D., and Held, T. J., **2025**, "Experimental Study of the Real Gas Effects of CO2 on the Aerodynamic Performance Characteristics of A 1.5-Stage Axial Compressor," ***ASME J. of Eng. For Gas Turbines and Power***, Aug. Vol. 147, 081012.

Performance characteristics of 3-stage CO2 axial compressor (Aerodynamic and aeromechanic performance)

* Jeongseek Kang, Alex Vorobiev, James Sutton, William Stewart, Harold Miller, Joshua D. Cameron, Scott C. Morris, Mark G. Turner, Kyle P. Sedlacko, and Timothy J. Held, **2026**, "Performance Test of A 9MW-Class 3-Stage Axial CO2 Compressor," ***ASME J. of Eng. For Gas Turbines and Power***, June, Vol. 148, 061014.

6

TEST COMPRESSOR : 3-STAGE AXIAL COMPRESSOR



Rotational Speed	rpm	19,800
Inlet Total Pressure	kPa	2,770
Inlet Total Temperature	℃	98.0
Mass flowrate	kg/s	125

7

Test Facility Schematic

[CO_2 Inventory System]
- Two 5 Ton CO_2 tanks

[Cooling towers – 12MW]

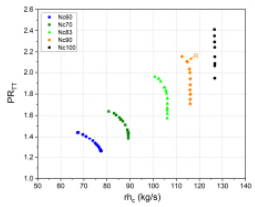
[Heat Exchanger]

[Coriolis flowmeter:12"]

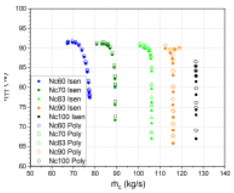
8

Performance Map of Compressor

Total Pressure Ratio



Efficiency



9

Section

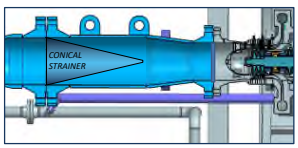
Lessons Learned

ND POWER & PROPULSION

10

1. Compressor Inlet Filter (1/3)

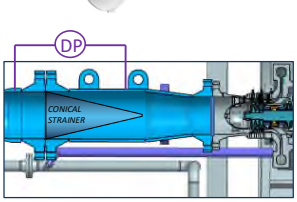
- Pipe size: 16”
- Opening size: 238 micron
- Pressure drop @ DP: 2.4 psi
- Burst pressure @ DP: 12 psi



11

1. Compressor Inlet Filter (2/3)

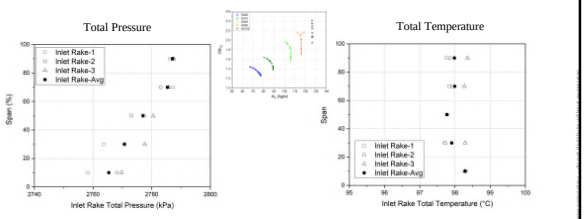
- Pipe size: 16”
- Opening size: 238 micron
- Pressure drop @ DP: 2.4 psi
- Burst pressure @ DP: 12 psi



Saved testing!

12

1. Compressor Inlet Filter (3/3)

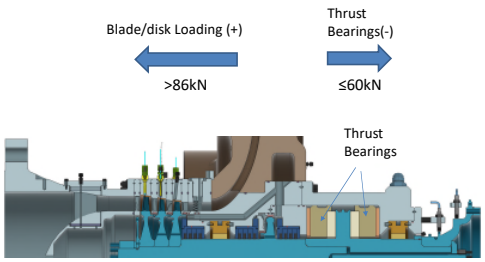


- Circumferential variation : ±3.8kPa (±0.14%)
- Radial variation : ±10.8kPa (±0.39%)
- Circumferential variation : ±0.2K (±0.06%)
- Radial variation : ±0.26K (±0.07%)

(a) TOTAL PRESSURES AND (b) TOTAL TEMPERATURES MEASURED AT THE INLET RAKES AT A 90% SPEED CONDITION MARKED AS "R" IN FIGURE 1

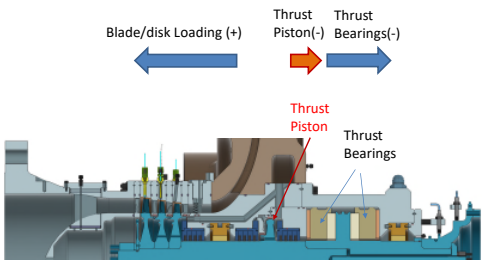
13

2. Thrust Balancing (1/3)



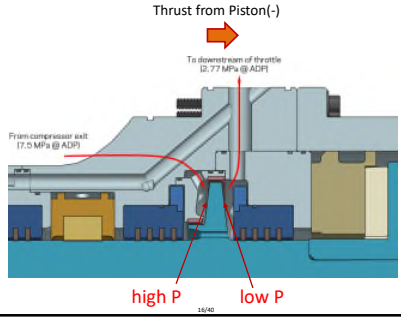
14

2. Thrust Balancing (2/3)



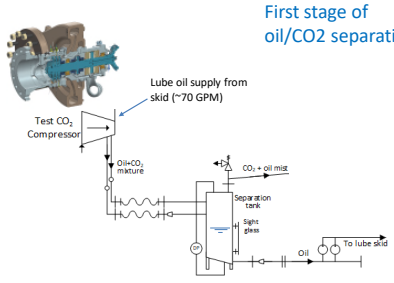
15

2. Thrust Balancing (3/3)



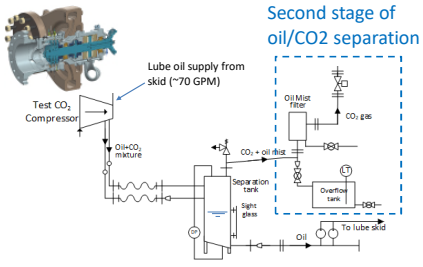
16

3. Lubrication Oil System (1/3)

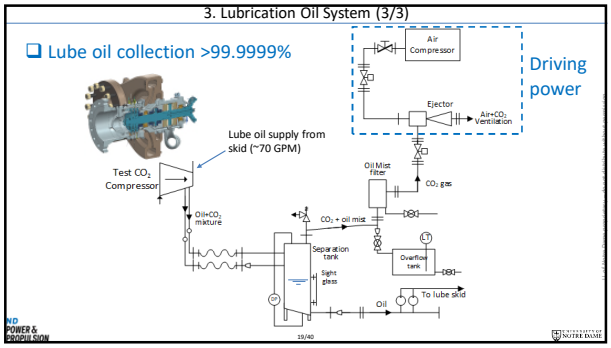


17

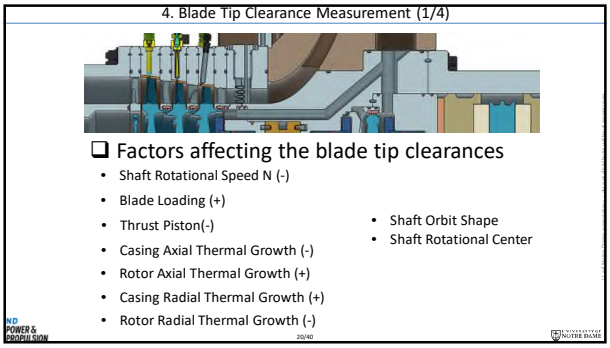
3. Lubrication Oil System (2/3)



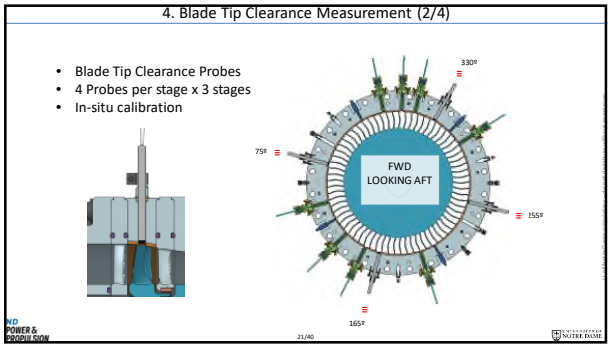
18



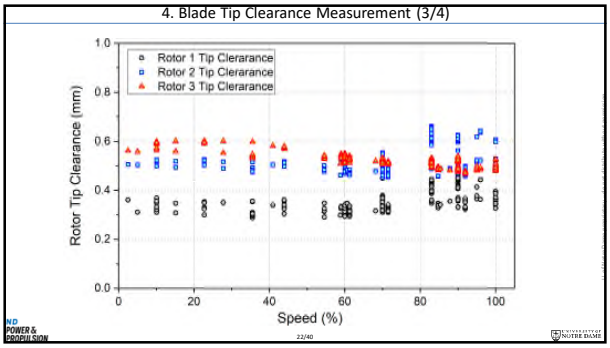
19



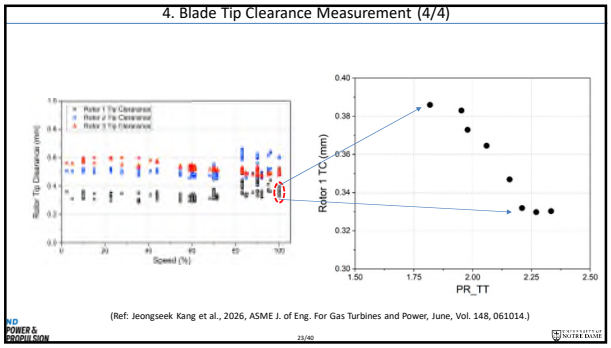
20



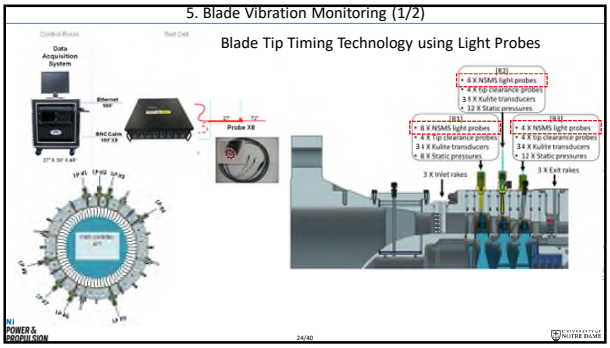
21



22



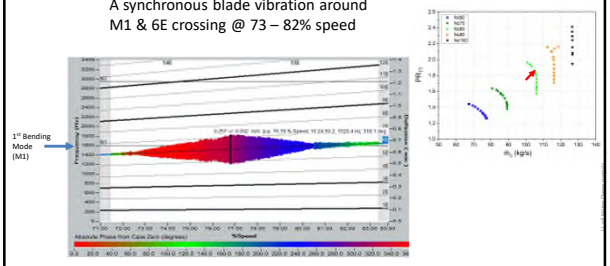
23



24

5. Blade Vibration Monitoring (2/2)

A synchronous blade vibration around
M1 & 6E crossing @ 73 – 82% speed



25/40

25

Summary

10MW Compressor Test Facility @ Notre Dame

	Lessons	Learned
1	Compressor inlet filter	Saved a compressor!
2	Thrust Balancing	Passive thrust balancing worked!
3	Lubrication Oil System	Two-stage oil/CO_2 separation collected 99.9999% oil
4	Tip Clearance Measurement	Clearance monitoring matters in complicated rig testing
5	Blade Vibration Monitoring	Captured blade vibration very well even in high density CO_2 gas

26/40

26

Section

Backup

ND POWER & PROPULSION

27/40

27

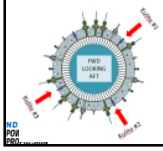
Rotating Stall @ 60% Speed (Nc60)

Stage 1

- Number of stall cell : Single stall cell
- Popagation speed : 60.4% of shaft speed

Stage 2

Stage 3



28/40

28