University R&D Panel

5th International Supercritical CO2 Power Cycles Symposium

San Antonio, TX March 30, 2016

Jay Kapat

Center for Advanced Turbomachinery & Energy Research (CATER)

University of Central Florida, Orlando FL

Background: We are located in Orlando

Siemens

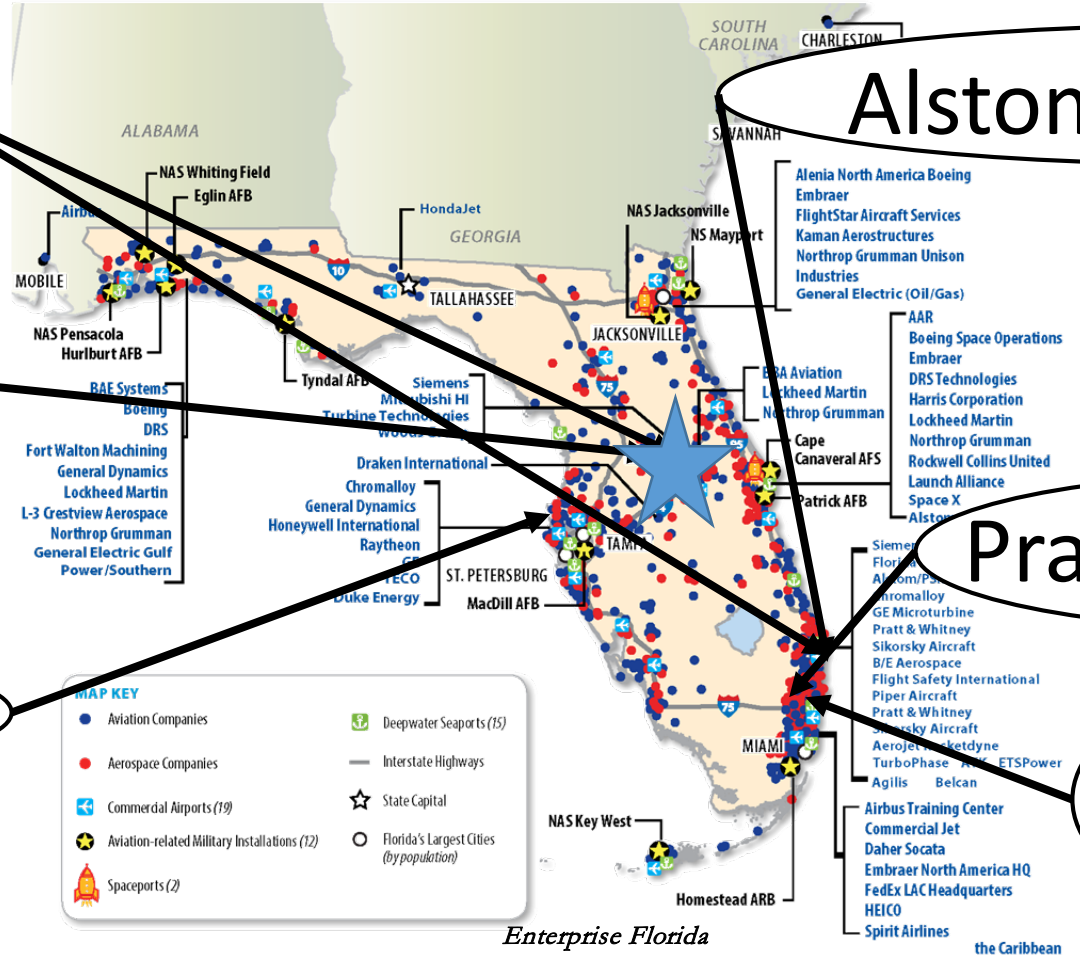
Mitsubishi

GE Aviation, avionics

Alstom -> Ansaldo

Pratt & Whitney

Aerojet Rocketdyne



Enterprise Florida

Location led to Creation of CATER

Aerodynamics & Heat Transfer

Combustion & Emissions

Alternative Fuels

Cycle Innovation

Dynamic Integrity

CATER

8 Core Faculty (2 Full, 3 Associate, 3 Assistant)
4 researchers, 58 Graduate & 49 UG Students

Plant & Grid Transients

Extreme Temp Materials

Mechanical Integrity

Design & Manufacturing

Polymer/Ceramic Composites

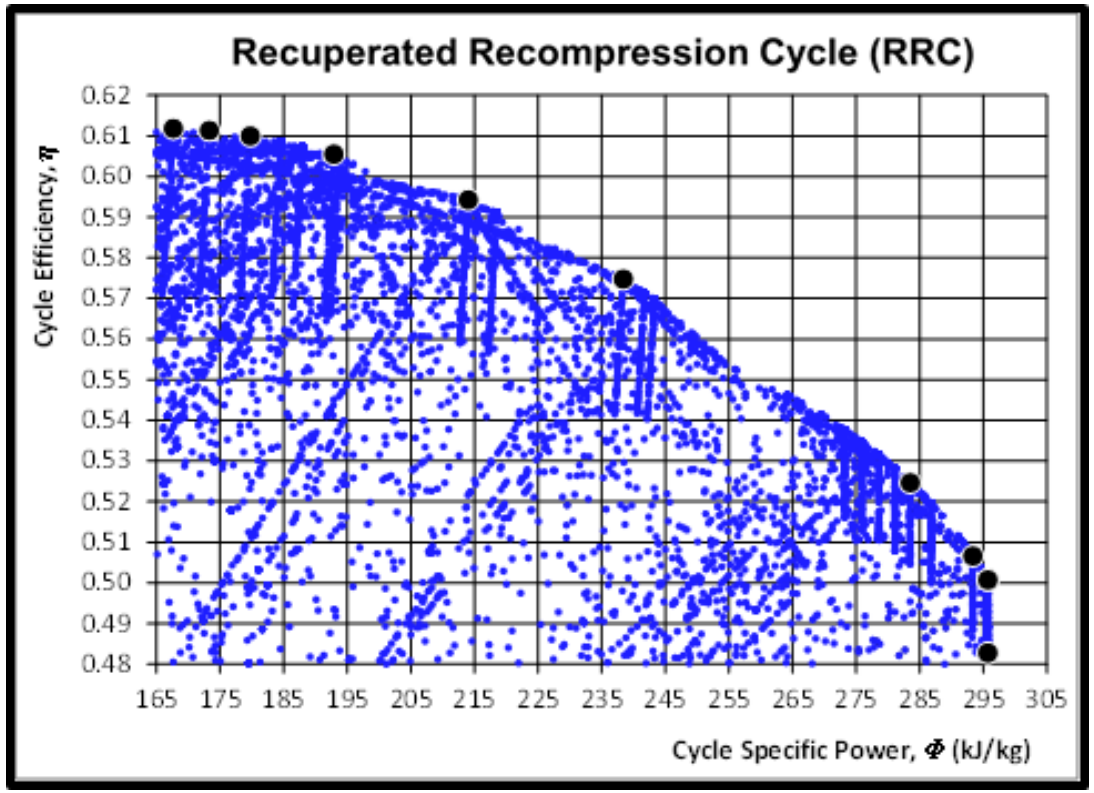
Current Industrial Partners

- Siemens Energy Center
- GE Global Research Center
- Alstom Power -> Ansaldo
- Aerojet Rocketdyne

2013:
ASME Turbo Expo, San Antonio (GT2013-94799)
ASME Power, Boston (POWER2013-98231)

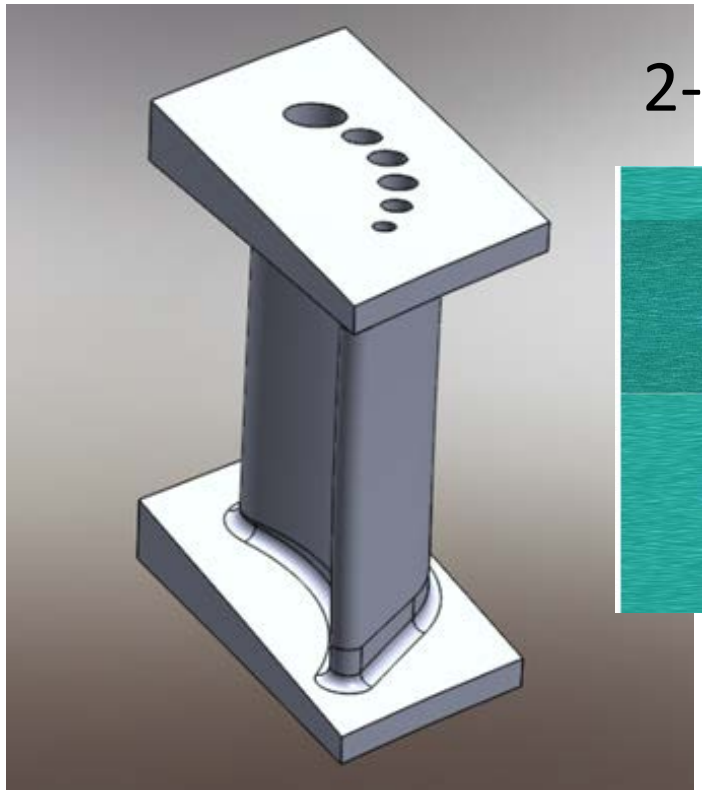
- Our interest started with sCO2 turbomachineries.
- Accurate cycle analysis and optimization is needed to establish useful boundary conditions.
- Using Genetic Algorithm and in-house cycle code for optimization, RC, RRC, RRIRC and various other variations were compared.
  - Efficiency vs complexity?
  - Decided to focus on RC and RRC only.
- A mean-line design for a 100 MW turbine started
  - existing loss models may not be very accurate: small relative tip clearance, larger work transfer compared to the size of the airfoils

2014: ASME Turbo Expo, Dusseldorf (GT2014-27152, 27214)

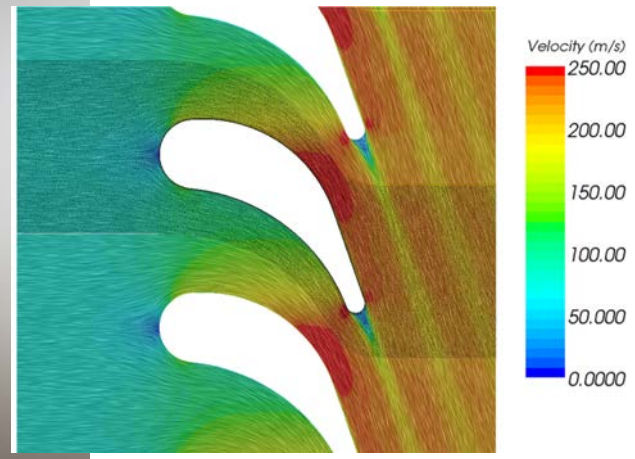


Cycle specific power can be important for thermo-economic optimization.

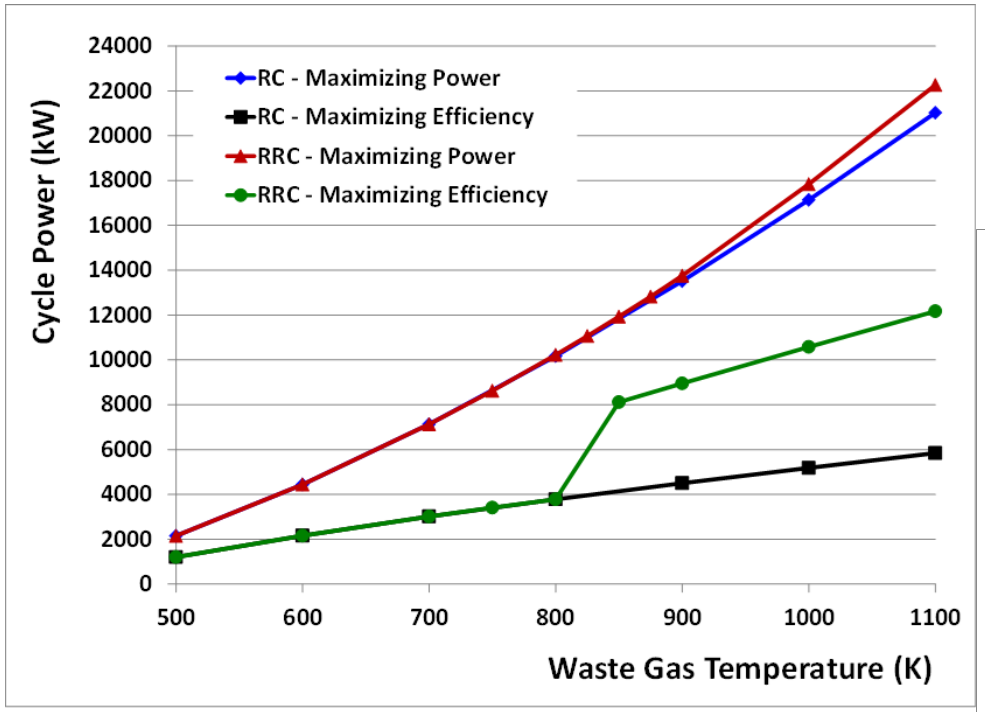
In case one is interested in higher TIT requiring cooling, large (TIT – $T_{c,exit}$)/TIT can simplify cooling

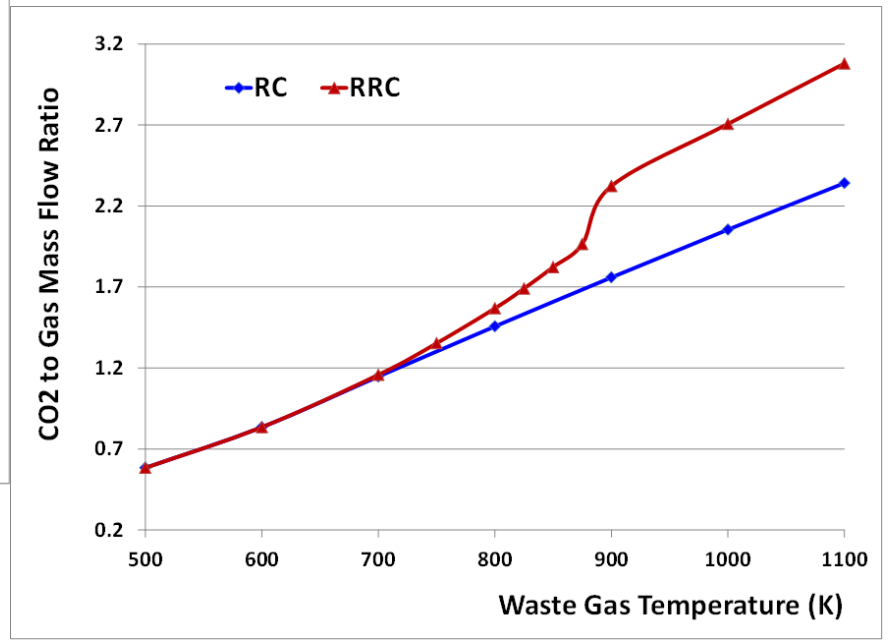


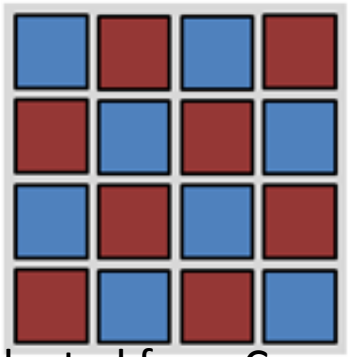
2-d Aero-simulation



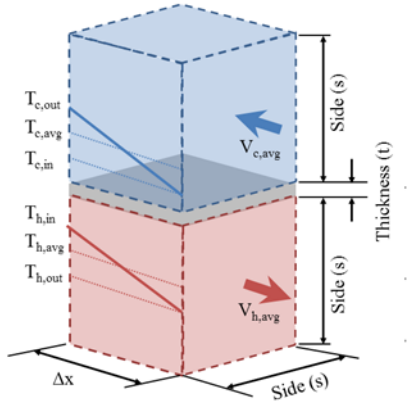
2014: SCO2 Symposium, Pittsburgh
2015: ASME Turbo Expo, Montreal (GT2015-43761)



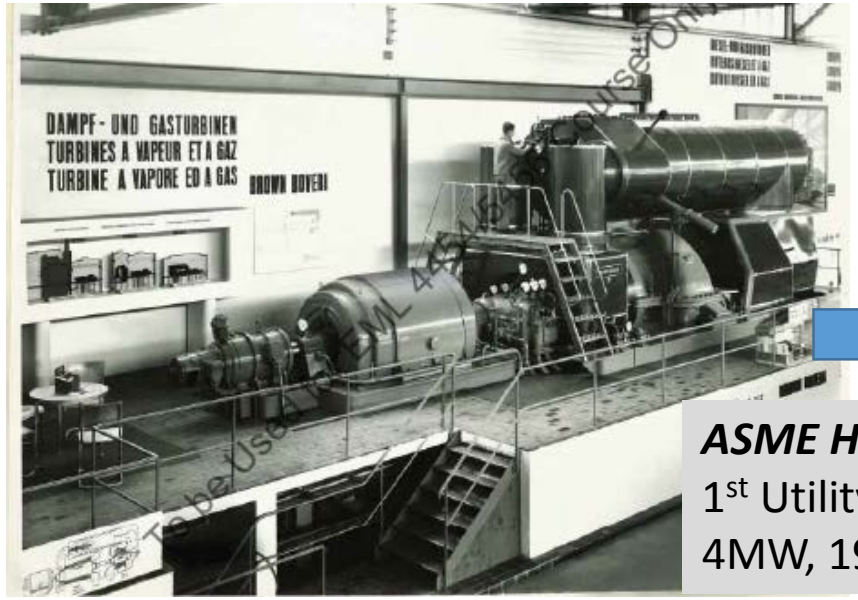




Adapted from Carman et al., Turbo Expo 2002, Amsterdam

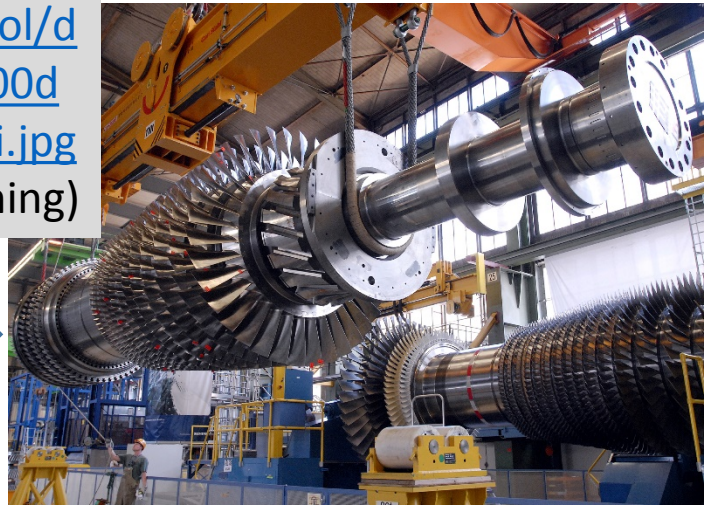


Moving Forward: Learning from History



ASME Historic Landmark
1st Utility Gas Turbine,
4MW, 1939 (Neuchatel)

http://www.siemens.com/press/pool/de/pressebilder/2010/photonews/300dpi/PN201002/PN201002-02_300dpi.jpg
400 MW in simple cycle, 2011 (Irsching)



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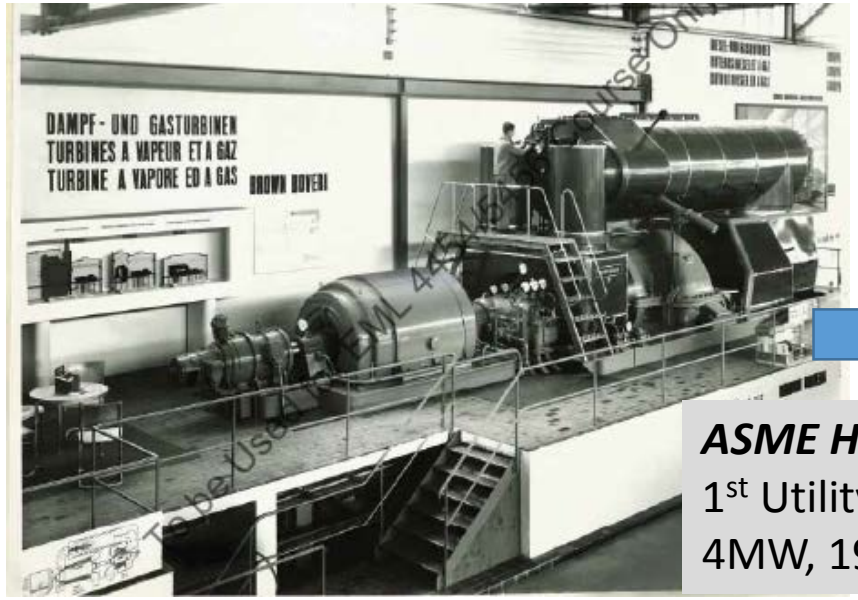

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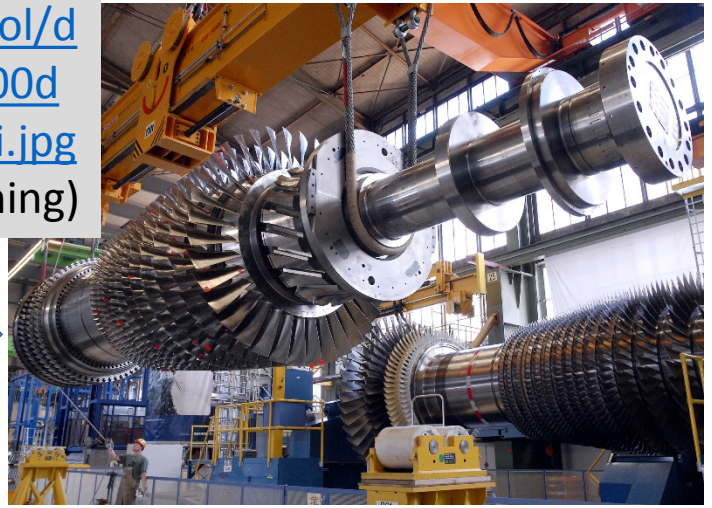


Echogen EPS-100

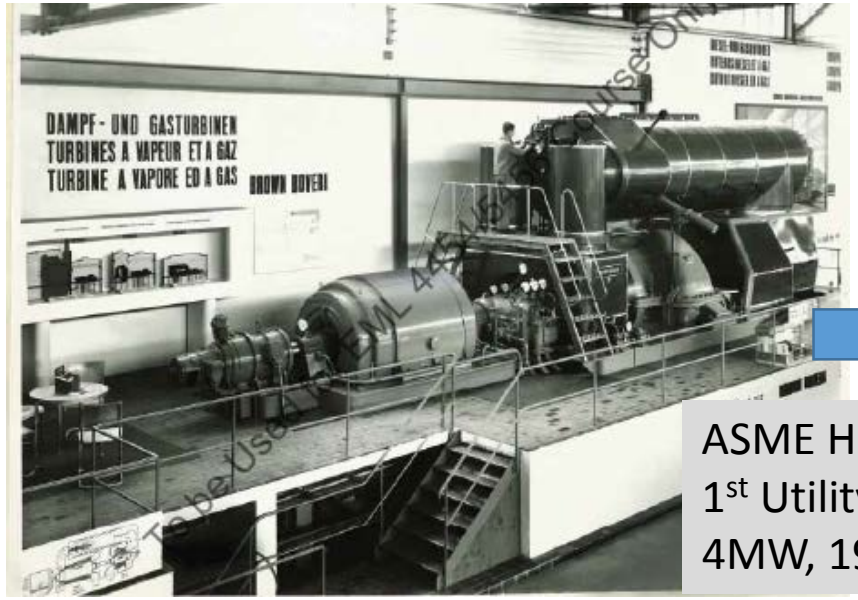
In 75 years

?

Potential Topics

- Better Understanding of turbomachinery aerodynamics
  - Tip loss, secondary flows, surge
- Oxy-Combustion system for direct firing
  - Kinetics (***UCF UTSR project***), dynamics and acoustics, combustor design
- High temperature recuperators at lower cost?
  - Highest temperature is not limited by turbine, but by recuperator
- Cooling and SAS: large (TIT – $T_{c,exit}$)/TIT can lead to simpler/innovative cooling
  - but what does it do to the cycle?
- Fluid dynamics of leakage flows: Seal optimization
- Materials and manufacturing
  - blisk?? – impact on self/forced excitation
  - material compatibility; coatings; accurate corrosion models
  - life prediction under cyclic loads

Moving Forward: Learning from History



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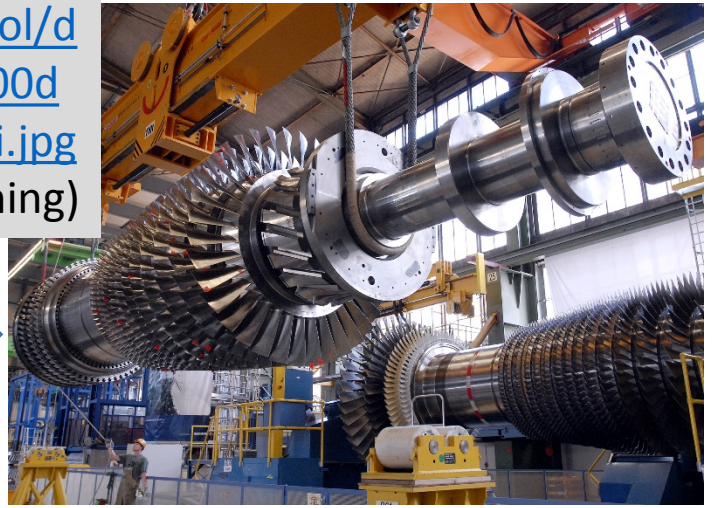

System testing and system demo

Optimized system through component optimization

Help needed from/for US Academics

- Real fluid effect and near-critical effect need to be brought to the classrooms.

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  We need to bring in potential fundamental publication and funding opportunities

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- NSF/NETL such as NSF/EPRI for ACC???
- DOE - BES

Thank you!