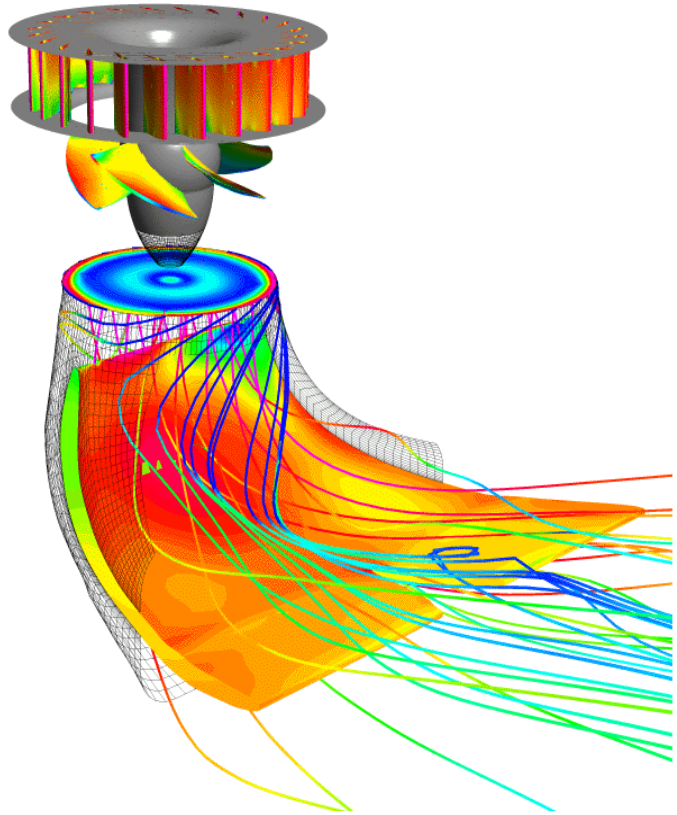
Ansys Fluent Rotating Machinery Modeling

Lecture 01: Introduction

Release 2020 R2

Motivation

- Flows within rotating systems occur frequently in science and engineering applications…
- Examples
  - compressors and turbines
  - fans and pumps
  - rotating cavities, seals, and bearings
  - mixing equipment
  - fluid coupling devices and torque converters
  - air motors
  - marine and aircraft propellers
  - and many more…
- Computational Fluid Dynamics (CFD) now plays a central role in the design and analysis of these systems



Examples of Rotating Machinery

Multistage compressor

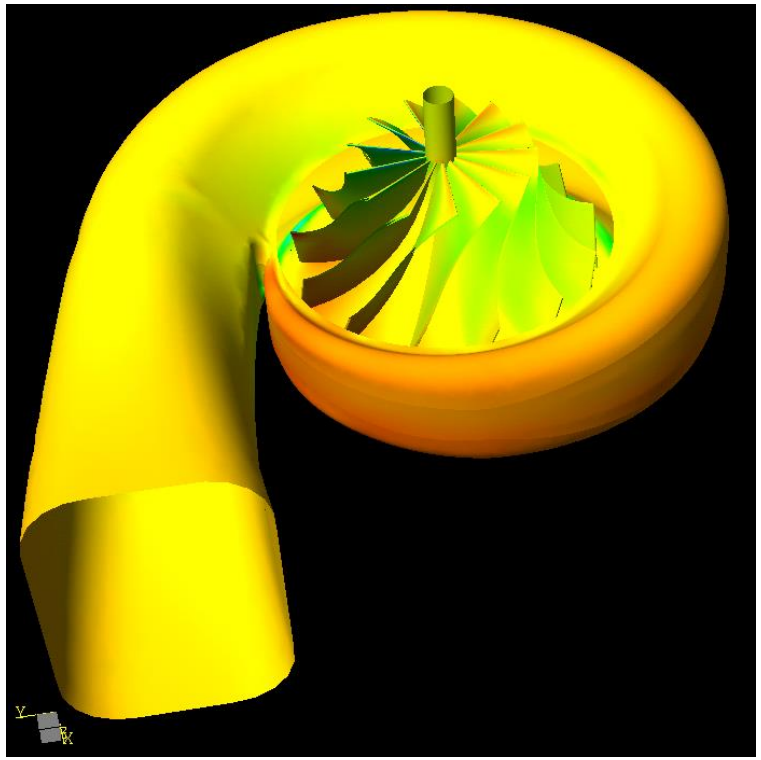
Aero engine

Turbocharger

Wind turbines

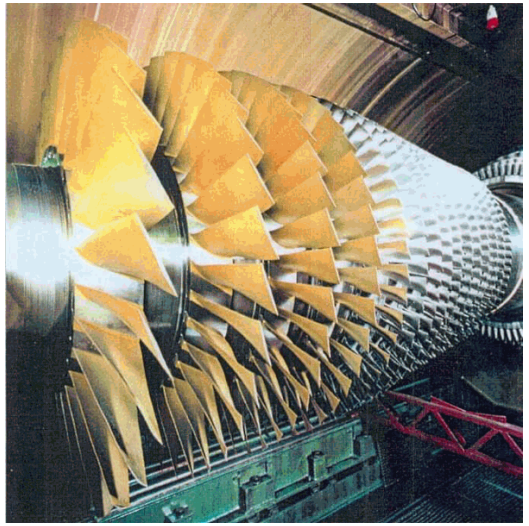
Goals of the Training

- Examine the major classes of rotating machinery problems
  - Single rotating component analysis
  - Multiple component analysis (combination of rotating and stationary components)
  - Transient methods
- Present the workflow for modeling rotating machinery problems with Ansys Fluent
  - Problem definition
  - Model setup
  - Solution process
  - Post-processing (including special turbomachinery mode in CFD-Post)

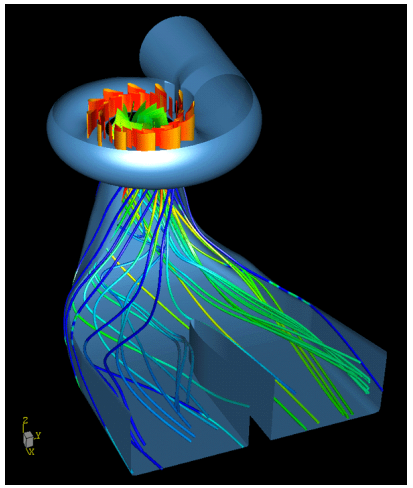


Types of Rotating Machines

- Turbomachinery
  - Machines which add work to or extract work from a fluid
  - Examples
    - *compressors, fans, pumps* - add work to achieve a pressure or velocity rise in the fluid
    - *turbines, windmills* - extract work from fluid to produce power or drive other machines
- Mixing equipment
  - Machines which are designed to mix fluid (and possibly solid) materials for use in a chemical processing applications
  - Example: industrial mixing tanks
- Other Devices
  - Disk cavities and labyrinth seals in gas turbine engines
  - Electric motors and generators



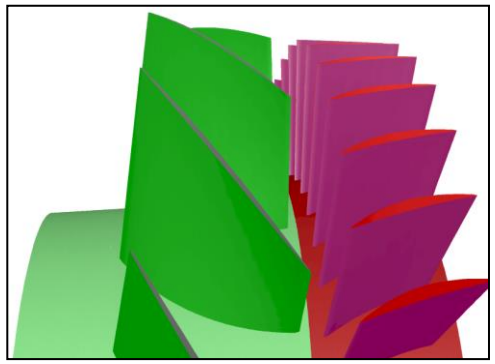
Compressor section of a large land-based gas turbine
Courtesy Siemens AG

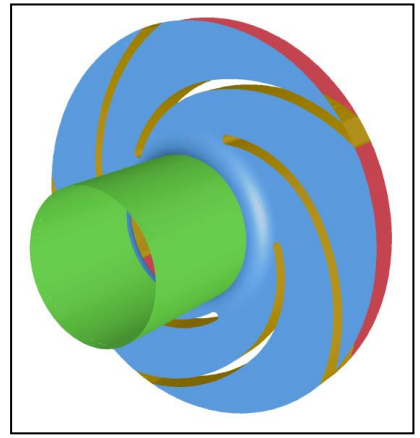


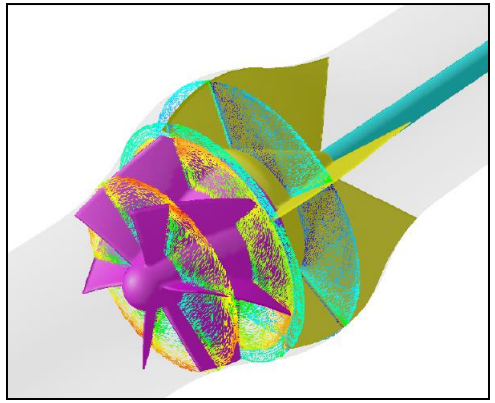
Francis turbine
Courtesy Turboinstitut
Republic of Slovenia

Classification of Turbomachinery

- Axial machines
  - Flow through the machine is aligned with the axis of rotation
    - Examples: propellers, axial fans/compressors/turbines
- Centrifugal/Radial machines
  - Flow through the machine is (in general) perpendicular to the axis of rotation
    - Examples: liquid pumps, centrifugal fans/compressors, radial turbines
- Mixed flow machines
  - Flow through the machine is somewhere between axial and centrifugal
    - Example: mixed flow compressor, oil well pump, water propulsion system



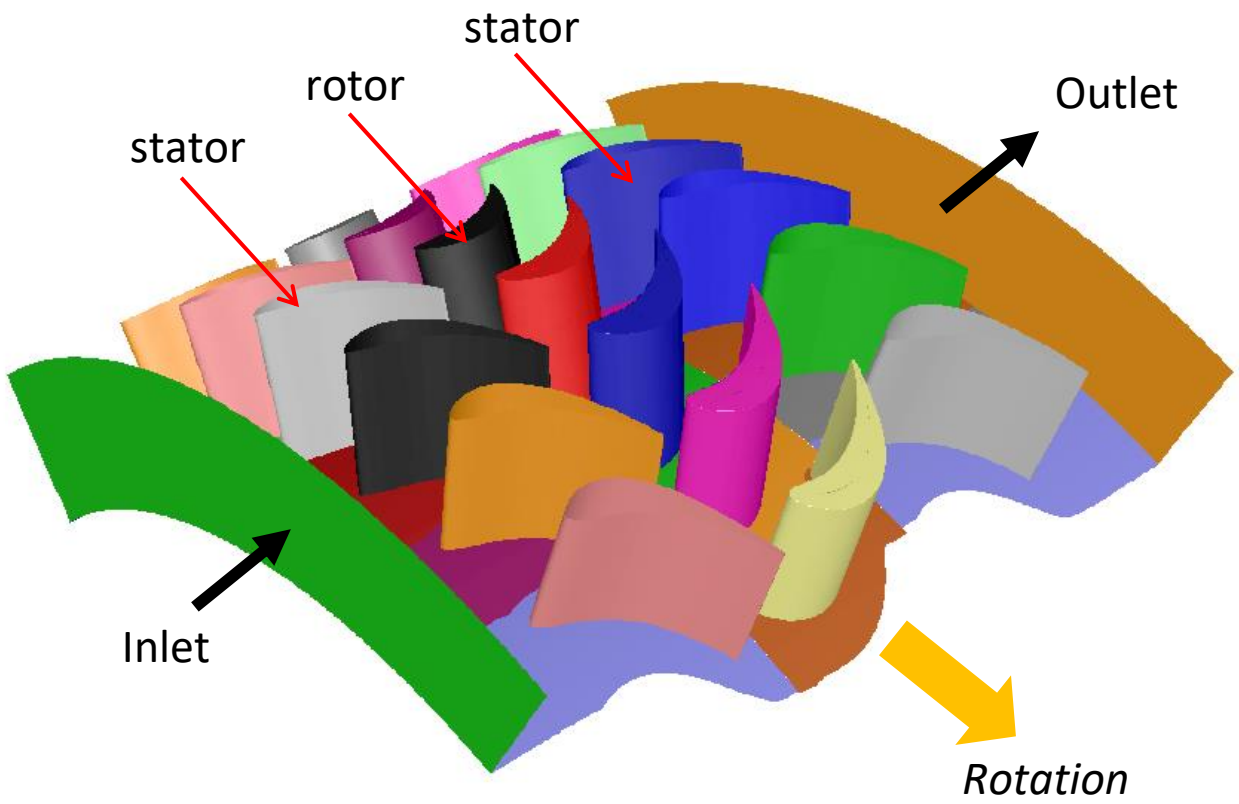




Rotating Machinery Systems

- Rotating machines usually consist of multiple components to facilitate the flow process in the system
- Example: Multistage compressor
  - Rotor blade passage followed by a Stator blade passage
  - The rotor increases the swirl in the flow (transfers energy to the fluid)
  - Stator directs the flow into the rotor at an optimal flow angle. The downstream stator turns the flow back into the meridional direction, decelerates the flow and, therefore, increases the static pressure of the flow
  - Full compressor will consist of several stages to achieve a desired pressure rise →multistage compressor
- Example: Liquid pump components
  - Inlet duct – directs flow to the eye of the impeller
  - Impeller – increases the pressure of the fluid
  - Volute – collects and diffuses the flow

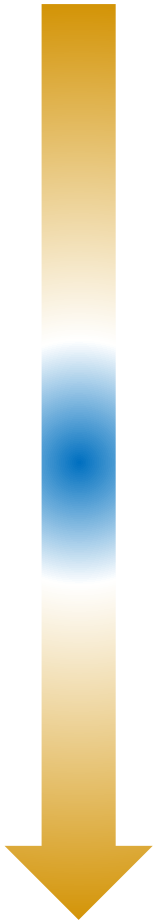
Multistage Turbomachine Example



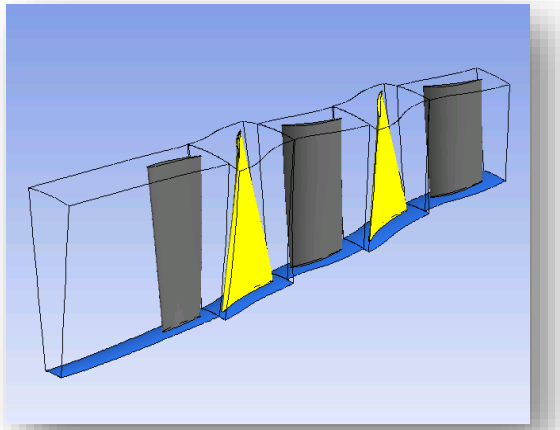
1.5 stage axial turbine

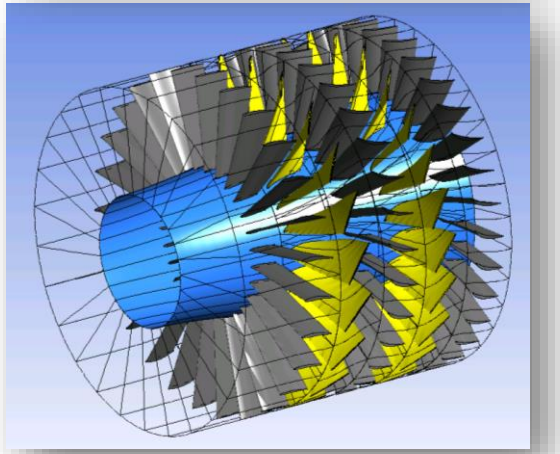
Various Modelling Approaches

- Single Rotating Component Analysis (Steady-State)
  - Entire domain in a single moving reference frame
  - Steady-state solution
- Multiple Component Analysis (Steady-State)
  - Multiple components are required (e.g. additional blade rows, volutes, baffles, struts, etc.),
    - Frozen Rotor Model, Mixing Plane Model
- Multiple Component Analysis (Unsteady)
  - Transient full-annulus
  - Transient pitch change



Increasing complexity





Summary

- Various rotating machine types
  - Turbomachinery, mixing, other…
  - Axial, centrifugal, mixed

- Various Modelling Approaches
  - Single Rotating Component Analysis (Steady-State)
  - Multiple Component Analysis (Steady-State)
  - Multiple Component Analysis (Unsteady)

End of presentation