This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 662116.

sCO2 HeRo
The supercritical CO_2 heat removal system

sCO2-HeRo Workshop
Řež, 01. September 2017

Development of the Turbomachine

University of Duisburg - Essen
Chair of Turbomachinery
A. Hacks

The requirements to the turbomachine

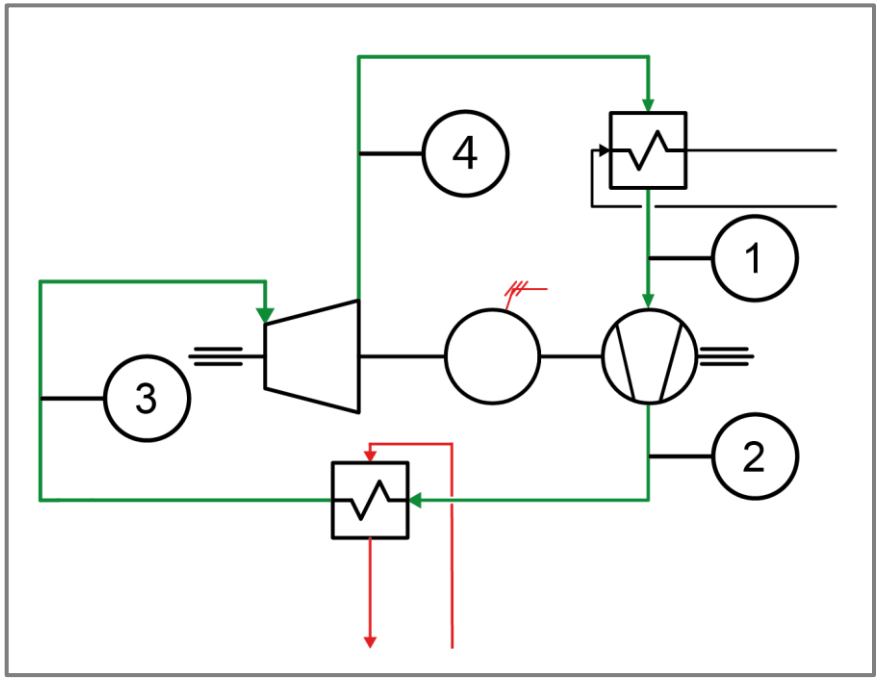
1. Propel the loop to transport the residual heat to the heat sink
   - Cycle efficiency > 0 %
2. Self-starting, self-sustaining and self-propelling
   - Avoid auxiliary units such as additional pumps
   - Robust to changing operation conditions

Design Parameter

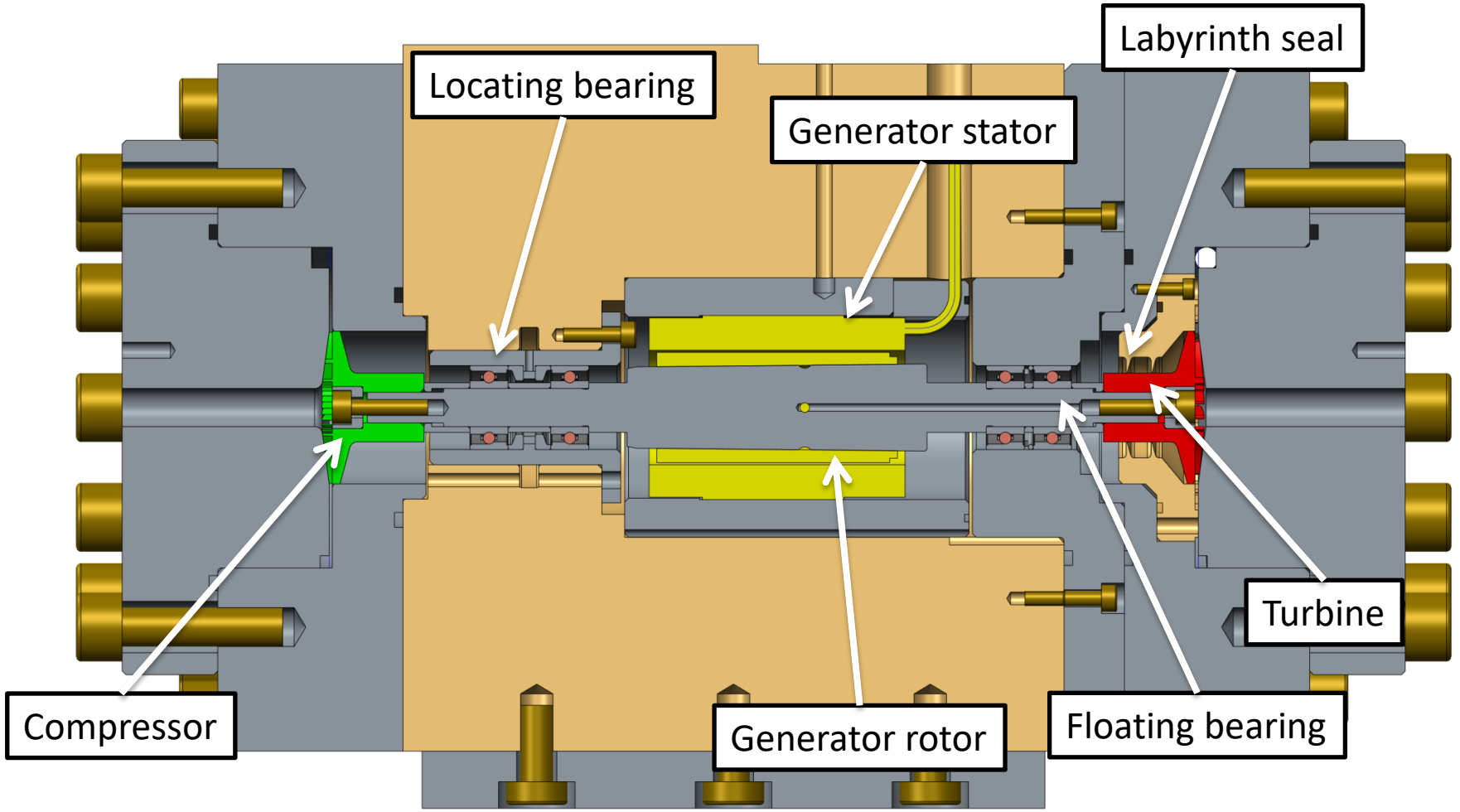
T_1	33 °C	T_{crit}	30,98 °C
p_1	78.3 bar	p_{crit}	73,75 bar
π	1.5		
T_3	200 °C		
$\dot{m}$	0.65 kg/s		

Lower mass flow as in all currently realised demonstration loops
Factor: 1:5 (1:2)

Simplified cycle scheme

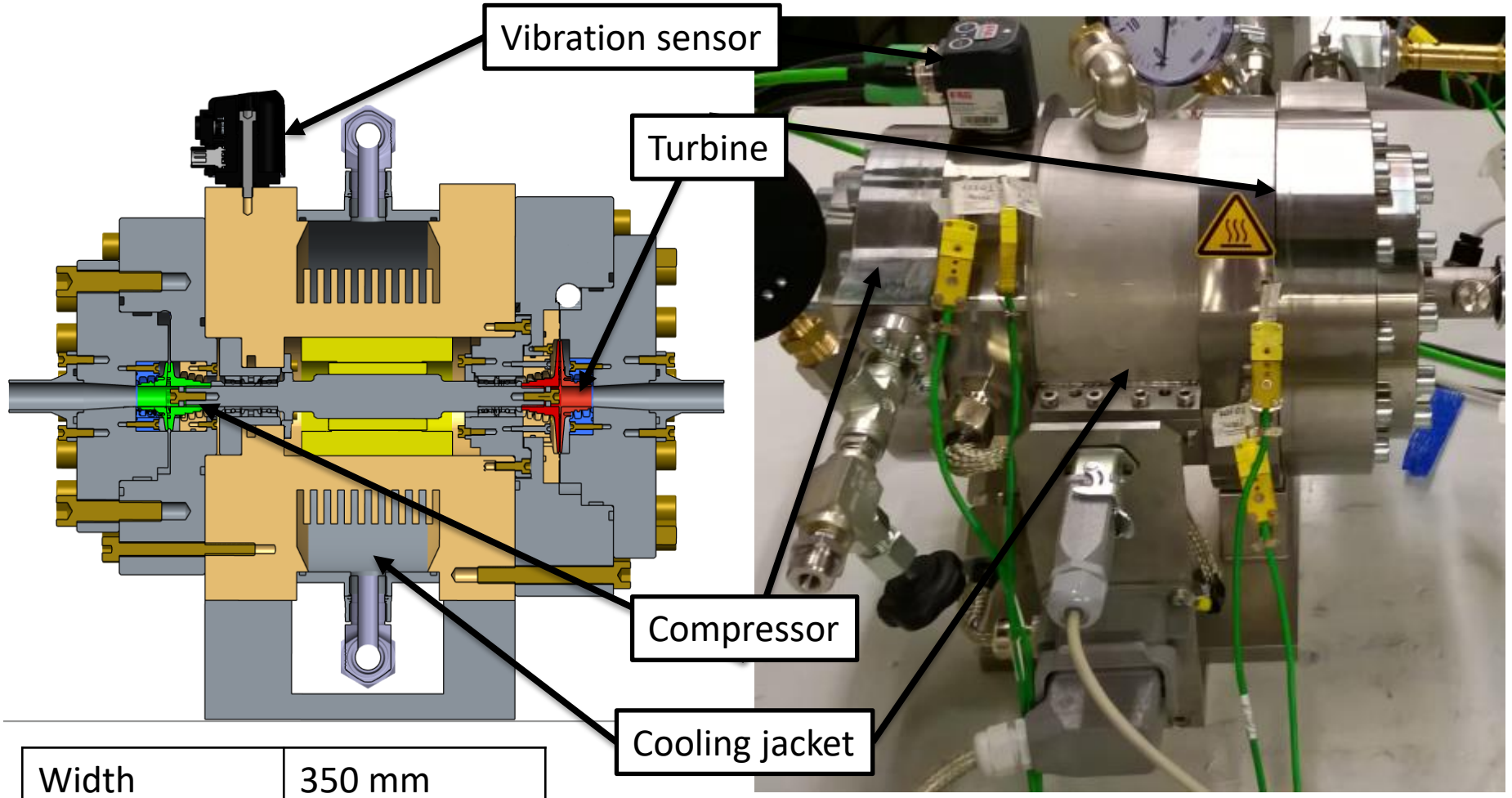


The first design …



- Integrated design (TAC)
- Unshrouded impellers
- Ball bearings
- 200,000 rpm
- Simple blades 2D blades with constant thickness

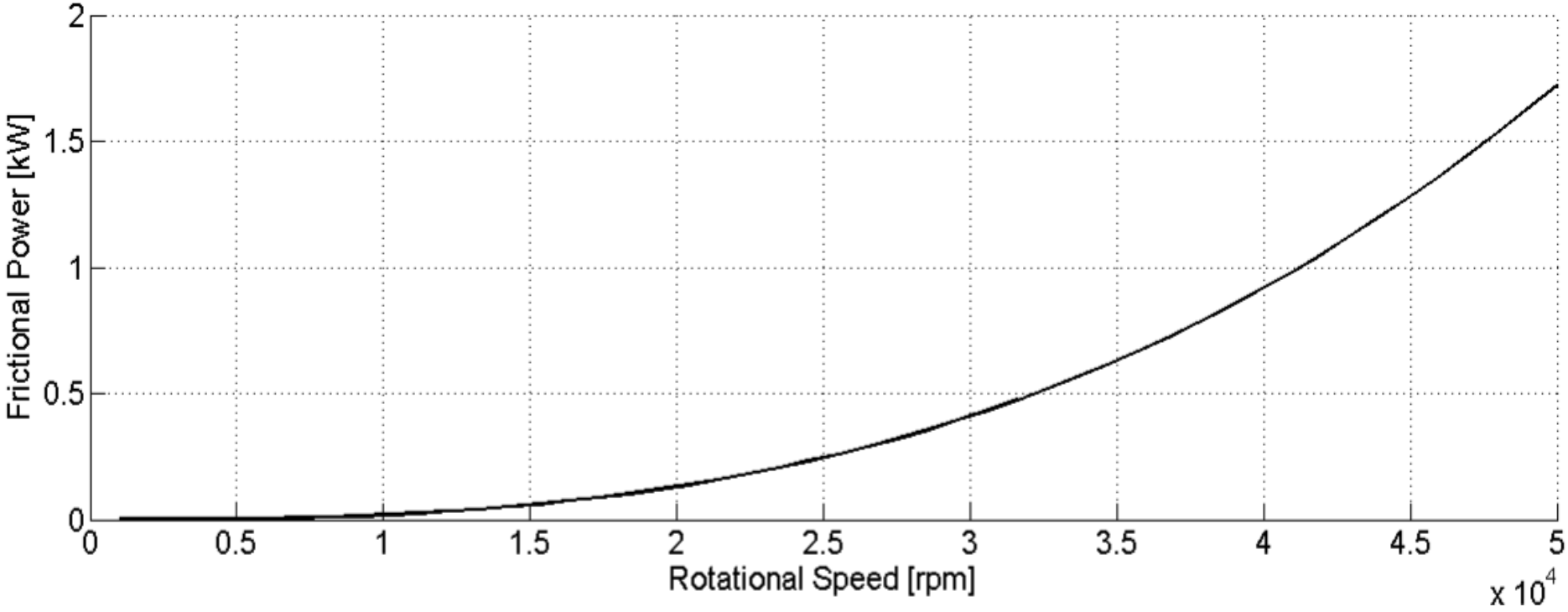
CAD-Model and machine as build



Width	350 mm
Diameter	250 mm

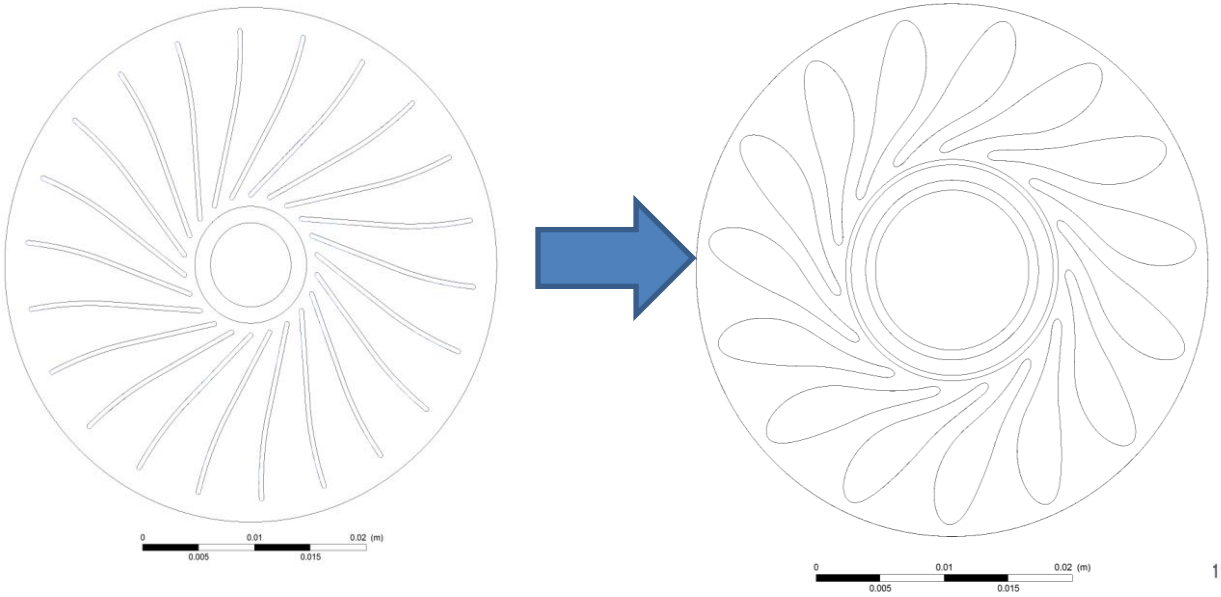
- Shrouded impellers
- 50,000 rpm
- Advanced 2D-blading
- Additional Labyrinth seals

Aerodynamical friction

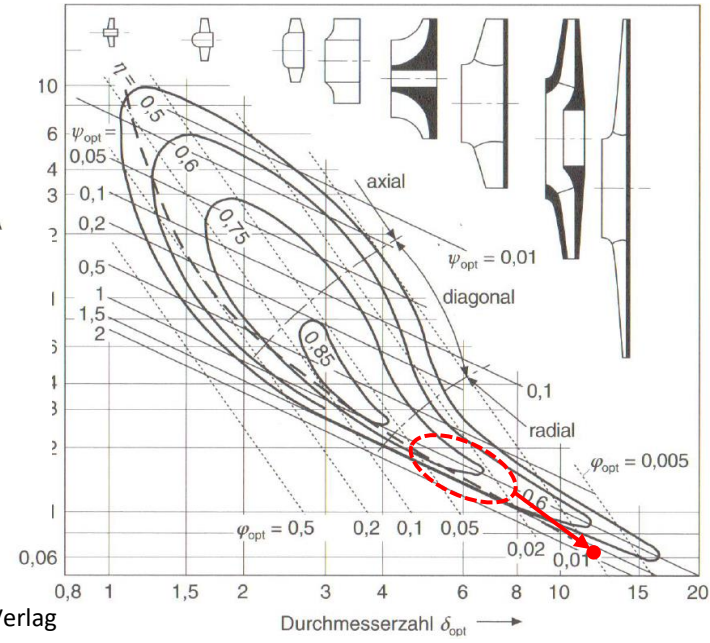


- Reduced surplus power at design speed
- Friction limits rotational speed because the increasing friction power consumes the surplus power of the turbine

Blading design of the compressor

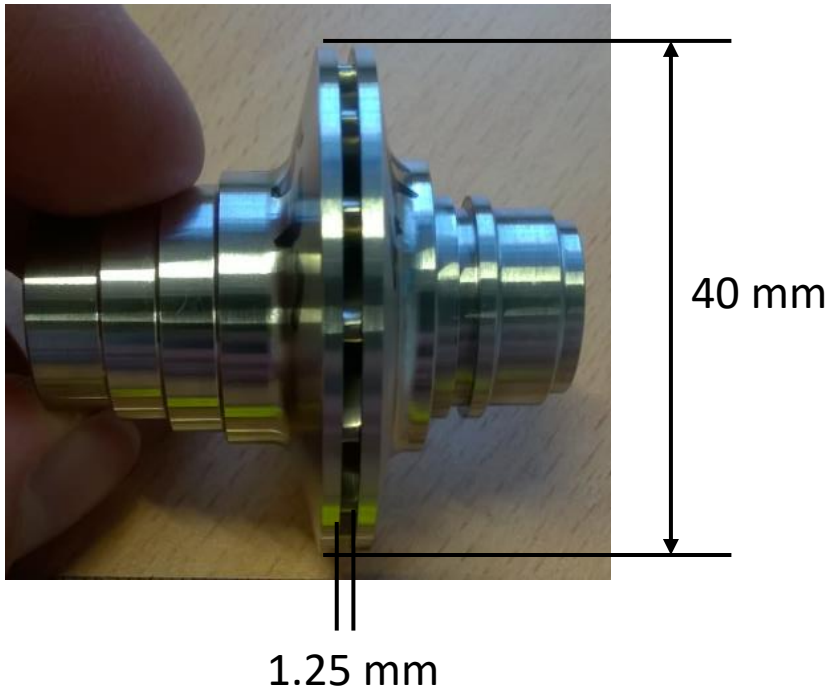


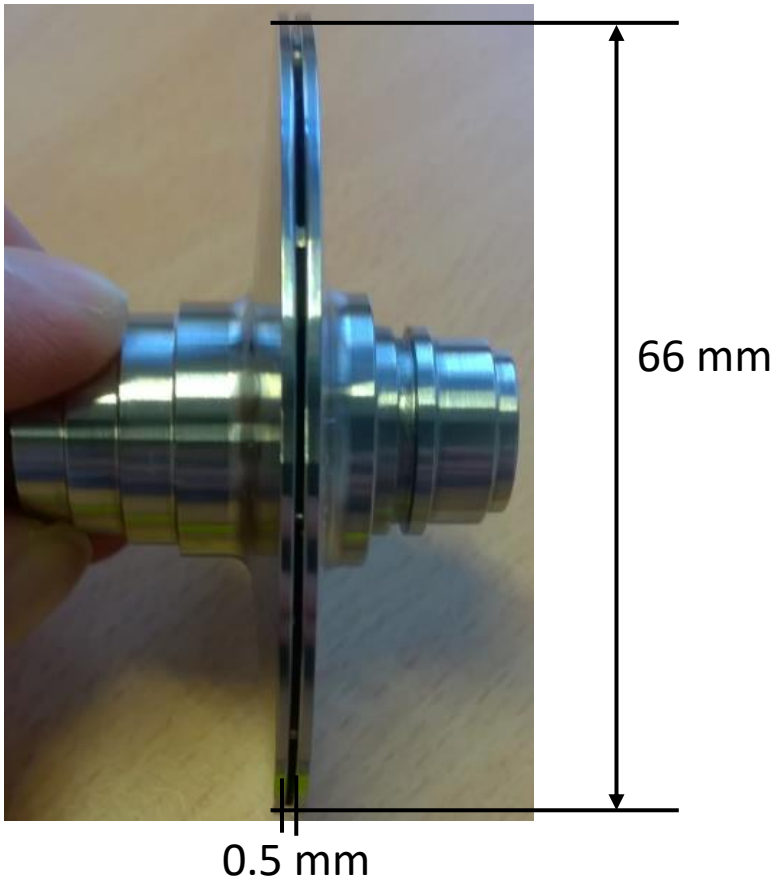
- With parallel plate diffusor
- Blades account for a low through flow coefficient
- Isentropic efficiency of about 70 %



Bohl/Elmendorf, "Strömungsmaschinen 1",11th edition, Vogel Verlag

Impellers





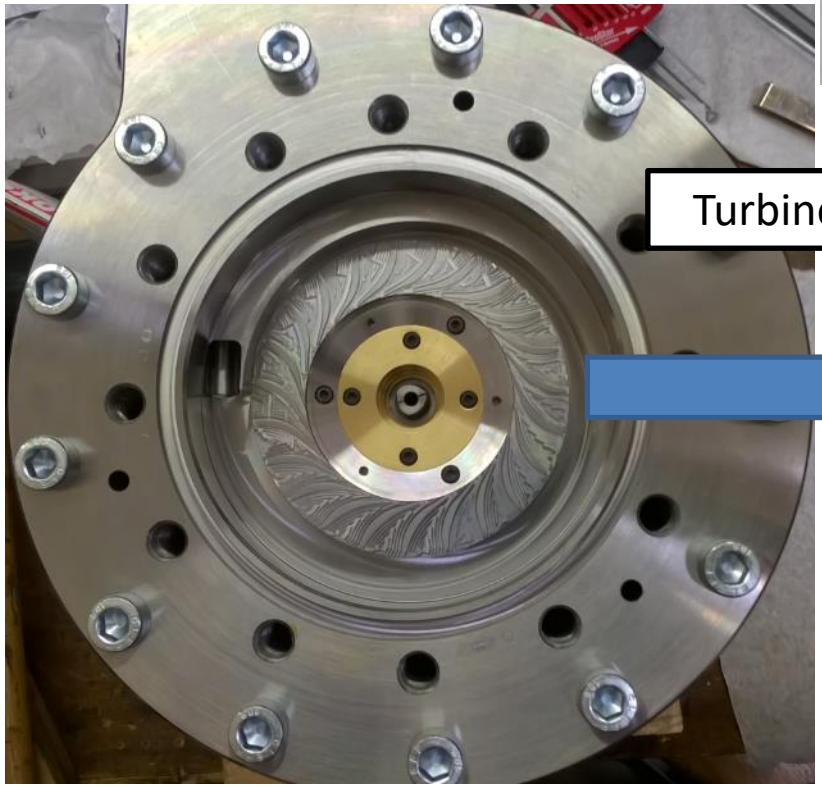
Applied joining techniques

- **Diffusion welding**
- **High temperature vacuum brazing**
- **Other possibilities:**
  - Laser beam welding
  - Erroding

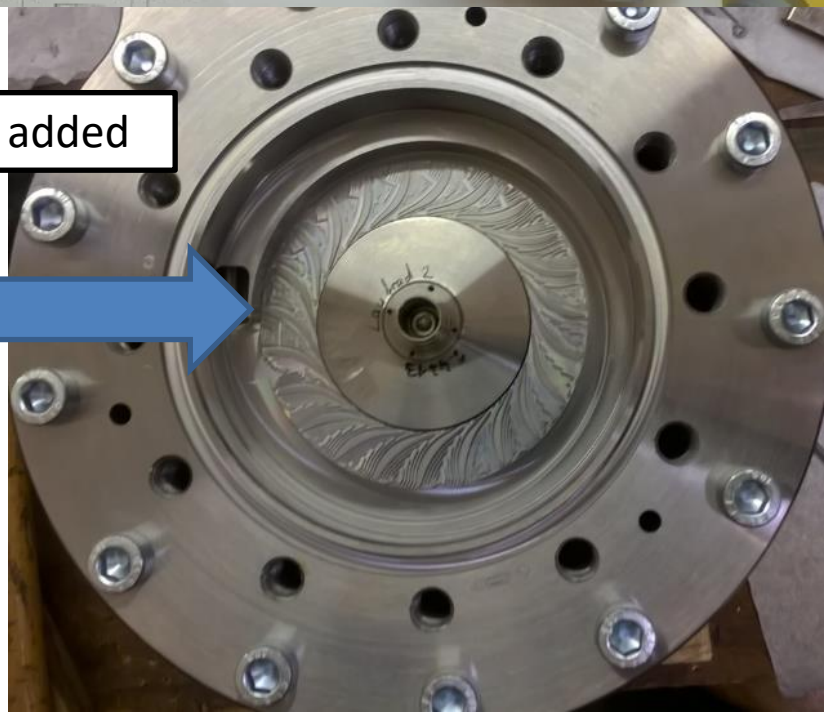
Assembly

- **Parts fit well together**
- **No rubbing of rotor and stator could be observed**

Rotor



Turbine impeller added



Tests for operational safety

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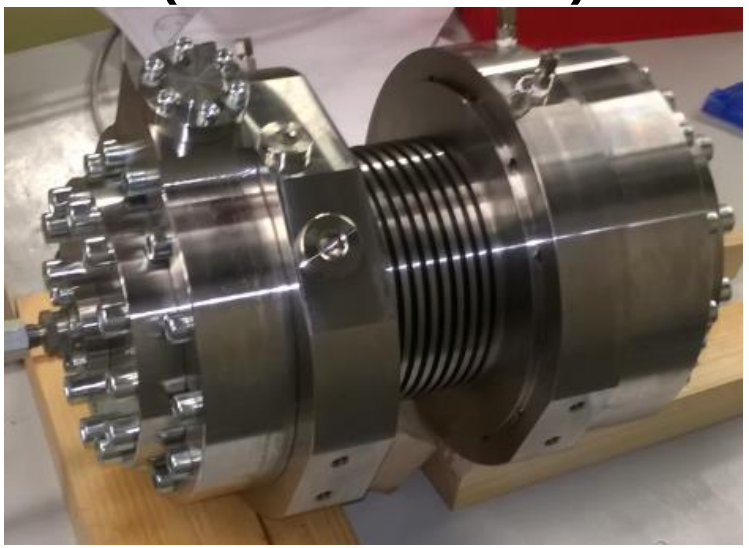
Spin test at 60000 rpm

Carried out by IFA

Pressure test at 180 bar (test fluid: water)



Test of the electrical equipment according to standard

Includes high voltage test of the motor according to VDE 0530

Overview on the cold-run air tests

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Main goal: Test mechanical integrity

- Is there any rubbing between rotor and stator?
- Are the vibrations in an acceptable range? (Eigenfrequencies)
- How does the temperature of the bearings and generator behave?
- Do all signals come out fine and are all settings correct?

Additional tests:

- **First start-up test:**
  - Run-in of the bearings
  - Test the functionality of the frequency converter and vibration sensor
- **Leakage test:**
  - Compare calculated results with measurements
- **Compressor and turbine test:**
  - Compare measurements with CFD results

Thank you for your attention

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