Centrum Výzkumu Řež

Experimental loop SCO_2 SUSEN

presented by
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SCO_2 Power Cycles 4th International Symposium
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Content of presentation

- **SUSEN**
  - Introduction of the project
  - Technological experimental loops
- **Key issues of real CO2 cycle**
- **Description of the CO2 loop**
  - Goals and objectives
  - Design of the experimetal loop
  - Experimetal capabilities
  - Announced and planed projects
- **Possibilities of cooperation**

SUSEN – introduction

- **SUSEN = SUS**tainable **EN**ergy

Subject of the project:
Building of a research infrastructure to extend energy research possibilities with emphasis laid on nuclear technologies

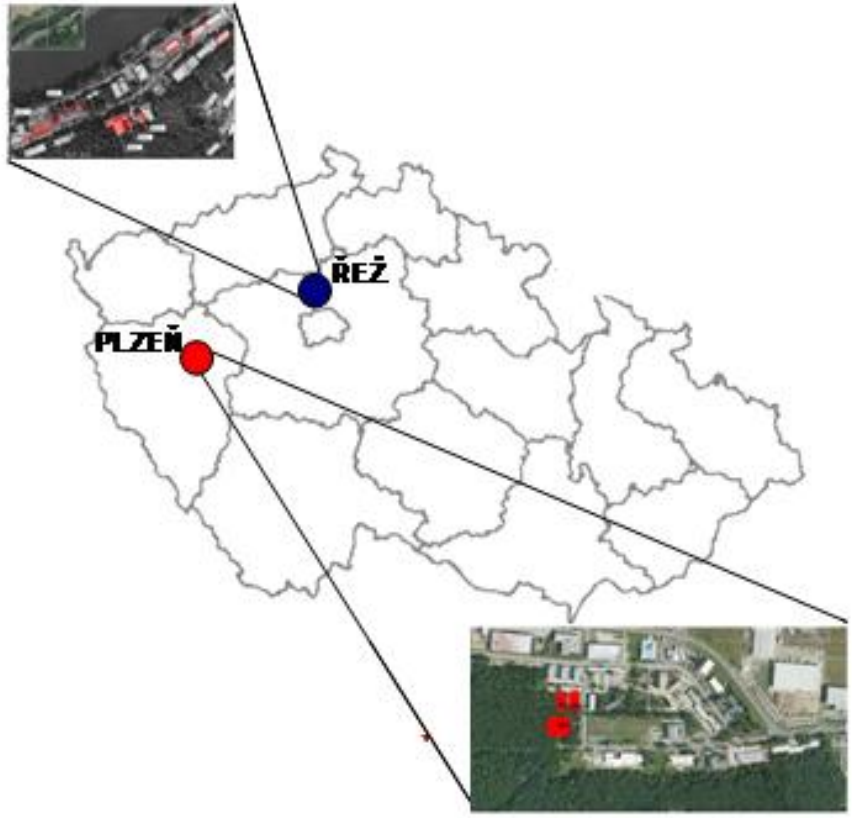
SUBSIDY BENEFICIARY**:**
Research Centre Rez
A member of the UJV Group

PARTNER:
University of West Bohemia in Plzeň

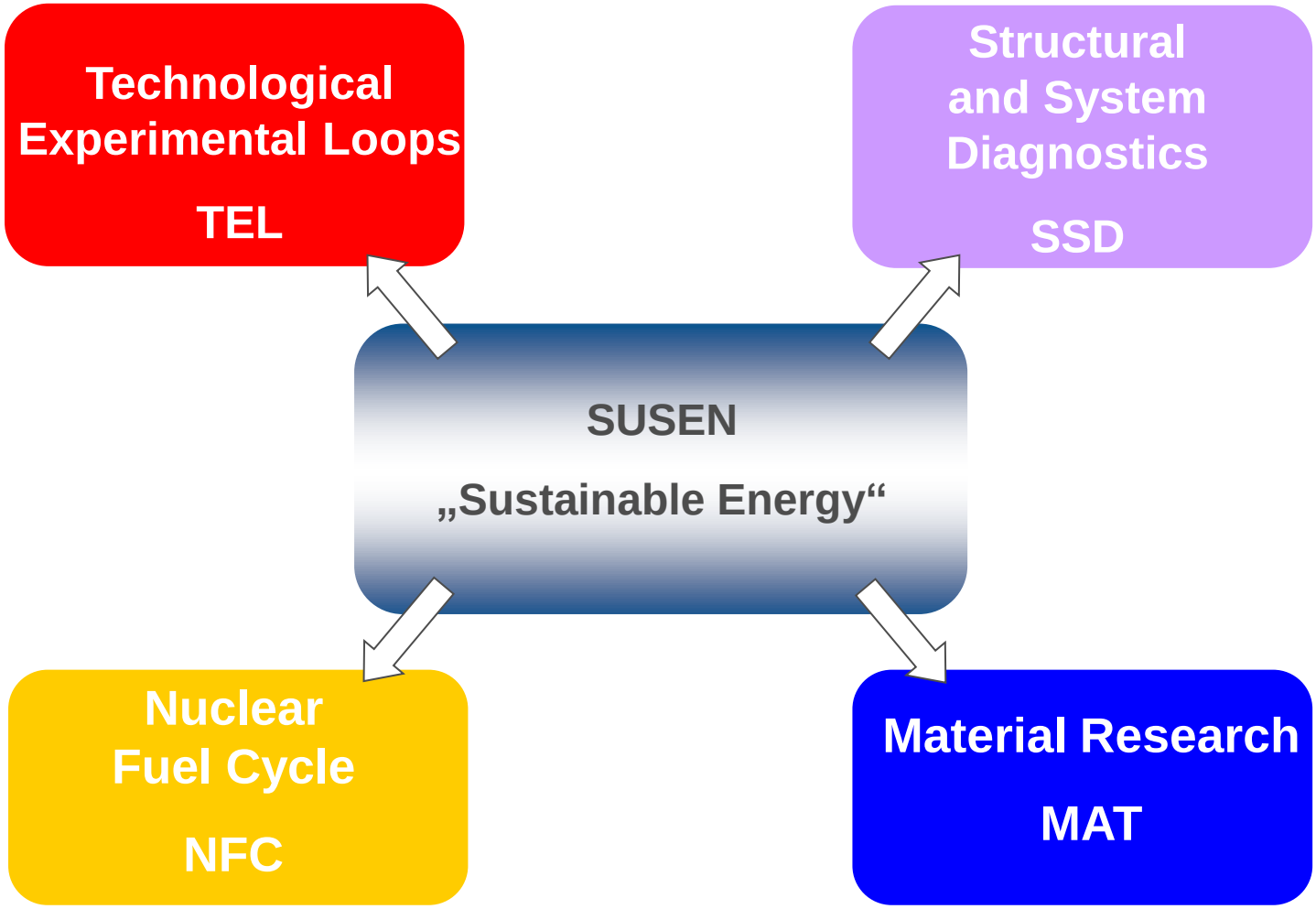
12/2011:
Approval

09/2015:
End of building

12/2013 -12/2020:
R&D outputs and proving sustainability



SUSEN – structure, R&D programs



SUSEN – Technological Experimental Loops

Objective

- To build up large-scale experimental facilities allowing R&D in the area of GEN IV reactors and fusions reactions

Research topics

- Effects on the materials of construction
- Thermodynamic and thermal-hydraulic properties
- Manufacturing technologies are not known
- The necessary components are not available, etc.

Studied media

- Supercritical water (*for SCWR*)
- Helium (*for V/HTR, GFR, fusion reactor*)
- **Supercritical carbon dioxide** (*secondary circuits for heat transfer*)
- Heavy liquid metal (Pb)

Experimental facilities planned in the TEL program

- Supercritical water loop for material testing – active, LVR-15, Řež
- High temperature helium loop – active, LVR-15, Řež
- Experimental loop for supercritical CO_2 – non-active, Řež
- High temperature helium loop for the GFR/HTR concept

Key issues of real CO_2 cycle

- **Heat exchangers**
  - What type of the heat exchangers is ideal for supercitical CO_2?
    - Micro-channel HX
    - Clasical Shell&tube HX
- **Heat transfer**
  - Different Cp
  - Pinch point
  - Heat deterioration/enhancement
- **Turbomachinery**
  - sealing
  - Material testing (corrosion and erosion)
  - Blades (power density)
- **Flow instabilities**
  - Density wave oscilation
  - Flow induced vibrations
- **Purity control system**
  - Influence on physical properties

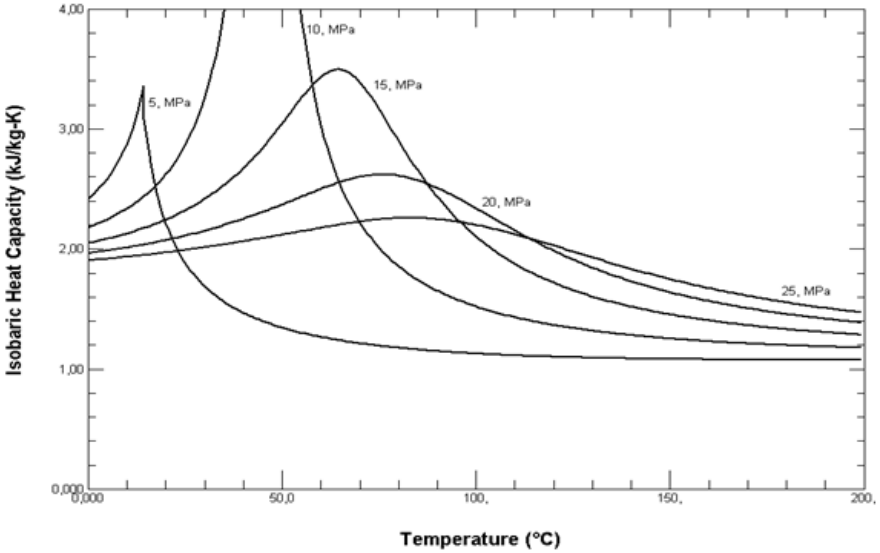


Figure 1 - CO_2 Isobaric Heat Capacity versus Temperature

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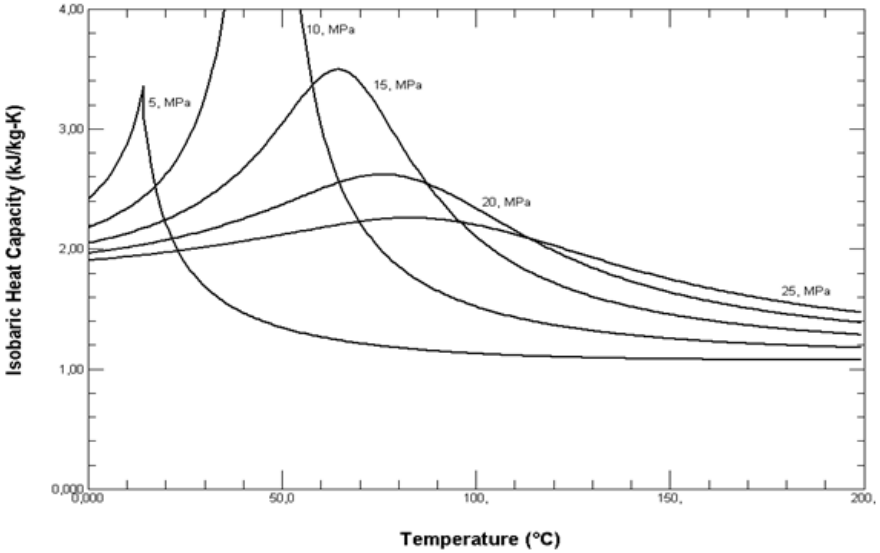
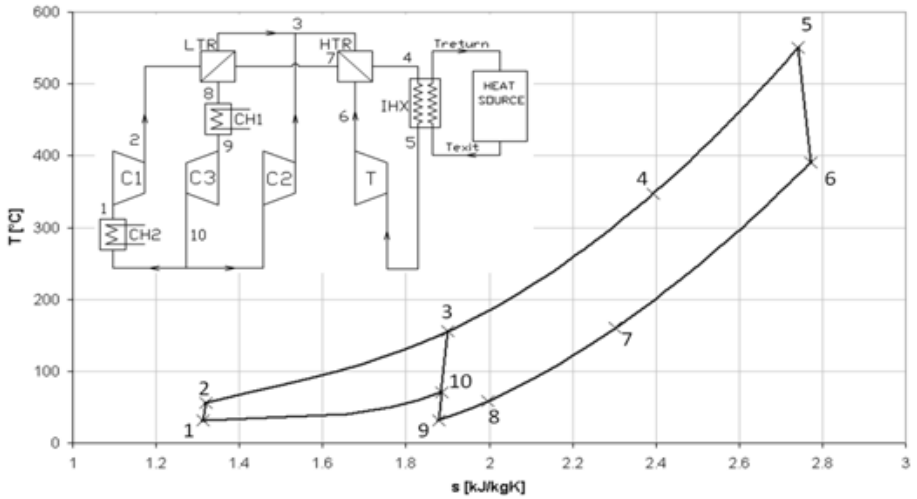


Figure 1 - CO_2 Isobaric Heat Capacity versus Temperature

SCO_2 loop – goals and objectives

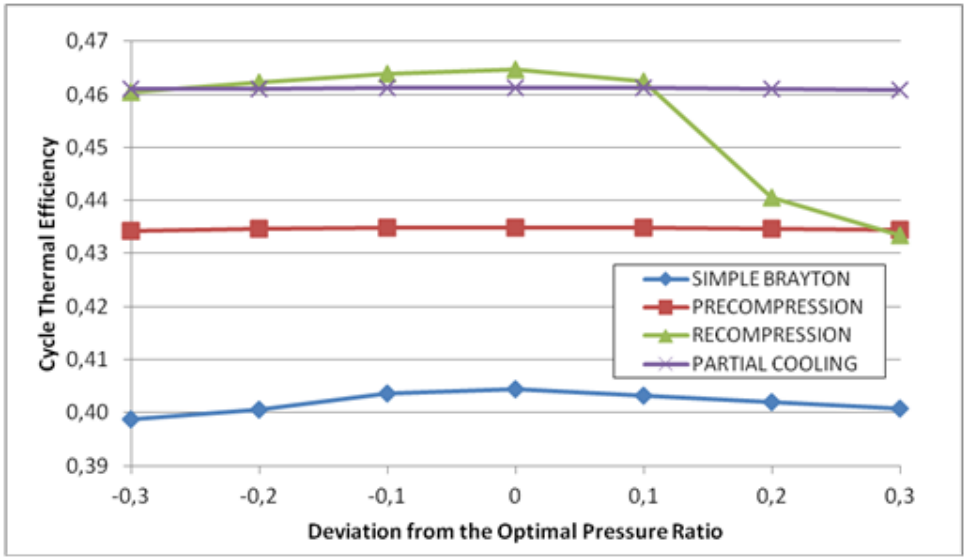
- Research and testing of the heat transfer for various operating conditions of the supercritical CO_2
- Testing of the heat transfer efficiency for various loop composition
- Material testing for S-CO_2 cycles
- Corrosion and erosion material testing in the S-CO_2 environment
- Physical properties with different composition (CO_2+CO)
- Density wave oscilation

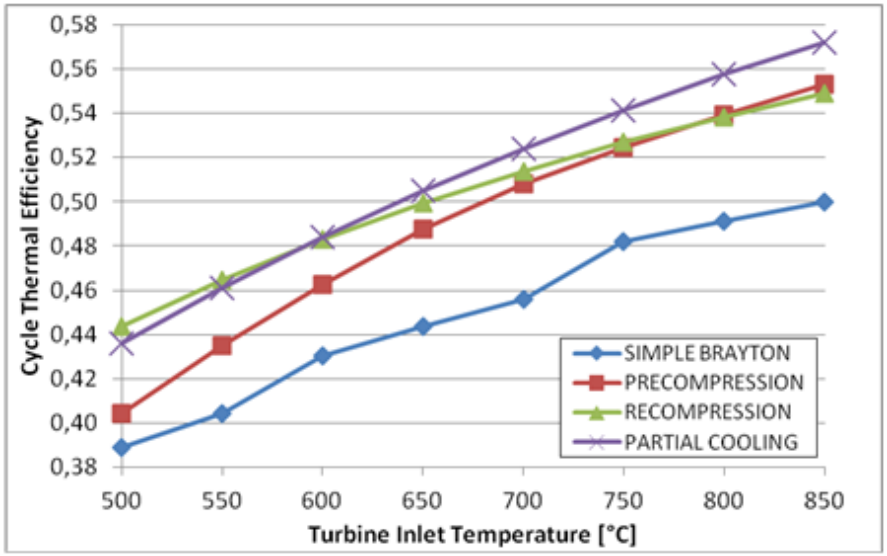


Partial-cooling Cycle Temperature - Entropy Diagram

S-CO_2 loop – main parameters

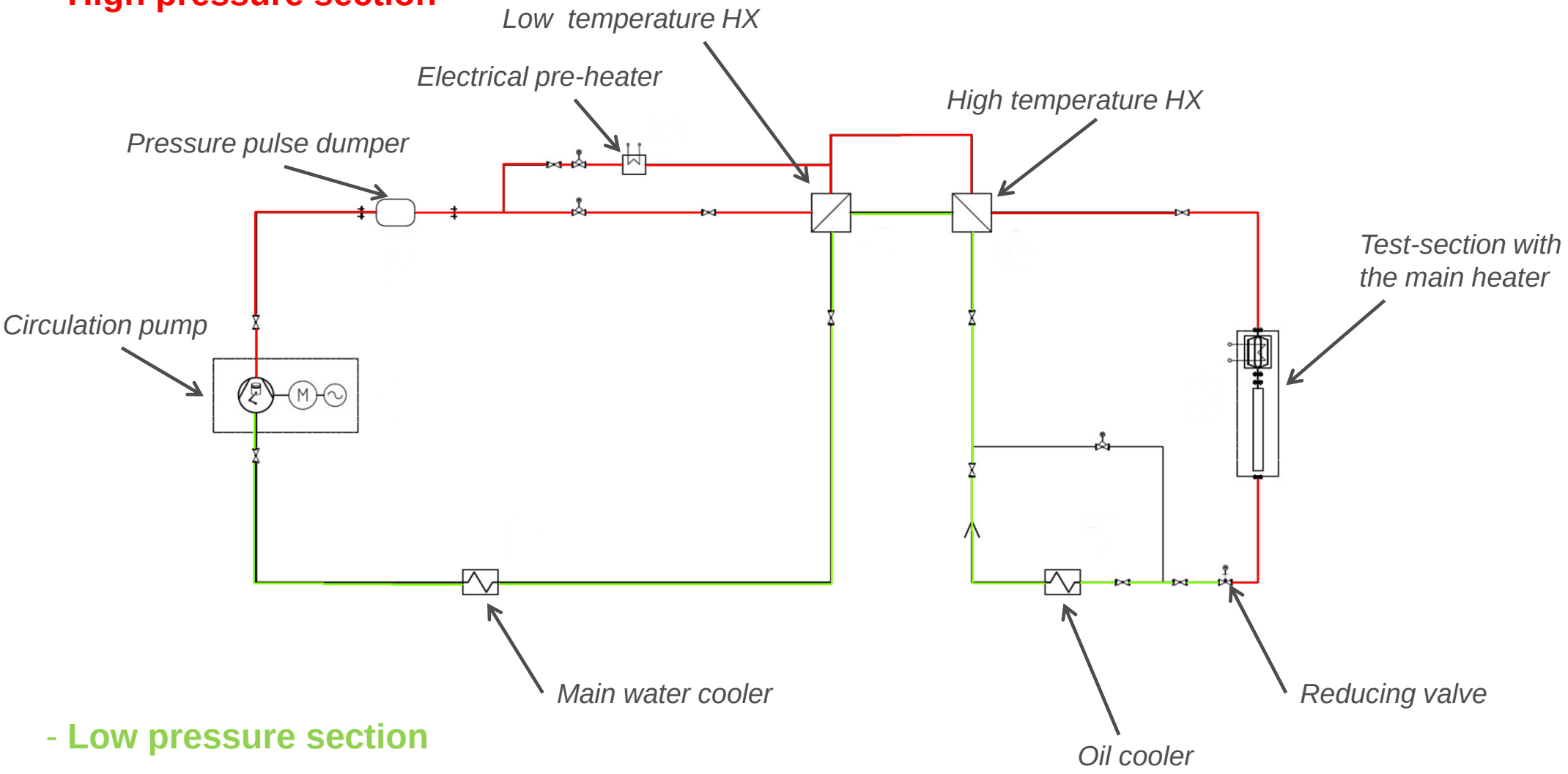
- Max. operating temperature: 550˚C
- Pressure at low pressure site: 7 - 12,5 MPa
- Pressure at high pressure site: X – 25 MPa
- Nominal flow rate : 0,35 kg/s
- Total heating power: 120 kW
- Power of the pre–heater : 20 kW
- Power of the main heater : 100 kW





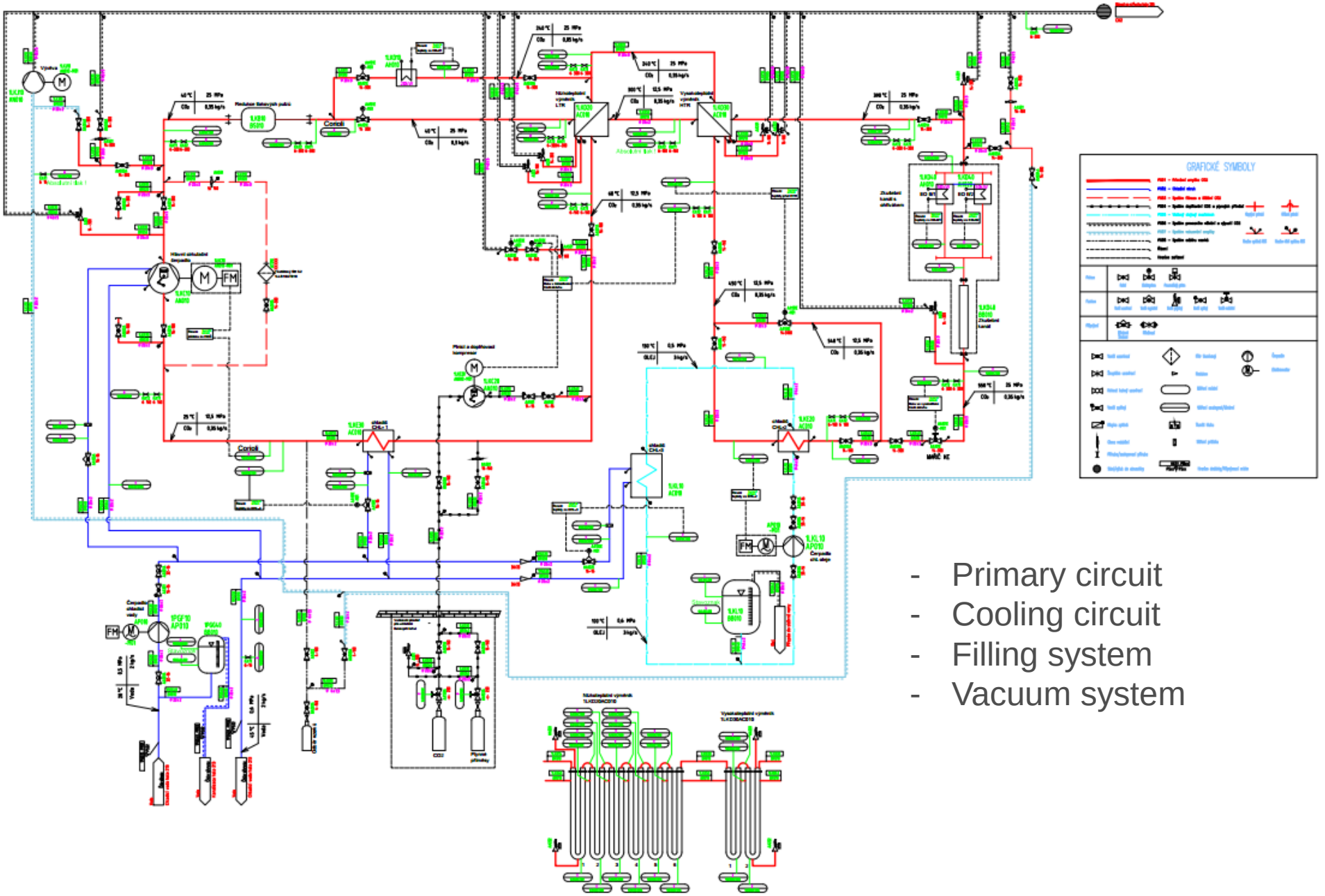
S-CO_2 loop – primary circuit

- **High pressure section**



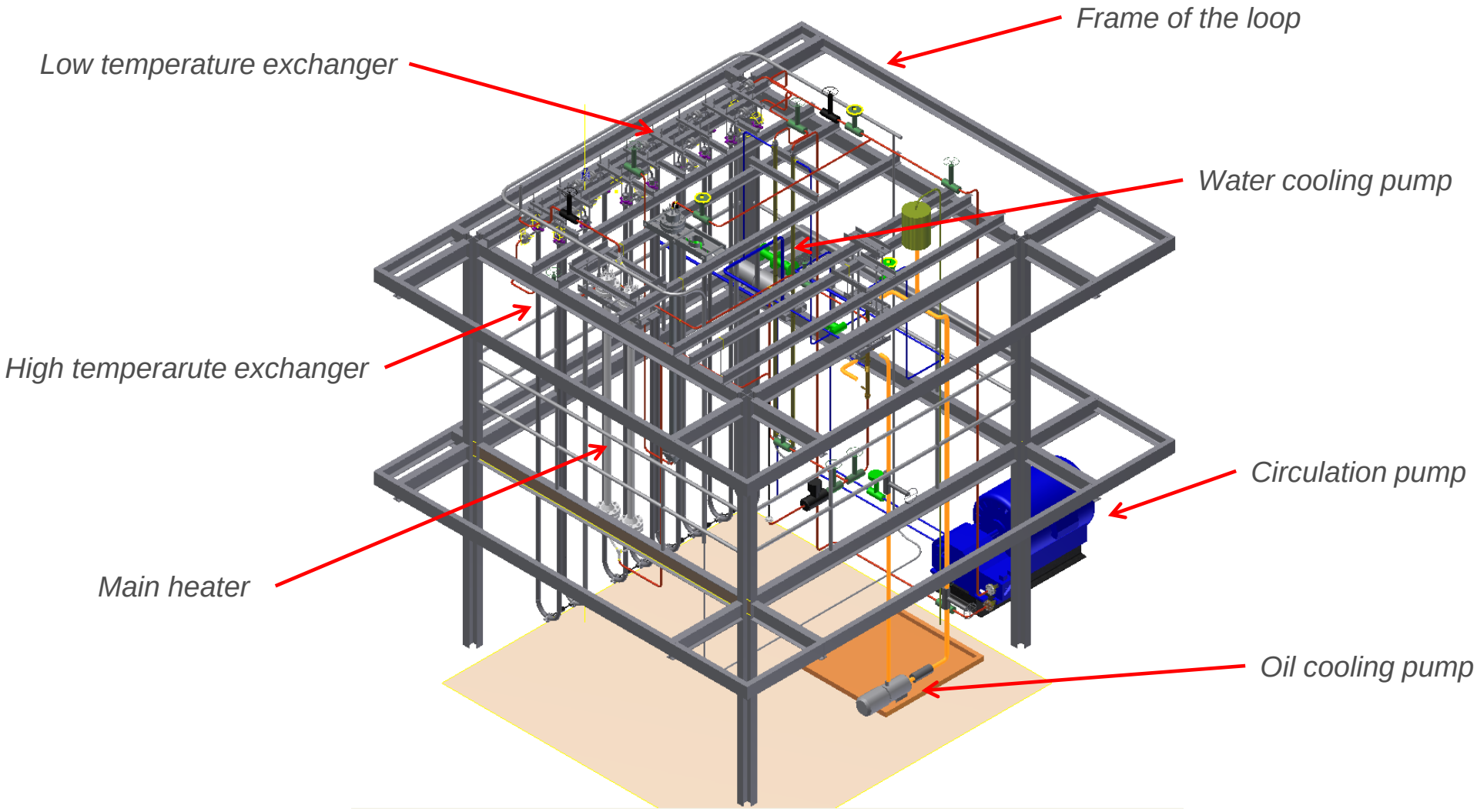
- **Low pressure section**

Experimental loop S-CO_2 SUSEN



- Primary circuit
- Cooling circuit
- Filling system
- Vacuum system

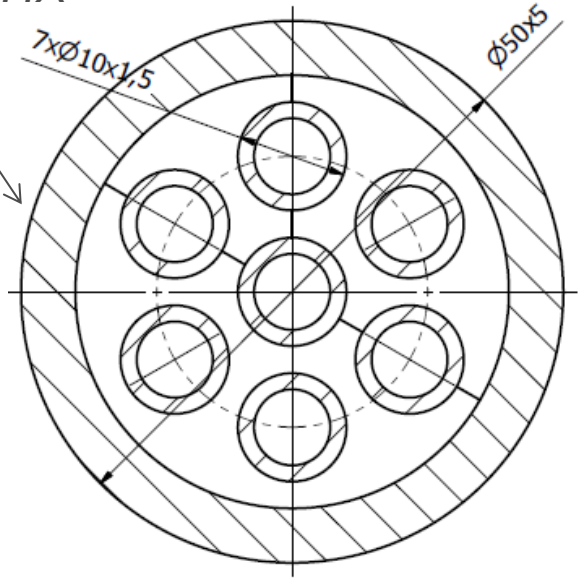
Design of the experimental loop



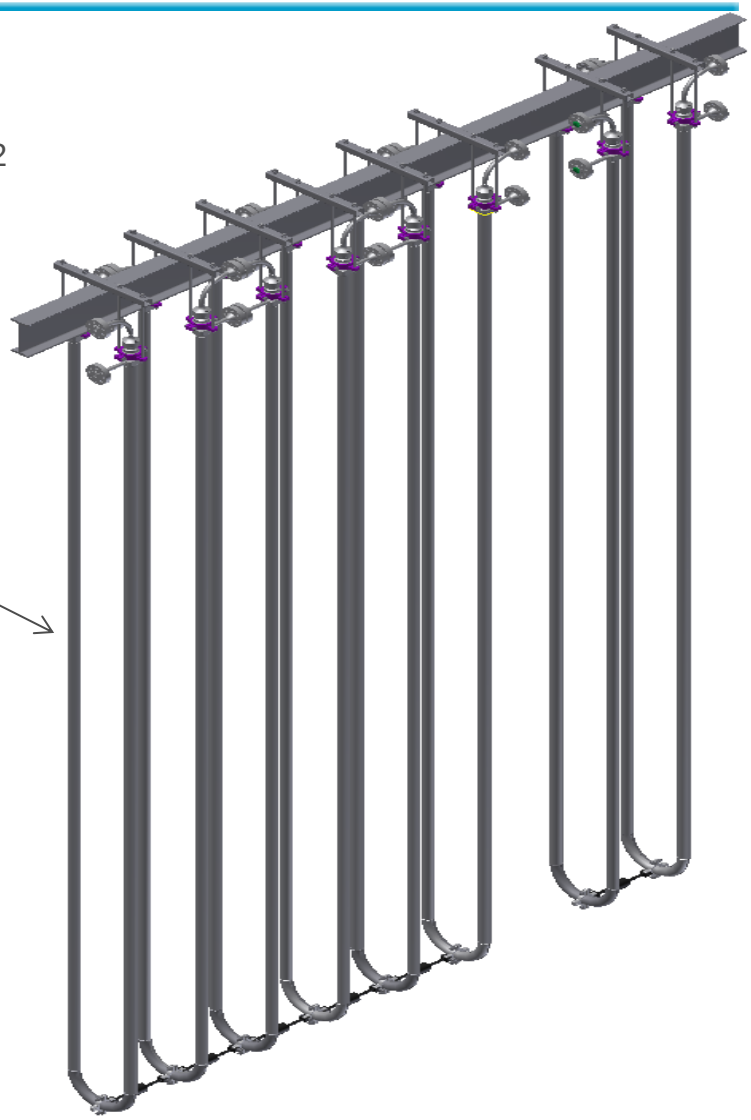
Experimental capabilities

- **Heat transfer**
  - Capability to dose loop with other gases (→ mixture CO_2
- **Heat exchangers**
  - Test of the poperties heat exchangers

Crosscut of HX



Exchangers assembly

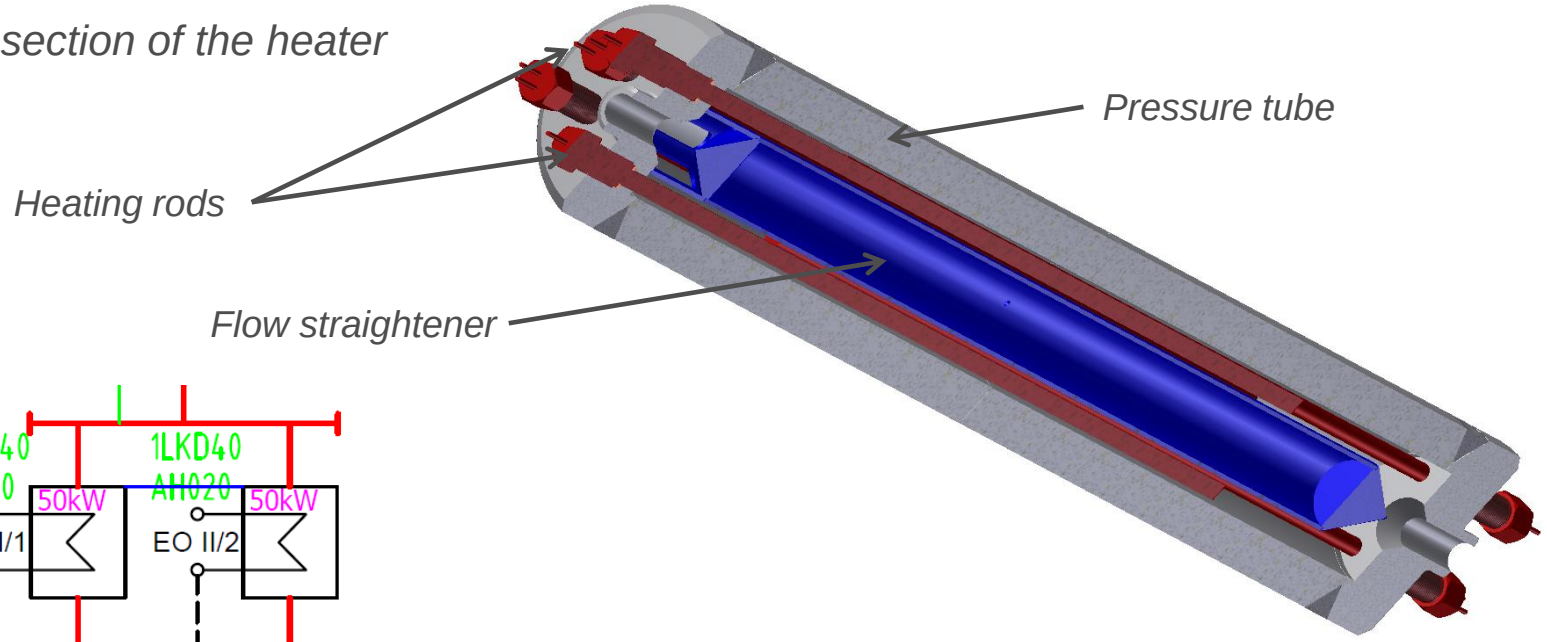


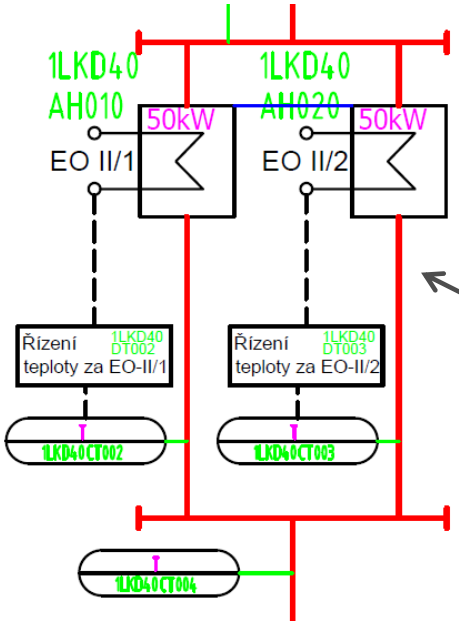
Experimental capabilities

Density wave oscilations

- The loop is going to be heated by two parallel heating sections with independent power controll

One section of the heater



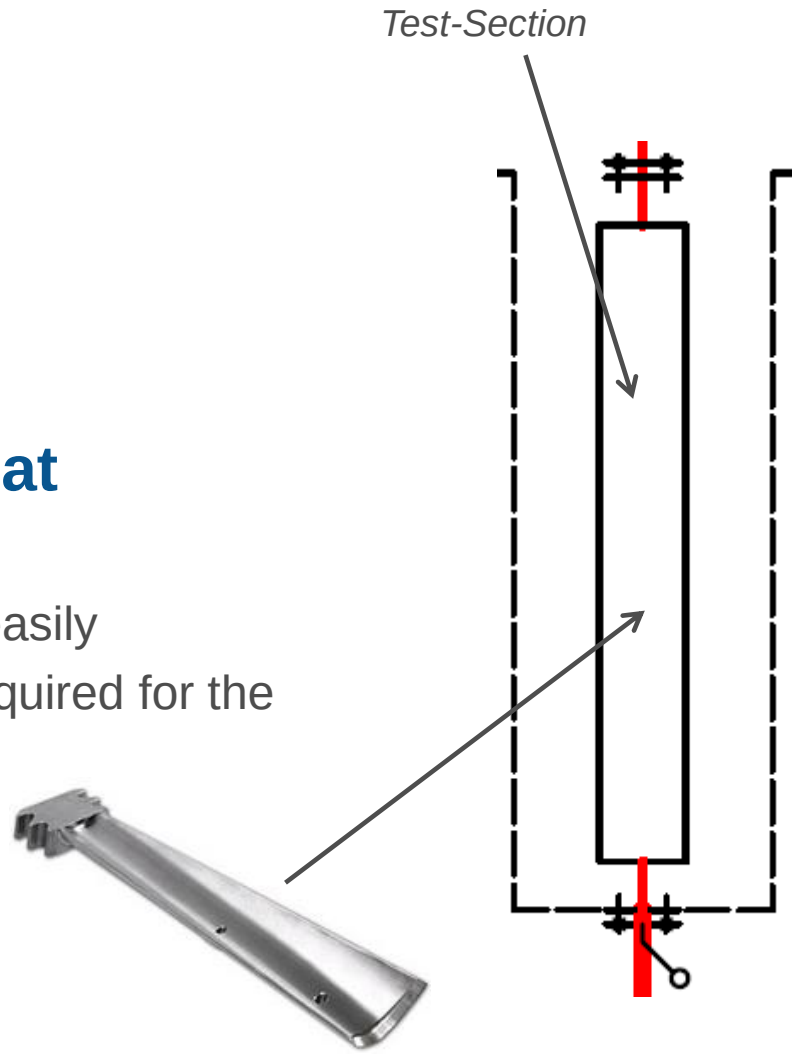


Scheme of the two parallel heating section

Experimental capabilities

- **Turbomachinary (in the future)**
  - The loop is ready for:
    - Compressor testing
    - Turbine testing
    - Turbomachinary testing

- **Test-Section – corrosion, erosion at different parameters**
  - Loop is built to change different Test-section easily
  - Test-section in the loop will be designed as required for the specific tests



Announced and planed projects

- **COPRO – submited under call „TAČR – Epsilon“ (2015-2018)**
  - Topic: Research of the CO2 cycles for sustainable energy
  - Project participants:
    - Research Centre Rez
    - Doosan Škoda Power s.r.o.
    - UJV Rez
  - Key CVR issue:
    - Material testing
    - Heat transfer verification
- **HeRo – submited under EURATOM call „NFRP - 3“ (2015-2018)**
  - Topic: R&D of the CO2 cycle for support of Gen. II and Gen. III reactors safety
  - Project participants:
    - Research Centre Rez, UJV Rez, TU – Delft, UDE, US
  - Key CVR issue
    - Testing of the turbo-machinary
    - Cycle calculations

Other benefits - future

- Experimental data library
- Benchmark workshop for computational codes validation
- Verification of cycles efficiency in the different configurations

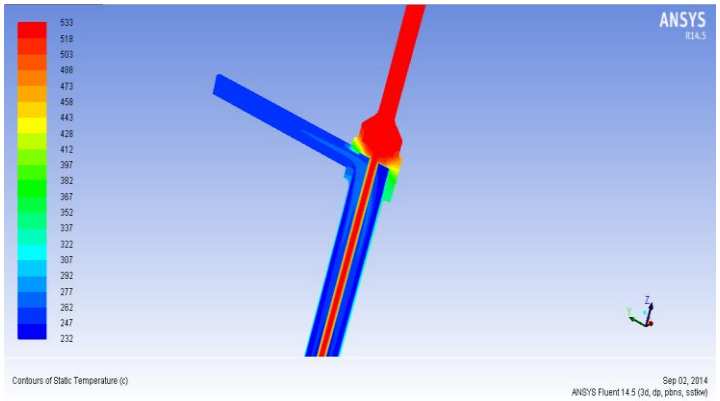
Possibilities of cooperation

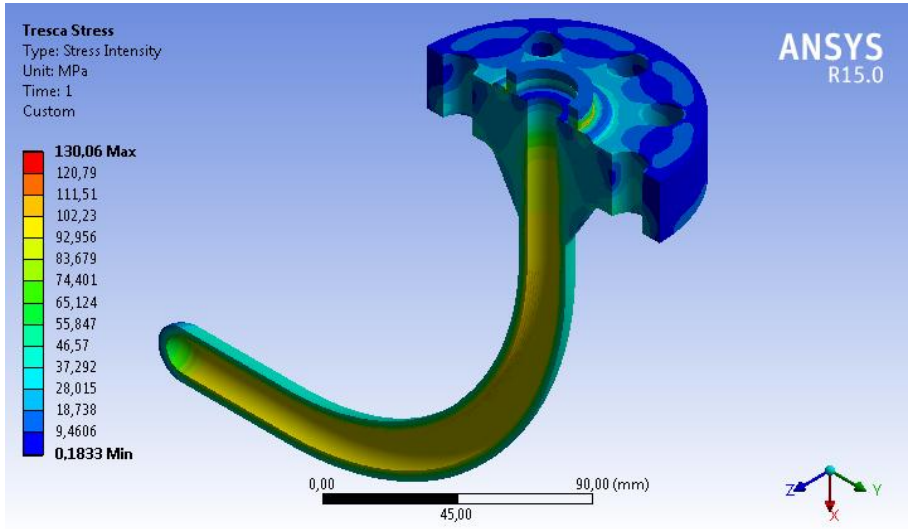
Experimental capacity

Experimental data

Our work on development of the loop

- Construction of all parts with detailed manufacturing documentation
- Overall stress analysis of the pressure components
- Overall stress analysis of the supporting elements
- Thermal-technical calculations in CFD
- Technical documentation





Thank you for your attention

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