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Norwegian University of Science and Technology

Design of an Experimental Expander Setup Using Natural Working Fluids

HighEff Annual Consortium Meeting 2019

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The HighEff goals

Increase energy efficiency and reduce greenhouse gas emissions:

- Industrial section
- Building sector
- Transportation sector

Areas of action

- System and component optimization (reduce)
- Thermal storage (reuse)
- Waste heat recovery (recycle)

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- **Waste heat recovery (recycle)**

What is waste heat recovery?

Waste heat recovery is the conversion of unused thermal energy into work

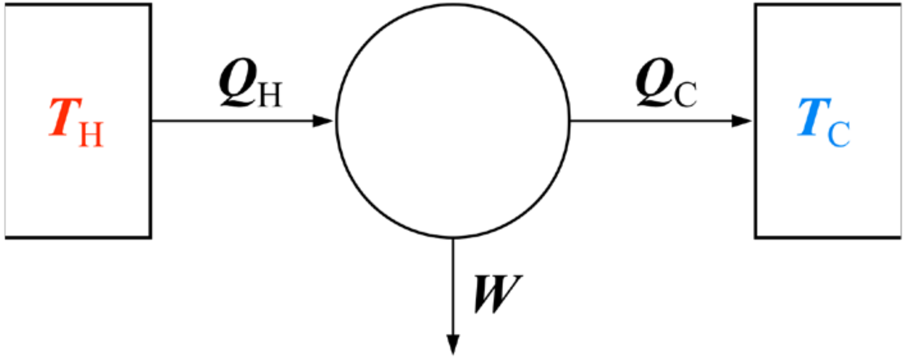
Advantages:

- Increase energy efficiency
- Reduce carbon dioxide emissions
- Reduce thermal pollution
- Interesting investment opportunity

How to convert waste heat into work?

Many technical options

- Rankine cycles
- Brayton Cycles
- Stirling cycles
- Other cycles



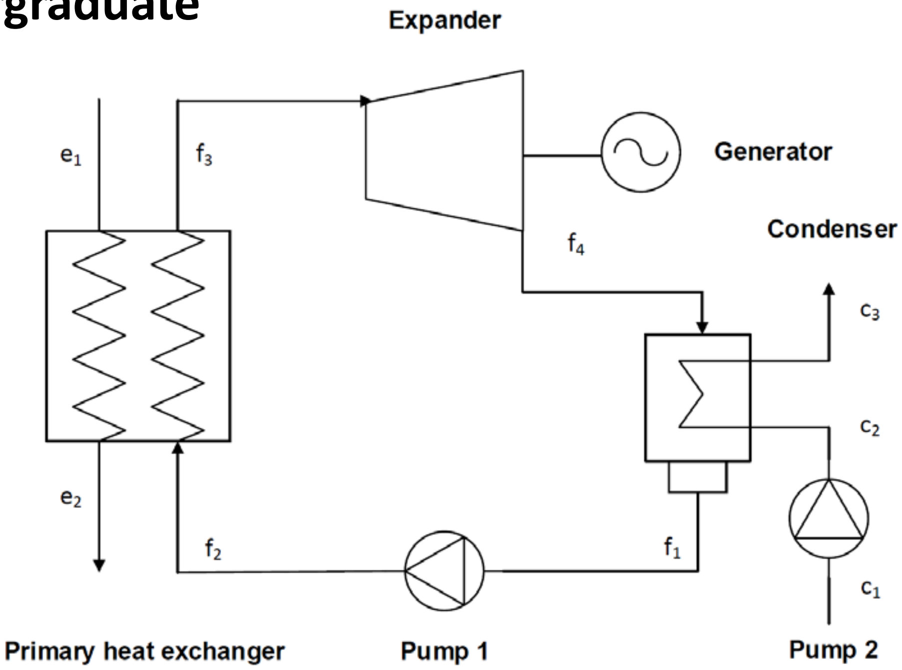
Rankine cycles are the best suited for low-temperature heat sources

What is a Rankine cycle?

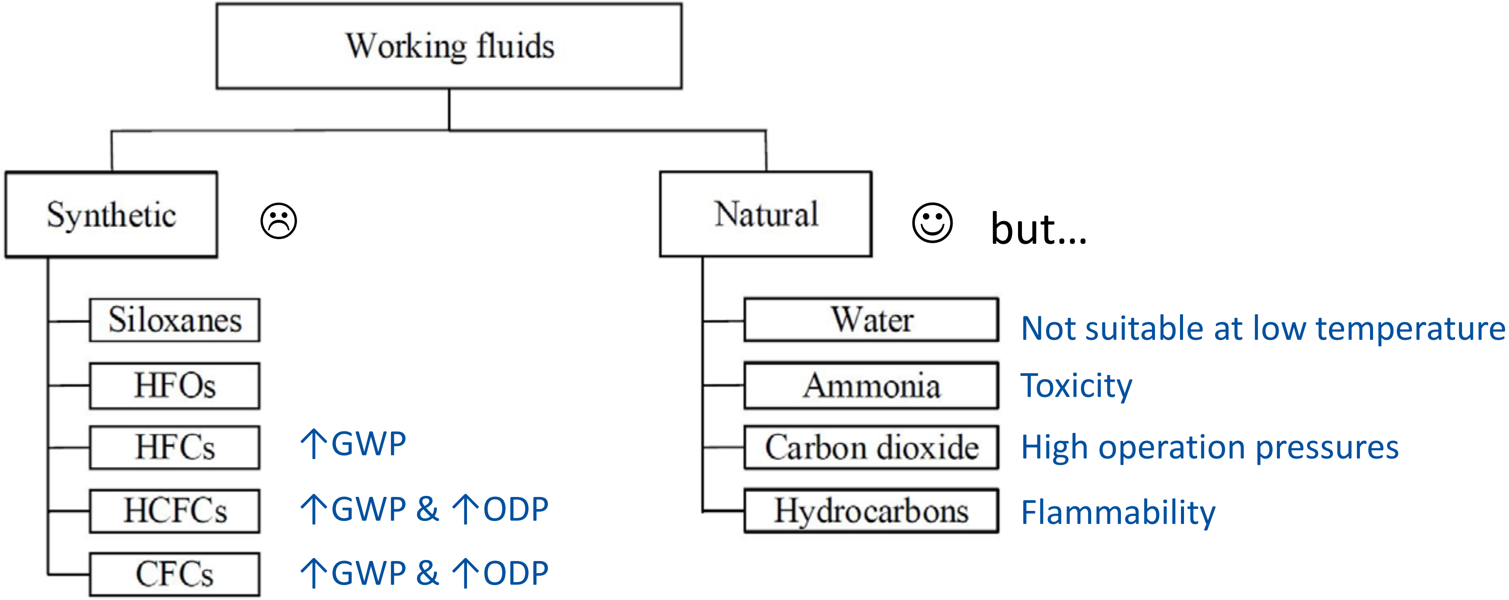
Quick recap from your undergraduate thermodynamics lectures

1. Compression
2. Heating
3. Expansion
4. Cooling

Repeat!



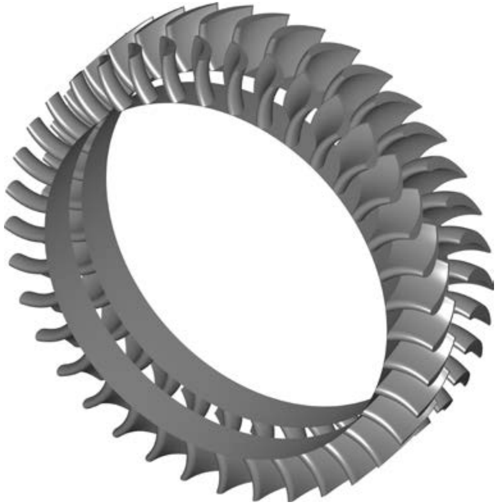
What working fluid to use?



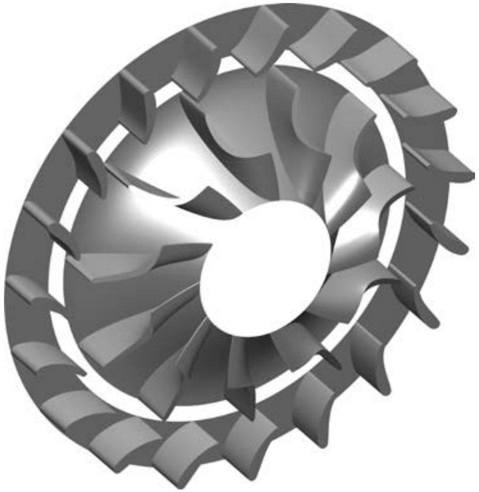
Unfortunately there is no free lunch

What expander to use?

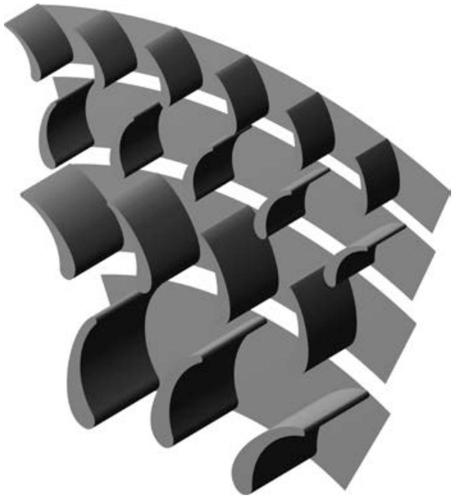
Dynamic expanders



Axial turbine



Radial inflow turbine



Radial outflow turbine

What expander to use?

Volumetric expanders

Screw expander

Scroll expander

Piston expander

The HighEffLab expander test rig

Limitation

Lack of experimental data for turbines:

- Using natural working fluids
- Operating in thermodynamic regions with real-gas effects
- With transonic-supersonic flows

Consequence

Turbine design methods have not been validated for these conditions

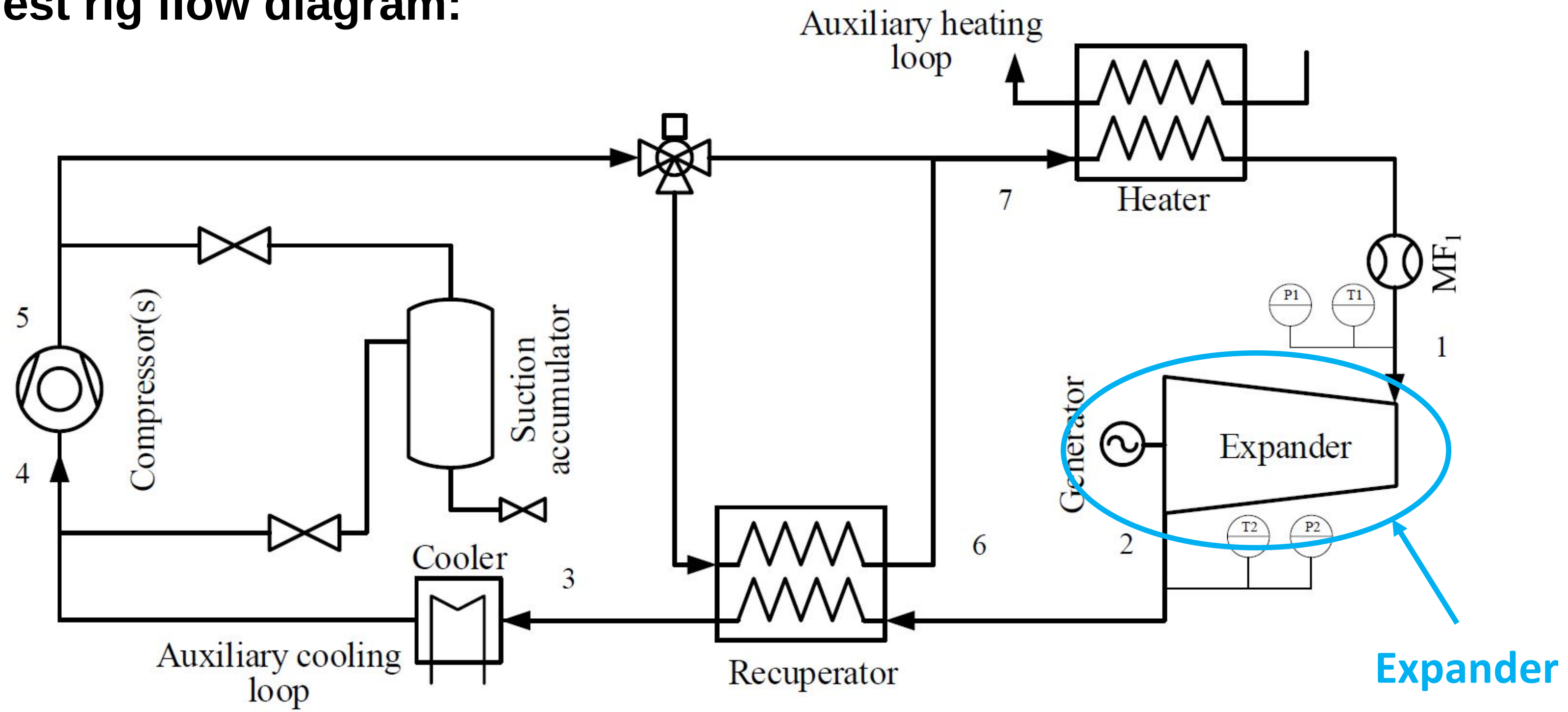
Bridging the knowledge gap

Build a test rig to

- Characterize the performance of expanders
- Validate existing design methods

The HighEffLab expander test rig

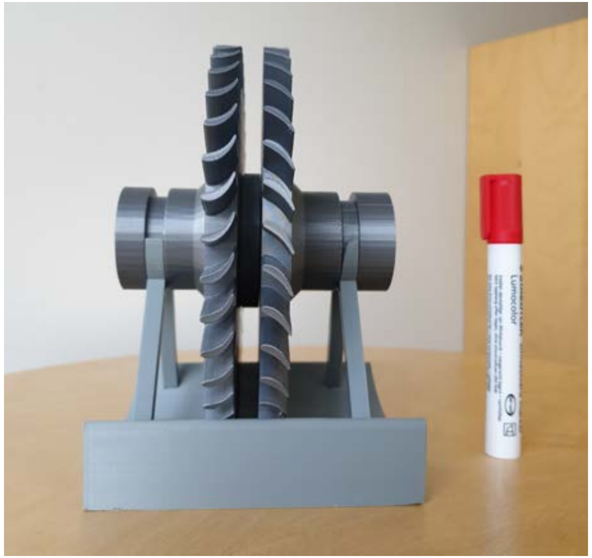
Test rig flow diagram:



First experimental campaign

Variable	Value	Unit
Working fluid	Isobutane	–
Turbine type	Axial Flow	–
Number of stages	Single-stage	–
Power output	$\dot{W} = 30$	kW
Inlet temperature	$T_1 = 120$	°C
Inlet pressure	$p_1 = 3.0$	bar
Outlet pressure	$p_2 = 1.5$	bar

Definition of the expander test rig case



3D print of the preliminary design

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Come and see the poster if you want to know more!

Turbine preliminary design and optimization