C T U in Prague

The Research of S-CO_2 cycles at CTU in Prague

L. Vesely, V. Dostal, M. Soukupova

Czech Technical University in Prague,
Faculty of Mechanical Engineering,
Department of Energy Engineering

2016

CTU in Prague

Introduction

Research at CTU in Prague

- Study of thermodynamic properties of CO_2
    - Effect of mixtures in S-CO_2 power cycle
- Study of S-CO_2 power cycle - configuration of cycle layout

Experimental loop:

- Net power – 10 MW
- Turbine inlet temperature – 550 °C
- Compressor inlet temeprature – 32 °C

C T U in Prague

Investigated cycles

Experimental loop:

- Research of cycles layouts for basic S-CO_2 cycles

The six basic cycles:

- Simple Brayton cycle
- Re-compression cycle
- Pre-compression cycle
- Split expansion cycle
- Partial cooling cycle
- Partial cooling with improved regeneration

Design of heat exchangers

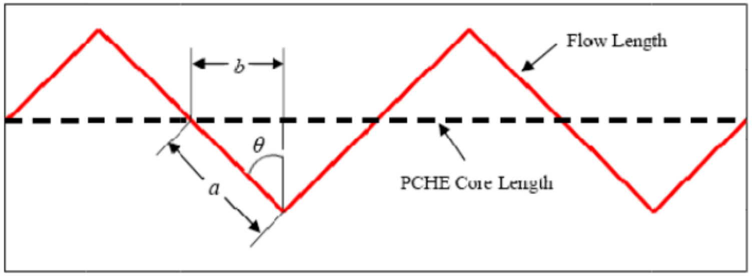
Type of heat exchangers:

PCHE – Printed Circuit Heat Exchangers

- The minimum temperature drop can be only 2 ° C
    - CO_2-CO_2
    - CO_2-molten salts or (helium, water)

Paramaters for calculation:

- Diameter of the channel - 0.002 m
- Angle clutching channels - α = 128 °
- Length - 0.004 m
- The wall thickness - 0.0006 m
- The height of the tip of the channel - 0.0026 m
- The plate thickness - 0.0016 m
- Thermal conductivity of austenite - 50W / mK
- The thermal conductivity of titanium - 21W / mK

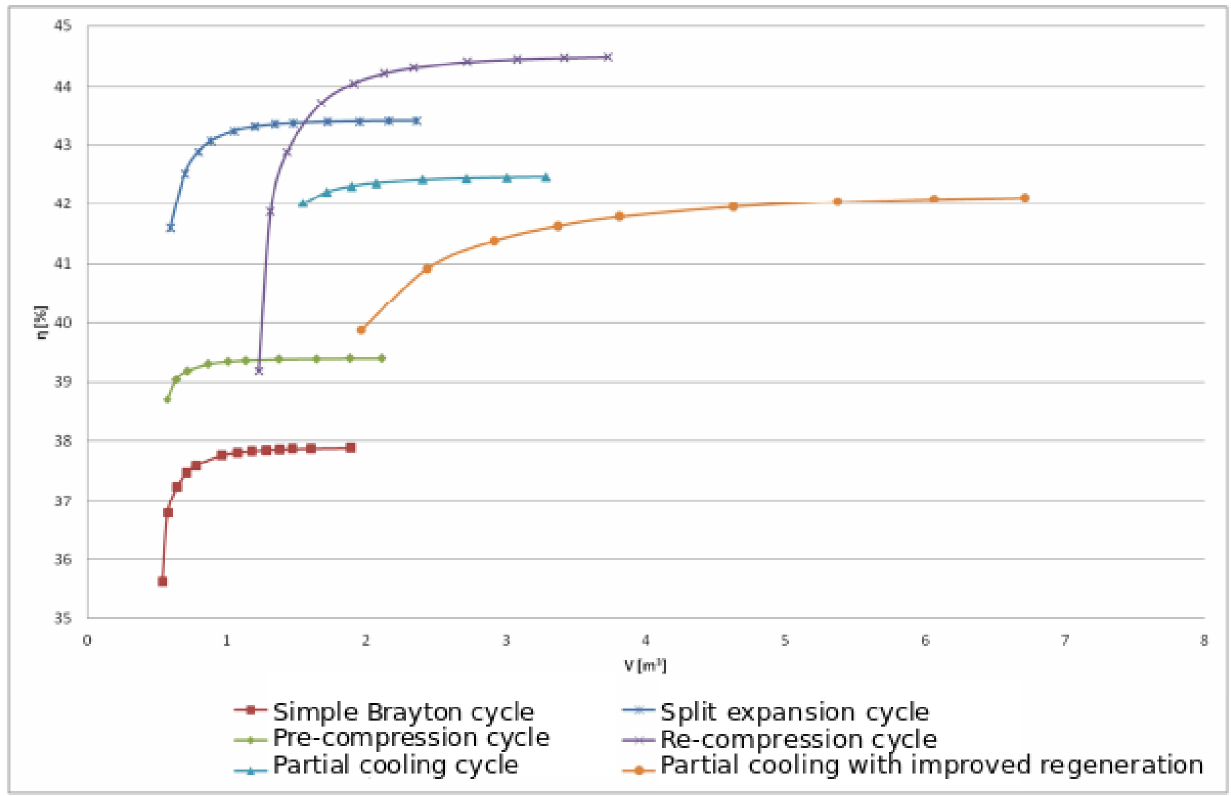


CTU in Prague

Design of experimental loop

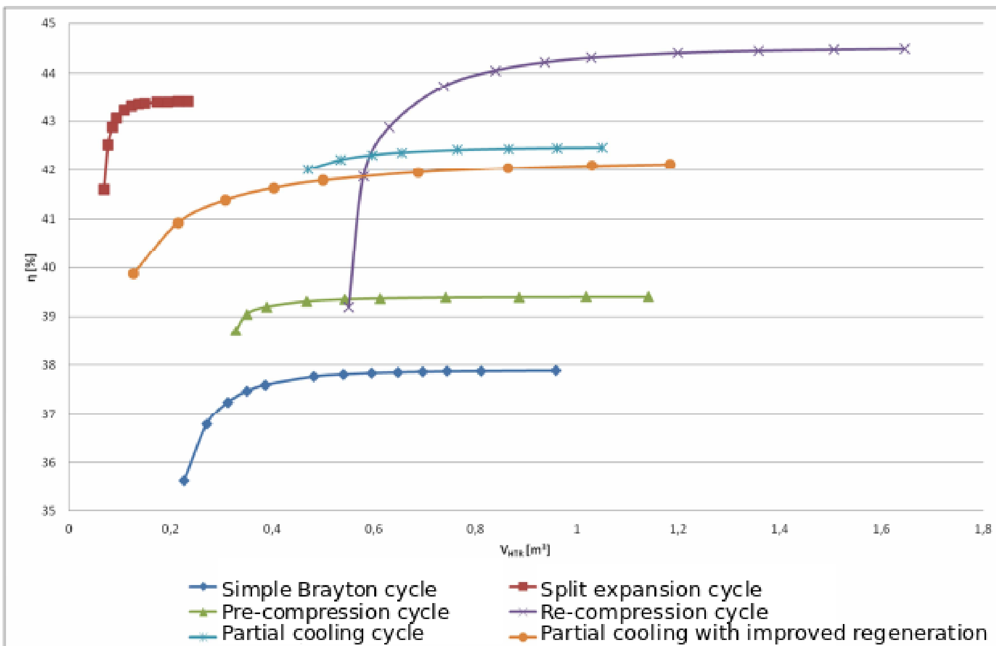
The main goal:

- Determining the minimum number of heat exchangers
- The dependence of the total sum of the individual volumes of heat exchangers from basic layouts of cycles on their effeciency.

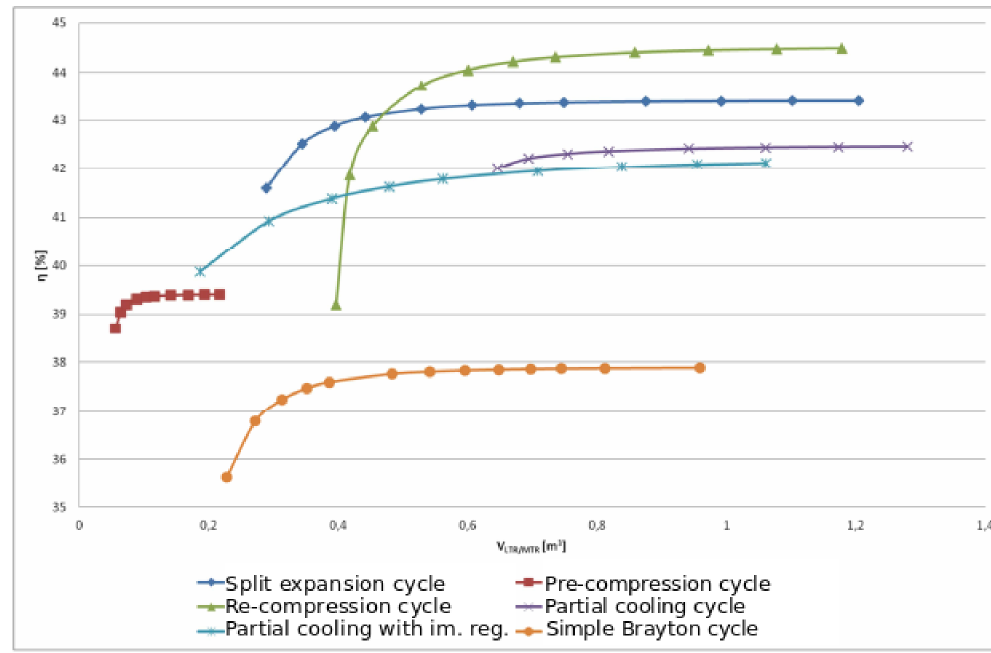


- Number of channels: 300 000

The total volume of HTR/LTR

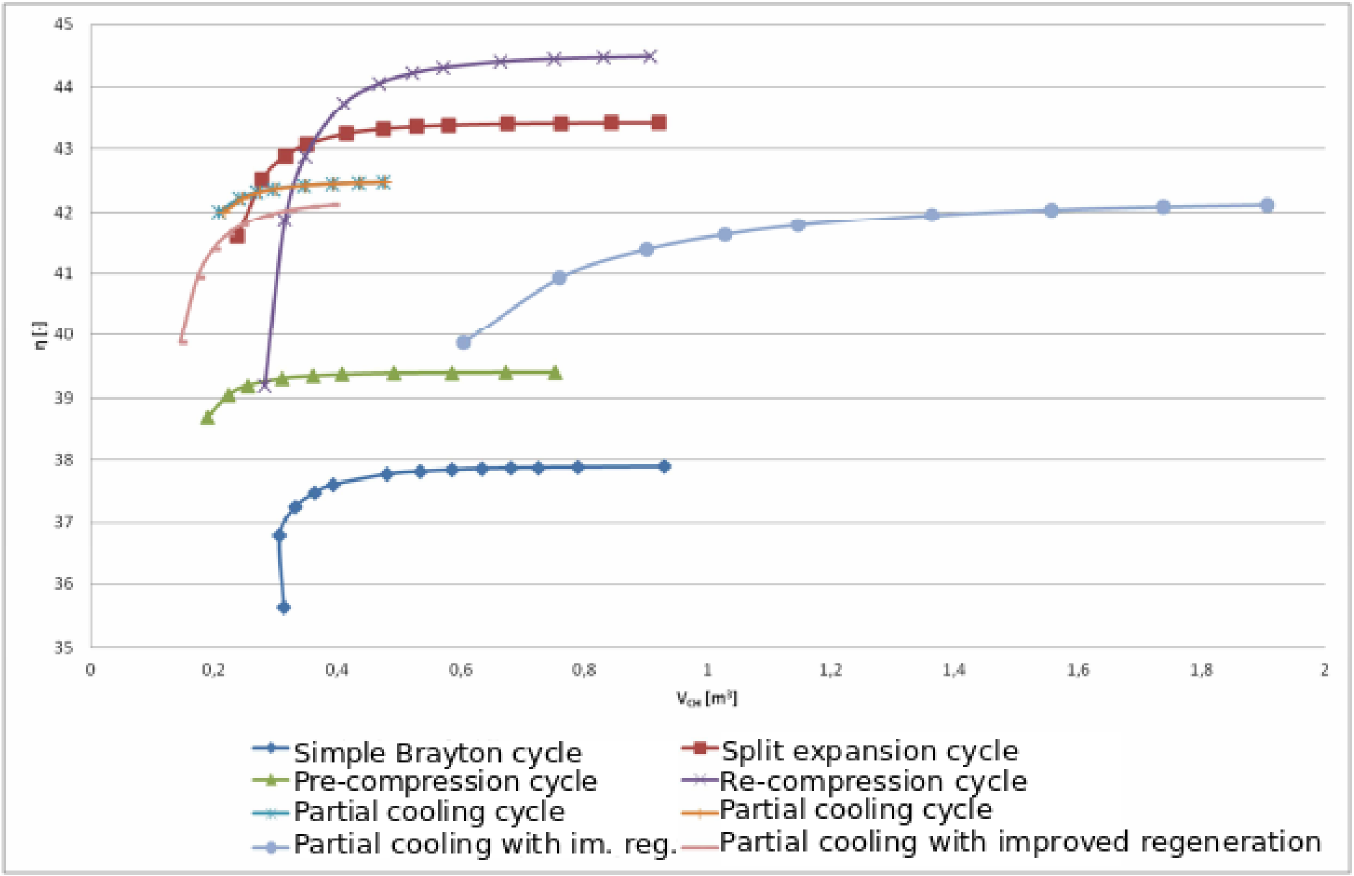


The dependence of the cycle efficiency on the total volume of the HTR

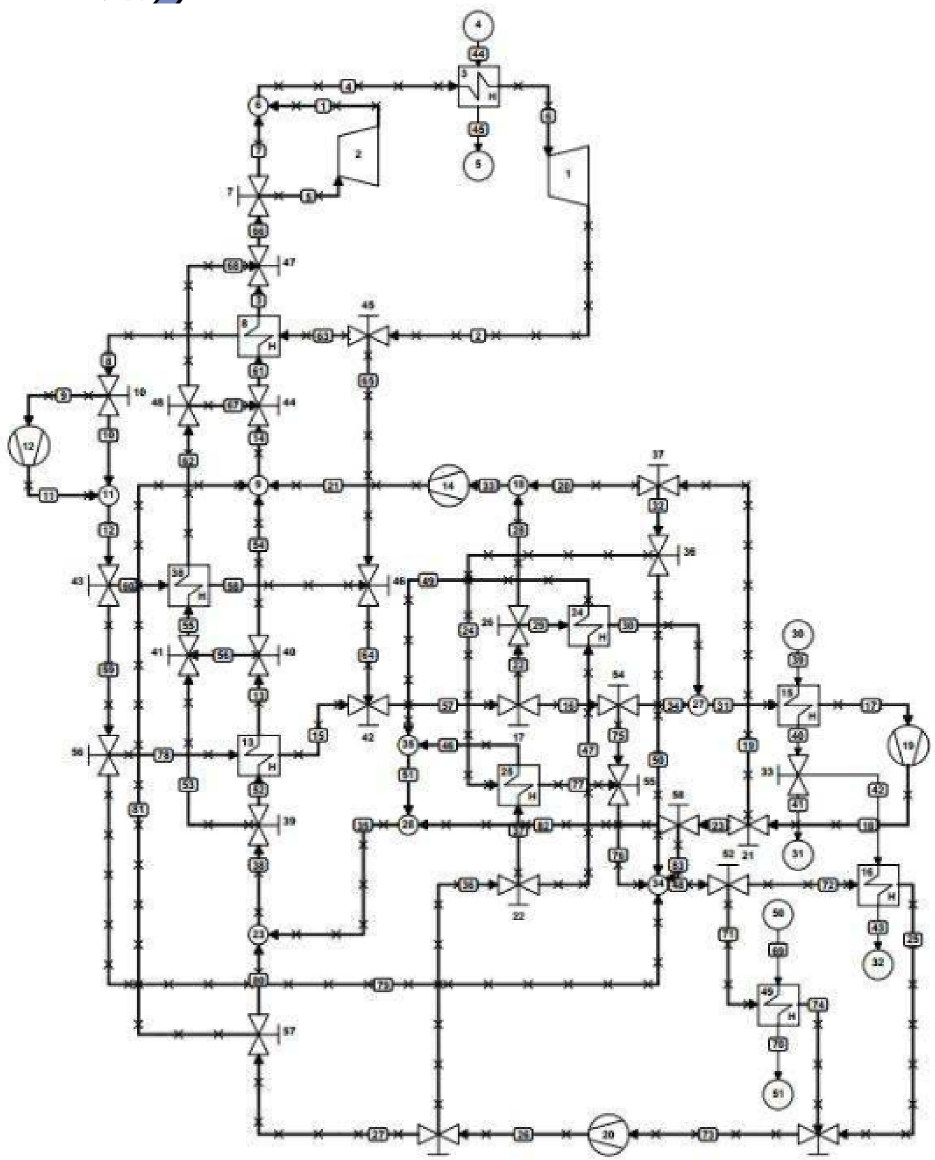


The dependence of the cycle efficiency on the total volume of the LTR

The total volume of cooler



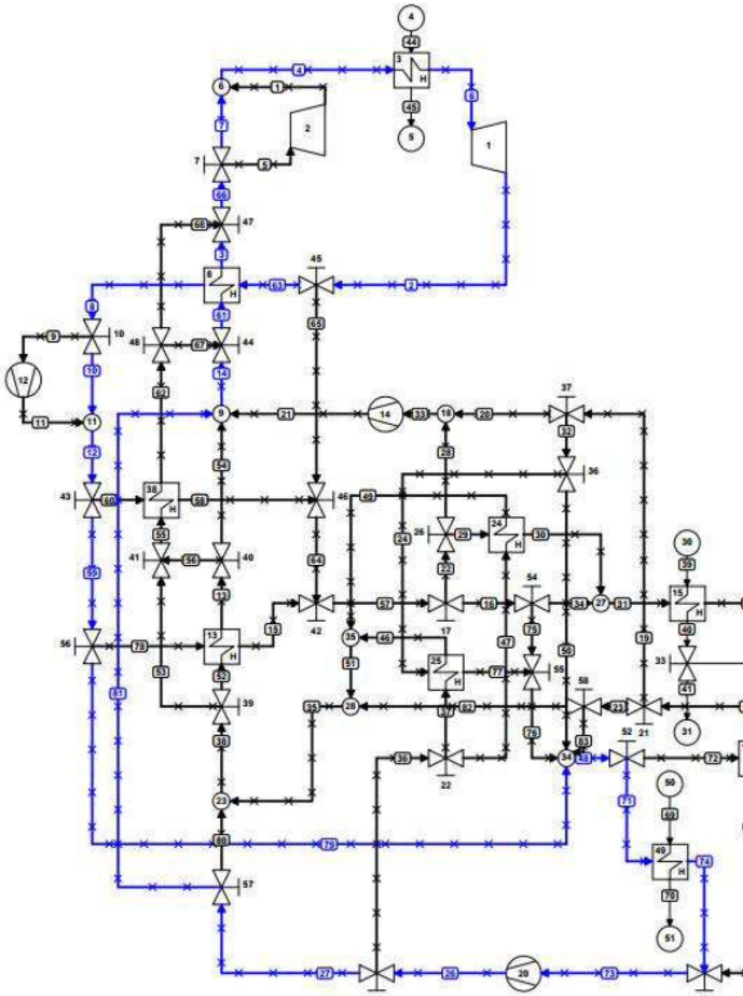
The layout of experimental loop

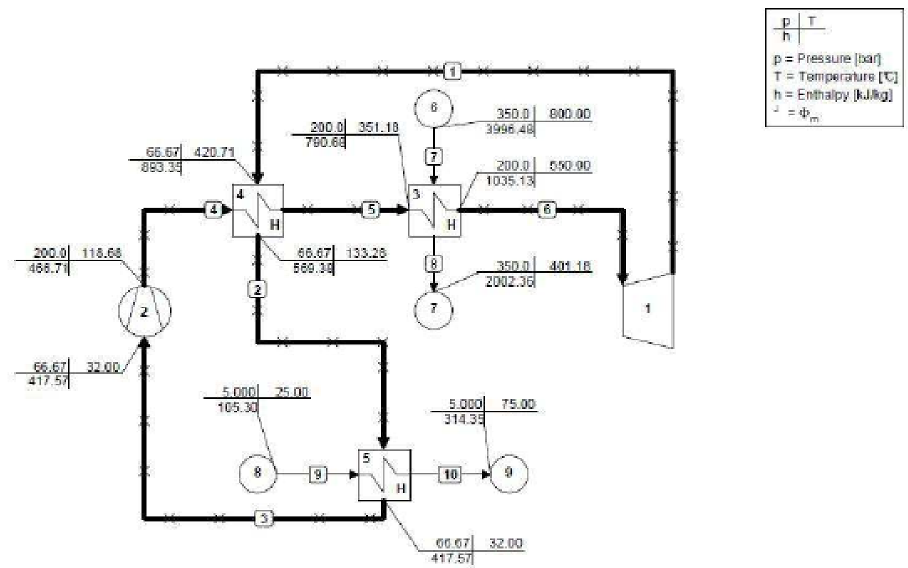


	Number in Fugure	Volume [m3]
HEX no.1	8	0.95
HEX no.2	13	1
HEX no.3	38	0.23
HEX no.4	24	0.8
HEX no.5	25	1.43
Cooler no.1	49	0.93
Cooler no.2	15	0.45
Cooler no.3	16	0.39

	ηid [%]	ηr [%]	Δ [%]
Simple Brayton cycle	37.88	37.27	1.6
Re-compression cycle	43.41	42.56	1.9
Pre-compression cycle	39.4	38.9	1.2
Split expansion cycle	44.9	42.15	6.2
Partial cooling cycle	42.47	41.8	1.5
Partial cooling with improved regeneration	42.11	39.9	5.2

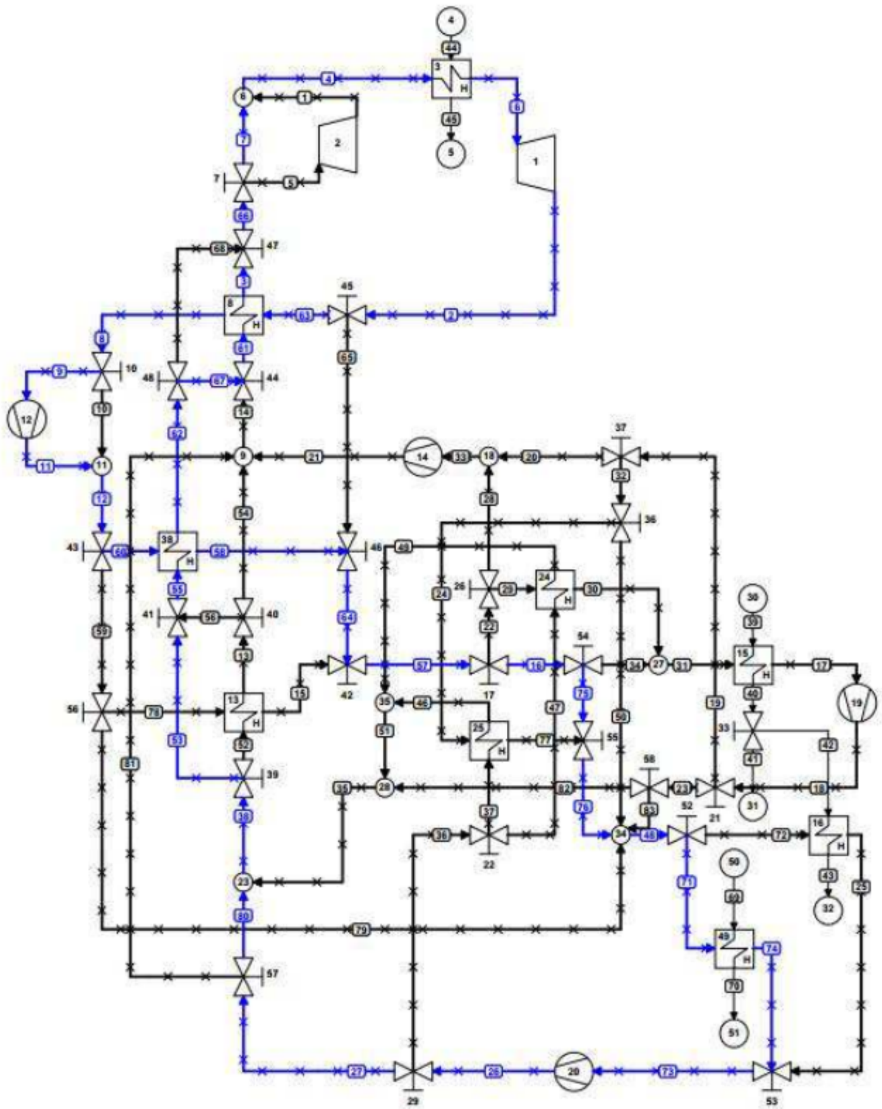
Simple Brayton cycle

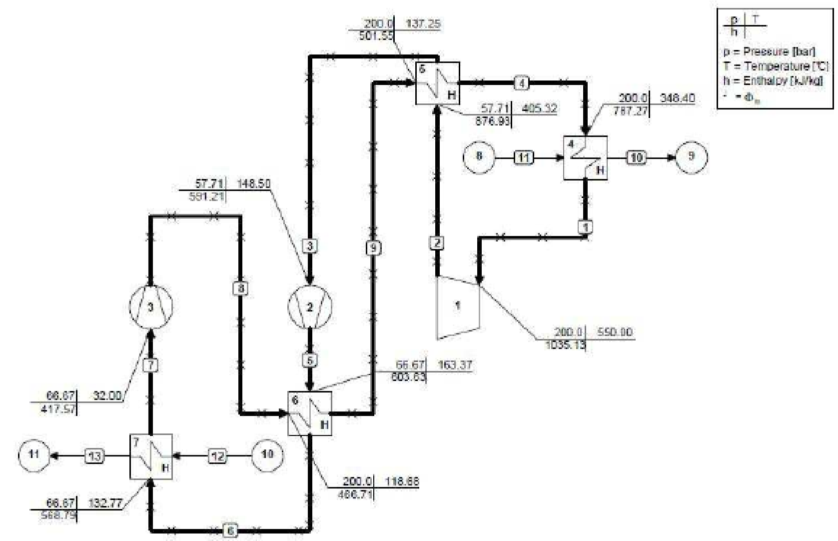




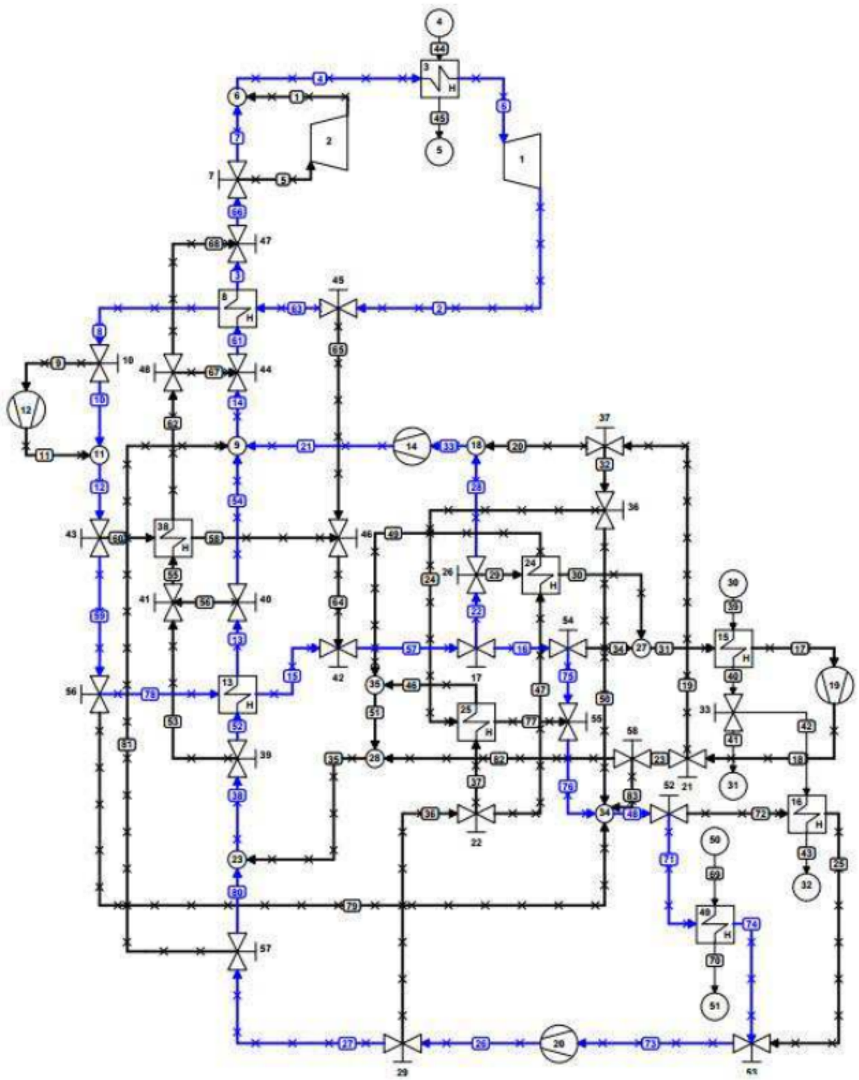
CTU in Prague

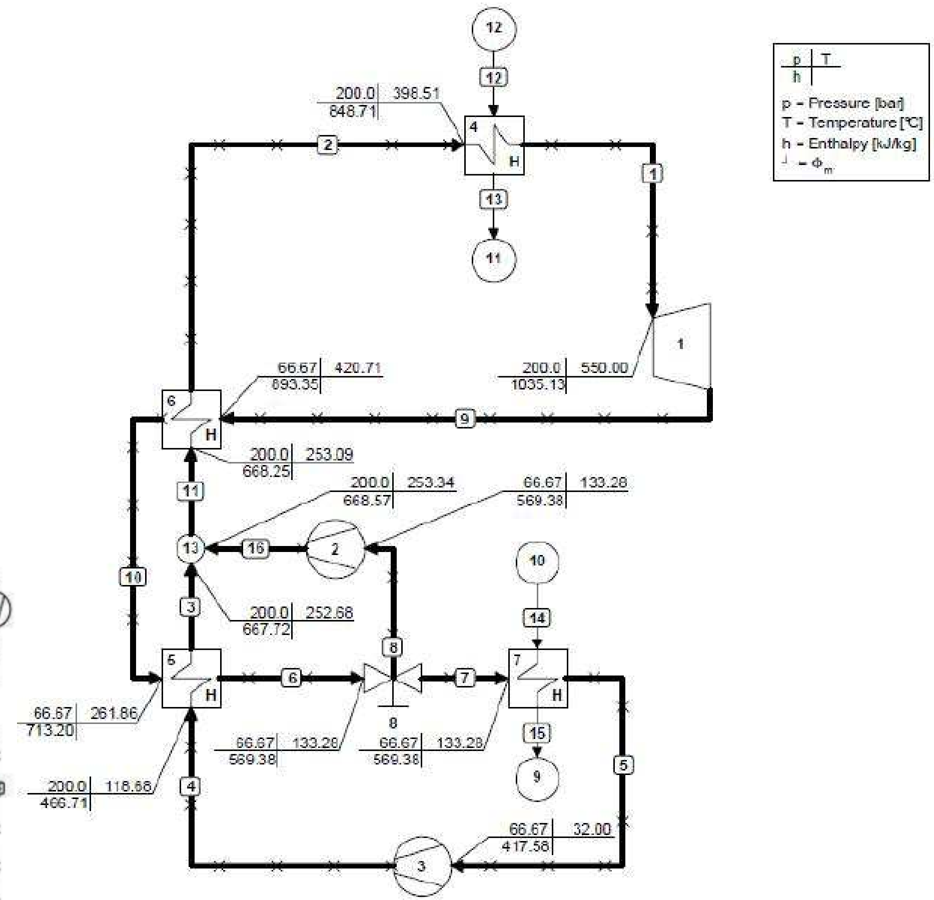
Pre-compression cycle



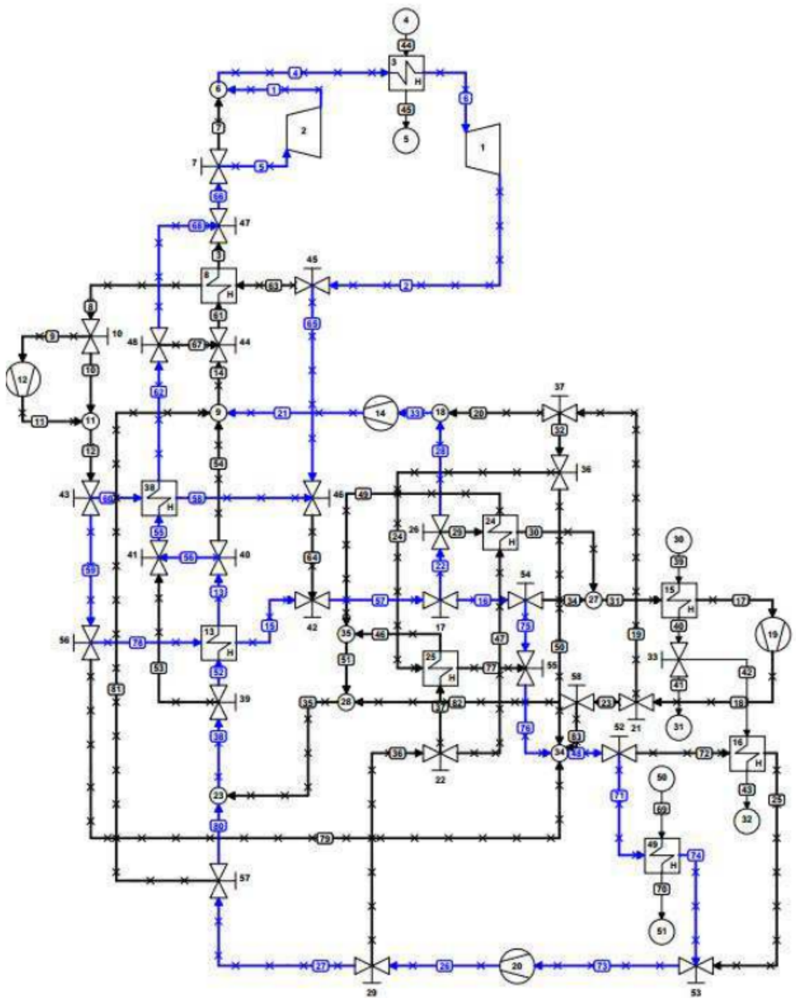


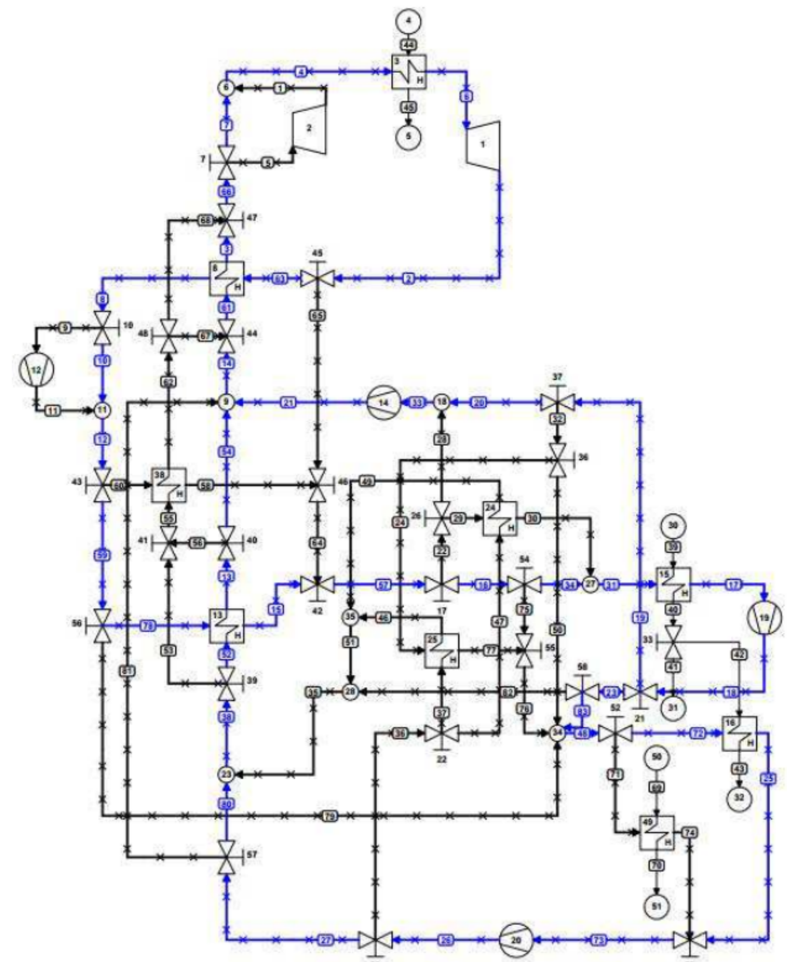
Re-compression cycle





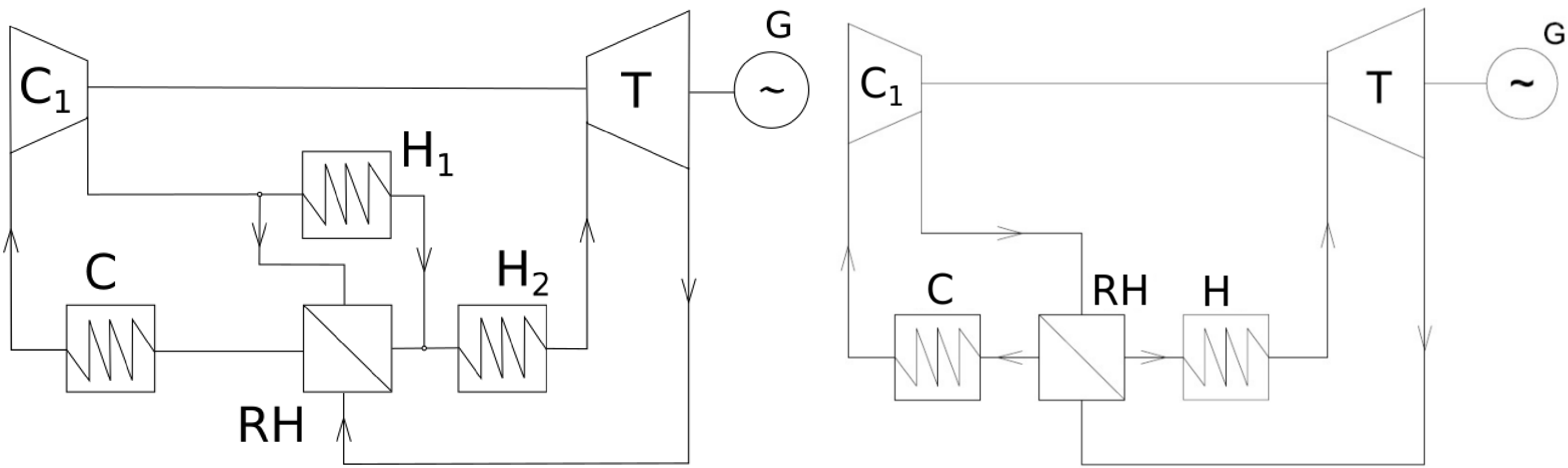
Split expansion cycle
Partial cooling cycle





CTU in Prague

Waste heat recovery systems

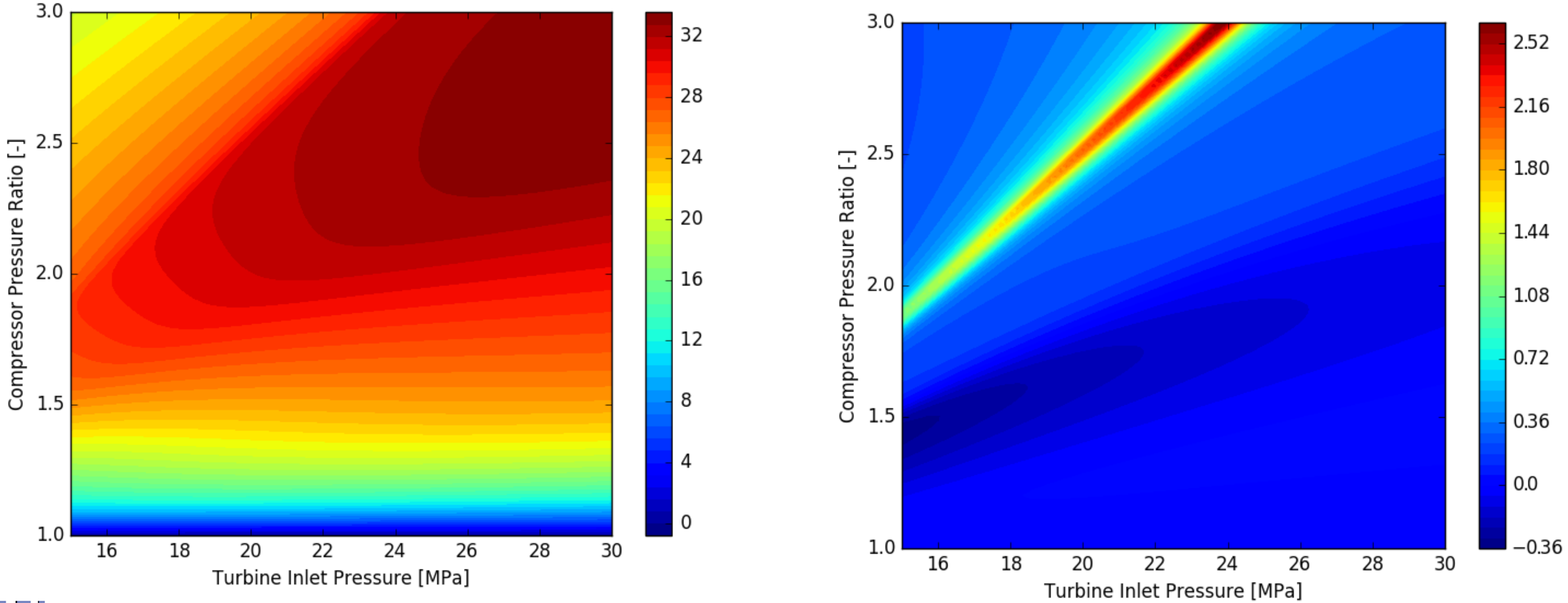


	Preheating C.	Simple C.	
Cycle efficiency	32.1	27	%
Net power output	9.8	6,9	MW
Compressor input power	3,1	2.9	MW
Turbine power output	12.9	9.8	MW

Effect of mixture

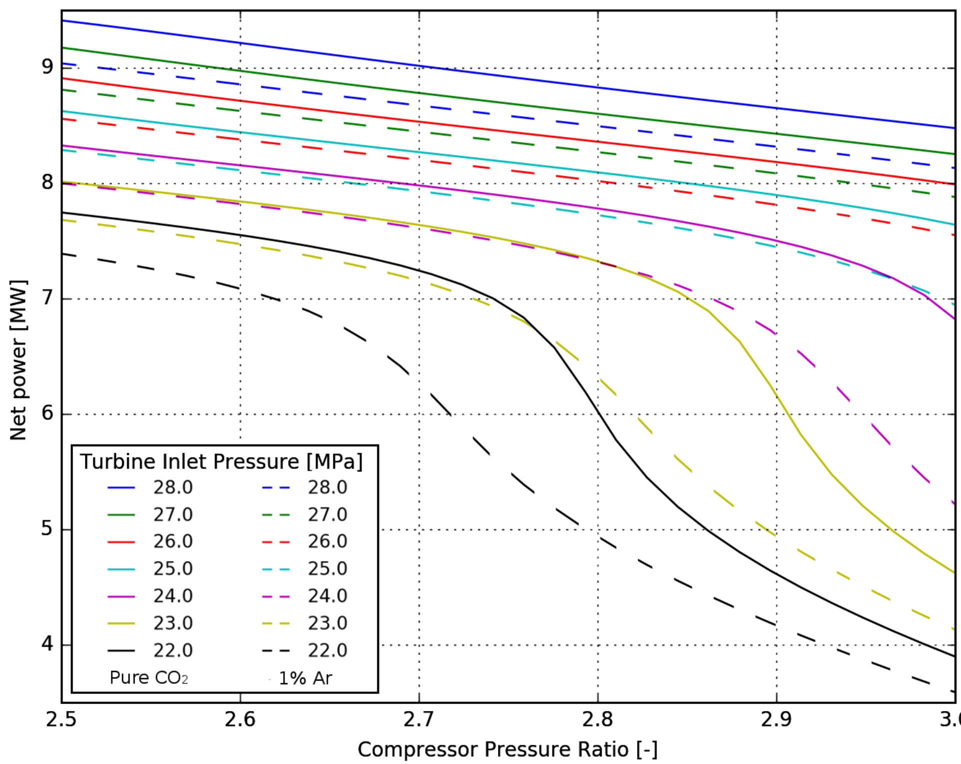
The **maximum cycle efficiency** (pure CO_2) - **33 %.**

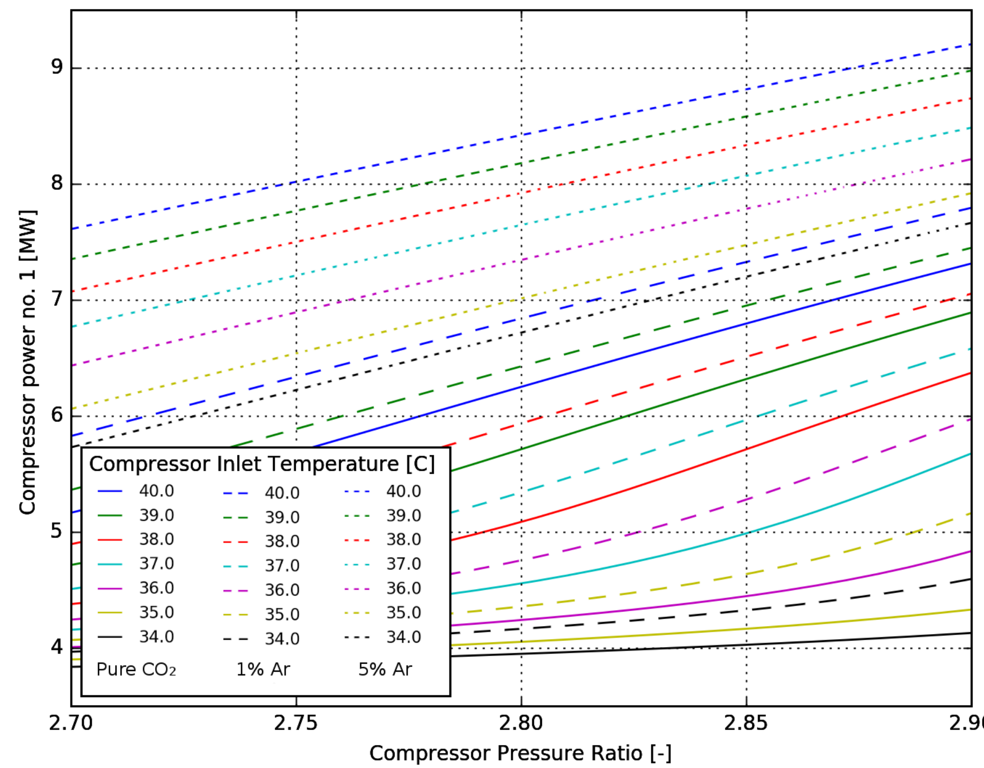
- The difference of cycle efficiency is up to 2.5 %.
- The results is for 0.01 mole fraction of secondary substance.
- Results are for mixture CO_2 – Ar.



Vesely L., Dostal V., Stepanek J., Effect of Gaseous Admixtures on Cycles with Supercritical Carbon Dioxide, 2016: Proceedings of ASME TurboExpo 2016: Turbomachinery Technical Conference and Exposition.

Effect of mixture





Vesely L., Dostal V., Stepanek J., Effect of Gaseous Admixtures on Cycles with Supercritical Carbon Dioxide, 2016: Proceedings of ASME TurboExpo 2016: Turbomachinery Technical Conference and Exposition.

C T U i n P r a g u e

Thanks for your attention

Ladislav Vesely
Department of Energy Engineering
Faculty of Mechanical Engineering
Czech Technical University in Prague

Contact: Ladislav.Vesely@fs.cvut.cz