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TEKNOLOGISK INSTITUT

Steam compressor technology and development: a general overview

Steam generating heat pumps, OST Webinar, 18 March 2024

TEKNOLOGISK INSTITUT

Steam compressor technology – a general overview

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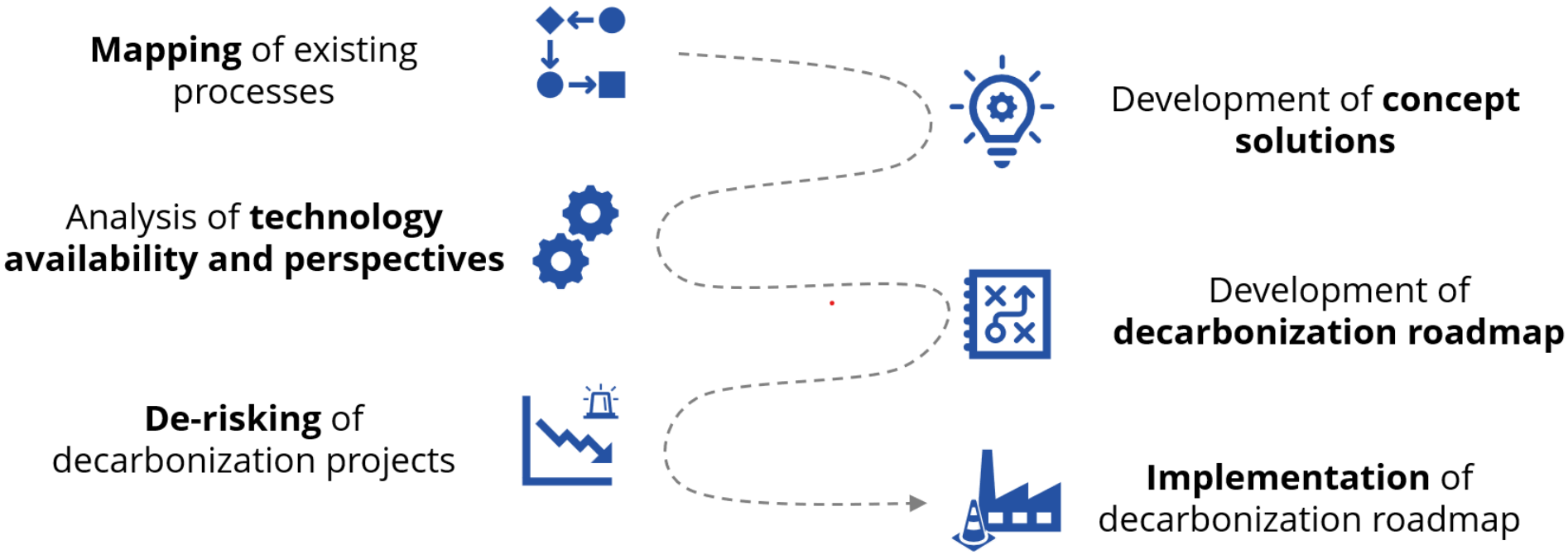
Steam generating heat pumps

OST Webinar, 18 March 2024

Steam compressors - overview

Activities at DTI:

Development of decarbonization strategies (consultancy, concepts, projects, tests,..):



Steam compressors - overview

Steam as refrigerant:

Benefits:

Very efficient, in particular in the 100°C to 250°C range, due to physical properties

High critical temperature (371°C)

Environmentally safe

Cheap, readily available and well-known by the industry

Challenges from a compressor perspective:

Immiscible with oil – oil free compressor types or water as lubricant and seal

Low atomic mass - high pressure-ratio and high discharge temperature

Steam compressors - overview

Steam as refrigerant:

TRL 9 :

Originates from process industry – large capacities, multi-stage, customized system

Originates from MVR process – around 100°C, small temperature lift

Special development for HTHP – very few options

< TRL 9:

Modified or adapted versions of existing compressor technology

Modified or adapted versions of vacuum pump technology

Great need for further development for standard units at lower capacities and high temperature lift

Steam compressors - overview

TRL 9:

Integrally geared centrifugal compressors

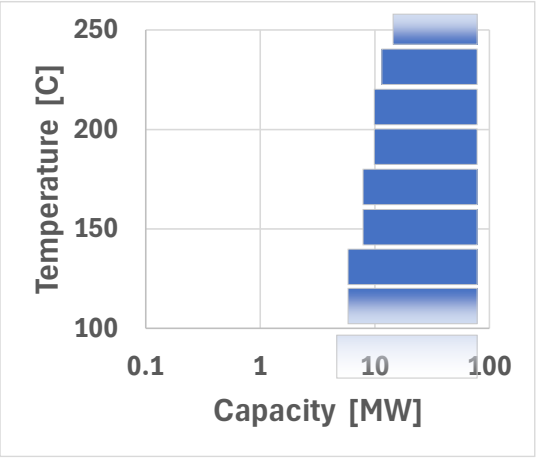
Customized systems of a number of centrifugal stages

Origin:	Process industry
Capacities:	≈10 MW to ≈80 MW
Temperature lift:	20°C to 25°C per stage
Supply temperature:	Up to >250°C, superheated

Manufacturers:

Siemens, MAN, Atlas Copco, Howden, Turboden, ...

(Howden)

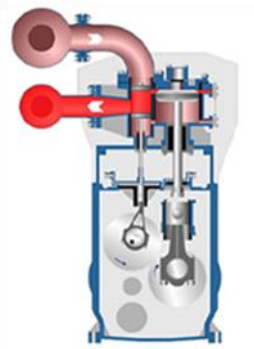


Steam compressors - overview

TRL 9:

Piston compressors

Customized systems with a number of cylinders and a number of stages



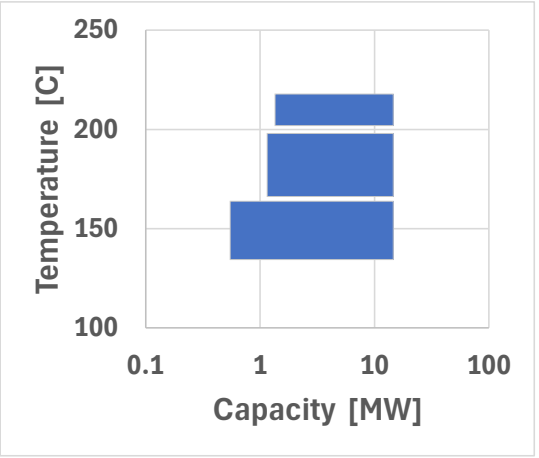
(Spilling)

Origin: Process industry

Capacities : ≈1 MW to ≈10 MW

Temperature lift: 30°C to 40°C per stage

Supply temperature: Up to ≈220°C, water injection



Manufacturers:

Spilling

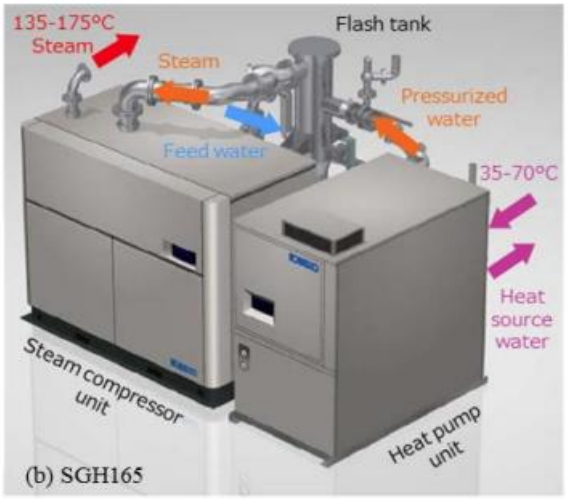
Steam compressors - overview

TRL 9:

Screw compressor

Standard unit

(Kobelco)

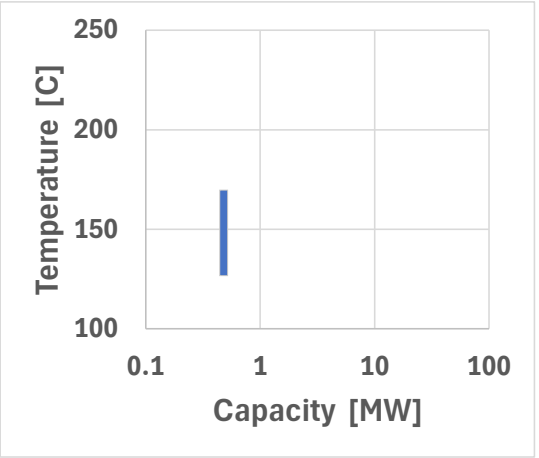


Origin: High-temperature heat pump, developed specifically for the SHG heat pump

Capacities: 0.6 MW

Temperature lift: 40°C

Supply temperature: 165°C to 175°C, water injection



Manufacturers:

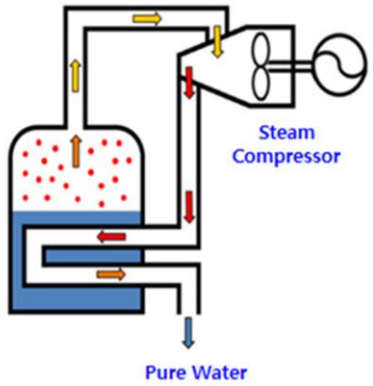
Kobelco

Steam compressors - overview

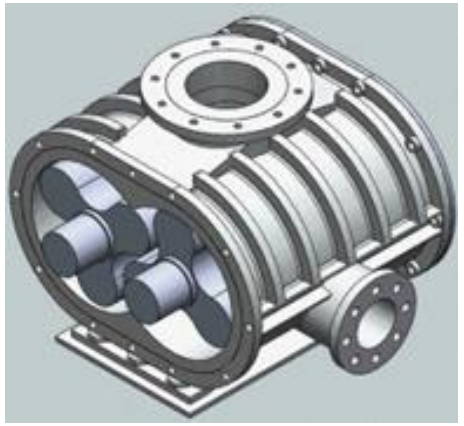
TRL 9:

Roots (lobe) compressor

Standard units and customized units



(MVR process)

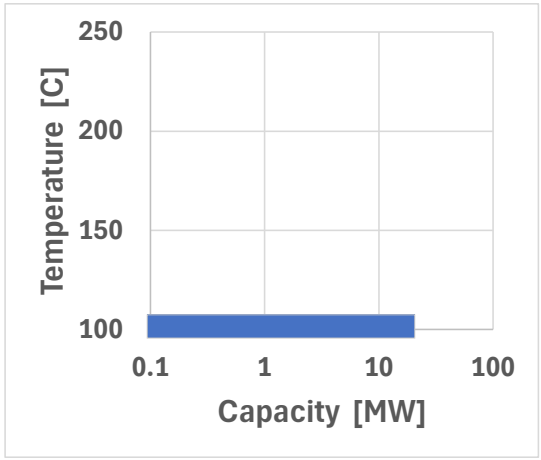


Origin:	MVR process
Capacities:	0.1 MW to 15 MW
Temperature lift:	10°C to 20°C
Supply temperature:	105°C to 115°C

Manufacturers:

Kay, Kaeser, Shangu, Robuschi, Kubicek, ...

(Kay)

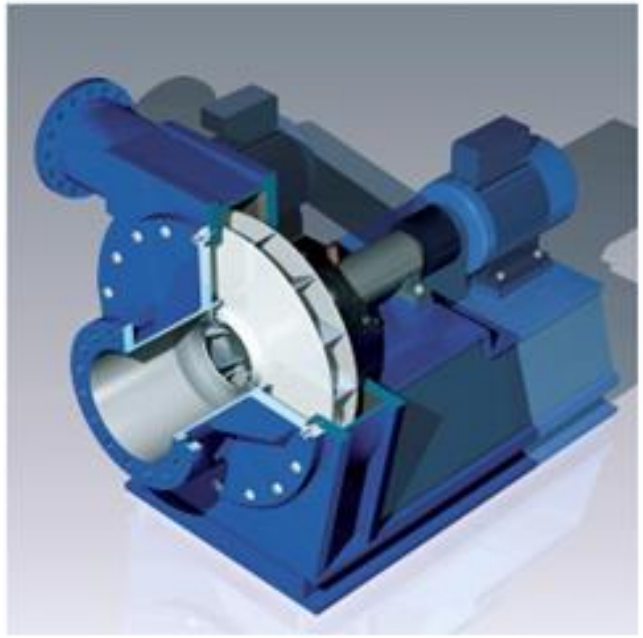


Steam compressors - overview

TRL 9:

Turbo fan

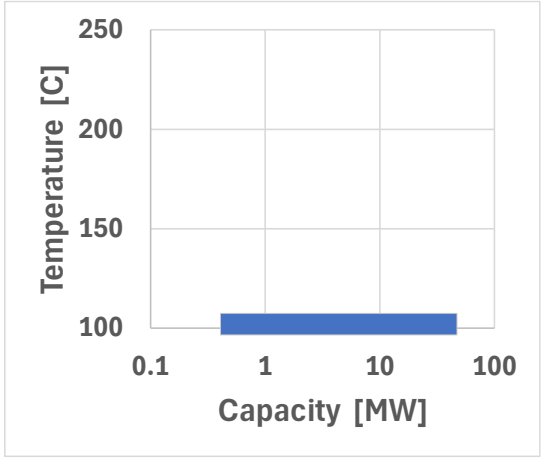
Standard units and customized units



Origin:	MVR process
Capacities:	0.5 MW to 50 MW
Temperature lift:	10°C (to 20°C)
Supply temperature:	105°C to 115°C

Manufacturers:

Piller, Howden, Atlas Copco, ...



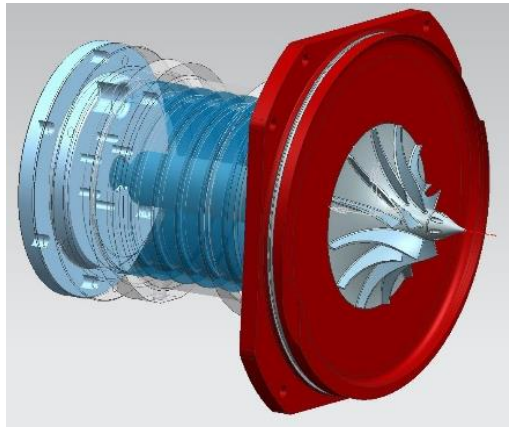
Steam compressors - overview

TRL < 9:

Direct drive turbo compressors

Standard units and customized units

(Weel & Sandvig)



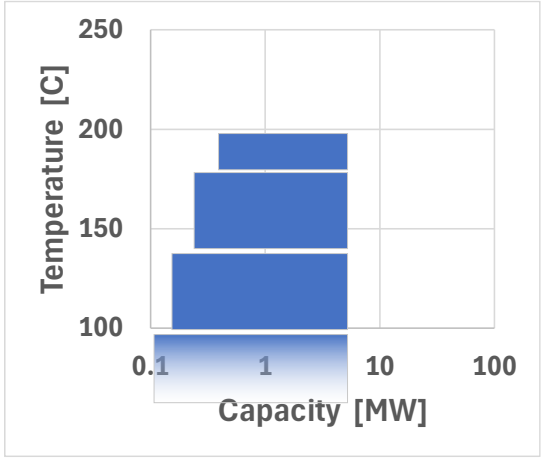
(CSTechom)

(Rotrex)

Capacities: 0.1 MW to 5 MW

Temperature lift: 30°C to 40°C per stage

Supply temperature: 100°C to 200°C, superheated



Developments:

Rotrex, Weel & Sandvig, CSTechcom, ...

Steam compressors - overview

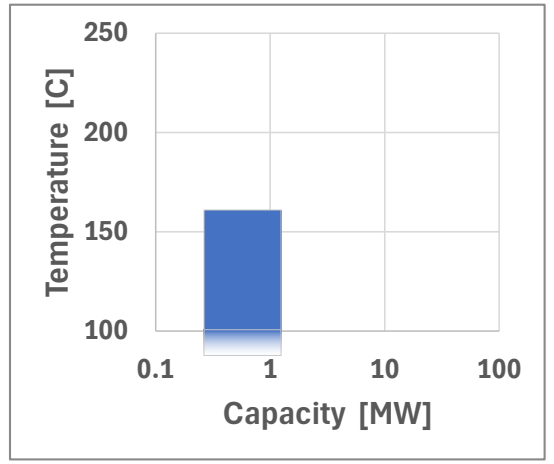
TRL < 9:

(SRM)

Screw compressors

Standard units

Capacities:	0.3 MW to 2 MW
Temperature lift:	50°C to 70°C
Supply temperature:	130°C to 165°C, water injection



Developments:

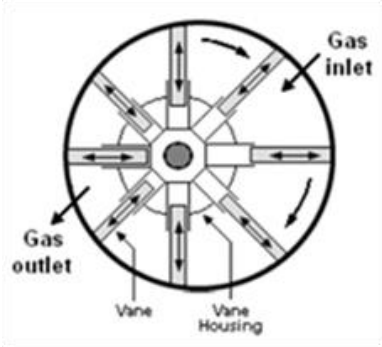
SRM, Atlas Copco, Howden, ...

Steam compressors - overview

TRL < 9:

Rotary vane

Standard units

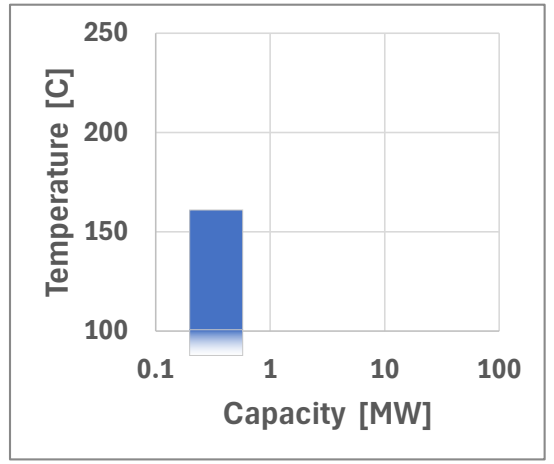


(ToCircle)

Capacities:	0.2 MW to 0.6 MW
Temperature lift:	50°C to 60°C
Supply temperature:	160°C to 170°C, water injection

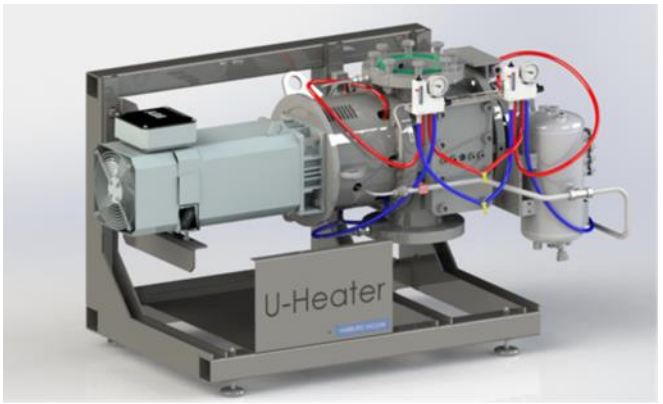
Developments:

ToCircle



Steam compressors - overview

TRL < 9:

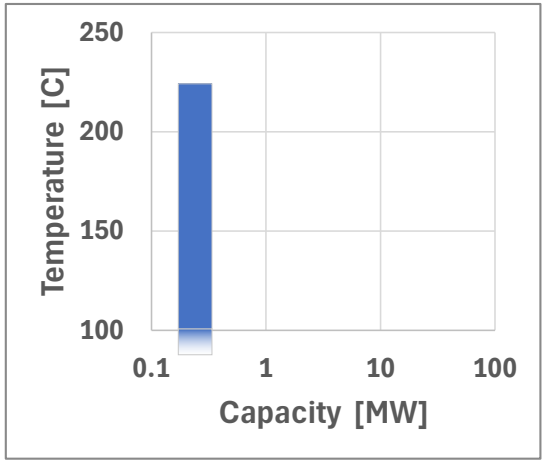


(Hamburg Vacuum)

Spindle compressor

Standard units

Capacities:	0.2 MW to 0.6 MW
Temperature lift:	80°C to 120°C
Supply temperature:	160°C to 230°C, water injection

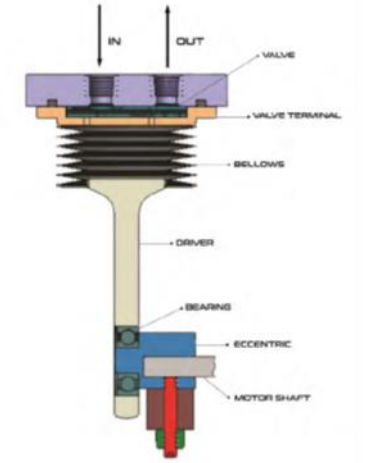


Developments:

Hamburg Vacuum

Steam compressors - overview

TRL < 9:

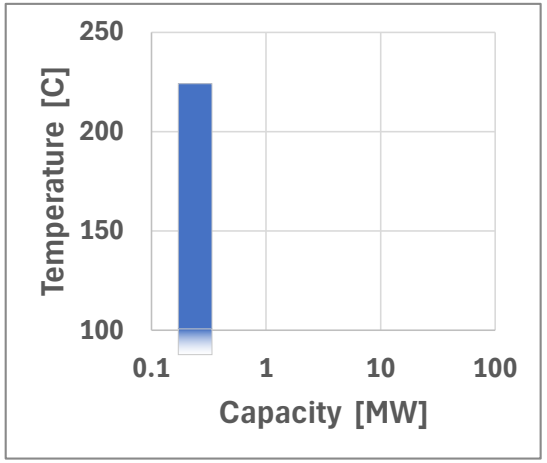


(Senior Metal Bellows)

Potentials: Scroll, claw, bellow

Standard units

Capacities:	0.1 MW to 0.5 MW
Temperature lift:	30°C to 80°C
Supply temperature:	120°C to 200°C, water injection



Developments:

None as steam-based heat pump

Steam compressors - overview

Activities at Danish Technological Institute (DTI)

Development and demonstration projects:

SuPrHeat, InterHeat, SPIRIT, .. new applications ..

Goal:

To establish HTHP units for demonstration at end-users (hardware development and process integration) ,

supply temperatures in the range 140°C to 200°C, 0.5 MW to 1 MW

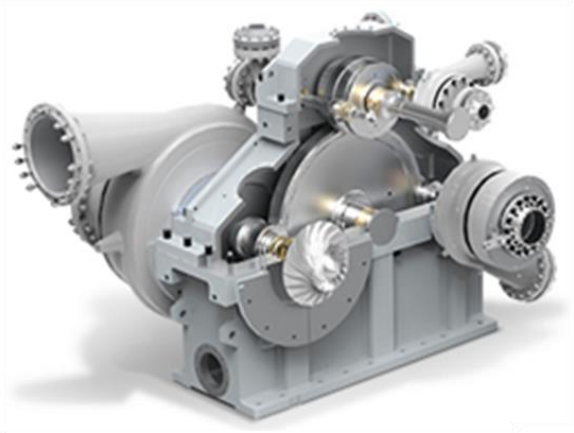
Refrigerants (cascade):

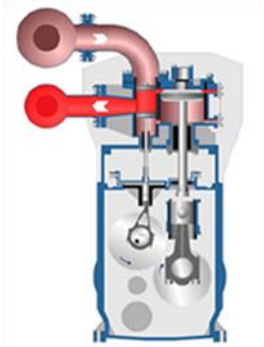
Hydrocarbons, CO_2, steam, NH_3

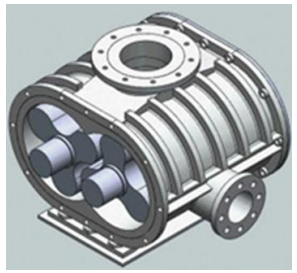
Steam compressor technologies:

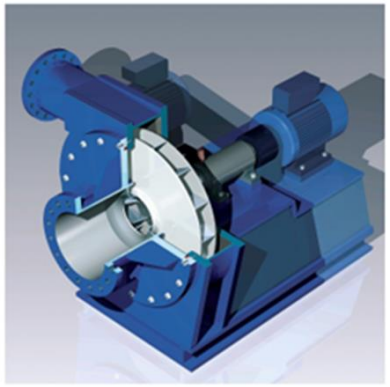
Direct drive turbo compressor, spindle compressor, screw compressor, piston compressor

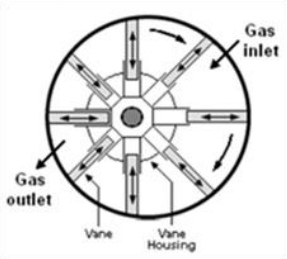
Steam compressors - overview











Thank you