The new technology of condensed rotational separation

μ-separation

The New Technology of

Condensed Rotational Separation

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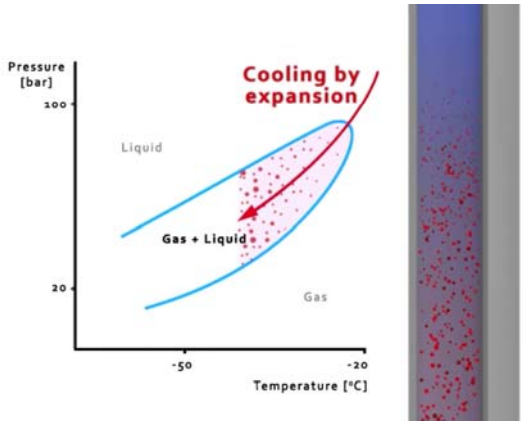
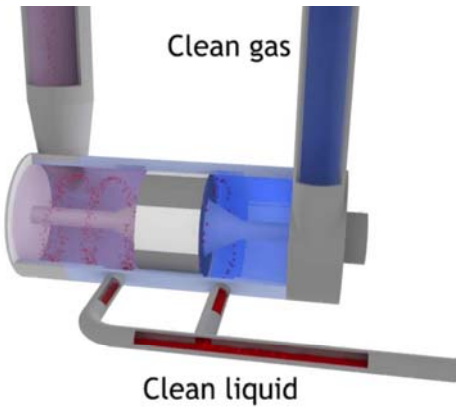


Innovation 1:

Fast cooling of mixture into the two phase region by expansion through J-T valve or turbine

One component becomes a mist of fine droplets.

μ-separation 1 Principles of CRS and RPS

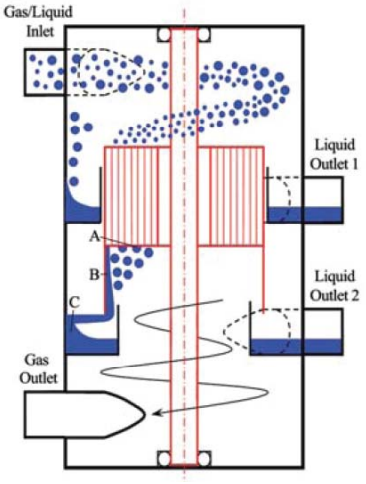


animation: www.mu-separation.com

Innovation 2:

The fine droplets are separated by the Rotational Particle Separator

μ-separation — 2 RPS designs



The **rotational phase separator** (RPS) is a cyclonic device wherein a rotating element is placed. The rotating element is a simple cylinder consisting of a very large number of axial channels or pipes of a few millimeters in diameter.

The cylinder is freely mounted in an enclosed stationary housing. Rotation is generated by the tangential velocity of the gas entering the device.

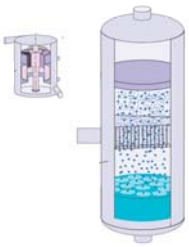
The micron-sized droplets are centrifuged to form a liquid film at the channel-wall. The film is ripped of at the exit of the channel in the form of droplets; typically 50 micrometer or larger. These droplets are separated according the working principles of ordinary axial cyclones.

Large droplets are centrifugated to the wall in the inlet part of the device. They leave via outlet 1. The fine droplets (1 to 10 micrometer) enter the channels of the RPS, coagulate, leave the channels as large droplets and leave the RPS via outlet 2

FILTRATION (2012) 12(1) 49-60

μ-separation — 2 RPS designs

Size advantage of the RPS



Selection Guide - Mist Elimination Equipment					
	Knitted Mesh	Vane	Fiberbed	Cyclone	RPS
Cost	1	2-3	10	3-5	5-10
Gas Capacity	5	6-15	1	15-20	20-50
Liquid Capacity	5	10	1	10	20
Particle Size (micron)	3-10	10-40	< 0.1	7-10	0.5
Pressure Drop, WC	< 25 mm (1")	<10-90 mm (0.4" - 3.5")	50-500 mm (2" - 20")	200-240 mm (8" - 14")	200-240 mm (8" - 14")
Solid Handling	3	10	1	8	8
Relative scale based on 1 as the lowest. Others are scaled.					

adapted from: Koch-Glitsch "Mist Elimination"

The characteristics of the RPS makes it possible to separate particles below 10 micrometer especially under pressure in large throughput installations.

μ-separation — 2 RPS designs

The RPS offers economic advantages in all processes where demisters are needed:

Solvent recovery	Inlet separators
Evaporators	Turbo-expander suction drums
Steam drums	Dew-point separators
Knock-out pots	Compressor suction drums,
Inert gas scrubbers	Glycol dehydration
MSF/MED desalination	
Sulfuric acid absorbers and dryers.	

The RPS is particularly applicable to systems where reduction in size / weight is advantageous such as offshore production. The rotating equipment used in CRS eliminates the need for high structures on deck and is not affected by the motion of the platform.

In i.e. solvent and LNG plants the RPS improves efficiency by reducing liquid carry-over and equipment volume.

The RPS improves efficiency and reduces size in all processes where droplets < 10 micrometer occur.

The RPS enables the use of efficient high pressure expansion processes for large throughput plants.

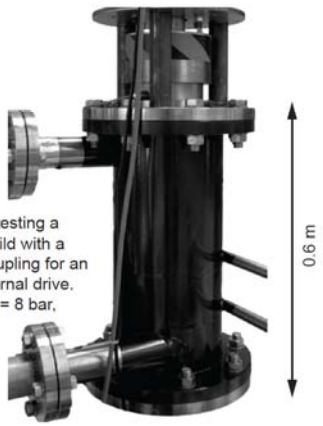
μ-separation — 2 RPS designs

For evaluating the cryogenic pressure distillation process of Condensed Rotational Separation two gas- liquid versions are realized: one at lab scale for real process conditions and one at real scale but atmospheric conditions.

T = -60 °C, P = 27 bar,
m = 0.02 kg/s

T = 20 °C, P = 1 bar,
m = 0.3 kg/s

For general testing a version is build with a magnetic coupling for an optional external drive.
T = 20 °C, P = 8 bar,
m = 0.3 kg/s



All versions perform according to the design specifications

J. Fluids Eng (2010) 132(3) 031301-1 Chem Eng Techn (2012)

μ-separation

The RPS as an efficient and compact demister allows new processes such as Condensed Rotational Separation for:

-Removing H2S/CO2 from natural gas

-CO2 removal from flue gases

-H2 production from syngas

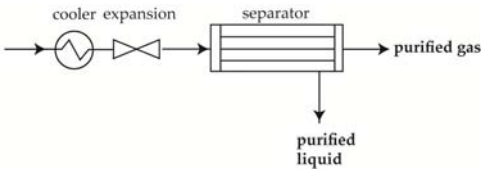
The potential of the applications is assessed on two criteria:

-Energy costs (=OPEX)

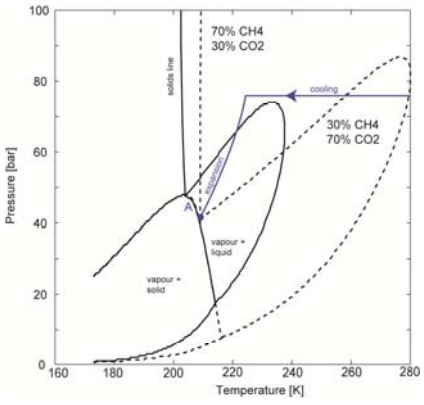
-Volume (=residence time = CAPEX)

Oil & Gas J. (2006) 104(42)

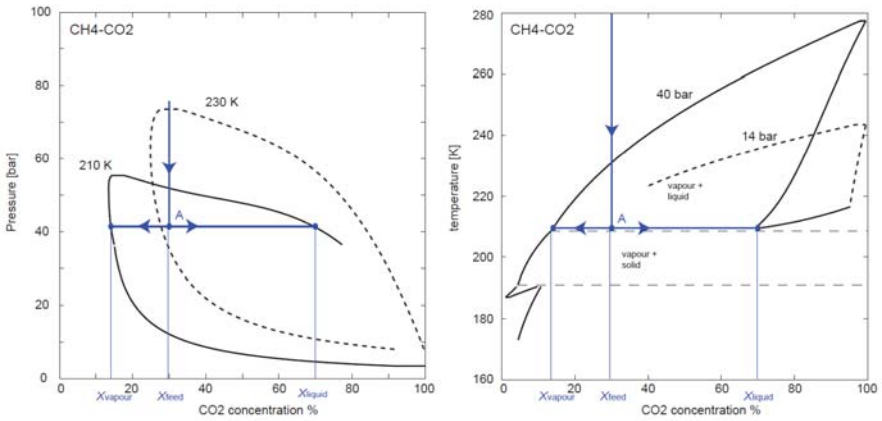
μ-separation 3 CRS for contaminated natural gas



In CRS the gas mixture is chilled by a combination of cooling and expansion to a point in the phase diagram where the purity of the gas is maximal (A).



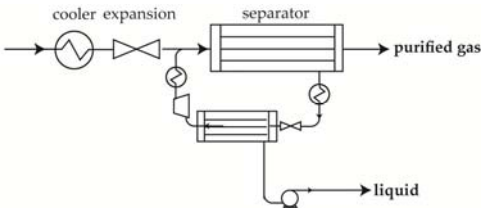
μ-separation 3 CRS for contaminated natural gas



The purity of the gas is independent of the feed concentration

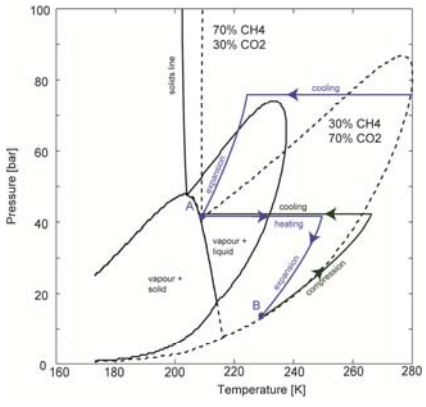
The liquid still contains a considerable amount of methane

μ-separation 3 CRS for contaminated natural gas

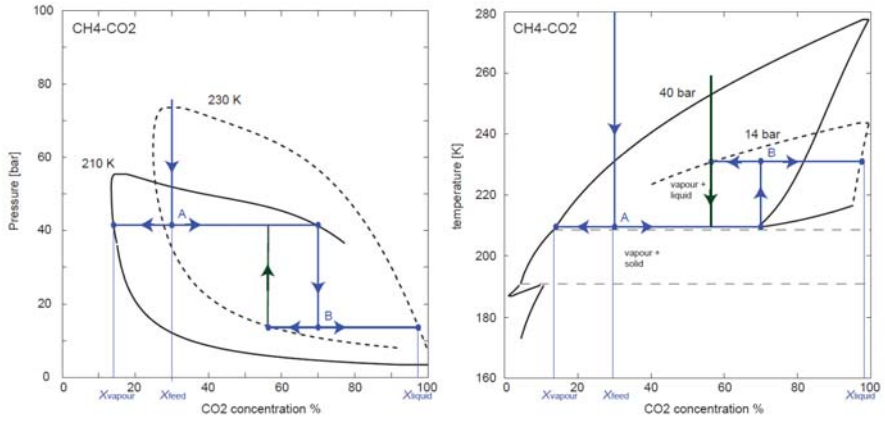


The liquid stream is subsequently heated and expanded to a point of maximum purity of liquid contaminant (B).

The gas from the second flash is compressed and refed to the first stage.



μ-separation 3 CRS for contaminated natural gas



The liquid is also near the maximal value

μ-separation 3 CRS for contaminated natural gas

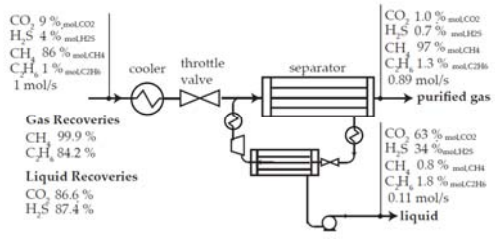
Wasit gas plant Saudi Arabia

Condensed Rotational Separation

produced gas purity [%mole]	98.5
equipment size [-]	0.03
energy costs [% incoming heating value]	0.64

Amine treatment

produced gas purity [%mole]	99.9
equipment size [-]	1
energy costs [% incoming heating value]	3.8



CRS Performance Summary:

Gas Purity:
- contaminant CO2+H2S : reduction to ~1%
- contaminant H2S only: reduction to < 1% but not ppm
- contaminant CO2 only: reduction to 12-15 %
  independent of incoming concentration

Liquid (H2S/CO2) purity: 95 - 99%

Methane recovery: 99.0% - 99%

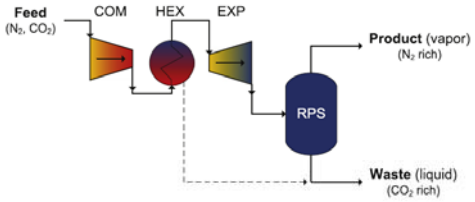
Energy consumtion: 1% - 3% of methane heating value

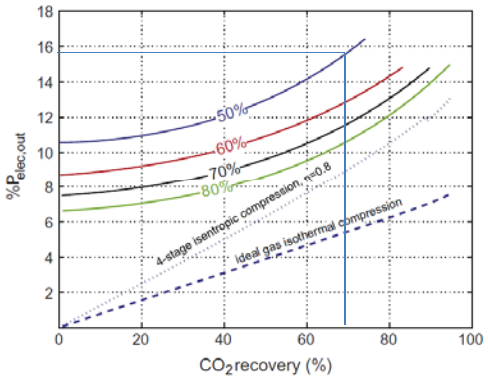
Residence time 0.1 s hence compact installation

CRS facilitates profitable exploitation of gas fields with contamination levels up to 70 %

J Petrol Explor Prod Technol (2012) 2:49–56

μ-separation 4 CRS for CO2 removal from flue gas





Requires enrichment of CO2 in the feed stream to only 50 % (i.e. by membranes) for a CO2 recovery of 70%.

The energy penalty of CRS is only slightly higher than the energy required to compress gaseous CO2: CRS consumes little extra energy

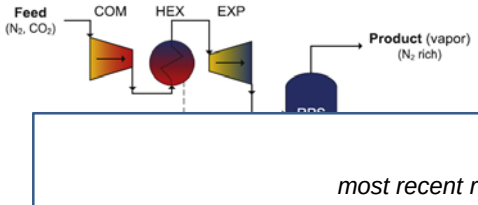
The advantage is that the capital and operation costs are relaxed on the enrichment step prior to CRS.

Net result: Size of installation and energy consumption because of CO2 capture become less when CRS is introduced.

CRS becomes more economical with increasing CO2 content in the flue gas (cement production, steel works etc)

Applied Energy (2012) 93 457-465

μ-separation 4 CRS for CO2 removal from flue gas

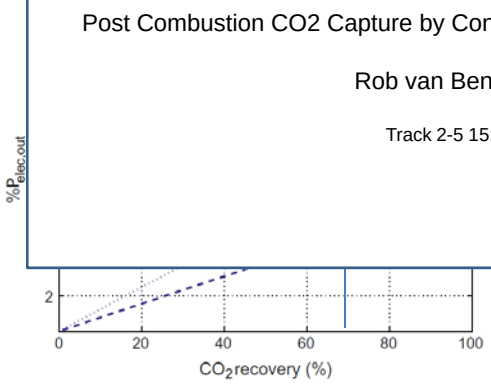


most recent results:

Post Combustion CO2 Capture by Condensed Rotational Separation

Rob van Benthum

Track 2-5 15:50

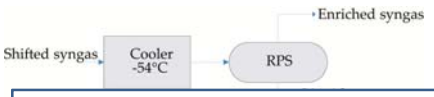


Requires enrichment of CO2 in the feed stream to only 50 % (i.e. by

CRS becomes more economical with increasing CO2 content in the flue gas (cement production, steel works etc)

Applied Energy (2012) 93 457-465

μ-separation 5 CRS for CO2 removal from syngases



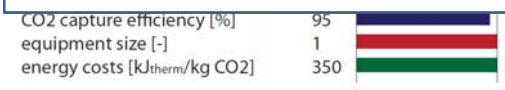
Two sequential steps:

most recent results:

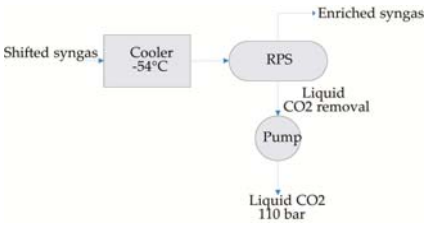
Condensed Rotational Separation for CO2 removal from syngases

Erik van Kemenade

Track 2-2



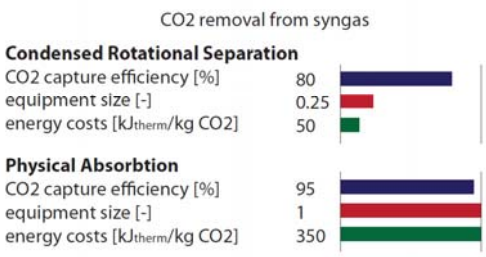
μ-separation 5 CRS for CO2 removal from syngases



Two sequential steps:

1 Cooling of syngas, leaving the coal gasifier, to -54°C. Part of the CO_2 condenses into droplets

2 Separation of CO_2 droplets from the syngas stream with a Rotational Phase Separator (RPS)



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6 Conclusions

Semi – cryogenic separation offers a large energy advantage compared to absorbtion techniques.

Condensed Rotational Separation ads a large size advantage over distillation columns by using the Rotational Particle Separator.

The Rotational Particle Separator is available to industry as a very efficient mist eliminator.

Condensed Rotational Separation (CRS): ready for field test in
- upgrading H2S/CO2 contaminated natural gas fields
- CO2 removal from flue gases
- CO2 removal in H2 production

Can CRS advance your process ?

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Thanks for your attention

This presentation and much more is available on:

www.mu-separation.com