COMPART COMPRESSOR TECHNOLOGY CO.,LTD

Valve problems and their solutions based on practical examples

Peter Rausch

1. Introduction

Valves as control elements are important components of a reciprocating compressor which are subject to a heavy strain.

The aim of this workshop is to explain the use of different versions of valves, including both advantages and disadvantages.

Starting with the classical plate valve – in use more than a 100 years – the geometrical basics of different designs, the dimensioning of the valves up to the dynamics of the valve plate in different applications will be described.

Researches on reciprocating compressors have ultimately revealed that the valve design alone leads only in exceptional cases to a better operating valve.

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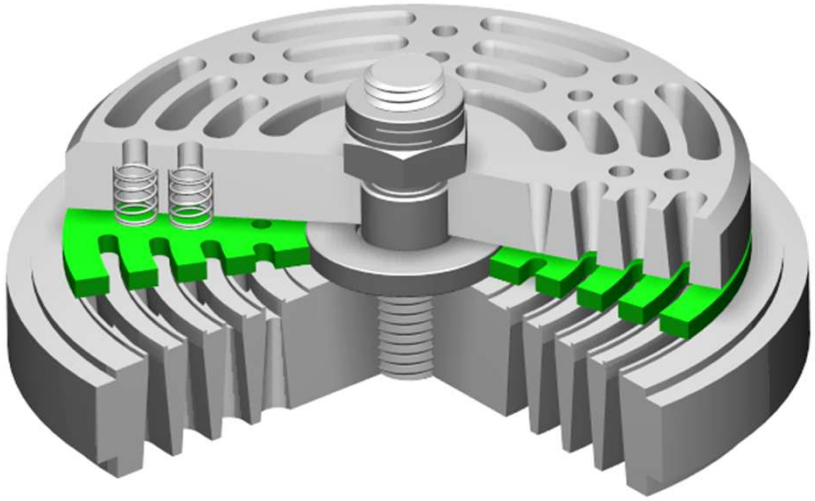
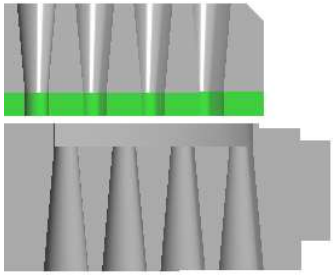
2. Valve designs and their different flow geometries



2.1 Plate valve



Classical compressor valve for universal applications.

Suited for any gas, pressure and speed.

Designing the ports more slender makes it possible to increase their amount which leads to a smaller lift of the valve plate by equal passage area and a lower impact.

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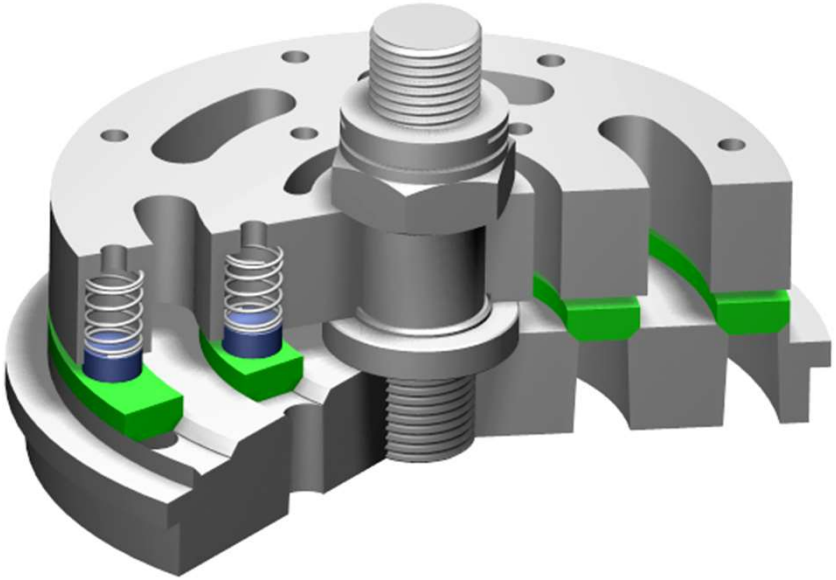
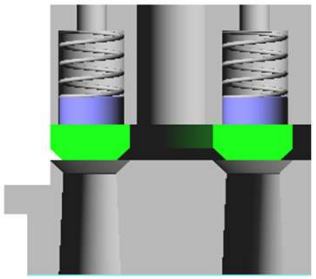


2.2 Ring valve with profile 40°



The geometry of the profile rings reduces the pressure loss of the valve.
The individual rings cope better with condensates in the gas. Large ports and self-cleaning effect due to the tangential contact of the rings against the conical sealing faces build an advantage in polluted gases.
However, temperature has an disadvantegeous effect caused by different expansion rates of the ring and seat material.
Large rings are subject to torsions which – as well as temperature – can lead to valve leakages.
Due to the profiled design of the ring is a higher lift for an equivalent valve passage area required (at 45º profile = 30%). Thus the actual advantage of the ring geometry is reduced.

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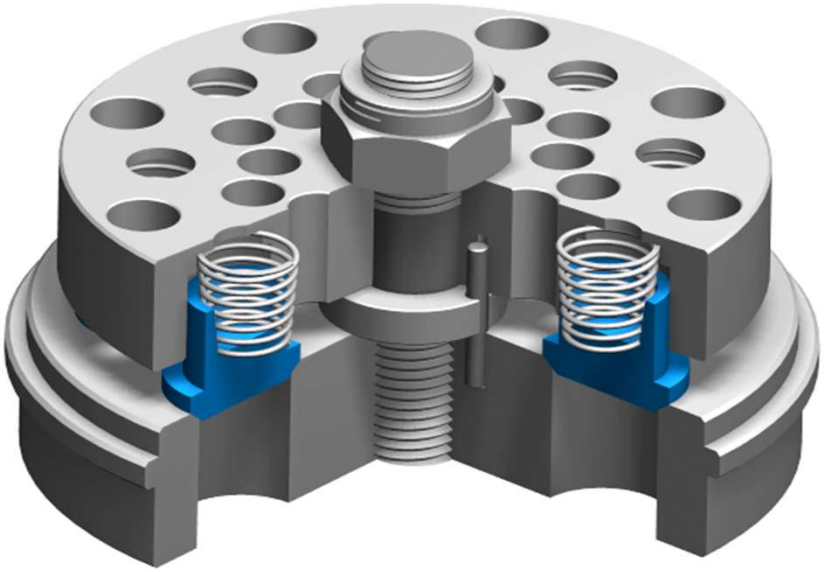
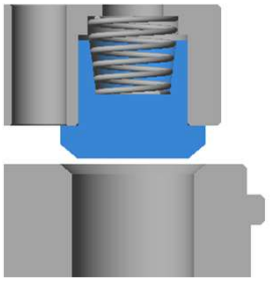


2.3 Poppet Valve with profile 45°



Good flow characteristics with the poppets, similar to profiled rings.

The reduction to one sealing face leads specially in light gases to a minimized leakage.

As a result of the reduction of the sealing face area is a higher lift of the poppets required, beyond that is due to the design of the poppet additional lift of 30% needed to achieve the same passage area as by a comparable valve. That leads to a reduced speed of the compressor when using large poppets.

However, positive flow characteristics in the seat with its large ports are limited in the stop plate due to the redirection of the gas.

Just like profile ring valves are poppet valves very suitable for use in highly polluted gases and condensates.

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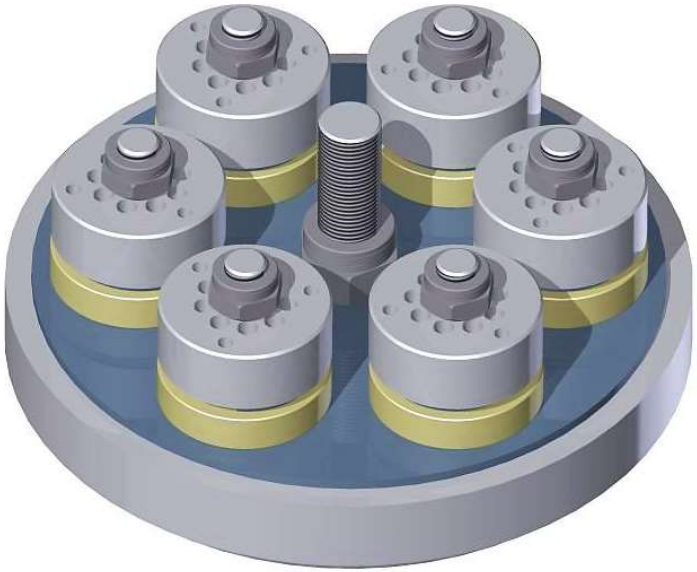
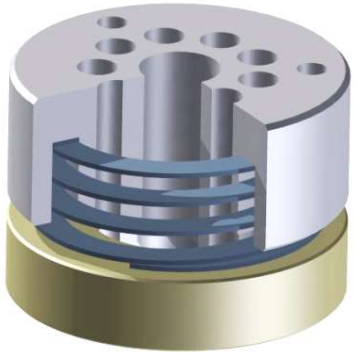


2.4 PRValve



The PRValve differs from the poppet valve by using rings instead of poppets. This design improves the flow area by using two sealing faces per ring and the lift can be reduced which results in a lower impact.

Additionally are the sealing faces replaced by a changeable seat plate. These seat plate can be separately manufactured and heat-treated to achieve higher durability and longer life time.

Another advantage is the possibility to recondition the valve without any machining only by changing the wear parts.

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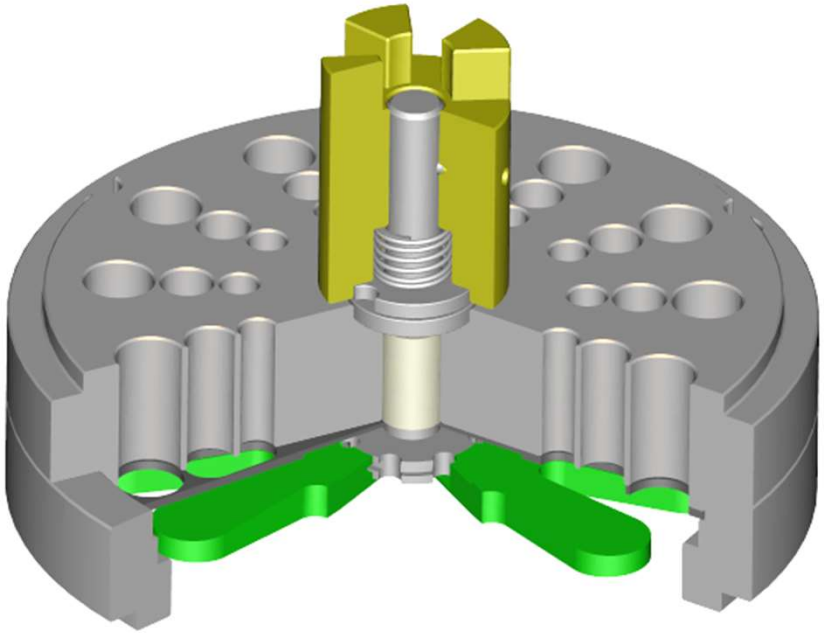
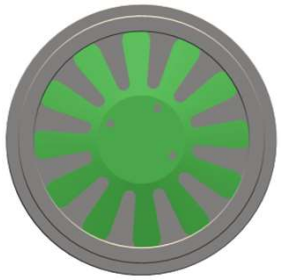
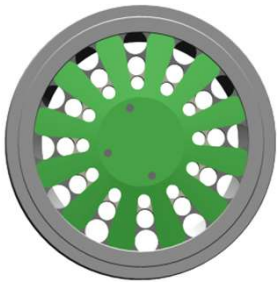


2.5 Special design PCValve





Force actuated rotary slide valve enables stepless capacity control.

Control data is acquired from the process and the valve plate is made subject of rotating movement. Due to the absence of lift and springs operates this valve independent of the gas density.

Therefore is PCValve among other applications specially suitable for the capacity control of flare gas compressors.

Due to the electronic control is this valve able to adapt to changing process conditions.

Furthermore result from the large seat area and straight flow characteristics of the gas the least pressure losses of all above mentioned valves.

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3. Comparison of different valve designs

The comparison data of the valves have been calculated for a compressor with following operating conditions:

Speed:	600 rpm
Suction pressure:	1,00 bar
Discharge pressure:	3,06 bar
Medium:	Air, dry
Valve sizes:	according to 105 mm sealing face-Ø

The following table clearly shows that with nearly identic passage areas the lift of the individual valves varies considerably:

	Plate valve 3 channels	Ring valve 40° 2 channels	Poppet valve 45° 1 row	PRValve 1 row	PCValve 2 rows
Seat area [cm²]	**34,96**	**39,52**	**25,13**	**23,56**	**16,78**
Passage area [cm²]	**16,78**	**16,26**	**16,71**	**16,96**	**16,78**
Sealing length [mm]	**1398**	**930**	**503**	**942**	**701**
Lift [mm]	**1,20**	**2,35**	**4,70**	**1,80**	-

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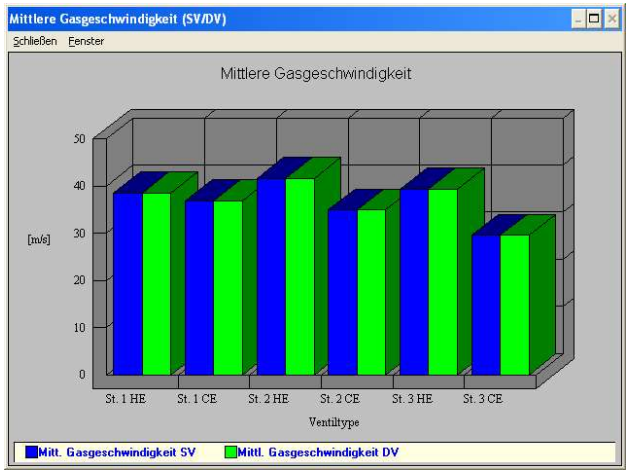
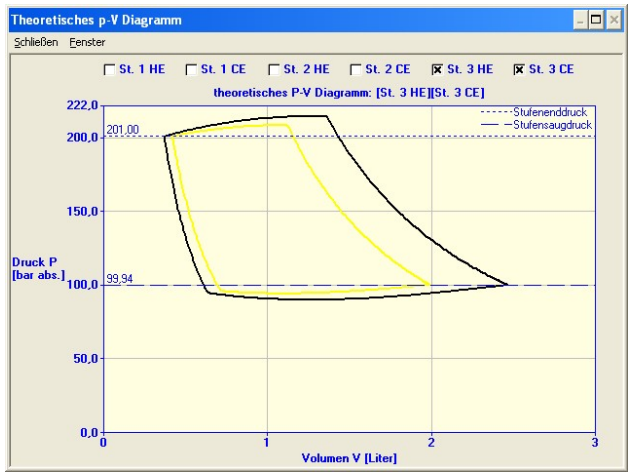
4. Common reasons for valve problems

Research on compressors over many years has shown that most of the valve problems are caused by insufficient valve plate lift and unqualified spring systems and that the design of the valve leads only in exceptional cases to a better working valve.

Case 1 – Valve plate cracks

Natural Gas Compressor Reinjection, 3 stages / Pressure 10,4 – 210 bar





Valve problems in the 3rd stage caused by too high gas velocity.

Resulting from the gas velocity also high pressure losses.

Reason:

Passage area too small.

Solution:

No existing valve solution. A new cylinder is required for a bigger valve pocket to increase the passage area in the 3rd. stage

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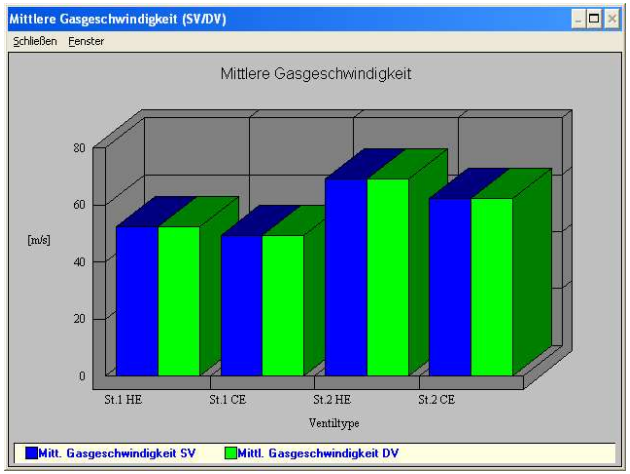
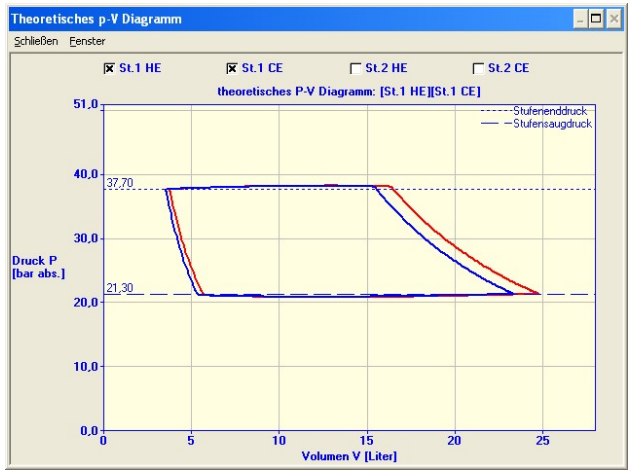
4. Common reasons for valve problems

Case 2 – Valve plate cracks

Hydrogen compressor, 2 stages / Pressure: 21,3 – 66,7 bar





Valve problems in the 1st stage caused by too low gas velocity.

Insufficient gas forces and minor pressure losses.

Reason:

Passage area too big.

Solution:

Reducing the lift from 1.80 to 1.20 mm.

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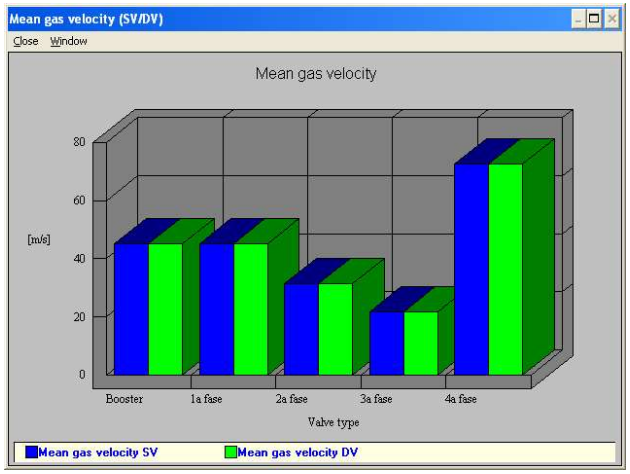
4. Common reasons for valve problems

Case 3 – Valve plate cracks and high loss of pressure

Ethylen Compressor, 4 stages + Booster / Pressure: 1,0 – 280 bar



Valve problems in 4th stage caused by extreme gas velocity.

Very high gas velocity and consequential pressure losses.

Reason:

Very small passage area.

Solution:

New valve by the same diameter with a bigger passage area.

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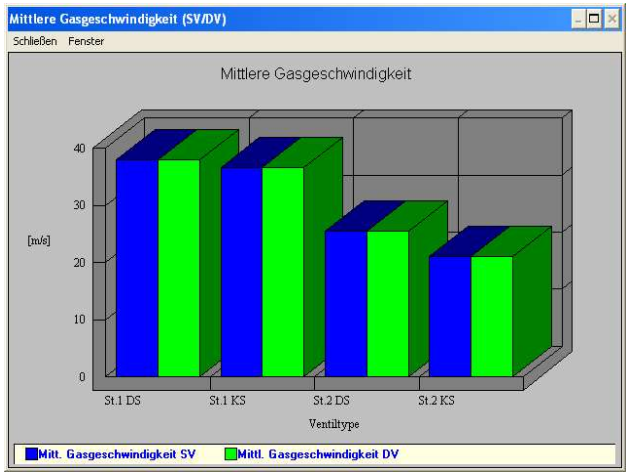
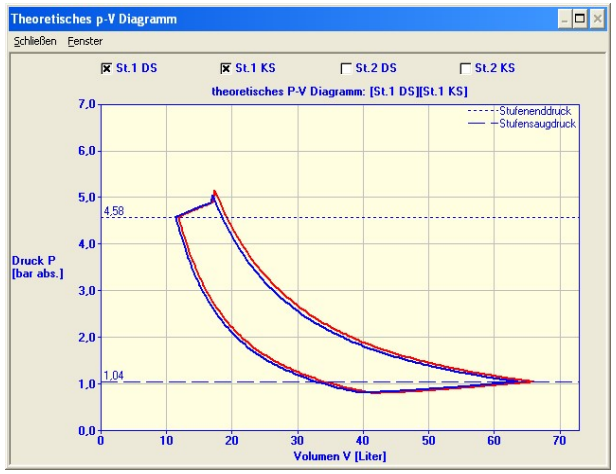
4. Common reasons for valve problems

Case 4 – Limited life times

CNHM compressor, 2 stages / Pressure: 1,04 – 17,6 bar





High suction and discharge valve losses of ca. 12% of the 1st stage caused by too high gas velocity.

Reason:

Passage area too small.

Solution:

Increase the lift from 1.40 to 2,00 mm.

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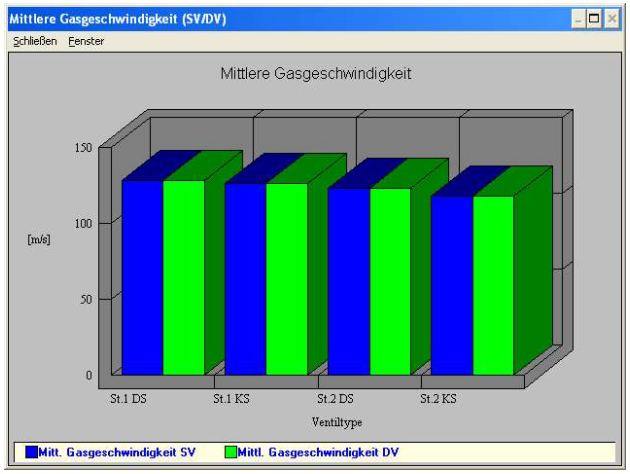
4. Common reasons for valve problems

Case 5 – Pressure losses

Hydrogen compressor, 2 stages / Pressure: 1,5 - 13,0bar



Suction and discharge valve losses of ca. 4% in the 1st and 2nd stage caused by too high gas velocity.

Reason:

Passage area too small.

Solution:

Increase the lift by 0.4 mm in the 1st. stage and 0.8 mm in the 2nd. stage.

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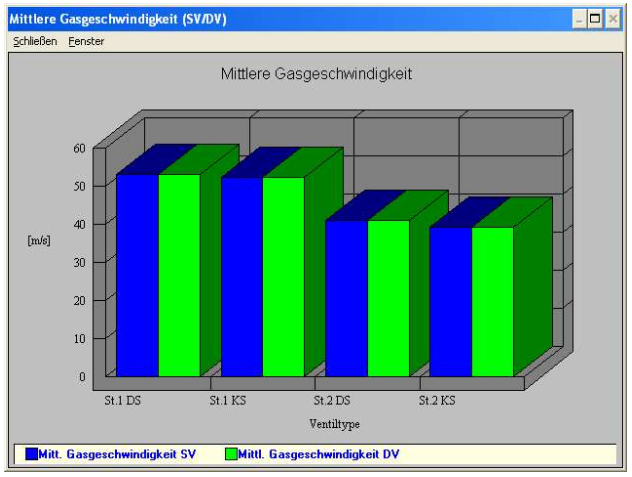
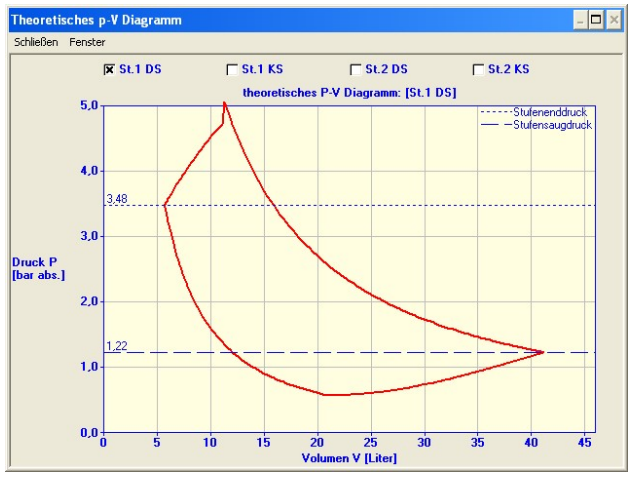
4. Common reasons for valve problems

Case 6 – High pressure losses

Propane gas compressor, 2 stages / Pressure: 1,5 - 13,0bar





Pressure valve loss of ca. 31% in the 1st stage caused by too high gas pressure.

Reason:

Passage area too small.

Solution:

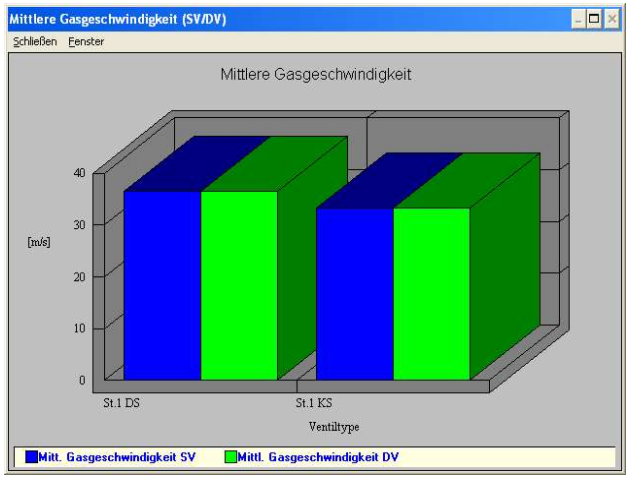
Increase the lift from 1.20 to 1.80 mm.

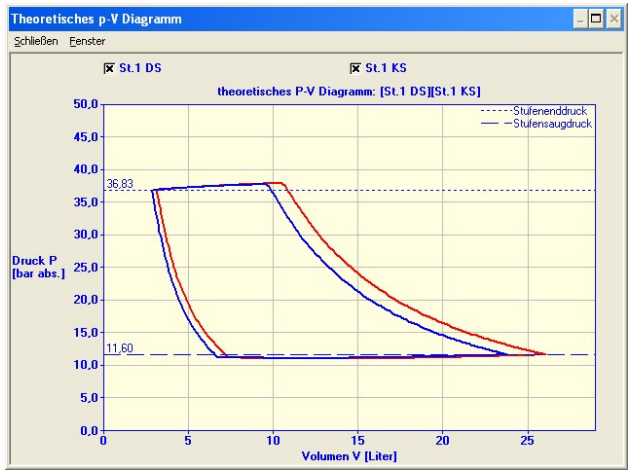
The above described cases from daily practise are limited to problems caused only by incorrectly designed valve lifts. All valve problems were solved either by modification of the valves or by optimized new valves, with the exception of the valves of the Natural Gas Reinjection Compressor. In this case were the valve compartments designed too small to achieve an improvement by installing larger valves.

4. Common reasons for valve problems

Case 7 – Valve problems caused by very high spring forces

H2 Mixed Gas Compressor, 1 stage / Pressure: 11,6 – 38,0 bar





The calculations of gas velocities and the theoretical p-V diagram did not reveal any problems.

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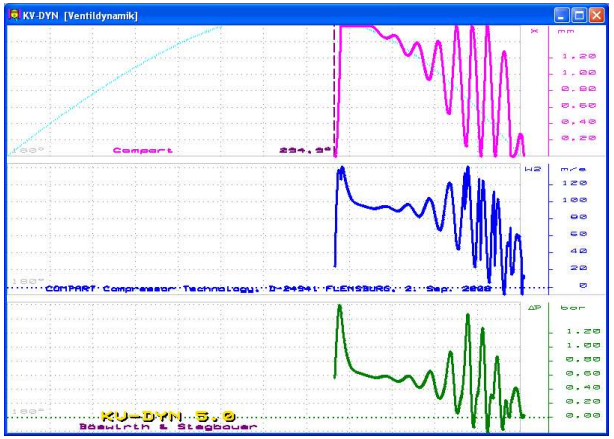

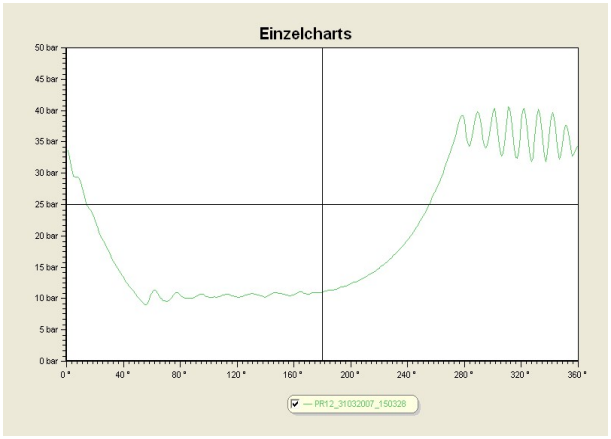

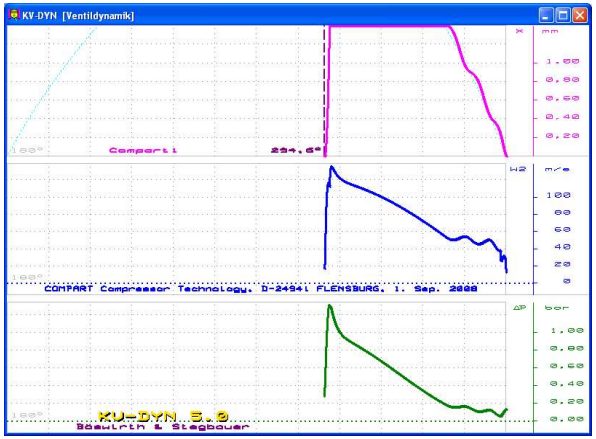

The actual problem was not discovered until the valve plate dynamics in consideration of the valve spring rates were calculated:
The relative spring force was too high in relation to the gas flow force which led to undesired valve plate dynamics. The measurement of the internal cylinder pressure and the results visible in the p-T diagram practically confirm the calculation.
An according recalculation and a consequential new design of the spring forces led to the following result.

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5. Summary

Years of research have shown that ca. 35% of the recalculated compressors suffer from valve problems due to insufficient plate lift and spring forces. When no greater trouble occurs the compressors can be operated for many years while the problems remain unnoticed by the operators.
In many cases are these problems only discovered by coincidence when the compressor is recalculated for the purpose of performance increase, insufficient delivery rates or process-related actions.
Furthermore, due to production and cost pressure it is not always possible for an operator to optimize an existing system. Therefore are these units in many cases operated by the principle “Never touch a running system” even when a thorough check or bench test is highly advisable.

On this occasion – in the interest of the operators – we want to point out the reconditioning of valves. By reconditioning are often high demands set on the surface quality of the sealing faces and the valves are being tested with predefined leak rates.
However, in case a valve belongs to the 35% of the valves that do not have a proper dimensioning, the tested and approved valve is in order only when it is not being operated. As soon as the valve is being operated in the compressor again and the valve plate closes several times during a crank shaft rotation, is with a leak test nothing gained. Fatal is the fact that after every reconditioning are valves retrofitted in the compressor without modification and operated in a compressor for many years.
This problem exists by all valve types described above, with the exception of the PCValve which operates without valve plate lift and springs.

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Thank you for your attention!

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