Valve selection and design under harsh conditions

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HOERBIGER compression technology

Contents

- Harsh conditions for valves (examples):
  - Liquid carry over / overlubrication
  - Particles (e.g. catalytic dust, sand, …) in the gas stream
  - Corrosive attack
- How to identify the root cause of a valve failure?
  - Some guidelines
- What can be done?
  - Improved process know how:
    - Valve selection / engineering beyond pure application parameters
  - Valve design measures:
    - Plate Valves vs. Ring Valves
      - Independent ring movement
      - geometry considerations
    - Sealing element materials
      - Nonmetallics vs. metallics

Harsh conditions

- Harsh conditions for valves (examples):
  - Liquid carry over / overlubrication
  - Particles (e.g. catalytic dust, sand, …) in the gas stream
  - Corrosive attack
- Valve problems due to process problems, plant problems e.g.
  - process modification
  - gas composition deviates from specified values
  - dirty gas
  - polymerisation, condensation, freezing
  - etc.

Failure examples

Refinery

Valve type: 143CGD

Gas:

78%-82% H2, CH4, C2H6 +

other hydrocarbons + H2S

P1: 17-24 bara

P2: 30-48 bara

T1: 30-50 deg C

T2: 100 deg C

Dirt

Clogging of valve ports

(flow restriction)

Sticktion effects

Failure examples

Polypropylene

vertical Labyrinth piston type compressor

Valve type: 154CROK

Gas: C3H6 (C3H6+C2H4)

P1: 1,1 bara

P2: 5,3 bara

T1: 40 deg C

T2: 120 deg C

Polymerisation

Clogging of valve ports (flow restriction)

Sticktion effects

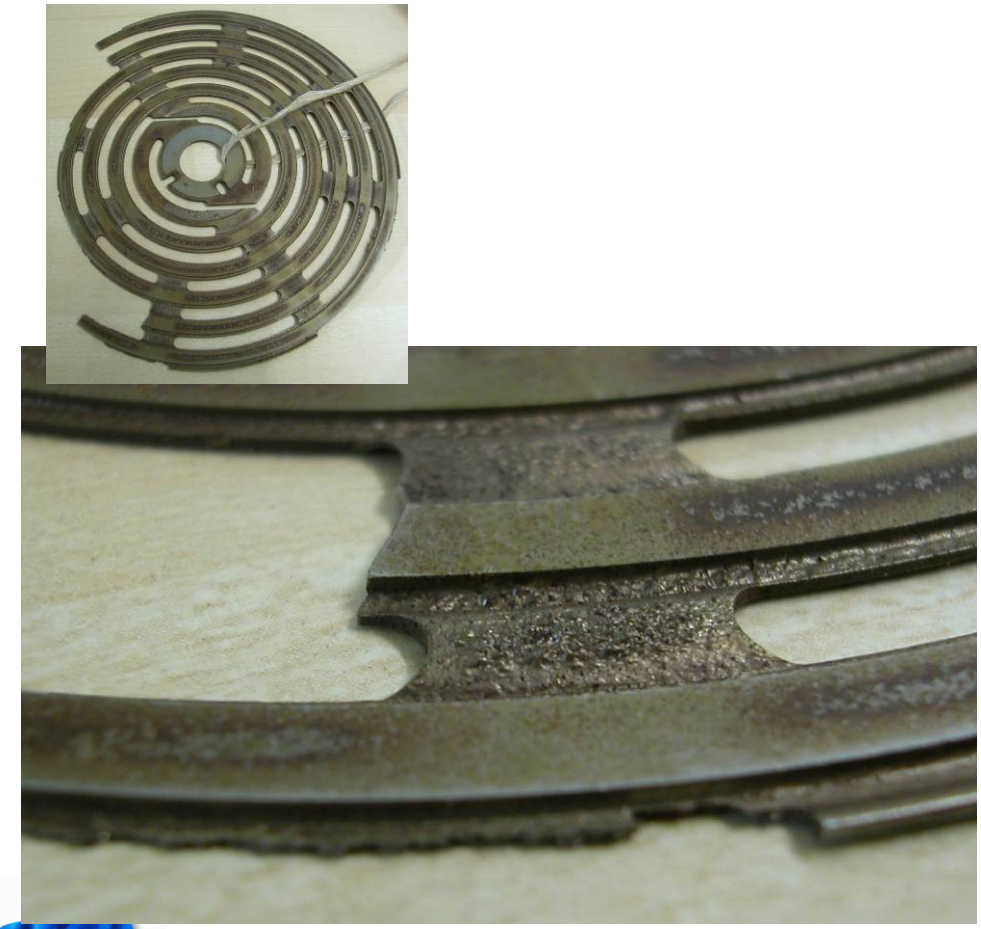
Failure examples

- Valve plate failure due to liquid or condensate
- breakages not on the outside of the plate
- Remedy: Prevent condensation e.g. by insulating of suction line, prevent liquid carry-over

Failures Examples

- Corrosion
- valve plate not yet broken but
- leakages increase the gas temperature
- happens very often not during operation but during stand-by period
- Remedy: Upgrade material, conversion to non-metallic material

Failure examples



- Heavy corrosion of martensitic material (50) in a Cl_2-compressor
- Remedy: Improve material to austenitic grade (60) or nonmetallic HP-material

How to identify root cause of failures?

Frequency of occurrence of failures	very rare / sometimes / considerable

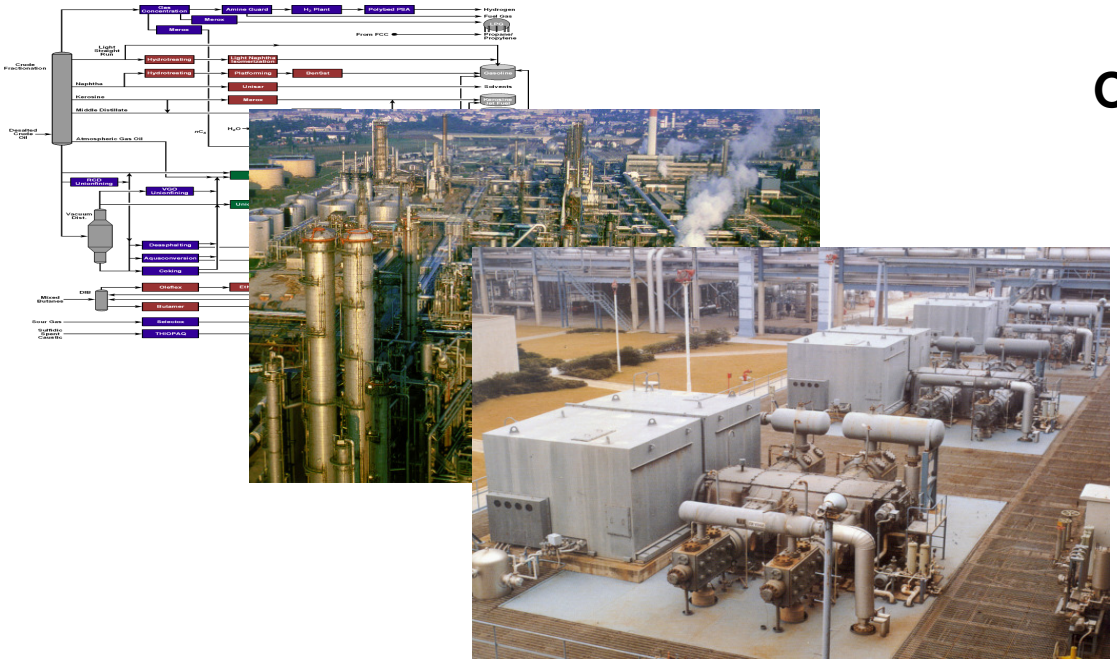
Valve seat / guard cracked or broken

Symptom / Appearance	Possible Causes
fracture surface shows fatigue failure	high differential pressure
	incorrect seat design
	corrosion
fracture surface shows forced rupture	liquid slug / liquid carryover

Valve plate damaged or broken

Symptom / Appearance	Possible Causes
segments of outermost ring broken off	excessive lift
	incorrect spring load
	high impact velocity due to oil
sticktion	molecular weight of gas different to original layout
	extremely asymmetric gas flow
	solid particles in gas
	condensate in gas
	polymerisation in gas
	liquid carryover
	gas pulsations
cracks on webs or on the inner area of the plates	liquid carryover
	consequential damage due to broken parts passing the valve

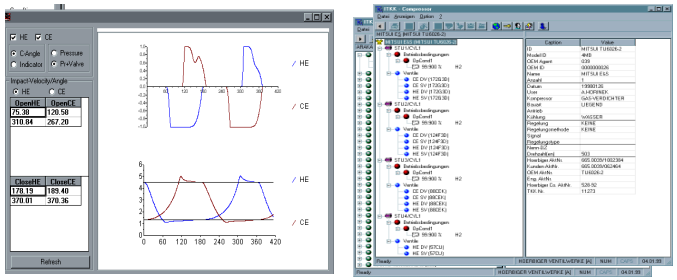
What can be done - knowledge of Application



Operating characteristics

- **Empirical values**
  - Dirt/Polymerisation
  - Liquids
  - Corrosive components
  - Process characteristics

Valve sizing & engineering



Both sides need to be considered!

EFRC training on challenging environments

20 October 2010

What can be done - knowledge of Application

- **H2 from steam reforming**
  - Chemical reaction taking place: CH4 + H2O -> H2+CO -> H2+CO with C-particles → extremely abrasive!
  - **Countermeasure:** use valve design with spring savers and nonmetallic inner parts

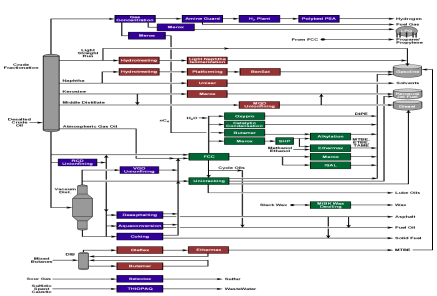
- **CCR catalytic reforming**
  - organic chlorine used in process (cannot be seen from gasanalysis)
  - extreme corrosion through chlorides on valve seat / guard and springs
  - **Countermeasure:** correct material specification

- **LDPE - Polyethylene Booster Primary**
  - Frequent polymerisation in 1st stage
  - Sticky white substance which cloggs springs, spring pockets → highly loaded sealing element and springs
  - **Countermeasure:** usage of nonmetallic sealing elements with high impact resistance, optimized dynamic design of springs

Product Selection based on Application

Process characteristics

- Changing conditions, dirt, liquids,….

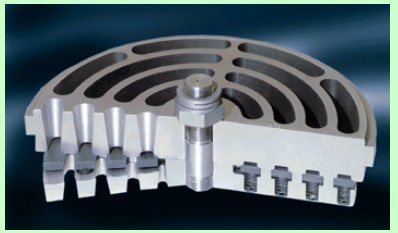


Experience

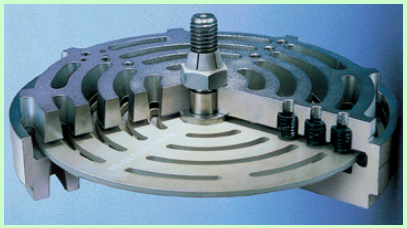
- Known effects & proven solutions

The “Best” Product

- Ring valve



- or plate valve



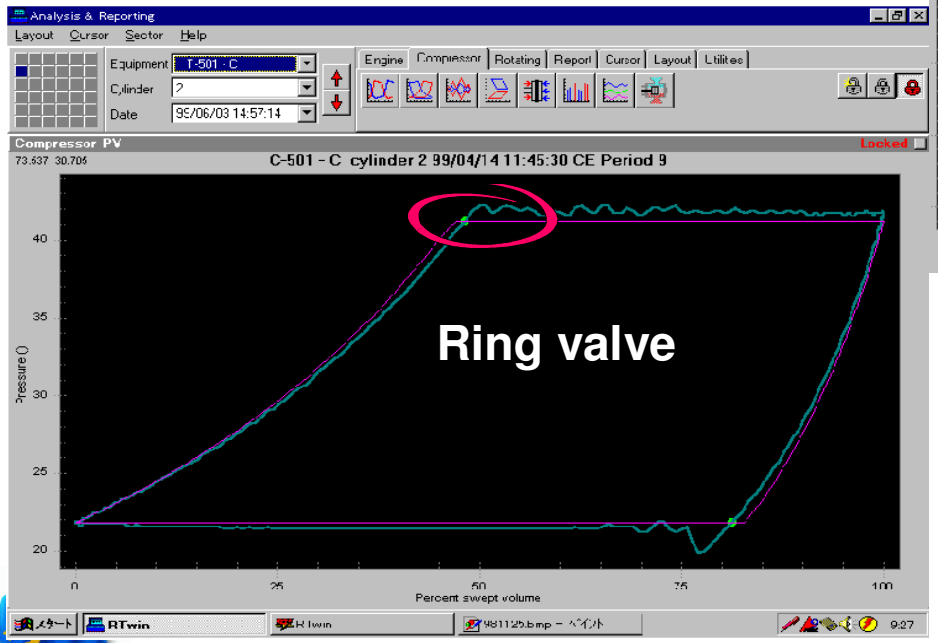
What can be done – valve design

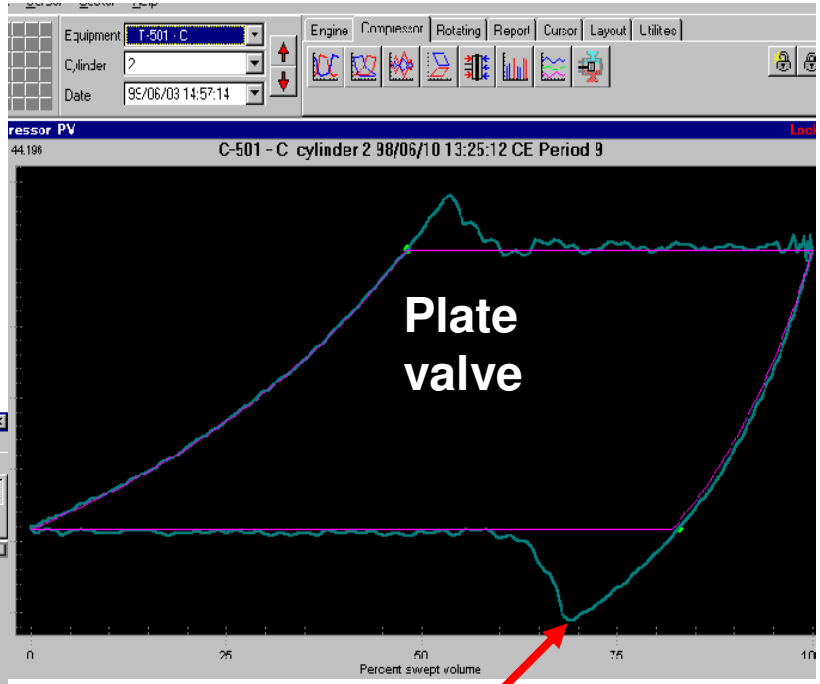
Hydrogen Compressor

Plate valve failing after short amount of time – pV reading revealed sticktion effects

Changed to ring valve -

lifetime now 16.000 h





Sticktion effect:
huge pressure overshoot due to delayed opening of sealing element

The profiled geometry of ringvalves (line contact) leads to less sticktion

What can be done – valve design

Operating Company

Site	Map Ta Phut, Thailand
Service	CCR Net Gas Booster

Compressor

lubricated

Operating conditions

Gas	Hydrogen Rich Gas (MW 8)
Suction Pressure	5,6 bara
Final Pressure	47,5 bara

The Problem

originally fitted with non-metallic plate valves
Discharge valve failures after
1 day to 2 months operation due to severe liquid carryover

The solution:

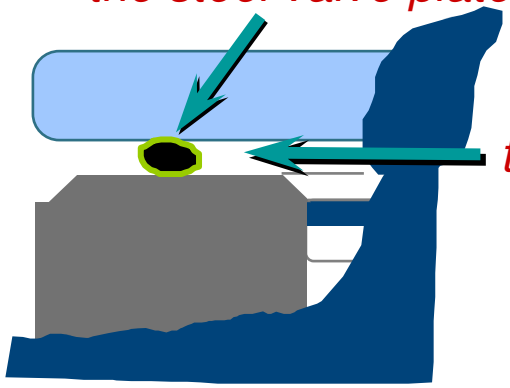
Ringvalves fitted
Valve run time improved to 26000 h

In ringvalves each ring can move independent from the others, making it easier to cope with liquid slugs

What can be done – valve materials

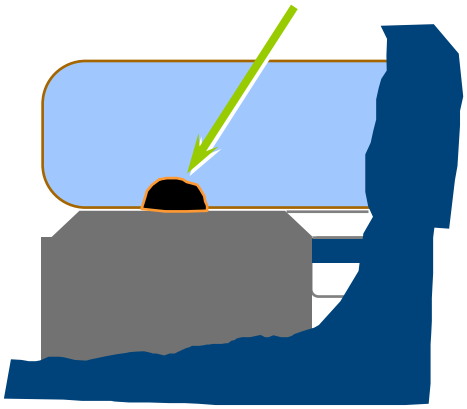
Resistance to dirt particles – e.g. polypropylene

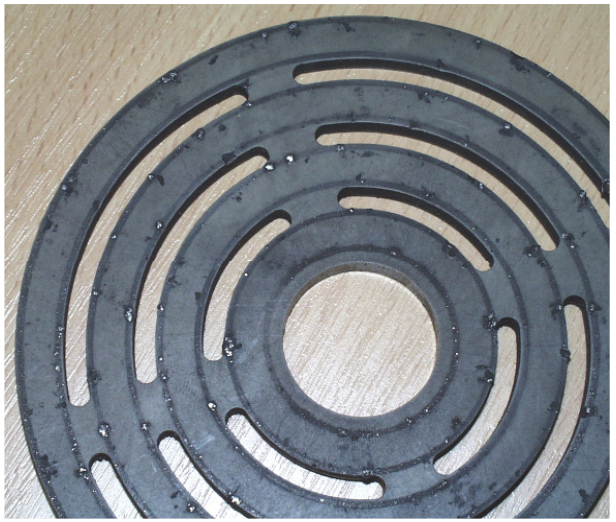
the steel valve plate is hard - danger of breakage



the valve seal is not tight

The plastic valve plate can deform,
the particle is embedded





Plastic valve plate with embedded particles

What can be done – valve coating

Flare gas compressor:
Low pressure Hydrocarbon Mix Gas +
H2S wet (MW 22-36)

Valves taken out of compressor and
water cleaned

Guess which valve is coated?

Coated valves were running 19500h,
allowing customer to extend service intervall

Conclusions

- Reliable performance of reciprocating compressors requires design and engineering beyond pure specification – the key is the application knowledge
- Examples showed that process knowledge and good interaction of end user / OEM / component manufacturer is needed to have good solutions
- Most of the failures could have been prevented