EFRC Workshop: Pulsations Effects on Compressor Reliability

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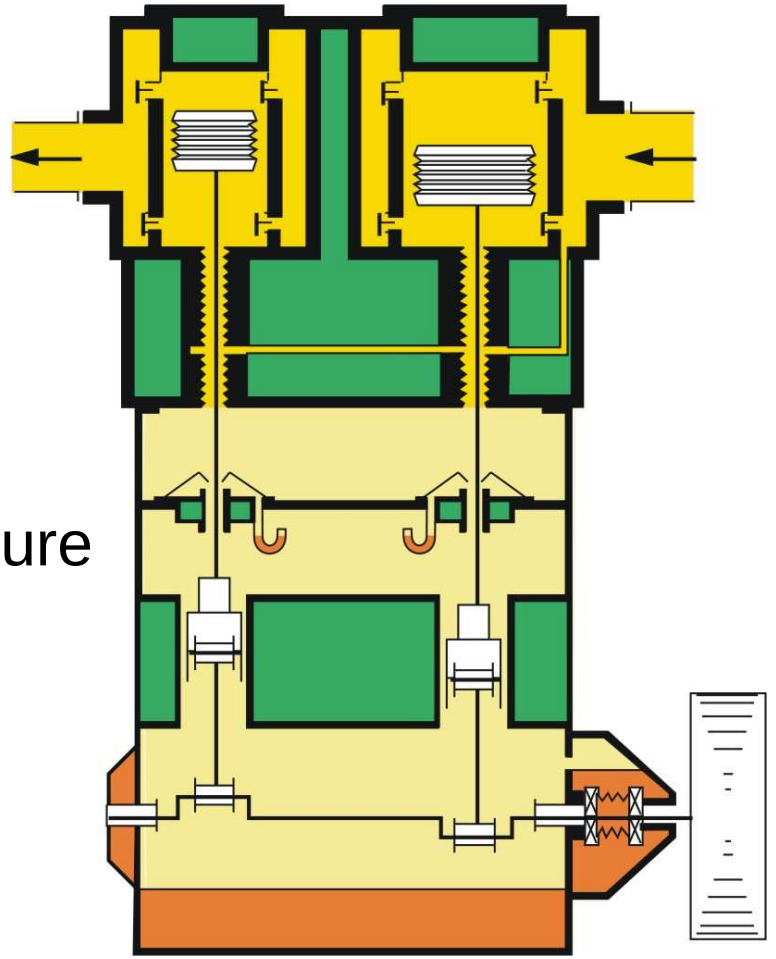
Overview

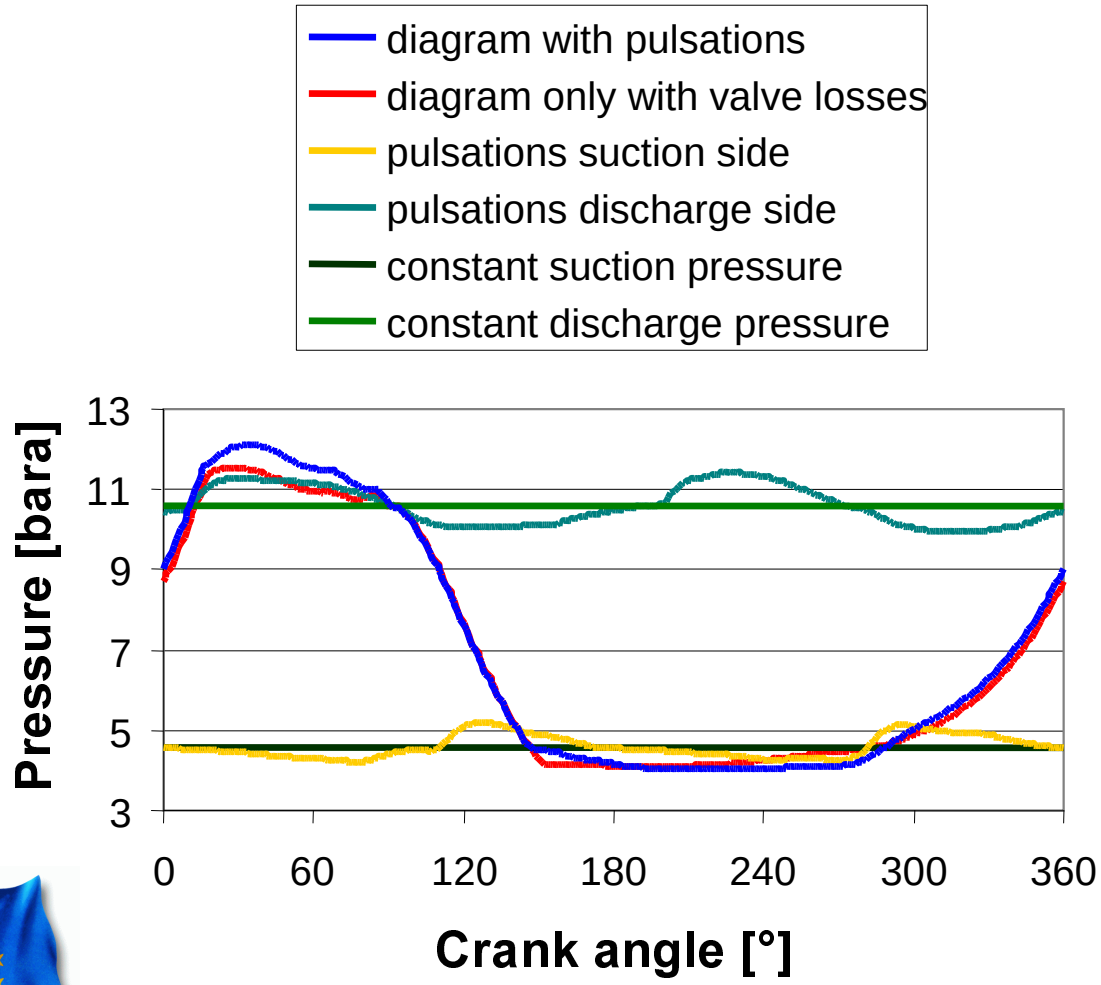
- Influence of pulsations on different parts of a compressor and possible resulting failures, respectively methods to avoid such failures
  - Compression chamber
  - Valve unloaders, clearance pockets
  - Valves
  - Piston, piston rod
  - Crosshead
  - Crankshaft
  - Motor
- Summary

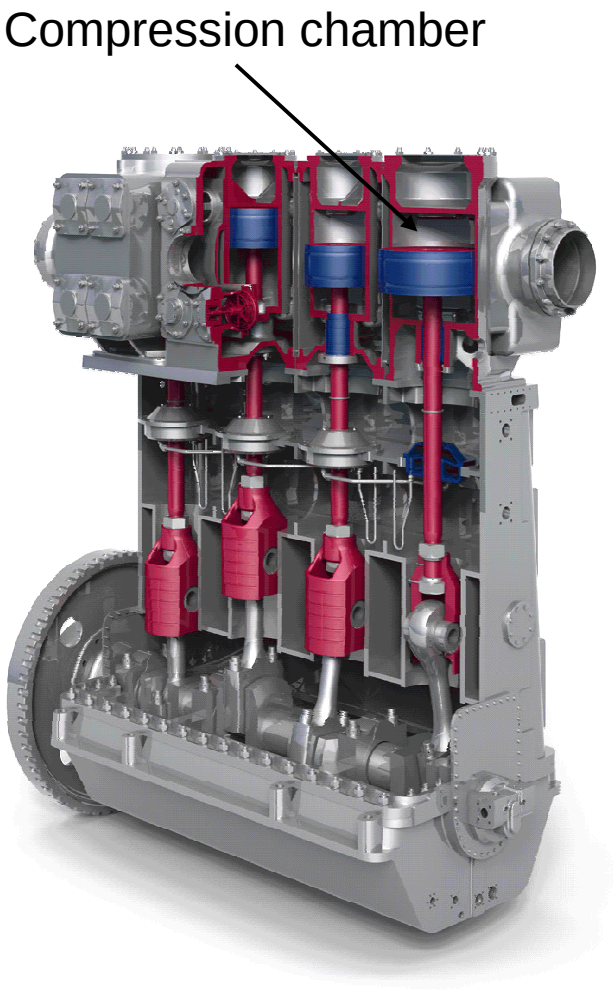
Example

- Compression of [mol %]
  - 86.3% Propane
  - 13.7% Ethane
- From
  - 4.5 bara suction pressure
  - 10.6 bara discharge pressure



Pressure in Compression Chamber

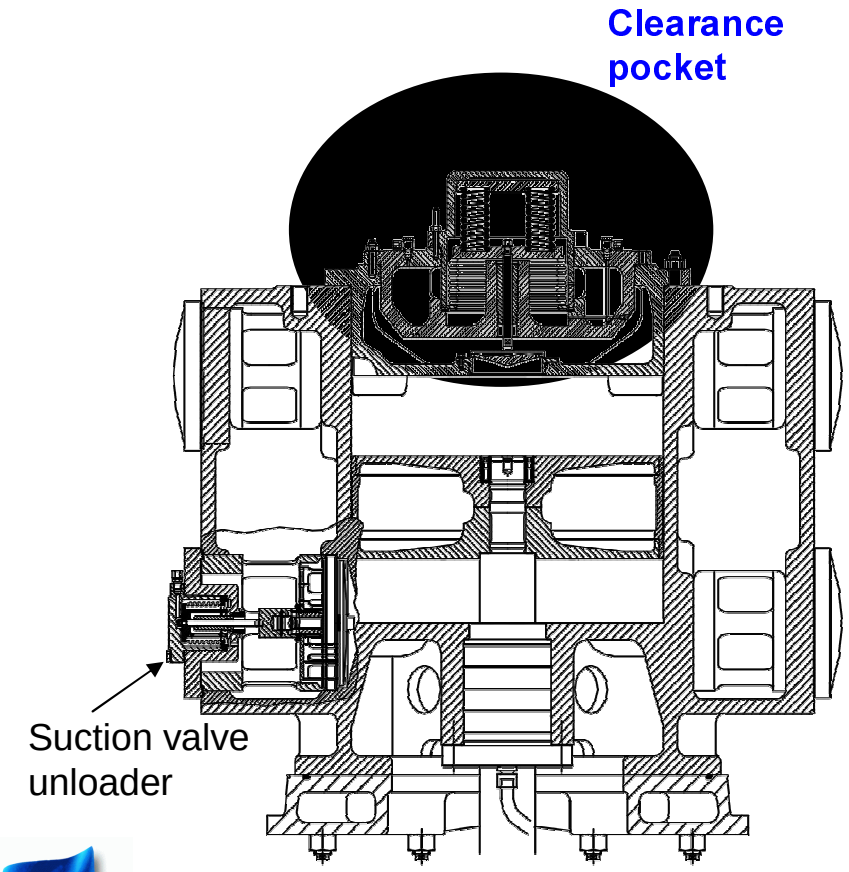


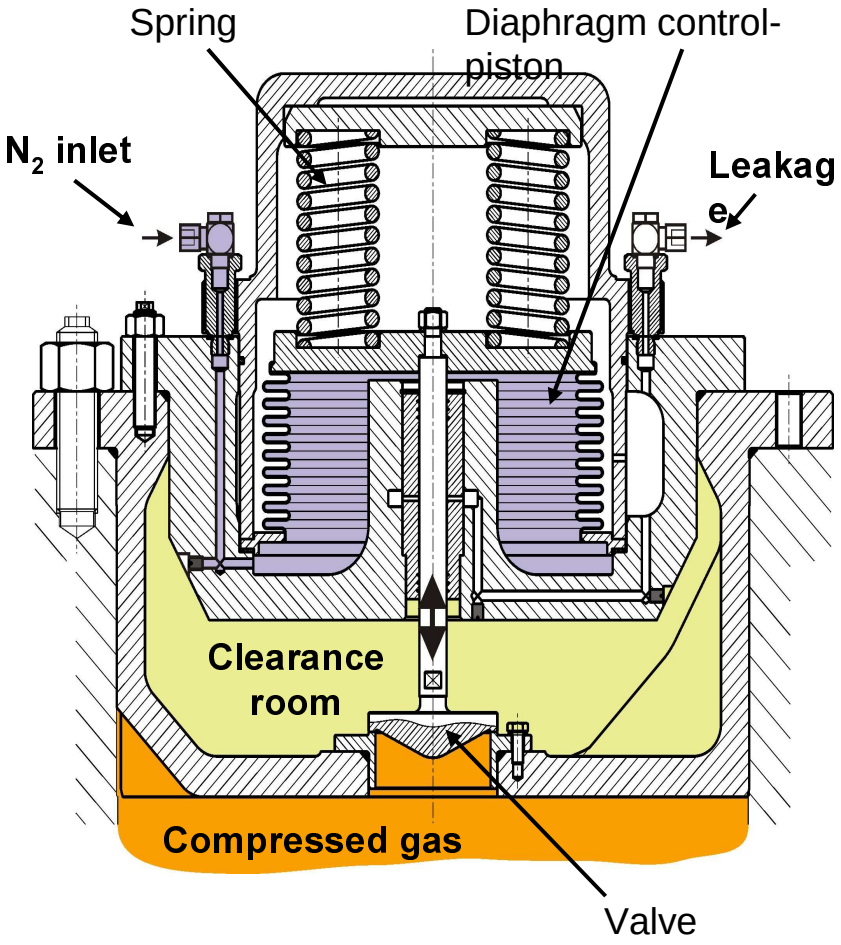


Pressure Effects

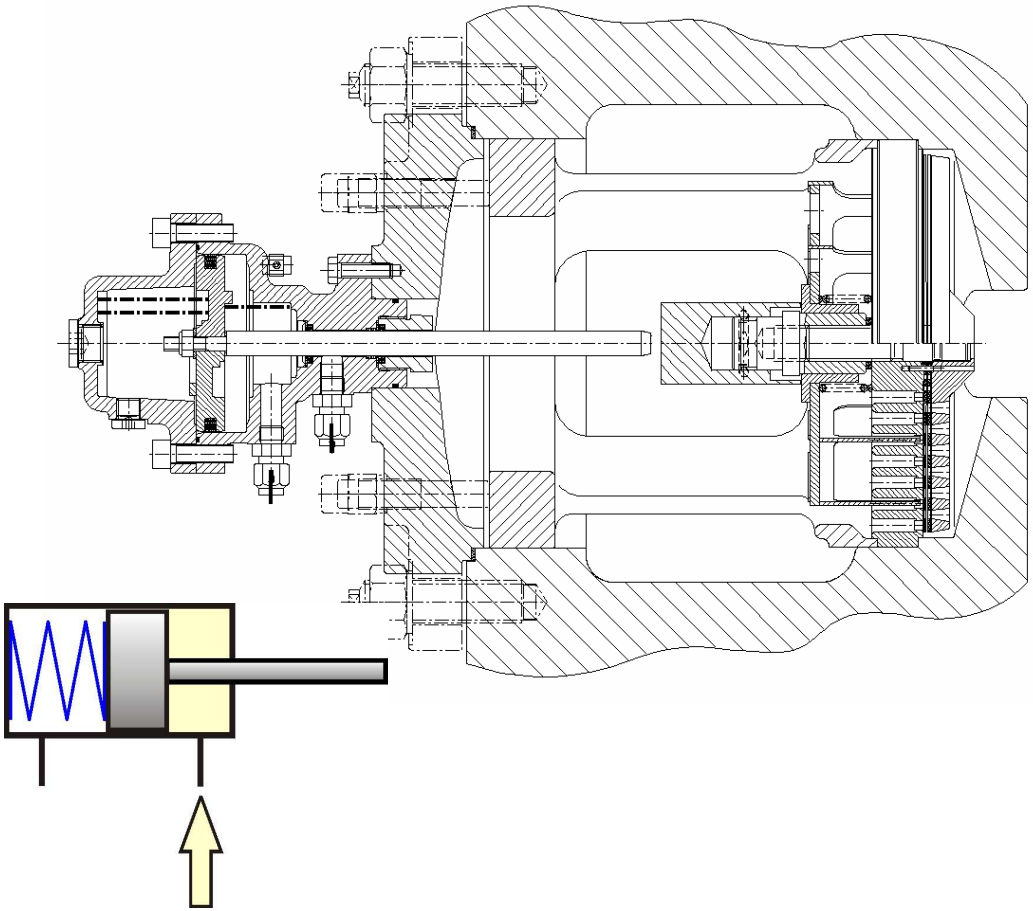
- Pulsation effect in compression chamber (with line Pulsations)
  - Varying suction pressure
  - Varying discharge pressure
- Influence on
  - Valve unloaders (Sizing of spring and unloading medium pressure)
  - Clearance pockets
  - Test pressures, safety valves settings

Clearance Pocket



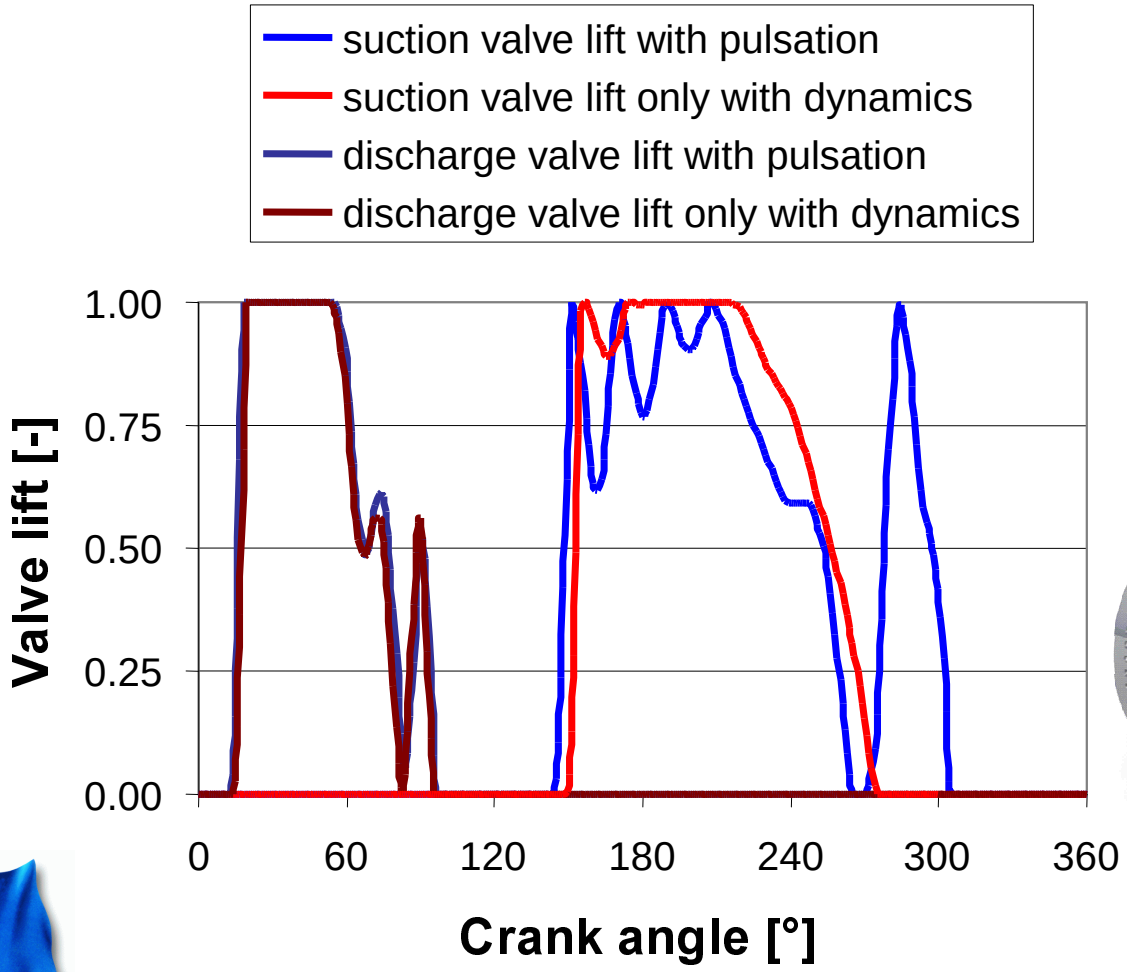


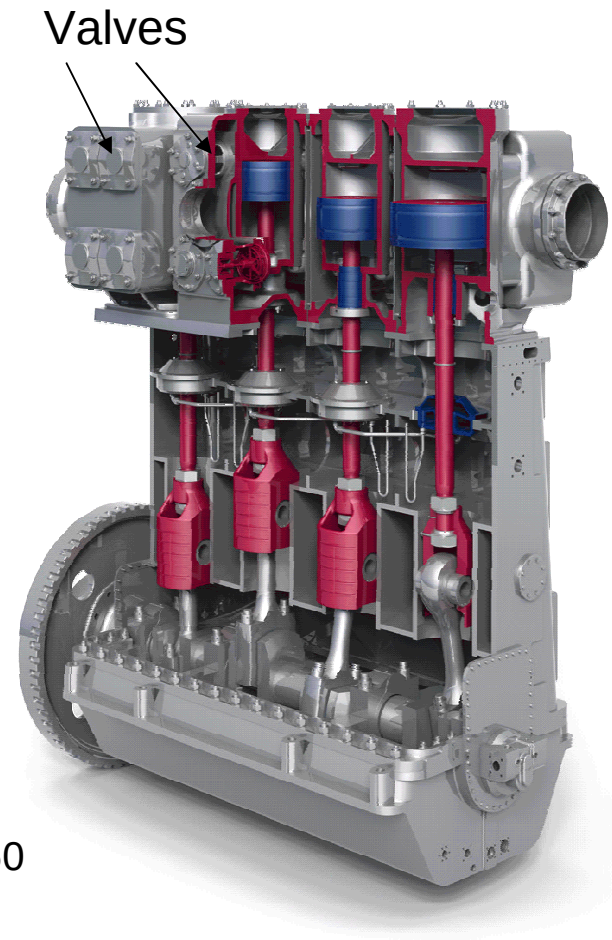
Valve Unloaders



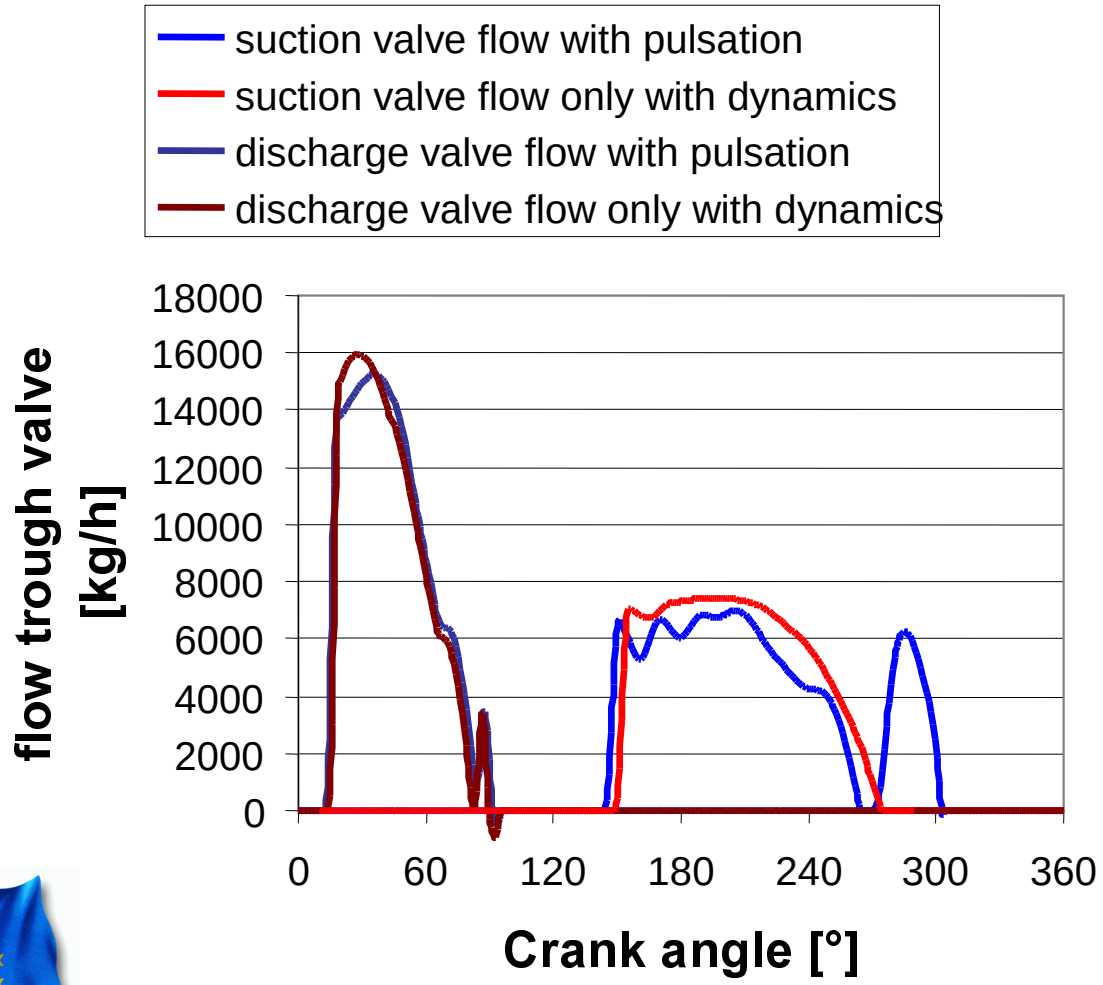
Energized → 100% operation

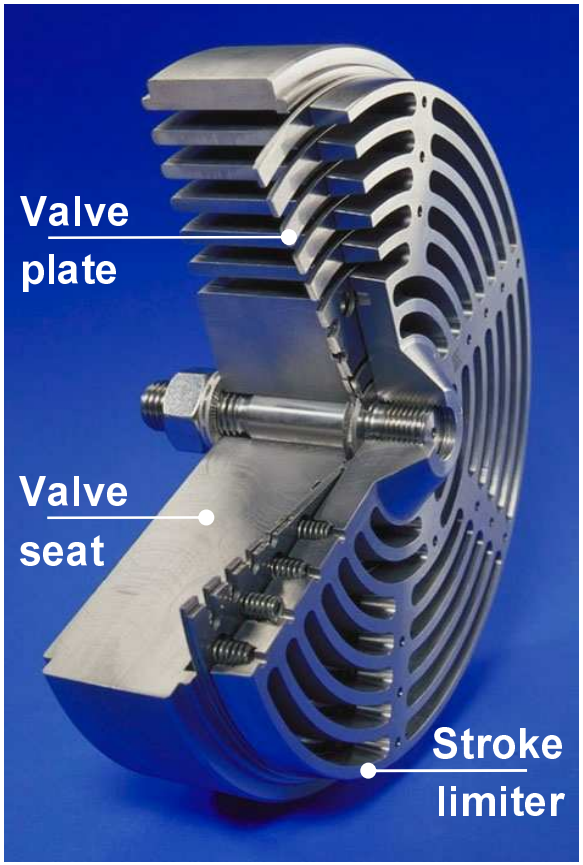
Influence on Valve Dynamics





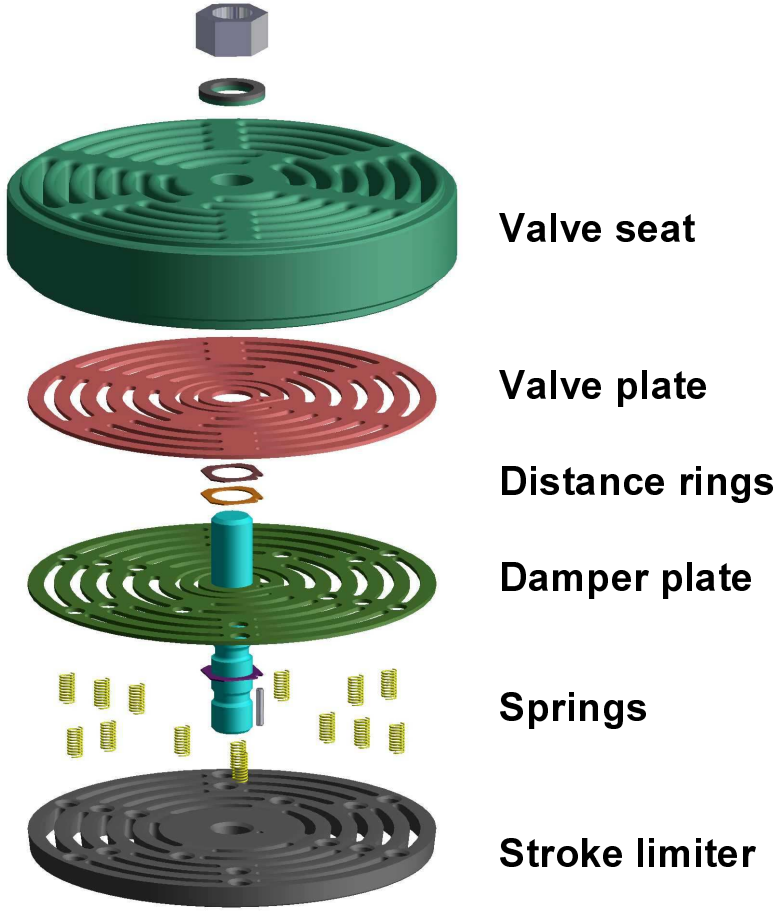
Flow Through Valves





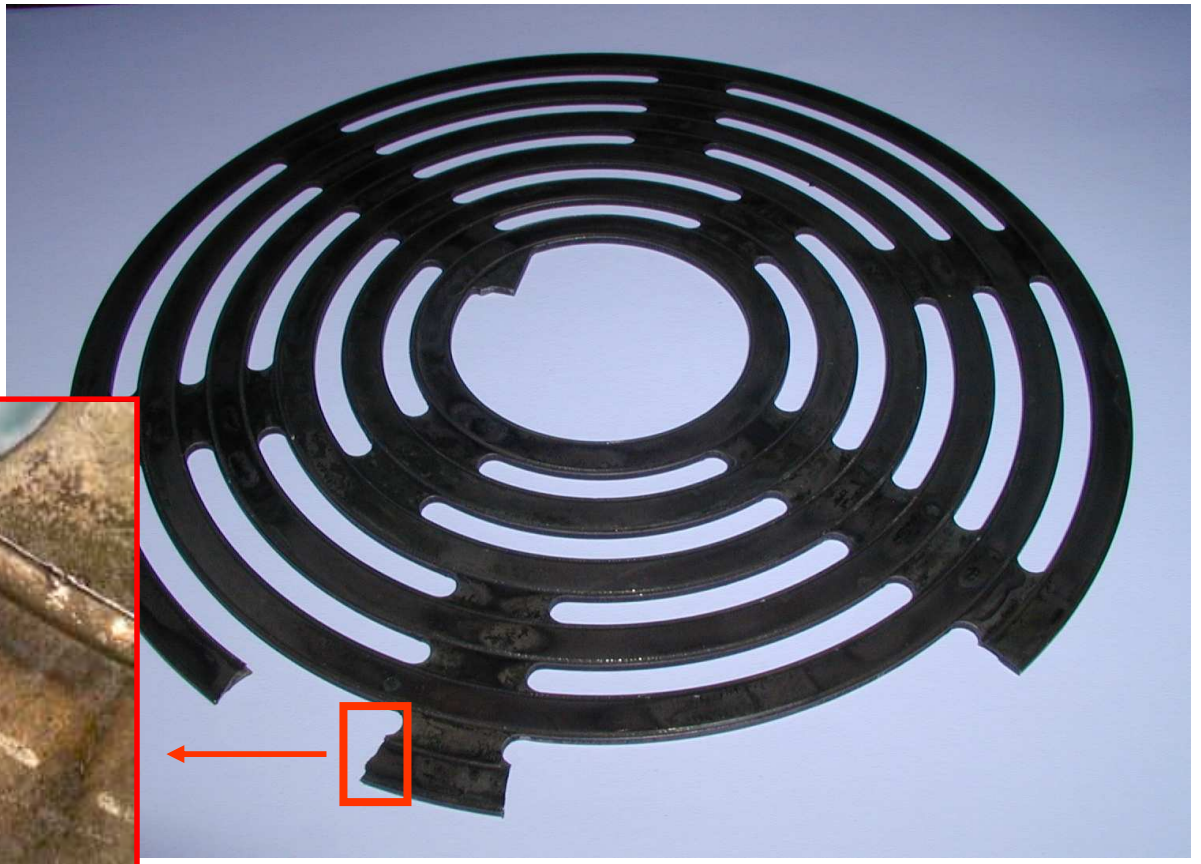
Impacts of Pulsations on Valves

- Due to pulsations
  - Possible different valve plate impact velocity
  - Possible different numbers of impacts
  - Decrease of lifetime
- Pulsation optimized sizing of the valves
  - Dynamics (springs, lift)
  - Materials, Selection



Broken Valve Plate due Pulsations

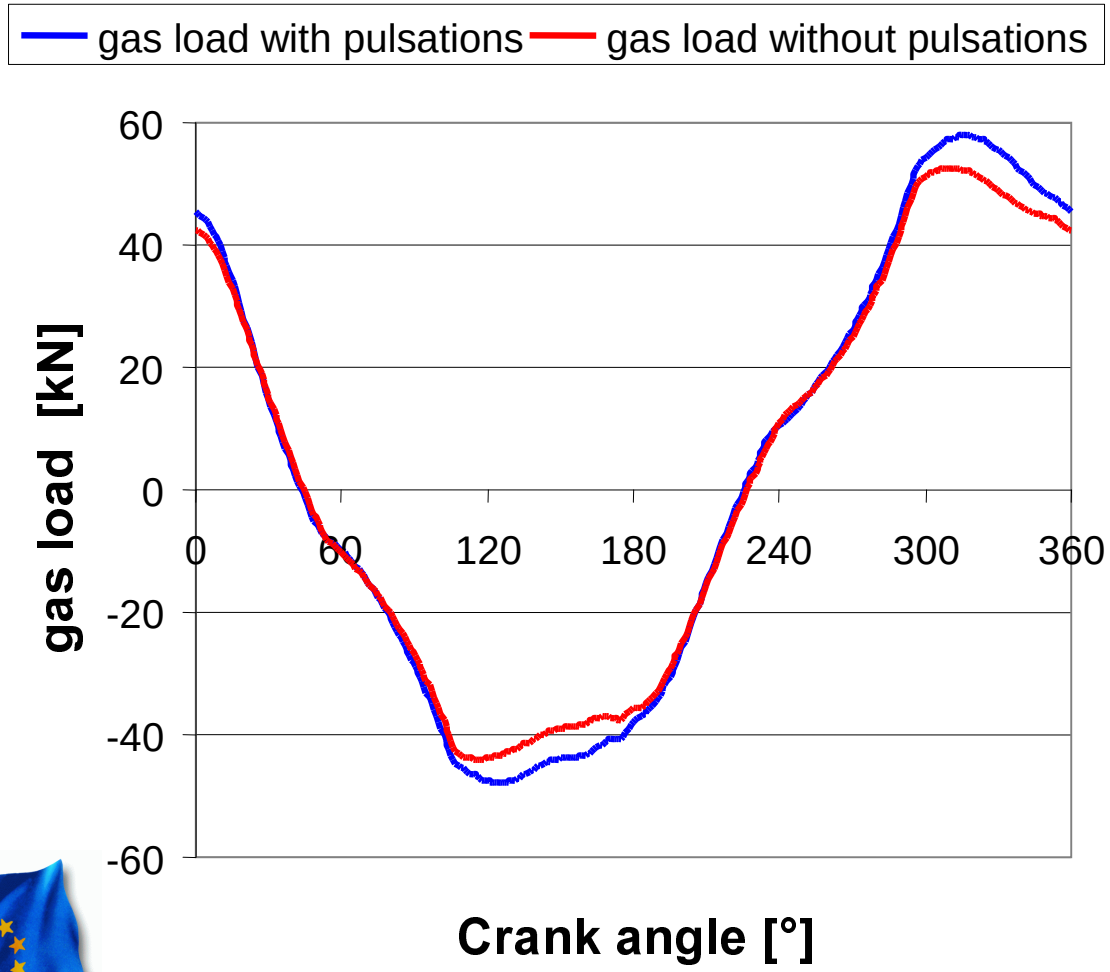
- Modifications made:
  - Change of valve lift
  - Change of spring flexibility



Broken Valve Plate and Springs

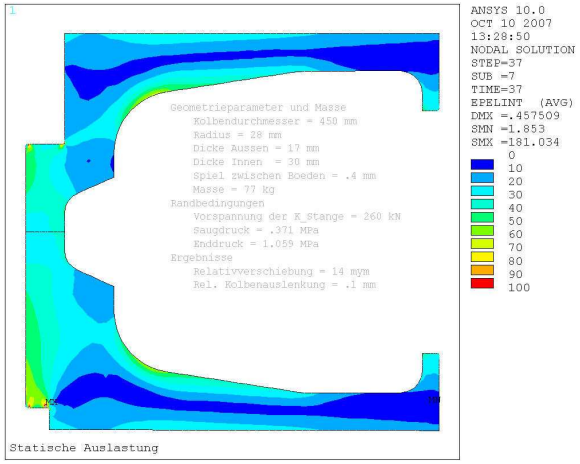
Broken springs

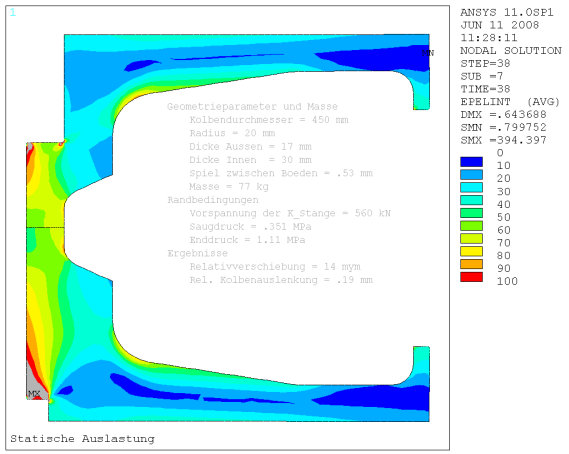
Gas Load


gas load with pulsations
gas load without pulsations
60
40
20
0
-20
-40
-60
0
60
120
180
240
300
360
gas load [kN]
Crank angle [°]

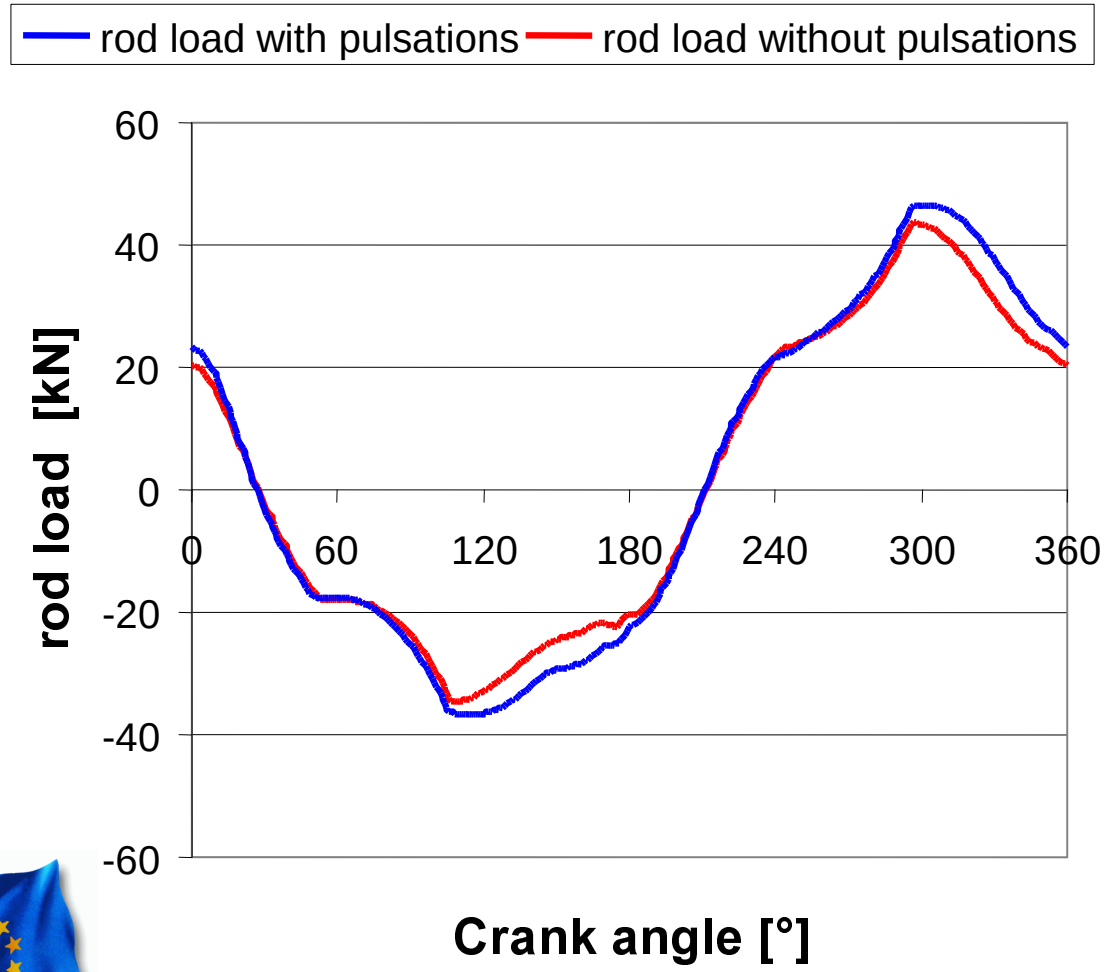
Impact of Gas Load

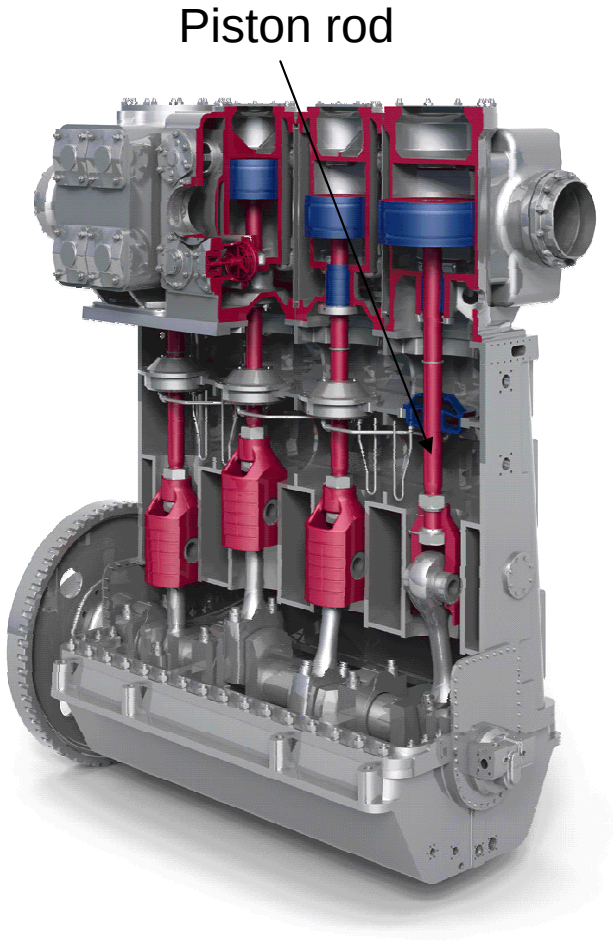
- The Gas load influences the piston design
- Calculation of pistons with gas loads including pulsations





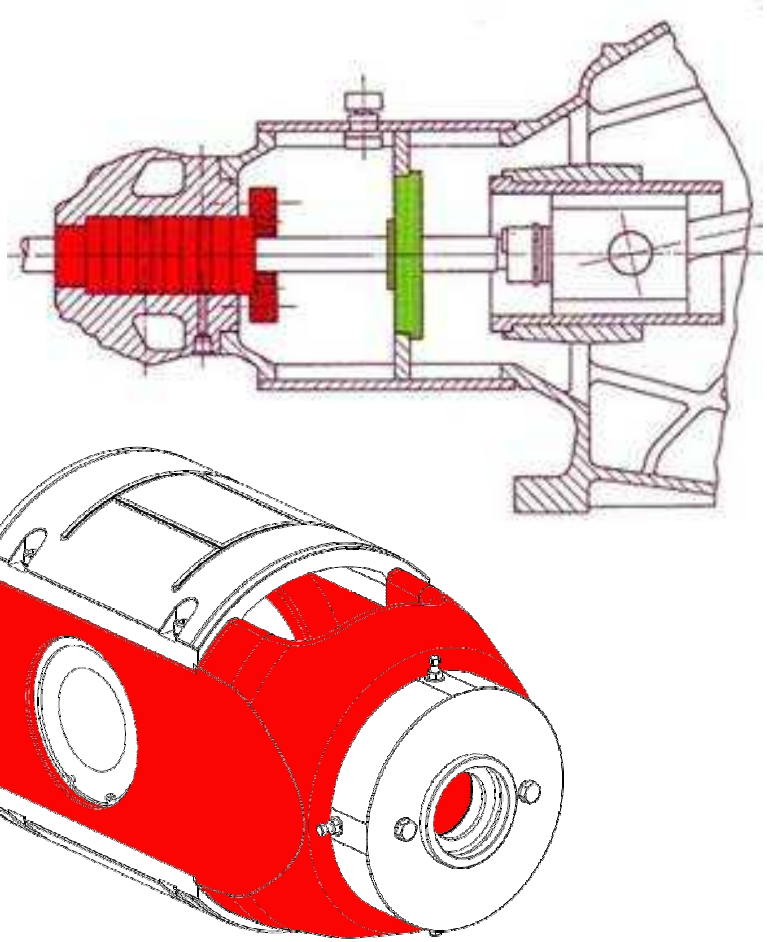
Piston Rod Load



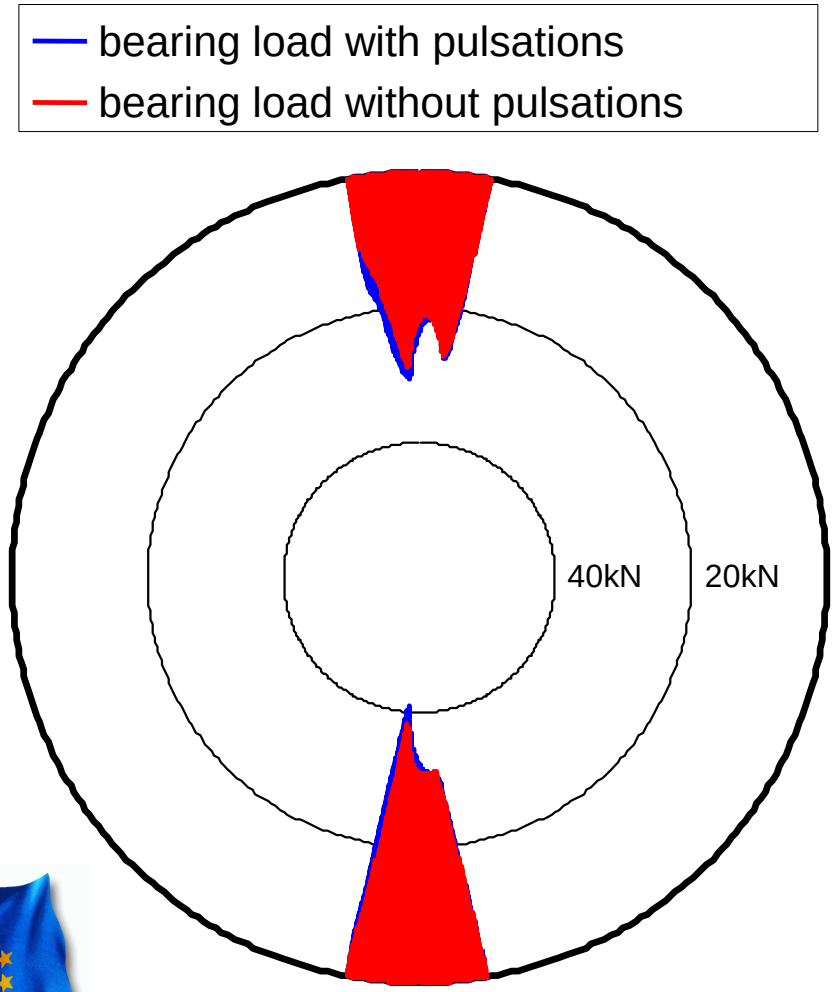


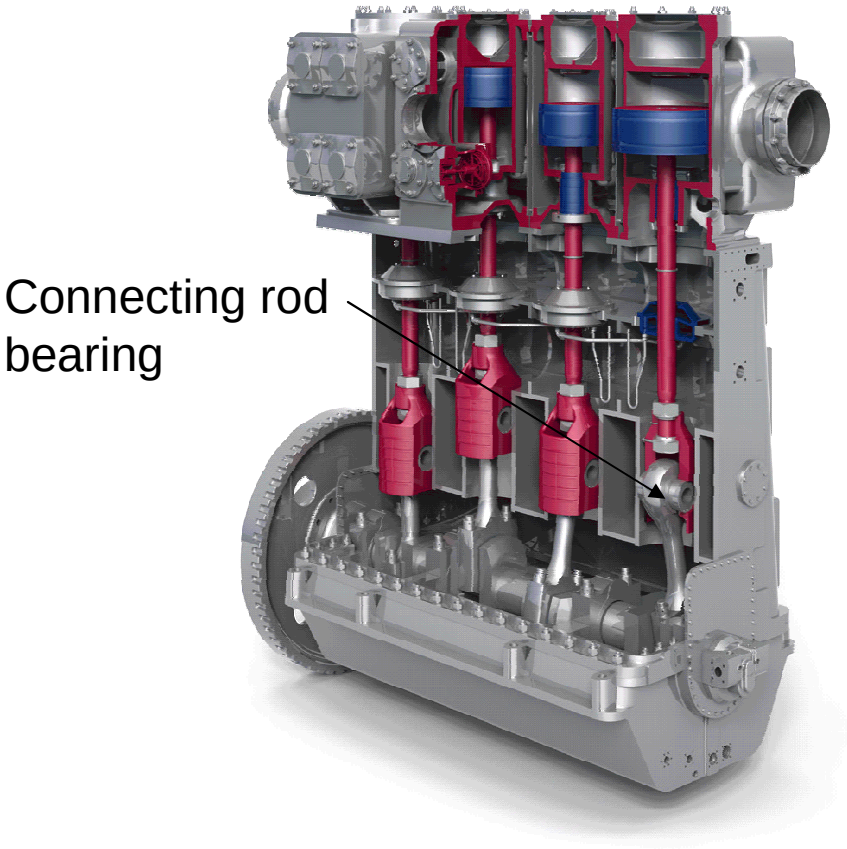
Connection Piston Rod-Crosshead

- For the design of the connection piston rod – crosshead the pulsation forces are considered



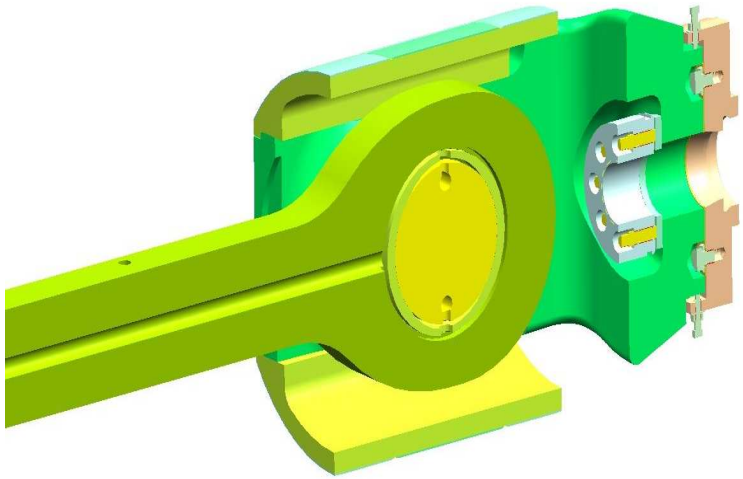
Connecting Rod Bearing Load

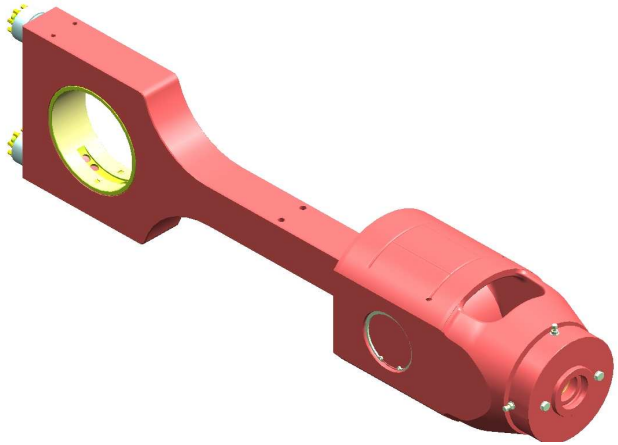




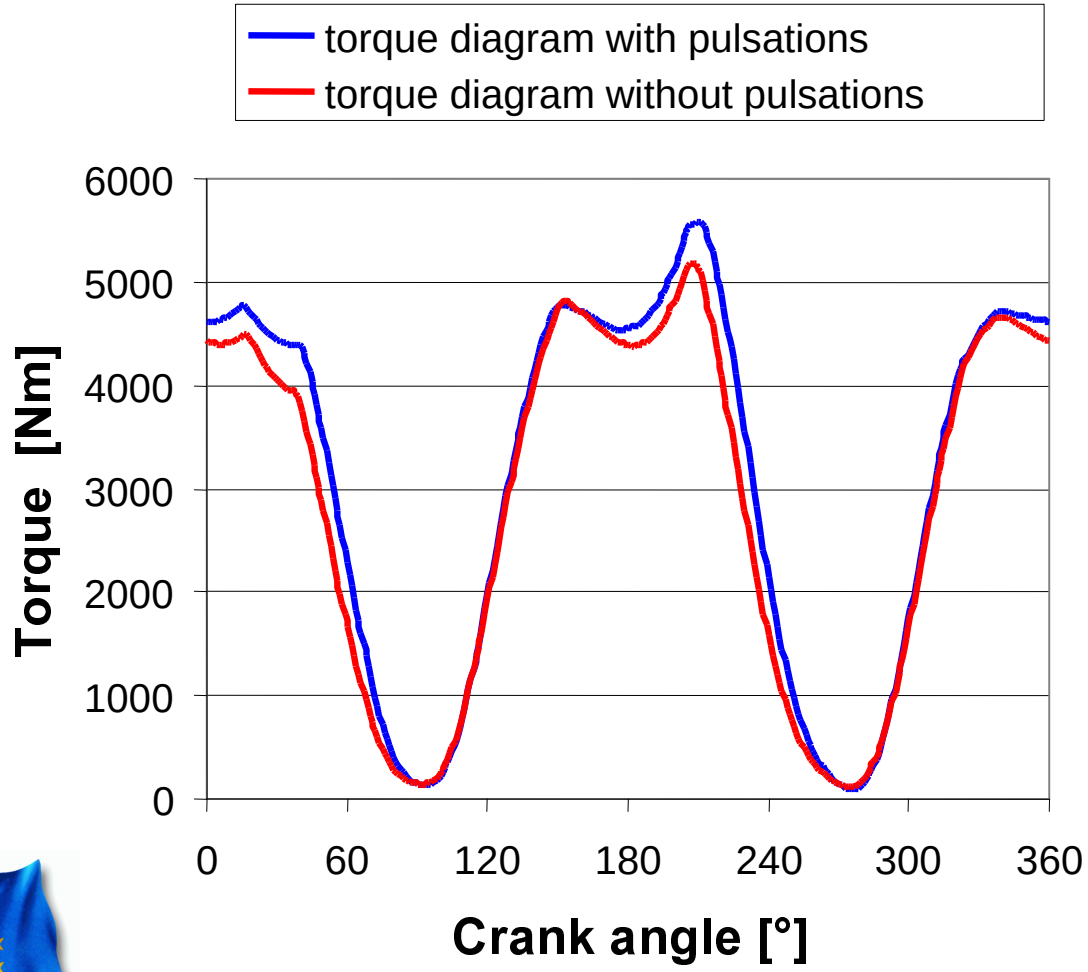
Load on Connecting Rod

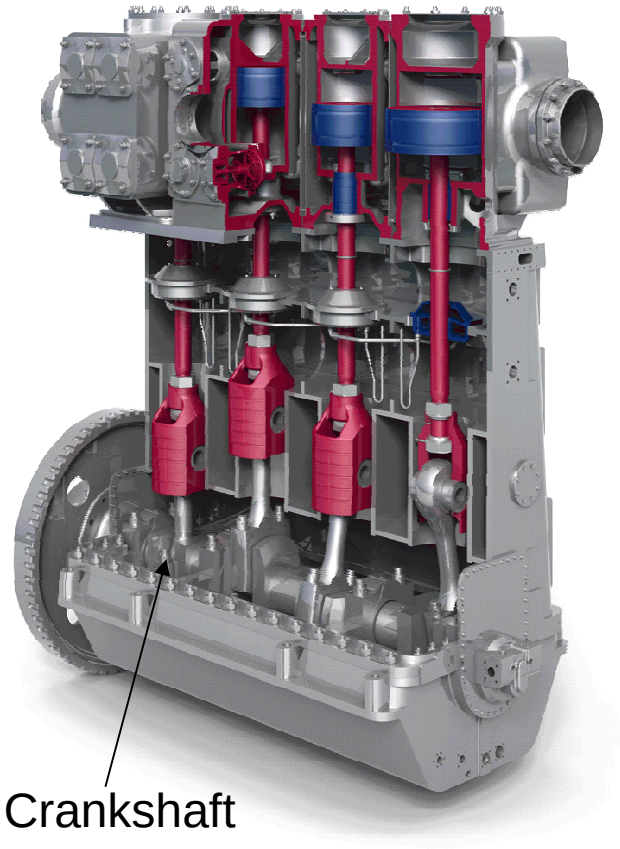
- Impact on rod load and rod reversal (loads from both side of the bearings)
- Too small rod reversal can result in lubrication problems
- Regulation / Guidelines for allowable minimum rod reversal (e.g. API 618 fifth edition 6.6.4) or design practices





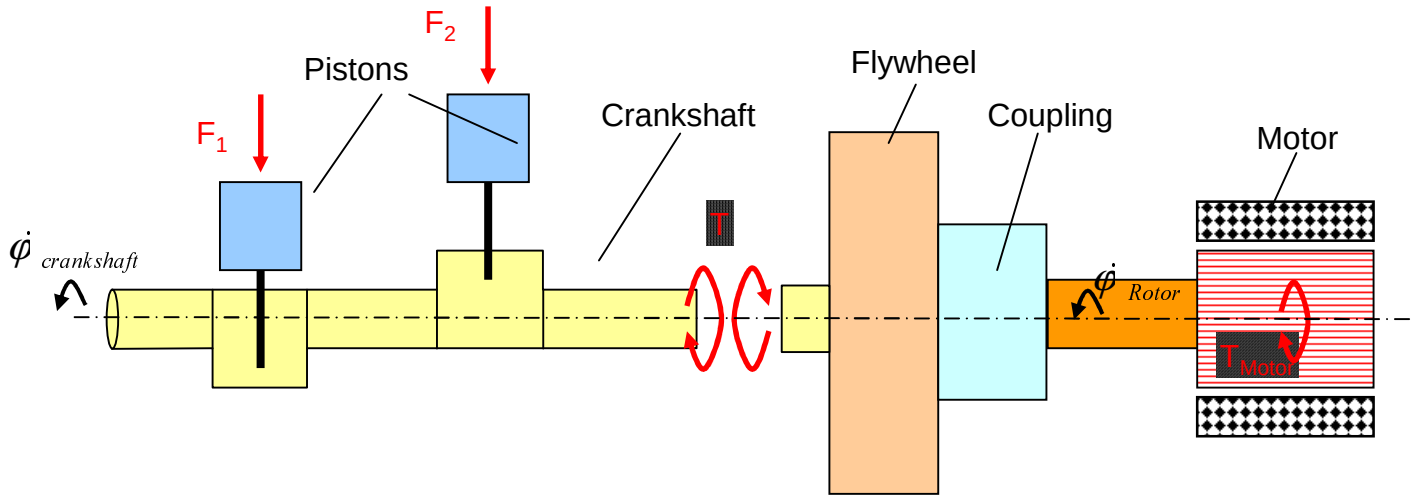
Torque Diagram



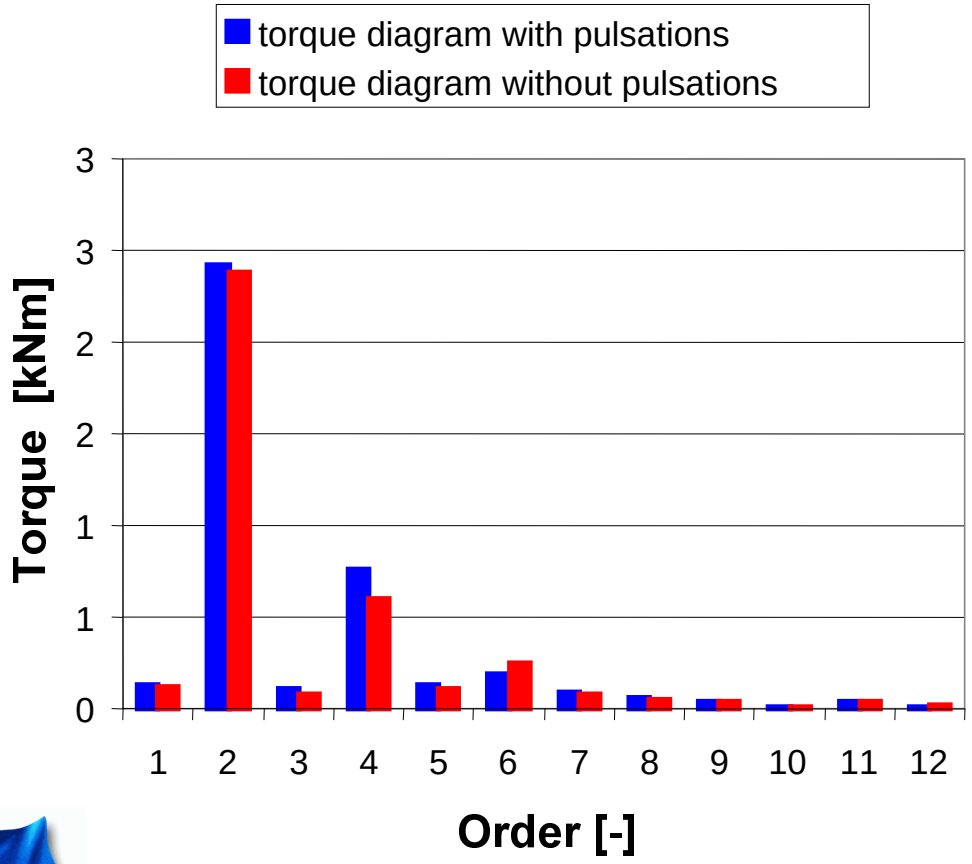


Impact on Coupling and Motor

- Influences of pulsations on
  - Power consumption
  - Exciting frequencies
  - Degree of Irregularity



Results of the Example



- Exciting frequencies with and without pulsations
  - Degree of Irregularity without pulsations 1/178 and with pulsations 1/172
- Loadings with and without pulsations
  - Additional load between 5-8% due to pulsations (with 15% ptp cylinder flange pulsations)

Summary

- Pressure Pulsations have an influence on the loading of the compressor from the compression chamber to the motor
  - For the most parts the dynamic motion remains the same
    - The load due to pulsation must be included in the design of the different components
  - For compressor valves the dynamic motion of the internal moving parts can be affected by pulsations
    - Pulsations can reduce valve lifetime