Progressing Cavity Pump Applications

Calgary Pump Symposium

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Technical Presentation

1. Introduction

2. Working principle Progressing Cavity Pump (PCP)
   a. Hydraulic design
   b. Universal joint (power transmission)
   c. Mechanical seal
   d. Motor and Gearboxes
   e. Materials
   f. System requirements

3. Applications of PCP

4. Case studies and references
Technical Presentation

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Pump Classification

- non positive displacement pump
  - venturi type
  - jet pump
  - centrifugal pump
  - centrifugal open impeller type
  - centrifugal closed impeller type

- positive displacement pump
  - reciprocating pump
    - plunger/piston/diaphragm pump
    - air operated diaphragm pump
    - screw pump
    - peristaltic pump
  - gear pump
    - internal gear pump
    - external gear pump
  - impeller/ve ne pump
    - progressing cavity pump
  - rotating pump
    - screw pump
    - screw pump
Pump Classification

Positive Displacement
• displace liquid by creating a chamber or cavity between the pumping elements.
• The chamber or cavity is moved by the reciprocating or rotary motion.
• API 676 Rotary Positive Displacement Pumps applies to progressive cavity pumps.

Dynamic (centrifugal)
• imparting velocity energy to the fluid.
• API 610 and ANSI standard applies.
PC Pumps - Operating Principles

- Progressing cavity pump
- API 676 Rotary Positive Displacement Pump standards apply
PC Pumps - Operating Principles

The Rotor

- Rotating pumping element
- Elongated screw shape
- Single external helix geometry
- Eccentrically manufactured
PC Pumps - Operating Principles

The Stator

- Internal shape of a double screw
- Screws pitches start 180° apart and opposed
- Stationary pumping element
The cavity is created and carries the process fluid.

The cavity volume is transferred through the pump by the rotation of the rotor.
In order to achieve optimal efficiency and long service life, the interference between rotor and stator and the “d”/“D” ratio of the interference are of vital importance.

Due to interference fit, a fluid film is required to lubricate sliding surfaces.

In multiphase applications, high gas fractions can be pumped….0.5% of a pumps volume flow is required as liquid.
Higher pressures are achieved by adding ‘stages’.

Adding stages increases the length of the sealing line and therefore increases the resistance to fluid flowing back through the pump (slip).
Advantage PCP pressure stability in comparison to centrifugal pumps

![Graph showing head vs. flow rate for different pump types.](Image)

- **Head - H**
- **Flow rate - Q**
- **Centrifugal pump**
- **Pos. Displacement pump**
- **Theor. Pos. Displacement pump**
- **System performance curve**
Performance Curve: Q and n directly proportional

Typical performance curve of a positive displacement pump

PC pumps are ideal for gentle transfer of

- homogenous and heterogeneous fluids and suspensions
- viscous and corrosive media
- Media containing solids
- Media for dosing
4 NEMO® Rotor/Stator Geometries provide high efficiency for your application

- **S-Geometry**
  - Lobes: 1/2
  - Double stage
  - Flow rate: 100%
  - Differential pressure: 12 bar

- **L-Geometry**
  - Lobes: 1/2
  - Single stage
  - Flow rate: 200%
  - Differential pressure: 6 bar

- **D-Geometry**
  - Lobes: 2/3
  - Double stage
  - Flow rate: 150%
  - Differential pressure: 12 bar

- **P-Geometry**
  - Single stage
  - Lobes: 2/3
  - Flow rate: 300%
  - Differential pressure: 6 bar
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Universal joints are required to compensate between concentric motion at the pump shaft/seal area and the eccentric motion of the rotor.
PCP Pin Joints

- Simple robust design
- Maintenance free
- High quality SM-seal
- 100% oil filled design (other manufacturers use grease)
- The most common kind of joint
- Abrasion resistant external steel sleeve to protect against ingress of solids
PCP V Pin Joint

- For longer service life in difficult applications
- Strengthened by hardened bushings fitted into boreholes in the coupling rod and the rotor/drive shaft head
- Easy to remove for maintenance purposes
PCP K-Joint

- Long service life due to transmission of torque and axial load on separate paths
- Preferred for continuous operation under high load
- Double seal design, therefore optimal chemical resistance to pumped product and optimal joint lubricant.
- Installed, patented oil grooves in the ball cup guarantee lubrication under heavy load conditions
PCP Z-Joint

- The joint for the highest mechanical demands
- Axial forces and torque are transmitted by the bearings of the pivot
- Easy maintenance due to cartridge design
- Double sealed design
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Mechanical seal are located in the free flowing area in the casing.

Typically mounted on the suction side (low pressure and therefore lower loading)
Mechanical seal

- Seal faces are self flushing and give very good service life in abrasive solids loaded applications.

- Flush plans are available, but not always necessary
Mechanical seal

- Pre-assembled cartridge seal

Single acting for quench  
Double acting for applications with and without sealing pressure
Quality of PC Pumps

- Mechanical Seals engineered according to API 682, SAE according to API 610
Mechanical seal

- Medium: Dilute Sand Slurry
- Showing: API plan 31 system (mini solid-liquid hydrocyclone separator)
Mechanical seal

- Showing: API plan 53A seal system with instruments in a heated enclosure for extreme cold temperature environment
Mechanical seal

Solutions available

- Solution for high incoming pressure or high design pressure rating are available and in operation.

ANSI 1500 lbs RF flanges to handle a 90 bar (1305 psi) inlet pressure
Mechanical seal

- Delivered solution for 94 bar (1305 psi) inlet pressure.
- API plan 53B
Typical installation on a pump
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PC Pumps – Motor and gearboxes

Block design

Auger and wide throat hopper design for high pasty non flowable solids (such as drill cutting)

Bearing housing
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Elastomers
- Hydrated Nitrile-Butadiene-Rubber
- FKM – Fluoro Carbone Mixture

- Ethylene-Propylene-Diene-Mixture
- NBR – Nitrile-Butadiene-Rubber
- BR – Butadiene Rubber

Solid materials
- Plastics
- PTFE – Poly-Tetra-Fluor-Ethylene
- PA – Poly-Amide

Metals
- Grey cast iron
## Rotor Materials

### Standard
- 1.2436 hardened: Hardened tool steel
- 1.7225 VCP: Tool steel, VCP
- 1.4301: Stainless steel, 304
- CrNiMo 17-12-2: Stainless steel, 316 L / 316 Ti
- SIC/1.4462: Ceratec® - Solid Ceramic
- PVDF: Only C.Pro

### Special
- 1.4462: Duplex steel (20.000 ppm Cl-, 40°C)
- 1.4410/1.4501: Super Duplex steel
- 1.4539: Alloy steel Ni-Cr-Mo-Cu (Corrodur®)
- 2.4602: Hastelloy C22 (NiCr21Mo14W)
- 2.4617: Hastelloy B2 (NiMo28)

### Coating
- VCP: Hard chrome plating
- CRC: Chromium Carbide Coating
Materials for Wetted Parts

Standard

- **St**
- **0.6025**
- **Cr-Ni-Mo17-12-2**
- **(1.4404, 1.4571, 1.4401)**
- **PP**
- **PU**

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Grade Details</th>
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<tbody>
<tr>
<td>St</td>
<td>A570 36</td>
</tr>
<tr>
<td>0.6025</td>
<td>A 278 30</td>
</tr>
<tr>
<td>Cr-Ni-Mo17-12-2</td>
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<tr>
<td>(1.4404, 1.4571, 1.4401)</td>
<td>316L, 316Ti, 316</td>
</tr>
<tr>
<td>PP</td>
<td>Poly-Propylene</td>
</tr>
<tr>
<td>PU</td>
<td>Baydur® Poly-Urethane</td>
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</tbody>
</table>

Special

- **0.6025**
- **1.4462**
- **1.4410/1.4501**
- **1.4539**
- **2.4602**
- **2.4617**
- **Inconel 625, Inconel 825**

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</tr>
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<tr>
<td>0.6025</td>
<td>A 278 30, internally rubber lined or plastic coated</td>
</tr>
<tr>
<td>1.4462</td>
<td>A 182 F51, duplex stainless steel</td>
</tr>
<tr>
<td>1.4410/1.4501</td>
<td>A 182, A 276, A 479, super duplex stainless steel</td>
</tr>
<tr>
<td>1.4539</td>
<td>904L Ni-Cr-Mo-Cu (Corrodur®)</td>
</tr>
<tr>
<td>2.4602</td>
<td>Hastelloy C22 (NiCr21Mo14W) N06022</td>
</tr>
<tr>
<td>2.4617</td>
<td>Hastelloy B2 (NiMo28) N 10665</td>
</tr>
<tr>
<td>Inconel 625, Inconel 825</td>
<td>For Very High Chlorid Content</td>
</tr>
</tbody>
</table>

- Further materials on request

- Certificates (3.1, NDT, PMI, WPS/PQR (ASME-Section IX) etc)
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System requirements

- no piping spool available
- Lots of space behind the motor
- Hydrocyclone feed pump on Bunga Orchid A platform

Stator removal space
System requirements

- Dry Running Protection
System requirements

- Over Pressure Protection

Pressure Gauge with Contact(s) and a Pressure Transmitter
Connection: 3/4” BSP
System requirements

- Progressive cavity pumps are positive displacement pumps. Pressure relief valves are always needed.
- Relief valve sizing and piping back to suction of the pump must be sized for full flow.
- Consider back to tank relief valve routing for larger relief system system volume.
Progressive Cavity Pumps

- Quality of PC Pumps

  - Capacity: 0.01 l/h (0.0026 gal/hr) to 600 m³/h (2642 gal/min)
  - Operation pressure of transfer pumps: up to 72 bar (1044 psi)
  - Re-Injection pumps: 33 m³/h (9146 gal/min) at up to 240 bar (3480 psi)
  - Temperatures for elastomer stator design up to 160 °C (320°F)
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Progressive Cavity Pumps
Downstream process applications

- Progressive cavity pumps (pcp) are used successfully in offshore applications all around the globe. The characteristics of the pump design fits well with offshore services.

- The following list show some of the services where they are applied successfully:
  - Hydrocyclone feed pump
  - IGF skimmer pump
  - Separator produced water transfer pump
  - Compressor scrubber pump
  - Closed drains pump
  - LP Flare KO Drum pump
  - HP Flare KO Drum pump
  - Open drains pump
  - Skimmed oil pumps
  - MEG recycle and brine slurry pump
  - Diesel ring main pump
  - Drains caisson pump
  - Amine sump pumps
  - Crude oil transfer pump
  - Low volume water injection
PC pumps in the oilfield
Application process flow chart

PC pumps for pumping multiphase liquids in oilfields, 2013
The fluid handling characteristics of the PCP can be summarized by the following statements:

- **Low NPSH required.** NPSH available as low as 0.5m (1.64 ft) can be handled with solutions for lower NPSH available ready for application.

- **Low Shear pumping.** The gentle way in which the fluid travel in the cavities of the pump means PCP’s never create inseparable emulsions and do least damage to the oil droplet it conveys.

- **Solids handling.** Capable of handling coarse or fine particle solids. Sand can be pumped away.

- **Handles low to high Viscosity.** Virtually any viscosity can be pumped with a PCP.
Progressive Cavity Pumps
Mid- & Downstream process applications

- **Stable flow.** Positive displacement characteristic curve with stable flow even against changing pressures.

- **Capable of frequent start/stop**
  - Can be started and stopped on demand. Can be started against open circuit or a pressurized line.
  - Need not be operated continually on a bypass loop circuit as some centrifugal pumps are operated. Start up and shut down of the pump does not introduce unwanted ‘run-up’ vibration.

- **Does not gas lock.** Can displace 100% gas in event of gas flooding of the pump. Does not gas lock as some pump technologies do.

- **Capable of a wide temperature range operation.** Can operate at a wide range of operating temperatures. Some gear and sliding vane pumps are limited in the operating range they can tolerate due to clearance fits in gear and vanes.
Progressive Cavity Pumps
Downstream process applications

- Water Injection Pump in Brazil
PCP MPP in the oilfield
PCP MPP in the oilfield

- Application Example in Peru

Pump NM105SY01L06K
Speed: 250 rpm
Suction pressure: 30 psig
Discharge pressure: 120 psig

Multiphase flow rate: 18.115 BFPDe
GVF: 90%
Oil flow rate: 1.500 BOPD
Water flow rate: 310 BWPD
PC Pumps for International Projects

- Multi-phase Pumps in Russia
PC Package capabilities demonstrated
PC Pumps supplied North Western Australia

- Equipment list of pumps supplied:

  - Pump tag OP-0923 A/B Brine pumps
  - Pump tag OP-0957 MEG Slurry pump
  - **Pump tag OP-0963 A/B Brine pumps**
  - Pump tag OP-6403 A/B Oily water sump pumps
  - Pump tag OP-0906 Rich MEG storage tank skimming pump
  - Pump tag OP-0946 Rich MEG storage tank skimming pump
  - **Pump tag OP-0922 A/B Recovered MEG return pumps**
  - Pump tag OP-0962 A/B Recovered MEG return pumps
  - **Pump tag OP-0980 & OP-0980A MEG slurry export pumps**
  - **Pump tag OP-1011 A/B Drain Pumps Gorgon**
  - Pump tag OP-1051 A/B Drain pumps Jansz
PC Pumps supplied for North Western Australia

- Pump tag OP-0980 & OP-0980A MEG slurry export pumps
PC Pumps supplied for North Western Australia

- Pump tag OP-0963 A/B Brine pumps
PC Pumps supplied for North Western Australia

- Pump tag OP-1011 A/B Drain Pumps Gorgon
PC Pumps supplied for North Western Australia

- Pump tag OP-0963 B Brine pumps - Test house
PC High Pressure Pumps for Russia

Medium: slop/hydrocarbons containing sand and silt
Capacity: 20 m³/h
Diff. pressure: 2329 kPa g (= 23.29 bar)
Material: Duplex 1.4462
Pump size: NM063SY04S24B

Medium: Hydrocarbons/Water
Capacity: 11,4 m³/h
Diff. pressure: 5619.6 kPa g (= 56,196 bar)
Material: Duplex 1.4462
Pump size: NM053SY12S72Z
Applications in multiple industries

<table>
<thead>
<tr>
<th>Environmental &amp; Energy</th>
<th>Chemical, Pulp &amp; Paper</th>
<th>Food &amp; Pharmaceutical</th>
<th>Oil &amp; Gas Upstream</th>
<th>Oil &amp; Gas Downstream</th>
<th>Dosing Technology</th>
<th>Systems</th>
</tr>
</thead>
</table>

Presentation BU P&S, 11/2012
Highlights of PC Pumps

Remember pc pumps for:

- Stable flow
- Low shear
- Viscosity is not a limitation for the pump
- Ability to handle solids
- Low NPSH Requirements
- Can handle multiphase liquids
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