ARTIFICIAL LIFT SYSTEMS

PROGRESSING CAVITY PUMPS SOLUTIONS

Applications

Cold Heavy Oil
- CHOP
- CHOPS
- EXTRA HEAVY OIL

Light Oil

Thermal Oil Recovery
- SAGD
- CSS

Gas Well Dewatering
- CSG / CBM

PCM | keep it moving

ABOUT PCM

Founded in 1932 by René Moineau, the inventor of the Progressing Cavity Pump, and Robert Bienaimé, from Gevelot Group, PCM is today one of the world's leading manufacturer of positive displacement pumps and fluid-handling equipments.

Our specialty is developing solutions for the lifting, transfer, dosing, mixing and filling of abrasive, fragile, viscous, corrosive, hot or heavy products. Present around the world, we provide solutions to three main sectors : Oil & Gas, Food and Industry.

PCM IN THE OIL & GAS

PCM provides cost-effective PCP-based pumping systems and integrated services for all your upstream applications in the Oil & Gas industry.

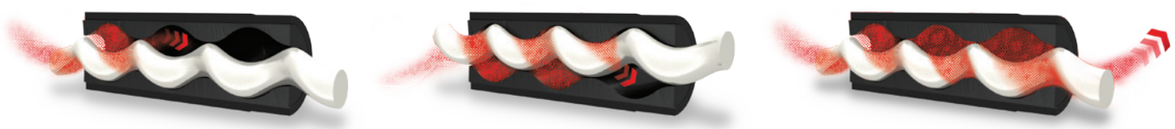
Our longstanding expertise, practical insights and widest range of PCP technologies give you the control you need to maximize production and equipment performance and to reduce downtime and maintenance to a minimum. We accompany you in building your PCP life cycle strategy to increase your mature field production and get the fullest potential of your wells.

PCM PROGRESSING CAVITY PUMP SYSTEMS

MOINEAU™ TECHNOLOGY

Principle
A Moineau pump consists of a helical stainless steel rotor turning inside a helical stator moulded in elastomer. With the rotor inserted into the stator, a double chain of watertight cavities is created.

When the rotor turns inside the stator, cavities are progressing along the pump without changing either shape or volume. This action transfers the fluid from the pump intake to the pump discharge without shearing the fluid.

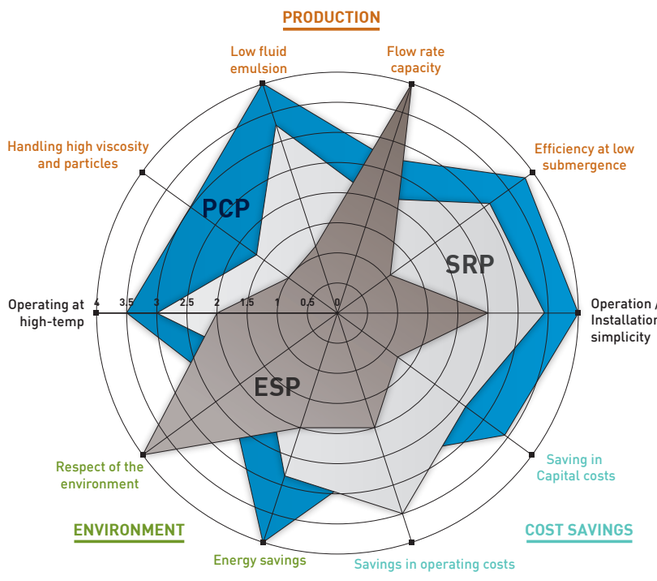


PCP TECHNOLOGY OVERVIEW

PCP systems offer lower capital costs for the same pump capacity as traditional pump and are the best choice for use in conditions that other artificial lift system cannot handle.

There are no expensive foundations to be laid. Construction is simple and can be adapted to any kind of well head. The compact size of the pump drive units means you can fit more drive heads into a given space, thereby reducing capital outlay. Installation is quick and reliable, which keeps rig mobilization and costs minimal.

PCPs provide cost-effective operations with longer lifespan and less manpower to operate and maintain than other artificial lift systems. The remarkable volumetric efficiency and overall mechanical efficiency of PCP systems increase field production and lower power requirements.



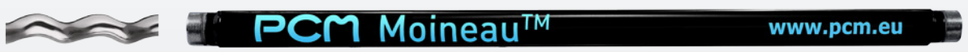
PCM PCP TECHNOLOGIES AND RANGES

Our exclusive PCP technology panel covers each phase of the field life cycle from early production to maturing fluids and thermal enhanced oil recovery.

PCM MOINEAU™
Elastomer Stator

Performance:
- Elastomer broad selection
- Pressure : 330 bar
- Flowrate* : 700 m^3/d (4400 bfpd)
- Range : 73 models

Benefits:
- Transfers viscous fluids
- Handles high level of sand cut, water and gas
- Operational simplicity



PCM MOINEAU™ HR
Long life rotor / pump

Performance:
- Hydraulic regulators embedded in the rotor
- Pressure : 330 bar
- Flowrate* : 570 m^3/d (3 600 bfpd)
- Range : 37 models

Benefits:
- Handles high gas content
- Improves uniform pressure distribution
- Optimum performance and longer run life

PCM VULCAIN™
Metallic Stator

Performance:
- High-temperature package (350°C / 660 °F)
- Pressure : 135 bar
- Flowrate* : 900 m^3/d (5650 bfpd)
- Range : 15 models

Benefits:
- High temperature up to 350°C/660°F
- Efficient with any water cut
- Through-stator steaming proof. No heavy work over before or after steaming

*During pump operation at 400 RPM and 2/3 max head

PCM PRODUCT & SERVICE OFFER

Our comprehensive PCP solutions include surface and downhole equipment, optimization software and consultancy and field services

DOWNHOLE PUMPS
- PCM Moineau™
- PCM Moineau™ HR
- PCM Vulcain™

DRIVES
- Electrical Driveheads
- Hydraulic Driveheads
- Motors
- BOPs

POWER UNITS
- Prime Movers
- Hydraulic Pumps
- Shelters

ROD STRING
- Couplings
- Conventional Rods
- Continuous Rods
- Hollow Rods
- Rod Centralizers

TUBING STRING
- Insert Nipples
- Torque Anchors
- Gas Separators
- Anti Vibration Subs (AVS)
- Tubing drains
- Sand screens

WELL SURVEILLANCE
- Variable Speed Drives
- Monitoring surface
- Monitoring downhole
- Well manager
- Data transmission
- Software

PROJECT MANAGEMENT
- Dedicated Project Manager
- Documentation
- Factory Tests
- Supply Chain

SITE SERVICE
- Inspection & Assembly
- Installation & Commissioning
- Monitoring
- Troubleshooting
- Maintenance

WORKSHOP SERVICE
- Stock Management
- Failure Analysis
- Repair
- Tests

PERFORMANCE OPTIMIZATION
- Design
- Surveillance
- Optimization
- Training

PCM SOFTWARE SUITE:

design
Online PCP solution for design & optimization

field track
PCP Operations management tool

COLD HEAVY OIL PRODUCTION (CHOP)

COLD HEAVY OIL PRODUCTION HAS LARGE RANGE OF COMPLEX REQUIREMENTS

Because of its physical characteristics and huge potential, heavy oil production faces a double economical and technical challenge.

TECHNICAL CHALLENGE

Huge challenges are involved in developing such reservoirs: very high viscosity (1500 to 4000cP) at low reservoirs temperature, shallow reservoirs meaning low initial pressure, pump intake fillage and increasing GOR along field life cycle.
In addition, CHOP faces potential gas and water inflow on low producing mature fields.

ECONOMICAL CHALLENGE

Million barrels of heavy oil recoverable reserves are affected by a price discounted versus light oil. Combined with technological challenges it makes CHOP an OPEX sensitive business that needs very short delivery.

HSE CHALLENGE

Extracting cold heavy oil on a very large scale using "conventional" production technique requires low profile surface equipment. The compact size of PCPs and lower power consumption versus other artificial lift systems is more environmentally acceptable while reducing capital outlay.

PCM IN COLD HEAVY OIL

PROGRESSING CAVITY PUMP BENEFITS

- As a positive displacement pump, PCP is able to pump mixtures of oil, water and solids.
- PCP low shear technology has high viscous fluid handling capability contrary to ESP which has unacceptable hydrodynamics losses in the high-speed impeller.
- Constant torque and axial stress, smooth operation.
- Offer no rod fall unlike SRP pumps and lower OPEX.

PCM BENEFITS

- Low speed and short pitch PCP geometry for improved pump fillage.
- PCM high runner 1**94 soft elastomer** with unmatched records in Canadian CHOP.
- Exclusive and patented **PCM Moineau™ HR** multiphase technology drastically increases run life of conventional PCP's in high GOR wells.

TYPICAL SERVICES:

- Worshop facilities with large inventory close to field operation
- Pump delivery with hydraulic test according to customer target
- Failure analysis facilities and procedures to support and enhance runlife on the field using unique **PCM Field Track** monitoring software.

NOTABLE REFERENCES:

- Pioneer in Canada in the early 80' with PCP. Thousands of pumps installed in Canadian CHOP application since then.

COLD HEAVY OIL (CHOPS)

COLD HEAVY OIL PRODUCTION WITH SAND RECOVERY TECHNIQUE

CHOPS recovery technique allows producing sand inside the well bore along with oil in order to improve the productivity of the well. As the sand is produced, wormholes develop in the reservoir, which slowly increases the ability to access remote regions of the pay zone.

TECHNICAL CHALLENGE

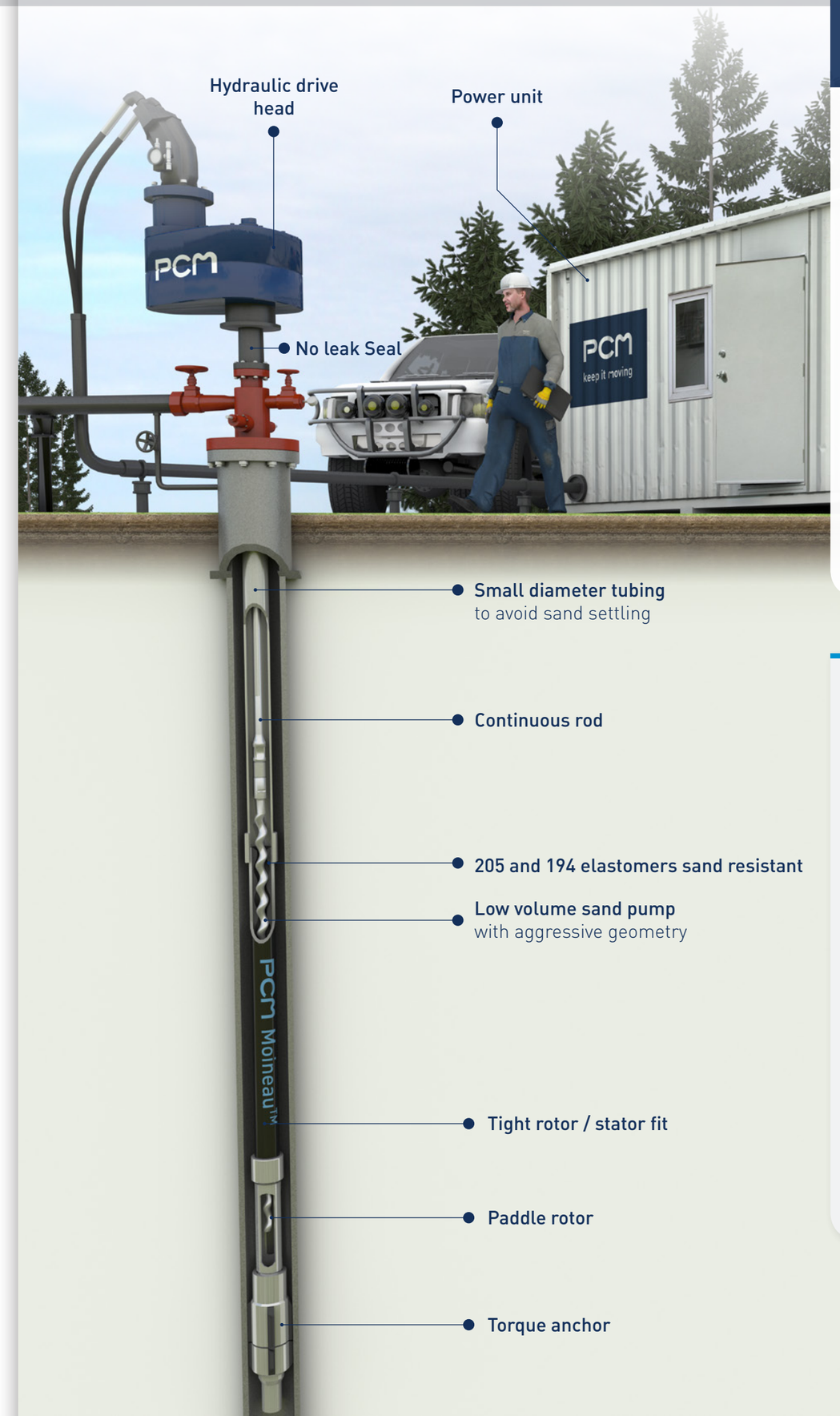
High sand cut production is challenging because of high abrasion, plugging risks, and high starting and operating torque. High viscosity of oil production in cold conditions combined with sand mixture worsens pump intake fillage. Shallow reservoirs with increasing GOR along field life cycle reinforce the inherent difficulties of sand production.

ECONOMICAL CHALLENGE

Producing the oil with sand has a quicker and higher rate of recovery than producing the same well in cold heavy oil production without sand. However, harsh abrasive conditions are critical for artificial lift life span and result in very high operating costs.

HSE CHALLENGE

Bringing the entire mixture of sand, water and oil to the surface requires a sealing system to be abrasion proof.



PCM IN COLD HEAVY OIL / CHOPS

PROGRESSING CAVITY PUMP BENEFITS

- Unrivalled ability to face high sand cut
- Low speed design to reduce abrasive wear
- No rod fall and ball valve wear issues unlike SRP's
- Tolerates high percentage of free gas
- Can be operated with low drawdown and high discharge pressure
- Low profile surface equipment / low power consumption lowering OPEX

PCM BENEFITS

- Special PCM low volume pump range of aggressive geometries for sand
- Unique well life cycle strategy to reduce starting torque and improve stator wear performance : selecting PCM **205 elastomer** for high sand cut and low water cut at early production phase; then extending the PCP run life when water cut increases and sand cuts decrease by converting into PCM 1**94 elastomer**

TYPICAL SERVICES:

- Workshop facilities with large inventory close to field operation
- Pump delivery with hydraulic test according to customer target
- Failure analysis facilities and procedures
- Unique **PCM Field Track** monitoring software to manage sand in all phases of production and enhance run life on the field

NOTABLE REFERENCES:

- Pioneer in Canada in CHOPS, thousands of PCM pumps installed

EXTRA HEAVY OIL

MEETING THE NEEDS FOR HIGH PRODUCER WELLS IN EXTRA HEAVY OIL

Extra-heavy oil plays a key role in reserve replacement although the low mobility of extra-heavy oil in reservoir conditions makes recovery more difficult. One of the most prolific regions is the Orinoco Belt in Venezuela. This region has become a global reference for the cold recovery of this unconventional oil with viscosity ranging from 1,500 to 10,00cp, and gravity less than 10°API.

TECHNICAL CHALLENGE

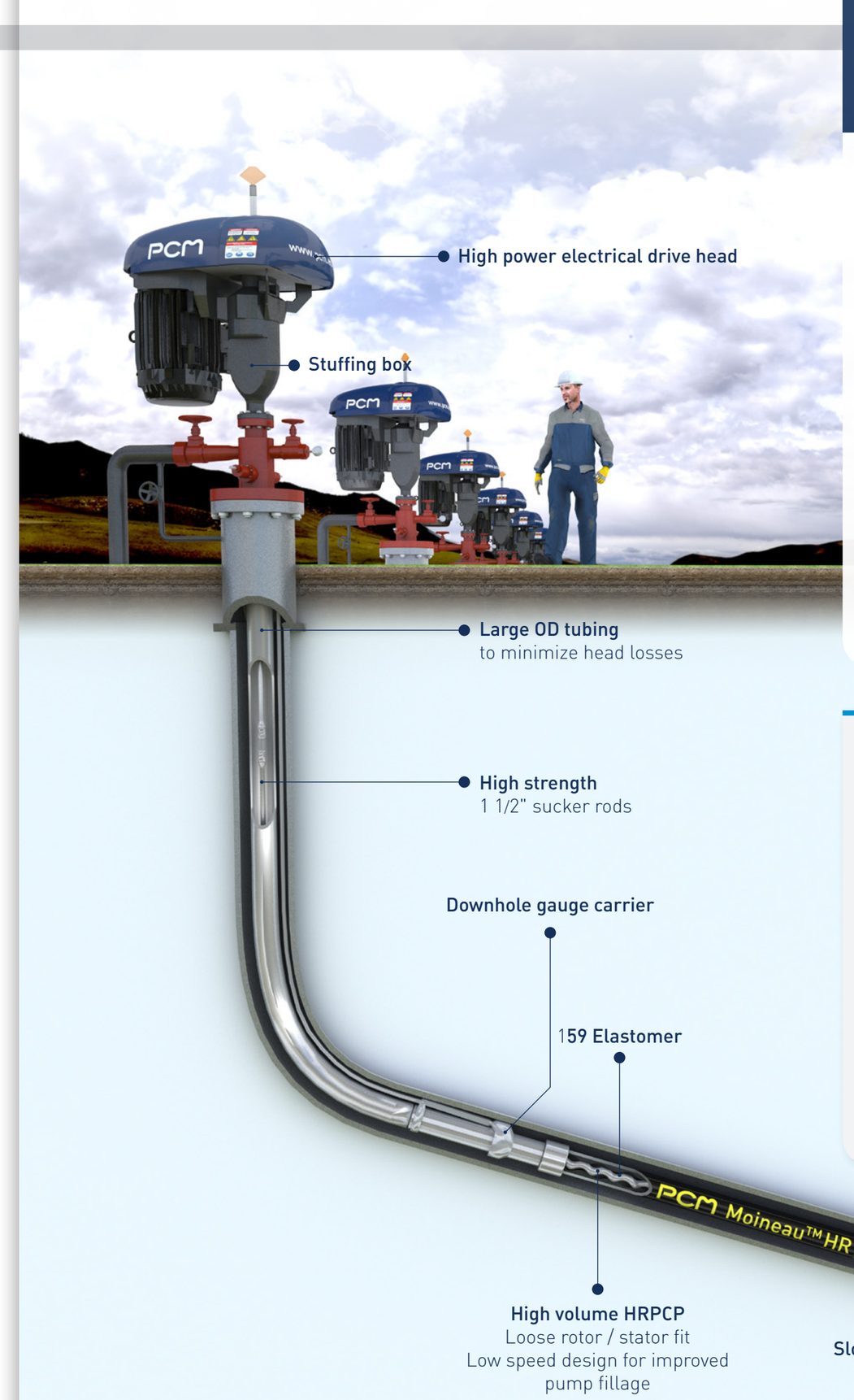
Technical challenges lie in extracting oil from high flow rates wells, with a very high viscosity in shallow reservoirs. These reservoirs are often produced under the bubble point pressure, at temperature above 50°C with increasing GOR along field life cycle. In situ cold production techniques can be applied using a diluent injected into the bottom of the well to lower the oil viscosity.

ECONOMICAL CHALLENGE

The costs of extra-heavy oil developments remain high: in addition to the high initial capital expenditure, sustaining production levels in situ entails high operating costs. Improving project economics is the top priority to maximize the value of extra-heavy oil crudes.

HSE CHALLENGE

Among the many environmental challenges of extra-heavy oil, energy weighs significantly. Finding energy savings in production through the most efficient artificial lift system will lower operational costs at the same time.



PCM IN EXTRA HEAVY OIL

PROGRESSING CAVITY PUMP BENEFITS

- Better control during start-up of the wells versus ESPs
- Low shear PCP technology for high viscous fluid handling capability
- More reliable and lower operating expenses than SRP
- PCP elected best technology for extra heavy oil in Venezuela

PCM BENEFITS

- Development of high volume PCP systems. 5" series of pumps and 6"5/8 model specifically designed for extra-heavy oil
- Highest flow rate range (5,000bpd)
- High power electrical drivehead range to run biggest pump completion
- PCM high runner **159 elastomer** with unmatched records in Orinoco Belt
- **PCM Moineau™ HR** patented technology to increase runlife for High GOR wells

TYPICAL SERVICES:

- Installation and commissioning
- Large inventory and logistics support
- **PCM Design™** software for PCP evaluation and optimization
- Well surveillance through innovative **PCM Field Track** monitoring software

NOTABLE REFERENCES:

- High flow rates pumps with decades of experience in Venezuela extra-heavy oil 8° API
- Proven track records of over 10 years in Junin Orinoco area

LIGHT OIL

OVERCOMING AGGRESSIVE LIGHT OIL CHARACTERISTICS

Light crude oil has a low viscosity (< 50cP) and a high API gravity (> 32°API) due to the presence of a high proportion of light hydrocarbon fractions. The hostile fluid conditions require specific elastomers and special care will be given to rotor-stator sizing and to well operation monitoring.

TECHNICAL CHALLENGE

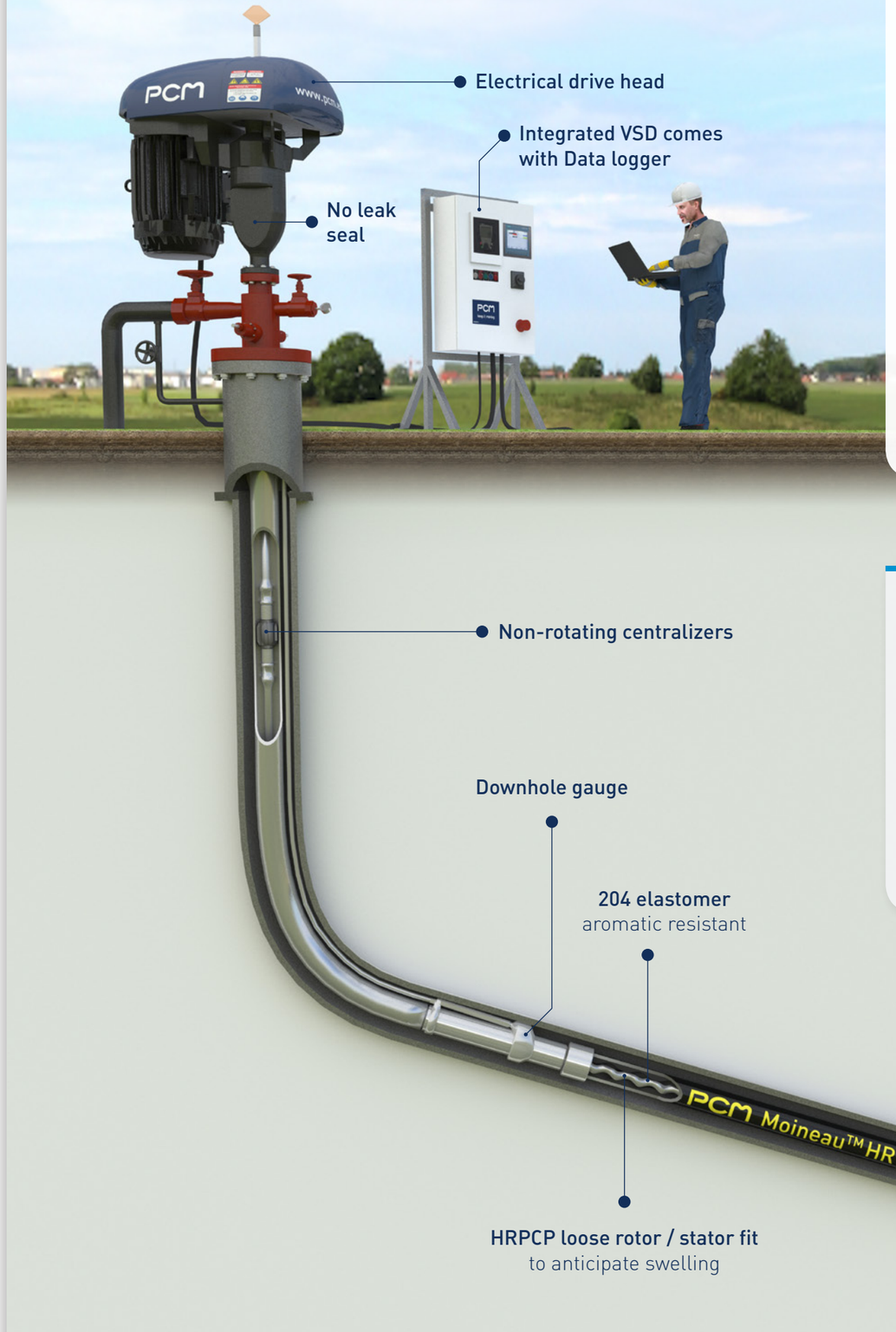
High percentage of aromatics and high gas content induce swelling and softening of the stator. CO2 and high water cuts may accelerate corrosion. H2S can cause extended vulcanization which results in an adverse effect of hardening the elastomer material. Light oil is usually found at deeper reservoirs where temperature worsens the aggressiveness of the fluid against elastomer.

ECONOMICAL CHALLENGE

The high value of light oil will require minimum downtime. Lower life cycle cost on mature fields is also required to postpone the well abandonment.

HSE CHALLENGE

Energy savings in production will benefit to lower operational cost.



PCM IN LIGHT OIL

PROGRESSING CAVITY PUMP BENEFITS

- Great simplicity of the PCP reduces rig immobilization time
- Easy to operate, the PCP system enables fast production optimization and easy maintenance
- Energy efficient (10 to 50% savings compared to other ALS).
- Lower CAPEX than ESP.

PCM BENEFITS

- Unmatched PCM **199 and 204 elastomers** both resistant to aromatics
- PCM swelling tests procedure for best match of elastomer selection and pump sizing for longer PCP life span
- **PCM Moineau™ HR** pumps handle gas and are a must above 40% GVF.
  - No gas separator required, no gas lock issue occurs as for ESP and SRP
  - It offers much longer run life than conventional PCPs

TYPICAL SERVICES:

- Swelling tests
- Well surveillance and monitoring
- PCM Application Engineer support

NOTABLE REFERENCES:

- 41° API in Canadian Bakken play
- 39° API with 20% aromatics in China
- > 35° API Offshore West Africa
- 47° API in Colombia

THERMAL ENHANCED OIL RECOVERY / SAGD

UNLOCKING UNCONVENTIONAL OIL WITH STEAM ASSISTED GRAVITY DRAINAGE

Steam assisted gravity drainage (SAGD) involves the injection of steam into the reservoir to assist the heavy oil recovery by reducing the oil viscosity and improving its mobility. Two horizontal wells are drilled, one above the other. Steam is injected into the upper well to heat the oil so that it can drain down into the bottom producer well. The oil is then pumped to the surface with an artificial lift system.

TECHNICAL CHALLENGE

To overcome high temperatures, low to high operating viscosities and multiphase content, the technical challenge is to find a specific PCP technology to eliminate chemical and thermal degradation of elastomer stators. For low pressure SAGD featuring low pump inlet pressure, a reliable artificial lift offering low submergence is of the essence. The AMPCP developed by PCM answers all those needs.

ECONOMICAL CHALLENGE

SAGD process requires high capital investment and operating costs. The right artificial lift technique used is an important part of the success factor for improving thermal heavy oil recovery economics.

HSE CHALLENGE

Water resource and energy consumption require low steam-to-Oil ratio process. Meeting the challenges of thermal recovery also involves supporting the environment through low power consumption equipment with small profile that easily blends into the surroundings.

*HT = High Temperature

PCM IN SAGD

PROGRESSING CAVITY PUMP BENEFITS

- Small footprint
- Downhole pump assembly simplicity
- Low capital and operating expenditures versus high temp ESPs

PCM BENEFITS

- **PCM Vulcain™** unique patented **All Metal PCP technology**
- High temperature technology package
- Supports cold and extremely hot fluids **(350°/660°F)**
- Through-stator steaming proof, at warm up phase
- No heavy work over before and after
- Low steam to oil ratio
- Resilient to steam breakthrough during operations
- Wide range of AMPCP models covering 50 to 5600 bfpd
- Single design allowing wide range of viscosities (1-10,000+ cP) with high efficiency

TYPICAL SERVICES:

- Exclusive **PCM Design™** software for **PCM Vulcain™** design
- High skilled Field Technicians for installation in thermal operation with long term service experience
- High temperature maintenance equipment
- PCM Application engineers support

NOTABLE REFERENCES:

- PCM High temperature technology **PCM Vulcain™** used in large scale field development for oilsands production in Canada with up to 40 months life span. Proven also in Carbonates formation with excellent track records

THERMAL ENHANCED OIL RECOVERY / CSS

CYCLIC STEAM STIMULATION EXTENDS HEAVY OIL RECOVERY

Cyclic Steam Stimulation (CSS) or "huff and puff" technique is a three stage common thermal EOR. A single well is used to inject steam into a heavy-oil reservoir to heat the oil and reduce its viscosity. After a "soaking" period, the production phase can start and when the well productivity is too low due to the cooling of the reservoir, steam is re-injected to begin a new cycle.

TECHNICAL CHALLENGE

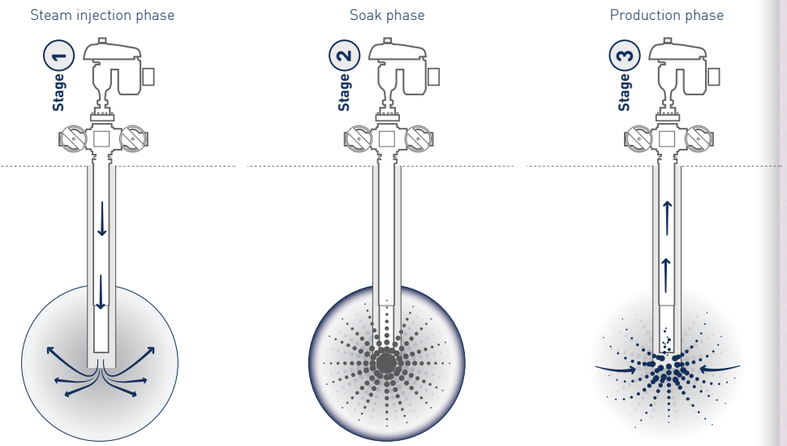
Main lift difficulties are the high fluid temperatures, important viscosity changes and flow rate variations during production cycle from high to cold reservoir temperature. All elastomers used in PCP will experience accelerated deterioration with exposure to high temperature. Highly versatile artificial lift is required to handle a wide range of operations conditions of the CSS.

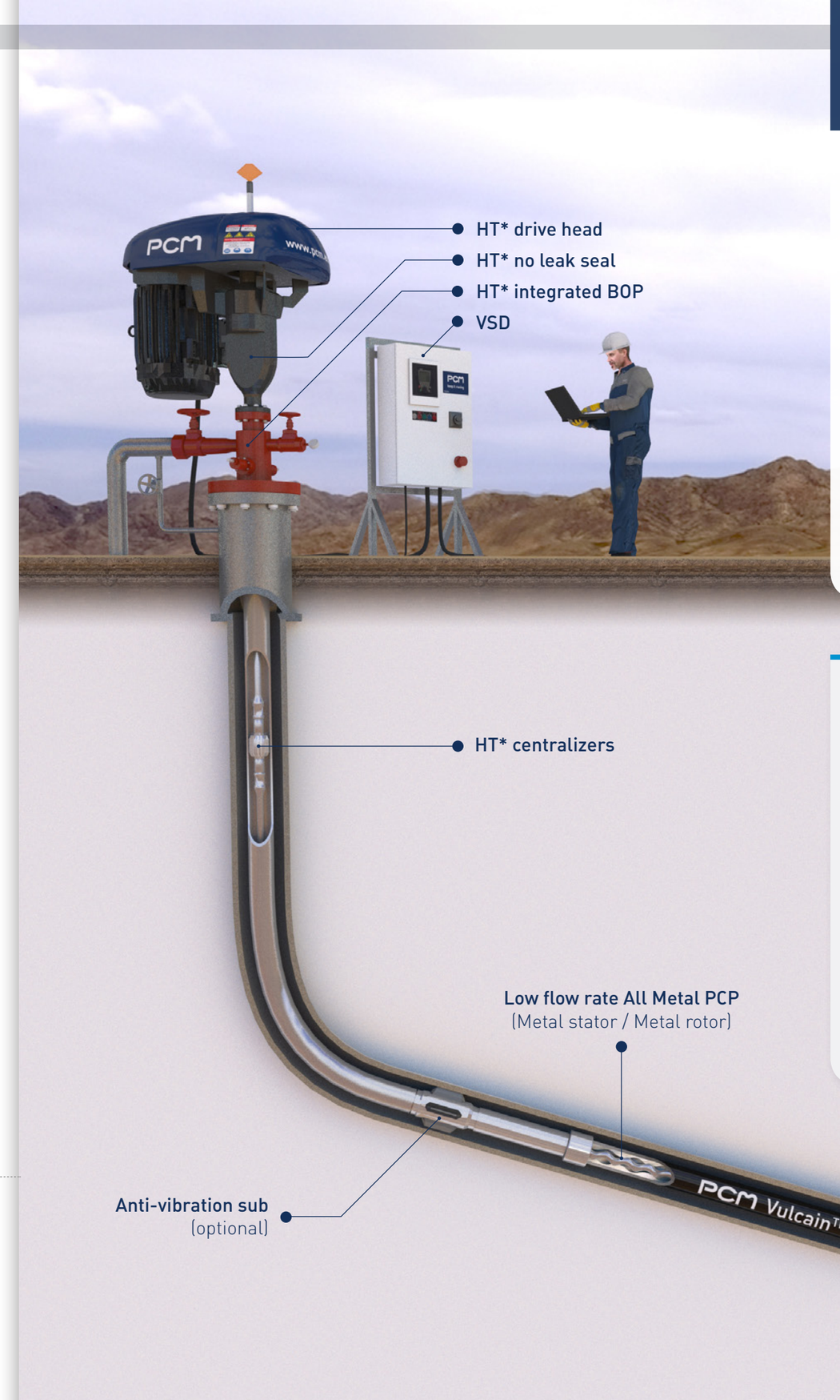
ECONOMICAL CHALLENGE

CSS is less capital intensive than SAGD as it can use existing wells to convert into thermal wells. However, CSS thermal heavy oil recovery involves high capital expenditures to fit with high temperatures conditions and high operating costs due to steam generation

HSE CHALLENGE

Minimizing energy consumption and CO2 emission as well as minimizing work over on stimulated hot wells is in line with HSE requirements while meeting business savings.





*HT = High Temperature

PCM IN CSS

PROGRESSING CAVITY PUMP BENEFITS

- Downhole pump assembly simplicity
- Simple to operate
- Low capital and operating expenditures versus SRPs and high temp ESPs.

PCM BENEFITS

- **PCM Vulcain™** high temperature PCP package
- Unique patented **All Metal PCP technology**
- Eliminates chemical and thermal degradation of elastomer stators
- Supports cold and extremely hot fluids **(350°/660°F)**
- **Through-stator steaming proof**
- No heavy work over before and after steaming
- Wide range of AMPCP models covering 50 to 5600 bfpd
- Wide range of viscosities (1-10,000+ cP) with one single system
- Long term field proven technology

TYPICAL SERVICES:

- Exclusive **PCM Design™** software for **PCM Vulcain™** design
- High skilled Field Technicians for installation and maintenance in thermal operation
- PCM Application engineers support

NOTABLE REFERENCES:

- PCM High temperature technology **PCM Vulcain™** successfully deployed in Canada, Europe, Africa and Middle East in vertical and deviated wells, CSS and steam flooding applications

COAL SEAM GAS

THE BOOMING NATURAL GAS INDUSTRY

Coal Seam Gas (CSG) also names Coal Bed Methane (CBM), is natural gas recovered from coals seams. Methane may be extracted by drilling wells into the coal seam where water prevents the gas from flowing. Artificial lift is necessary to remove the water from the well in order to release the gas to the surface.

TECHNICAL CHALLENGE

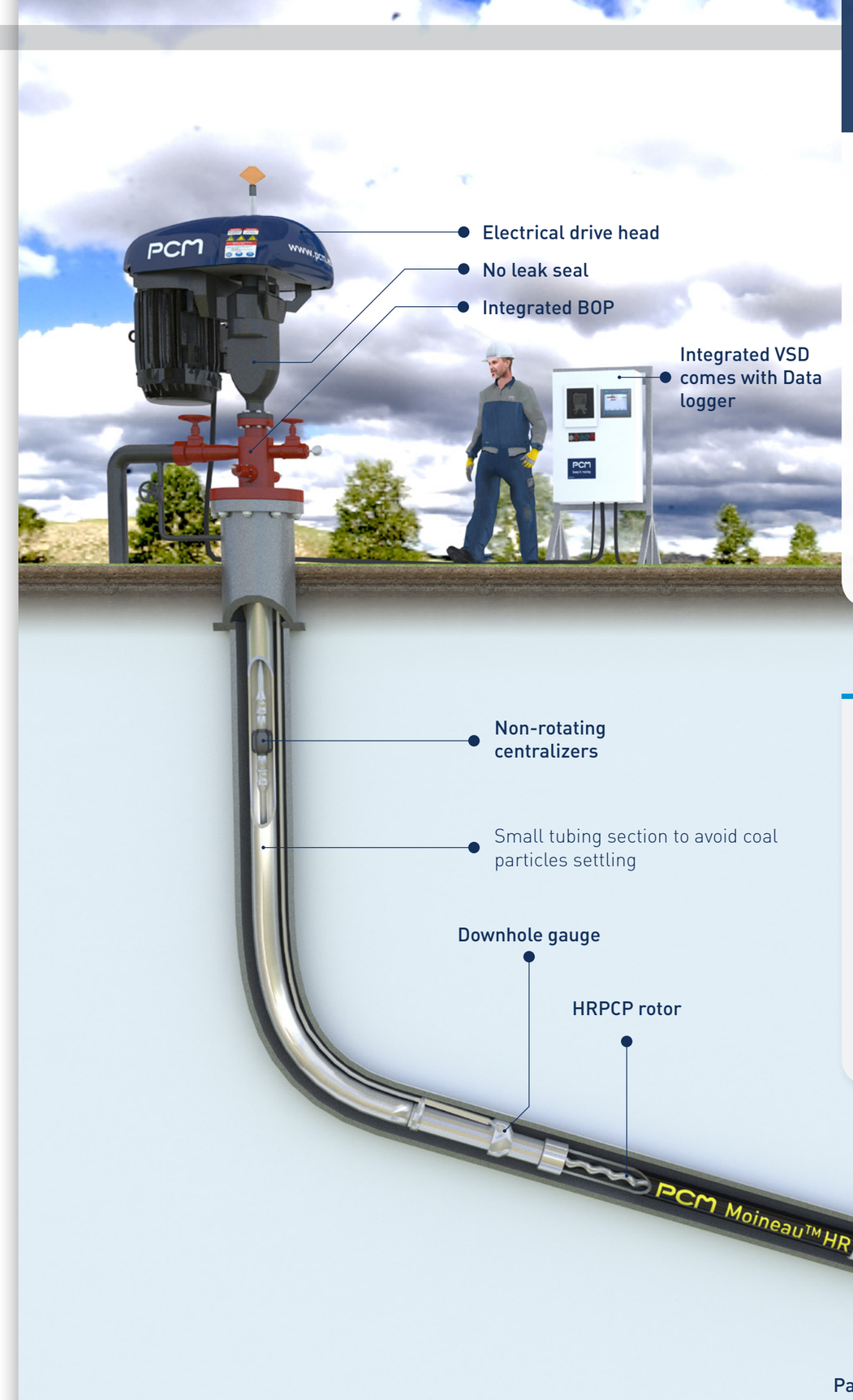
The fine particles of coal in the water can affect any artificial lift system performance. PCP's have become one of the most common types of artificial lift methods for dewatering CSG/CBM wells. Elastomers selection must be done to overcome the corrosive and poor lubricating properties of water. The pumping system must also accommodate the high flow rates in early production phase. Gas present in the water is detrimental to the conventional PCP life system impaired by the multiphase flow. PCM dedicated multiphase technology brings the inherent benefits of PCP to multiphase conditions.

ECONOMICAL CHALLENGE

CSG/CBM wells usually have relatively quite modest gas flow rates and profitability is highly sensitive to gas market price and tax regime. Capital outlays and operating expenses must consequently be minimized for these operations to be economically viable.

HSE CHALLENGE

Compared to other artificial lift system, the PCP low energy consumption benefit to lower production costs. The small footprint and low profile of the PCP systems are environmental friendly especially in farming landscape where CSG/CBM wells can be found.



PCM IN CSG

PROGRESSING CAVITY PUMP BENEFITS

- Best suited ALS to handle coal, fines and particles
- Constant flow
- Low power consumption compared to other artificial lift systems
- High volumetric efficiency
- Low maintenance costs

PCM BENEFITS

- Unmatched low-swell elastomers providing high abrasion resistance when facing coal particles
- Aggressive geometries providing lower start up torque and greater solid handling
- High gas acceptance **PCM Moineau™ HR** technology to increase pump life in multiphase condition : pump installation above perforation, eliminating need of gas separator and associated risk of plugging

TYPICAL SERVICES:

- PCM Application Engineer support
- Swelling test and elastomer selection procedure for optimized run life.
- Pump delivery with hydraulic test according to customer target
- Careful and precise selection of rotor/stator interference
- Workshop facilities for failure analysis and run life improvement
- **PCM Field Track** monitoring software to maximize production

NOTABLE REFERENCES:

- Over 1 000 pumps operating worldwide in USA, Canada, India, Indonesia, China and Australia, operated by major CSG/CBM world-class players

PCM

Ref. B-000325 - B - 12/2015 - Non contractual pictures