APPLICATION REMIT

PressureTuner Fluid Level Monitoring

OPTIMIZING DEWATERING OF COAL SEAM GAS WELLS

Challenges

In many cases the cleat system of coal seam gas (CSG) reservoirs is 100% water saturated. Therefore water must be recovered to lower formation pressure below the gas desorption pressure to initiate gas production. In under saturated CSG reservoirs this dewatering phase can last many months, or in some cases years, before onset of gas production occurs. This contrasts completely with development strategies for conventional natural gas reservoirs.

The volume of water to be produced is strongly influenced by well drainage area, number of individual CSG reservoirs being completed, coal aquifer sizes, and extent of connection with other non-coal aquifer sources or other recharge. Water production rates that can be achieved will dictate type of artificial lift system (ALS) used and production tubing size. ALS selection will be further refined by extent of coal fines co-production anticipated, which can lead to severe plugging and damage of well completions equipment.

Because coal seam reservoir pressures are typically very low, the chosen ALS must maintain a low wellbore water level to minimize flowing bottom hole pressure and optimize gas production. To lower flowing bottom hole pressure as much as possible the ALS pump is often positioned below the deepest coal interval. It is also vital that uninterrupted ALS operations be sustained throughout the dewatering phase, as unlike a conventional gas well, shut-in of CSG wells can result in significant loss of gas producing potential. This is due to water encroachment and pressure recharge of the drainage area, as well as inefficiencies associated with relative permeability effects.

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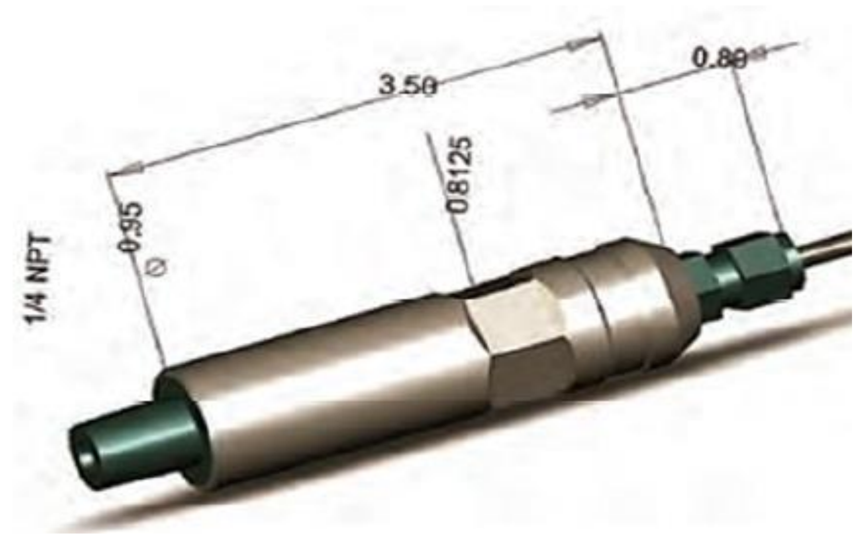

FEATURES & BENEFITS

- Allows water levels in coal wells to be accurately monitored on a continuous basis
- Data can be used to ensure operation of the ALS system is maintained within pre-defined limits, minimising pump ware, and in so doing prolonging pump life

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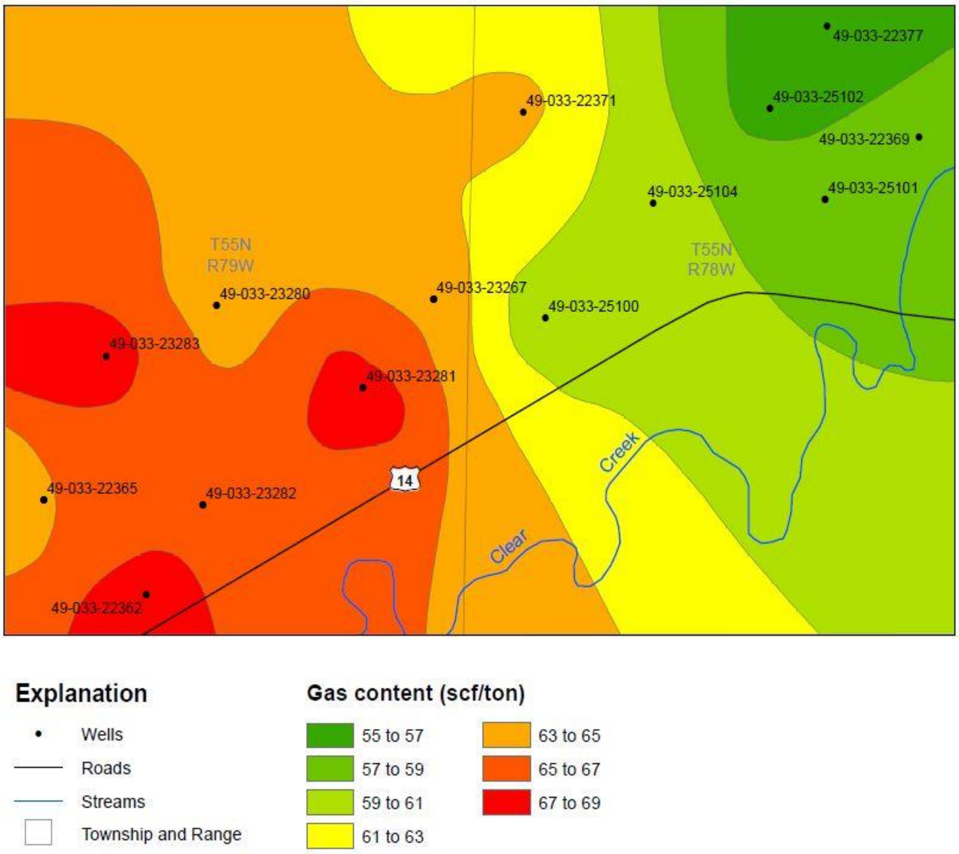
FEATURES & BENEFITS

continued

- Data from PressureTuner can be handed-off to third party VSD controllers, enabling operation of ALS systems to be adjusted automatically to minimise flowing bottom hole pressure and thus optimise well productivity
- Monitor critical well pump down operations during initial well unloading, or following any well shut-ins, to ensure no surging of water and gas into the wellbore. minimizing risk of coal fines and other solids mobilisation, which can otherwise increase completion skin through plugging of fractures and/or perforations
- Comparing bottom hole pressure data from PressureTuner with other surface and ALS pump parameters aids diagnostics of well and completion performance problems as well as to refine pump size selection for use in future well workovers, identify pressure bottlenecks and optimise extent of surface compression required
- Reservoir Engineers might also be able to extract meaningful trends from the bottom hole pressure data that, in conjunction with surface measurements of water and gas rates, could be used to validate reservoir models through history matching
- Integrating signals from PressureTuner with SmartPumper facilitates remote control and monitoring of ALS systems to be managed and controlled real-time via a dedicated web-based application

Gas content



If shut-ins are sufficiently long, or reservoir flow capacity is high enough, gas productivity can be lost completely.

Equally important is the manner in which the well is pumped down after any well shutdown. Pumping the well down creates a pressure drop in the near wellbore region. The gas saturation in this region can be high. If flowing bottom hole pressure is lowered too quickly, formation shock and surging of gas and water into the wellbore will cause co-production of damaging fines that can lead to perforation/fracture plugging, resulting in an increase in completion skin and consequential loss of productivity. Sudden and massive fines production can also potentially impact ALS operation integrity. It is thus crucial that bottom hole flowing conditions be monitored during unloading operations.

Lastly, in order to optimize ALS pump uptime, it is important to avoid the “pump off” condition, whereby the fluid level in the wellbore is not sufficient known as "fluid pound", causing excessive wear and possible damage to rod strings.

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Constraints

The system used to permanently monitor water level in the well tubing annulus must be compatible for use with all common ALS technologies used in CSG wells – Electrical Submersible Pumps (ESP), Progressive Cavity Pumps (PCP), Plunger Lift and Reciprocating Rod Lift. Specifically, they must be immune to the E-M noise generated by ESP systems, sufficiently rugged to cope with vibrations created by all pump types and contend with sour water corrosion potential. They must also be integrated into the completion string in a manner that does not interfere with in-well servicing of the pump units, with an independent means required to transmit signals to surface.

Furthermore, the data from the downhole sensors must be made available for interfacing with third party variable speed drive (VSD) systems using a variety of communication and signal protocols.

Core Studies

It is possible to quantify permeability from tests on whole cores under precise controlled laboratory conditions. However, accuracy of such tests can be impacted by number of factors, including method used to capture the cores, extent of filtrate invasion, damage to cores during retrieval, poor core preservation at surface, improper re-stressing of cores in the laboratory, re-stress hysteresis of cores, and scaling effects (core diameter relative to primary, secondary and tertiary fracture network spacing). Furthermore, the high cost of coring and core laboratory studies imposes an economic limit on the number of such tests that can be performed, resulting in a discrete data set that is often too small to adequately capture field-wide variations and establish trends.

Wireline Logging

It is also possible to construct continuous profiles of permeability through the reservoir using wireline logs. Given it is not possible to measure permeability directly, complex multi-parameter correlations are used instead which equate permeability with other measured physical reservoir characteristics. The correlation coefficients are calibrated through comparison of computed permeability's with measured values obtained at discrete depths from core laboratory studies, which as mentioned previously, are in any case prone to sizeable errors. Measuring the parameters used by the correlations also involves running a combination wireline toolstring (typically gamma, Microlog, NMR, Bulk Density & Neutron Porosity), which again can be cost prohibitive. Furthermore, the values of permeability derived from these correlations are not deemed sufficiently accurate for certification of 2P reserves.

Geological setting, coal seam structure, tectonic activity, natural fracturing, reservoir composition and reservoir physical characteristics can vary widely, all of which can impact bulk permeability. In coal seams, permeability is impacted by frequency of the natural fractures, their interconnections, fissure aperture, direction of butt and face cleats, burial depths, matrix shrinkage upon desorption, post-fracture mineralization and in-situ stresses.

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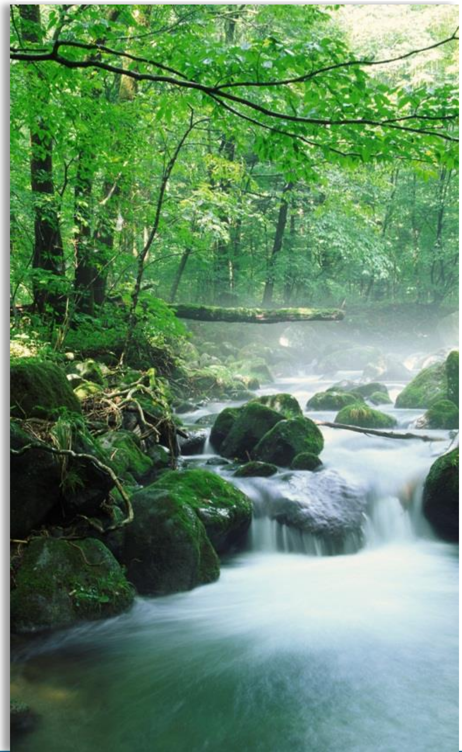
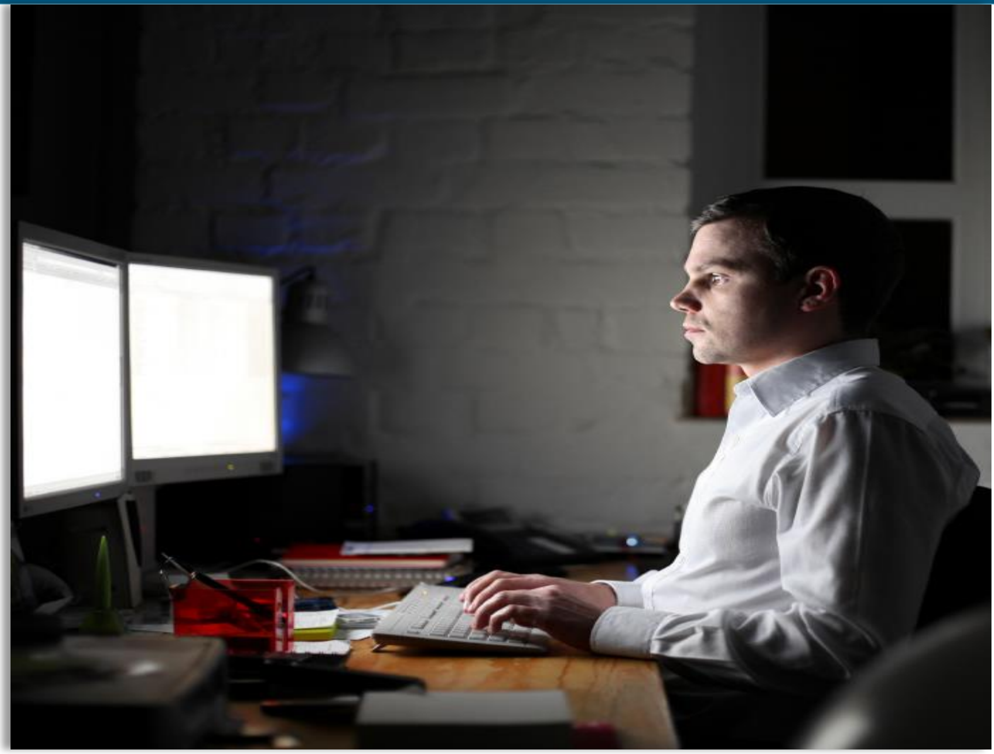
Reservoir Engineering Technical Support

Another important aspect of WellDog's PermSpotter service is provision of reservoir engineering technical support to help assist with test selection and design. Test selection methodology is driven by a decision tree that takes into consideration the well type, design, and status, as well as stimulation status, anticipated permeability, expected reservoir pressure, produced fluids from the target zone of interest, level of saturation and rig equipment.

Test design is driven by need to optimize quality of the pressure data acquired. This means performing tests, if possible, under single phase flowing conditions or, if multi-phase flowing conditions are unavoidable, minimizing saturation changes. It is also important to minimize changes in effective earth stresses, and prevent sudden pressure shocks to minimize completion skin effects. This needs to be counter-balanced against the desired radius of investigation.





Real-Time Data Acquisition

While technical due-diligence is crucial in shaping test selection and test design, uncertainties in reservoir characteristics may require changes to the test design during execution in order to optimize validity of pressure transient analyses. Access to real-time formation pressures during the flow and shut-in periods is therefore critical. WellDog's PermSpotter technology offering also includes provision of either wire-less or electric-line surface readout formation pressure monitoring systems.

The wire-less system relays pressure data to surface using a low frequency electromagnetic (E-M) signal propagated through the surrounding overburden to one or more receivers staked in the ground at surface, eliminating the need for complex inductive coupling systems or wet-mate connections and associated wireline equipment, thus saving costs and mitigating interruptions to rig operations. However, the use of a low frequency signal limits available bandwidth, constraining both data rate and pressure resolution.

For high permeability reservoirs, resulting in small and rapid pressure transients, pressure data can instead be acquired real-time using a pressure gauge deployed on conventional electric-line. Use of electric-line allows more resolute pressure data to be transmitted to surface at much higher data rates.

Pressure Transient Analysis

Real-time data from the surface readout pressure gauges is captured using ResPlot RTTM, which provides a means for viewing data as text, and also graphically as Cartesian plots. Basic real-time pressure transient analyses (PTA) can also be performed, comprising display of both semi-log (Horner) plots and log-log plots (c/w derivative). Data acquired by ResPlot RT can also be shared real-time with remote client offices via an Internet connection using Webex.