ANTI-AGEING TECHNOLOGY

Justin Bowersock,
TAM International, USA,
reviews various technologies that are helping operators overcome cement integrity challenges key to the revitalisation of ageing Gulf of Mexico assets.

Initial results indicate that advanced ultra-deepwater exploration campaigns, targeting previously untapped reservoirs in water depths exceeding 7500 ft, may very well yield record-level production in the years and decades to come. However, the recent resurgence of activity in the Gulf of Mexico cannot be attributed solely to the development of these promising reserves. In fact, independents and international majors alike are leveraging recent innovations in seismic, drilling and completions technology to revitalise fields first drilled over 50 years ago. Previously-unreachable, undetectable, or unobtainable reservoirs are now some of the most highly coveted assets in the Gulf of Mexico.

Appearances can be deceiving

By definition alone, some of these targeted prospects may be considered benign when compared to other recent offshore

discoveries, as they are neither 'extreme', 'ultra', nor 'high' pressure or temperature. Likewise, several of these fields reside in 'shallow' water depths less than 1000 ft deep. Unfortunately, in this case perception does not equal reality as drilling and completions operations can be extremely demanding despite the advent of the enabling technologies referenced above.

Decades of production have resulted in highly depleted reservoirs at varying depths throughout the Gulf of Mexico, creating challenges in virtually every phase of wellbore construction. In many cases, the margins between pore pressures and fracture gradients in these intervals are essentially non-existent (Figure 1). When drilling windows become this tight, maintaining the balance between flowing and fracturing can be extremely difficult. If equivalent circulating densities (ECDs) are too high, pressure-induced fracturing can occur resulting in formation damage or extreme fluid losses. Conversely, as efforts are made to avoid these excessively-overbalanced conditions, well control can potentially be compromised as hydrostatic pressures drop below pore pressure across potential flow zones. At this point, an influx of hydrocarbons is then free to travel up the wellbore to permeable, low pressure formations or all the way to surface in some instances. In either scenario, the safety, efficiency and ultimate profitability of the well are jeopardised, emphasising the importance of achieving viable annular isolation in these fields.

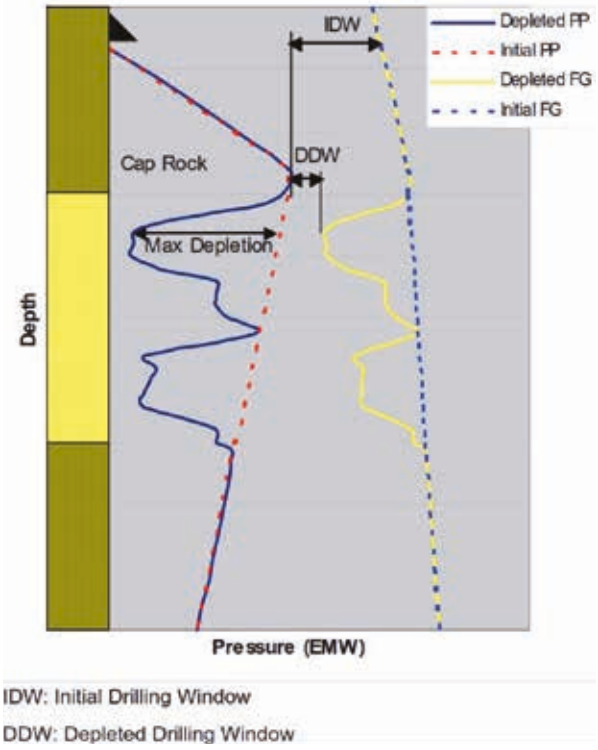

Figure 1. *Years of production results in a reduction of reservoir volume, which ultimately leads to a reduction in pore pressure and fracture gradient as annotated by the depleted drilling window (DDW) in the illustration above (Line Hoff Nilse, StatoilHydro).*

Innovative approaches

In recent years, cementing companies have introduced a variety of innovative new, lightweight slurries tailored to provide annular isolation in complex applications such as these. Each proprietary blend has been engineered with lower densities and a host of additives to promote higher compressive strengths and faster transition times. In theory, these cements should be light enough to avoid overburdening weak spots in the formation, but set quick enough to prevent annular flow during the critical hydration period as the cement transforms from liquid to solid. It is likely that these premium blends perform as designed when cementing best practices can be effectively followed in controlled environments or applications in which the pressure gradient is somewhat predictable.

However, this is not always realistic due to the complex nature of the Gulf of Mexico subsurface geology and the existence of countless depleted zones littered amongst untapped, virgin-pressured reservoirs. A given well could encounter borehole stability issues, unconsolidated formations, thief zones, tar stringers, salt canopies and/or a variety of other challenges (Figure 2). Often, these conditions preclude the ability for operators to follow recommended cementing practices such as circulating or conditioning the hole to remove drilling mud and filter cake prior to displacement, or rotating/reciprocating pipe during the primary cement job. In these instances, it is extremely unlikely that viable annular isolation can be achieved by pumping a single stage, regardless of the quality of the slurry design.

Rising rig rates

As rig rates run anywhere between several hundred thousand dollars to over one million dollars per day, the cost of fixing an inadequate cement job can add up at a rather alarming rate. Multiple attempts to perform remedial perforating and squeeze cementing operations are typically required before annular isolation is successfully achieved. Unfortunately, casing integrity is severely compromised in these instances, increasing the likelihood that subsequent remedial operations will be required at some point during the life of the well. In one well-documented case, an operator spent over US$ 20 million over the course of 13 months in an attempt to eliminate sustained casing pressure (SCP) in seven Gulf of Mexico wells (Figure 3). In order to avoid these potential complications, operators are now incorporating a number of complementary cementing accessories into their well designs from the surface casing through the production casing.

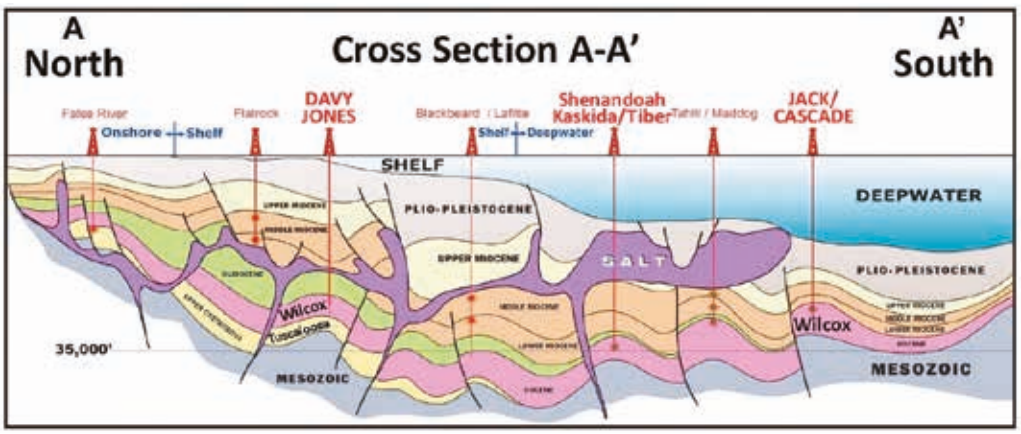

Figure 2. *McMoRan's subsurface modelling highlights the complex nature of faulted formations and the presence of an extensive salt weld (McMoRan).*

Solutions

The TAM Port Collar is a mechanically-actuated stage cementing tool designed to provide a means of selective annular communication without creating ID restrictions or compromising casing integrity. Unlike traditional hydro-mechanical stage tools, the Port Collar does not rely on balls or plugs to function, eliminating the need to drill up seats and other restrictions to regain full bore ID.

This feature enables the tool to be used in contingency applications. If a primary cement job is deemed inadequate, the tool can be utilised to perform a contingency stage or squeeze job. Once displacement is complete, the tool is closed and tested prior to reversing out any remaining cement in the workstring and tripping out of the hole. However, if primary cementing operations are deemed successful, subsequent drilling or completions operations can continue without the need to address the tool in any way.

The Port Collar's robust design has been modified and adapted over the years to create a portfolio of application-specific configurations to meet the unique challenges faced when cementing casing strings of all sizes. For example, large-diameter rotational versions are utilised to ensure difficult conductor and/or surface casing cement jobs are successful as shallow brine flows, unconsolidated sands and weak formations often make these operations extremely challenging. In other instances, premium Port Collars utilising a metal-to-metal sealing design are incorporated in critical intermediate and production strings to ensure cement integrity and casing integrity are both optimised for the life of the well.

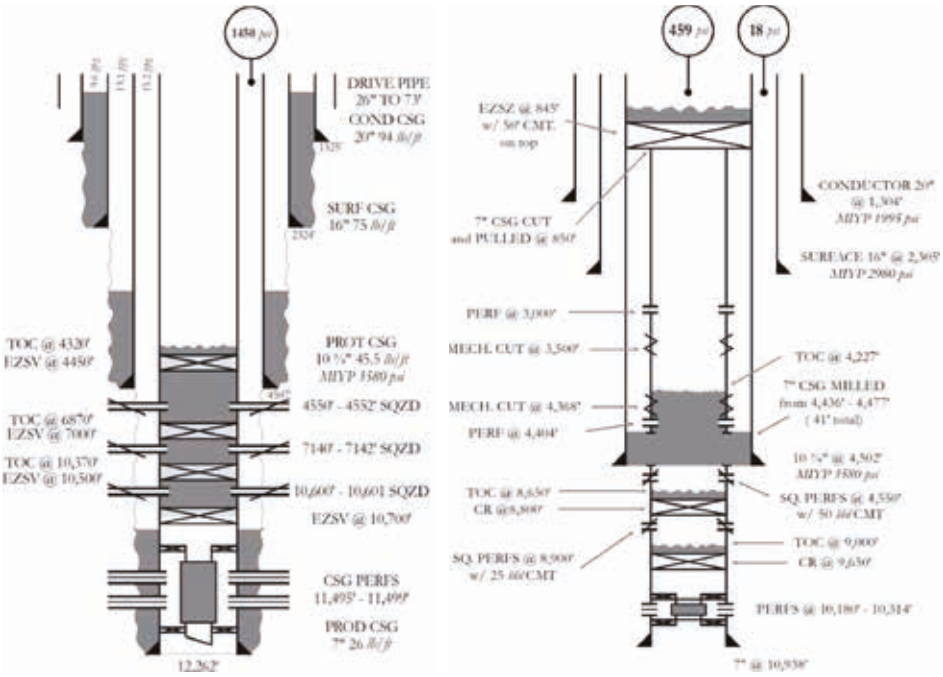

Figure 3. *Two examples of extremely costly, time consuming, and unsuccessful workover operations intended to eliminate Sustained Casing Pressure (SCP) in Gulf of Mexico wells. (Bourgoyne, Scott, Manowski – A Review of Sustained Casing Pressure Occurring on the OCS)*

Operators in the Gulf of Mexico are now utilising these technologies in new wells and sidetracks alike to mitigate the likelihood of imposed remediation operations to address inadequate annular isolation or insufficient zonal coverage. In fact, some operators have incorporated more than one Port Collar in certain casing strings to provide multiple points of selective communication in order to accurately target critical intervals if necessary.

The TAM Casing Annulus Packer (CAP) is another component of the company's cement integrity product portfolio. Inflatable packers provide a number of benefits when utilised to enhance annular isolation. It is well documented that a cement column's hydrostatic load diminishes as it develops static gel strength and becomes self-supportive. At this point, an influx of formation fluids or gas is able to enter the wellbore, contaminating the slurry and/or creating channels in the column of cement. An inflatable packer installed above a potential flow zone can create an instantaneous barrier, preventing any degradation of the sheath above it. In other applications the CAP serves as a dependable platform for 2nd stage cementing operations as it is capable of providing a seal in extremely washed out or irregular boreholes.

Gulf of Mexico operators have deployed CAPs and Port Collars on their production casing in horizontal completions to proactively improve their chances of attaining complete zonal isolation. In these scenarios, the CAP is inflated with applied internal pressure after the primary wiper plug bumps and seals at the casing shoe. If adequate isolation is achieved, the tool is not functioned. Otherwise, it is utilised to perform a contingency 2nd stage job above the packer ensuring the slurry is not contaminated and is forced in the desired direction.

In applications with more extreme requirements, the TAM HATCH Packer offers an solution. The tool is composed of a metal-to-metal Port Collar and modified inflatable CAP. The packer element is inflated conventionally off of plug bump to provide instantaneous annular isolation and a platform for 2nd stage operations. The TAM Combo Tool is then run in the hole to function the Port Collar. Once the 2nd stage cement job is complete, the Port Collar is shifted closed. In this unique

Figure 4. *TAM International tool display in Aberdeen utilised for internal and customer training. Metal-to-metal HATCH packer can be seen in the foreground.*

configuration, the metal-to-metal seals in the Port Collar are engaged, isolating the elastomeric seals in the CAP inflation valve assembly, resulting in life-of-well casing integrity as there are no longer any exposed elastomeric sealing elements in the system.

The HATCH Packer was initially developed specifically for a major operator plagued by shallow gas zones when cementing its 9 5/8 in. production casing offshore Indonesia. Over 150 successful installations have been performed to date eliminating previous spend allocated to remedial operations. Other configurations including 7 in. and 13 5/8 in. offer a number of potential benefits to operators focused on revitalising Gulf of Mexico fields facing similar cementing challenges.

Another component of TAM's suite of cement integrity solutions offers an interventionless means of isolation-enhancement in virtually any application. FREECAP swellable packers are actuated simply by exposure to correlating wellbore fluids. A portfolio of elastomers consisting of water-activated, hydrocarbon-activated and hybrid-swelling compounds is utilised to create application-specific packer designs for every job. This technology is currently being utilised in a number of Gulf of Mexico deepwater developments as a means of redundant liner top isolation on intermediate and production casing strings. Premium liner top packers still serve as the primary means of annular isolation as they are engaged immediately after the cement job is complete. However, a swellable FREECAP, designed to swell in the wellbore fluid or spacer above

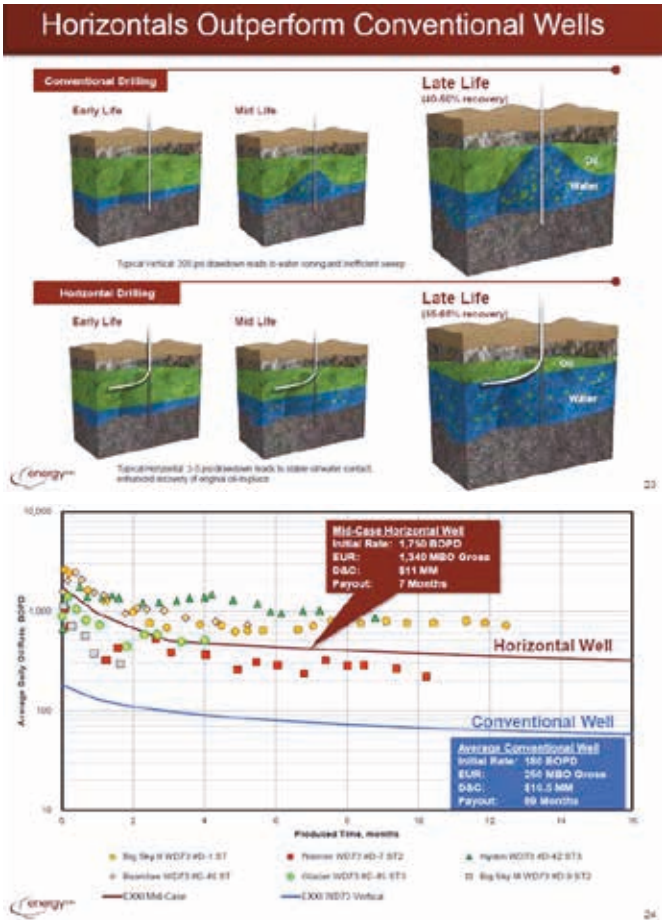

Figure 5. *Published results from operators such as Energy XXI highlight the advantages and benefits of utilising horizontal completions in fields such as West Delta 73 (Energy XXI).*

the primary cement job, can provide a secondary liner top seal often rated to over 10 000 psi up to 400˚F.

In many of these applications, a second swellable FREECAP is actually run deeper in the well as a means of enhancing the integrity of the cement sheath above the top of potential flow zones. This packer will be designed in order to provide a means of channelling mitigation or micro annulus remediation in the event that the quality of the cement sheath across and above these zones is inadequate to achieve total isolation.

This functionality can also be utilised in cemented, horizontal completions, which are becoming increasingly more common in new wells and sidetracks on the shelf (Figure 5). A number of operators have been leveraging this technology for land applications as it has proven to enhance annular isolation in situations where long laterals, insufficient centralisation and key seating routinely complicate wellbore conditioning and cementing operations. The FREECAPs will not expand with enough radial force to displace the slurry; however, they will be capable of swelling and sealing in annular voids not exposed to the slurry. Conversely, if catastrophic losses occur and cement is not circulated past the packers, they will be able to provide a means of full bore isolation and compartmentalisation for stimulation and production operations if sized appropriately.

Conclusion

The aforementioned applications represent an extremely small sample size of the challenges faced by operators targeting new reservoirs in aging assets in the Gulf of Mexico today. In order to safely and effectively optimise valuable resources and maximise production in these fields, customisable cement integrity solutions can be utilised as a means of complementing and enhancing existing cementing operations.