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Extensions to and Roll Out of Data Driven Production Surveillance and Optimization

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Abstract

Oil and gas production from a cluster of wells is conventionally relatively difficult to manage, at least partly due to field conditions, subsurface uncertainty and the multiphase nature of the well effluents. This can lead to late diagnosis of production problems, slow and conservative handling of production constraints and restricted understanding of subsurface potential. FieldWare Production Universe (FW PU) is a software application developed by Shell International Exploration & Production and Shell Global Solutions International that allows data driven well models to be constructed and updated from real time production data, and thereafter applied to track well-by-well production in real time. This paper updates on extensions of FW PU data driven techniques and also on the experience so far on the wide scale field implementation, roll out and support of the technology.

The successful embedding of a real time technology that such as FieldWare PU, which allows a step changes in the level of surveillance of well-by-well production, and the realization of maximum value from its use is a non-trivial exercise. In an ideal implementation, the software application needs to match the dynamic physical production elements (reservoir inflow, well performance, production processing and testing facilities) and the capabilities of the production staff as well as their production management processes. Key elements of the FW PU roll out in field operations include evaluation of actual production surveillance challenges vis-à-vis the value of the tool to be introduced, hardware and software readiness checks, clear setting of goals and expectations, post implementation evaluations, training of users and super-users, adjustment of workflows, and embedding the use of the application into the relevant operational processes.

This paper further discusses extensions of the data driven approach to a wide spectrum of applications, including real time operational optimization, the tracking of well productions in subsea and smart wells, and for specific types of production operations such as for beam pumped wells as well as wells which are intermittently operated. In particular the application of data driven techniques to beam pump pump-off controls, circumventing the need for load cells, is highlighted.

Introduction

FieldWare Production Universe (FW PU) is a data driven modelling application developed by Shell to address some fundamental gaps in the management and surveillance of oil and gas production operations. The development background and early operational experience of FW PU within the Shell Group are described in Poulisse et al. [1] and Cramer et al. [2]. Using data driven models derived from production well testing, FW PU essentially provides a “virtual” three phase meter for each well.

The introduction of FW PU for well-by-well production surveillance is regarded to be of significant interest as it addresses a fundamental problem in conventional oil and gas production operations, that of tracking of three phase (oil, water and gas) production from individual oil and gas wells in a cluster of wells. This is as the oil, gas and water production of the wells are not conventionally measured in real time, and the well productions are normally commingled before separation and metering of the individual phases.

Historically, and perhaps even in the current state of the art, there do not seem to be any multiphase flow meters effective over the entire potential water cut and gas-oil-ratio (GOR) range encountered over the life of a well which are economically suitable for deployment to individual wells. As such, production from individual wells is usually evaluated by routing the production from each well in turn to a well production testing facility, comprising a well test separator or a multiphase meter. Hence the production from wells is commonly measured perhaps only one day once a month. Well production volumes are then commonly reported by assuming the same production level holds over the rest of the time, with the possible exception of various periods in which the wells are *known* (or detected) to be "closed-in" or not producing. This leads to significant difficulties in the proactive management of the wells and the day to day tracking of production and well productivity, due to

- varying well conditions (e.g., downhole scaling or waxing, tubing heading/slugging, liquid loading, sand ingress),
- mechanical and process mal-operation (tubing leaks, liftgas injection interruptions, subsurface safety valve sticking),
- subsurface uncertainty (e.g., well decline, water breakthrough, gas coning).

While the above conditions may be qualitatively inferred by examination of wellhead measurements, for example, tubing head pressures, the well under examination nevertheless then has to be tested to again establish the actual well production rate. The above collectively lead to:

- late diagnosis of production problems, and unexplained production deferments,
- inability to react to changes in the production requirements, or environment
- slow and conservative handling of production constraints
- restricted understanding of subsurface potential.

The introduction of FW PU and data driven modelling, see for example reference [1], is intended to address the fundamental issue of intermittent well testing and the consequent non-continuous and slow-reacting surveillance of oil and gas production. This paper discusses some of the progress achieved in the roll out and deployment of the application. The wide scale roll out of FW PU continues to also highlight many of possibilities for the extension of the data driven modelling framework to address other significant gaps in the day to day management in oil and gas production operations. Some extensions have been discussed in detail in references [7]. [8], [9] and [10] and will be discussed briefly here. However, the main extensions to be addressed here will be the use of data driven methods for the tracking of non-continuous production flow wells, such as beam pumps and intermittent gaslifted wells.

Well Production Surveillance and Data Driven Modelling

A brief reference to using data driven models for virtual metering, albeit using a less structured neural network approach, is given in Oberwinkler et al. [3]. A recent paper that touches on the potential for data driven modelling is [4] by Stone. Historically, there have been a number of approaches using well physical models combined with real time wellhead pressures and temperatures to predict 3-phase flow in real time or near real time. However, in practice, well physical models were found to be difficult to set-up, calibrate and sustainably maintain in an operating environment.

The data driven approach of FW PU is designed to take full advantage of the well test and production metering available in conventional production operations, and also to address the operational sustainability issues related to using physical models for well production surveillance, particularly in the face of changing well conditions and instrumentation uncertainty. How are models constructed in FW PU, and what does it do with the models ? In brief, the FW PU supports the following intuitive workflow:

1. Put the well to be modelled on test on a test separator or multiphase meter. The well should be tested at multiple rates, possibly by varying its production choke opening or its lift gas rate.
2. The time series data (gross liquid flow rate, water cut, gas flow rate) is combined with the time series data at the well (tubing head pressure, lift gas flow, etc.) from the well test, and perhaps also previous well tests, to mathematically generate a data driven well model.
3. During normal well production when the well is not on test, but producing as one well in a cluster of wells, FW PU uses the data driven well model and the real time measurements at the well (tubing head pressure, lift gas flow, etc.) to estimate the production from the well (e.g., gross liquid flow rate, water cut, gas flow rate etc.).

Interestingly, the actual field implementation on a practical basis of the above seemingly straightforward steps is actually fairly revealing of the overall state of instrumentation and well testing and surveillance practice of the particular production facility.

Although the underlying real time signal processing, process controls, matrix computation and numerical algorithms are relatively complex, the FW PU application has fairly straightforward graphical user interfaces allowing well test data to be loaded and displayed, and well models configured, created, validated and brought online by operational staff. In particular, due to the simplicity of the underlying concepts, and the clear relation of the modelling process to the already familiar well production testing process, typically a locally based super-user with a some training will be able to develop and maintain the majority of models with occasional external help. Well tests can be automatically uploaded into FW PU as they are conducted, ready for model validation or updating. Algorithms within FW PU also indicate when a well model requires updating.

The use of data driven models for well production surveillance provides a number of advantages, one of which is the simplicity of the approach and how it incorporates, supports and extends the conventional well testing process. No numerical assumptions need to be made about the underlying physics or flow mechanics of the well or the composition of well effluents. Further, FW PU requires only repeatable well measurements; within limits, absolute measurement accuracy at the well is not critical.

The foregoing discussion has briefly described the use of FW PU as an application for setting up and online tuning of individual well virtual meters for conventional oil and gas production systems with well test facilities, as per [1]. The next section will discuss the wide scale roll out of the application and rest of this paper will discuss various extensions to the FW PU capability and scope of coverage.

Wide Scale Roll Out of FieldWare Production Universe

The successful embedding of a real time technology that such as FW PU, which allows a step changes in the level of surveillance of well-by-well production, and the realization of maximum value from its use is a non-trivial exercise. This is also due to its very nature - using usually noisy and possibly initially unreliable data to monitor the multiphase production performance of a time varying uncertain physical system that is a well and its underlying reservoir. In an ideal implementation of FW PU for an oil and gas production site, the software application functionality needs to match and complement the physical production elements (wells, production processing and testing facilities), the specific production management challenges, the measurements and data acquisition system and the capabilities of the production staff as well as their production management processes.

The FW PU roll out effort builds on the collective Shell Exploration and Production Group experience in the management of and support of real time systems for computer aided production operations. The experience stretches back to the 1970s, see for example [11], [12], [13], [14], the latest embodiment being the FieldWare suite of tools. The FieldWare suite includes applications such as FieldWare BeamLift, Flow Monitor, Well Test, ESP, Gaslift, Injection and Cone Control. Even excluding Production Universe, the FieldWare suite already provides surveillance and well testing support for a large number of wells in operating companies within the Shell Group, see for example [2].

To effectively apply FW PU across thousands of wells is a complex undertaking. It is also crucial to reap the associated rewards not just in the short-term but over the entire production life cycle. Key elements of the roll out and sustainability of in the field operations require engagements with production personnel, evaluation of production challenges and value of the tool to be introduced, hardware and software readiness checks, clear setting of goals and expectation, post implementation evaluations, training of users and super-users, adjustment of workflows, and embedding the use of the application into the relevant operational processes. See Figure 1.

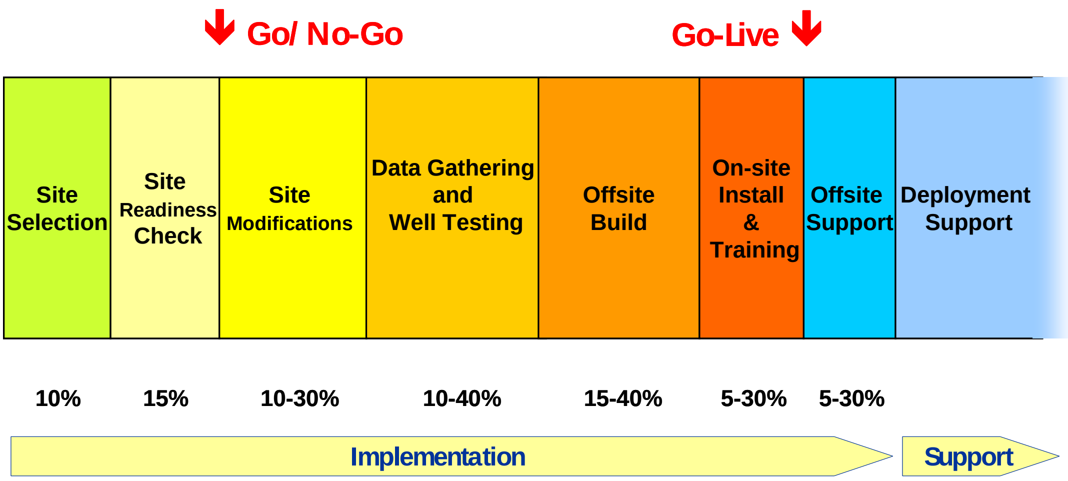

Figure 1: Sequence of Implementation for FW PU.

A typical roll-out sequence of activities for FW PU for a given oil and gas production site is as follows:

i) Site Selection: This is performed in conjunction with operating staff for the production site. This involves the engagement of the production management and surveillance staff to identify sites that will particularly benefit from FW PU installation, consistent with the strategic production improvement plans for the company.

ii) Site Readiness Check: Once one or more sites for FW PU installation are selected, readiness checks for each of the selected sites are required to confirm that basic infrastructural and organizational elements are in place to allow full expected value to be derived from FW PU installation. Infrastructural checks include availability and working condition of associated instrumentation, telecommunications, DCS, SCADA systems. Once infrastructural updates and organizational adjustments have been put in place, FW PU will be installed with confidence that it can be effectively operated and sustained over the production life cycle of the facility. In particular, the verification of the good operational readiness of basic well surveillance, well testing and bulk measurement instrumentation is critical. A good understanding of the operating company organization vis-à-vis FW PU with respect to managerial vision / support, roles and responsibilities, user motivation, identification of users and super-users and their work loads, and training plans is also required.

iii) Site Modifications: The management staff for the production site then raises an associated project to scope and execute the requisite critical hardware, software and organizational adjustments that require to be completed prior to FW PU installation. For example, this can be as simple as to ensure all wellhead remote telemetry units and pressure and liftgas flow transmitters are operational. Also data historian compression settings may need to be changed and servers may need to be installed to host the FW PU application.

iv) Data Gathering and Well Testing: This involves the identification and collection of data required for FW PU. In many cases, for example, well test data can be directly acquired by remotely connecting to the Data Historian server. FW PU deliberately disturbed well tests are typically executed by the operating unit with the FieldWare team closely monitoring remotely and providing feedback as required.

v) Modelling (offsite build): The initial FW PU well models are typically constructed by relating the well test facilities data to the well flowline data over the duration of the test, in conjunction with historical test data. The modeling and validation exercise is typically done offsite using remote connections to the local network.

vi) Installation and training: This involves installing FW PU for the production site at a local server, and ensuring that all users are trained to use the system effectively. Users of the FW PU estimates are provided with training to be able to use the estimates and appreciate the underlying computation process for their derivation. Local system support staff also need to be trained to perform first line maintenance and to extend the system as appropriate, e.g. configuration of new wells. A competency assessment scheme is in place to ensure the required level of local support. Online awareness training has been set up for the orientation of casual FW PU users.

vii) Offsite support: Second-line support is available over the application life cycle. At present, a dedicated team of over 20 IT and oil and gas production operations personnel is in place to provide support for the maintenance and further development of the FieldWare suite of tools, including FW PU.

To date, FW PU has been installed for the surveillance of well-by-well production in more than 30 production facilities onshore and offshore worldwide, covering over a thousand wells. The locations where FW PU is installed include the Americas, Europe, Africa, the Middle East and South East Asia. FW PU surveillance currently covers a whole range of wells, including free flow wells, gaslifted wells, jet pumped wells, ESP lifted wells, subsea wells, lean and rich gas wells and smart multizonal wells. While in some sites, it can remain a challenge to put workflows in place to sustainably maintain FW PU models and to use FW PU data, FW PU has proven to be a clear success in many other sites, becoming very much part of the way of working. FW PU is also embedded as part of Shell Smart Fields operations; see for example [5] and [6].

The roll out of FW PU continues. However, there are also many possibilities for the extension of the data driven modelling framework to address other significant gaps in the day-to-day management of oil and gas production operations. To fully realize the potential gains from data driven modelling, a parallel effort is also in progress to fully establish the benefits of data driven modelling techniques across the wider spectrum of production operations. The rest of this paper will discuss various extensions to the FW PU capability and scope of coverage.

Operational Optimization using Data Driven Models

The FW PU data driven models used to estimate well flow in real time can also be used to generate predictions of well production for given values of commonly manipulated well production variables, such as production choke position, lift gas injection rates in combination with the well tubing head or flowline pressures. The FW PU Optimizer thus uses data driven models to optimize estimated oil production from a single well by computing the choke or lift gas “set points” for maximum oil or gas production from that well alone. The optimization can be conducted subject to various constraints, for example,

- keep the gas/liquid or gas/oil ratio below a value required for good reservoir management and to prevent coning, or
- keep liftgas injection rate within pre-specified limits.

It is also possible, for example, if downhole measurements are available, to optimize production by minimizing the downhole pressure of a well. The practical implementation of the FW PU optimizer has been previously discussed in [6], [8], [9].

FW PU can also be used to optimize the production of a cluster of wells subject to various well, processing facilities or export constraints. Common optimization problem formulations include:

- maximizing net oil production with limited lift gas, including when part of the liftgas compression capacity is lost via trips or scheduled maintenance,
- maximizing net oil or condensate production whilst meeting gas export nominations, or sudden changes in gas demand.
- maximizing oil production subject to gross and gas handling constraints, while maintaining a minimum level of water production for water injection, and at the same time minimizing water disposal and gas flaring.
- if both oil and gas are exported, and the relative incremental fiscal revenue values of the oil and gas streams are known, optimizing the short term revenue (cash flow) of the facility.

Given the above production targets and constraints, plus FW PU models of the wells and the headers, the FW PU Optimizer can then automatically compute optimal liftgas and/or production choke setpoints. It is also possible to generate data driven header pressure versus gas or liquid production rate models. This, together with the well models which incorporate tubing or flowline pressure, allow well interactions effects to also be modelled simply in the FW PU Optimizer.

There are, of course, many previously reported applications that perform online production optimization, for example [14]. More references are cited in [9] and in the survey papers [15], [16]. However, the vast majority are based on well and production system physical models. As noted previously, in practice, such physical models are difficult to set-up, calibrate and maintain in an operating environment.

Well Surveillance with no Well Test Facilities

In most production stations found in the industry, there is at least one Test Separator / Multiphase Flow Meter available that allows for a weekly or monthly production test on each of the individual wells. However, there are also numerous sites where there are no facilities available for the conventional testing of individual wells, or where the test facility is oversized or undersized to test the wells. Typical examples of these sites are:

- Subsea production clusters, where having to run separate dedicated test line from the subsea cluster to the surface production facility is a major investment. In [7] it is described how FW PU data driven models in combination with Testing-By-Difference is used for well production estimation on the Penguin Cluster in the North Sea.
- Gas production locations, where in many gas production facilities, the gas wells are provided with venturi wet gas flow meters and do not have a well test facility. Hence well by well condensate tracking is problematic.
- Smart Wells with multi-zonal or multi-lateral completions. In such cases, as the well zones or branches share one conduit to the surface, the zones or branches cannot be tested individually without shutting in the rest of the zones or branches. This is described in more detail in [9], which additionally discusses the use of FW PU for downhole zonal inflow control valve setpoint computation.

Building on the data driven techniques of FW PU, various algorithms and functions have been introduced in FW PU to support the testing and data driven modelling in the above scenarios. Experience to date indicates that even for production systems where there are no well test facilities for well-by-well or zone-by-zone production testing, FW PU can be applied to systematically track well-by-well production using testing by difference and multi-rate well testing based on production measurements only, and also based on variations in longer term production data.

Local Well Controllers for Beam Lifted Wells

Almost all beam lift pump-off control units rely on the interpretation of rod load vs. displacement of the walking beam. This can be traced back to, for example, Gibbs and Neely [17] and the references therein. From these measurements pump off can be locally detected by a number of strategies. The management of pump off is an important part of beam lifted well surveillance; see for example references [13], [18]. Production rate is inferred from stroke length, speed and pump diameters adjusted for estimated pump efficiency. Alternatively the surface pump card (dynagraph) is transformed to a down hole card by use of a physical model. The estimated production from these methods is generally regarded to be not reliable. Setting up pump-off controllers for wells with significant gas production can also prove to be difficult. A number of circumstances can affect the accuracy of these conventional dynagraph based surveillance methods. A shallow tubing leak can result in circulation of oil back to the casing but still provide credible rod load readings. As always, physical models are sensitive to errors in measured input parameters such as pressure and temperature and are dependent on “tuning" factors to force a match to reality.

Recognizing the above limitations, and driven by future requirements to operate fields with large numbers of beam pumps, an investigation was initiated to apply the FieldWare Production Universe data driven modeling capabilities to update beam pump surveillance and optimization capability. A series of tests on wells in the Far East and Europe were conducted over a number of years. The net result was a locally mounted control and optimization panel, the "Advanced Local Well Controller" (ALWC) which uses data driven models; a radically different approach to commercially available equipment.

Test wells were equipped with flow restriction orifices inserted between existing well flow line flanges to allow the estimation of flow via measurement of differential pressure across the orifice. The resulting differential pressure measured on the beam pump well production flow line was used by the ALWC to infer production using FW PU data driven modelling techniques. Use of FW PU techniques circumvented the usual orifice plate flow measurement requirements for straight lengths, steady single phase flows, and sharp orifice edges, etc. This inferred flow can be further refined by using a direct power measurement (installed in the electrical cabinet) as an additional input to the data driven model. Well pump off is unambiguously seen in the power signals and specifically in the signal shift with time. No recourse to down hole pump models is needed to detect pump off – only a low cost power measurement. This is a fully data driven approach that contrasts to the work of [24] in which the motor torque and velocity are computed from voltage and current supplied by the VSD to the motor, and the information, together with the surface unit model and a down hole model are used to optimize the performance of the pump. The method of [24] is also not specifically used for pump off detection.

Testing revealed that having a casing head pressure measurement, flow line differential pressure and high frequency power measurement provided fit for purpose and robust monitoring and optimization capability. Working with this set of instruments has the advantage that all instruments are at ground level and are accessible for maintenance and calibration. The resulting capability of the ALWC includes the following:

- Pump off detection from the power and flow line differential pressure models
- Continuous production from the flow line differential pressure and power models
- Fluid level estimation from power difference at start up and at pump off, plus casing head pressure
- One shot rebalancing of the surface unit, which requires power plus surface unit model.
- No requirement for load cell or inclinometer.

The auto optimization capability of the control unit was also developed again applying techniques developed for FW PU. By having an accurate estimate of well fluid production from the differential pressure/power models, it is possible to allow the controller to vary the “off time” for the unit after pump off detection and determine the optimum off time setting. The controller is capable of periodically re-validating this setting by cycling the well over a range of off times. Another optional feature of ALWC is the introduction of a control valve in the casing outlet. This allows the casing pressure to be varied and its impact on production be assessed. This is important for gassy wells.

Figure 2: An FW PU Advanced Local Controller Prototype with Beam Pump in the background.

A limited number of wells have been equipped with the ALWC control unit developed. Application to a 1,600 meter-depth gassy well gave the following results:

- Change in Well Cycle time – from 4 minutes ON and 15 minutes OFF to 15 minutes ON and 30 minutes OFF. This results in a reduction in 16,000 well cycles per year (44 cycles per day), with a consequent expected reduction in mechanical and electrical failures due to startup and shutdown stresses (for example, rod, switchgear, motor belt failure).
- Changing the casing pressure from 450 - 480 kPa to 800 - 1200 kPa. Optimum casing back pressure for high rate of production was found to be at 800 to 900 kPa
- Production increased from 13 m3/d to 20 m3/d, even as there was a 15% power saving with due to electrically balancing the unit. The balancing reduced peak load by 34%.
- Pump off detection was almost impossible to set with the originally installed Rod Pump Controller due to gas. However, pump off was consistently detected by the ALWC.

Although the ALWC does not rely on a load cell, a surface dynagraph can be produced from the power measurement and surface unit kinematic model. The normal functionality of a rod pump control unit in terms of alarm limits, protection and communication are provided also in the ALWC. The ALWC uses industry standard components and no proprietary hardware. Thus software and hardware are separated and dependency on a single supplier for hardware is removed.

The optional introduction of sound sensors potentially allows the sound fingerprint of the unit to be logged while the unit is operating optimally (balanced with no faults such as belt slipping, loose or sheared foundation bolts). This fingerprint can then be used to detect faults such as belt slip or sheared foundation bolts. Other faults such as leaking stuffing box or pump hitting down are expected to also be discernable.

Intermittent Operation Wells

It is well known that while there is a preference to produce wells continuously, there are some cases in which wells are more suitable to be produced on an intermittent basis. This can be the case for wells nearing the end of their productive lives, or for wells for which tend to have gas or water breakthroughs, or even gas wells which liquid load.

Wells Operated in Intermittent Production Mode

The production optimization concepts developed for the beam pump controller are in fact generic and can be applied to a variety of wells. FW PU has been installed for the monitoring of wells which cone gas. The coning wells are initially stabilized by the FieldWare Cone Control [19], [20], [21] algorithm, and thereafter FW PU allows the tracking of the gas oil ratio of the wells. Another area of potential application for FW PU is on “stop-cock” wells in a gravity oil gas drainage (GOGD) field. Wells in this field close to the gas oil contact tended to ramp up to high GOR’s over very short time intervals and needed to be closed in for days and sometime weeks to allow the gas cone to subside. The process of well cycling was managed by routine well tests to establish individual well rate and GOR in conjunction with the overall field gas balance. The reaction time to bean back the well or close in the well was not always optimal and production from the field not optimized. This process was time consuming and stretched the existing staff in the field.

In a field trial, FW PU data driven modeling techniques were applied to a number of GOGD wells. The wells required to be kicked off with gaslift after a closed in period. Once the wells could sustain natural flow the gaslift was closed in. The wells were equipped with a series of pressure transmitters on the tubing head, flow line and down stream of the choke. A casing head pressure transmitter was also installed which provided additional information on the wells. Down hole the wells were equipped with a single kick off gaslift valve (choke and check valve). After kick-off cycle, the gaslift supply was shut in. In time the casing pressure equalized with the flowing bottom hole pressure, as there was only a choke and check valve installed in the valve body. The flowing bottom hole pressure also decreased as the well GOR increased during the production phase of the well cycle. This pressure information provided a valuable data input point for the data driven models.

After well close in to allow coning to subside, slowly recharging the casing allowed determining the pressure at which gaslift re-injection into the tubing was re-established. This allowed the fluid level in the tubing to be computed (simple gas liquid gradient equation solution). Repeating this exercise periodically allowed the increase in fluid level in the well to be tracked over time and determine the point at which the well could be brought back into production. The flow line choke position was also known and included in the models. Provision for temperatures was included in the data driven models.

Standard FW PU deliberately disturbed well tests were carried out to establish the base models for the wells. These models were developed for the full production range of the well from initial kick off on gaslift through to full gas coning. With these models it was simple to detect the onset of coning and to continuously estimate the oil and gas rates for the wells. The speed with which corrective action (choke bean back) was applied was critical. Where control was applied promptly the wells could be produced for longer periods at lower GOR. The rate of increase of the GOR could also be influenced. Ultimately the wells coned gas to such a level they had to be closed in due to field flaring restriction. As with the beam pump controller the FW PU optimization capability allows the duration of the closed in period to be varied (days rather than minutes) and the optimal closed in period of the well to be established. An alternative control strategy is to produce the wells on a continuous flow at a reduced rate, see [21]. While operationally it is preferred to operate the wells continuously, it is expected that in some cases an intermittent operation approach may be more optimal, yielding a higher overall production or a lower GOR.

Intermittent Gas Lifted Wells

Intermittent Gaslift is a production technique where the liquid in the tubing string is periodically lifted to the surface in a “slug” by injection of high-pressure gas, which expands between the accumulated slug and a down hole standing valve. The expanding lift gas displaces the liquid slug to surface. Intermittent Gaslift has been used in Shell over the years, e.g., [22], but success has been patchy. Various forms of intermittent gaslift are common:

- Continuous liftgas injection, with a downhole casing pressure operated liftgas valve
- Intermittent liftgas injection, with a downhole casing pressure operated liftgas valve
- Intermittent liftgas injection, with a downhole casing pressure operated liftgas valve, with a plunger is introduced to act as a non-sealing barrier between the expanding gas and the liquid slug to increase lift efficiency (Plunger Assisted Intermittent Lift (PAIL), see for example [23]).

Intermittent gaslift is usually applied when there is significantly falling production with declining reservoir pressure. As production from continuously gas lifted wells declines, instability usually sets in with tubing and sometimes casing heading. The conventional operator response is to increase lift gas to re-establish stability. As lift gas consumption increases the final decision is usually taken to convert to a mechanical pumping form of artificial lift, either ESP, beam pump or PCP. Intermittent Gaslift can however provide an economic alternative. Intermittent lift in all it variants can be used to extend well life under a gaslift regime to final abandonment without recourse to mechanical pumping. The problem to date with intermittent lift is that it is time consuming to implement and monitor. Applying FW PU data driven modelling techniques to better track and operate these wells potentially yields significant benefits.

A trial project applied Plunger Assisted Intermittent Lift (PAIL) together with a smart local controller. The local control unit uses some of the FW PU data driven modeling and optimization techniques. The net result is a control unit that delivers increased production and a reduction in gaslift. The controller is fully automated in terms of well production optimization and gaslift management. It incorporates auto restart features and relieves the operators of most of the tedious aspects of operating intermittent lift wells. The control unit also synchronizes lift from different wells so that the slugs from the wells do not coincide, as this can possibly flood the production separation facilities.

Conclusion

The application of data driven modeling techniques have the potential to significantly bring forward the practical level of surveillance and optimization in oil and gas production operations. To date, the FieldWare Production Universe application has been installed for the surveillance of well-by-well production in more than 30 production facilities onshore and offshore worldwide, covering over a thousand wells. The wide scale roll out of FW PU is systematically conducted and builds on the long Shell experience with real time production operations applications. FW PU surveillance covers a whole range of wells, including free flow wells, gaslifted wells, jet pumped wells, ESP lifted wells, subsea wells, lean and rich gas wells and smart multizonal wells. While the roll out of FW PU continues, there are also many possibilities for the extension of the data driven modelling framework to address other significant gaps in the day to day management in oil and gas production operations. This paper discusses the various extensions to the FW PU data driven approach capability and scope of coverage, ranging from the subsea and smart wells to end-of-life wells on intermittent production. In particular the application of data driven techniques to beam pump pump-off controls, circumventing the need for load cells, is highlighted.

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