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DIGITAL OIL FIELDS — INTELLIGENT WELLS AND PLATFORMS

ЦИФРОВЫЕ НЕФТЯНЫЕ МЕСТОРОЖДЕНИЯ — ИНТЕЛЛЕКТУЛЬНЫЕ СКВАЖИНЫ И ПЛАТФОРМЫ

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The demand for oil and gas at present is very huge across the globe. The forecast is that this demand is going to shoot-up only and it would be a huge burden on the Oil & Gas Operators to produce more and meet the demand.
Most of the offshore platforms around the world are Normally Unmanned Installation (NUI) type with the sole purpose to produce the maximum from the reservoir and send the produce to onshore for processing. NUI philosophy is normally to have minimum facilities to reduce trips to the platforms due to HSE reasons and reduce cost of such trips.
It is a huge challenge to sustain production at around the same rate as in the beginning and for a longer duration. Some of the major factors remain unknown if the wells are conventional type without any feedback mechanism.
Intelligence added to the wells in offshore platforms do a lot of wonder. Operators get equipped with loads of information with which they can maximize the production, cut down on the water production, cut down on the volume of gas being used for gas lift process, reduce manual intervention, cut down on the risks involved in an offshore environment, reduce OPEX significantly etc. The CAPEX will obviously be higher compared to a traditional configuration, however, the benefits are aplenty in the long run.

Key words

offshore platforms, Normally Unmanned Installation, smart wells, intelligent wells, smart technology, Permanent Down Hole Monitoring System, Smart Well Completion Systems, benefits

В настоящее время спрос на нефть и газ огромен по всему миру. Прогноз заключается в том, что этот спрос будет только расти, и это будет огромной нагрузкой на нефтяные и газовые компании для удовлетворения всевозрастающего спроса.
Большинство морских платформ по всему миру обслуживаются беспилотными установками, цель которых добыть максимум углеводородов из месторождений и отправить их на берег для переработки. Обычная беспилотная установка — это тип автоматизированной морской нефтегазовой платформы, предназначенной для работы в основном дистанционно без постоянного присутствия персонала.
Существует серьезная проблема для поддержания производства примерно в том же темпе, что и в начале, и на более длительный срок.
Умные технологии, используемые на морских платформах, вызывают много удивления. Операторы получают массу информации, с помощью которой они могут максимально увеличить производство, сократить производство воды и газа, используемых для газового лифта, сократить ручной труд, сократить риски, связанные с работами на море. Капитальные затраты на умные скважины выше по сравнению с традиционной конфигурацией, однако в долгосрочной перспективе преимущества в этом случае значительны.

Ключевые слова

морские платформы, обычная беспилотная установка (NUI), интеллектуальные скважины, умные скважины, интеллектуальные технологии, система постоянного контроля дымовых отверстий, системы интеллектуального заканчивания скважин, преимущества

Objective

The demand for oil and gas at present is very huge across the globe. The forecast is that this demand is going to shoot-up only and it would be a huge burden on the Oil & Gas Operators to produce more and meet the demand.

Most of the offshore platforms around the world are Normally Unmanned Installation (NUI) type with the sole purpose to produce the maximum from the reservoir and send the produce to onshore for processing [1–10]. NUI philosophy is normally to have minimum facilities to reduce trips to the platforms due to HSE reasons and reduce cost of such trips.

The recovery factor from reservoir stands at around 35–40 % universally due to several factors. It is a huge challenge to sustain production at around the same rate as in the beginning and for a longer duration. O&G Operators always find the production reduced after a year or so due to several factors. Some of the major factors remain unknown if the wells are conventional type without any feedback mechanism.

O&G Operators across the globe have the following goals for any NUI type of platform:

— to sustain production rate;

— to reduce manual intervention on platform production and reservoir management;

— to reduce Operating Expenditure (OPEX).

To achieve the above goals, Operators need to shift their focus from the conventional methods of building and using the wells. Sophisticated upcoming technologies shall be used to meet the goals. ‘Smart or Intelligent Wells’ is one of the methods which Operators can rely upon to achieve the goals.

What is an Intelligent Well?

An Intelligent Well is one which provides ‘real-time’ data on production parameters like pressure, temperature and flow profile of the well production strings to remote location system to assess the health of a reservoir.

It is not possible to access the reservoir to detect problems and hence it is always important that some kind of variables are available at the ***Control System to monitor the reservoir behavior.***

Saga’s Snorre Tension Leg Platform established in North Sea in 1997 was the first facility with intelligent wells.

Purpose of an Intelligent Well

The investment on any Oil & Gas platform is very huge and that too, very significant and apt in today’s context when the Oil price is so low. O&G Operators always like to ensure control on the CAPEX (Capital Expenditure) and maximize production to break-even the investment quickly and start reaping profits. This is possible only when the OPEX (Operating Expenditure) is checked by implementing strict and controlled Operating and Maintenance Plans, maintain resource and spares etc. These look good on paper but is difficult to implement, that too, with respect to the reservoir maintenance. This is where Intelligent wells help.

Intelligent wells are more so important with horizontal and multi-lateral well configuration. This is because the smart technology helps control the flow through the individual downhole control valves (called the Inflow Control Valve or ICV). The ICVs at various location on horizontal wells with thin oil rims with entrapped gas or dissolved water help control the production when gas or water breaks. The valves can be throttled to control the effluents.

The intelligence helps control the water seepage through to the oil production strings through the fractures (or cracks) in the compartments around the well-strings. The control valves help to control such seepage.

In gas lift wells, the ICVs help to control the gas quantity and the flow rate to lift oil.

Thus smart wells provide a lot of benefits. A study performed in Garben Field Installation (located in Nigerian Delta, near Usari Fields) with ‘Intelligence’ would cost 19.3 million dollars whereas a conventional field with one reservoir would require around 15.6 million dollars. Thus CAPEX will be higher for wells with ‘intelligence’ compared to traditional wells. However, the benefits with regard to increased production, reduction in manual intervention, savings on HSE risks, etc. would be higher on an intelligent field and thus help compensate for the heavy initial cost.

Reservoir behavior is always erratic and is difficult to fathom. It is very difficult to predict reservoir behavior due to numerous factors. The production profile would be healthy in the initial years of the platform but start drooling as the years go by. This results in frequent shutdown, loss of production, quality and so on. This is where the ‘Well Intelligence’ pitches in, to help Operators with handful of significant data to manage the reservoirs from remote. The Intelligence concept is being found highly useful on horizontal and multi-lateral wells.

Benefits of Intelligent Wells:

— Helps to maximize production;

— Helps to manage daily production based on actual readings of pressure, temperature and flow rates from the well-strings;

— Reduce intervention cost;

— Provide zonal controls;

— Reduce safety and environmental risks;

— Better control of water breakthrough;

— Better control over water and gas injection wells;

— Helps to manage multi-lateral wells.

How to achieve Intelligence in offshore wells?

Wells are made Intelligent in various ways. O&G Operators are implementing sophisticated methods to obtain real-time data from the reservoirs at remote location.

Instrumentation Systems like Permanent Down Hole Monitoring System (PDHMS) and Smart Well Completion (SWC) are examples of 'intelligent' systems on offshore NUI platforms for gathering valuable information regarding reservoir behavior. There are O&G Operators who have been using PDHMS and SWC extensively.

Saudi Aramco uses PDHMS and SWC for well monitoring at remote location. ADMA uses PDHMS and Shell uses SWC (Figure 1).

All said, it is very important that quality inputs are available from the reservoir assets to ensure quality decisions (Figure 2). The decision could be related to safety of the platform, production management, reliability, maintenance etc. Quality and accurate inputs from rugged and reliable instrumentation would help Operators ensure the following:

— Maintain minimum or zero staffing of offshore platforms;

— Monitor equipment performance and take timely action in case of any fault;

— Plan predictive maintenance and ensure availability of spares.

PDHMS

PDHMS uses special pressure and temperature sensors on the production well-conductors across the Down Hole Safety Valve (DHSV) to detect the pressure and temperature gradient. Refer Figure 3 for details. The gradient readings inform the Operator that there is a damage to the conductor in terms of leak or crack etc. The higher the gradient, the higher is the damage.

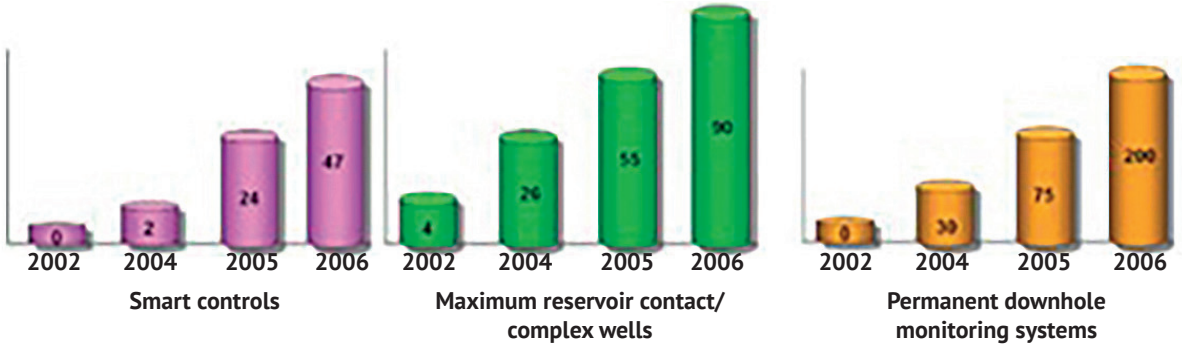

Figure 1. Trend in applying Intelligence in Saudi Aramco Projects

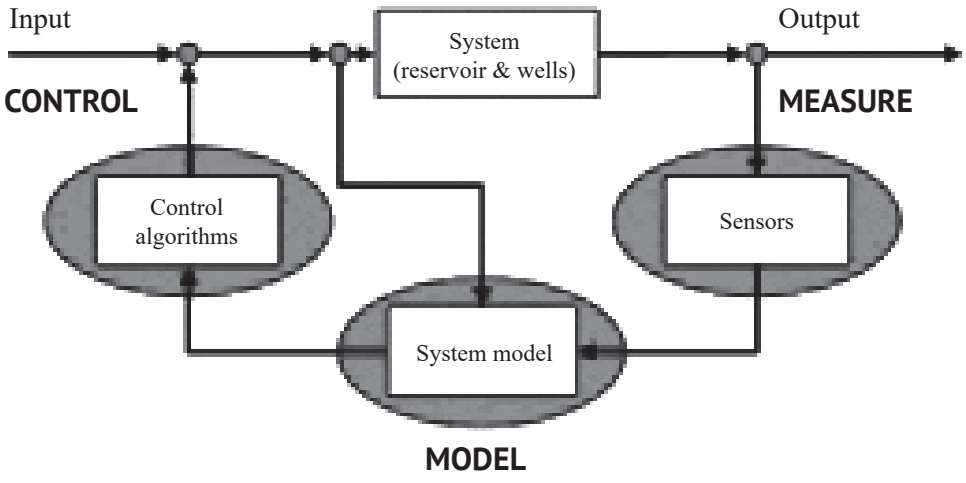

Figure 2. Flow Chart for Achieving Intelligence

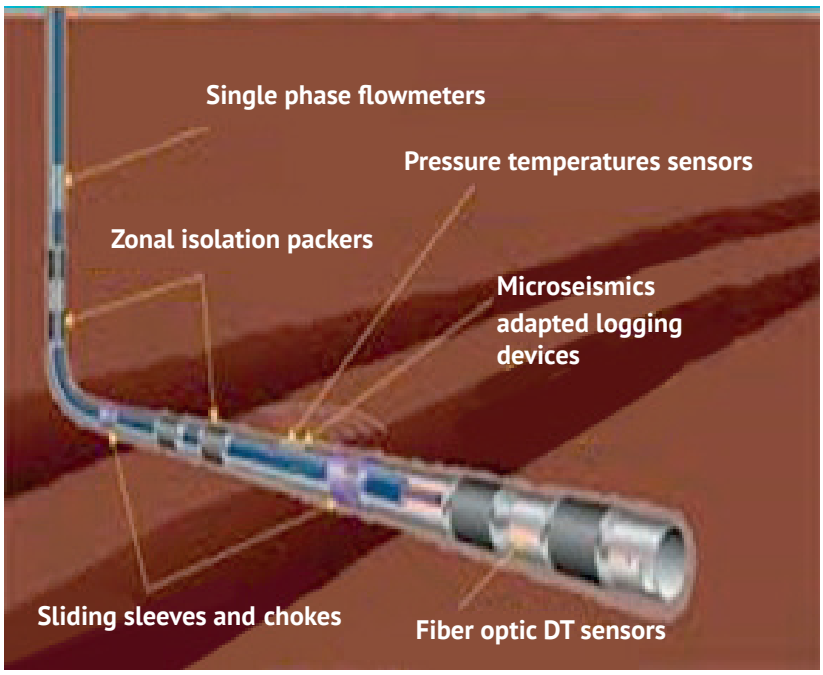

Figure 3. PDHMS

PDHMS is normally used on 'observation' wells to observe the reservoir behavior. Such 'observation' wells are used for production only and not for gas or water injection or gas lift.

Pressure and temperature readings provide the Operator, inputs on the reservoir behavior. Any leak in the conductor is detected with the readings on the pressure and temperature gradients and action is prompted.

Special resonating quartz crystal sensors are used to measure pressure and temperature at the downhole. Resonating frequency of the electrically excited crystals provide the readings.

An emerging technology called Distributed Temperature Sensing (DTS) technology using fiber optics is gaining importance. This technology has been claimed to find flow behind pipes and cross-flow. This technology uses optical fibers and measures temperature over the continuous length of the fiber with an accuracy of ±0.1°C. The technology uses Optical Time Domain Reflectometry or Optical Frequency Domain Reflectometry for temperature measurement over long distance.

PDHMS aids the reservoir engineers in calculating real-time productivity indices for each lateral leg and performing pressure build-up tests without well intervention. This information is used to maximize the production from each leg, maximize the drawdown, maximize the efficiency of ESP (Electric Submersible Pump) and update the reservoir model.

SWC

SWC is another tool to manage and maintain reservoirs. Refer to Figure 4. It contains hydraulic operated Inflow Control Valves (ICV) on the conductor with a SCADA for monitoring and transmission to remote System. The SWC includes the hydraulic reservoir and pumps to generate the necessary pressure to operate the ICVs.

SWC scheme will provide a lot of information to the Operator — production profile, water-cut, oil and gas production rates, etc. SWC helps on water or gas shut-off on daily basis. Detection of water could be done using the pressure and temperature sensors at the ICV.

Installation of ICVs on lateral wells helped Saudi Aramco to sustain production rate of 1.5 MBD even after 6 years. Intelligence also helped Saudi Aramco helped to optimize on the number of wells to be drilled and thus brought down cost.

With sophisticated electric-fiber optic hybrid system for pressure and temperature measurement in various zones of a multi-lateral wells, Operators can rely upon the data to take firm decisions regarding the reservoir management. Dubai Petroleum Corporation uses the temperature profile for adjusting the gas lift process for various wells. This prevents the lengthy process of wireline operation to gather information before gas lift.

ICVs are coming with numerous positions to place and this gives flexibility to the Operators to control water injection and gas lift processes.

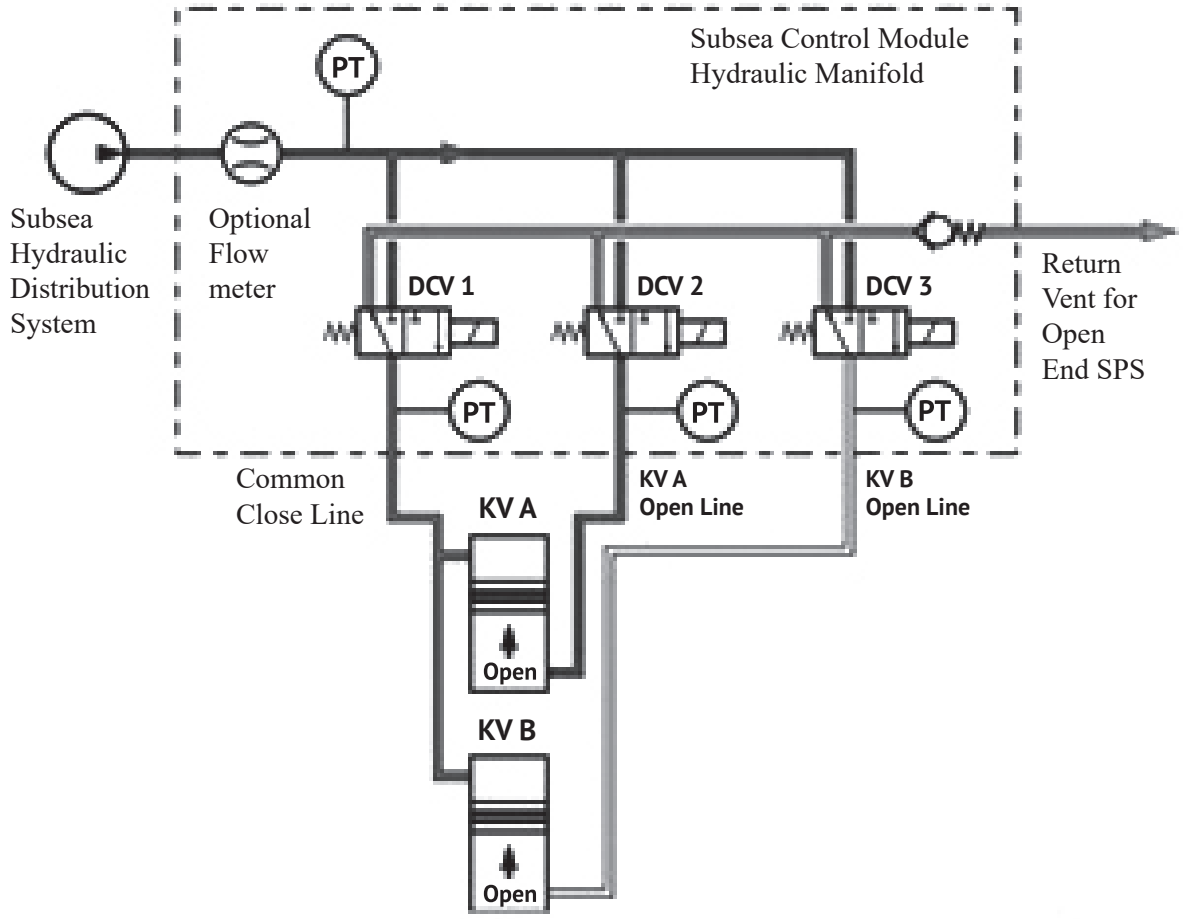

Figure 4. SWC scheme

MPFM/WGV

Multi-Phase Flow Meter (MPFM) on top-side provides important data regarding the reservoir production profile and reservoir behavior. The measurement available from MPFM at the remote Control Room helps to know the pressure, temperature, production profile, flow rates, water cut etc. These readings help the Operators decide on various steps to choke the production, thus control the water produce, sand production, etc.

MPFM readings help the Operators to open or close the choke valve more to control water production, sand production etc. Such actions help control the reservoir and optimize the production.

If the Gas Volume Fraction (GVF) is more than 95 %, a Wet Gas Venturi (WGV) scheme is used on the flow lines to gather fractions for gas, condensate and water being produced from each string. These readings help the Operators to assess the reservoir production and take corrective action, as relevant to reduce water production.

Manufacturers of MPFM and WGV work closely with the Operators to monitor the reservoir behavior and advice on the adjustments to be made to control the gas and oil production and reduce water production.

Operators must maximize the use of all such parameters available from MPGM and WGV at the remote Control Room to maximize the benefits from the reservoir.

Sand Monitoring System with interface to MPFM/WGV system help predict the reservoir production profile more accurately. This helps Operators to check and ensure that the sand production is controlled using ICV and top-side choke valves.

Gas lift process can use the intelligence available on the well strings for optimization on gas volume used. Annulus and tubing pressure gauges close to the gas lift valves measure up- and down-pressures. Gas lift rates can be calculated from this pressure data and this help to size the gas lift valves accurately.

Conclusion

Intelligence added to the wells in offshore platforms do a lot of wonder. Operators get equipped with loads of information with which they can maximize the production, cut down on

the water production, cut down on the volume of gas being used for gas lift process, reduce manual intervention, cut down on the risks involved in an offshore environment, reduce OPEX significantly etc. The CAPEX will obviously be higher compared to a traditional configuration, however, the benefits are aplenty in the long run. Many Operators have started implementing the intelligence in their platforms and it is on the rise. Suppliers are coming out with sophisticated technologies to improve the intelligence, especially on the flow measurement technique. Combined with pressure and temperature measurement, the flow measurement will help the Operators sitting in a remote Control Room to manage their assets still better and reap huge benefits on the CAPEX.

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