Petroleum Production Optimization

Technology | Petroleum Production Optimization

Fundamentals

Production Optimization refers to the various activities of measuring, analyzing, modelling, prioritizing and implementing actions to enhance productivity of a field: reservoir/well/surface . Production Optimization is a fundamental practice to ensure recovery of developed reserves while maximizing returns. Production Optimization activities include:

- **Near-wellbore profile management**
  - gas–water coning and fingering,
  - near-wellbore conformance management
- **Removal of near-wellbore damage**
  - matrix stimulation or acidizing
- **Maximize the productivity index**
  - hydraulic fracturing
  - maximum-reservoir-contact well with multilateral completion
- **Prevention of organic and inorganic solid deposition in the near-wellbore/completion/pipeline**
- **Well integrity**
  - prevention and remediation of casing and cement failure
- **Design of well completion**
  - optimization of artificial lift performance at field and well level

    - sand control management
- **Efficiency of oil and gas transport**
- **Design of surface facilities and fluid handling capacity**
- **Production system debottlenecking**

Production Optimization, along with Reservoir Management, is a central part of a company's field development and deliverability strategy. Key factor in production optimization is the capability to mitigate formation damage during well construction and production routine operations. Formation damage mitigation can be accomplished assuring that operational details are achieved before reaching the pay zone to the last production parameters recorded.

Various approaches to petroleum system production optimization

Technologies

Production optimization allows to increase productivity from existing field and uses encompass several areas of interest. In this context, contributes can come from the application of different technologies.

ADVANCED COMPLETION

Production optimization requires advanced and intelligent well completions.

- ***Intelligent Well Completion***

  An Intelligent (Smart) completion is a well that contains a "Remotely Operated Adaptive Completion System" which provides real-time data and the capability to re-configure the well architecture without well interventions.

  The system is able to collect, transmit, and analyze reservoir production data and to proof completion integrity, and to enable remote action to better control reservoir, well, and production processes.

These systems generate large amounts of real-time production data and the key challenge is to realize direct added value to operations with this data

Their primary objectives are to maximize or optimize production/recovery, minimize operating costs, and improve safety.

Intelligent well completion system

Intelligent completion for a multi lateral well

WELL PRODUCTIVITY

An ideal well productivity is the final goal of Production Optimization. In particular, well productivity is determined by a well inflow performance and in this context, a common approach is "Nodal Analysis". It is a system analysis approach applied to analyze the performance of systems composed of interacting components.

Well Performance Analysis

The Inflow Performance Relationship (IPR) is defined as the functional relationship between the inflow production rate and the inflowing pressure at node . The Outflow Performance Relationship (OPR) is defined as the functional relationship between the outflow production rate and the outflowing pressure at node. The interaction of IPR and OPR is the Working Point of the system.

IPR and OPR interaction

Productivity Index (PI or J) expresses the ability of a reservoir to deliver fluids to the wellbore. Optimal well productivity is achieved by the use of an integrated approach of disciplines and operations.**WELL STIMULATION**

Well stimulation is a term describing a variety of operations performed on a well to improve its productivity. Stimulation

operations can be focused on the wellbore or on the reservoir. They can be conducted on old wells and new wells and they can be also designed for remedial purposes. There are two main types of stimulation operations: matrix stimulation and hydraulic fracturing. Matrix stimulation is performed below the reservoir fracture pressure in an effort to restore the natural permeability of the reservoir rock. Well matrix stimulation is achieved by pumping acid mixtures (acidizing) into the near-wellbore area to dissolve the limestone and dolomite formations or the formation damage particles between the sediment grains of the sandstone rocks. Hydraulic fracturing is the most common mechanism for increasing well productivity.

- In certain hard carbonate reservoirs “Acid Fracturing” is performed;
- In other soft carbonate and in all sandstone reservoirs “Propped Fracturing” is used.

Hydraulic fracturing id used to by-pass near wellbore damage and Increase well production by changing flow regime from radial to pseudo-linear, to reduce sand production and to increase access to the reservoir from the well bore.

Graphical representation of IPR under different conditions

SAND CONTROL MANAGEMENT

When oil is produced from relatively weak reservoir rocks, small particles and sand grains are dislodged and carried along with the flow. This sand production can create erosion in flowlines and other equipment. Sand management can be considered as a key issues in field development in most of world’s oil and gas fields. Sand control management can be counted as an activity which shares risks (safety, environmental, process and cost) of producing sand to the surface vs. the risks of trying to keep it down in the reservoir using different mechanical or chemical control

techniques.

Step process for sanding

Methods of sand control

Softwares

Computer Simulations software provide geoscientists and engineers with insights into the behavior of the well under changing conditions. The simulations have moved on from their ‘run’ on time consuming and expensive supercomputers to faster and cost effective intelligent platforms. New systems provide more accurate results, better understanding of extractable reserves enabling timely reactions to ever changing market conditions and significantly lower total cost. Some of the most popular software suits are briefly described below. **IPM-PETREX** The IPM suite Integrated Production Modelling – is developed by Petroleum Experts (Petex). IPM model is an oil or gas production system which includes reservoir, wells and the surface network. The following table give a synthetic description of production models:

Integrated Production Modelling

Open Server Communication

IPM allows the integration with the reservoir simulation models – Eclipse, VIP, etc. – to evaluate the impact on production. **PIPESIM- SCHLUMBERGER** PIPESIM is a flow simulator that can create well models to help increase production and understand reservoir potential. PIPESIM simulator models multiphase flow from the reservoir to the wellhead and considers artificial lift systems, including rod pumps, ESP, and gas lift. PIPESIM enables to

- design optimal well completions and artificial lift systems;
- diagnose problems that are limiting well production

potential;
- optimize production from existing wells by quantifying actions to increase flow rates.

PIPESIM includes all the standard completion model types for vertical, horizontal, and fractured wells, and allows for complex multilayered completions using a wide variety of reservoir inflow parameters and fluid descriptions.

Gas Transmission Network – Case study

PERFORM – IHS

PERFORM is well-performance software standard for NODAL and well analysis allowing to gain understanding of flow in each component of a well, cutting costs and maximizing production. PERFORM allows to model well production performance, including downhole networks for multilayer and multilateral wells, different completion types, horizontal, deviated wellbore, fractured and non-fractured formations. It also allows calculations of coiled tubing, velocity strings, gaslift, and flow assurance.

Detailed Interface displays both input and output parameters

Well System analysis (NODAL) plot

SAND MANAGEMENT SOFTWARE – SCHLUMBERGER

Sand CADE is a gravel-pack design and evaluation software Sand CADE software performs engineering calculations to assess the sand control treatment design and supports job execution and evaluation for open-hole and cased-hole gravel-pack completions.

Sand Advisor Software supports screen and gravel selection in open-hole applications by analyzing the formation particle-size distributions.

SandCADE horizontal openhole gravel placement simulation

Innovations

THROUGH TUBING DRILLING AND COMPLETION

Through-tubing drilling and completion is a cost effective technology for increasing production and recovery. TTDC is a generic term for drilling sidetracks in existing producers and injectors, and covers both coiled tubing drilling (CTD) and through-tubing rotational drilling (TTRD), including installing the associated lower completion, typically liners or screens. The main advantage of the technology is that new reservoir sections can be reached without having to remove the existing x-mas tree, the completion or the production casing, thereby reducing operational time significantly compared to a “standard” slot recovery or side-track. TTDC- wells are particularly useful for accessing pockets of isolated oil and gas in mature fields. Due to the deep side-tracks achieved with this technique it is possible to minimize borehole lengths and avoid drilling problems in overlying formations.

Through tubing rotary drilling

WELL MATRIX STIMULATION WITHOUT HCl

Well acidizing is a common practices in the oil industry and hydrochloric acid (HCl) has been used as the main acid for limestone stimulation purposes There are several concerns with the use of HCl acids: health and safety of the field crew, corrosive nature of the acids for the flow lines and equipment, and environmental effects of the produced HCl. A new product called FF-01 is an environmentally-friendly and equipment-friendly product. It is a conversion to an organic base to maintain very low pH as a vehicle for aggressiveness, along with the creation of buffers and surface tension relievers. Low pH, slower reaction rates with limestone, small amount of residue after reaction, safety, minimum damage to equipment, and longevity are the properties of this product. Tests have been conducted to develop this new product and

study possible improvements in this blend. It has been observed that FF-01 dissolves limestone rock samples with smaller reaction constants compared to HCl However, it will dissolve the same mass of rock if enough time is given, and it lasts longer during the course of reaction while leaving fewer residues. HCl performs better in cleaning the near wellbore rock while FF-01 performs better in generating long wormholes and higher effective permeability compared to the cores that were treated using HCl.

UNCONVENTIONAL STIMULATION

The acoustic stimulation technology has the potential to provide a low-cost procedure for enhancing oil recovery in mature fields. Low frequency shock waves produced downhole can increase oil production in currently producing well with high WC mobilizing immobile oil in ¾ mile range. Application of this technology well suits well/field having the following properties:

- Oil Viscosity less than 10 cP
- High water cut, ideally greater than 80%
- Low GOR, ~10 m3 per m3 of fluid produced is ideal
- Minimum spacing of 400 m between source wells with production wells spaced within 300 m radius “stimulation zone”, if multiple tools are run.

ACOUSTIC STIMULATION TECHNOLOGY