# Production Enhancement of Highly Depleted Reservoirs of Pakistan Using UBD PRO: A Software Approaches

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**Abstract:** Overbalance drilling is executed in sapped reservoirs; that results in loss of circulation and causes formation damage which in turn causes loss in millions of dollars every year. However, underbalanced drilling provides with constructive solution for conventional drilling problems. In order to overcome such problem in this paper a close loop system of surface control equipment for underbalanced technology is executed. This strategy is useful in both vertical and horizontal wells where infiltration of drilling fluids into initial formation can terminate into extreme damage and low flow rate wells. The idea is to penetrate these formations so that there is no constraint in the formation flow with least damage and achieve highly producing wells. This is accomplished by using equivalent circulating densities (ECDs) necessary to drill those sections utilizing these drilling methodologies. The close loop system is particularly useful in drilling highly depleted and fractured reservoirs. It has been widely used to access sandstone and carbonate formations. Underbalanced operation helps to achieve less formation damage, prevention from differential sticking and loss circulation in depleted reservoir.

**Keywords:** *Underbalance drilling, "UBDPRO" simulation, formation damage, drilling depleted reservoirs*

## 1. Introduction

Underbalanced drilling is described by (IADC) International Association of Drilling Contractors. The drilling fluids may normally fewer than formation pressure and develop such condition by adding methane, nitrogen to fluid phase of drilling mud. The outcomes of underbalanced condition may be an invasion of formation fluid, which can must distributed from the wellbore and regulate at the surface. The wellbore conditions are assured by managing wellbore pressure, which is kept always less than the formation pressure. Prime control of wells is not more overbalanced block of fluid stake. Alternatively, flow control is merged with mud injection pressure, and surface choke pressure. Blow out preventer stack and the rig choke manifold system is same as the secondary well-control barrier. Underbalanced drilling is advanced drilling technology which is applied nowadays to drill depleted zones. Underbalanced drilling reduces the formation damage in the reservoirs, whereas overbalanced drilling reduces the production due to formation damage [1-2].

An overbalanced drilling is a conventional method of drilling in which drilling fluid is pumped into the formation through well shaft at the pressure higher than the reservoir pressure. Hydrostatics pressure more than formation pressure keeps the normal behavior of the reservoir, but the high pressure can damage the rock around the wellbore. "Overbalanced drilling was replaced by underbalanced drilling as it could produce new zones while drilling, gives no skin damage and safely drill well to true depth without problems". Underbalanced drilling is a desirable operation, due to its ability to minimize formation damage, increase rate of penetration, and reduce loss of circulation. It is promoted over any other drilling method due to its well control ability, affirmed equipment's safety and capability to secure a well Underbalanced drilling equipment is designed to manage gas and oil production from the reservoir to the surface [1-5]. The excessive gas is guided through pressure control equipment at surface which allows the hydrocarbons to flow in a controlled and safe manner. "To achieve success underbalanced technology must be applied to a high pressure reservoir and then executed according to the practices. As a result, a correctly applied underbalanced project can provide an increased Net Present Value and increased the amount of economical recoverable reserves" [2-4].

The purpose of this thesis is to acknowledge underbalanced drilling in conventional reservoirs, specifically. The application of underbalanced drilling operation will have a major focus on highly depleted reservoirs or mature reservoirs in a developed field". Underbalanced drilling drives its operation based on the drilling fluid used. In early 1900s, air was used to lift gas for production. Later in 1930s, mist drilling became quite popular. In mist drilling, drilling operation is proceeded while the fluids flow into the well [3-5]. The risk of downhole fire decrease but the penetration rate is still slower; together with water influx makes mist drilling uneconomical.

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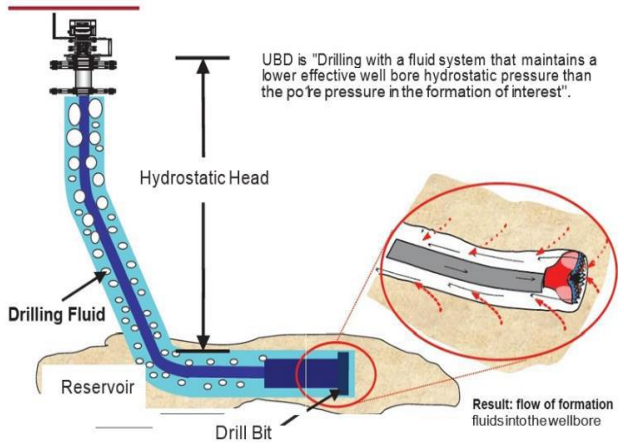


Figure **Error! No text of specified style in document.** Underbalanced drilling operation

Underbalanced drilling depend upon the fluid density, fluid density decreases than the hydrostatics pressure will be less than the formation pressure [2-6]. A control over the wellbore and formation represents a successful underbalanced drilling operation. A schematic behavior of the underbalance drilling annular behavior is shown in Figure 2.

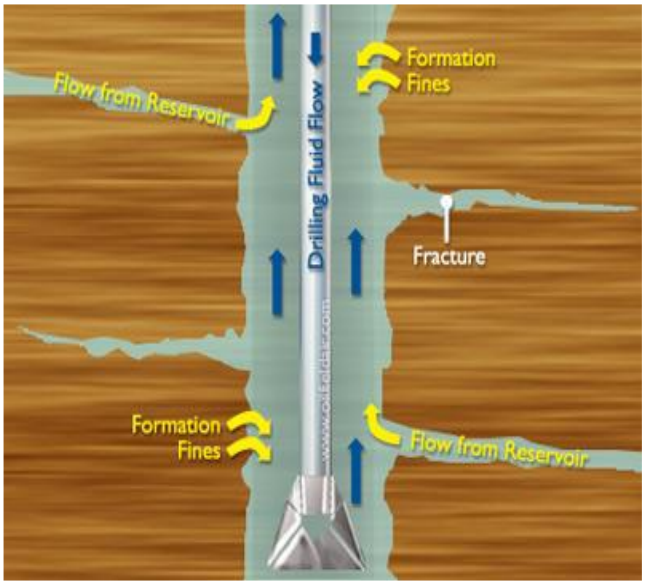


**Figure 2** Underbalanced drilling annular behaviour [24]

## 3. Methodology

### *3.1 System model*

Computer Modelling has allowed far better understanding of the underbalanced drilling than previous possibilities. In this paper **"UBDPRO"** is developed to model the complex hydraulics for compressible fluids including air, mist, foam and mud. Two candidates are taken into consideration having different well path and pressure profile. The simulation has to be performed for both wells and the results will be analysed. Hydraulic modelling of these candidates will help to analyse and propose various drilling parameters [5-9]. Hydraulic modelling will predict the following drilling parameters:

1. Gas rate
2. Liquid rate
3. Surface Choke Pressure
4. Equivalent Circulating Density (ECD)
5. Type of Drilling Fluid
6. Cutting Transport Ratio
7. Foam Quality
8. Foam Density
9. Drill string and annular velocities.
10. Bit pressure Drop
11. Flow Pattern
12. Mixture Density

Optimize gas and liquid injection rates to control the Bottomhole pressure. Predict equivalent circulating densities (ECDs) at any location in the well. Evaluate job results by comparing the pre-job simulation to on-site recorded job data thus allow to optimize future designs or analyse and pinpoint the probable cause of a "problem" job

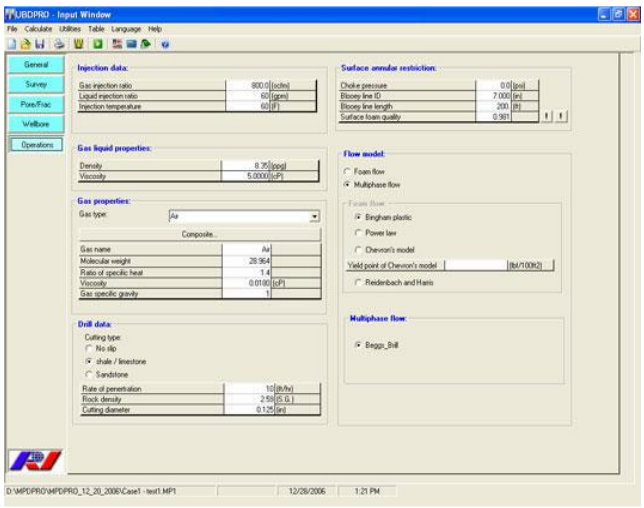


Figure 3. UBDPRO simulation system working window

The status updates influences of different drilling parameters and their impact will be analysed. Several researchers have performed underbalance problem analysis of conventional reservoirs at different depths. However, this paper will address the issues related to unconventional wells which are nowadays research. In this paper the wells were selected for an example reservoir in order to perform the simulation and these would be further implemented on real reservoir for the applications [7-12].

## 4. Results and Discussion

The overbalance drilling is not appropriate in over pressured unconventional reservoirs; hence the underbalcence drilling execution becomes more important for such reservoirs. In this paper, the case of horizontal ell was studied and the implications of the simulations are

provided. Underbalanced drilling operation can be executed in most safe manner if proper practices are implemented. Underbalanced drilling operation is less time consuming and cost saving operation. Underbalanced drilling showing variety of drilling fluid, in different formation. The process of transportation of cutting also depends on the drilling fluid used. The underbalanced drilling has many advantages over any other drilling method for depleted reservoirs. Reduced formation damage, increase in penetration rate, saving bit life, secure the well and cost saving. The input parameters are provided in Table 1 of the paper prior to execute the simulation using UBDPRO software.

Table.1. underbalance drilling simulation input parameters

**Case of Horizontal Well at 700 Psi**

**Well Information:**

| | | | |
|---|---|---|---|
| **Date** | 31st October 2017 | **Type of Job** | Underbalanced Drilling |
| **Operator** | MUET | **Location** | Pakistan |
| **Well Name** | X1 | **Comments** | Highly Depleted Reservoir |

**Formation Details:**

| | | | |
|---|---|---|---|
| Formation Type | Limestone | Reservoir Type | Gas |
| Formation Pressure | 700 Psi | Formation Thickness | 100 feet |
| Fracture Pressure | 3000 Psi | Porosity | |
| Reservoir Temperature | 190 F | Permeability | |
| Formation Comments | Formation pressure is very low and is highly fractured. | | |

## Well path:

| | |
|---|---|
| T. Measured Depth | 7200 ft. |
| True Vertical Depth | 4277 ft. |
| Kick Off Point | 1400 ft. |
| Well Type | Horizontal Well |
| Vertical Section | 4162 ft. |
| Horizontal Section | 1400 ft. |

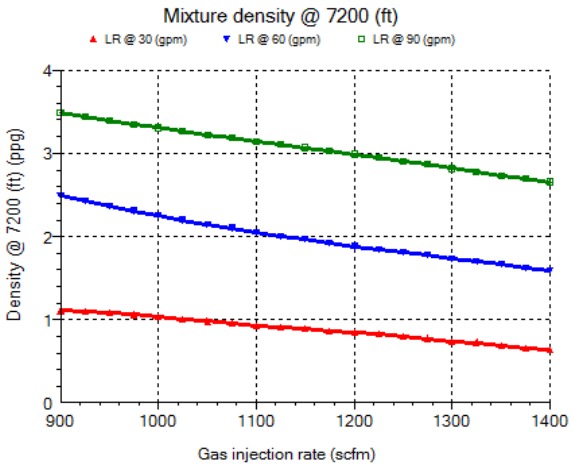


Figure.4 Simulation results of the designed system

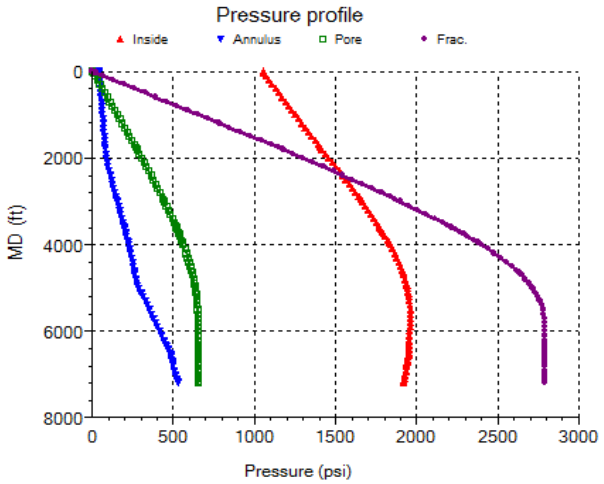


Figure 5. This graph shows that the annulus pressure of the candidate is 530 psi and pore pressure is 650 psi. It shows that the operation is underbalanced.

The graphs (Figure 4&5) shows that the annulus pressure of the candidate is 530 psi and pore pressure is 650 psi. It shows that the drilling operation is performed underbalanced. The criterion that enables us to execute successful unbalanced drilling operation includes the screening and selection of underbalanced drilling candidate that generates a drilling plan according to offset data. Moreover, the Selection of appropriate underbalanced drilling technique depends on the appropriate use of the air drilling, mist drilling, or foam drilling operations. Further it is essential to select and design drilling fluid (Air, Mist, Foam) with cautions. Selection of equipment is also more important and facilities according to their capacity and function. Hence the Underbalanced drilling has many advantages that increase penetration rates. Underbalanced drilling provides increased bit life having low drilling fluid density. Underbalanced drilling effectively prevents loss circulation problems. Due to hydrostatic pressure which is less than pore pressure. Underbalanced drilling prevents differential sticking that is caused by mud cakes and less efficient drilling fluid properties. Underbalanced drilling shows minimum formation damage which reduces well

completion time. Other benefits include the less time consuming with optimum production and the operations does not require stimulation jobs (Acidizing or Surfactant treatment.

To maintain the ECD during circulation breakdown choke pressure is applied from the surface. To maintain ECD the recommended choke pressure is 70 psi Figure 7.

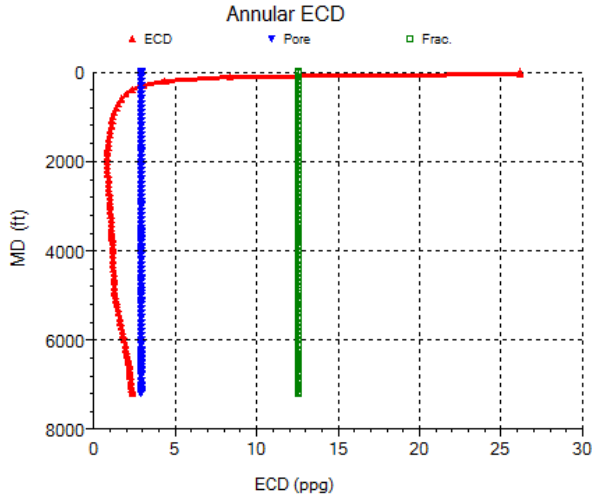


Figure 6. The ECD calculated for this candidate is 2.5 ppg that is required to maintain underbalanced condition.

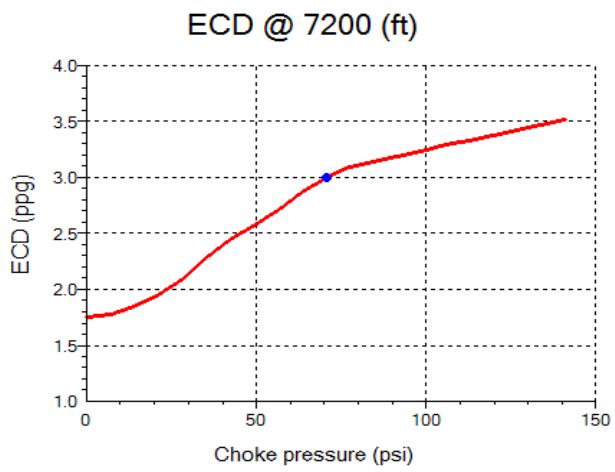


Figure 7. Illustration is the ECD profile versus choke pressure.

## 5. Conclusion

In this paper, we studied the problem of drilling fluid loss due to overbalance drilling operations under different drilling environments. To accomplish this goal, we performed sensitivity studies using UBDPRO simulation software. There we propose a framework for safe operation without damage to reservoir and without any loss, which has four main objectives: (1) identify the candidate reservoir or related clusters of reservoir categories (2) collect information of these reservoir and assess the exact problem, (3) provide solution for these reservoirs for safe operations based on the collected information and (4) to execute the job effectively.

1. Underbalanced technology was proven to be a safe method of drilling in various fields. No major safety or environmental incidents have occurred in underbalanced operations so far.
2. Underbalanced drilling proved efficient penetration rates and longer bit life. That also minimizes the formation damage.
3. Equipment such as selection of Rig, Drill pipe, Blowout preventer, Rotating control device, separation system, scrubber system and flare line etc. that will be critical for future operations to ensure the safety and environmental standards, as well as the successful underbalanced drilling operations

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