Underbalanced Drilling: An Overview And Its Viability

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Abstract

Underbalanced drilling has been emerging as a drilling process which has been successfully able to reduce damage encountered to the formation while hydrocarbon exploration is done. However various challenges are encountered as drilling a well underbalanced calls for a complex design of additional surface equipment and drilling fluids. Besides a comprehensive plan beforehand, underbalanced drilling operation is also an expensive procedure. Hence drilling a well underbalanced or overbalanced is a major decision that has to be planned beforehand by judging a number of parameters failing which can lead to a major economic drawback. This work tries to study the various pros and cons of an underbalanced drilling operation and when can this otherwise unconventional process be efficiently implemented for optimum productivity and maximum economic profit.

Keywords: *UBD, OBD, BOP, Formation damage, Production rate.*

1. INTRODUCTION

Underbalanced drilling is the process of drilling a well where the hydrostatic head of the drilling fluid is kept less than the formation pressure, in contrary to conventional overbalanced drilling in which hydrostatic head of the drilling fluid exceeds the pressure of the formation being drilled. Rapid advancement of the world in recent times have increased the demand of energy considerably. This is where efficiency of a drilling operation plays a crucial rule with regard to economics and feasibility. Hole problems such as pipe sticking and lost circulation can be substantially reduced by switching to underbalanced drilling which will optimize the drilling job. Drilling a hole underbalanced however requires special kind of drilling fluids that have reduced fluid densities ranging from slightly above 0 PPG to 7 PPG. However, the equipment setup for underbalanced drilling (UBD) is quite intricate and demands proper supervision to function in a safe and efficient manner. Naturally, an UBD operation imposes a lot of challenges that must be resolved. This study briefs on the technique of UBD and tries to examine the challenges encountered while drilling underbalanced.

2. TECHNIQUE OF OBTAINING AN UBD SITUATION

(A) Application of fresh water and diesel: Using diesel and fresh water as drilling fluids decreases the pressure of the wellbore. Here, there arises a drawback because in many reservoirs wellbore pressure cannot be decreased to such an extent that underbalance condition is achieved.

(B) Application of gas through drill pipe: Pumping air or nitrogen in the drilling fluid improves the penetration. This method is particularly beneficial because if does not require the specific configuration of an unbalanced well. However, an overbalanced situation may arise when the well is shut-in.

(C) Application of gas through external pipe: Here, a pipe is installed outside the intermediate casing. However, this method is expensive and time consuming.

(D) Application of nitrogen foam: In this technique there arises a restriction of temperature. Hence it can be applied only to wells which have a depth of less than 12,000 feet. Although, this technique reduces the damage done to reserves.

3. WELL CONTROL SETUP AND SEPARATION DESIGN FOR AN UBD WELL

(A) BLOWOUT PREVENTERS: The BOP stack here is having the same arrangement as that of a conventional well. It includes annular preventers, pipe rams, blind rams installed above the wellhead. Also a choke system is included which is an arrangement of valves and pipes to divert the fluids produced to the separator system.

(B) ROTATING CONTROL DEVICE (RCD): It is a special equipment used to seal off the annular space around the Kelly such that drill pipe can be rotated and run into the wellbore while drilling. It is particularly important when pressure in the annulus exceeds the pressure exerted by the drilling fluid to such an extent that a blowout can occur. It is installed at top of the annular BOP and almost has the same configuration of an annular preventer. However in RCD, the rubber element is installed on bearings which allow rotation of the drill pipe.

(C) SEPARATING EQUIPMENTS: The produced fluid consist of a mixture of four phases. Those phases consist of:-

- Mud + water
- Formation/Injection gas
- Crude oil
- Solid impurities and drill cuttings

Hence, a four phase separator is required. The mud will be recirculated after conditioning and the hydrocarbon phase is send to production facilities. The water is disposed after cleaning while the hydrocarbon gas is flared or can be used for injection later in required production optimization processes.

4. ADVANTAGES OF AN UBD OPERATION

(A) Reduction of formation damage: Formation damage occurs due to the invasion of mud during overbalanced drilling as the hydrostatic head of the mud exceeds formation pressure. It is due to contamination of the formation by the invasion of the heavier drilling fluids used during conventional overbalanced drilling (OBD). It can also be caused due to plugging by the solid contents in the mud. Since hydrostatic head of drilling fluid is less in UBD, there is no chances of invasion by drilling fluids into the formation causing formation damage.

(B) Prevents differential pipe sticking: Differential pipe sticking is caused when the hydrostatic head of mud exceeds the formation pressure by a large amount and also when thick mud cakes are formed. This condition can never arise in UBD, preventing differential sticking.

(C) Preventing loss circulation: Loss occurs when the drilling fluids is forced into the formation drilled, especially in fractured or high permeability zones. There is no physical mechanism of forcing the drilling fluid into the formation in case of UBD, preventing loss circulation.

(D) Increased bit life and rate of penetration (ROP): The hydrostatic head at the bottom of the drill bit is less in case of UBD. Hence, ROP is more which leads to reduction in time of the drilling operation, leading to increase in life of the bit.

(E) Increasing recovery efficiency: OBD involves the invasion of mud filtrates into the formation which can reduce the formation permeability considerably and also alter the viscosity of fluids in the formation. Drilling a well underbalanced does not let this change in property to happen, maximizing the hydrocarbon recovery.

(F) Increases reservoir knowledge: UBD allows the inflow of formation fluids simultaneously with the drilling process. Hence, we obtain a more accurate data regarding reservoir fluid, inflow performance relationship, pressure of the reservoir and such essential information which lets us know about the reservoir thoroughly.

5. LIMITATIONS AND CHALLENGES ENCOUNTERED

(A) Factors concerning safety issues: In UBD operations, the formation pressure is the dominant pressure which can cause an uncontrolled influx of formation fluids if not properly maintained. Hence, the safety equipment at the surface must be satisfactory in terms of quality.

(B) Complexity in designing the drilling fluids required in UBD: Due to the complications in their compositions it is very much difficult to predict their flow pattern downhole.

(C) Unexpected formation damage in case of sudden overbalanced: There is no mud cake on the formation walls during UBD. Also, it is difficult to maintain an underbalanced situation at all times. Hence, any instantaneous condition in which an overbalance occurs can lead to damage on the unprotected walls of the formation.

(D) Uses of measurement while drilling (MWD) tools: MWD tools transmit signals through fluids which are non-compressible such as conventional heavy drilling muds. Hence, signal transmission becomes a problem in UBD as it uses compressible fluids such as gas, foam etc.

(E) Cost factor: UBD is an expensive process as a detailed planning is required beforehand. There is also a requirement for additional sophisticated surface equipment

owing to the complexity of the procedure, exhaustive separation techniques and a larger safety margin due to higher risk of a blowout.

6. SOME SCENARIOS OF UBD IN FORMER TIMES

(A) In Algeria, a sandstone field was introduced to UBD after years of OBD. There was a substantial reduction in drilling time and hence production rate increased. UBD has also been able to enhance performance of the well to a large extent in several carbonate fields in Oman.

(B) In Mexico, UBD has been extensively used in depleted reservoirs and also in fields where formation damage was encountered. UBD enhanced the production rates which contributed to the growth of the E&P firms.

(C) In the Philippines, two drilling operations were conducted in the same field. One well was drilled underbalanced while the other was drilled overbalanced. The underbalanced operation showed enhanced production rates.

7. INTRODUCTION OF UBD IN INDIA

The first execution of UBD in India was carried out by ONGC in the Bombay High. This was in the year 2016. India's domestic production especially the shale gas resources has not been fully exploited till now. Hence, UBD will lead to improve production if it can be implemented in a viable manner in the upcoming years.

8. CONCLUSION

UBD is naturally an expensive operation. The real challenge therefore lies in managing the economics in a feasible manner. Depleted formations where pressure has dropped below its adjacent zones are difficult to be produced through OBD. Hence, these zones can seem viable for an underbalanced operation. Although, a conventional horizontal well may not prove fruitful in regard to economy. Thus, we can implement the process of drilling a lateral well from the existing wellbore to reduce the expenses and maximize the profit in a depleted reservoir.

Similarly, drilling a marginal well becomes a critical situation due to its low productivity which can hamper the feasibility of the process. Drilling a marginal well underbalanced may reduce the skin effect to a large extent thereby, enhancing the initial production rate in the life of the reservoir. Also, it has been proved that under many circumstances if drilling a well conventionally leads to formation damage and demands well stimulation techniques later on, it is more reasonable to drill the well underbalanced from the start.

Most of the drilling operations today are directional or horizontal wells. Drilling the lateral portion of a horizontal well for a large distance increases the degree of invasion by heavier muds than in a vertical well. Hence, if borehole stability is not a limitation, UBD is more beneficial to be carried out in horizontal wells.

Therefore, realistic and comprehensive planning is an important part of UBD. UBD is still in its developmental stage and even then, the benefits of this process has been innumerable in many fields across the globe due to which it is emerging at a rapid rate. Thus, once the limitations associated with UBD are being acted in the coming years, we can safely assert that it will lead to an economically viable drilling job reducing formation damage and other such problems associated with conventional OBD process.

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