Radial Drilling Technique For Improving Recovery From Existing Oil Fields

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Abstract: Radial Drilling (RD) is an economic, environmentally friendly technique to drill numerous micro diameter lateral horizontal wells from different levels from an existing well. In this paper emphasis has been given to study the process of radial drilling technology, its advantages, overcoming its limitation, its usage in the recovery of left out crude oil from exiting reservoirs especially those from brown fields. The paper also provides ways to implement RD to such oil & gas fields before implementing the expensive IOR-EOR methods and also an analysis of its economic feasibility is discussed. The Indian prospects of Radial Drilling technique has also been analysed and recommendations has been given based upon the possibility of implementing in the brown/ depleted fields of India.

Index Terms: Microholes, Multilevel & multilevel drilling, Skin bypassing technique, Brown fields, Economical, Indian Scenario, Pre IOR-EOR implementation

1 Introduction

Radial Drilling is a technique which utilizes Hydraulic jet energy of fluids to drill lateral holes inside the reservoir. In this several small diameter holes are drilled from a mother well which radiate in different direction & levels throughout the depth of the well or wherever there is possibility of finding more Oil & Gas. It is mainly used to stimulate depleted or dead wells by bypassing the damaged/skin zone & extracting crude from unreached virgin lateral holes extending beyond the skin region. Brown fields are the best candidates for RD operations. RD can be applied in the reservoir before any tertiary recovery process i.e. EOR which uses high cost exotic fluids to prolong life of a field.

2 The radial Drilling Technique

2.1 Definition

RD is an unconventional drilling method which utilizes Coil Tubing conveyed drilling to create micro diameter holes by expending the energy of high velocity jet fluids. A small section of casing of the mother well is cut and then lateral holes are drilled in desired direction.

2.2 The equipment used

The hardware used are bottom hole assembly consisting of Casing cutter, small diameter bit, mud motor, hydraulic piston along with auxiliary tools of tubing end connector, anchor, orienter, steering tool, controller. Also a coil tubing unit is use to convey the drilling process from the surface.

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2.3 Technical parameters & specification

Generally lateral hole of about 300ft-500ft length are drilled having a diameter of 30mm-50mm (1.2 inches-1.9inches). The bit size is about 1 ¾ inches connected to deflector shoe with flexible shaft via end connector to the coil and then to a conventional mud motor. Some observation made were that well with deepest lateral hole show significant increase production rate. Consolidated rock shows better results of this technique than unconsolidated. Rock mechanics need to be studied properly in lieu of the decrease of rate in well no. 3 before RD job is done. Also penetration mechanism testing needs to be done along with penetration direction. For unconsolidated formations gravel packing and slim tubes can be used to control blockage of holes.The maximum working depth is about 10,000ft. Bottom hole tempetature should be of maximum 248 degree farenheit.Drilling fluids varies deending on reservoir lithology and formation fluid properties. Water is generally used in most operations. For water sensitive formations diesel fuel may be used which also is useful when dealing with waxy reservoir fluids. Hydraulic acid can be used as a drilling fluid in carbonate formation. Because of high jet fluids, casing and formation get eroded for which abrassives are used

2.4 Procedure of the job

Briefly it has three parts consisting of Milling, Jetting & Washing. The steps for performing the drilling are as follows:

1. Run in hole (RIH) with deflector sub (an orienting tool) on the drill string to the depth as per as log data.
2. The drill sting is oriented to correct direction through a gyro tool.
3. RIH with a milling tool to cut the desired casing location to start the lateral holes.
4. Pull out of hole (POOH) the milling tool.
5. RIH with jetting tool.
6. POOH with hose and jetting tool.
7. The deflector shoe is rotated and operation is repeated at each lateral hole for any horizontal layer.

3 Historical Application & case studies of RDtechnique

In 1985, Dickenson-Dickension introduced a system to drill hole of 100ft-200ft of 4inches diameter with a jetting velocity of 6ft/min to 120ft/min. apart from horizontal hole paths this can also be used in offshore reservoirs, waste disposal & mineral recovery among its various application. In 1989, Dickension et

al. introduced Ultra Short Radius System (USRS) where multiple radial hole can be drilled from same level and also on multiple level along with gravel packing method. In 1992, Dickension et al. started water jet drilling combined with coil tubing, USRS and quick radial system. In 2000, Yonge et al. developed application of using USRS by high pressure jet flow technique for two wells. In 2001, Elsahawl et al. presented several case studies performed in Belayim fields of Sinai, Petrobel-Egypt to enhance their Production.In 2011, Marbun et al. presented various discussion relating reservoir parameters, characteristics with drilling operations & parameters.RD technique was first applied in Belayim land oil field in Egypt by Petrobel Company. Three cases were taken for 3 wells.

Well no. 1: Static reservoir pressure of about 900 psi & PI of 2 BPD/ psi was present. RD job were performed by milling and jetting 7 lateral holes drilled randomly with 164 ft lateral depth at different depths. Hydraulic jet pressure used was 7000 psi. It produce from two zones with net pay thickness of 82ft. Gross production rate showed an increase from 252 BOPD before job to 346bpd after job and net oil rate increased from 220BPD to 289BPD showing an increase of 37.5% for gross rate and 31.4% for net oil rate. The average rate remained for nearly one year after which it declined but decline rate was still above pre job rate

Well no. 2: It produced from 3 zones having rock porosity of 20% and heterogeneous permeability having static reservoir pressure of 1990 psi and PI of 1 BPD/ Psi with net pay thickness of 133ft. RD job were performed by 6 lateral hole at two depths. Holes were drilled based on geological maps and fault orientations. Gross production rate increased from 472 bpd to 818BPD while net oil rate increased from 465BPD to 686BPD. But Static well pressure decreased due to fluid level decrease with PI still remaining same. Production performance declined in less than a year after RD job and that too decline rate went below pre job rate. Maybe this was due to heterogeneous nature of the pay zones.

Well no. 3: The well is produced from only one zone with static reservoir pressure of 970psi with PI of 2BPD/ Psi and porosity of 20% and heterogeneous permeability. Pay thicken was 87 ft. Four lateral hole were drilled at two depths in that zone after RD job production performance showed a little increase for very less period of time and then declined at rates mostly below pre job rates.

5 INDIAN SCENARIO

RD has been done by Selan Exploration Technology Limited recently for the first time in India for lateral jet drilling. The zone where it was done were mostly of Kalol VIII reservoir, Ahmedabad, Gujarat. Three wells were selected and each well was performed with 6 numbers of lateral wells. The reservoir is a silty sandstone layer having low permeability and porosity. The operation was done in two steps: casing cutting using a tungsten carbide bit of size 22mm and then performing jet drilling using high pressure jet hose in variety of jet angles to drill the lateral holes. Coil tubing unit has been used for the surface equipment. Hence from this it can be seen that RD jobs have been started and can be applied in other states of India. The cost is low and dead fields can be reused to produce leftover crudes.

6 PROPOSAL FOR IMPLEMENTATION OF RD TECHNOLOGY IN INDIA PROSPECT

In many Indian states, especially that of Assam, Maharashtra & Gujarat many of the fields are either in late of their production life or are nearly brown and dead. Such fields can be revived with RD techniques. Many such fields are being produced with artificial gas lifts, SRP, Water Flooding techniques, EOR processes etc. These methods are moderately costly job. So it is proposed that RD technique can be taken as a sub step in field development strategy after primary recovery and before applying IOR methods. Also various work-over jobs are being done to stimulate damaged producing zone. So before any work-over jobs for improving skin are being performed Radial Drilling jobs can help as it is a bypassing method. It bypasses the damaged skin zone and reaches to the virgin zones beyond the damaged region from where newer unexploited existing crudes can be extracted.

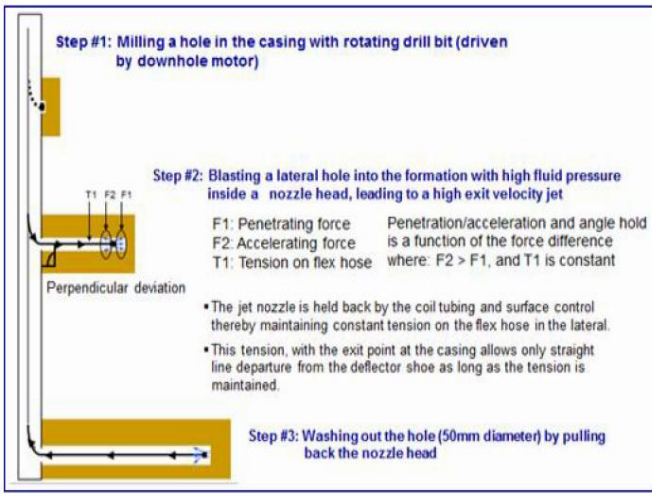

Fig. 1. The radial Drilling Process

This will help reduce the number of work-over jobs perfield/reservoir. After radial drilling is done the filed can be produced for other one-two years without much of workover/IOR-EOR jobs mostly. After that work-over jobs can be taken up to stimulate the previously damage zone as well as zone extracted through radial drilling techniques.

7 DISCUSSION

From the case studies discussed and Indian Scenario, it can be stated that Radial Drilling Technology has indeed very much of usage in the coming future. It is already been done in many countries with successful results. The Egypt chapter was the pioneering of this method and this has spread to other countries. There had been different results from different wells, two wells showed increase whereas well no. 3 showed decrease. This has helped to study RD technique in more detail to improve the process. Though in a nascent stage, lots of research is going on throughout the world. It has also been started in India in a small scale. It needs to be expanded to other parts of the country where expense and logistics are complex. These techniques require very less hardware and also are economically very suitable. India is a developing economy which heavily relies on import of oil & gas from foreign countries due to lack of advanced technologies.

Countries pursuing radial Drilling Techniques can be invited and collaboration can be done between them and India for investment in India as well as technology sharing among these countries which will greatly help both the sides. Service companies providing RD services can be of great help to implement them in India.

8 Recommendation

RD method is highly encouraging and evolving technique. Its primary usage is to improve production which is needed to be implemented in the brown and dead fields. Apart from improving production, it is also a bypass technique which increases productivity without improving the damage zones in a reservoir. Also wherever IOR-EOR methods needs to be implemented, RD technique can be applied first. It helps reduce initial cost as well as buys some extra time of another one –two years of average production. Advanced and target specific Sand control methods needs to be developed. Since hole diameters is very small hence micro sized proppant particles needs to be used to keep holes open especially in unconsolidated formations. Chemicals such Resins can also be used. Apart from dead fields RD technique can also be used in low permeability as well as heavy oil reservoirs. For this also, techniques needs to be added which will improve mobility of oil as well as lightening of oil to be produced. Formation specific drilling fluids need to use in order to be compatible with the different types of formations. Indigenously developed microbes can also be used in RD techniques to improve production form very thick oil bearing zones. It is economically a very viable method with lesser investment but higher rate of returns. Also effort needs to be done to increase the peak and average production life generated due to RD techniques from one to two years to at least a target of eight to ten years. In such a way dependence on costly jobs will decline and also at the same time economy of the country can improve will which further add revenue to its bucket and also encourage more investments on existing newer exotic IOR methods.

9 Conclusion

RD technique will definitely be a coming of age technology in the Oil and Gas Industry worldwide. It will gain momentum as the number of its implementation goes on increasing in the coming future. This will not only help in risk analysis by different companies but also give an assurance to them to invest in it as it is a relatively low cost method. RD methods will especially help developing economies where monetary constraint is a major factor in Oil & Gas Business. Such economies will be willing to go for RD techniques in collaboration with developed economies and service providers worldwide. Marginal & Brown fields will find new way to survive and hence their production can be revived to help meet growing demands. Also existing new field developing operations can include RD techniques in their Field Development strategy. Research is very important in such areas and Industry-Academia relations can greatly contribute to its development. Technology transfer as well sharing needs to be encouraged among countries which will create a win-win situation for all. This technique has a great future ahead and will certainly hep in reviving and prolong oil & gas production.

10 Abbreviations

1. RD: Radial Drilling
2. psi: Pounds per square inch
3. BPD: Barrels per day
4. BPD/psi: barrels per day per pounds per square inch
5. ft: foot or feet
6. mm: millimeter

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