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Applications of Water Injection Using Power Dump Flood Technology and Energy Optimization

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Abstract – Decreasing production in depleted reservoirs is considered the most critical problems in oil fields. One of greatest challenges for oil companies is resuming production again very fast and in safe manner. Solutions harmonize environmental policies and sustainability development are very important for petroleum companies. In depleted reservoirs, pressure decrease with time. Primary recovery methods do not achieve production targets. Secondary recovery by water injection can be used for supporting reservoir pressure and achieve production targets. Water injection can come from surface facility or power dump flood technology. PDF technology takes water from source formation (aquifer) and forces it to be injected in target (reservoir) formation. PDF technology consists of Electric submersible pump increases water pressure which is out from Aquifer (Source formation) to the designed required rates and pressures for water injection. Water is forced toward injection (reservoir) formation by using Y-tool that prevents water moving upward across the tubing by plug. Through this, water moves downward to reservoir(target) formation with required injection rates and pressures. Isolation packer (between aquifer and reservoir formation) prevents injected water from moving upward at the anulus.The injected water with required rates and pressures support reservoir pressure and sweep oil to producing wells and improve oil production.

This paper aims to share the experience and learnings of improve oil production and power optimization by innovative power dump flood technology, which is used for water injection at petroleum fields. Application of this technology enables us to overcome great challenges of reduction for oil production, cost optimization for Opex and Capex budgets, reducing hazards and accidents at workplaces and power optimization to correspond environmental policies that are one of the important elements which govern the reputation of companies, the value of their shares in the stock market, and bring them the necessary financial funds.

***Keywords*:** Power dump flood-Electric submersible pumps-Depleted reservoirs-Water injection -Y-tool

1-Introduction

Oil and gas are contained in pores of reservoir rock. Production of hydrocarbons requires energy to sweep them from reservoir and lift them to the surface facility. The driving mechanism for reservoirs may be water, gas cap, gas expansion or combination drives. Once production of hydrocarbons starts from reservoir, the reservoir pressure will decrease. If there is aquifer or gas cap, they will support the reservoir pressure. This supporting for reservoir pressure keeps production at required rates.

In depleted reservoirs, there is not supporting for reservoir pressure so it decreases with time. At First, we use primary recovery methods for keeping production at required rates. When the pressure is not sufficient to lift the oil to surface naturally, we use the suitable artificial lift method (Like Electric submersible Pump, sucker rod pump, gas lift or Progressive cavity pump).

If the primary recovery methods are not enough for required production rates, we will use secondary recovery methods. We can use water injection or gas injection for support reservoir pressure. Water injection will sweep oil from reservoir toward oil wells and so resume high production rates. Water injection has two techniques surface injection or power dump flood.

2-Methodology and Results.

Water injection has two techniques surface injection or power dump flood.

2-1 Surface water injection

Source water may be (produced water, sea water, aquifer or fresh water). We filter source water from solid impurities by treating it to be suitable for injection by chemicals. We use surface injection pumps to increase pressure to the required injection pressure for reservoir. The injected water transferred to injection wells through injection

lines. Water treated with suitable chemicals to avoid injection problems like corrosion, scale &blockage of rock pores.

2-1-1 Surface water injection types,

-**Produced water**: -Which is accompanied to oil production from reservoir and separated from it at process facility by separators, desalters &during storage tanks. And almost produced water quantity is not sufficient and need to mix with sea or river water.

- **Sea water**: - which can be used for offshore injection facility or pumped to onshore injection facility.

-**River water**: - which need filtration process.

-**Aquifer water**: - water from water formations on the same structure of oil reservoirs and this water has the advantage of chemical computability to reservoir and purity.

2-1-2 Surface water injection stations have many components like

-**Water tanks** to store water before injection.

- **Booster pumps** to increase pressure to be adequate for required injection pumps.

-**Injection pumps** to inject water to oil reservoir with required pressures.

-**Injection lines** to connect injected water to injection wells.

-**Chemical pumps** for different chemicals types to avoid injection problems.

2-2 Power dump flood technology

PDF is downhole water injection system. It supports reservoir pressure for depleted reservoirs.it uses E.S. pump (with special design) to inject water (supplied from aquifer formation) with required rate to reservoir formation.By using different sizes of E.S. Pump, we can inject the target rates for the reservoir & support reservoir pressure. Injection process by PDF is considered as closed system as Injection in the same wellbore from source formation(aquifer) to target formation (reservoir).

2-2-1 Power dump flood components

Power dump flood system consist of many parts.

2-2-1-1 Electric submersible pump

The Electric Submersible Pumping (ESP) System is one of primary recovery methods. ESP is one of artificial lift systems that used to produce large oil volumes. ESP transfers electrical energy from the surface to a down hole motor that converts it into a mechanical force(torque). This rotational movement turns the pump's impellers and lifts the well fluids to the surface.ESP pumps (centrifugal pump) is a machine that moves fluid by spinning it with a rotating impeller in a diffuser that has a central inlet and a tangential outlet.

The pressure (head) develops against the inside wall of the diffuser because the curved wall forces fluid to move in a circular path and converting velocity head to (pressure) head.

2-2-1-2 ESP components

2-2-1-2-1 ESP consists of downhole equipment

-**ESP Motor**: - drives the downhole pump by converting electrical energy into mechanical energy which will rotate pump shaft that connected to the motor shaft.

-**Protector**: -The protector section connects motor shaft to pump intake. The function is to isolate motor oil from formation fluid, equalization for pressure between inside and outside motor, allow expansion and contraction of motor oil, and absorption the thrust load of the pump.

-**Pump intake: -** is the entry for well fluid to the pump from annulus.

-**Centrifugal pump: -**It is multistage sections. Each stage consists of impeller, shaft &diffuser. the impeller rotates around the pump axis and give centrifugal force to the well fluid then to diffuser which turns fluid velocity into head and move to next stage.

-**Discharge head**: -The end of pump section which transfer fluid from inside the pump to the tubing.

-**ESP cable: -**transfer power from surface source to the downhole motor. It is designed flat or round. It consists of copper, insulation, jacket & metal armor. It is very important to avoid system failure (short circuit).

2-2-1-2-2 Surface Equipment

-**Junction box: -** It is the main contact point between the downhole cable and the surface cable. It is used to check faults of down hole or surface cable &vent gases to atmosphere that escape through the cable insulation to prevent fire or explosions.

-**VSD (Variable speed drive)**: - It is connected to transformer.it allows fine tuning for electrical frequency so increase efficiency and minimize unit cycling. It provides soft starts to the unit which reduces system stresses, Protects the downhole equipment from current as well as voltage unbalance and adjust them to well condition so increase ESP run life.

-**Transformer:** -It converts the supply voltage to the required system voltage. It is flexible for multiple tap & designed to be greater than the required total KVA for downhole system.

-**Power source:** -It supplies the hole system with the required power. It may be generators, overhead from electrical Grid or renewable energy

- **SCADA system**: - that connected to down hole sensors and transfer data to operators.

2-2-1-3 Y-tool block component Fig(1)

-**Saddle block.**

- **Swivel Nipple Sealed-closed.**
- **Y-tool plug.**
- **Tubing support sub**.

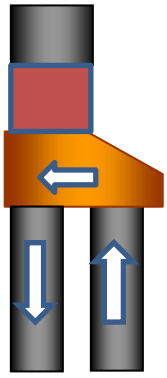


Fig (1) ESP Y-Tool

2-2-1-4 Other components

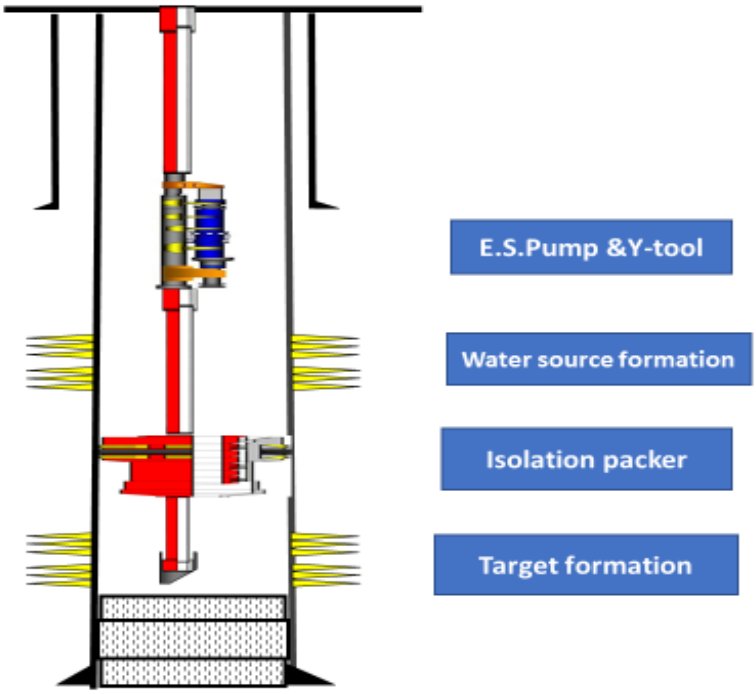
-**Isolation packer**: - isolate anulus between source formation and reservoir formation.

-**X charismas tree**.

2-2-2 How is the system work? Fig(2)

Water is supplied from source formation to the wellbore then to pump intake at ESP system. ESP system increases the pressure to the required pressures for injection. Water is forced toward injection (reservoir) formation by using Y-tool that prevents water moving upward across the tubing by plug.

Then Water moves downward to target(reservoir) formation by high discharge pressure from E.S. pump system. Isolation packer (between aquifer & reservoir formation) prevents injected water from moving upward the anulus. The high-pressure forces water to enter the target formation and sweep oil toward oil well. Injected water with the required rates & pressure will support reservoir pressure and increase it so stop decline in production & resume it to economic rates.



Fig(2) Power dump flood system

2-2-3 Power system optimization

The system needs power to start up, running ESP and all its component. This power may be supplied from diesel generators, electrical power grid or renewable energy. Diesel generators have many problems as high carbon emissions, air pollution, many down times for oil and gas wells (reduce wells production & short run life for ESP systems) and high cost of diesel. Because of these problems &power optimizations, replaced diesel generators by Power from national Power Grid which is running with renewable energy (solar, wind, hydroelectric) and clean energy. Transferred electrical power from NPG to PDF systems through electrical cables, electrical cells, RMU units (remotely main units), electrical transformers, Many VSD (variable speed drives), switch panels, Scada systems, digital meters for electrical consumption.

2-2-4 Example of PDF technology

We have depleted reservoir which its pressure decreased from 2800 to 1000 PSI. Production decreased by more than 75%. Source water formation existed and have compatibility with reservoir formation. We used PDF systems to get water from source formation and injected to reservoir formation.

As example, we used PDF system to inject 2000 BwPD to target formation with ESP pump discharge 2200 psi so we resumed production from 570 BoPD to +/- 1424 BoPD which means we have gain about +/- 850 BoPD. Application of PDF systems to depleted reservoir improved production by 2-3 times before that.

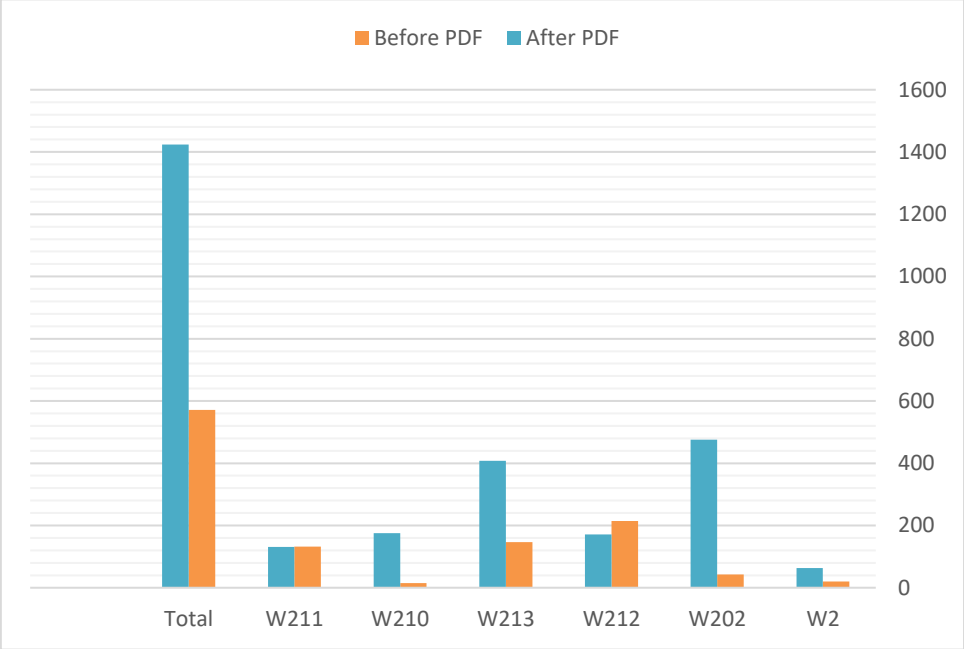


Fig (3) Example for results application of PDF Technology

2-2-5 Advantages and results of technology applications: -

2-2-5-1 PDF is more suitable from environmental and safety policies(the most important target for oil industry) as

-Elimination surface injection water line problems like leakage and holes which resulting from corrosion (accompanied to surface water injection stations).
-Avoiding soil pollution problems resulting from leakage or cracks in injection lines that are very critical especially in agriculture area.
-Less environmental problems (like overflow from tanks, corrosion in surface facility) as injection system is closed in same well.
-Avoid chemical injection problems with surface injection facility resulting from chemical hazards. These hazards may lead to accident or death.
-Source power problems were avoided from diesel generators (like high carbon emissions, soil and noise pollutions) which is needed for surface facility& running the system.
-Avoid a lot of trips for operation activities to check the injection lines &facility (sometimes unsafe, dangerous or very difficult in bad weather).
-less risk assessment from surface injection facility as no need for it.
-less risk assessment from fabrication injection lines as no need for it.
-Eliminate hazards of transferring water to surface injection facility like truck accidents& soil pollution problems.
-Eliminate hazards of work inside surface injection facility which may lead to accidents and fatal.

2-2-5-2 PDF has improved rapidly production 2-3 times

2-2-5-2-1 Fast filling & support reservoir pressure.

As the technology leads to reduction of time
-To fill up reservoir &increase reservoir pressure.
-To start water injection project by saving time to construct surface facility& injection lines.
- To drill injection wells.
So, all of this increase production at short time which cause more money and profits for shareholders.

2-2-5-2-2 Flexibility to control rates of injection & pressures

-As control pump parameters from VSD on surface so increase or decrease the injection rates and pressures to injection targets. -Remotely monitoring by scada system so we have better understanding for what happen at down hole & reservoir.

-Through online and accurate recording for data by downhole sensors, we make correct decisions for water injection system.

-Better study for water injection and reservoir as a lot of data available & saved for parameters like pump intake, pump discharges and down hole temperatures.

2-2-5-3 PDF has cost saving for CAPEX & OPEX as

-No large surface areas as one well for injection system (especially agriculture areas or offshores).

-Save cost of surface facility injection (consist of tanks, pumps &pipelines) which is +/- 3 million dollars for one simple facility.

-Saving drilling injection wells which is about +/- 4 million dollars per well.

-Save high cost of diesel which is required for running the system& surface facility (7 million dollars/year).

-Save high cost of transportation water from source wells to surface facility (Trucking& lines if onshore or agriculture area).

-Remotely monitoring so reduce need &cost of manpower.

-No need for injection lines from surface facility to injection wells.

-Save cost of power required to be used for surface injection facility.

-Reduce cost of environmental agreements & government permissions especially in Agriculture, offshore or residential area.

-Reduce chemical cost as chemical injection dozes and types smaller than the amounts used at surface facility. (as PDF is closed system in one well).

-Reduce cost of hazard operation & risk assessment studies as no surface injection facility.

2-2-5-4 PDF has other advantages

-It is more suitable as gas is not available for injection or low amounts.

-Avoid compatibility problems like scale formation as the source formation for water injection may be from the same formation of reservoir.

3- Conclusion

Low production of oil fields &High carbon emissions from diesel engines and generators, climate change, high cost for Opex and Capex are the most critical challenges for petroleum industry. Through application of PDF technology for water injection and running by clean energy sources, we will improve HSE &production, reduction & avoid these challenges. By applying 10 PDF systems & all previous, production increased 2-3 times and saved more than 50 million dollars from fields development.

PDF technology is more economic than surface injection facility. It is recommended as rapidly resuming target production& more save Opex and Capex budgets. It is recommended for fields with limited space such offshore &agriculture area. It is more suitable for environmental and safety policies. It is suitable for digitalization &artificial intelligence technology by connecting through Scada system and electronic sensors.

The world is moving rapidly towards reducing carbon emissions and net zero carbon emissions, and it still needs energy from petroleum to meet the high daily needs of it. This technology offers one of solutions to that.

Nomenclature

Abbreviation	Meaning
PDF	Power dump flood.
ESP	Electric submersible pump.
Y-Tool	ESP By-pass tool.
Opex	Operation expenditure.
Capex	Capital expenditure.
Scada	Supervisory control and data acquisition system.
BwPD	Barrel water per day
Bopd	Barrel oil per day

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