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Evaluation of Artificial Lift Methods to Increase Oil Production from Depleting Oil Wells in Gulf of Mexico

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ABSTRACT

This paper summarizes the research work with reference to artificial lift methods to increase oil production form mature oil wells in Gulf of Mexico.

Increase oil production or oil recovery from oil reservoirs is very important. If the average worldwide recovery factor from hydrocarbon reservoirs can be increased beyond current limits, it will alleviate a number of issues related to global energy supply. Currently the daily oil production comes from mature or maturing oil fields and reserves replacement is not keeping pace with the growing energy demand.

This paper presents big picture overview of artificial lift methods for mature oil wells in Gulf of Mexico.

Keywords— Artificial Lift, Mature Wells, Oil & Gas Production, Offshore

I. INTRODUCTION

Oil Companies are abandoning mature wells if it not economical viable and looking for new oil rich fields. Due to the challenges in finding new reserves and the current high prices of hydrocarbons, the oil and gas industry has made efforts to increase the rate of recovery in mature fields. Extracting the greatest possible quantity of the hydrocarbons in place in the reservoir is a key objective in order to improve the recovery factor.

In view of the increasing global demand for fossil fuels during the next decades, it is the task of the oil and gas exploration and production industry to develop innovative and cost effective technologies to substantially increase the rate of recovery from today's average of 35% to over 50% for oil. An oil well called "mature" well when its primary recovery has been completed. Mature fields are oil fields those are reaching the end of their productive life. Typically, mature fields have been producing for more than 30 years and are located in certain geographical areas for different historical and geopolitical reasons. These fields accounted for over 70 % of the world's oil and gas production. Mature fields possess the advantage of an existing infrastructure, providing the least expensive means to increase reserves and production.

Oil Companies are abandoning a mature well if it is not economical viable but when mature oil wells are prematurely abandoned, significant quantities of oil remain behind. Now these days' regulatory bodies are appearing more and more unreceptive toward abandoning producing wells too early so now we need to look for new technologies to increase production from mature oil wells to sustain economic viability and minimize global warming challenges. Worldwide energy demand is increasing day by day and worldwide energy consumption projected to increase by nearly 50 percent by 2050 [7] so it is very critical to enhance oil recovery from mature oil wells.

Decline in oil production from mature oil wells is a serious issue which may affect worldwide supply and in turns it may cause in increase in oil price and short of energy available in the world market. This research work is motivated by the Oil & Gas Industry need to enhance oil recovery from mature oil wells to provide adequate and affordable energy that will power global prosperity and meet world energy demand.

Energy plays a very important role to improve and maintain living standard of human beings, industrial growth and economy of the county. Petroleum is still major energy recourse, and it makes up to 40% of total energy production. Due to the challenges in finding new reserves and the current high prices of hydrocarbons, we need to make some efforts to increase the rate of recovery from mature fields. Sweeping the greatest possible quantity of the hydrocarbons in place in the reservoir is a key objective in order to improve the recovery factor.

In spite of the current challenges confronting the worldwide economy all in all and the oil and flammable gas industry in particular, the Gulf of Mexico oil and flammable gas industry will probably keep on being a significant wellspring of energy creation, business, GDP, and government incomes for the United States. A few recommendations have been progressed as of late which would majorly affect the industry's movement levels, and the monetary action upheld by the Gulf of Mexico seaward oil and petroleum gas industry. The recommendations shift broadly, yet with the end goal of this report three situations were created, a situation dependent on a continuation of

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current approaches and guidelines, a situation inspecting the likely effects of a prohibition on new seaward rents, and a situation looking at the possible effects of a restriction on new penetrating licenses endorsements in the Gulf of Mexico [8].

A study was conducted on various artificial lifts with the help of well simulations using PIPESIM 2017 software. PIPESIM 2017 software has been used to identify appropriate artificial tool for mature oil fields to enhance oil recovery. For this study, mature wells in Gulf of Mexico were selected to study their production drop and identify tools to increase the production.

II. METHODOLOGY

In this study, researcher collected production data from three mature wells and simulated for various artificial tools such as gas lift, rod pump and electrical submersible pump for optimum oil production. After this various simulation trials, the researcher able to identify cost effective solution to enhance oil recovery from mature oil wells which is great achievement for the community to get required energy and protect mother earth. The methodology adopted for this study as follows:

1) Criteria for selecting the field: It was based on current production life of the field by conducting review of available data.
2) Sampling and data collection: Convenience sampling method was used for sampling and questionnaire survey was used for data collection of mature oil fields and mature wells in Gulf of Mexico. Well oil production data was collected every quarter over three years.
3) Well characterization: Review filed data, review well engineering data, well oil production data, technical specifications for designing well model,
4) Artificial lifts: Identification of artificial lifts and their use.
5) Analysis well production using PIPESIM 2017 simulation tool.
6) Assessment of well performance: (i) Investigation of impact of different artificial lifts on production, (ii) Identification of suitable artificial lift system, (iii) Implementation of identified gas lift system for economic feasibility calculations.
7) Comparative study of various methods to improve oil production
8) Recommendation and guidelines for appropriate artificial lift system based on simulation results.

Researcher collected field data from federal company Energy Information Administration, 2016, well data from operators and well production data by collecting data every month over three years of time. Researcher has used collected field and well data to develop a well simulation using PIPESIM 2017.

III. FIELD DESCRIPTION

The Gulf of Mexico (GoM) basin is one of the world's extraordinary oil mega- areas, with a hydrocarbon delivering history extending over 100 years. Regardless of its development, the Gulf stays one of the most dynamic and successful exploration regions in North America, pulling in various homegrown and global exploration organizations. Goliath oil discoveries offshore and growing tight-sand and shale gas plays onshore keep up the force of discovery that will support production well into the 21st Century. The Gulf of Mexico basin has end up being an exceptionally effective hydrocarbon area, and the immense undiscovered volume of both oil and gas guarantees that the basin will proceed as a significant player for quite a long time to come.

Figure 1: Gulf of Mexico [9]

Field is a giant oil and gas field resulting from the favorable occurrence and history of many key geologic parameters and conditions. The major growth fault system bounding in this field is instrumental in the formation of rollover anticlinal traps. Faulting was contemporaneous with deposition throughout the Pleistocene and continues today. Salt domes around the periphery of the sub-basin were integral in the formation of growth faults, and some of the extremities of the fault system extend to these diapirs. Antithetic faults also are present and subdivide the structure into numerous producing fault block reservoirs.

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Filed is located approximate 200 miles southwest of New Orleans, LA in offshore [10]. Oil Wells in this field are connected with fixed platform via subsea flow lines. This fixed platform was built on steel legs anchored directly onto the seabed and it consist a supporting a deck with space for drilling rigs, production facilities and crew quarters. Fixed platforms are not only support production operation it also useful for drilling and storage operations.

This field consist several reservoir and structure of reservoir is nearly flat. Extracted Hydrocarbon from this field contains moderate sulfur from 0.5 to 2.0 wt%. Gravity of hydrocarbon spread between heavy oil (190 API) to light oil (40 API). Oil viscosity observed in this field from 1 cP to 11cP. Hydrocarbons are in lower Paleogene reservoirs.

The principal problem observed at the field is productivity and profitability. With time, there has been a decrease in oil production, while operating costs continue to increase. To maintain pressure in the reservoir is the main concern. The major producibility problems are related to cost-effective, field-scale reservoir management; reservoir connectivity caused by carbonate rock architecture and heterogeneity; pressure communication caused by carbonate petrophysical and engineering properties; and cost-effective operations associated with the oil recovery process. Production fluid compositions for this field are given in table 1.

TABLE 1: FLUID COMPOSITION

Component	Mole Fraction (%)
Nitrogen	0.073
Carbon Dioxide	1.878
Hydrogen Sulfide	0.002
Methane	15.122
Ethane	15.122
Propane	15.122
Butane	15.122
Pentane	15.122
Hexane	15.122
C_7+	7.317

IV. ANALYSIS & RESULT DISCUSSION

Initially the production of the fields was going on for years before the production dropped reached to the point of concern. To keep the production economically viable, there were studies conducted in order to choose whether to continue producing, or to abandon the well, or to have artificial aid in production. The operations alone cost a lot and if unviable economic conditions rise, even though the well is still producing, the production in-charge can decide to abandon it. The fundamental driver is economics for oil left in oil well. In general, the process of recovering oil from any reservoir requires:

1) A pathway which connects oil in the pore spaces of the reservoir to the surface,
2) Sufficient energy in the reservoir to drive the oil to the surface.

Oil left in the oil reservoir is because of lack of a pathway or lack of adequate reservoir energy in an environment in which it is not economic to implement incremental development activities. Oil left in the oil reservoir of Gulf of Mexico can be classified under a variety of oil trapping mechanism.

1) Non-development of the reservoir,
2) Premature abandonment,
3) Reservoir volumes not connected to wells,
4) Lack of natural pressure,
5) Lack of fluid displacement drive mechanism,
6) Capillary forces which hold residual oil in the pores of reservoir.

Prediction was that at a particular reservoir pressure and fields production dropped so low, that it was no longer going to be economically viable. Studies conducted and costs estimated decided for the abandonment or artificial interference in the fields. Keeping in mind, the environmental impact of drilling new fields further and a number of restrictions from the local governing body, also constituted to the ultimate decision of conducting studies for artificial lift, so that cost estimations could be made. Final decisions would be taken after the studies were conducted.

Researcher collected production from nine selected wells in three mature fields in Gulf of Mexico over 36 months and conducted simulation using Pipesim simulation toll to predict future oil production from these wells.

Oil Production without Artificial Lift

Production data shows that well 1 produced 27759 barrels of oil in 2017 and dropped 44 % oil production in 2018. Well has produced 15595 barrels oil in 2018 and 11215 barrels in 2019. Oil production drop is less in year 2019 in comparison of 2018. Oil production drop in 2019 is 28%. Production drop in three years in

approximate 60 % and this well would stop production in 2020 if external energy not employed.

Well 2 produced 98576 barrels of oil in production and well is experiencing production decline. Well produced 83834 barrels in 2018 and 54851 barrels in 2019. Researcher conducted simulation to predict future oil production and simulation results shows that well will produce 35040 barrels of oil in 2020 with its internal energy. Simulation results also shows that this well will stop production in 2021.

Well 3 is experiencing very high production drop. This well has produced 119536 barrels oil in 2017 and dropped 65% production in one year. Well produced 42261 barrels in 2018 and further production drop of 80% in year 2019. Oil production will drop to 8752 barrels of oil in 2018. Well is experiencing very high production drop. Researcher conducted Pipesim simulation to predict oil production for 2020. Simulation results shows that well will stop production in 2020.

Oil Production with Artificial Lift

Researcher conducted simulation using Pipesim 2017 simulation software tool to predict future well behaviour and oil production by adding following artificial lift methods:

- Gas lift
- Rod Pump
- Electrical submersible pump
- Gas Lift and Rod Pump
- Gas Lift and Electrical submersible pump
- Rod pump and Electrical submersible pump
- Gas lift, Rod pump and Electrical submersible pump

Well 1 – Researcher added above mentioned artificial lift methods and conducted simulation using Pipesim 2017. Simulation results shows that well will continue production after adding artificial lift system. Well will produce 162 barrels of oil per day in year 1 after adding gas lift system, 374 barrels of oil per day using rod pump and 447 barrels of oil per day using electrical submersible pump.

Researcher also conducted simulation by applying a combination of two or more methods. Well will produce 370 barrels / day oil using combination of gs lift and rod pump. Simulation results shows that adding gas lift with rod pump will decrease the production. Gas lift and ESP combination will produce 205 barrels of oil per day which is more than gas lift or ESP oil production. Combination of gas lift, rod pump and electrical submersible pump will produce 370 barrels of oil per day which is equal to gas lift and rod pump production. Adding electrical submersible pump to gas lift and rod pump is not adding any value.

By analyzing simulation results, electrical submersible pump is suitable method for this well. Approximate 795 thousand barrels additional oil can be recovered from this well in five years and well will continue to produce few more years.

Well 2 – Well will continue production in year 2020 without artificial lift method. Simulation results shows that well will produce 96 barrels per day in year 2020 and well will stop production in year 2021. Simulation results after adding artificial lift method for well A 15 shows that oil production will increase. Well will produce 255 barrels of oil per day in year 1 after adding gas lift system, 103 barrels of oil per day using rod pump and 330 barrels of oil per day using electrical submersible pump.

Researcher also conducted simulation by applying a combination of two or more methods. Well will produce 60 barrels of oil. This method has adverse effect, oil production after employing this method is less than natural flow. Combination of gas lift and electrical submersible pump will produce 205 barrels of oil per day which is equal to gas lift production. Electrical submersible pump does not have value in this combination for this well. Combination of rod pump and electrical submersible pump will produce an average of 104 barrels of oil per day which is very close to rod pump production. Combination of gas lift, rod pump and electrical submersible pump will produce 61 barrels of oil per day which is less compare with any other method.

Simulation results shows electrical submersible pump is suitable method for this well. Approximate 594 thousand additional barrels oil can be recovered from this well by adding electrical submersible pump.

Well 1 – Well will stop production in year 2020. Simulation results after adding artificial lift method for well A 16 shows that well will continue production after adding artificial lift system. Well will produce 71 barrels of oil per day in year 1 after adding gas lift system, 35 barrels of oil per day using rod pump and 472 barrels of oil per day using electrical submersible pump.

Researcher also conducted simulation by applying a combination of two or more methods. Well will stop oil production for combination of gas lift and rod pump. Combination of gas lift and electrical submersible pump will produce 75 barrels of oil per day which is less than electrical submersible pump oil production. Adding gas lift with Electrical submersible pump will reduce the production rate. Combination of rod pump and electrical submersible pump will produce an average of 35 barrels of oil per day. Combination of gas lift, rod pump and electrical submersible pump will produce 1 barrels of oil per day which is very less compare with any other method. Simulation results shows that electrical submersible pump is suitable method to increase the production ad extend well life. Approximate 837 thousand additional barrels oil can be recovered from this well in five years by adding

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electrical submersible pump whereas gas lift adds 37 thousand barrels of oil in five years.

Below figure summaries actual oil production in past and future expected oil production using electric submersible pump from selected three wells from Field 1.

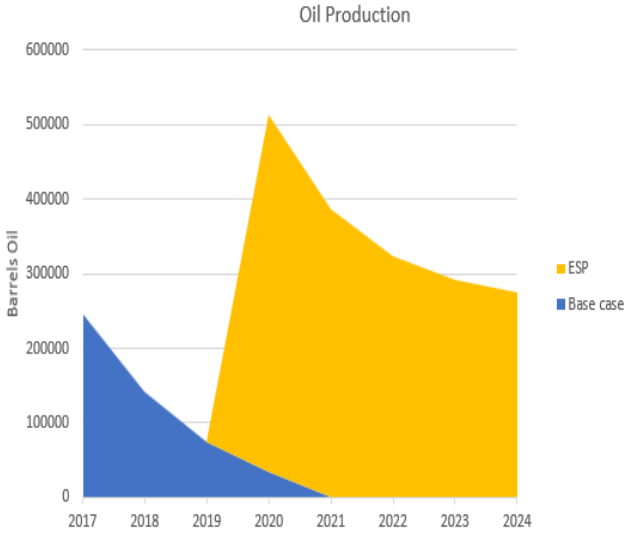

Figure 2: Expected Oil Production using ESP

VI. CONCLUSION

After all the thorough studies conducted and the steps taken towards assuring flow in the system, producing the wells despite their aging life by the use of artificial methods, the author concludes that the use of Electrical submersible pump will be most efficient among the discussed cases of artificial lift. Rod pump is suitable for well 1 in field 1. Gas lift is not economical in deep-water application because higher operating pressure and operating cost required for production. For selecting a feasible method, economics of installation and operation has been considered for these methods. Electrical submersible pump will be the cheapest and most profitable producer of crude resources from these fields and their individual cases.

Each well has a completely new scenario in oil and gas industry. No two standards can be formed based on the past projects and studies of any subsea or onshore field.

The wells behave completely differently and thus are a new challenge every time. Also considering the routing of the pipeline from the riser base to the subsea tieback, and its elevation difference, play an important role in the way the production will occur. The losses can be magnified or diminished unpredictably based on the location of the sources.

In conclusion, for this study, the electrical submersible pumps are feasible solution to increase oil production from mature oil wells in Gulf of Mexico.

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