

ANALYSIS OF WORKOVER CAUSES FOR WELLS WITH INSTALLED DOWNHOLE SUCKER-ROD PUMPS

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Abstract: Primary oil production represents the process of production only by exploiting the natural reservoir energy (reservoir pressure), i.e. eruption phase. This mode of production lasts until the reservoir pressure drops, so that it is no longer capable of pushing the oil to the surface. Oil wells which can't erupt, must apply one of the methods of artificial lifting. The artificial lift system of oil production by using downhole sucker-rod pumps with piston rods is the oldest system for lifting fluids from wellbore to the surface. It is also the most widespread artificial lift system in practice in the world (over 80%). The basic principle of the operation of a downhole sucker-rod pumps is based on the transfer of the drive energy from the surface to the pump by piston rods. In principle, downhole sucker-rod pumps with piston rods can be applied in oil wells from depth of 500 to 2500 m while enabling production ranging from 1 to 100 and more m³/d of liquid. This system is suitable for wells with a smaller gas factor and consolidated production layers. The advantage of downhole sucker-rod pumps is their efficiency and economy because initial capital investments per well are lower. The disadvantages of downhole sucker-rod pumps are higher maintenance costs, i.e. more frequent workovers. This paper analysis the most common causes for well workover that produce oil with downhole sucker-rod pumps and recommendations in order to reduce their number.

Keywords: ARTIFICIAL LIFT, DOWNHOLE SUCKER-ROD PUMP, PISTON RODS, WORKOVER, TUBING

1. Introduction

Oil is mainly produced from three stages: primary stage, secondary stage and tertiary stage (improved production - increased oil recovery (EOR)). Primary production represents the initial phase of the production of hydrocarbons from the reservoirs, while secondary production and EOR require additional effort to produce additional amounts of hydrocarbons. In the primary stage oil is displaced to the surface by the action of natural reservoir energy such as: dissolved gas in oil, gas in a gas drop and compressed groundwater. Because of the difference in pressure between the reservoir (higher pressure) and the borehole (lower pressure) the fluid starts to flow to the bottom of the borehole, then through the tubing pipes and finally to the surface facilities where oil, water and gas are separated in separators. By oil production, the natural reservoir energy gradually decreases until it reaches the limit at which the pressure is so small that there is no overflow, ie oil can not erupt on the surface, so the production of hydrocarbons with the natural reservoir energy is no longer possible. On such wells the reservoir energy raises fluid only to a certain level in the well and it is necessary to apply one of the methods of artificial or mechanical lifting of liquid from the bottom of the well. The basic ways of raising oil by mechanical means are: a) gas lift installation (gas lifting), or b) installation of downhole sucker-rod pumps.

This paper will present an analysis of the causes of workovers on oil field in Republic of Croatia where the oil production has been going on for more than 40 years.

2. Sucker-Rod Pump System

The artificial lift method of oil production with sucker-rod pumps is the oldest system for raising fluid from the wells to the surface and at the same time being the most widespread in practice in the world (over 80%), while in the Republic of Croatia oil production with this method is represented by over 50% of the all production wells [1]. In principle, sucker-rod pumps can be applied in oil wells ranging from 500 to 2500 m depth and production between 1 and 100 and more m³/d of liquid [1]. The advantage of this system is manifested mainly in a small initial capital investment per well, while the deficiencies are manifested in higher maintenance costs, ie in more frequent workover on each production well.

Five basic system components are needed to lift the fluid with a sucker-rod pumps. These are [1]: a) drive motor, b) pumpjack with gear reducer, c) polished rod, d) the sucker rod string and e) the subsurface pump shown in figure 1.

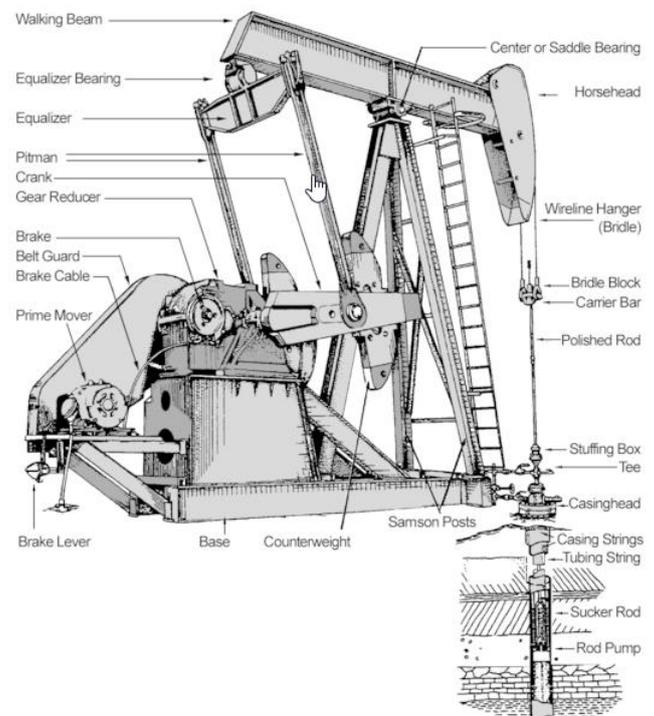


Fig 1. Sucker-rod pumping system [2]

The sucker rods are made of a full-profile round section of high-quality steel and serve to transfer power from the surface to the subsurface pump. Their length ranges from 7.62 m to 9.1 m, with reinforced male threads at the end and a part of the square shape for handling (Fig. 2).

Polished rod is one of the most important elements of sucker-rod pump system since it is exposed to the highest loads. It takes maximum load capacity because it is the uppermost and is also exposed to friction in the sealing system.



Fig 2. Sucker rods

The main components of a subsurface pump are [1, 3]: a) working barrel connected to the tubing, b) plunger connected to the sucker rods, c) traveling valve and d) the standing valve.

Figure 3. shows the two principal categories of subsurface pumps: a) the rod pump on the left and b) the tubing pump on the right.

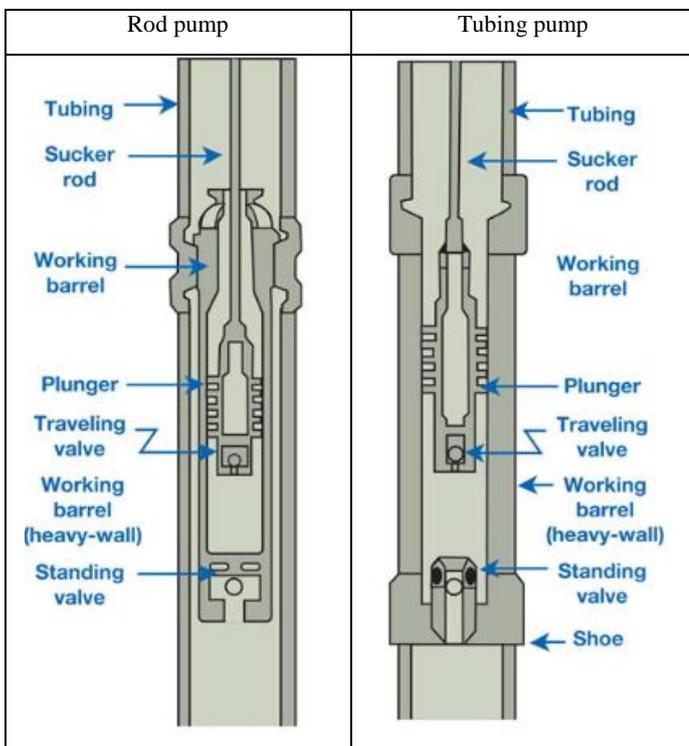


Fig 3. Rod pump (left) and tubing pump (right) [3]

The principle of production with sucker-rod pump is in alternating opening and closing of standing and travelling valves. By moving the piston upwards, standing valve open and traveling closes, where the fluid is sucked out of the reservoir into the working barrel and the amount of fluid accumulated above the traveling valve is squeezed into the tubing. When the traveling valve reach top position, the traveling valve open and the standing valve close to allow the working barrel to be filled with oil. When traveling valve reach down position it closes and the whole cycle is repeated.

3. Analyses of workover causes on oil field in Republic of Croatia

Analyzed oil field is located in Republic of Croatia. Oil production started in mid 60s with only 5 production wells [5] and until now is drilled more than 90 wells. At the present, there are more than 40 production wells with installed sucker-rod pumps [4]. The reservoir rocks are consisted of fine-grained quartz and tiny sandstones, weak to medium consolidation.

The analysis of the workovers causes includes place where failure occurred expressed as a percentage. Analyses covers a period of four years, from 2011 to 2014 where 220 workovers were done on this oil field according to data find in paper Bakarić [4].

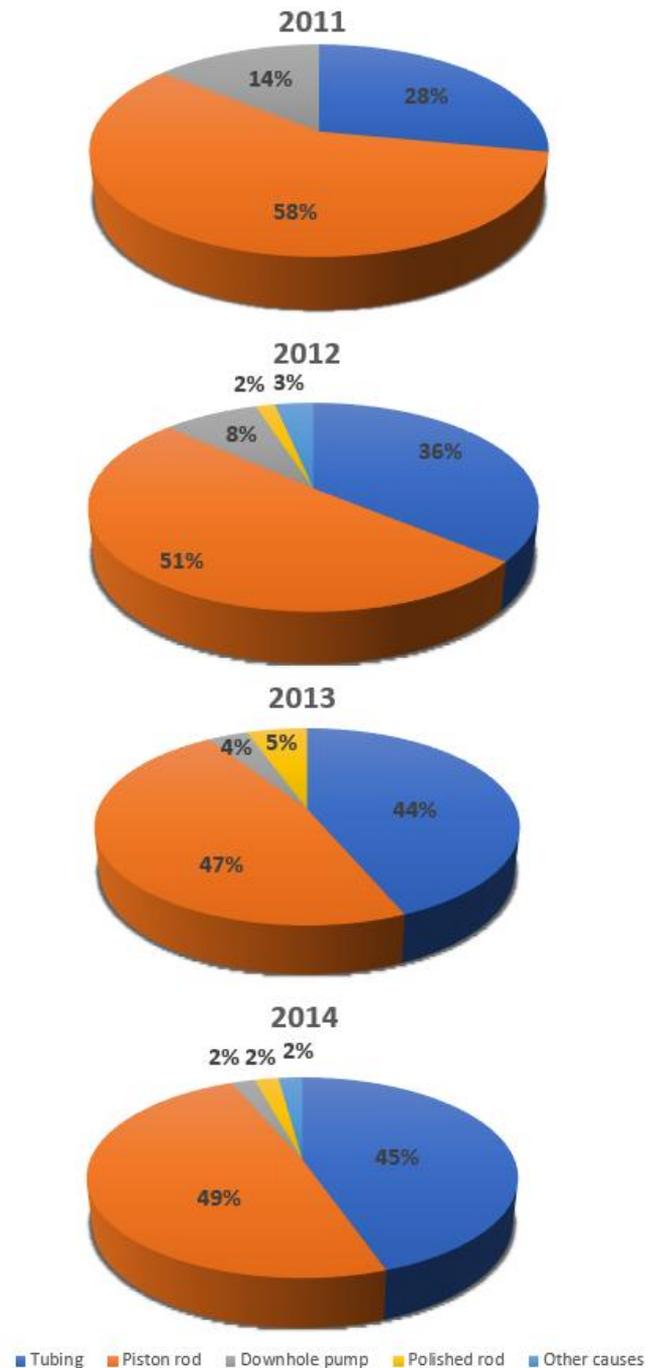


Fig 4. The analysis of the workovers for each year [according to 4]

As it can be seen from figure 4, in 2011, of all workover causes almost 58 % was sucker rod failures, then 28 % tubing failures and 14 % downhole failures. In 2012, sucker rod failures and downhole pump failures were reduced, while tubing failures were increased. Also, there were some polished rod failures and other causes. Other

causes mainly include problems with sand production and seating of plunger in working barrel. In 2013, sucker rod failures decreased while tubing failures increased, which also can be seen for 2014 year.

According to figure 4, it can be concluded that most failures are related to sucker rods and tubing, more than 90 %.

Figure 5 shows summary of all workover causes over period from 2011 up to 2014.

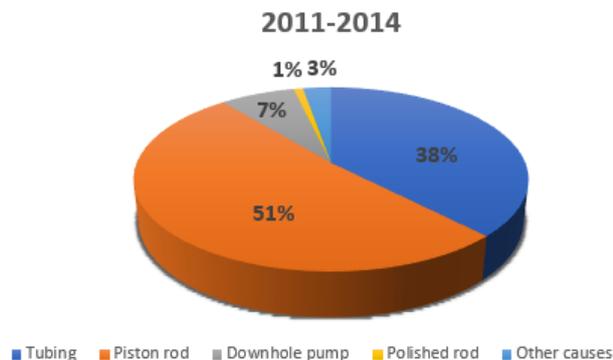


Fig 5. The analysis of the workovers for whole period [according to 4]

It can be seen that sucker rod failures are main workover cause in more than 50 % of all causes, while on the second place it tubing failures with 38 %. Other causes are relatively rarely recorded, less than 10 %.

The main reason why those failures are most common in sucker-rod system for this field in Croatia can be found in long-lasting production from oil wells (more than 50 years). In first period, fluid produced from wellbore mainly consist of oil while amount of water is negligible. During the production, oil amount in 1 m³ of produced fluid drops while amount of water increase. At this moment, average water production from this field is more than 90 %, so friction between sucker rods and tubing occur at more spots in some wellbores. Those spots are weak and during the time sucker rod or tubing failures occur.

Usual location where tubing failure occur is body of pipe (figure 6) caused by friction between sucker rods and tubing, and tubing joints failures caused because of inadequate handling and tightening (figure 7). Also, sucker rod failures occur because of the same reason, so due to the strength of the material, tubing or sucker rod failures occur.



Fig 6. Tubing body failure



Fig 7. Tubing joint failure

In figures 8 and 9 sucker rod failures are shown. Figure 8 shows sucker rod joint rupture, while figure 9 shows reduction of the wall thickness of the joint which an lead to rupture with further use.



Fig. 8. Sucker rod joint rupture



Fig 9. Reduction of the wall thickness of the sucker rod joint

4. Recommendations for reducing workover

As it can be seen from figures 4 to 9, main problem is tubing and sucker rod failures, ie. friction between sucker rods and tubing, with water content in produced fluid more than 90 %. Because of that, there is no adequate lubrication, so failures often occur, for some wells, more than few times per year.

To overcome the above-mentioned problem, first it is needed to do an analysis shown in figures 4 and 5 to determine the main causes. After that, for every wellbore, previous workover causes should be investigated, especially locations of causes (depth and failure type) in order to make the correct selection of equipment in the future and thus reduce the wellbore workover, resulting in a reduction in maintenance costs.

After the proper selection of workover causes operator can decide what to do in order to reduce failure causes and thus reduce maintaining costs.

Common solutions can be instalation of [6]: a) rod rotators, b) tubing rotators, c) rod guides, and (d) polyethylene lined tubing.

Rod rotators and tubing rotators are used in order to decrease the friction between oil well tubing and sucker rods, thus preventing unwanted unscrewing of sucker rods and reduce the deposit of wax and paraffin on the surfaces of tubing and sucker rods [7, 8].

Polyethylene lined tubing provide sufficient reduction of friction between tubing and sucker rods. The pilot test was conducted on 17 rod pumped wells in Texas where polyethylene lined tubing has installed and have outpetiormed their previous failure history [9].

In Croatian practice most common used equipment is rod guides (figure 10). They are installed on sucker rod pumps and they reduce friction between tubing and sucker rods.



Fig 10. Rod guides [10]

This paper analyses the workover causes on one oil field where as main artificial lift method sucker-rod pumps are used. Also, some recommendations for reducing amount of needed workover are proposed. In the last few years, above mentioned additional equipment were installed on such chosen wells, and in the future, it will be possible to make such analysis that will show if there were successful application of additional equipment.

5. Conclusion

During the long-term oil production, the share of produced water increases while the share of oil decreases. Therefore, in the oil field equipped with sucker-rod pumps, there is an increased need for workovers. The main reason is the friction that occurs between sucker rods and tubing that causes failures of sucker rods or tubing which requires repair work because such wellbore cannot produce oil at that moment. After the main causes of the workovers are established, operators need to think about the proper mode of workover reduction. With the development of new technology, the causes of the workover can be reduced using additional equipment on boreholes such as rod rotators, tubing rotators, rod guides and

polyethylene lined tubing in order to reduce friction that occurs constantly in places where sucker rods and tubing are in contact.

6. References

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