Exchanging traditional pumping unit for a "Geron" hydraulic drive

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Abstract. This work was devoted to analysis of the efficiency of the application of a "Geron" hydraulic drive as an alternative to a beam pumping unit. The issue of replacement old drives for new one was considered in the context of economic profitableness taking into account field conditions of Russia and neighbor countries. To prepare this scientific article, different data about field experience of usage the machines in different countries and fields were asked for and obtained. Thanks to information got general characteristics of both machines with their advantages and disadvantages based generally on technological, energetical and economic data were composed. After this the drives were compared with each other. As a result, hydraulic drive "Geron" was taken to be a good alternative of traditional pumping unit.

1. Introduction

Oil companies were always interested in high level of fluid extraction. Out of the fact that modern extraction is mostly mechanical, pumps and drives play very important roles in production. Consequently, any offers of modernizations in this field are always hotly debated.

One of that offers is exchanging traditional pumping units for hydraulic drives. Some experts has already mentioned about prospects of this operation in own articles, for example, Karchagin V. [1] Molchanov A. [3,4], Blokhin S. [5], Kiselev A. V.[6], Grigoriev S. [7], Seduch A.[8].

The main purpose for this research was to determine if such replacements do interesting from the practical point of view.

Currently, one of the main trends in the development of pumping units is an increase in the stroke length of the suspension point of the rod string, however, in the implementation of "classical" mechanical schemes using a lever converting mechanism, such machines become enormous and inconvenient to maintain. Besides that they require creating large foundations. As practice shows, balancing pumping units with a stroke of more than 4.2 m are not used on an industrial scale, and the actual maximum stroke is about 3.5 m.

Hydraulic drives were originally developed in the United States as devices that provide stroke lengths of more than 6 m. Operation of such hydraulic actuators was successful, however, hydraulic actuators did not receive wide industrial use due to maintenance complexity, bulkiness, and low reliability. Attempts to repeat these structures using the domestic element base of the hydraulic drive also were not successful.

In the 70s-80s of the last century, reliable and effective hydraulic drives for oil production using rod pumps appeared. Simultaneously domestic production of parts of the hydraulic drive base began to be established: pumps, valves, seals, distributors, etc. Development G.V. Molchanov's hydraulically operated rocking chair, known under the code "AGN" was the first design that was mass-produced and began to be widely used in the fields.

The use of a tubing string as a balancing load was a distinctive feature of this installation, which, in combination with a volumetric hydraulic drive, made it possible to install it directly at the wellhead without a special foundation. Specially designed sealing devices of the hydraulic drive ensured...
reliability and compactness of installations, as well as the use of elements of the volumetric hydraulic drive developed and used in road machine-building engineering and construction.

In addition to large stroke lengths and reduced metal consumption, the labor intensity of installation maintenance has decreased; additional possibilities have appeared for adjusting the drive in order to strictly regulate the conditions in the rod string, maintain plant performance, etc. These advantages were made possible through the use of elements of hydraulic automation, and in some cases, microprocessors that control the apparatus of hydraulic actuators.

In addition to the mentioned drive, from the 60s of the last century to the present, many hydraulic drives have been developed. Studying their designs, it is easy to trace the path of search and development of fundamentally new for that time schemes, many of which are still the basis for modern equipment. Currently, about 100 units of hydraulic installations are in operation. Positive indicators of their work in combination with the continuous modification of the elemental base of the volumetric hydraulic drive indicate the prospects of this direction in the development of drives.

Lower at the picture 1 a principal scheme of modern hydraulic drive "Geron" can be seen.

![Figure 1. Principal scheme of modern hydraulic drive "Geron".](image)

HC - hydraulic cylinder; CSR - column of sucker rods with deep well pump; HP - hydraulic pump; HT - hydraulic tank; IECS - an intelligent electronic control system; SP - linear system for feedback position of the piston HC.

Hydraulically driven units can be particularly effectively used for trial well operation, well operation in remote and hard-to-reach areas located in marshy areas or ramps. But, as practice shows, fundamentally new equipment does not completely replace the old one.

Moreover, today a significant part of the oil well stock of the Russian Federation operates at the expense of pumping units. The tendency is unlikely to change in close future. Some specialists analyzed this problem, for instance technical director of the "Chernushkaneft" Vladimir Karchagin and leader of the "PSM-Impacs" Sergey Grigoriev, confirm prospects of hydraulic drives but at the same time say that such machines won’t soon replace traditional equipment [1].

The beam-pumping unit is a machine whose design has been improved throughout the history of the oil industry. In the existing constructions of changes is not expected. Energy intensity and specific power of beam pumping unit are determined by strength properties of materials, changes of which are also not expected. At the same time, the resultativeness of modern machines of this type are rather low [2]. Previously successful technology fairly outdated is not able to provide high performance. For this
Some specialists say that the installation of the pumping units on the wells can no longer be considered cost-effective. This work offers an objective look at things.

The thing is that the work of pumping units, as a mechanical drive of sucker-rod pump is characterized by the following main disadvantages:

- The pumping unit operation requires a special foundation that causes the inconvenience of mounting it;
- Changing the operating mode of the Hydraulic Drive for Deep Well Rod Pump "Geron" (HDDWRP) driven by the pumping unit is possible only when the well is completely stopped, since it is necessary to adjust the number of swings and the stroke length of the rod, which in turn requires changing the pulleys, shifting the crank fingers, and adjusting the counterweights;
- The need to hire maintenance personnel and operators.

The solution of these problems is proposed by the company "Konkov's Petro-Hydraulic drives". It engaged in manufacturing "Geron" - a hydraulic drive that allows, due to minor innovations, to significantly reduce power consumption, save on installation and operating personnel, change the mode without stopping the operation of the well. Its image is presented in figure 2 [5].

![Figure 2. The Hydraulic Drive for Deep Well Rod Pump "Geron".](image)

Hydraulic drives "Geron" have already found application in the fields of many countries, including Russia, Turkmenistan, Kazakhstan, Colombia. On the territory of the Russian Federation, in the period from 2015 to 2017, companies such as "Orenburgneft", "RN-Nyaganneftegaz", "TATOYLGAZ", "Kara Altyn", "Turkmennebit Group of Companies" have tested and adopted. In a number of foreign countries, trial operation is planned in the near future. Figure 3 shows the geography of the use of hydraulic drives "Geron".

2. Methods of research
The main method of research was comparison. Results of hydraulic drive field test were analyzed and compared with data from design documentation. According to it technical and economic efficiency of «Geron» was estimated and some conclusions made.
To form in readers’ minds the real image of «Geron» here, in this chapter, full information about hydraulic drive testing sample was given.

Not so long ago in 2018 pilot tests were performed for "RN-Nyagannetegaz". A comparative analysis of "Geron" and pumping unit will be conducted according to this recent project.

First of all, it should be said that for this company, HDDWRP -140-6.0 was chosen as a sample for testing with electricity. According to the project, this drive should provide:

- The operation of one or several submersible borehole pumps with a wellhead loading up to 14 tons;
- Uninterrupted operation of the facility represented by the well stock of the electric centrifugal pump unit with a liquid flow rate of up to 30 m$^3$/ day, characterized by a periodic mode of operation.

Figure 3. The geography of the use of the "Geron" by countries (red color is already used; blue - trial operation is underway / trial operation is planned).

The need for the implementation of the "Geron" in the company arose due to a decrease in oil recovery at the stock of wells equipped with electric centrifugal pump unit and the desire to transfer wells from the periodic mode (34.9%) to the permanent mode of operation.

In this regard, several main objectives of pilot field operation were identified:

- Confirmation of the operational reliability of HDDWRP 140x6-0A during operation of the drive-in field conditions of the "RN-Nyagannetegaz";
- Qualitative verification of the stated reduction in electricity consumption;
- Identification of the intellectual capabilities of the "Geron";
- Achievement of key performance indicators (no downtime due to equipment failure);
- Reduction prevention of fluid production of candidate wells;
- Reduction of specific electricity consumption (kW) per 1 m$^3$ of produced fluid in comparison with the previous method of operating a candidate well by 10%;
- Simplicity and ease of maintenance.

The main technological advantages provided by the "Geron" over the base variant / alternative technical solution are: the possibility of operating a low flow well stock in a constant mode of the sucker-rod pumping unit at depths of over 2000 meters; the ability of this drive to convert the energy of the weight of the pump rods into electrical energy and return it to the supply network (when the drive rod moves down) due to the use of a frequency converter with a recovery function and a motor-generator providing operation at nominal load on the wellhead up to 140 kN (14 mc).

The disadvantage compared with the basic version / alternative technical solution was only the lack of confirmation of the resource reliability of the tested equipment in the field conditions of the "RN-Nyagannetegaz".
Tests of the hydraulic drive "Geron" were conducted from November 2017 to May 2018. HDDWRP -140-6.0A "Geron" with a standard weight changer of the type RRS-18 which was mounted on a dedicated well No. 5515, hive No. 15 of the Sever-Talinka Strengthened oilfield assets and put into operation with the following parameters:
- Depth of the submersible pump: 2450 m;
- The number of double moves was set to: 2.5 per minute;
- The stroke length of the hydraulic cylinder rod: 4 m;
- Load on the hydraulic cylinder rod during lifting: 9–9.5 t;
- Load when lowering on the hydraulic cylinder rod: 4 - 5 tons.

3. Results and discussion
During the operation of the hydraulic drive, it has been established that the drive complies with the design documentation and the declared technical parameters, namely:
- 1. The noise level does not exceed 65 dB;
- 2. The number of double strokes can vary widely depending on the stroke of the hydraulic cylinder rod in the range from 0.2 to 4 strokes per minute;
- 3. The smoothness of the course is regulated continuously by an electronic control system;
- 4. Automatic switching on - turning off the heating and cooling systems of the working fluid according to the temperature sensor readings;
- 5. Continuous full-flow filtration of working fluid with control of clogging of filter elements;
- 6. Automatic start-up after shutdown - power on with saving settings;
- 7. Display on the display of the current operating parameters of the hydraulic drive: the temperature of the working fluid, the load on the rod, the operating pressure in the system, the current time, the number of double strokes, the total operating time of the drive in hours, the reason for stopping the equipment, the passage of position sensors (upper and lower);
- 8. Display of the dynamogram at the request of the operator with a memory of up to 20 dynamograms.

During the testing period, the following happened:
- 01.02.2018 – a technical service was carried out by the representatives of the "Konkov's Petro-Hydraulic drives";
- 03.07.2018 - equipment shutdown due to metal rupture through the body of the axle hanger HDDWRP -140-6.0A, which led to the bending of the polished rod and the hydraulic cylinder shaft HDDWRP -140-6.0A (total simple well amounted to 325 h. 12 min., because of the delay in admission of workers of the "Konkov's Petro-Hydraulic drives" of a simple well due to the fault of the "Konkov's Petro-Hydraulic drives" 19 hours 45 minutes).

On 08.05.18 pilot field tests HDDWRP -140-6.0A produced by "Konkov's Petro-Hydraulic drives" from the moment of the beginning amounted to 181 days (the actual hours worked including stops were 167 days; operating ratio - 0.93).

During the reporting period, there was one failure of controllable equipment which led to well shutdown because of the RRS-18 produced by "Neftekh" failed.

There was no significant reduction in the specific electricity consumption (kW) per 1 m3 of the produced fluid during operation of the hydraulic drive of the submersible sump pump HDDWRP -140-6.0 compared with the previous method of operating the candidate well.

| Table 1. The test results. |

| Number of test | Period of time | Type of equipment | Q<sub>liq</sub> m<sup>3</sup>/day | Energy used kW* day | Energy used kWh/day | Specific energy used kW/1m<sup>3</sup> |
|----------------|----------------|-------------------|-----------------------------|-------------------|---------------------|-----------------------------|
| 1              | 23.09.-25.09.16 | ECP 50/2400, SEM 45-117 (CES) | 7                           | 118,2             | 4,9                 | 16,9                        |
Thanks to data shown technical and economic efficiency was estimated:

1. There was 1 stop 07.03.2018 (after 118 days of continuous operation of the drive) due to the failure of the weight tool, the test goal is 0, the proportion in the estimate is 40%, if 1 stop is considered, then the estimated value will decrease to 0.9.

2. During the specified period of testing, the volume of produced fluid was 8 m³ (based on acts for the period of operation), the goal was achieved, the proportion was -30%, the estimated value was 1.

3. Reduction of specific electricity consumption to 14 kW per 1 m³ of produced fluid, when operating a sucker-rod well pump for hydraulic HDDWRP-140-6.0 compared with the previous method of operating a candidate well: Target value -10%, estimated value -0, specific weight -10%.

4. Simplicity and ease of maintenance of ground equipment (drive of a sucker rod pump of a hydraulic pump HDDWRP-140-6,0 manufactured by "Konkov's Petro-Hydraulic drives"): estimated value -1, specific gravity -20%.

The percentage of efficiency is defined as the sum of the values of the product of the estimated coefficient by the specific weight, for each indicator.

Total: 0.9 * 40 + 1 * 30 + 0 * 10 + 1 * 20 = 86%

4. Conclusion

The obtained results indicate that the equipment HDDWRP -140-6.0 produced by "Konkov’s Petro-Hydraulic drives" can be considered a worthy alternative to the pumping unit.

At the same time, it is worth noting the prospect of reducing the cost of electricity, since during the pilot operation at other facilities, “Geron” proved to be very worthy in this regard. Thus, for example, at the pilot operations in the "Orenburgneft", the measurements of consumed and delivered electricity were confirmed by the manufacturer’s stated functions of returning electricity to the network, thereby ensuring a reduction in the cost of electricity consumption in the amount of 13.4 thousand rubles/month.

According to the obtained results, the specialists of the "Orenburgneft" developed a program for the implementation of equipment, according to which in 2015 ten such installations were installed [8].

5. References

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