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STUDY OF THE IMPACT OF SAND PENETRATION ON PUMPING EQUIPMENT OPERATION MODES IN THE KIZILKUM REGION CONDITIONS

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Abstract

The article presents an analysis of technological methods aimed at investigating the consequences of sanding in wells in the Kyzylkum region. The main causes of sanding and their impact on pump operation are considered, including damage to working parts, reduced pressure characteristics and increased frequency of repairs.

Keywords: Sand penetration, pumping equipment, intensity of sand removal from the formation, methods of reducing sand penetration in wells, equipment wear, optimisation of pumps operation.

Introduction

Sanding is one of the main problems in well operations, as it leads to accelerated wear of pumping equipment, reduced productivity and increased operating costs.

The analysis of scientific works related to the research and development of development techniques and technology in the conditions of wells with unstable rocks allows classifying the causes of well failure and sand removal into three main groups, based on the conditions of occurrence: geological (peculiarities of the formation-borehole bedding, lithology), technological (conditions of formation opening and well operation) and technical (bottom hole design).

DISCUSSION OF THE PROBLEM

Analysing the data given in scientific sources and articles and experience of operation of the main part of wells of Kyzylkum region, on influence of mechanical impurities on pumping unit operation, it is possible to draw a conclusion that, on geotechnological wells operation is complicated by big removal of mechanical impurities that makes about 74 % from the total volume of complications (fig. 1). These are wells with sand content in productive solutions more than 100 mg/l.

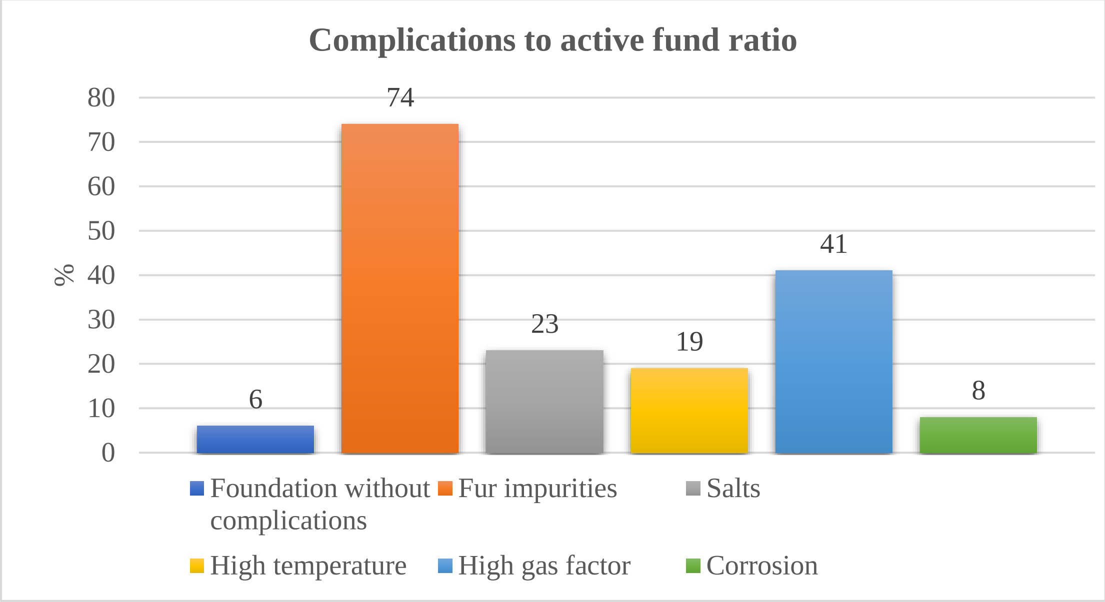


Fig. 1. Distribution of complications in wells with electric centrifugal pump installations at PV mines.

At the same time in the total number of mechanical impurities the determination of the share of particles will play an important role. Analysing the given data of authors' researches on diffraction analysis of mechanical impurities, according to the method of Bondarenko V.A. it is possible to determine their distribution by classes of particles, which is presented in Fig. 2.

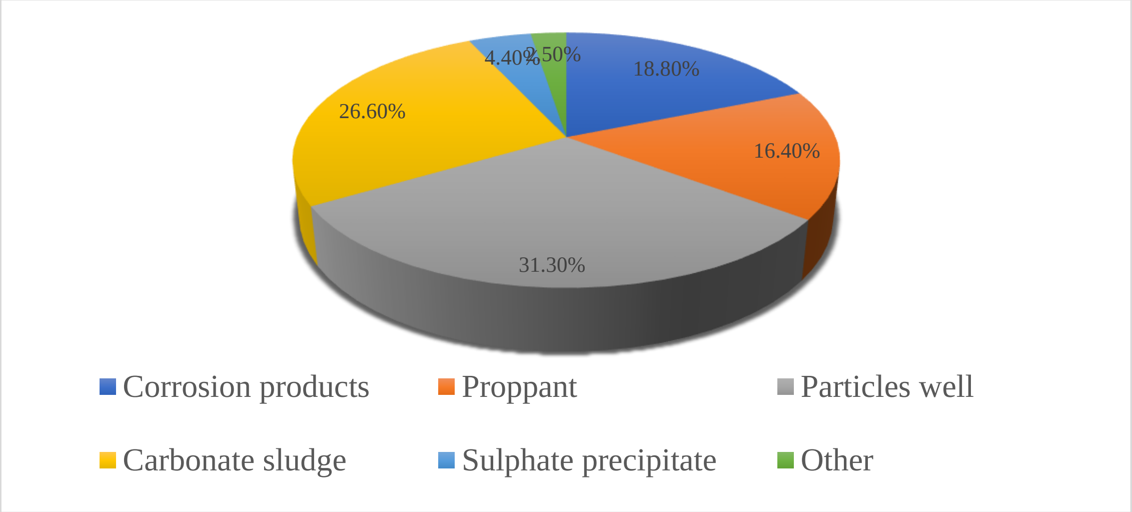


Fig. 2. Distribution of mechanical impurities by particle classes in samples of productive solutions according to the results of diffraction analysis

According to the data of the author Bondarenko V.A. on study of microphotographs of mechanical impurities, received at disassembly of pump installations and their granulometric researches it is established that sizes of the basic part of them make from 0,11 to 0,19 mm (53 %), about 30 % reach in sizes 0,20 mm and more, and in 17 % of cases sizes of particles do not reach and 0,1 mm.

The performance of a submersible electric centrifugal pumping unit (ECPU) is affected by a large number of factors, ranging from the processes that take place in the reservoir itself to the design of the well.

Sand pressure in the annulus can be thought of as the difference between the pressure at the submersible pump inlet and the reservoir fluid column above the pump inlet. Therefore, the value of pressure at the submersible pump intake is of particular importance. In practice, when operating wells equipped with ECPU's, the value of pressure at the ECPU intake is always less than the saturation pressure, which predetermines the operation of the submersible pump with a certain amount of sand.

The main parameters affecting the operation of ECPU at increased sand and gas factor should also include the volume fraction of sand and gas, which determines the structure of the sand-gas-liquid mixture (SGLM) flow and the size of sand and bubbles; pressure (the higher the pressure, the smaller the density difference between the productive solution, sand, gas and liquid); surface tension (its increase prevents the formation of large bubbles, so ECPU with sand and gas works worse on water).

The sand-gas content at the pump inlet is the ratio of the sand and gas flow rate to the mixture flow rate:

$$ПГ = \frac{Q_{пг}}{Q_{пг} + Q_{ж}}$$

where Q_{pg}- flow rate of sand and free gas entering the pump, m^3/day;

Q_w - liquid delivery by pump under the same conditions, m^3/day;

Since sand separation and degassing occurs at $P_1 = P_{us}$, which corresponds to the unstable operation mode of the pump, the stability number is determined by the formula:

$$P_1 = \sigma\Delta\rho + P_{нас}$$

where Δρ is the velocity head of the first stage (pressure drop after and before the first stage of the pump).

The equation, with appropriate safety factors, characterises the condition of stable operation of the ECPU during sand separation and degassing. Then, when operating with inlet pressure above saturation pressure, dissolved gas will be released only upstream of the pump.

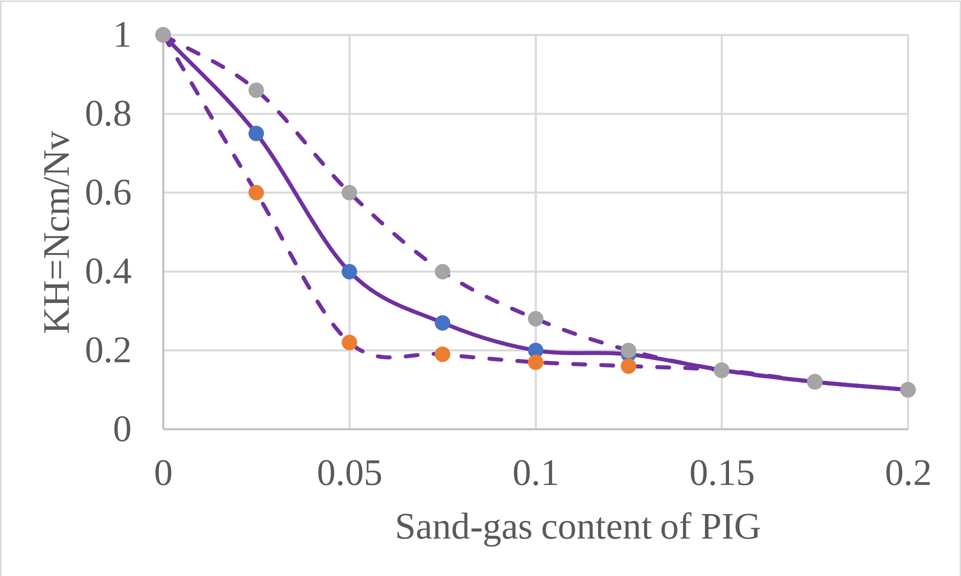
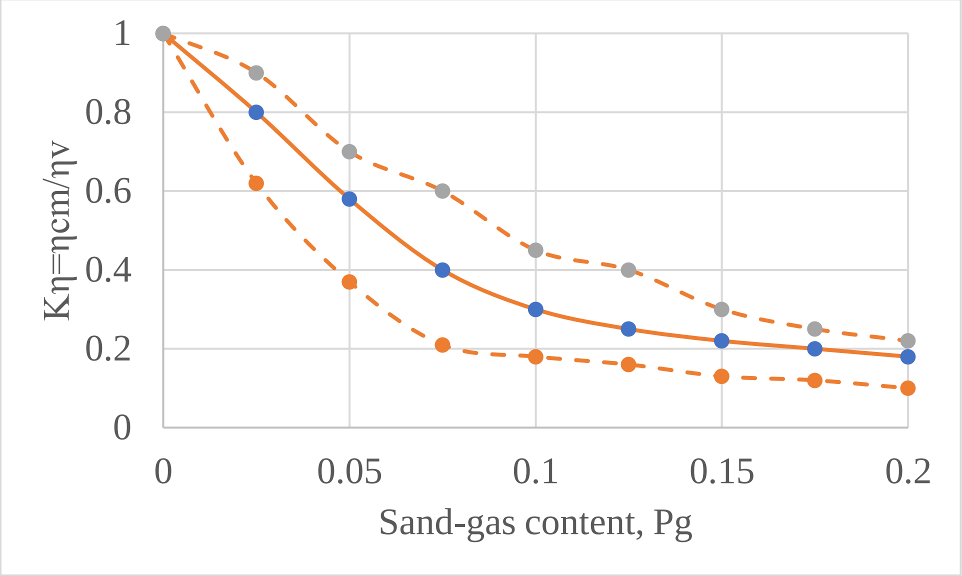
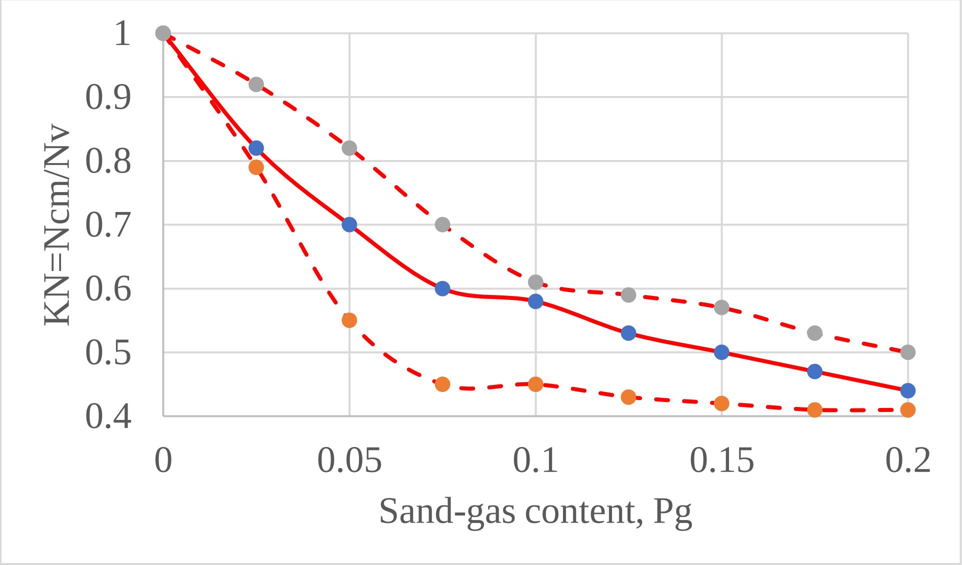


Fig.3. shows the general established dependences of head coefficients (K_H), C.P.D ($K_{(\eta)}$) and power (K_N) as a function of content value



a)



b)

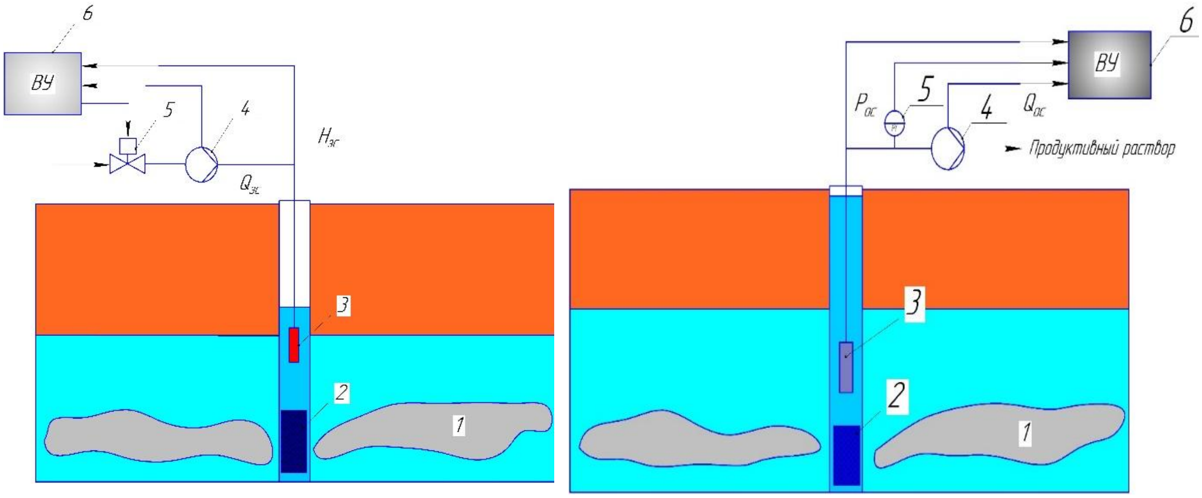
Fig. 3. General dependences of K_H(a), $K_{(\eta)}$)(b) and K_N(c) values on sand-gas content function

Thus, from the above-mentioned it is possible to draw a conclusion that the problem of rational efficiency of ECPU in wells with high sanding and gas factor has not been fully solved, as the experimental studies were carried out in the area of small sand-gas content (0,01-0,1); the proposed methods are applicable only for submersible ECPU, operating with the number of revolutions per minute 2800-2900.

DISCUSSION RESULTS

In the identification question, consider the interaction between a pumping well and a disposal well in which the composition of the pumped solution has gas-solids. In the injection well the main variable determining its operation is the level of leaching solution. In a pumping well, the main process variable is the head differential generated by the submersible pump.

Injection well (Fig.4. a) is designed for injection into productive formations (1) of leaching solutions through a filter (2), capable of dissolving uranium-bearing minerals, which are used to maintain reservoir pressure and regulate the rate of mineral extraction. The main technological variable of the process, which would allow solving part of the problems on qualitative control of SP, is continuous control of dynamic level in injection wells by means of hydrostatic level gauge (3). An electro-valve (5) for flow control and a flow meter (4) for continuous measurement of the flow rate of the stripping solution are installed in the wellhead. Processing of measured parameters and control of the solenoid valve is carried out by a computing device or controller (b).



a) б)

Fig. 4. Functional scheme of monitoring parameters of injection (a) and pumping wells (b)

To determine the change of flow-pressure characteristics of the pumping equipment during the peculation in the well, we use the formula, which is a mathematical model of the change in pump power.

The useful power of a pump is the power developed by the pump to transfer energy to the liquid discharged through its head, without taking into account energy losses. If a pump delivers **Q**, m^3/h, of a liquid with density **ρ**, kg/m^3, and gives it a head **H,** m, its second work, or useful power **Nn**, W, will be as follows

Nn = gQH ρ

where g is the acceleration of free fall. Taking g = 9,81 m/s^2 and dividing the right part of the equation by 1000, after reduction we obtain the formula of useful power of the pump in kilowatts, kW:

Nn,$\frac{\rho QH}{102}$

where ρ - density of liquid, kg/m^3; Q - pump delivery, m^3/s; H - total head of pump, m; number 102 in this formula is a coefficient of conversion of measurement units

(1kW= 1000N×1m/s; 1H= 0.10197kgf -' 1000H=101.97kgf≈ 102;

1 kW= 102kgf×1m/s)

The consumed or effective power, Nv kW, (sometimes called shaft power) Nv is greater than the useful power by the amount of power losses in the pump itself, which are characterised by the total efficiency of the pump η .

$$Nv = \frac{\rho QH}{102\,\eta}$$

The total **efficiency of** a pump η characterises its efficiency and means the ratio of the useful power of the pump N_n to the effective power N_c, i.e.

$$\eta = \frac{N_n}{N_c} .$$

The value of η is usually given in the pump's data sheet. The total efficiency of modern large centrifugal pumps is up to 0.92 and of small pumps up to 0.5...0.6.

Fig.5 shows the obtained results of research by mathematical calculations with the help of the above formulae and the dependence of the change in the power value on the pump delivery.

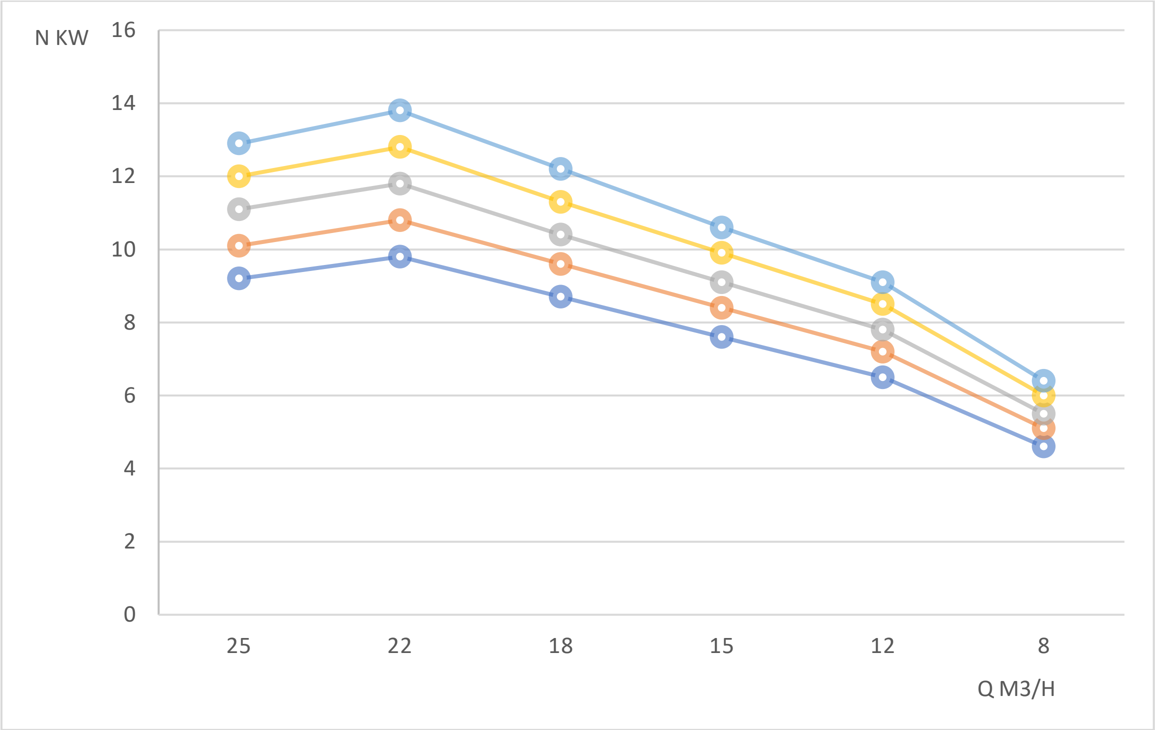


Fig. 5 - Flow-pressure characteristic of URN 6 25/14 borehole pump

Based on the results of the study and analysis of the dependence of the change in the power consumption of pumping equipment on the ore deposit at the content of solid particles and from the level of solution in the injection wells can be selected such a flow rate Q_{zs}, which provides maximum differential at the core deposit and reduce the proportion of solids in its content.

CONCLUSION

Summing up on the level control system of the operation mode "well - ore deposit - pumping well", it is realised by gradients of change of pumping equipment power consumption in the ore deposit and maximisation of uranium concentration at the pumping well, and by the algorithm of quality analysis of the in-situ leaching process and decisions are made on distribution of loads on leaching solutions and obtaining of productive solutions, application of non-stationary operation modes of pumping pumps, as well as increase of efficiency of the leaching process.

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