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Study of Gas Separation Conditions during the Commissioning of a Rod Pumping Unit

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Abstract. This article presents the outcomes of an investigation on gas separation inside the intake of pumps used in wells using the rod pump technique. Experimental investigations indicate that the gas separation coefficient is affected by both the geometric configuration of the pump intake and variations in gas flow rate. An empirical formula was constructed from the analysis of experimental data to ascertain the separation coefficient at the pump input. The calculations conducted indicate that the suggested formula allows the determination of the separation coefficient with enough precision.

1. Introduction

The study of wells utilizing the Rod Pump Method (RPM) depict that the gas separated from the liquid significantly affects the performance of the downhole pump unit [1-5]. The analysis of the wells which employ RPM within the AzNEFT Production Union indicates that associated gas adversely impacts efficiency of pump by 25-30%. This also leads to significant oil losses and a considerable decline in economic performance. Various gas-handling devices with distinct designs are employed to improve the efficiency of downhole pumps in oil fields [1,2,5].

It is known that gas separation at the intake of a rod pump is influenced by various factors, including the dimensions of the protective collar and the pump's geometric measurements, the characteristics of the equipment installed at the pump intake, and the liquid flow rate.

2. Methodology

A number of large-scale experiments were conducted in a special laboratory facility for the purpose of studying gas separation in wells equipped with gasifiers. The scheme of the device is given in Figure 1.
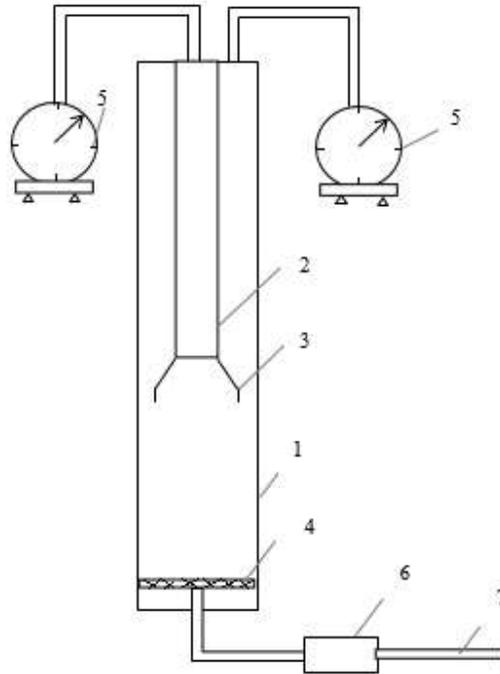
1-external pipe; 2-inner tube; 3-nozzle; 4-grinder;
5-gas meters; 6-reducer; 7-gas line.

Figure 1. Schematic of the experimental setup

The apparatus comprises a 45 mm glass tube (2) situated inside a 152 mm glass tube (1). Multiple sizes of nozzles (3) are situated at the bottom of the inner tube. A grinding tool (4) is positioned at the base of the device to achieve a quasi-homogeneous mixture. The gas traversing the grinder reaches the inside of the pipe and the pipe-back area, subsequently flowing via gas meters (5) to quantify the amount. The gas flow rate provided to the device is controlled by a regulating reducer (6). It is important to mention that transformer oil served as the oil model throughout the experiments.

The principle of operation of the experimental device is as follows: after fitting a sleeve of the required diameter to the lower end of the inner pipe (2), the inside of the device (pipe 1) is filled with transformer oil. The oil level in the device is taken in such a way that liquid (oil) discharge does not occur in the lift pipes at the maximum value of gas flow rate.

Gas is supplied to the device through line 7. The supplied compressed gas passes through the grinder and forms a dispersed gas-liquid mixture in contact with the liquid. Thus, the zero mode of the lifting elevator is formed. The research was conducted at nozzle diameters of 13.6, 12.8, 12.0, 11.2, 10.4, 9.6 and 7.6 values.

3. Results

The results of the experimental researches are given in Figure 2 in the form of the dependence of the separation coefficient K_s on the flow rate v of the liquid.

K_s və v are defined as follows:

$$K_S = \frac{V_{ba}}{V_{ba} + V_b} \qquad\qquad v = \frac{1033}{1033 + \frac{h}{2}\rho_m g} \cdot \frac{Q}{F} \qquad (1)$$

Here:

$V_{b.a}$ – the amount of gas passing through the annular space of the pipe;

V_b – the amount of gas passing through the pipe;

Q – gas flow rate;

F – cross-sectional area of the riser pipe;

h – height of the liquid column;

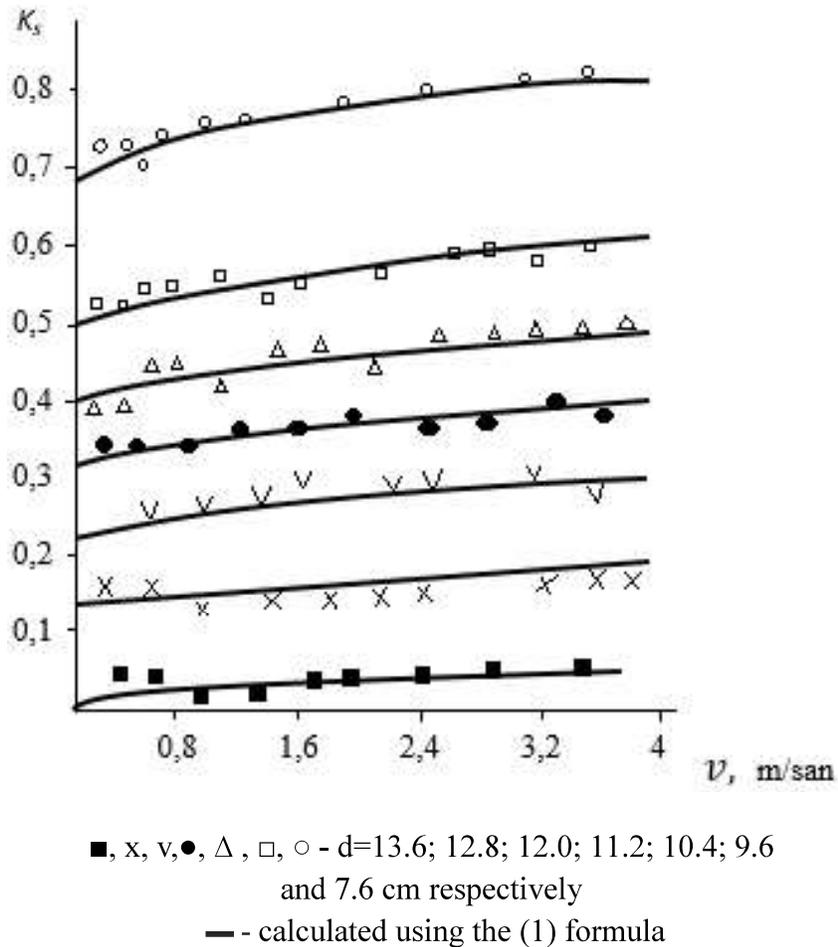ρ_m – liquid density;

g – acceleration due to gravity.

■, x, v, ●, △, □, ○ - d=13.6; 12.8; 12.0; 11.2; 10.4; 9.6
and 7.6 cm respectively
▬ - calculated using the (1) formula

Figure 2. Dependence of separation coefficient on the provided speed for different diameters of the nozzle

4. Conclusions

Based on the results of experimental studies, it can be said that the separation coefficient is influenced not only by the nozzle diameter, but also by changes in gas flow rate. As a result of the mathematical processing of experimental data, the following empirical formula has been derived to determine the separation coefficient, considering gas consumption in the zero regime:

$$K_S = 1 - \frac{1}{477\upsilon e^{-11.77\frac{d}{D}} + 0.71(\frac{D}{d})^2 + 0.15} \qquad (2)$$

Here:

d – pump inlet diameter;

D – pipe diameter.

Using the derived formula, calculations were made to determine the separation coefficient based on the provided gas speed. It has been determined that the results of the calculations using the formula closely match the experimental data with sufficient accuracy.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research

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