Model of mobile experimental stand for determine parameters of the gas-piston flow

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Abstract. Optical research methods are widely used to study gas-liquid systems. In practice, mobile experimental stands are in demand. This article describes the work of an experimental stand for observation, measurement of parameters of a gas-liquid flow. The measured parameters of the gas-piston flow regime correspond to the known research results. The presented technique is applicable for the implementation of a mobile measuring stands.

1. Introduction

Optical research methods are widely used to study gas-liquid systems [1, 2]. The movement of a two-phase gas-liquid flow during the joint transportation of two media along a sealed one-pipe collection system differs radically from the movement of a single-phase flow. The structure of the gas-liquid flow is commonly understood as a distribution of the gas and liquid phases in the process of their joint movement along a pipeline. The presence of two phases leads to the diversity of the structural forms of the flow. Phase speeds can vary significantly. The following combinations are possible: the gas and liquid phases move laminar, one is laminar, is turbulent, both are turbulent. Different flow regimes are realized in the gas-liquid flow (dispersed, annular, slug, foamy, bubbly). The flow regime of the gas-liquid mixture significantly depends on the processes of interaction of the phases. Multiphase systems are widely used in practice. For example, the ring flow mode is implemented in heat exchange devices. Foamy two-phase flow is used in cleaning systems. The working mixture of fuel and air is dispersed. Its thermal parameters significantly affect the efficiency of power plants. Slug and cork flow modes of gas-liquid flows in oil and gas pipelines are the cause of vibrations. Diagnosis and elimination of flow patterns of multiphase flows, contributing to the occurrence of vibration loads in pipelines, is an important practical task. The transition from one to another flow regime occurs with an insignificant change in the thermal parameters of the flow. The problem of diagnosing gas-liquid flow regimes remains relevant. Experimental studies are the basis for identifying flow regimes of two-phase media [1]. In work [2], original methods for studying the three-dimensional structure of primary and secondary waves of a liquid film are implemented. Flows in channels of circular and rectangular cross section in downward, ascending, horizontal flows are studied. It is shown that the dependence of the wave characteristics on the flow rates of the phases in the case of high gas velocities is qualitatively the same. In an experimental study [1] the dimensions and speed of the shells were determined. The dynamics of the gas-liquid flow as a whole was considered. The velocity of the gas projectiles in the slug flow regime in this stand was measured using two electrodes located at a distance of 0.5 meters from each other. Probes were made of nickel wire with a diameter of 0.5 mm, and insulated with PVC. The bare ends of the probes were turned towards the incident flow and were one of the electrodes; the second electrode...
was located on the wall of the pipe through which the gas-liquid mixture was supplied. To these electrodes, a constant voltage was applied and the current in the circuit was recorded using an oscilloscope. By the drop in the magnitude of the current in the circuit, the passage of a gas projectile was recorded, in ascending order - a liquid plug. The waveform obtained in this experiment is shown in (figure 1).

The waveform obtained at such a stand, uniquely allows you to record the passage of gas projectiles. The signal can be used to obtain information about the parameters of the slug flow. The time “t₁-t₂” is the time for the passage of projectiles between electrical probes. But its use is limited into the laboratory. The generalization of a large number of experimental studies shows the dependence between the feasibility of each method and the tasks. The above works have some disadvantages, such as: high cost, complexity and low mobility of the experimental stands. These studies also used a limited set of operating fluid. In practice, mobile experimental stands are in demand.

2. Experimental stand

This article describes the work of an experimental stand for observation, measurement of parameters of a gas-liquid flow, including when changing flow regimes, based on the optical registration principle. A photoresistor was used as a recording element, and the LED was a light source. By weakening the current through the photoresistor, the passage of a liquid plug was recorded. In the process, gas content and flow pressure were varied. Transient processes in the ascending gas-liquid flow using hardware registration considered. The experimental setup with a closed fluid cycle (figure 2) consists of a vertical glass tube (4), liquid phase dispensers (1,2) installed in the lower part of the glass tube, a storage tank (5), a compressor (6), an ammeter (7), with the help of which the current in the electric motor compressor is registered, auxiliary valves [3].

![Figure 1. The waveform obtained on the installation with electrical probes.](image1)

![Figure 2. Scheme of the experimental setup.](image2)

The measuring part of the stand changed in comparison with [3]. Photoresistors (8) calibrated (photosensitive elements). Their parameters differ from each other, even from the same manufacturer batch. The opto-pair in the stand was isolated from ambient light, and the light intensity of the source (9) was chosen experimentally in accordance with the capabilities of the oscilloscope (10). Figure 3 presents the electrical wiring diagram of the recording part.

The parameters of the resistor R, suppressing interference, are chosen experimentally, account their effect on the signal amplitude. The measurements were carried out at the maximum current intensity to the light source, in this case an indicator-type LED (LED). The power of the LED was carried out through the PWM controller (PWM), for precise adjustment of the luminous intensity.
3. Experiment results

Measurements are carried out under the following flow conditions: bubble, ring, slug. In the course of the experiment, the signal quality parameters were regulated. The corrected waveform was displayed on the oscilloscope screen and recorded on a computer. The experimental work has shown that: waveform (figure 5) allows reliably identify the slug flow regime (figure 4). Compliance with the results of previous studies [1]: the presented method is applicable to optical media that are transparent to the applied radiation it is possible in principle to determine the parameters of "shells" by the characteristics of the signal. If the gas phase flow rate is known, then according to [1, 4] the expression:

$$W = 0.01247 \left( Q \cdot z \cdot T \right) / \left( D^2 p \right)^{1}$$

where $W$ - speed of movement of the "shells" m/s; $Q$ - gas flow rate through this section (at 20 °C and 760 mmHg), m³/h; $z$ is the compressibility factor (for an ideal gas, $z = 1$); $T = (273 + t °C)$ is gas temperature, K; $D$ is the internal diameter of the pipeline, cm; $p = (p_{rab} + 1.033)$ absolute gas pressure, atm. In the same case, the received signal can be used to calculate the size of the shells for this it is enough to know the speed of the shells and the sweep value of the oscilloscope [1]:

$$l = W \cdot x \cdot n$$

where $l$ is the length of the projectiles, $W$ is the velocity of the projectiles, $x$ is the value of the sweep of the oscilloscope, and $n$ is the number of divisions of the oscilloscope between the peaks, a signal characterizing the passage of the boundary between the projectiles. Here, when you scan 3 ms and the speed of the shells is 0.5 m/s, the length of the projectile will be 2 cm.

**Figure 3.** Electrical wiring diagram of the recording part.  
**Figure 4.** Example of projectile flow regime recorded by the stand.  
**Figure 5.** An example of the received signal (slug flow mode).
Conclusion
As a result of the work, the parameters of the gas-piston flow regime of the air-water mixture are determined. Good agreement was obtained between work [1] and presented. It seems appropriate to implement a mobile stand based on this measurement technique. The advantage of this technique is the non-contact method of measuring flow parameters. The work performed showed the possibility of using various photosensitive elements and recording equipment. Computer processing of the results will significantly reduce measurement errors. It is technologically possible to form an autonomous diagnostic measuring complex to connect to the measurement object.

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