CAPABILITIES OF APPLICATION OF SUPERSONIC SEPARATORS IN THE OIL AND GAS INDUSTRY: REVIEW

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Natural gas has become the most preferred fuel and plays an increasingly important role in energy efficiency due to its environmental disposal, greater efficiency and profitability [1,7].

Currently, gas condensate fields of the Thule regions are most-coveted in the Russian Federation. The selection and further optimization of the process of gas field preparation for transport is one of the main problems of field development. This problem is solved through the creation of integrated complex gas treatment plant (CGTP). Currently, most CGTPs are based on low-temperature separation technology (LTS). LTS is implemented using throttle devices, as well as with the use of turbo-expanders. This technology does not meet modern requirements and resource efficiency and energy efficiency. Therefore, the new technology of supersonic gas-dynamic separation (GDS) is becoming more common.

The principle of action of supersonic separators is based on gas cooling in a supersonic swirling flow. Supersonic flow is realized by dint of the Laval nozzle. The swirling device creates a centrifugal pull in the flow, under the action of forces the liquid droplets are moved into the boundary layer. Next, the supersonic, swirling and cooled stream passes through a diffuser, where the liquid fraction is separated from the dry gas.

Currently, there are two types of supersonic separators [5]. The first one is shown in Figure 1. It was developed by «Twister BV» [6], [4], [9] – supersonic separator with reverse cyclone replacement. This technology is called «Twister I». In the separator of this design, a swirling device is installed behind the Laval nozzle.

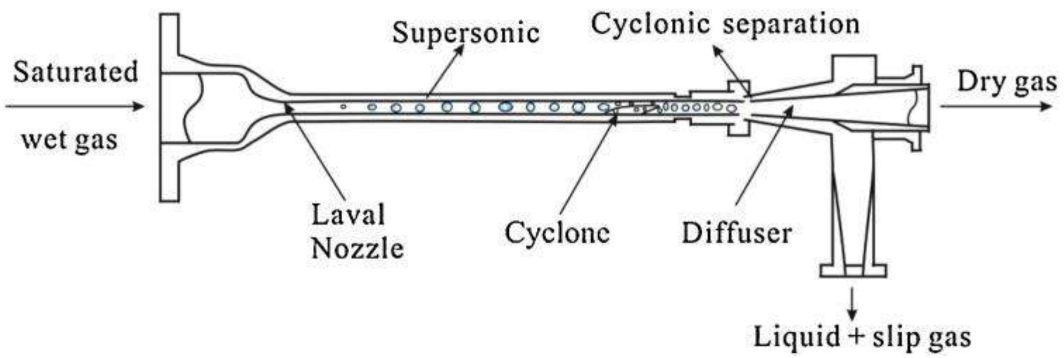

Fig. 1. Structure principle of the "Twister I" separator [3].

Another type of separator was developed by ENGO and is called the Super Sonic Separator («3S»). In the 3S separator, a swirling device is installed upstream of the Laval nozzle (Fig. 2).

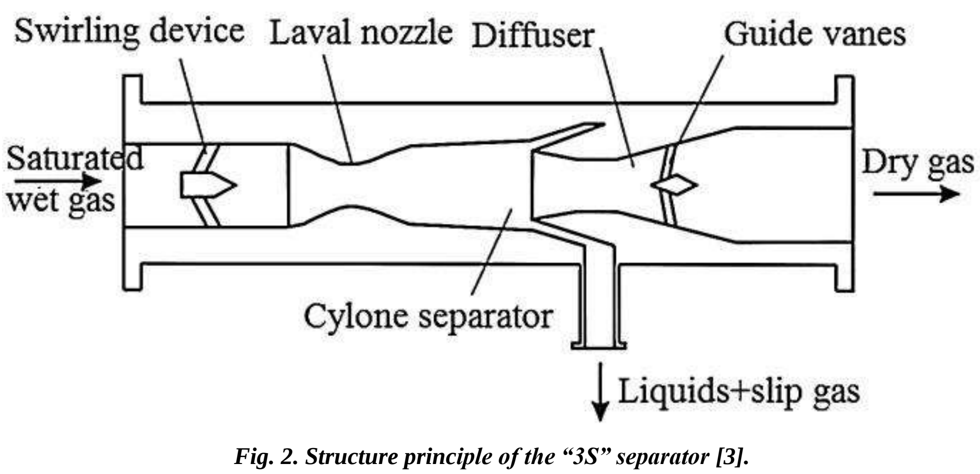

Fig. 2. Structure principle of the "3S" separator [3].

Supersonic vortex separators have several advantages. They have no moving parts, which ensures high reliability. Such separators are smaller, cheaper, lighter and emit less emissions than other LTS unit [5]. The supersonic separator prevents problems with gas hydrates and eliminates the need for inhibitor and regeneration systems due to the short residence time in the separator, providing environmentally friendly equipment [6].

The existence of a new technology of supersonic separation may find application in the development of new gas condensate fields A pilot test facility in Alberta, Canada, has shown that the 3-S separation device uses 10-20% less compressor JouleThomson valve or turboexpander based on the same extraction level [8]. Also, this technology has been tested in Russia on the basis of the enterprise OOO «Gazprom Dobycha Yamburg» [2]. Tests have shown that replacing the Joule-Thomson valve with a supersonic gas-dynamic separation unit at existing LTS unit allows simplifying the design and increasing the rate of extraction of liquid hydrocarbons from well production. Also in China's oil and gas industry, 3-S separator plants are already being successfully applied.

More and more scientific papers are devoted to supersonic GDS. Particular attention is paid to the introduction of this technology in the oil and gas industry.

A lot of work in this area was made by Alferov V. et al. It was they who conducted the experiments in Canada [8]. In their works, they explore the characteristics of supersonic separators and try to find their application in the process of preparing natural gas. Also, Alferov V. et al. are working with a separator, which they called the Super Sonic Separator («3S»), which has already been described above.

In addition, Esam I. Jassim, in his work in 2019, published in the Arabian Journal for Science and Engineering, is working to improvement of the effectiveness of supersonic separators [9]. Namely, he is working on the choice of the optimal geometric shape of the nozzle, creating a supersonic flow. The experimental results show that the nozzle geometry affects the particle separation efficiency. The triangular supersonic nozzle performed the particle collection process very well compared to other shapes with a relatively high nozzle pressure ratio (NPR). However, the round nozzle has the highest separation efficiency at low to medium pressure ratios.

Work is also underway on the numerical simulation of the gas flow in the course of the work of the GDS installations. Understanding and calculating processes allow you to select the required Mach number and increase the efficiency of gas preparation. One of the latest researches in this area is the experience of Yan Yang et al. in the work presented in the journal «Applied Energy» [10]. The article developed a mathematical model for estimating gas-dynamic parameters with different Mach numbers and their influence on the pressure recovery coefficient.

As a result of the foregoing, it can be concluded that the GDS units can and should find application in the field preparation of natural gas for transportation. Due to a number of advantages, supersonic separators are able to completely replace existing LTS technologies. The novelty of the technology of supersonic separation causes a lack of knowledge of the optimal design features and their influence on the gas-dynamic parameters. But the prospects of this technology and the demand for gas on the world market stimulate the emergence of new works and developments.

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