

## Section 1. Technical sciences in general

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### RESEARCH, PATENT ANALYSIS AND PROSPECTS OF APPLICATION OF IN-LINE SEPARATOR TECHNOLOGY

**Abstract.** This paper is devoted to research and analysis of in-line separator technology – innovative devices designed for effective phase separation in multicomponent media flows inside pipelines. In the course of the study, a review of existing scientific and patent sources devoted to in-line separators and related technologies was carried out. The main attention is paid to technical characteristics, principles of operation.

**Keywords:** in-pipe separation systems, oil transportation, infrastructural loss elimination, pipeline system management, crude oil processing, oil and gas industry, process optimization, pipeline efficiency, energy industry lenity, separator.

Due to the constant development of technology and market needs, conducting patent and literature searches becomes necessary to investigate existing developments, identify new trends and determine the prospects for the application of in-line separators.

The purpose of this article is to review modern developments in the field of in-line separators, to analyze patent information and scientific publications devoted to this topic, to determine the prospects for the development of this equipment.

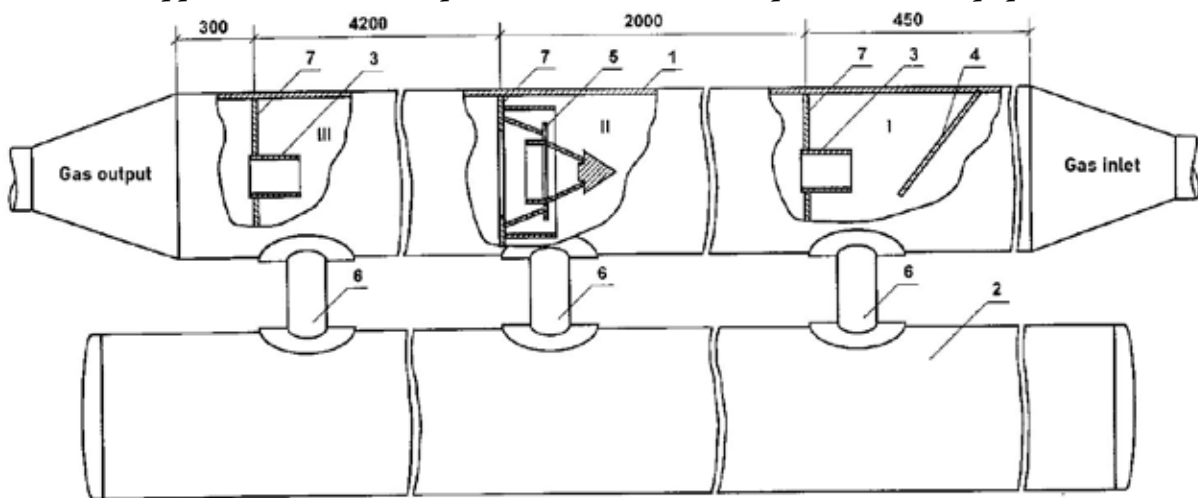


Figure 1. Drawing of in-line separator from patent No. 19658: 1 – body of in-line separator; 2 – condensate collector; 3 – branch pipe (partitions); 4 – reflector; 5 – swirler; 6 – branch pipe connecting the body with condensate collector; 7 – partitions

Patent No. 19658, describes a device called an in-line separator. It is designed for in-line purification of gas from liquids at fields and facilities. The closest analogs of the in-line separator from the devices are a centrifugal separator and an expansion chamber. The simplicity of construction, lower metal intensity, ability to capture finely dispersed liquid phase, which is in the form of a mist, are claimed as advantages [1].

This device is designed for gas purification, which does not fulfill the required purpose, namely,

purification of oil and gas liquids from high concentration of associated petroleum gas (hereinafter – APG).

Patent No. 2747403 describes an in-line separator device. The invention relates to the field of devices for separating liquid from gas, in particular, to separators widely used in the oil and gas industry for separating hydrocarbon condensate and water from natural or associated gas [2].

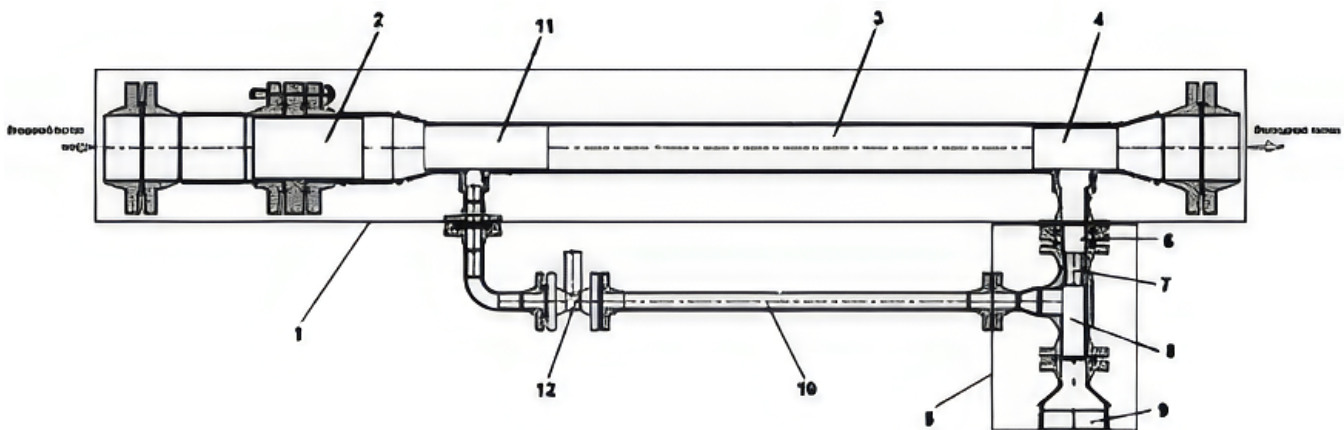


Figure 2. Drawing of in-line separator from patent No. 2747403: 1 – main channel; 2 – first swirler; 3 – first liquid separation section; 4 – gas-liquid flow extraction section; 5 – first additional channel; 6 – second swirler; 7 – second liquid separation section; 8 – liquid extraction section; 9 – vessel; 10 – second additional channel; 11 – ejector; 12 – regulating valve

Patent No. 107070 describes a device similar in principle of operation to an in-line separator called a flow separator [3].

The device is used to separate components from the flow in the oil and gas industry. It con-

tains a cylindrical body with a fairing, swirler, diffuser, confuser and collecting vessel. It allows to increase the flow velocity of gas-liquid mixture and increase the efficiency of liquid separation from this mixture.

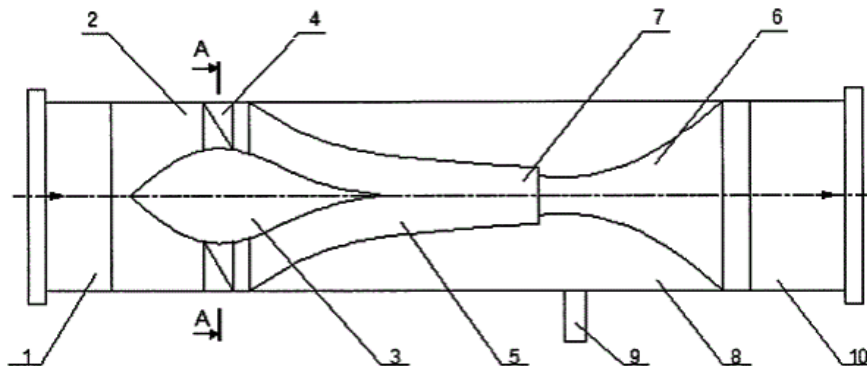


Figure 3. Drawing of in-line separator from patent No. 107070: 1 – inlet pipe, 2 – cylindrical body, 3 – fairing, 4 – swirler, 5 – diffuser, 6 – confuser, 7 – annular gap, 8 – collecting vessel, 9 – drainage pipe, 10 – outlet pipe

In addition to the considered device, patent No. 94479 [4] entitled “Straight Spiral Separator” has been investigated.

The device is used to separate dispersed particles from gases or vapors in various industrial applications. It includes a housing with inlet and outlet connections, a multi-bore screw column and other components. The separator provides direct gas-liquid flow, improves the efficiency of liquid-gas separation, and has certain dimensional parameters, such as the diameters of the shell, separator and drift eliminator. The distributor insert, shell, cut-off device and droplet eliminator achieve the required phase separation and removal of liquid from the gas stream.

Foreign patents were analyzed to find alternative designs. Patent No. 2229922 describes a device called “Inertial separator and method for supersonic separation of a component” [5].

The invention is intended for separating components from a stream. The inertial separator includes a taper-expanding nozzle for creating an emulsion flow with supersonic velocity.

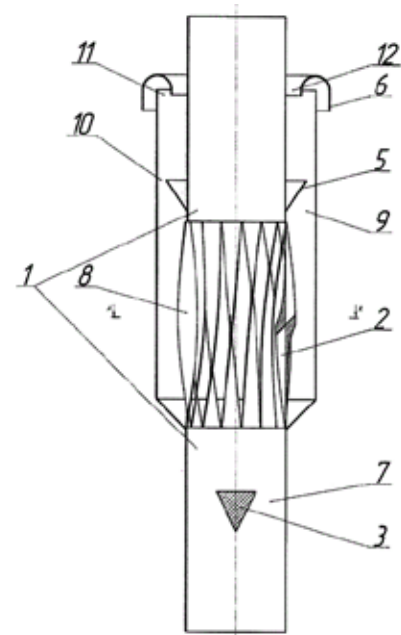


Figure 4. Drawing of the in-line separator from patent No. 94479: 1 – body; 2 – helical multi-start column; 3 – distributor insert, 4 – shell, 5 – cutoff device, 6 – drop eliminator, 7 – annular channel, 8 – blades; 9 – cavity, 10, 11, 12 – annular gap

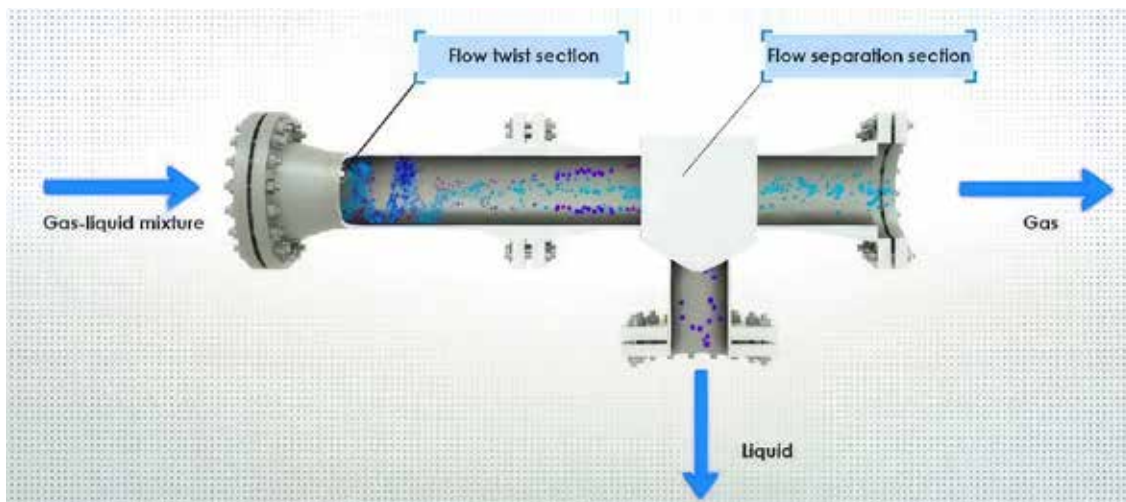


Figure 5. General view of in-line separator

The manufacturer’s website describes the principle of operation of the in-line separator, which is based on the use of centrifugal forces in an axial cyclone. The gas-liquid mixture is swirled in a tangential or vane swirler installed at the inlet of the device

and is directed into a cylindrical channel, where the liquid is separated on the walls of the channel. A liquid film is formed on the walls of the cylindrical channel, and a stream of purified gas is formed in the near-axis zone. At the outlet of the cylindrical

channel there is a separating section where the flow is separated into gas and liquid flow. All separator elements are mounted inside the pipeline [6]. A brief illustration of the device is shown in (Figure 5).

The article “Application of In-line Separation Systems to Prevent Droplet Liquid Entrainment from Condensate De-ethanization Columns” describes the experience of applying in-line separation systems after a condensate stabilization column at the Termokarstovoye field gas treatment unit of Terneftegaz, a subsidiary of NOVATEK. The launch of the in-line separator eliminated the drift of liquid hydrocarbons (C3+) from the top of the column and ensured additional production of de-ethanized condensate in the amount of more than 12 tons per day [7].

In the article of the journal “Oil and Gas of Siberia” [8], describes the application of the in-line separation system within the installation of the intelligent block “Metering-Well”. The main principle of its operation is the separation method of measuring well

flow rate, but unlike conventional capacitive separators, the intelligent block metering system (hereinafter – IBMS) uses compact in-line separators. In the course of the tests the specialists made sure that the mobile block of the IPMS provides stable measurement of well flow rates in a wide range of oil and gas flow rates. The arithmetic average error for all measurements amounted to 2.3% for well fluid flow rates and 3.6% for associated gas flow rates. At the same time, the maximum gas factor at the wells reached 1200 st. m<sup>3</sup> per ton of oil.

In the article of the Gas Industry magazine [9] the difference between the use of in-line separators and ejectors is described [9] describes the difference between the use of in-line separators and ejectors, the main scenarios for the use of in-line separators, advantages and disadvantages.

The article of the journal “Engineering Practice” describes the scope of application of in-line separators and ejector systems based on them [10].

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