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INCREASING THE QUALITY OF SEPARATION IN THE PHASE OF PREPARATION OF OIL FOR TRANSPORT

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Abstract: In order to prepare oil for transport, it is necessary to extract certain amounts of dissolved gas, water and various impurities. The extraction of gas from oil begins already in the reservoir, and then in the well due to the reduction of pressure (depression). Further separation of the gas and liquid phases is achieved by the following technological processes: separation of oil (separation of gas and liquid), dehydration of oil (separation of formation water and oil) and storage of oil. Oil transport is divided into domestic transport, which includes the phase of oil collection and preparation as well as the main transport, defined as the transport of oil from dispatch stations to the central dispatch station. The final phase of transport is transport from shipping stations to refineries. There are one-stage and multi-stage separation. In order for the oil to be better prepared for transport, it is necessary to increase the quality of the separation itself, and this is achieved by installing additional equipment, such as: defoamers, vortex breakers, coalescers and droplet traps, droplet traps in emulsions and sand washing system. In order to achieve the highest possible quality of separation, it is necessary to understand that in the entire system of internal collection of oil and gas, collection stations have the most important role. Their task is to collect the produced oil and gas from a certain number of wells, to separate the gas from the oil, individually and collectively measure these fluids, store the oil and transport it to the loading station, as well as transport the gas to the compressor station and other consumers.
Keywords: petroleum, transport, oil separation, oil dehydration, oil storage, single stage separation, multistage separation, defoamers, vortex breakers, coalescers and droplet traps, droplet traps in emulsions, sand washing system, collection station

INTRODUCTION

Oil and gas collection means the entire transport of oil and gas in the field, from wells to loading stations. The collection systems used for this can be divided into two large groups: open and closed. Due to their great advantages, only closed oil and gas collection systems are used everywhere in the world today. The companions of oil are natural gases (methane, ethane, propane, butane), it can be accompanied by nitrogen, hydrogen, carbon monoxide, salt water (it has a corrosive effect).

Crude oil must be refined before use. According to its chemical composition, oil is a mixture of hydrocarbons such as alkanes, cycloalkanes, aromatic hydrocarbons, benzene. Some oils also contain iron, nickel and molybdenum (catalytic poisons). The mixture of oil and gas extracted from the wells is collected at appropriate places (measuring or collection stations) where the separation of the liquid and gas phases is performed. How many collection or measuring stations there will be in the oil field will be determined, first of all, by the distance and number of wells, as well as the amount of wells.

After separation and measurement, the gas is shipped through a low-pressure gas pipeline and subjected to transport preparation processes. The liquid remaining after separation contains not only oil as the desired product of separation, but also a certain amount of water produced. In the last few years, world demand for crude oil has increased by approximately 38% - from 9.55 x 106 m^3 / day in 1985, to 13.13 x 106 m^3 / day in 2004 [4]. To the amount of oil produced is accompanied by an equal or greater amount of free water and bound water, which forms emulsions with the oil.

MATERIAL AND METHODS

— Oil collection

Collection, as one of the basic functions of the collection – transport system, implies the transport of liquids from individual wells to a common location where preparation for transport is performed.

The fluid is transported either by individual oil pipelines or collector pipeline systems, which mostly depends on factors such as reservoir size, terrain morphology, well layout and number, as well as the dynamic pressure at the wellhead. The mixture of oil and gas extracted from wells should be directed to measuring or collection stations where the separation of gas and liquid phases is performed, measurement of extracted quantities of oil and oil gas and oil storage if it is a collection station.

There are three systems for collecting a mixture of oil and gas:

a) individual system,
b) a system of separate pipelines or multiple measuring or collecting stations, and
c) collection system [6].

— Oil preparation

In order to prepare oil for transport, it is necessary to extract certain amounts of dissolved gas and water. Extraction of gas from oil begins already in the reservoir, and then in the well due to the reduction of pressure. Further separation of gas and liquid phases is achieved by the following technological processes:

a) separation of oil (separation of gas and liquid),
b) dehydration of oil (separation of formation water and oil) and
c) oil storage [6].

— **Oil separation**

The final phase of separation takes place in separators at a certain constant pressure and constant temperature. Separators are devices that separate gas and liquid (oil + water).

The efficiency of the separator is determined by the phase equilibrium, which is primarily influenced by the pressure, temperature and composition of the mixture, but also by the appropriate structural elements within the separator that ensure better separation of the liquid and gas phases.

Extraction of gas from oil takes place in two ways, basically following the same ways of separation that occur in the reservoir itself. The first way is the contact separation of the gas phase, during which the liquid and gas phases are in constant contact. The process is caused by a change in pressure and temperature, and the significance of this separation is the molecular action in which a part of medium-heavy hydrocarbons passes from the liquid to the gas phase.

Another way is the differential separation of the gas phase in which there is no contact of two separate phases, but the formed gas phase is completely separated from the process. The simplified principle of such separation is based on the gradual reduction of pressure, during which gas is released while the entire amount of medium and heavy hydrocarbons remains in the liquid.

In the separator, there is a one-stage separation and a multi-stage separation. One-stage separation is identical to the contact separation of gas and liquid phase due to the fact that it is performed in a closed system with a change in temperature and maintaining a constant pressure. Separation is performed in one or more parallel separators within which there is no change in phase equilibrium. Multi-stage separation takes place in line-mounted separators with different pressures and different temperatures [3].

— **One-stage separation**

The process takes place in one or more parallel separators in which the same pressure and temperature prevail. The phases that are formed in such conditions are in contact all the time of separation and there is no change in the composition of the mixture. Therefore, the conditions under which phase equilibrium occurs remain the same throughout the process. The characteristic of such separation is the increased amount of gas phase enriched with heavier hydrocarbon components.

Thus, one-stage separation can be equated with flash gas degassing from oil. Since this is the only, and thus the last stage of separation, oil and gas are sent from the separator for further processing, storage or transport [5].

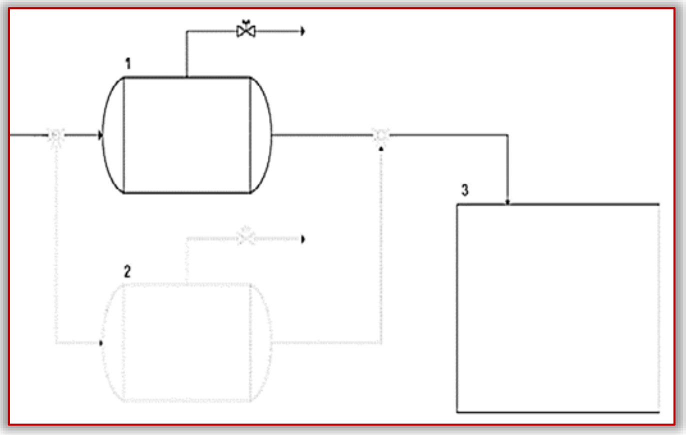

Figure 1. Composition of equipment in single-stage separation [5]
1-separator;
2-possible additional separator for larger quantities of mixture;
3-tank.

— **Multistage separation**

In this case, the mixture obtained from the well goes through several stages of separation. Each stage is characterized by a different, lower value of pressure and temperature at which gas escapes from the oil (Figure 2). Since gas and liquid phases are formed inside the separator, one of them is separated from the process. The rest of the mixture, which is no longer of the same composition, is then sent to the next stage of separation.

The procedure is repeated as many times as the degree is defined by the process. Several comparative separators can be used for each stage, depending on the amount of fluid. This principle can be equated with the differential or gradual release of gas from oil. The characteristic of this method is reflected in the gradual reduction of the pressure of the mixture and finally in a larger amount of the obtained liquid phase [4].

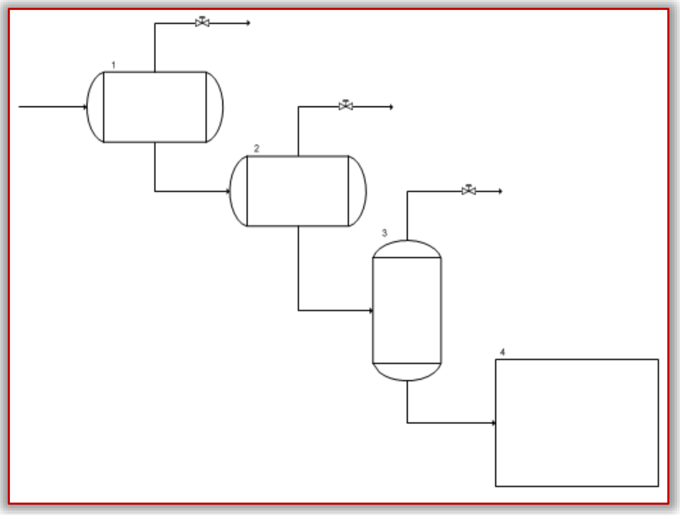

Figure 2. Composition of equipment in multi-stage separation [5]
1-high pressure;
2-medium pressure;
3-low pressure separator;
4-tank.

— **Separator equipment**

The purpose of installation is to increase the functionality of the separator and the efficiency of the separation process. The standard equipment of the separator is considered to be: input separator elements and coalescers, which are installed regardless of the shape of the separator or the number of phases that are separated.

The rest of the equipment is added as needed, most often in horizontal separators because they are more flexible in terms of available space and possible layout, and at the same time they are more susceptible to negative phenomena that occur during operation.

When choosing the equipment, the most attention should be paid to the characteristics of the mixture and the design of the separator, because in case of non-compliance, the opposite effect can occur, that is disruption of the separator [3].

— **Defoamers**

The foaming of the surface layer of oil, except when the mixture enters the separator, also occurs when gas bubbles are released from the oil. This problem complicates the separation and automatic regulation of the process, and can be solved by adding chemicals at the inlet to the separator or, more simply, by mechanical defoamers. It is a series of parallel, obliquely placed longitudinal plates that cover the height to which the oil-gas boundary moves.

By passing the foamed mixture through the separator, there is contact between the formed foam bubbles and the plate, breaking the bubbles into droplets which then merge into the accumulation section of the separator [9].

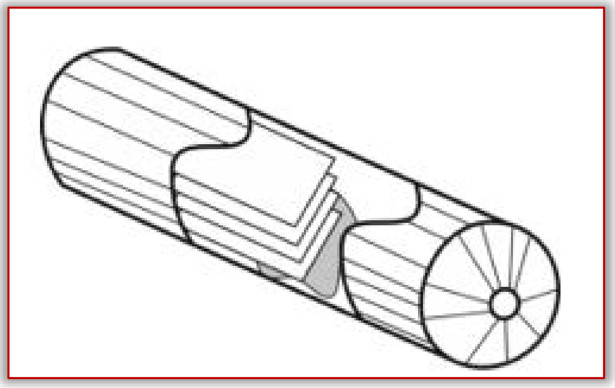

Figure 3. Scheme of defoamers in the separator [1]

Barriers to neutralize the shock waves of the mixture

The formation of waves inside the separator can occur due to the pulsating inflow of the mixture or in the case when the separator is placed on the platform. Since this phenomenon negatively affects the separation process, it is necessary to install appropriate elements that will reduce their effect. This is especially true for long horizontal separators in which the action of waves is most pronounced.

Barriers are placed vertically on the flow of liquid, so that they cover the accumulation section from the bottom to above the barrier or so that they cover only the profile of a certain height around the level of the barrier. The picture shows a full profile partition with perforations [8].

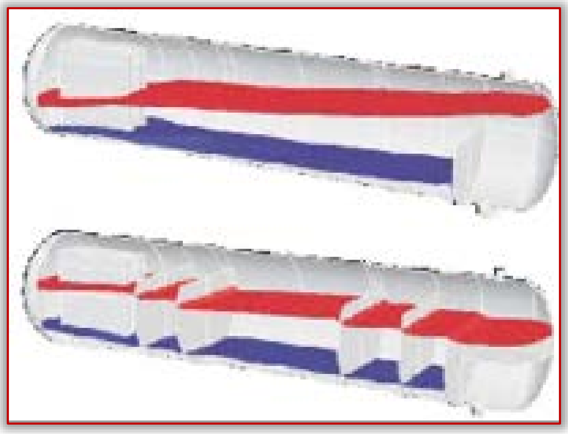

Figure 4. Influence of barriers on liquid rolling and barrier appearance [1]

— **Vortex breakers**

Vortices are the result of poorly designed drains from the separator, and they occur when the valve is opened and liquid is drained from the separator.

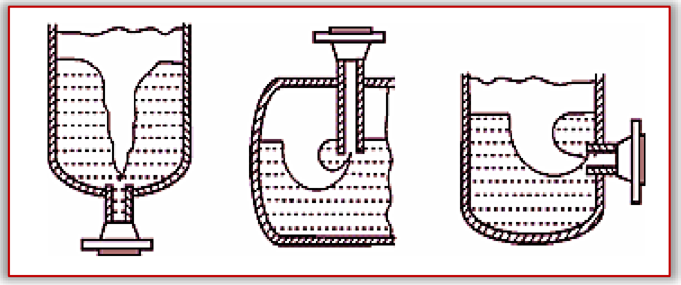

Figure 5. Possible places of vortex formation in the separator [1]

Their formation in two-phase separators leads to the withdrawal of gas into the oil outlet line, which, in addition to the unwanted presence of gas in the outlet line, also leads to a large drop in pressure in the separator. In three-phase separators, the layer of oil and water also mixes, which in the end can mean the suction of oil into the outlet line during the discharge of water. Prevention of vortex formation is achieved by installing the so-called Vortex breaker. These are various plate elements that are placed above the outlet or elements that are installed in the outlet pipe (Figure 6) [7].

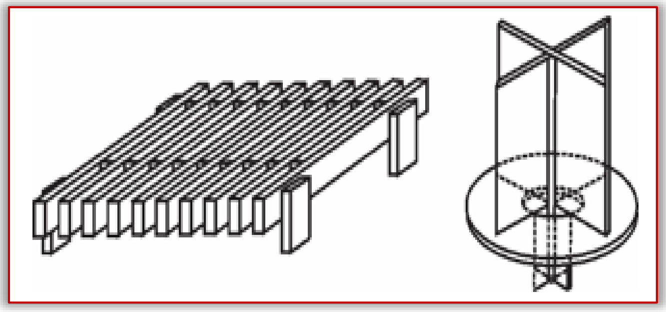

Figure 6. Basic types of vortex "breakers" [1]

— **Coalescers and droplet catchers**

The quality of separation is also reflected in the content of the liquid phase in the gas leaving the process. The lower that concentration, the more successful the process. Therefore, different elements are used to separate the droplets from the gas stream. The size of the droplets present in the gas phase depends on the method of formation, and their diameters can range from 0.1 to 5000 μm.

The smallest are those droplets that occur as a consequence of gas condensation (size from 0.1 to 5 μm). If the larger droplets are separated into smaller ones by mechanical action, for example when the mixture passes through a semi-open valve at high speeds, then their size can range from 10 to 200 μm. Finally, the largest droplets are formed during direct expulsion from the liquid due to the entry of fluid of uneven inflow, hitting the barriers and the like [2].

Figure 7. Droplet catchers of various constructions [2]

— **Sand washing system**

Accumulated sand can occupy a fairly large part of the separator after some time, which can lead to disruption of the separator. This problem is especially pronounced with horizontal separators, and an alternative to manual cleaning of the bottom can be the installation of a flushing system. The system consists of manifolds and nozzles arranged to cover the bottom of the separator.

For rinsing, water obtained from the process whose output speed from the nozzle (5 m / s) causes the movement of the sand layer towards the drainage openings through which the mixture of water and sand exits the separator is most often used. During the rinsing, the separation process does not need to be stopped. The system can act selectively, so that it rinses only the desired part or the entire separator, and with the appropriate equipment it can be fully automated. The figure shows the rinsing system and rinsing technique [2].

Figure 8. Flushing system [2]

— **Horizontal separators**

Horizontal separators are a very common choice in practice where they are mostly used as three-phase separators. Their construction results in the following advantages over other types of separators:

- the possibility of processing a large amount of mixture,
- possibility of processing the mixture subject to pulsating inflow and foaming,
- the possibility of processing the mixture with a medium and high proportion of the gas phase - due to the large contact area between the liquid and gas phases, and the large length are suitable for quality gas separation and
- for the same supplies, they are cheaper than upright separators (simpler construction).

The disadvantages of horizontal separators are:

- are not suitable for processing mixtures with a high proportion of solid particles. After some time, the precipitated solid particles cover the bottom of the separator along its entire length, which makes their removal more difficult.
- the possibility of gas re-entering the liquid,
- require more storage space and are not suitable for installation in places such as platforms,
- uneven flow of the mixture into the separator can cause level control errors and even cause accidental interruption of the process, which is a problem in the automation of the separator [6].

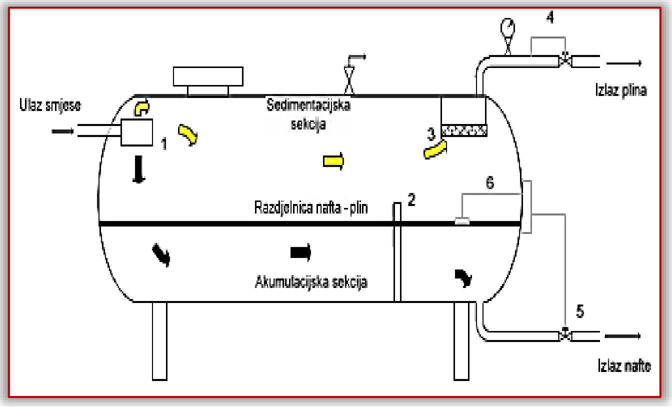

Figure 9. Scheme of horizontal separator [6]
1-entrance partition;
2-partition;
3-droplet catcher;
4-pressure regulator and gas discharge valve;
5-oil drain valve;
6-level regulator (float).

— **Upright separators**

In practice, in addition to horizontal, separators of upright construction can usually be seen. Upright separators are mainly used for processing a small amount of mixture with a small proportion of gas phase. They are a good choice if solid particles are present in the produced fluid, because the bottom of the separator is concave in shape, due to which the precipitate comes out of the separator together with the liquid or a separate drainage hole can be placed below the liquid outlet line. The probability of gas re-entry is small, because the phases after the initial separation have the opposite direction of movement. The height of the separator ensures easier and more reliable placement of control parts for automatic regulation, and due to the construction, they are mounted in places where space is limited [6].

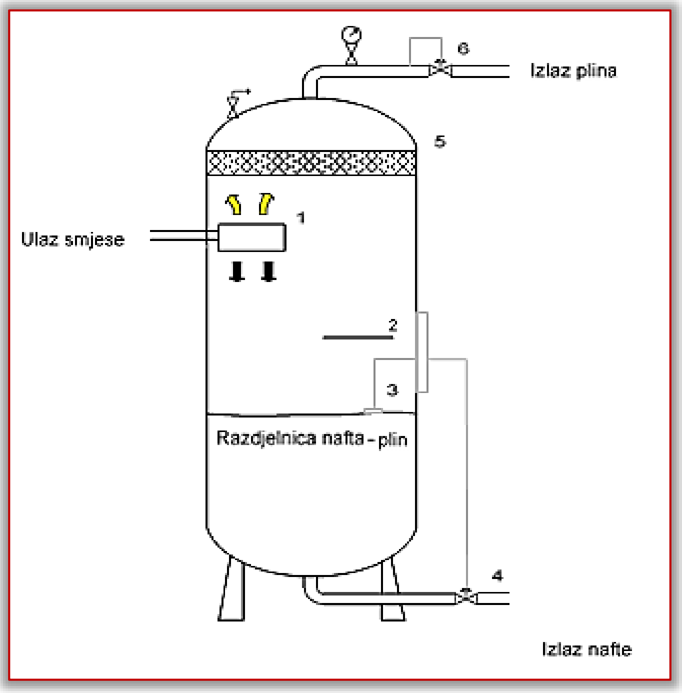

Figure 10. Schematic of an upright two-phase separator [6]

RESULTS AND DISCUSSION

— **The first stage of separation**

In two-phase separators, the liquid and gas phases are separated. The gas phase is discharged from two-phase separators into the drip tray (separator of a small amount of residual oil into gas), and the liquid phase (water / oil) with a small amount of the remaining gas phase into a three-phase separator.

Table 1.Characteristics of vertical separators [6]

Name of equipment	Operating parameters				Project parameters			
	Amount of fluid/oil Q, [m3/h]	Amount of gas Q, [m3/h]	Pressure p, [bar]	Temperature t, [oC]	Amount of fluid/oil Q, [m3/h]	Amount of gas Q, [m3/h]	Pressure p, [bar]	Temperature t, [oC]
Vertical two – phase measuring separator	6,79	21,6 5	2 – 4	55	52	471 0,36	8,5	60
Vertical two – phase collective	6,79	21,6 5	2 – 4	40 – 50	52	471 0,36	8,5	60
Gas dripper	-	43,3	2 – 4	10 – 40	52	471 0,36	8,5	60

From the drip tray, the gas phase is directed to the boiler room, to the boiler, for the production of hot process water, and the excess is burned on a torch.

Table 2. Parameters of horizontal three-phase separator [6]

Name of equipment	Operating parameters				Project parameters			
	Amount of fluid/oil Q, [m3/h]	Amount of gas Q, [m3/h]	Pressure p, [bar]	Temperature t, [oC]	Amount of fluid/oil Q, [m3/h]	Amount of gas Q, [m3/h]	Pressure p, [bar]	Temperature t, [oC]
Horizontal three – phase separator	13,58	43,3	2 – 3	40 – 50	533,33	4357 0,83	4	60

When guiding the separator, it is necessary to maintain the level of the water phase at the highest possible value, in order to prolong the retention time in the separator. Extending the retention time of the aqueous emulsion and passing through the existing coalescing device in the second chamber of the separator, contributes to the desired reduction of the proportion of dispersed oil droplets in the aqueous emulsion that is increasing the efficiency of the device.

CONCLUSION

Separators are steel vessels under a certain pressure. They can be located at a well, measuring or collection station where the acceptance and processing of hydrocarbon mixtures from nearby production wells is performed. Their main task is to separate the mixture into gas and liquid phase. The type of separator to be used depends first of all on the properties and quantity of the mixture, as well as the working pressure. In the process of selecting the separator, future changes in the properties of the produced fluid should be taken into account, in order to avoid problems in the operation of the separator and possible additional costs at a later stage of production.

Note:

This paper is based on the paper presented at IIZS 2020 – The X International Conference on Industrial Engineering and Environmental Protection, organized by Technical Faculty “Mihajlo Pupin” Zrenjanin, University of Novi Sad, in Zrenjanin, SERBIA, in 08–09 October, 2020

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ISSN: 2067-3809