VORTEX TUBE IN WELL SEPARATORS

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Abstract. The article presents modern constructions of sand well separators. The technology is based on a sand separator, which contains a body with an opposite re-winded bilifar helix and a coaxially installed mesh blanket. There are three center-by-deck adapter subs and three fishings installed inside the body. Well fluid sifting of sand and solids is based on usage of the physical process: a centrifugal effort and a scattering phenomenon. Modern constructions of sand well separators are more and more similar to the classical form of Ranque-Hilsch vortex tube. Features of liquid flowing in the vortex tube are used to create an effective construction of the sand well separator. Expansion of Ranque-Hilsch vortex tube attachments is connected with putting additional elements in operation in the central part of the tube. Sizes of the added internal tube in the vortex tube are optimized. Development trends of the sand well separator construction are defined taking into consideration Ranque-Hilsch vortex tube.

1. Introduction

Well sand separators are used to clean wells from sand and other solids during exploitation in case of returns. Oil well separators usage leads to a substantial reduction of a solid particles concentration in formation fluid. It is necessary for improving the reliability of a deep well pulser and a lifetime extension; those are pacing factors of well separators usage.

Well sand separators are installed as a part of production casing in pay formation of oil and water wells. Nowadays plenty of well separators are being developed. When choosing a type of the separator, one must take into

consideration working conditions: pressure, temperature, corrosion substance, a reservoir type, etc. The separator has to have high capacity, optimal life and keen price. It has to be able to entrap sufficiently small grains, not to be difficult in use.

2. Well separator structure

Let us consider a well separator design (patent RU 156936 U1) [1]. It consists of body 1; there are three center-by-deck adapter subs installed inside – high one 2, provisional 3, lower 4. Each sub is connected with fishing 5, provisional – 6, lower – 7. Besides, subs are fitted with a central tube and matrix-type drains for downflow. The number of subs can be increased. On body 1 outside, at the scale of provisional and lower subs 3, 4 and fishings 6, 7, bilifar helix 8 is coaxially installed with opposite re-winding. On helix 8, mesh blanket 9 is coaxially installed. Lower sub 7 is made with end-to-end arcuate drains 10. The curved axis of each drain 10 is a bow of Archimedean or log spiral; it is tilted from the edge of the sub's circumferential side to its centre. Lower fishing 7 is made in the form of a tapered diffuser; it means that the diameter of a bottom-most portion is bigger than that of the upper portion.

Appliance works were performed in the following way. The separator is plunged into the well, added to tubing for well operation. The liquid, e.g. oil, flows into the space between mesh blanket 9 and body 1 and the space between helix 8 turns. Helix 8 drives the slipstream twist of the liquid around body 1; the liquid's phase rate and sand grains' tangential acceleration improve to the edge. The liquid flows into lower fishing 7 through arcuate drains 10 of lower sub 4. Oil consecutively flows through the central tube of lower sub 4 and matrix-type drains from lower fishing 7 to provisional sub 3 and provisional fishing 6. Then it flows into high sub 2 and fishing 5. Sand coarse fractions, which are found in liquid, are held in mesh 9, sand small fractions plate out on the bottoms of fishings 7, 6, 5 by gravity. Using pumps clear of sand liquid is entrapped to oil skids by flowlines.

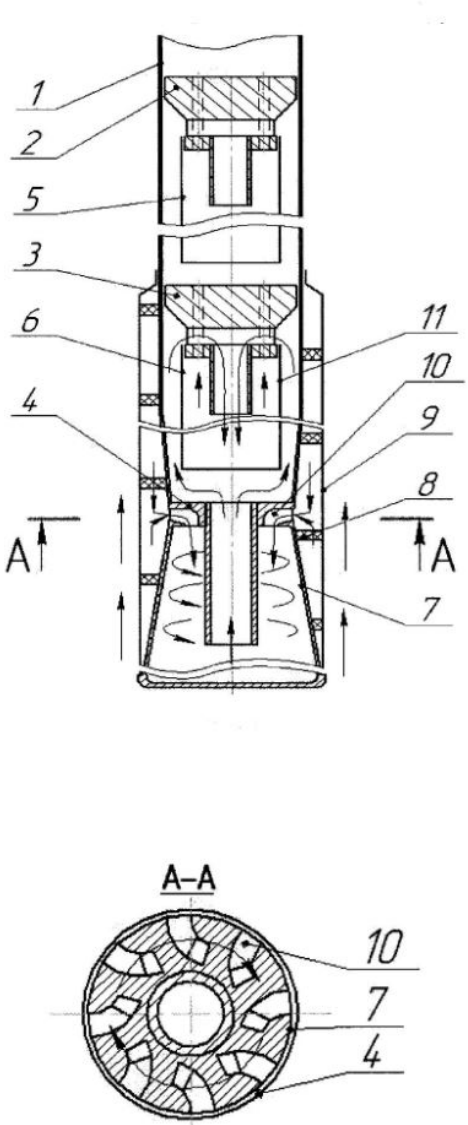

Figure 1. Separator design (patent RU 156936 U1)

3. The vortex tube usage in fluid recovery

The vortex tube, also known as the Ranque-Hilsch vortex tube, is a mechanical device that separates a compressed gas into two streams, twirling it in a cylindrical or conical chamber. Those twirling streams have opposite directions of twirling, different speeds and temperatures. This appliance is called as the vortex tube. As a result of numerous experimental researches, a great number of concepts of vortex tubes were created. The main design concept is making a tangential inlet of pressure gas or liquid and the length of a cylindrical part (eddy zone) of the tube. [2]

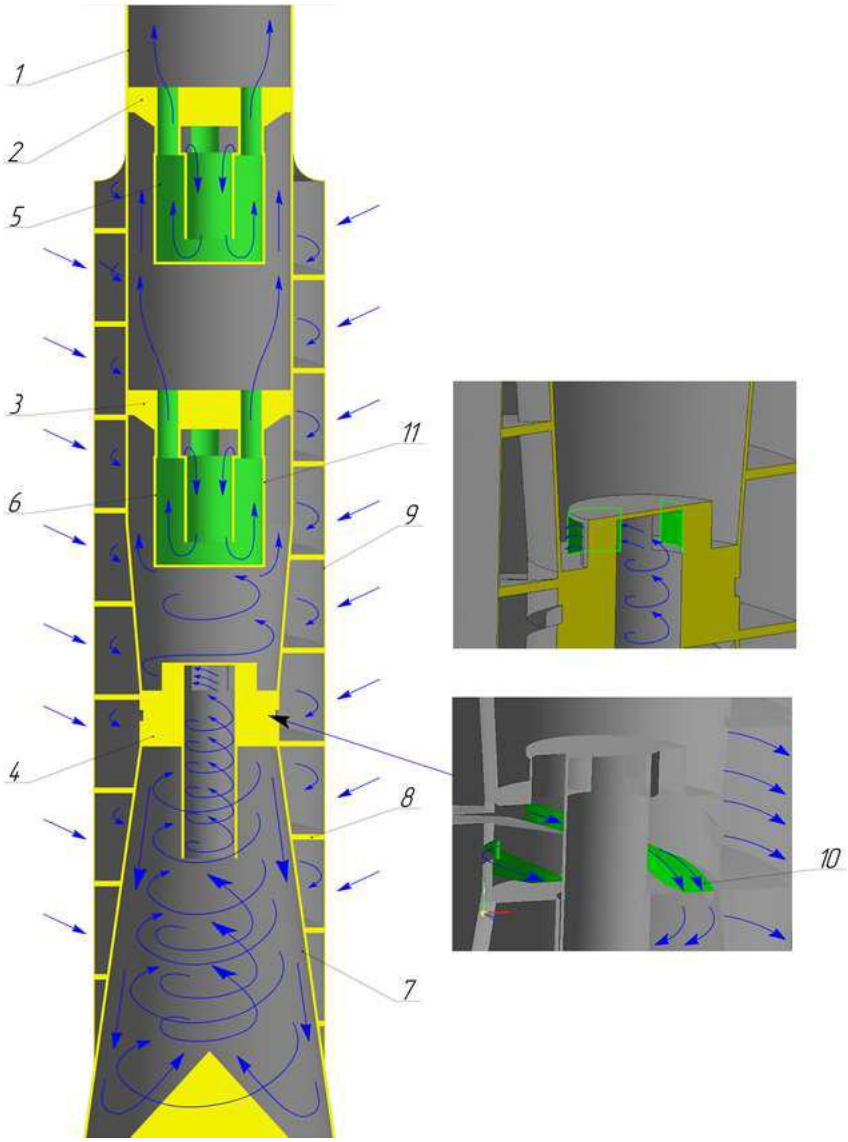

Figure 2. A scheme of integration of the vortex tube usage in sand well separators

The vortex tube usage in well separators is relevant due to the goal of effective sand sifting. It is possible in case of delivery of the tangential liquid inlet and a sufficient eddy zone length. Also, it is necessary to match its diameter and the diameter of the outlet fitting. Those characteristics depend on design concepts of inlet liquid, pressure, mass density, viscosity and other liquid's conditions. The eddy zone length is in the range from 9 to 50 gauges using a cylindrical mold. The conical mold of the eddy zone gives an opportunity of reducing its length to 4 gauges using optimal angle 7 degrees. The nozzle inlet has to make a continuous liquid inlet into the eddy zone and the axial symmetry of developing whirlwing. Moreover, it is necessary to set proportion between the diameter of the vortex tube

and the square of the nozzle inlet's orifice size by research in order to get optimal characteristics of the vortex tube usage for well fluid epuration from solids. [3]

Picture 2 presents the suggested vortex tube usage in the sand well separator. Due to the attachment of vortex tube fishing 7 lengthened to achieve necessary betweenness of the diameter and the length. Fishing can be implemented as a frustum of the cone. It will afford conforming minimal dimensional specifications of the eddy zone. The liquid intake into lower sub 4 changes to a tangential one. At the bottom of fishing, the cone for stabilization of swirling and for conforming symmetrical vortex formation is installed. As can be seen from the above-mentioned fishing, there is a rotochamber where liquid swirling and formation of two flows are happening. Those flows are directed oppositely according to the Ranque-Hilsch vortex tube.

Picture 2 illustrates it with arrows. In response to the direction change of swirling and change-over to the central flow, which is directed oppositely to the inflow, inertia forces, which throw back solids by virtue of increasing mass from central flow to the opposite one, affect the liquid and solids. Because of the gravity action, they do not crust at the bottom of fishing. The central flow goes through the central tube of lower sub 4 to provisional one 3 through slits, which enable a tangential liquid intake for further sand sifting by means of inertia forces and the gravity action. At a section of outlet fitting, it is necessary to use technologies in order to decrease flow friction of the vortex axis, which is caused by viscous friction. One of those technologies can be usage of special materials-processing technology or fitting allocation using a chock.

4. Conclusion

Effective operation of well separators is a basis for reliability growth of oilwell pumping units and for their lifetime extension; that is why, design development is important today. In the design of the well separator construction, it is essential to handle a problem of separation of small-sized solids if conditions of high capacity

are met most effectively to have optimum service life. It is possible only using modern technologies, one of which is the vortex tube, which forms two liquid oppositely directed flows. This effect occurs under particular constructive and technological conditions. Those necessary and sufficient conditions of effect's beginning, such as conicity of a rotochamber, needed length, tangential liquid intake and stated pressure can be implemented with relatively svelte structural changes. Because of that, the vortex tube has a substantial potential of usage in separators with different constructs. Application of separators with gravity and inertial effects in sand well improves efficiency of sand sifting without sacrificing capacity.

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