Pulsator for cleaning from asphaltene-resin-paraffin deposits

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Abstract. One of the factors that reduce labor productivity in the oil industry is the paraffinization of downhole equipment, oilfield pipes, pumps, oil collection and treatment equipment. The preventing paraffinization issue of field equipment is becoming increasingly essential. Complications caused by paraffin deposits lead to disruption of the normal operation of pumping units, metering devices, water separators, and reservoirs.

1. Introduction

Asphaltene-resin-paraffin deposits precipitated on metal surfaces of field equipment impede oil production and complicate the operation of oilfield equipment. The main components of ARPD are paraffin-naphthenic and, more rarely, paraffin-naphthenic-aromatic hydrocarbons condensed in asphaltene clusters, forming asphaltene colloids in the presence of resins. Asphaltene associates significantly affect the paraffinization of wells. On the one hand, they do not allow paraffin-naphthenes to crystallize and fall out of the flow, and, on the other hand, they themselves are the initiators of paraffinization forming large associates, which then coagulate and fall out on the pipe surface.

Paraffin is a mixture of higher methane hydrocarbons. Refined paraffin is a colorless or white crystalline mass, odorless and tasteless, slightly greasy to the touch, the specific gravity of which ranges from 0.907 to 0.915 at 150°C. Specific gravity of crude paraffin is 0.881-0.905. The melting point of paraffin depends on the molecular weight and ranges from 49 to 60°C. It is solid at a lower temperature.

Oil contains a certain amount of paraffin, their content in the composition ranges from 0.2 to 30% of the mass and more. Oil is subdivided into three types as a raw material for obtaining fuel and oils according by the paraffin content:

a) low paraffinic (up to 1.5% of paraffin)
b) paraffinic (from 1.5 to 6.0%)
c) highly paraffinic (over 6.0%)

Paraffin is restrictedly soluble in oil. Its solubility is most influenced by temperature; which growth facilitates the solubility increase. Besides, pressure, oil composition, amount and composition of dissolved gas, and paraffin composition affect the solubility of paraffin.

An essential characteristic of oil is its saturation temperature with paraffin, at which the first crystals of paraffin emerge from the oil.

Observations made by V.P. Raznicin, show that the formation of ARPD at the “Uzen” field begins at a temperature of 55-60°C, close to the temperature of oil saturation with paraffin.
ARPD formation problem during oil production remains a technologically complex issue and leads to the following consequences: cross-section decrease in the riser pipes; a decrease in the well flow rate and, subsequently, a growth of oil production costs; plugging of riser pipes and oil pipelines, complete or partial cessation of oil production and the need for overhaul of a shut-in well; enlargement of equipment wear; increase in energy consumption and pressure in the discharge pipes [1-12].

Solution ways to the given problem:
- mechanical cleaning method in practice is carried out using scrapers of various designs;
- physico-chemical method is based on the injection of various reagents of organic solvents into a working well, including specially prepared oil, aqueous solutions of SAS, reagents - dispersants. The essence of the given method lies in the dissolution and/or dispersion of ARPD with the specified reagents. The method is distinguished by high efficiency in relation to the mechanical way of cleaning from ARPD. The weak side is the high cost of operations due to the use of expensive reagents and low efficiency in removing strong ARPD.
- heat treatment methods for removing medium and high strength ARPD (solid consistency) from oil-well tubing are more applicable in practice. Previously, the method was mainly applied to treat wells with steam from a special mobile steam unit (MSU) and heating riser pipes with electric current - electrical dewaxing.

The steam method is used in wells with low annular pressure, and its economic efficiency is weak owing to the high steam consumption.
The pulsator was worked out due to negative economic and technological factors, the search for effective methods to combat ARP deposits.

2. Results and Discussion
A ground-based pulsator equipped with a linkage mechanism is designed to clean surface pipelines from ARPD using hydrodynamic waves [13-14].

Therefore, a spring-loaded linkage and a rotary valve device are adopted as a working body to create a low-frequency pulsator for ARPD flushing of wellhead pipelines, oil pipelines and downhole equipment.

The schematic diagram of the given device is shown in Figure 1.

The device consists of body 1, and cone 2, being inside of it, is attached to the body by an adapter sub 3. Stop 4 is equipped with stand 5, which has a thread in the lower part, and a square section in the upper part. Worm wheel 6 is seated on stop axle 4. Stand 5 is equipped with nut 8, the protrusions of which enter the stop with notch 7. Spring 9 leans nut 8. Sleeve 10, mounted on the spring, has protrusion 11. Lever 12 in the lower part rests on protrusion 11 and is connected to valve 13 by pin 14 in the upper part. Valve 13, in turn, is linked with body 1 by axis 15. Worm 16, which is mounted on 17 and 18 supports, serves to drive the worm wheel.
Figure 1. Schematic diagram of the given device: 1 – body; 2 – cone; 3 – sub; 4 – stop; 5 – stand; 6 – worm wheel; 7 – notch; 8 – nut; 9 – spring; 10 – sleeve; 11 – protrusion; 12 – lever; 13 – valve; 14 – pin; 15 – axis; 16 – worm; 17 – support, 18 – support, A- fluid inlet, B- liquid outlet.

The “valve-crank-spring” system takes the sequential position shown in Figure 2 when the remover is pumped under the action of hydraulic forces, thereby vibrating the ARPD remover. The amplitude and frequency of the pressure fluctuation of the remover are regulated by the spring 9 compression by means of the pulsator worm mechanism.

Figure 2. Various positions: a, b, c, d, e – “valve-crank-spring” systems during the pulsator operation.

Figure 3 is a schematic diagram of the pulsator operating elements. The working elements of the pulsator are installed in body 1, which has holes for the liquid inlet and outlet, centralizer 2 is mounted on spring 3, which, in turn, rests on stop 4. Rotary valve 5 is set on the body by means of axis 7. Crank 6 is connected to valve 5 using pin 8, with a centralizer - by pin 9. The device works in the following way. The valve and related elements begin to oscillate when the fluid circulation is restored due to hydraulic forces. Besides, the passage channel of the pulsator opens and closes, and consequently, hydrodynamic waves are excited.
3. Conclusion

The research outcomes are shown in Figures 4 and 5. Amplitudes of the pulsator oscillations demonstrate that the amplitude of the body oscillations is 235 µm at a flow rate of 0.008 m³/s, and 277 µm at a flow rate of 0.012 m³/s. A flow increase leads to an enlargement in the amplitude of oscillations.

Figure 3. Schematic diagram of the pulsator working elements: 1 – body, 2 – centralizer, 3 – spring, 4 – stop, 5 – rotary valve, 6 – crank, 7 – axis, 8 – pin, 9 – pin, 10, 11 – direction of fluid flow

Figure 4. Amplitude change of the pulsator oscillation in time, obtained at a liquid flow rate of Q = 0.008 m³/s with a rotary valve length of 135 mm, and a spring compression of 20 mm.
Figure 5. Amplitude change of the pulsator oscillation in time, obtained at a liquid flow rate of $Q=0.012 \text{ m}^3/\text{s}$ with a rotary valve length of 135 mm, and a spring compression of 20 mm.

Acknowledgments
The worked-out pulsator can be applied: for preventive cleaning of an operating oil pipeline from ARPD; for periodic cleaning of the oil pipeline; for periodic cleaning of operating oil pipelines.

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