Low-temperature plasma as a cleaning tool for pumping and compression pipes from asphalt, resin and paraffin deposits

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Abstract: this article deals with results of experimental research such as volt-ampere characteristics, electric arc traverse speed and end plasmotron operation performance index for cleaning the oil-pipes and melting of side-wall layer of asphalt, resin and paraffin deposits.

1. Introduction.
Pumping and compression pipes are very important components in oil and gas extraction from underground layers. Their strength and reliability ensure the uninterrupted process of oil and gas extraction. The repeated multiple use of pipes after maintenance defines the oil and gas cost price since they are a part of its cost.

There are a lot of means of asphalt, resin and paraffin deposits removal in the world. First, chemical (inhibition, dilution) as least expensive. Besides the chemical method of pipes cleaning the mechanical method is used (scrapers, lowered on the wire and bars). Other methods such as dewaxing by wave action (acoustical, ultrasound, explosive), electromagnetic and magnetic (impact to fluid by magnetic fields), thermal (heating of pumping and compression pipes with fluid or steam, current, thermochemical dewaxing) and hydraulic (line pipes sections choke restriction to initiate gaseous phase discharge) are used more rarely due to their relative expense.

2. Method.
Removal of asphalt, resin and paraffin deposits with low-temperature plasma is a relatively new technology since plasma is quite an energy-intensive tool.
Plasmotron suggested in this research is an end plasmotron i.e. as opposed to linear plasmotrons. The low-temperature plasma will completely envelop the pipe surface without consuming its energy for environmental air warmup. Thus this type of plasmotron gives an opportunity to effectively remove the asphalt, resin and paraffin deposits from pumping and compression pipes without damage to the environment [1].

3. Tasks.
Main task at plasmotron development is getting optimal parameters of plasma flow and plasmotron operation modes which ensure efficiency of technological process and high life cycle of plasmotron structural units.
4. Research part.
To solve the task the test installation was developed. The main components of test installation are power supply, plasma gas delivery system, measurements system (digital oscilloscope, rotameter, thermocouples etc.) and end plasmotron directly. End plasmotron on Figure 1 presents two parallel circular electrodes, 1 as a pipe fixed in body 2. Plasma gas is delivered to chamber 3 with following enveloping of electric arc 4 and exiting from nose as plasma. Electric arc 4 moves along the ring electrodes by force of its own magnetic field. Since the electric arc rotation speed is high, visually plasma exits the nose as a ring.

![Figure 1. End plasmotron cross section.](image)

Figure 1. End plasmotron cross section. 1 – Ring electrodes, 2 – plasmotron body, 3 – plasma gas delivery chamber, 4 – electric arc.

Operational characteristics of end plasmotron in test installation for cleaning pipes from asphalt resin and paraffin deposits: diameter of ring electrodes is chosen depending on diameter of pipes to be cleaned from asphalt, resin and paraffin deposits. In this research the diameter of ring electrode was 90 mm and electrode pipes cross-section diameter 6 mm [2]. Interelectrode spacing varied from 3 to 6 mm. Plasma gas consumption in it is regulated from 1 g/sec to 2 g/sec. Cooling liquid consumption on cathode 0.0088-0.0185 kg/sec, at anode 0.0068 - 0.0054 kg/sec [3]. Main energetic characteristics of plasmotron are also the thermal efficiency of device and dependency of arc discharge voltage from current by variation of plasma gas consumption, electrodes diameter, interelectrode gap - voltage-current characteristic (VCC) of arcs.
Figure 2. End plasmotron voltage-current characteristic. Figure 2 illustrates voltage-current characteristic of end plasmotron operation at different interelectrode gaps. In plasmotron with self-centered discharge length of arc VCC has falling view. From analysis of arc VCC the choice of interelectrode gap is defined by many factors (required power, continuous operation resource etc.) for specific technological process [4].

Figure 3 illustrates arc speed graph of behavior depending on arc current at different interelectrode gaps.

Figure 3. Arc speed graph of behavior depending on arc current at different interelectrode gaps
The graph shows that the highest arc speed happens at interelectrode gap 3 mm. Pic. 2 illustrates that arc voltage at 180 A and at interelectrode gap 3 mm is 40V [5].

Plasmotron efficiency was defined by calorimetric method. Geometry of chamber where plasma is located is designed in a way to decrease losses from emission to environment. Efficiency graph depending on the plasmotron power is illustrated on Figure 4, it is defined that its maximum value is achieved at interelectrode gap 3 mm, at \( U=70 \) V and \( I=110 \) A, and arc speed at given parameters is 14,5 m/sec. Consumption of cooling liquid for cathode was 18,5 g/sec and for anode 5,4 g/sec [6].

![Efficiency graph](image)

Figure 4. Efficiency definition graph depending on plasmotron power at different interelectrode gaps.

5. Conclusion.

Dependencies of output parameters of plasmotron from its geometrical and energetic parameters at input have been defined. Further research stage will consist of definition by experiment and calculations of effective end plasmotron movement speed along the cleaned pipe.

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