Localized thermal cleaning method for pumping and compression pipes from asphalt, resin and paraffin deposits using plasma

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Abstract: The article deals with temperature calculation results at the inner surface of oil-well tubing and side-wall melting of asphalt, resin and paraffin deposits.

1. Introduction:

Cleaning of pipes from dismounted main oil pipeline is not a simple task however reuse of such pipes after thorough cleaning of surface and application of insulating coating is a promising direction.

It is a known fact that during operation the hard asphalt, resin and paraffin deposits are built on the steel pipes surfaces.

To clean these pipes from oil residues the abrasive-spray, solvent washout method or treatment by overheated steam with following mechanical cleaning are applied as a rule. Other unconventional methods may be used as well. All methods are quite effective but energy and time-consuming.

To reduce the energy and time consumption of the process the localized thermal method of cleaning of pumping and compression pipes from asphalt, resin and paraffin deposits was suggested.

Method. The localized thermal method of cleaning of pumping and compression pipes from asphalt, resin and paraffin deposits is based not on the complete melting of asphalt, resin and paraffin deposits but only of the side-wall layer. This is achieved by heating of the outer surface of the cleaned pipe using the circular plasmatron; due to high-thermal conductivity of pumping and compression pipes material the heat flow leads to softening and melting of the side-wall layer adjunct to heated area of the cleaned pipe.

Gradual heating of the cleaned pipe starting from the lower part leads to consequent melting of the side-wall layer of asphalt, resin and paraffin deposits along the cleaned pipe; as a result of that free outflow of built gases and melting products of asphalt, resin and paraffin deposits is provided without causing explosion during gas formation and temperature expansion of side-wall layer of asphalt, resin and paraffin deposits in closed space.

Main mass of asphalt, resin and paraffin deposits in the center of heated area of the cleaned pipe does not melt due to low conductivity of asphalt, resin and paraffin deposits.

Melted side-wall layer of asphalt, resin and paraffin deposits can fulfill a function of lubricant at the outflow of hard mass of asphalt, resin and paraffin deposits from cleaned pipe under gravity.

After outflow of hard mass of asphalt, resin and paraffin deposits from cleaned pipe the heating of the cleaned pipe by several actuations of circular plasmatron is continued until all melted residues of asphalt, resin and paraffin deposits flow down to receiving container.

2. Calculation:

Important factor for removal process of asphalt, resin and paraffin deposits is melting temperature which allows to estimate the mobility of asphalt, resin and paraffin deposits and defined in the first place by chemical structure of asphalt, resin and paraffin deposits. The higher the melting temperature of asphalt, resin and paraffin deposits the higher the content of high-molecular and high-melting compounds in it, n-paraffines in a first place, the more difficult these residues can be removed. Chart 1 shows the physicochemical characteristics of the researched asphalt, resin and paraffin deposits.

Chart 1. The physicochemical characteristics of the researched asphalt, resin and paraffin deposits (ARPD)

№	Key figures	ARPD 1	ARPD 2	ARPD 3	ARPD 4	ARPD 5	ARPD 6
		Refinery ARPD			Field ARPD		
1	Density, g/cm3	0,94	1,0	1,3	1,0	0,9	0,81
2	Mechanical impurities content, mass %	6,97	49,9	44,5	37,34	12,06	18,53
3	Water content, %	5	2,6	1,4	-	0,3	4
4	Melting temperature, °C	44	57	53,4	75	70	66
5	Sulfur content, mass %	0,3	1,7	1,5	0,4	0,2 0,1	0,1
6	Boiling temperature of ARPD, °C	≈550	≈550	≈550	≈550	≈550	≈550

As Chart 1 shows the melting temperature depending on the type of asphalt, resin and paraffin deposits varies. Based on these data the decision was taken to calculate the temperature at the inner surface of the cleaned pipe.

The calculation was carried out using Star CCM+ software package. The calculation requires the development of the precise detailed computer model of the research object. Computer model of the research object was created in COMPAC 3D program. Then the computer model was imported to Star CCM+ program, volume mesh of finite elements was created. The further action was correct definition of initial and design parameters. The accuracy of such calculations depends on parameters of finite element mesh parameters. The volume mesh of finite elements is shown in Figure 1.

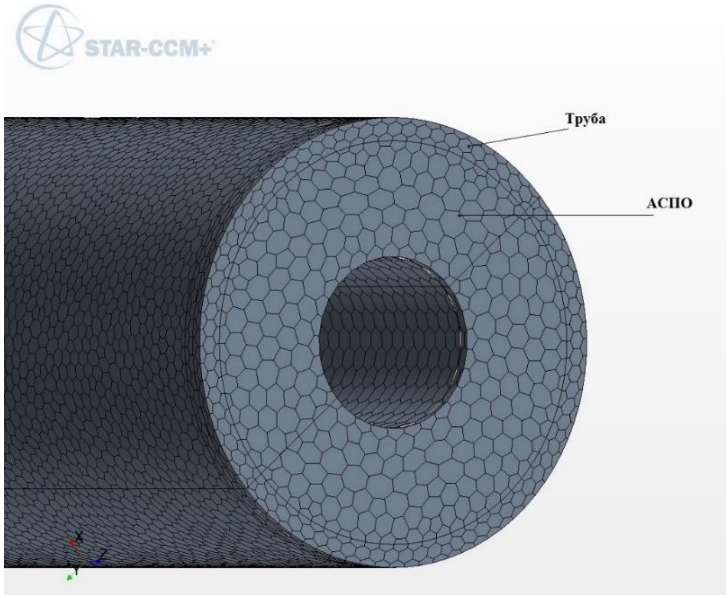

Figure 1. Computer model of research object in volume mesh of finite elements.

For computer modelling the steel 20 pipe with diameter 70 mm and wall thickness 4 mm was used. Physicomechanical properties of asphalt, resin and paraffin deposits in the computer model: density 1000.0 kg/m3, heat conductivity – 0,26 W/m*K, specific heat capacity – 2200.0 J/kg*K.
After computer modeling the temperature curve was obtained according to time in the beginning of pipe at the inner surface after thermal source removal i.e. circular plasmatron 2. Temperature at the inner surface of the pipe after removal of the thermal source will increase due to temperature conductivity of the pipe material before the temperature equalization throughout the pipe.

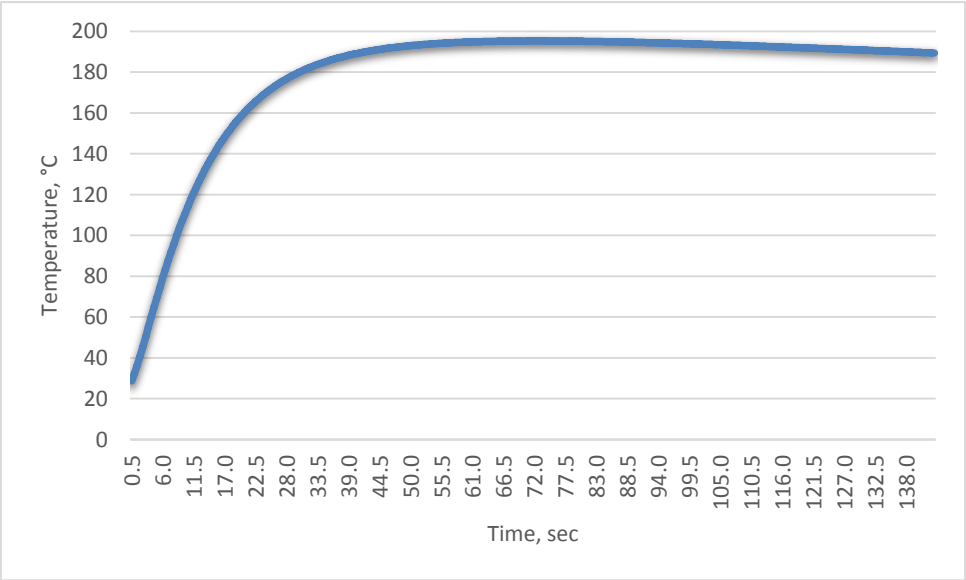

Figure 2. Temperature variation according the time in the beginning of pipe at the inner surface.

Melting temperature of asphalt, resin and paraffin deposits according to Chart 1 is not higher than 75°C and the boiling temperature ≈550°C. Figure 2 shows that temperature of the inner pipe surface does not exceed 200°C which is acceptable for this process of oil-well tubes cleaning from asphalt, resin and paraffin deposits [7].

3. Conclusion

Results of conducted research show that the temperature at the pipe inner surface is enough to melt the thin side-wall layer of asphalt, resin and paraffin deposits. This method of thermal cleaning allows to effectively clean pumping and compression pipes from asphalt, resin and paraffin deposits. Also this method is more energy-efficient due to application of low power plasmatron and low cost equipment.

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