TECHNOLOGY AND ORGANIZATION OF CONSTRUCTION

UDC 691.32-036.4

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METHOD FOR ARRANGEMENT OF HIGH-STRENGTH CORROSION-RESISTANT FOR EFFICIENT PROTECTION OF STEEL PIPELINES OPERATED IN THE EXTREME NORTH

Problem statement. At present, the problem of main pipeline protection from corrosion is extremely important. Principal gas-transport routes have the biggest length in the North areas where climatic and geotechnical conditions are adverse. Scientists of Voronezh State University of Architecture and Civil Engineering have developed new material, rubber concrete. This material is based on liquid oligodienes and has unique set of operational characteristics. The material can be efficiently used as insulation material for metal pipe in the conditions of the Extreme North.

Results. The method for arrangement of protective coating of metal pipe is developed on the basis of rubber concrete. The method is patented. Laboratory device which allows one to perform structures formation of rubber mastic on the surface of metal pipe is constructed. Physicomechanical properties of rubber concrete as insulation material for steel pipes are determined.

Conclusions. The results of experiments allow us to draw a conclusion on the expediency of the use of rubber concrete as a protection coating material for steel pipes operated in the Extreme North.

Keywords: rubber concrete (RubCon), metal pipe, Extreme North, stress-corrosion failure, protective coating, physico-mechanical properties.

Introduction

Severe weather and adverse geological and engineering conditions of Extreme North (mostly negative temperatures, sharp daily and annual oscillations in temperature, waterlogged soils,

etc.) cause high requirements made of protective coatings of building structures being operated. One of the most important problems being faced now is corrosion protection of main pipeline transport of over 180 thousand kilometers in length in the Gazprom Open Joint Company (OAO Gazprom). Major gas transportation routes with the longest span originate in the Northern latitudes. Fig. 1 presents a fragment of a scheme of a unified gas supply system.

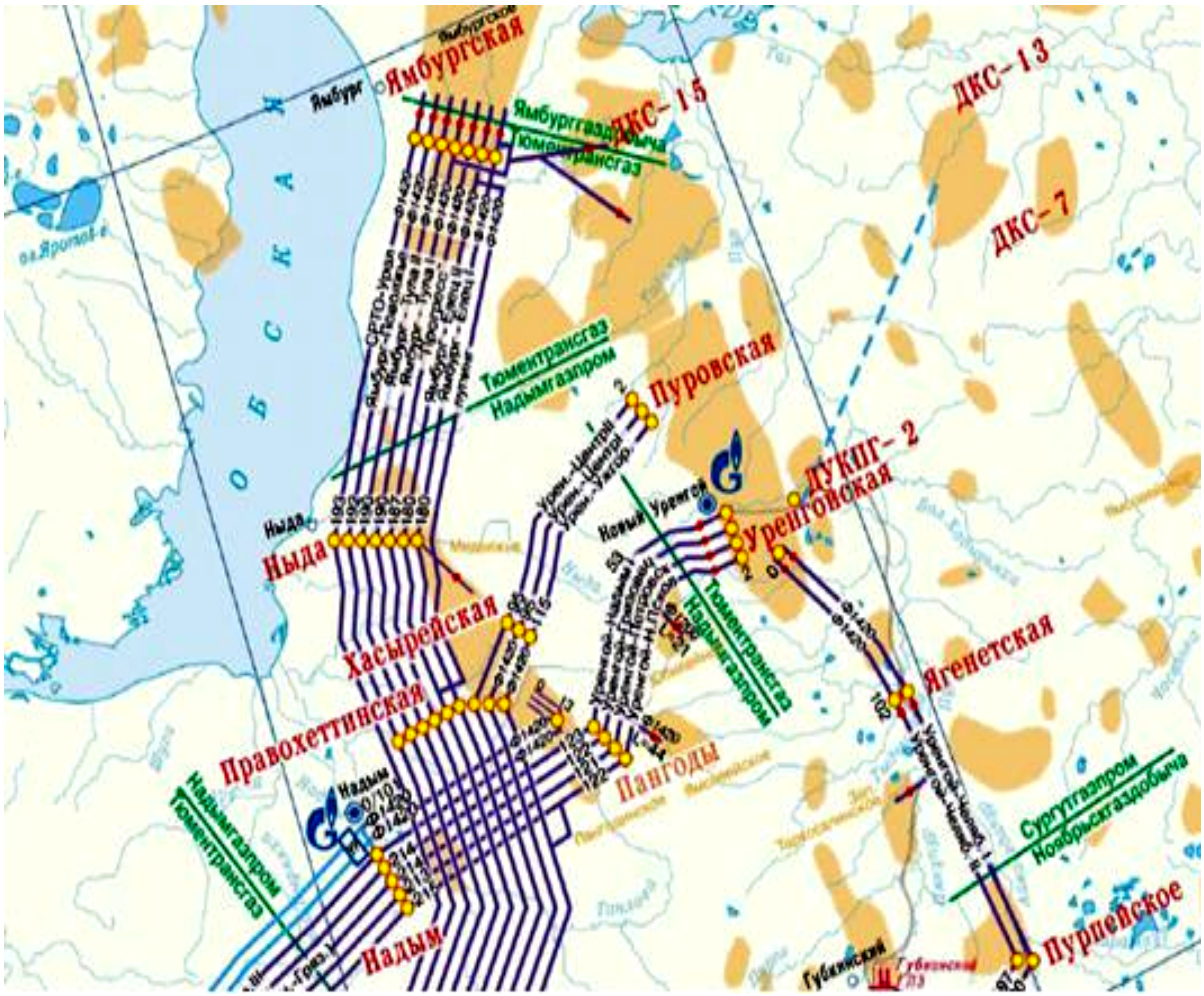

Fig. 1. Gas transportation routes in Western Siberia

Statistically speaking, 30 % of technological failures are caused by metal corrosion. Diagnostic examinations suggest that for every 100 kilometers of gas pipelines there are 4 stress-corrosion defects. Each of these defects can potentially lead to an accident. Average costs incurred in a gas pipeline accident are 45.6 million dollars.

There are 2000—3000 kilometers of main gas pipelines repaired annually by the Gazprom Open Joint Company (OAO Gazprom) to prevent stress corrosion. Repeated isolation of coat-

ing is performed in route and industrial conditions. Among that, areas of pipes deemed unfit for further operation are replaced by industrially isolated pipes.

These days, multi-layer anticorrosion coatings are extensively used to protect a metal pipe. They have a small temperature range of operation and a complex technological application scheme, which fact heavily impacts the production costs. Import raw materials are needed to produce them, this is why maintenance of such coatings is labor and time consuming in route conditions.

1. Physical, mechanical and operational characteristics of caoutchouc concrete that enable prediction of its efficient use as an insulant for steel pipes in the Extreme North

A brand-new material, caoutchouc concrete [1, 2], with a unique combination of physical and mechanical properties (Table 1) and universal chemical resistance (Table 2) was obtained in Voronezh State University of Civil Engineering and Architecture based on synthetic caoutchouc.

Table 1

Physical and mechanical characteriristics of caoutchouc concrete

Physical and mechanical characteriristics	Value
Compression strength, MPa	60÷110
Tensile strength, MPa	8÷20
Modulus of elasticity, $\times 10^4$ MPa	2.0÷3.5
Compression durability coefficient	0.77÷0.78
Poisson coefficient	0.18÷0.35
Heat resistance, ^{o}C	90÷100
Freeze resistance, a number of freezing-thawing cycles, no fewer than	500
Average thermal coefficient of linear expansion, 1/^{o}C	1.35×10^{-5}
Abradability, g/cm^2	0.15÷0.3
Water absorption, mass %	0.05
Contraction, mm/m	0.17÷0.21

The table suggests that caoutchouc concrete is a waterproof material that can endure as many as 500 freezing-thawing cycles and has high strength characteristics. Negative temperatures varying from 0 to –80 ^{o}C increase its durability up to 25 %, which is extremely

important when a material is operated in low temperatures. The coefficient of thermal linear expansion of caoutchouc concrete is similar to that of steel (otherwise a thermal deformation of a pipe would result in significant stresses in its surface coating that ultimately lead to a coating material failure).

Table 2

Coefficients of chemical resistance of caoutchouc concrete

Type of aggressive medium	Coefficient of chemical resistance of caoutchouc concrete in a year of exposure
20-% sulfuric acid solution	0.95
3-% nitric acid solution	0.8
10-% citric acid solution	0.9
20-% caustic soda solution	0.95
10-% caustic potassium solution	0.8
Saturated solution of chloride natrium	0.9
Diesel fuel	0.95
Water	1

2. Arrangement of protective coating on a metal pipe based on low-molecular oligodiene

A method of arranging a protective coating of a pipe metal based on caoutchouc concrete has been developed and patented at the base of Voronezh State University of Civil Engineering and Architecture. The patent for invention № 2380607 “Method of arranging a protective coating on a pipeline” [4] was received.

A scheme of a test bench implementing this method is given in Fig. 2. Inductive heater 1 includes a sectional self-contained cylindrical section concrete form made of heat-resistant dielectric (e. g. asbestos-cement) with a wire wrapped around it and connected to a high-frequency current generator 2. Inside of the inductive heater 1 is an isolated pipeline 3 with a caoutchouc-mix protective coating 4. A temperature mode is monitored with a thermocouple placed in a coating layer.

In the process of arranging a caoutchouc-mix protective coating 4 on a steel pipeline 3, the inductive heater 1 by generating a magnetic field 5 excites high-frequency currents in the steel pipe that heat up the pipe that consequently transmits a heat energy to the caoutchouc coating.

While heating up, the caoutchouc coating is conditioned for a while. Heating is then removed and the coating is sustained till it completely solidifies. The graph of heat treatment of caoutchouc mastic when arranging the coating of a pipe metal based on it is given in Fig. 3.

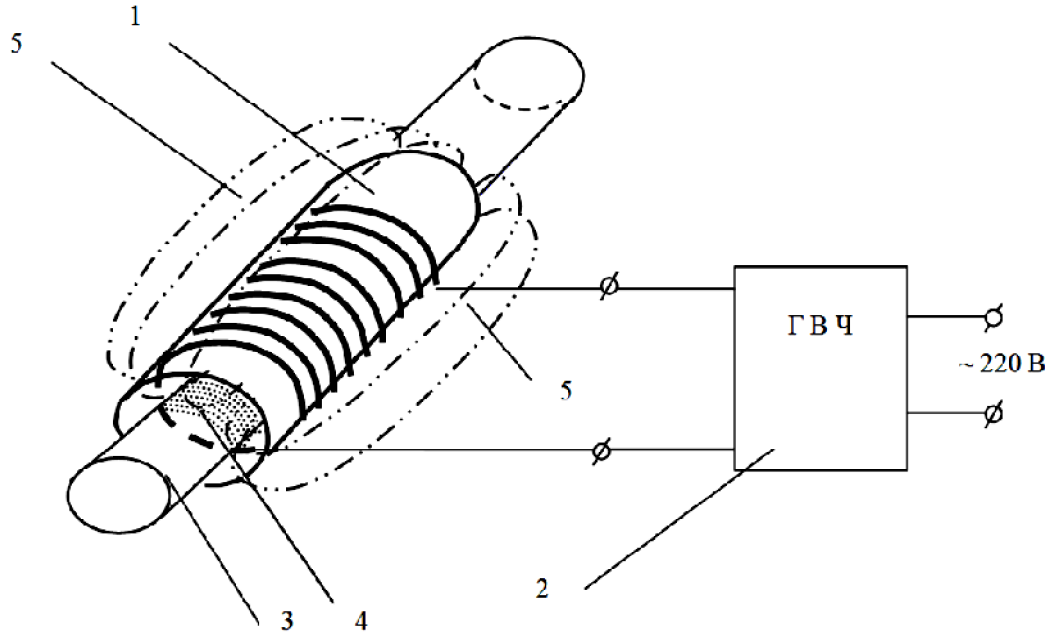

Fig. 2. Scheme of a test bench for arranging a protective coating of a pipe metal during vulcanization of caoutchouc mastic on its surface by the inductive heating method

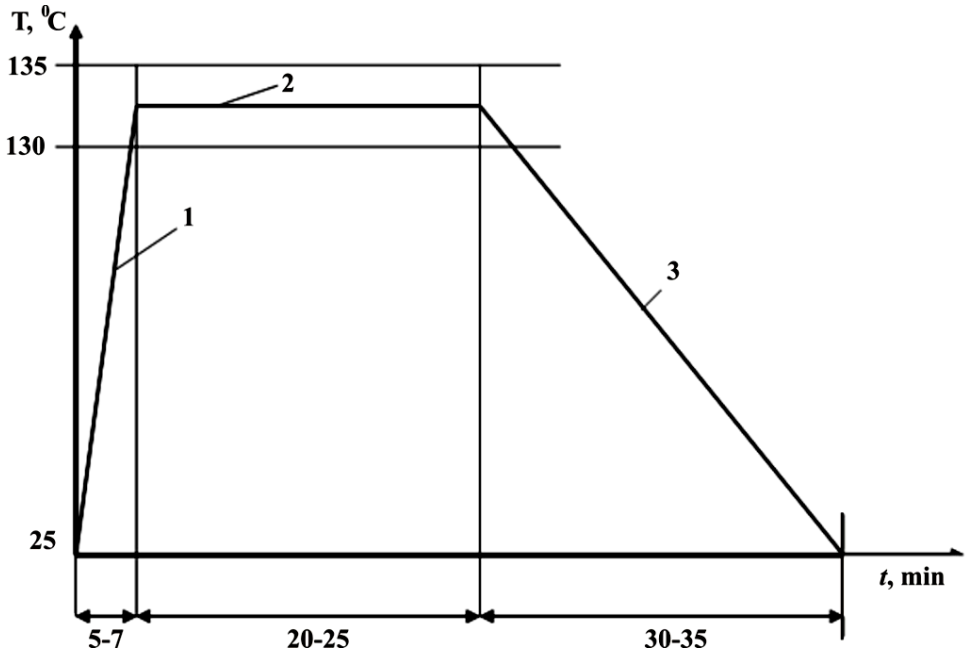

Fig. 3. Graph of heat treatment of caoutchouc mastic when arranging the coating of a pipe metal based on it

3. Defining the characteristics of a protective coating of a pipe metal based on low-molecular oligodiene

Based upon the obtained samples, the following characteristics were defined for a protective coating of a metal pipe based on low-molecular oligodiene (Table 3).

They are:

- adhesive strength,
- water resistance,
- tolerance of the coating to thermal cycling;
- transient resistance .

Table 3

Characteristics of a protective coating
of a pipe metal based on low-molecular oligodiene

Coating characteristics	Value	Notes
Shear adhesive strength, kg/cm^2	90—100	Samples failed in the coating material
Water resistance, % of adhesive strength decrease	3—5	High water resistance of the coating material
Freeze resistance of freezing-thawing cycle	Over 500	Freeze resistant material
Transient resistance after 100 days, ageing in a 3 % NaCl solution at 80 ^{o}C, Ohm/m^2	Over 10^{10}	Coatings shows a dielectric properties

Conclusions

1. A unique combination of physical and mechanical and operational characteristics makes it possible to use caoutchouc concrete as an effective protective coating of building structures operated in Extreme North [3].
2. Caoutchouc concrete is a composite that can be filled with organic and non-organic natural and artificial materials and with industrial wastes as well. Caoutchouc concrete is filled up to 85 % of its mass. Varying percentage ratios of components and various

fillers, we can obtain a material with a specified set of parameters, i. e. optimize the content of a material for its maximum effective operation under certain conditions.

3. Many industrial regions of the Extreme North have to encounter the problem of recycling of car tires that are deemed unfit for further operation. As one of recycling variants, it can be suggested that rubber crumb obtained as a result of grinding of tires should be used as a composite.

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