ANALYSIS OF THE USE OF COATED PIPES IN MARINE VESSELS

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Abstract

The information obtained through Arduino microcontroller is described in graphical dependencies in real-time mode of the result. When the crack is detected in the pipe, the maximum point of the recorded signal indicates on the diagram the part where the crack exists. Otherwise, the signal is described in the form of a straight line and indicates that no crack is found. The operator is able to determine any crack based on the signal recorded on the monitor. Due to the current leakage in the point of any crack the signal is transmitted to the Arduino microcontroller and, then, to the software. Based on the information received, the coordinate of the crack is found. So, since we obtain the information about the instantaneous displacement of the electrode with the encoder, we determine the coordinate of the crack according to the maximum value of the current leakage based on the diagram obtained.

Keywords: electrode wire, silicon pipe, marine ships, installation process, diagnose the cracks

Introduction

To diagnose the cracks in silicon coated pipes in offshore oil fields, proper organization of the work of the naval fleet, ensuring the silicon pipe strength and durability, the complete dependence of the region on the wave regime were studied. The wave quantities that characterize the wave mode are wave elements. To the wave elements include the wave height, length, period, the wave peak state according to the sea level, and etc.

The studies were carried out in the marine ship reservoir. The studies of the location of the large oil field in the open sea in this district helped to create the necessary conditions. In addition, it should be taken into account that hurricane wind waves approach ocean waves with a speed up to 40m/sec.

At present, the defects found in Ø400x20 mm pipelines of 35 km length drawn from marine ship to the shore are in the range of 1.5-3.5% and have created the basis for better quality of the installation process. It is recommended to use a relatively inexpensive programmable controller Panasonic FPWIN pro for the control system. A mathematical model of the process of the coating laying on the surface of pipelines with a diameter of Ø630x30, Ø300x20, Ø800x40 mm is specifically made. The technological process is carried out with the application of the defect scope to ensure more accurate diagnostics of cracks in pipe coatings [1, 2].

The accuracy of the heating temperature in the pipe coating is determined depending on the rotational, forward and geometric dimensions of the pipe in the technological installation. Errors in repeated measurements of the heating temperature of surfaces in pipe coatings of different diameters (x_1, x_2, $x_3 \ldots x_n$) fully depends on the given voltages, leakage current, the size of the crack and its thickness and electrical conductivity. In the same way, in cooling mode the errors of repeated measurements (x_1, x_2, x_3) depend on the geometric size of the coating, the thickness of the coating, the cooling mode, that is, the brand of the

Comparative meteorological characteristics of the flaw detector are shown in Table 1.

Table 1: *Determination of the pipe coating cracks through a diagnostic device*

Defect scope parameters	Defectoscope	
	Korona C	Advanced performance defect scope
Test pipe diameter, mm	100	350
Pipe coating thickness, mm	2	4
Electrode movement speed, m/sec	0.15	0.25
Defect detection interval	0.4	0.2-1.0
Joint defect distance	15	9
Test tension value, kV	1-30	1-40
Test tension, Kv	0.1	0.1
Test tension tolerance, %	5	2
Acceptable tolerance, %	9.75	5.1

Table 2: *Meteorological characteristics of a defectoscope*

Pipe diameter and thickness, mm	The number of cracks arisen in the coating of 100 pipes (%)	The number of microcracks arisen through control in the coating of 100 pipes (%)
Ø300x20	6.51	1.8
Ø400x25	7.23	2.5
Ø500x30	5.12	3.2
Ø600x35	8.14	4.3
Ø800x40	9.75	5.1

Therefore, the average calculation of these parameters is defined as follows [2, 3].

$$x_c = \frac{x_1+x_2+x_n}{N} = \frac{1}{N}\sum_{i=1}^{n} x_i \quad (1)$$

where,
x_i is the fault of the parameters of the technological regime upon making the coating in each pipe.
n is the number of cracks formed inside pipes.
N is the number of pipes with a common coating.

The number of absolute errors in the determination of cracks in any pipe coating is calculated as follows:

$$\Delta x_i = x_c - x_i \quad (2)$$

i= 1 2 3 ..n

Thus, the average absolute errors in measurements are calculated as follows:

$$\Delta x = \frac{1}{N}\sum_{i=1}^{n} \Delta x_i \quad (3)$$

The nominal faults are found by the formula $\varepsilon = \frac{\Delta x}{x_c}$.

Table 3: *Complete fault characteristics in measurement of cracks*

Pipe diameter and thickness	Coating thickness δ, mm	Average fault value, $\Delta x, \%$	Quadratic value of faults, s, %	Crack number, n
$\emptyset 300x20$	1-1.5	2.78	2.63	1-3
$\emptyset 400x35$	1.5-2.0	3.24	3.12	2-3
$\emptyset 500x30$	1.5-2.5	3.68	3.54	3-5
$\emptyset 600x35$	2.5-3.0	4.72	4.66	4-5
$\emptyset 800x40$	3.0-3.5	5.21	5.12	4-5

At the same time, the error of mid-quadratic inclination is determined as follows.

$$S = \sqrt{\frac{\Sigma(x_c - x_i)^2}{n}} \tag{4}$$

At the same time, the different faults of geometric dimensions of coordinates of the cracks were reported through the electric spark defectoscope via formulas (1), (3) and (4), and they are provided in Table 3.

The Table 3 shows the characteristics of the coatings observed in steel pipes of 100 different diameters.

As a result of the reports, the crack origin and fault values are shown below.

The information obtained through Arduino microcontroller is described in graphical dependencies in real-time mode of the result [3, 4].

When the crack is detected in the pipe, the maximum point of the recorded signal indicates on the diagram the part where the crack exists. Otherwise, the signal is described in the form of a straight line and indicates that no crack is found.

The operator is able to determine any crack based on the signal recorded on the monitor. Due to the current leakage in the point of any crack the signal is transmitted to the Arduino microcontroller and, then, to the software.

Based on the information received, the coordinate of the crack is found. So, since we get the information about the instantaneous displacement of the electrode with the encoder, we determine the coordinate of the crack according to the maximum value of the current The accuracy of the heating temperature in the pipe coating is determined depending on the rotational, forward and geometric dimensions of the pipe in the technological installation.

It was also taken into account that the technological process, which is the basis of the causes of cracks and defects, was not carried out accurately and the employees did not comply with the technological regulations. With all this in mind, scratches on silicate coated pipes, star-shaped, wavy and groove cracks in the form of fish flakes, black dots, thin cracks with small holes, and etc. occur. Geometric dimensions of such crack layers depending on the brand and thickness of the silicate coating accept the micro cracks in the range of 0.3÷3.0 mm and the macro cracks in the range of 3.0-5.0 mm, even the length of the cracks reaches up to 10 mm [4,5].

As a result, the temperature drop in the coatings of different brands should be determined in the operating conditions, and the characteristics of the coatings of different brands widely used are given in Table 4.

On the basis of the experiments, the optimized heating and cooling time in all branded silicon coatings is considered appropriate for the purpose in the interval τ=25-50 minutes. In order to fully implement these modes, the coating inside the pipe is cooled to a constant drop temperature, and the air is adopted as a cooling agent. Depending on the intensity of the air supplied to its surface with a special cooling apparatus, the cooling process is carried out [6, 7].

The cooling temperature of the refrigerator is determined by the following formula as known.

Thus, when cooling the coated pipe, the temperature area of the coating is obtained by solving the initial and boundary conditions of the differential equation of non-stationary heat conduction of the double cylinder. The temperature during cooling on the surfaces of the pipe coating according to the solution is determined by the following formula [8, 9].

$$T_1 = 9.81\exp(\frac{a\tau}{R}) \quad (5)$$

where: T_1 is the temperature on the coating surface upon cooling, a is the coating temperature transfer coefficient; τ is the cooling time.

$$R = \frac{R_3^2 - R_2^2}{R_2^2 - R_1^2}$$

is the relative coefficient of cross-section of the pipe and the coating. So, the temperature drop is determined in the cooling process as follows $\Delta T = T_1$-T_2.

Table 4: *Thermal and physical properties of the coatings*

Thermal properties of the coating	The coating industry brands				
	EP-1	EP-2	EP-10	EP-20	EP-30
Linear expansion coefficient $\lambda, 10^{-7}C^{-1}$	103	89	50	32	64
Coating softening temperature ℃	520	580	620	650	690
Heat transfer coefficient 20℃, Vt/m ℃	0.63	0.92	0.89	0.91	0.98
Coating density 10^{-3}kg/m^3	1.1	1.29	1.38	1.41	1.48
Special heat capacity Cal/kg ℃	1.7	1.8	2.1	2.8	3.2
Constant temperature drop in cooling (overheating) ΔT, ℃	8.2	7.5	5.0	10.0	9.5

*Note: EP – type of epoxy coating

Based on this formula, automatic adjustment with the control system depending on R_1, R_2, R_3, Q, T_1, T_2 parameters was carried out by adopting the temperature fall of the cooling process in the single time, i.e. τ=1 min in the interval of t_0 = 5 ÷ 10℃.

This study was carried out in the sequence as indicated in the "Matlab" in simulating package. The task of the system is to adjust the cooling process (5÷10℃), keeping the fixed given values of the cooling speed with the help of the cooling agent, as a result of the inclusion of high-temperature coated pipes into the cooling chamber.

The silicon coated pipes are dried at 20÷30 ℃ for some period and delivered to the furnace assembly to be heated at high temperature to obtain a full smooth coating [10, 11].

The silicon coated pipes entered the oven are treated as double cylinders. As the temperature in the oven is stable at 1000℃, it is accepted that the heat is evenly distributed along the surface of the pipes, since upon heating the temperature changes only in the radial direction of the pipe.

By applying the differential equation of thermal conductivity of the double cylinder to the coated pipe, using the initial and boundary conditions of the heating of the pipes, the mathematical expression of the regulatory parameters is obtained as follows [11, 12].

Conclusions

1. The coefficient of thermal conductivity versus the heating of the wall of a glass coating on a pipe was investigated experimentally. It should be noted that the coefficient of thermal conductivity of the glass coating on a pipe increases by several tenths of a watt with the temperature of the coating on the wall of a pipe rising up to 600℃.

2. These investigations show that an increase in the temperature of the glass coating effects a significant improvement in its thermal conductivity. The highest thermal conductivity obtains for coatings by glass of the makes S-89 and S-52-1. These makes of glass are recommended for coating pipelines operating at heightened coolant temperatures. On experimentally determining the

coefficient of thermal conductivity of a glass coating on pipes the maximum spread of the experimental data was equal to 1–3% depending on the change in glass temperature.

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