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Soil ph Control in the Mobile Corrosion Monitoring

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Abstract. Corrosion monitoring methods and pH measuring devices are studied. Considering the heterogeneity of the soil pH, depending on depth and sampling points, it is advisable to use solid-state potentiometric sensors that are capable of pH measuring with an error not exceeding 0.2 pH units. In the process of the pipeline installation necessary to control the soil pH value. While it is impossible to predict what kind of horizon will be in contact with the pipe material at different points. This problem requires future development of technique for the correct pH measuring for the purpose of mobile pipeline corrosion monitoring. When using cathodic protection has been required find the balance between the parameters which prevent the corrosion reactions and also take into account the hydrogen absorption on surface of the pipes material.

1. Introduction

Currently, pipeline transport one of most used method of energy transportation. Important effect accompanying the pipelines operation is the pipe material corrosion. Most emergencies occurring with pipelines exploitation are associated with corrosion, which is one of the main causes of depressurization.

Nowadays, corrosion monitoring is an effective way to estimate the equipment condition (in the stages of its design, operation, renovation). Monitoring of the underground steel pipelines corrosion state includes a system of observations, diagnosis and corrosion condition prediction for timely defect detection, estimating their extent and prevent of the effects of corrosion.

In corrosion monitoring at the stage of equipment operation using the following methods condition monitoring: visual inspection, determination of the medium redox potential, examination of inaccessible areas of equipment with telemetry systems, monitoring changes in the concentration of corrosion-active agents, etc., degradation products of the metal structure elements, determining material construction potential, determination of corrosion specimens kinetics, determination of specimens electrical resistance, ultrasonic, acoustic and magnetometric defectoscopy [1].

In mobile corrosion monitoring there is a problem consisting in sampling and subsequent analysis in the laboratory. This leads to high costs of time and human resources.

2. Research Questions

There are passive and active methods of protection material of pipelines from corrosion. Because the passive method doesn’t provide complete corrosion protection of pipelines, use an active protection based on the electrochemical processes occurring at the border of the soil electrolyte and pipe metal. The most common active method of corrosion protection is the cathodic polarization method based on the shift of pipe metal potential in the negative region relative to the equilibrium potential therefore the rate of metal dissolution is decreased [2].

The intensity of the pipeline material destruction considerably depends on the soil corrosiveness in contact with the pipe. Soil corrosivity is determined by the following parameters: moisture, permeability of soil, porosity, gas-phase composition of its pore space, organic compounds concentration in soil, acid and sulfate-reducing microorganisms, as well as pH, salinity and mineral salts composition of the soil electrolyte [3]. Selection of pipeline protection method directly based on the parameters of soils corrosion activity.

In determining the soil corrosiveness there is an effective tool, displays the thermodynamically stable form of elements existence (atomic crystals, metals, molecules and ions) in the soil solutions at various pH and the redox potential E. Proposed by Marcel Pourbaix [4], the chart is plotted in coordinates of E (ordinate) — pH (abscissa)(Fig. 1). It reflects the thermodynamically stable Fe form at a corresponding pH value and redox potential. For each chemical element, it is possible to design a Pourbaix diagram.

The Pourbaix diagram is a useful tool in determining the possible corrosion reactions on the pipeline, and also in the potential of cathodic protection determining.

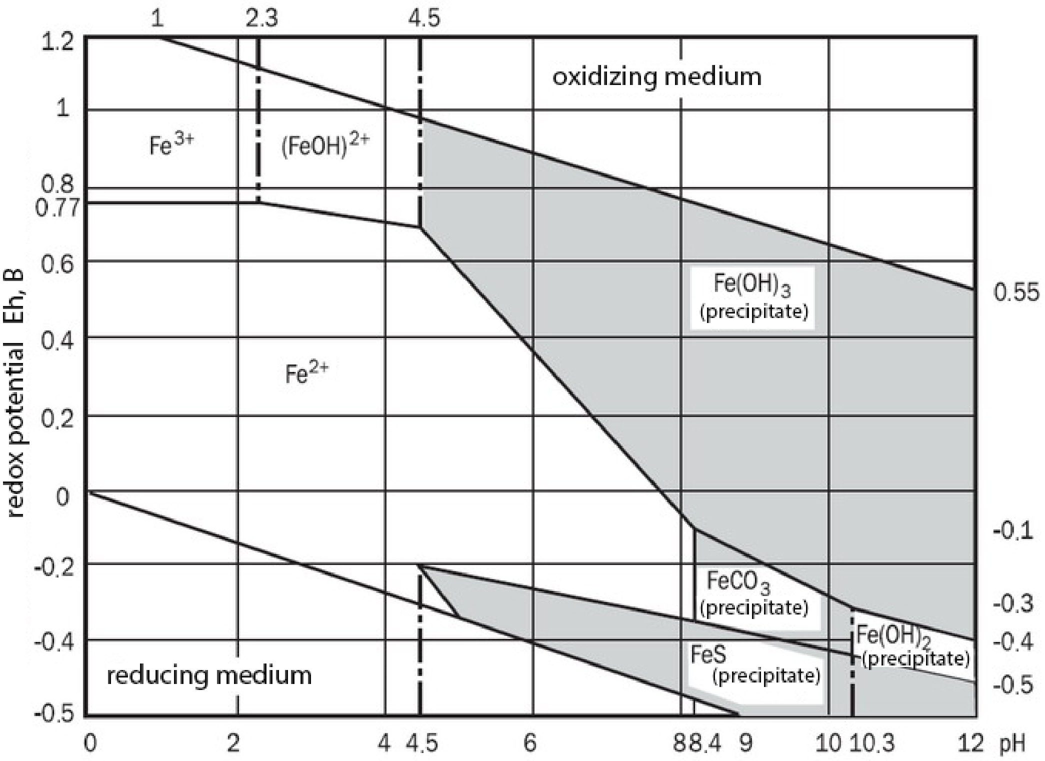

Figure 1. The possible reactions for the Fe-H_2O system**.**

Determination of soils pH is one of the important elements of soils corrosion activity evaluation. pH quantitatively expresses a solution acidity. It is a negative decimal logarithm of hydrogen ion concentration (exactly – activity). The soil is a multifunctional heterogeneous open disperse system formed by the weathering of rocks and living organisms. The soil profile is a set of horizons, which differ in chemical, mineralogical, granulometric composition, physical and biological properties. Soils are divided into types that differ from each other by a set of properties caused by the processes of soil formation and the major horizons system [5–7].

3. Research Methods and Problem Statement

Thus, it is necessary to develop equipment for measuring soil pH is suitable for use in mobile corrosion monitoring. Among the existing pH measuring methods, the most common method is the potentiometry. This method has sufficient accuracy for the pH determination (to 0.01 pH unit), small measurement time (about three minutes) and sufficient results reproducibility. In practice, the measuring system consists of two electrodes, one of which is sensitive to the hydrogen ions concentration, and the other one has a stable potential (the reference electrode). As a pH sensor usually used national standard recommended [8] glass electrode, and silver-chloride electrode as reference one.

Despite the high accuracy of the glass electrode [9] has a number of disadvantages:

- fragility;
- long-establish the equilibrium potential value;
- high electrode resistance;
- special storage conditions and preparation to work.

In addition to the glass electrode for soil pH measuring used antimony electrode [7]. It has a lower accuracy in comparison with a glass electrode, but is more suitable for use at-site.

In the literature [10, 11] it is known to use solid-state sensors based on quinhydrone to measure the pH of the environmental objects. Such solid-state electrodes have the following advantages:

- strength, adequate for use in field conditions;
- potential stabilization within minute;
- storage , transportation and preparation for work without specific conditions;
- low electrode resistance;
- wide sensor shape and size variation;

There are various methods for soil pH determininating characterized by different measurement errors. It is known from the literature [12] that the range of pH variation within a single soil type varies within 0.5–1 pH. Also, depending on the measurement depth, pH changes in each soil horizon from top to bottom from acidic to alkaline (from 4.0 in swampy soil types to 8.5 in pedogenic horizons).

4. Results and Findings

As a result of the experiment was determined variation of soil pH values sampled in the Tomsk and Kemerovo regions, depending on soil type, depth of sampling point in accordance with the methodology of GOST 26423-85.

Soil profile — a set of genetically mated soil horizons, which divided the soil in the process of soil formation [13]. Table 1, 2 illustrate the pH variation in different soil types and at different horizons. The following soil types: podzolic, light gray forest, alluvial meadow acidic, turfy, light brown, ordinary black earth forest-steppe, black humus, sod.

Table 1. The range of pH variation for different soil types (degree of freedom 3, significance level 0.05).

	Black humus	Podzolic	Turfy	Black earth	black earth forest-steppe
pH	6.05 ± 0.16	5.73 ± 0.19	6.33 ± 0.15	7.52 ± 0.3	7.29 ± 0.19
Confidence interval	0.32	0.38	0.3	0.6	0.38

These tables show that relation on soil type pH values spreading up to 0.6 pH units.

Table 2 illustrates pH variation in a soil horizons in different types of soils.

The differences in pH values between the various horizons are statistically significant and reaches 1 pH. Soil horizons are mixed when a pipeline is laying. Thus, the pipe contact with soil with different pH value.

Table 2. The range of soil pH variation on different horizons (degree of freedom 3, significance level 0.05).

	Podzolic	Dark humus	Black Earth	Turfy
pH	A: 5.51 ± 0.28	A: 5.74 ± 0.31	A: 7.19 ± 0.32	A: 5.83 ± 0.22
	A2B: 5.42 ± 0.24	A1A2: 5.98 ± 0.30	AB: 7.32 ± 0.24	A1A2: 6.55 ± 0.27
	B1: 6.4 ± 0.22	B1: 6.52 ± 0.27	B1: 7.88 ± 17	B1: 6.7 ± 0.24
pH range	5.51 ÷ 6.4	5.74 ÷ 6.52	7.19 ÷ 7.88	5.83 ÷ 6.7

To determine the pH sampling point influence was selected 3 areas of soil in Mikhaylovskaya grove (location - Tomsk city, soil type – light-gray forest), distance between sampling points approximately 5 meters.

Table 3. Variability of pH values in different sampling points within the same soil type (degree of freedom 3, significance level 0.05).

	1	2	3
pH	7.3±0.2	7.8±0.3	8.2±0.3
Confidence interval	0.4	0.6	0.6

From Table 3, we can conclude that depending on the selection point within the same soil type, the pH value can vary almost 1 pH unit.

5. Conclusions

Considering the heterogeneity of the soil pH, depending on depth and sampling points, it is advisable to use solid-state potentiometric sensors that are capable of pH measuring with an error not exceeding 0.2 pH units.

In the process of the pipeline installation necessary to control the soil pH value. While it is impossible to predict what kind of horizon will be in contact with the pipe material at different points. This problem requires future development of technique for the correct pH measuring for the purpose of mobile pipeline corrosion monitoring. When using cathodic protection has been required find the balance between the parameters which prevent the corrosion reactions and also take into account the hydrogen absorption on surface of the pipes material.

Solid-state sensors for the measurement of pH for corrosion monitoring are effective and have the following properties:

- measurement error less than 0.2 pH units;
- the range of pH 4 to 8;
- easement of using at site;
- mechanical durability.

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