Application of Anticorrosive Coatings Based on Modified English Kaolin and Epoxy Compound and Efficiency Evaluation Based on the Development of a Mathematical Process Model

Miradullaeva Gavhar

Check for updates

Abstract— ***The article presents the results of research on the development of compositions of organomineral materials for the protection of metal parts of technological machines and structures working mainly under the influence of electrochemical mechanism of the corrosion process. The compositions of modified organomineral materials for anticorrosive coatings with the use of micro- and nanoscale particles of layered silicates (mineral fillers) are offered. To assess the reliability of experimental studies, mathematical processing was carried out with the use of the interpolation function of Lagrange for polarization resistance from time to time in 98% H2SO4 solution.***

Keywords: organomineral materials, anticorrosive coatings, electrochemical medium, epoxy compounds, resin, kaolin, filler, corrosion, polarization electrical resistance.

I. BACKGROUND

Nowadays, there are quite a lot of fundamental and applied works devoted to the anticorrosive protection of mechanical surfaces of technological machine parts. One of the main factors is the electrochemical aggressive environment in which the machine parts work. These problems are usually solved by the traditional use of non-ferrous metals and stainless steels instead of conventional structural steels. For large-size and complex conPicuration parts, this is very expensive and does not pay for itself. And today special anticorrosive coatings of foreign production are known to be quite capacious and do not justify the operating costs of technological equipment of local production.

Purpose:

Development and research of anticorrosive coatings based on the epoxy binder and modified local Angren kaolins.

Components used:

As polymer binders have been selected thermosetting polymers - ED-20 rejected with polyethylene polyamine (PEPA) providing cold curing. As softener secondary have been chosen raw materials (withdrawal of production of the oil and fat industry) - the gossipolovy pitch (GP), as filler are used Angren kaolins - AKF-78, AKS-30, AKT-10, AKO (a tail product withdrawal).

Methodology:

We have chosen the method of concentric electrodes with the use of Terra ohmmeter E6-13A and DC bridge R4053 for research of electrophysical properties of protective coatings. Mathematical processing of the results of the study was carried out using the interpolation fiction of Lagrange.

Scientific novelty:

Influences of strongly aggressive acidic environments on the polarized electrical resistance of organomineral mechanochemical modified coatings using local raw energy resources are revealed.

Obtained data:

Compositions of organomineral materials for sewn coatings for use on working surfaces working in highly corrosive acid environments are proposed and applied. (92-98% H_2SO_4).

Features:

Polarization resistance of the proposed organomineral protective coatings varies from 150-175 Ohm at a duration of 25 days and can be used as protective coatings.

II. INTRODUCTION

It can be noted that at present there are quite a lot of fundamental and applied works devoted to anticorrosive protection of mechanical surfaces of technological machine parts. One of the main factors is the electrochemical aggressive environment at which the machine parts work. These problems are usually solved by the traditional use of non-ferrous metals and stainless steels instead of conventional structural [1-4]. For large-size and also difficult conPicuration parts it is very expensive and does not pay for itself the cost of expenses [5-9]. And the known today special anticorrosive coatings of foreign productions are rather volute-intensive and do not justify the operating costs of technological equipment of local production [9-12].

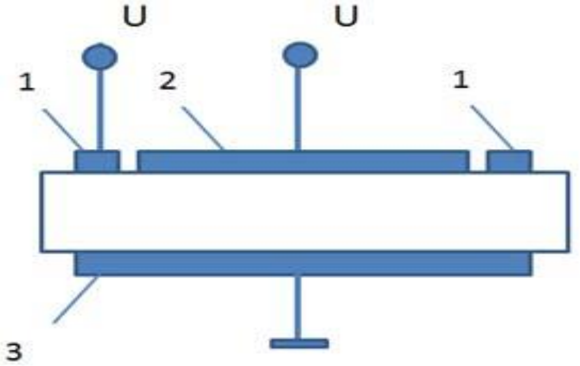
Manuscript published on November 30, 2019.
* Correspondence Author
Miradullaeva Gavhar*, a doctoral student at the Tashkent State Technical University, named after Islam Karimov, Tashkent, Uzbekistan. (Email: gavharmb@gmail.com)

III. TARGET

Development and research of anticorrosive coatings on the basis of epoxy binder and modified Angren kaolins (deposits of Uzbekistan).

IV. METHODOLOGY

We have chosen the method of concentric electrodes (Pic.1) with the use of Terra ohmmeter E6-13A and DC bridge P4053 for research of electrophysical properties [13].



Pic. 1. Location of concentric electrodes when measuring dielectric resistance: 1 - protective ring; 2 - central electrode; 3 - bottom electrode.

The developed compositions were evaluated according to (5 point scale) according to GOST (P58284-2018) and the reliability of experimental studies using the mathematical apparatus using the interpolation function of Lagrange. Other physical-mechanical, technological and operational properties are determined by well-known standard methods.

V. SCIENTIFIC NOVELTY

The influence of highly aggressive acidic media on the polarized electrical resistance of organomineral mechanochemical modified coatings using local energy resources is revealed.

VI. OBTAINED DATA & RESULTS

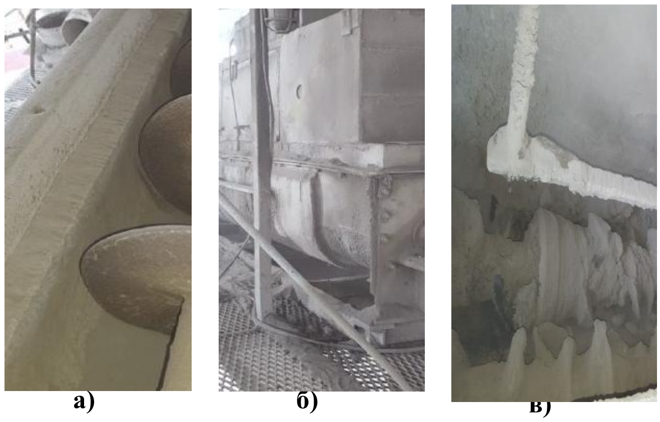
In order to study the operational properties we analyzed the work of complex configuration and large-size technological equipment of chemical industry enterprises working in the conditions of electrochemical corrosion.

One of the often repaired and in dire need of corrosion protection are the elements of screw conveying device and two rotary mixers of technological equipment for the production of superphosphate fertilizers (Pic.2).

Due to severe operating conditions: high-temperature (up to 2000C) mode and aggressive solution (92-98%) H_2SO_4 above-mentioned equipment requires frequent maintenance and repair.

At the analysis of literary sources works on the influence of strong acidic environments except for works [14] have not been revealed.

To ensure normal operation, all blades are replaced with new ones, and in some cases rubber is used at the end of the blades. In spite of all these technological lines of fertilizer production facilities often have to stand idle to carry out preventive work.



Pic. 2. General view of the screw conveyor (a), two-rotor mixer (b), vane rotor (c).

In the process of operation, parts and gutters of these equipment are exposed to strong corrosion, especially the elements of the rotary mixer. The geometric dimensions of the blades are intensively reduced during operation as a result of corrosion, which does not ensure normal mixing and leads to a decrease in the productivity of the equipment.

To assess the corrosion resistance of structural steels on a five-point scale (Table 1) per GOST R58284-2018, studies were conducted in different environments (Table 2.).

Table 1:
Assessment of corrosion resistance of structural of materials on a five-point scale

Corrosion rate, mm/year	Stability assessment, score.	Resistance Group
Not more than 0.1	Very resistant.	1
Above 0,1 up to 1,0	Resistant	2
Above 1,0 up to 3,0	Reduced resistant	3
Above 3,0 up to 10,0	Low resistant.	4
Above 10,0	Unresistant.	5
Note - a lower score characterizes more resistant metals.		

Table 2:
Examination of corrosion resistance of St-3 samples in different corrosive environments

Environment type	Test time (day)				
	5	10	15	20	25
H_2O	0,002	0,004	0,008	0,009	0,01
NaOH	0,04	0,09	0,15	0,22	0,3
H_2SO_4	0,08	0/15	0,3	0.45	0.6

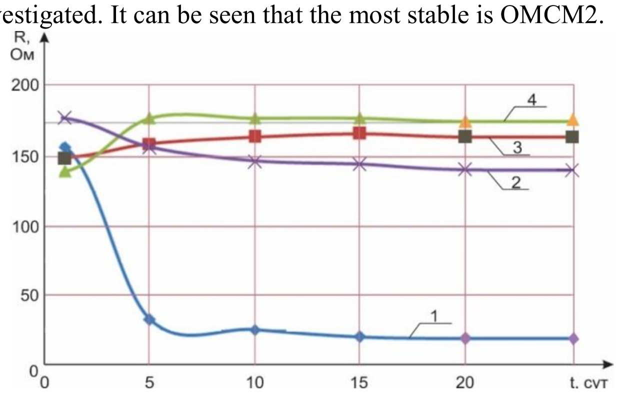
The results of the research have shown that structural materials of technological equipment used in corrosive environments today correspond to 4 points (low-resistance) on a 5-point scale.

In this connection on the basis of the received results of research compositions of organomineral materials for protective coverings for the technological equipment working in strongly aggressive environments are offered (tab. 3)

Table 3:
Proposed compositions of organomineral composite materials

Organomineral components Materials	Compositions of organomineral materials for coatings (mas.h.)		
	OMCM-1	OMCM-2	OMCM-3
ER-20	100	100	100
GR	10	10	10
AKF-78	2	2	2
AKO	20	-	-
AKT-10	-	20	-
AKC-30	-	-	20
PEPA	12	12	12

For an estimation of corrosion firmness of the offered protective coverings dependence of polarization resistance on time in an acid environment, 92-98 % H2SO4 is studied. As an example, the polarization resistance dependence on the time duration in the solution of 98% H_2SO_4 (Pic. 2.) is investigated. It can be seen that the most stable is OMCM2.



Pic. 3. Dependence of polarization resistance on time in solution 98 % H_2SO_4 1 - without coating; 2 - OMCM3; 3 - OMCM1; 4 - OMCM2.

The analysis of the results of the research in comparison with the assessment of the anticorrosive ability of compositions has shown that the compositions offered by us OMCM1, OMCM2, OMCM3 (Table 3) can be used to protect the metal parts of the most aggressive, high-temperature acid environments, increasing the service life of machines.

As a result of periodic inspections of the structure in order to determine the state of the metal surface of the structure and the anti-corrosion coating by non-destructive methods of control (ultrasonic and magnetic), there were no micro-cracks and peeling of the coating. To check the quality of the surface and the process of corrosion development, the coating was peeled off and a visual inspection of the metal surface was carried out. It was difficult to detach the coating layer. There were no signs of corrosion on the investigated metal surface.

To assess the reliability of the experimental studies mathematical processing was carried out with the use of interpolation function

$$L_n(x)=\sum_{i=0}^{n}\frac{(x-x_0)(x-x_1)..(x-x_{i-1})(x-x_{i+1})..(x-x_n)}{(x_i-x_0)(x_i-x_1)..(x_i-x_{i-1})(x_i-x_{i+1})..(x_i-x_n)}y_i \qquad (1)$$

We apply the interpolation function of Lagrange for polarization resistance from time to time in 98% H_2SO_4 solution, without covering 1-line

x_i	1	5	10	15	20
y_i	150	35	25	15	16

$$L_4(x)=\frac{(x-5)(x-10)(x-15)(x-20)}{(1-5)(1-10)(1-15)(1-20)}150+\frac{(x-1)(x-10)(x-15)(x-20)}{(5-1)(5-10)(5-15)(5-20)}35+$$
$$+\frac{(x-1)(x-5)(x-15)(x-20)}{(10-1)(10-5)(10-15)(10-20)}25+\frac{(x-1)(x-5)(x-10)(x-20)}{(15-1)(15-5)(15-10)(15-20)}15+$$
$$+\frac{(x-1)(x-5)(x-10)(x-15)}{(20-1)(20-5)(20-10)(20-15)}16$$

$$L_4^1(x)=150\frac{(x^4-50x^3+875x^2-6250x+15000)}{9576}-$$
$$-35\frac{(x^4-46x^3+695x^2-3650x+3000)}{3000}+$$
$$+25\frac{(x^4-41x^3+515x^2-1975x+1500)}{2250}-$$
$$-15\frac{(x^4-36x^3+385x^2-1350x+1000)}{3500}+$$
$$+16\frac{(x^4-41x^3+365x^2-1075x+750)}{14250}=$$
$$=0{,}011x^4-0{,}555x^3+9{,}635x^2-71{,}625x+215{,}75$$

We apply the interpolation function of Lagrange (1) for polarization resistance from time to time in 98% H_2SO_4 solution, for lines 2-; with OMCM-Z coating of line 2

x_i	1	5	10	15	20
y_i	180	160	140	135	130

$$L_4^2(x)=180\frac{(x^4-50x^3+875x^2-6250x+15000)}{9576}-$$
$$-160\frac{(x^4-46x^3+695x^2-3650x+3000)}{3000}+$$
$$+140\frac{(x^4-41x^3+515x^2-1975x+1500)}{2250}-$$
$$-135\frac{(x^4-36x^3+385x^2-1350x+1000)}{3500}+$$
$$+130\frac{(x^4-41x^3+365x^2-1075x+750)}{14250}=-0{,}001x^4-0{,}055x^3+0{,}375x^2-6{,}125x+187{,}75$$

We apply the interpolation function of Lagrazh (1) for polarization resistance from time to time in a solution of 98% H_2SO_4, for lines 3-; with OMCM1 coating of 3- line

x_i	1	5	10	15	20
y_i	150	160	175	170	170

Retrieval Number: D5362118419/2019©BEIESP
DOI:10.35940/ijrte.D5362.118419
Journal Website: www.ijrte.org

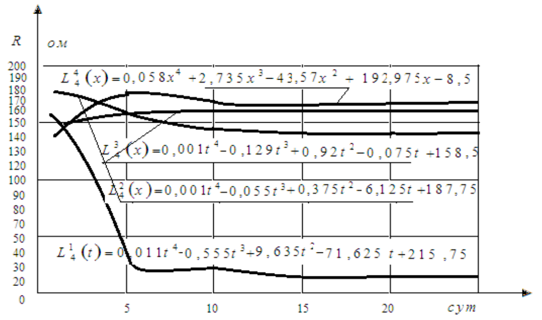
Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

$$L_4^3(x)=150\frac{(x^4-50x^3+875x^2-6250x+15000)}{9576}-$$
$$-160\frac{(x^4-46x^3+695x^2-3650x+3000)}{3000}+$$
$$+175\frac{(x^4-41x^3+515x^2-1975x+1500)}{2250}-$$
$$-170\frac{(x^4-36x^3+385x^2-1350x+1000)}{3500}+$$
$$+170\frac{(x^4-41x^3+365x^2-1075x+750)}{14250}=0{,}001x^4-0{,}129x^3+0{,}92x^2-0{,}075x+158{,}5$$

We apply the interpolation function of Lagrange (1) for polarization resistance from time to time in solution 98% H_2SO_4, for lines 3-; with OMCM2 coating 4- line

x_i	1	5	10	15	20
y_i	140	175	170	170	170

$$L_4^4(x)=140\frac{(x^4-50x^3+875x^2-6250x+15000)}{9576}-$$
$$-175\frac{(x^4-46x^3+695x^2-3650x+3000)}{3000}+$$
$$+170\frac{(x^4-41x^3+515x^2-1975x+1500)}{2250}-$$
$$-170\frac{(x^4-36x^3+385x^2-1350x+1000)}{3500}+$$
$$+170\frac{(x^4-41x^3+365x^2-1075x+750)}{14250}=-0{,}058x^4+2{,}735x^3-43{,}57x^2+192{,}975x-8{,}5$$



1-Line Correction Equation in Time

$$L_4^1(t)=0{,}011t^4-0{,}555t^3+9{,}635t^2-71{,}625t+21$$

2-Line Correction Equation in Time

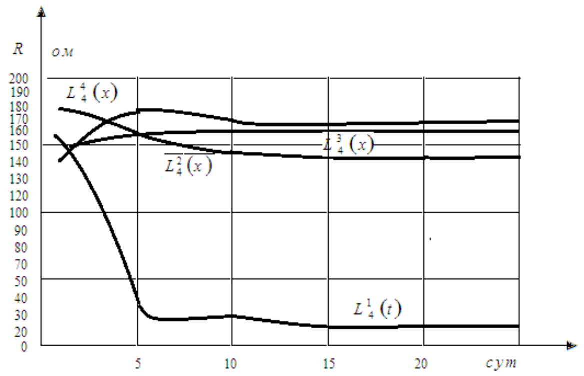
$$L_4^2(x)=-0{,}001t^4-0{,}055t^3+0{,}375t^2-6{,}125t+187{,}75$$

3-Line Correction Equation in Time

$$L_4^3(x)=0{,}001t^4-0{,}129t^3+0{,}92t^2-0{,}075t+158{,}5$$

4-Line Correction Equation in Time

$$L_4^4(x)=-0{,}058x^4+2{,}735x^3-43{,}57x^2+192{,}975$$



Picture 4. Examination of corrosion resistance of St-3 samples in different aggressive environments

$$(OMKM-1)x+(OMKM-2)y+(OMKM-3)=0$$

ER-20

$$100x+100y+100z=0$$

GR:

$$10x+10y+10z=0$$

AKF-78

$$2x+2y+2z=0$$

AKO

$$20x+0y+0z=0 \quad x=0$$

AKT-10

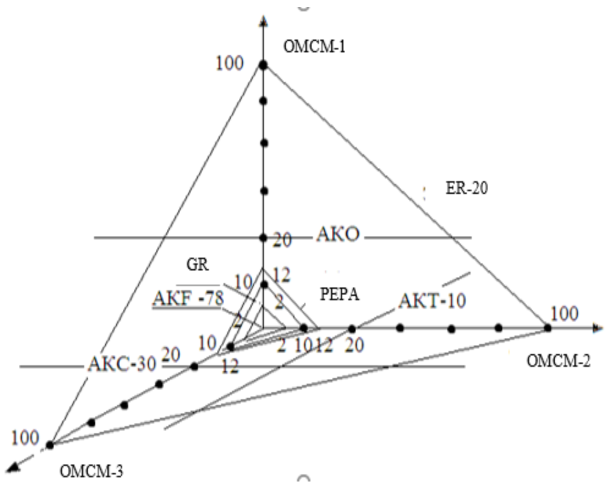
$$0x+20y+0z=0 \quad y=0$$

AKC-30

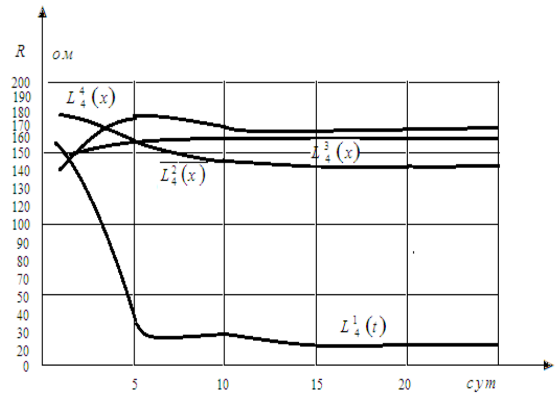
$$0x+0y+20z=0 \quad z=0$$

PEPA

$$12x+12y+12z=0$$



Picture 5. Compositions of organomineral materials for protective coatings for technological equipment operating in highly aggressive environments.



Picture 6. Dependence of polarization resistance of time in 98% H_2SO_4 solution

The analysis of the results of the processing mathematics has shown that the reliability of the data between the theoretical experimental values are within acceptable limits.

VII. CONCLUSION

Influences of strongly aggressive acidic environments on polarized electrical resistance of organomineral mechanochemical modified coatings obtained from mineral raw materials and energy resources are revealed. Compositions of organomineral materials for sewn coatings for use on working surfaces working in highly aggressive acid environments are proposed and applied. (92-98% H_2SO_4). Polarization resistance of the proposed organomineral protective coatings varies from 150-175 Ohm at a duration of 25 days; it shows that they can be used as protective coatings.

REFERENCES

1. Asish Gandihi. Storage Tank Bottom Protection Using Volatile Corrosion Inhibitors //CORTEC CORP. Supplement to Material Performance. Jan 3.
2. A. Grossman. Corrosion of Aboveground Fuel Storage Tanks// Material Performance, 2005, September, p. 44.
3. Tyutyuev A.M. Progressive technologies for an overhaul of the insulation coating of MG// Gas industry. - − 2005. - − № 2. - p. 74.
4. N.N. Glazov, S.M. Ukhlovtsev, I.I. Reformatskaya et al. Carbon steel corrosion in soils of different humidity // Metal protection. - 2006. - T. 42. - p. 645.
5. Medvedeva M.L. Corrosion and equipment protection in oil and gas refining: a manual for oil and gas universities. - Moscow: Gubkin Russian State University of Oil and Gas, 2005.
6. Nizev, S.G. Modern materials and coatings used for the corrosion protection of the main oil pipelines (in Russian) // Corrosia, NEFTEGAZ territory. - 2007. - № 2.
7. R. Heidersbach. Metallurgy and Corrosion Control in Oil and Gas Production. AjohnWiley&sons, inc.publication, 2011, p.280.
8. Baldaev N.H. Metalization protector coatings: Collection of reports in the catalogue of the II interbranch conference "Anticorrosive protection". - 2011.
9. Ziyamukhamedova.U.A., Bakirov. L.Y., Rakhmatov.E.A., Bektemirov.B.Sh. Structure and Properties of Heterocomposite Polymeric Materials and Coatings from them Obtained by Heliotechnological Method//International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8, Issue-3S, October 2019. pp.399-402
10. G.B.Yuldasheva et al. High-strength materials on the basis of the polytrafluoroethylene: monograph / G.B. Yuldasheva, S.V. Avdeichik, V.V. Voropaev, A.A. Skaskevich, A.A. Ryskulov; under the scientific editorship of V.A. Struka. - Tashkent: "VEKTOR PRESS", 2012. – p. 320.
11. Ryskulov A.A. Nanocomposite materials on the basis of the combined matrices for the protective coatings. (edited by ASRUz, Doctor of Technical Sciences, Professor O.U.Salimova and Doctor of Technical Sciences, Professor V.A.Struka) - Tashkent: "Fan", 2010. – p. 304.
12. A.B. Dzhumabaev et al. Fundamentals of ensuring the operational reliability of the heterocomposite polymeric materials for the machine parts: monograph / Dzhumabaev A.B., Sobirov B.A., Miradullayeva G.B., Bakirov L.Yu., Khalimov Sh.A.; under the general editorship of Prof. A.B. Dzhumabaeva. -TashSTU, 2018. –p. 440.
13. Investigation of structural formation processes of heterocomposite machine-building materials based on local minerals and thermosetting polymeric binders. Research paper report GBRP-2. - Tashkent: Tashkent State Technical University 2017. –p.106. (intermediate).
14. Gonik A.A. Prevention of sulfide-corrosion cracking of repaired steel tanks/// Metal protection. - 2004. - T. 40. - № 3. - pp. 325-328.