International Journal Of Engineering Research And Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 20, Issue 7 (July, 2024), PP. 349-353

Production of Metallic Corrosion Resistant Paints to mitigate Corrosion of Petroleum Product Pipelines

Ojoye Ololade Mariam, Danladi King Garba, Shuaibu Ochetengu Yakubu
Department of Mechanical Engineering
Faculty of Engineering and Technology, Nigerian Defence Academy
Kaduna, Nigeria.

ABSTRACT
Pipeline systems form a key part of transportation and distribution of petroleum products in Nigeria and disruptions to the performance of pipelines results in negative impacts in the oil sector, on the economy and the living and health conditions of the citizens. Many pipelines are buried underground to minimizecontact with external influences and others are on ground surface for operational reasons.In the petroleum industry, it is highly important to continually create new and improved corrosion mitigation, as not doing so will definitelybe more costly on the long run.One of the most economical and highly efficient methods of mitigating corrosion in the engineering world is the surface treatment method, alternatively referred to as coating. This research entails the production of metallic paints by a mixture of alkyd gloss paints and three high corrosion resistant metals as copper, nickel and chromium in the ratio 2:1.The development of these metallic paints serves as a method of protective coating to isolate petroleum pipelines from direct contact with the soil and atmosphere and to combat the high rate of pipeline corrosion in the oil and gas industry.
Keywords: *Corrosion, Metal-based, Paints, Petroleum, Pipelines, Mitigation, Performance.*

Date of Submission: 12-07-2024 Date of Acceptance: 26-07-2024

I. INTRODUCTION

Metals are limited resources which are extracted and produced from their ores by applying vast amount of energy. Therefore, it is highly important from the viewpoint of conservation of energy and resources to prevent metals from being lost due to corrosion and various depletion methods. Petroleum pipelines are the main artery of the oil and gas transportation system, pipelines have been the preferred mode of transportation for liquid and gas over competing modes such as truck and rail for many reasons such as: less damaging to the environment, less susceptible to theft, more economical, safest, more convenient and most reliable.The Nigerian geographical space is transversed by a network of oil and gas pipelines most of which are buried underground. These pipeline infrastructures are exposed to diverse and extreme climatic and soil conditions, the performance reliability of the pipeline also decreases with age and use. Corrosion of pipeline systems has over the years been the major source of failure, revenue loss in the oil and gas industry and this has birthed several means of corrosion control to manage and prevent the devastating consequences of corrosion. The annual expenditure for corrosion prevention in the world presently is about 2.5 trillion U.S. dollars, which is over 3.4% of the world's GDP [1]. Mild steel, also known as plain-carbon steel, is now the most common form of steel used in the oil and gas industry because of its unique material properties for various applications and relatively low cost.Carbon steel is used for at least 80% of all components in the refineries, petrochemical plants, oil and gas pipelines and chemical industries because it is readily available, inexpensive, and easily fabricated [1]. The use of anti-corrosion paints and coatings has proven to be the easiest and cheapest method for corrosion protection and prevention whichslows down corrosion rate drastically.Coating is the first defense line in any corrosive environment in which petroleum pipes are buried.The development of these metal-based paints is aimed at preventing and mitigating corrosion in underground and on-ground pipelines. For underground buried pipes where recoating is almost impossible in short durations unlike other structures, the coating must be made durable for a reasonable period, hence the development of these metal-based paints.

II. LITERATURE REVIEW

The Engineering World and Profession is faced with corrosion problems as most of the materials we make use of are metallic. The activities of corrosion can be seen as a great menace to engineering, as it deprives the industry a huge amount of money both in revenue and maintenance. The secret of effective Industrial Engineering lies in controlling and preventing excessive corrosion, because it is almost impossible to eliminate corrosion.Corrosion has been identified as the main challenge affecting the efficiency of the oil and gas

pipelines which are mostly made of carbon steel in Nigeria and most parts of the world. There have been various incidents of pipeline failure in Nigeria in recent years. It was reported that a total of 654 pipeline failures across six states in the Niger Delta region of Nigeria in the period 2012-2021. Corrosion accounted for 42% of these failures [2].

Tar coatings are the oldest coatings that used in oil and gas transition pipes. For example, in the 1940s and 1950s, coal tar, wax, and vinyl tape were used; it gives minimum protection and it is highly toxic and flammable [3].Chromium plating began in 1926, it has been relied upon for its strength and hardness [4].In the 1960s, asphalts were used; this method has been phased out, because it has some disadvantages like high water absorption during use, poor resistance to soil stress, poor resistance to plant roots, limited temperature range, etc [5].Since the eighties, polypropylene copolymer coatings have been used for the protection of the external surface of on-shore and off shore pipelines. [6]. In another work, an intelligent coating was developed based on encapsulation of benzotriazole (BTA) inhibitors in prepared SiO_2 nano particle-based polyelectrolyte nanocontainers, and self-releasing of the inhibitors for corrosion inhibition to a pipeline steel in a chloride solution [7].The newest technology being introduced is the multi-component system including the powder coated and extruded three-layer polyethylene and polypropylene coatings [8].

III. EXPERIMENTAL WORK / METHODOLOGY

This chapter entails the equipments,material and processes involved in the production of themetal-based corrosion resistant paints.In the course of this research and production, some metals have been carefully considered from the many options available and can be used for this process, the table 1 shows the process of selectionof materialsbased on the required properties for the purpose. Below are the metals powders sourced (Copper, Nickel and Chromium).

99.9% Pure Copper Powder99.9% high purity Nickel Powder

99.9% High purity Chromium Powder

Identification of type of paint to use for mixture

High quality berger oil paints were procured in the following colours (red, blue, yellow, green, brown). The colour variation is necessary for the effective differentiation of the samples. In addition to the paints, primers were also purchasers to be used as a surface foundation before the paint is applied.

Five different colours of oil paints

Procedure of Metallic Paint mixing

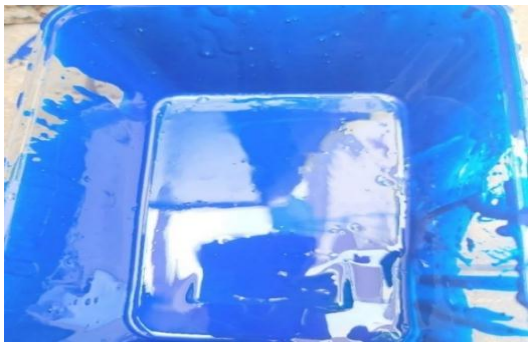
For this production, oil paint was sourced, the three (3) metal powders were mixed with different colours of oil paint in the ratio 2:1 (100g:50g). The variation in colour of paint was necessary for the purpose of differentiation. The copper powder metal was mixed with brown oil paint, the Nickel powder metal was combined with yellow oil paint, while the Chromium powder was mixed with blue oil paint. All combinations were vigorously and evenly mixed using a domestic mixer until powder was fully dissolved to enhance even mixture for application purpose.

Brown paint with copper powder

Mixture of Copper Metallic Paint

Yellow paint with Nickel Powder

Final mixture of Nickel Metallic paint

Blue paint with Chromium PowderFinal Mixture of Chromium metallic paint

IV. RESULTS

The metal powders mixed perfectly in the base paint resulting in finely mixed coatings which can be applied in different ways/methods due to their solubility.The metal-based paints are to be applied on steel petroleum pipelines to mitigate corrosion and prolong the lifespan of the pipelines in service.

V. CONCLUSION

The production of the three (3) metal-based corrosion resistant paints to combat petroleum pipelinescorrosion operating at ambient and elevated temperatures for both underground and ground surface was successful. The metallic based paint coatings applied on the carbon steel pipelines surface using a combination of modern oil paint and powder metals will improve durability and will definitely extend maintenance intervals, thereby increasing the lifespan of pipelines for approximately another 25-30years.The produced metal-based paints in this research is a break to tackling corrosion of petroleum product pipelines.

Table 1: Required Properties for the Selection of Materials for the Production of Metallic Paint

REQUIRED PROPERTIES FOR THE SELECTION OF MATERIALS	MATERIAL BEING CONSIDERED FOR THE PRODUCTION OF METALLIC PAINT							
	Copper		Aluminium		Chromium		Nickel	
Ability to mix well with paint		5		3		4		2
Corrosion resistance		4		5		4		2
Class of metal	Non ferrous		Non ferrous		Ferrous		Non ferrous	
Compatibility with corrosive fluids		5		4		3		2
Durability		4		5		3		2
Maintenance costs		3		5		4		2
Reaction with CO_2		3		4		5		2

Reaction to moisture		5		5		4		4
Reaction with acids		3		3		4		4
Availability of material		4		5		3		3
Cost of material		4		5		3		2
Reaction with soil microorganisms		2		2		3		3
Longevity		4		5		3		2
Density		5		3		2		4
Conductivity		5		4		3		2
Total		**57**		**56**		**48**		**40**

KEY

Colour code	Numerical value	Rating
	5	
	4	
	3	
	2	

REFERENCES

[1]. Corrosion in Petroleum Refining and Petrochemical Operations Published 2015 ASM Technical Books Journal "Corrosion in the Petrochemical Industry Second Edition"https://doi.org/10.31399/asm.tb.cpi2.t55030292

[2]. Zoran Petrovic "Catastrophes caused by corrosion" ResearchGate Publication January 2016 Vojnotehnicki glasnik 64(4):1048-1064 DOI:10.5937/vojtehg64-10388

[3]. Roder. Y. Coal tar enamel the protective pipeline coating of the past, present and what's new. Proceedings of the PIC on Conference, May 20, 2000, Canada.

[4]. Corrosion of Petroleum Industry Essay page 1. "Increasing Corrosion Resistance with Nickel-Chromium Coatings" thermalspray.com February 2021.

[5]. Krupavaram Nalli: Appendix VI "Corrosion and its mitigation in the oil and gas Industries" Willy Online Library 2012.

[6]. G.P. Guidetti, G.L. Rigosi, R. Marzola; "The of polypropylene in pipeline coatings" SpringerLink Journal 2019 Polymer Science and Technology Series Volume II.

[7]. Yuanchao Feng, Y. Frank Cheng; An intelligent coating doped with inhibitor-encapsulated nanocontainers for corrosion protection of pipeline steel. Department of Mechanical and Manufacturing Engineering, University of Calgary, Calgary, Alberta T2N 1N4, Canada researchgate.netJanuary 2017

[8]. Peter J. Singh; James J. Cox; Development of a Cost-Effective Powder Coated Multi-Component Coating for Pipelines. Paper presented at the corrosion 2000, Orlando, Florida, March 2000. Paper Number: NACE-00762, Published: March 26 2020.