

Analysis of Self Healing Epoxy Coating in Steel Pipelines

Mr. H. Bahuruteen M.E.,¹

Assistant Professor¹

Department of Mechanical Engineering
Velammal Institute of Technology,
Tiruvallur, India

J. Bharath Kumar², K. Praveen³, N. Venkat Ragavan⁴
^{2,3,4} UG Students

Department of Mechanical Engineering
Velammal Institute of Technology,
Thiruvallur, India

Abstract - The corrosion of ferrous metals is nowadays common in every metal of usage according to their load and natural event of a molecule used in pipe transportation. Transmission is the movement of goods in forms of liquid, electricity even types of loads in conveyors. This implies many issues on supplies of water, oil, and gas in transmission lines in many industrial applications for exporting and importing of fluids to their industry thereby frequent corrosion and cracking leads to deteriorating the pipeline. On replacing the transmission line may cause huge investment for maintaining the surface layers of the corrosion less cause thus, analysis of self-healing epoxy coating in pipeline helps to reduce investment as well as the improvisation of the surface material to avoid the moisture to let into the surface by making a barrier on to the pipeline. Normally the service life of a ferrous pipeline on frequent maintenance can be around 15-20 years. By coating the outer layer of oil pipe by three layers with the help of epoxies resin helps to be free from maintenance to exploit more years of service life.

Keywords: Corrosion, Epoxy Resin, pipelines, layers, Coating

I. INTRODUCTION

The pipe is a type of material that is used in the transmission of goods and fluids. These transmission lines are a long distance range in India from 2010 to 2017. The length of the total Natural Gas pipeline was 10246kms in India as on 31st March 2010. It is increased by 5.13% to reach 10772kms as on March 2011. The pipelines are about for transportation of Oil, Natural gas, Butane, Propane and types of hard viscosity like Food liquids and Beverages in food factories. The pipe is in a cross-section of circular, rectangular, even in hexagonal in shape. Thus, the pipe form helps in transmission even in the underground of fluid which makes in corrosion causing on the pipe by various types of agents such as atmospheric molecules, moisture, biological material and also in atmospheric conditions such as rainfall, acid rain, Earthquake^[1] and Tsunami. The paper is constructed as follows: The usage of commencement key concepts of underground transportation and summary of material illustration used in the every **urban underground rail system(UUR)**, the pipeline in **underground railway system** is the one runs within the former limits of the city by giving necessary way to penetrate into the tunnels mainly to transport the fuels and high kind of gaseous liquids. **Urban underground roads** move beneath a deep tunnel into the

soil of the cities having both entry and exit portals for transport the main lines from oil fields in marine irrigation from the soil.

The American Society of Civil Engineer (ASCE) estimates \$5.5 trillion required by 2027 to theorize substructure to acceptance conditions. And also, the ASCE tells a solution including "supporting research and transformation into innovative new materials, engineering science, and processes to regenerate and extend the life of infrastructure, expedite repairs or replacement and promote cost-saving". Steel is the mixture of various elements such as Carbon, Manganese, Cobalt, Chromium, Silicon, and potassium, etc., In this, the Carbon mainly decides the range of steel to in the which type of field for the usage or load purpose. There are 3 types of carbon steels they are., high, medium and low content of carbon. In high carbon steel, the content is up to 2.1% in weight. In medium carbon steel 0.29%- 0.54% in weight. At last, the low carbon steel composition 0.05%-0.25% of carbon content in metal. Thus the usage according to the necessary needs of the loading conditions. On placing the steel pipeline in the soil layer of the pipes get flooded up and mud compress with high pressure on the layer of the pipe material. Thus the high-pressure creation makes cracking in the body of the pipeline. Therefore, ^[5]crack develops and deteriorates occurs and needs a replacement of pipe cross-section and this increases maintenance cost and gets a problem in restoration. By developing the surface coating outer layer gets preventive covering from region moisture and sunlight this employs in the reduction of oxidation by preventing the impairment causing agent and reduces on cracking inch by inches. Nowadays usage of epoxy resin invention has made an evolution in the past decade this made to suppress many issues in material oriented Industries for implementing predicative corrosion that can make better protection for the material used to long years without corroding it. Let's see how epoxy helps?

The Epoxy resin's structure formula ($C_{21}H_{25}ClO_5$) which is an epoxied functional group of the polymer. Epoxy resin is also known as poly-epoxies. Epoxies are either themselves used through catalytic polymerize, with a wide range of co-reactants including polyamines, acids, phenol and alcohols, and thiols, etc., They are functionally utilized to form plastics and adhesives. They are higher resistance to chemicals and outstanding adhesion, durability,

and toughness have made them healthier in coatings. Even though it has high electrical resistance, durability at high and low temperature, and ease for cast without bubbles, epoxy resin is used in encapsulating electrical and electronic components and material, etc., Thus, the epoxies play a vital role in providing necessary coating invaluable needs for metal to fulfill the barrier between the corrosive layer. In this project, the Analysis of pipeline corrosion can be reduced by providing a necessary coating in means of three layers of effective layers of epoxies to fulfill the blockages on a molecule to the pipeline. The layers are described as follows: by coating three protective layers of epoxies such as Epoxy resin, Zinc Spray and Coal Tar. Thus, these level forms a preventive covering in transmission pipeline as necessary needs to reduce the obstacle from the atmospheric changes. The coating of pipe specimen is broken down by corrosion Test in means salt spray tested for standard temperature(°C), pressure(bar) for 10 days to prove the corrosion structure formation in the pipeline and viewed in Optical Microscope by vacuum filtration, and washed with deionized water and acetone before air-drying. Microstructural layers are imaged to determine the size distribution. Thus, let us see how is a mean done to provide resist corrosion.

II METHODOLOGY

A. MATERIALS

High carbon content steel used as the main source of specimen used for both Salt Spray Test and Optical Microscope which was tested simultaneously after the completion of salt spray test formation of layer scales and corrosive segment penetrate by the outer surface in the pipe sample. The pipe samples were brought in the ERW steel store. Then, the coating UV treated two parts and activator-Epoxy resin and Zinc Spray was brought from Shree chemicals Pvt Ltd., in Chennai. Then, the third layer Coal Tar brought from the Mythi paints Ltd., in Chennai. These layers are combined with every layer with adhesive strength named as glue. This was brought from Tirupathi samy stores Chennai.

B. MICRO-CAPSULE STRUCTURE

The operation was carried to condense the corrosive layer was based on the work of and is elaborated in discussion on a greater path in ShanQian^[4]. Concisely resorcinol(stabilizer), ammonium chloride which is mixed with urea with H₂O in a beaker for washing. The pH of the chemical liquid is 6.65 - 6.85 and stirred continuously for 15 minutes in a chamber and its temperature is 35°C. Tung oil was added into the bath to form a stabilized liquid or emulsion, in which the air pressure is about 14-18 Psi of air added into the bath. At last, concentrated Sodium chloride of 4.80-5.30% (NaCl) is added into the solution for testing for 10 days in salt spray with the coated pipe samples. And micro-structure of corrosive layer formation occurred. Then, the structure was an image in a Optical Microscope to discover the thick layers of coating.

C. EPOXY RESIN

(C₂₁H₂₅ClO₅) is the structural formula. The name "epoxy" refers to a chemical group of an oxygen atom

bonded to two carbon atoms that are already bonded in some structure. The epoxy is a three-member ring structure which is shown in figure II.1.

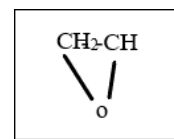


Figure II.1- Idealize Chemical Structure simple Epoxy (Ethylene Oxide)

Epoxy resin is easily curable at any temperature from 5°C to 150°C. The Epoxy Resin differs from polyester resins in cured hardener accustomed than the catalyst. The hardener, often an amine is helped to cure the basic need of addition reaction where broth material inter-mix together and forms a chain between the layer of metals and helps in this project attention to the anti-corrosion.

RESIN PART PREPARATION

The coating was prepared for a 10% weight of both adding two-parts of epoxy resin are added in a beaker. As a result of heating the epoxy at a medium temperature of 15°C for 5 minutes with continuous stirring of Epoxy resin and placed in a centrifugal mixer at 150 rpm for 1 minute then, kept in air drying before applying on the first layer of coating in the pipe samples.

D. ZINC

Zinc spray galvanizing is the process where a coating is applied to a steel surface by spraying with an atomized particle of molten zinc which has high anti-corrosive quality. The zinc spray was in the special combination of acrylic resin. Since it has a high density of 7.13g/cm³. Zinc when heated to 200°C it loses its elasticity and forms to zinc powder which is helped to form a liquid coating layer

ZINC SPRAY PREPARATION

Zinc spray was chosen to avoid the mixing of Epoxy resin with the Coal Tar and also the zinc prevents the outlet microbial in the soil. This acts as a cold galvanization against corrosion. The zinc spray To repair surface damaged by preventing in the corrosion over paint with air drying acrylic and synthetic lacquers which was heated up to 300°C. This product is a propellant-free CFC's. The 2nd layer was glazed with cleaning the epoxy layer and rinse with concentrated (NaCl) for 5minutes to avoid the microbial and dust interaction between the layer of zinc spray for the head of the bulge such as bubbling, pitting, etc.,

E. COAL TAR

Coal is biological material obtained from the earth crust this was extracted by various sources for many uses such as electricity, burning, and envelop of the coating. Coal has the chemical name of bituminous. The coal tar epoxy is a black surface protective polymer used on the surface to extremely corrosive Situations. It can be blended with various resins. It can be used in treatment facilities and tanks. This bituminous was brought in terms of the liquid container and it for 1 liter pure of Coal Tar.

PREPARATION OF COAL TAR

The Coal Tar was prepared by the pure content of grained coal mixed with crude oil to grain better and forms keen surface. A Non-Sticky beaker was taken to heating up the coal tar and gets into flame. The flame was heated at 120°C. The crude oil mixes well with coal tar heated to 70°C-80°C. While heating crude oil and the coal targets stirred to mix up well to form a high content-rich of coal on the oil. Then, the temperature is maintained for a long time and kept in air for a few seconds cooling before it gets sticky to the container.

F. CASE COMPOSITION

The specimen was prepared according to the current reference usage of pipes in the transportation of oil. The specimen matter is consists of high composition carbon content in steel material standard from ASTM 304 G1 grade was cut according to the cross-section. The material composition is silicon - 0.025%, manganese-0.060%, potassium-0.025% chromium 0.025%, etc., The cross-section was followed in test and statement.

III. RESULTS AND DISCUSSION

A. COATING PREPARATION

The coating was initiated to find whether the properties of mechanical and the corrosive strength of the pipe get balanced to each other. The specimen in the size flat surface of 2in X 1.5in X 0.10in (50mm X37.5mm X 4mm). This sample was created by a cut piece of the pipeline this was cutter grinder by which cutting cross-section of pipe gets cut in inches. The samples have three pieces of the same cross-section for testing both the corrosion test as well as the Optical Microscope. The three specimens represent the pipeline without coating, with coated with coal tar only and coated with three layers such as Epoxy Resin as the 1st layer, Zinc Spray as the 2nd layer, and Coal Tar as the 3rd layer.

All three specimen is treated to the outer surface and the inner surface of the specimen gets cleaned by high-pressure air to be free from dust and microbial environment. The coating is practical by dip coating on the Conc.H₂SO₄ to eliminate the rough surface while testing and to then, the specimen is etched to cure treat samples. The etching is the process of revealing micro-structure as polished evidence. In this project, specimen gets examination shallow etching for higher magnification to the sample on Optical Electron Microscope. After the etching is done, heat tinting is called thermal etching is used in this process to eliminate the oxidation on the inner molecule to avoid cracking while testing in salt spray bath. By this method coated and not coated specimen is tested for the corrosive strength which is to be done for 10days continuously to check the formation of scale layer^[6] on the surface of the steel.



Figure III.1 PIPE SAMPLES

As a Result, the entire progress is demonstrated in the scale of corrosive image formation on the steel material to engage that the not coated material is a highly corrosive formation of rust happens on the steel which was shown in the figure III.2.

SPECIMEN	0 DAY	4 DAY	9 DAY
uncoated			
Coal Tar coat			
Epoxy Zinc Coal Tar Coated			

Figure III.2 CORROSION TEST

The steel gets corroded when it treated to salt water because the sodium chloride in the salt forms a layer on the surface which is the same when reacted to the atmospheric conditions such as weather environment such as rainfall, Acid rain and muddy environment on the soil.

By the corrosion test, the procedures as followed, The test parameters on the salt test at a chamber temperature of 34.5-35.5°C. Since this temperature is very important in placing the specimen which should be even throughout the working environment. Then, the pH of the salt solution is maintained at 6.65-6.85 which is to be maintained as Acidic. This acidic solution helps in making the corrosion scales formation in then, the volume of salt solution collected is 1.00-1.50ml/hr. The volume is the content of the solution used in the salt bath for the testing. And also the concentration of the solution is maintained at 4.80-5.3% of Sodium Chloride solution (NaCl) throughout the testing of pipe samples. The atmospheric condition such as Air pressure is maintained at 14-18Psi on to the entire bath to prevent the many other problems on while testing like bubble formation or any harmful gases wasting the solution needs.

Even though the entire simple calculation is done the Specimen is loading in the chamber position is 30 Degree Angle to have a free solution flow on the pipe cross-section.

On entire progress the final results tell that the sample gets weight on every day on testing the specimen gains 0.002oz/day on the third day it gains 0.006oz/day. The fluid ounce (oz) is a measure of volume on a sample on the fifth day it acquires 0.009oz/day. On the tenth day 0.012oz/day such that the formation of corrosive layer formation on weighting it every day it gets the rust-brown surface and formation of main cracking as the root then, the deterioration of pipe occurs and the imaged views are clearly on figure III.3. Even though, the Coal Tar coating gains corrosive layer on forming from the depletion of the coal layer on the specimen II. It gains on weighting it gains 0.001oz/day, at last, it has a weight of 0.003oz /day. This implies the salt test to create rust on the sample. At last, the three-layer sample on having the big layer no formation scale layer of rust-brown content in the pipe sample. The entire progress is imaged on every day in the imaging devices as a photographic image as a document.



Figure III.3 OPTICAL MICROSCOPE

IV. CONCLUSION

The manuscript was elaborated and proved that eliminating the oxidation can be done on following procedures by detecting the layer scale rust fabrication which was demonstrated by the weighing sample. Thus, the increase in the layer thickness can help in reduction in scales now it can reduce the maintenance cost and inventory cost by reducing the damage by giving a protective layer of epoxies on outer layer testing with salt analysis on comparing with coal tar and not coated it elaborates on weighing it the composition of rust dust established oz/day. Thus, the three layer gives a replacement on galvanizing, replacing of pipeline, and maintenance of underground pipes. As the name indicates self healing is the zinc combines with two layer acts as a healing for biological matter and soil element in the ground. On implementing this type of coating the problems on the soil pipe cracking eliminated. Thus they are proved according to the replenishment and this type of coating without cracking and increases the lifetime of pipeline transmission.

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