Overview Production Process and Properties Of Galvanized Roofing Sheets

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Abstract
In search for solution to the challenges posed by the degradation of roofing steel sheet in an aggressive environment, galvanization of steel sheet for roofing of buildings and manufacture of other Engineering structures has been a valuable remedy. Galvanization of steel in recent years has emerged as a physical barrier which minimizes the penetration of contamination of sulphide and chloride ion. Zinc coating of steel top surface is a strategy that has been found to be effective for wide range applications. Galvanized steel sheets have been widely used by various manufacturing company. Occasional switching from steel to other metal like aluminum have not been cost effective because of the present economically situation. This makes substituting galvanized steel difficult. This mini review provides insight to the production process, stages and properties of galvanized roofing steel sheet use in Nigeria and most part of Africa.

Keywords: Steel; Zinc; Coating; Galvanizing; Roofing.

١,٠ Introduction

Prevention of Galvanized steel roofing sheet against degradation have become a ceaseless and intractable challenge of global interest. Deterioration of the sheet occurs naturally in an attempt to return their initial, stable, oxidized state. The magnitude and severity of the degradation of Galvanized steel roofing sheet is not only a function the material used but also its operating environment [١]. Global cost of replacement of roofing sheet in the developed and emerging economies is astronomical [٢]. Galvanized steel sheet resist degradation by a sacrificing the topmost layer made of zinc so as to combat environmental degradations which could result in pitting of the surface [٣]. Galvanized steel structures have been widely used for exterior constructions such as crash barriers, lamp poles, fences, buildings, facades, and roofs in the contemporary metropolitan society. The application of zinc on metallic surfaces had been carried out either by hot dipping or electroplating process [٤]. Hot- dip galvanized steel sheet is produced on continuous zinc coating lines either by hot or cold rolling in coil form. The thickness of sheet produced from hot rolling ranges from ٢,٠١ to ٣,٠mm while that of cold rolling ranges from ٠,٢٧ to ٢,٠mm [٥].

By galvanizing, protection of the steel structures against corrosion resistance is improved by numerous degrees of magnitude; the corrosion protection achieved by zinc-based coatings is as a result of the galvanic effect, because zinc is anodic to iron which make it acts a sacrificial metal in an aqueous or humid environment [٦], however, resistance to surface degeneration can be further enhanced by the incorporation of top coat on the galvanized surface [٧]. Galvanized steel sheets are also known for excellent shiny surface and formability attributes besides satisfactory peel-off resistance and fusing of the coating completely to the steel surface [٨].

Galvanized steel roofing is designed to serve for several years. Closed ٥٠ % of the annual world zinc production which is about ٣ million tons is utilized for the galvanizing steel so to minimize

the corrosion rate of steel in a corrosive environment [٩]. The Galvanization is the largest single use of zinc due the ability of zinc to form protective oxide and hydroxide layer that act as a barrier to environmental degradation. The presence of water usually increases the rate of corrosion, with the initiate corrosion product being zinc hydroxide which is further converted via the action of some air pollutants. However, it is very important to note that environments moisture penetrates unprotected zinc and expose the steel to white zinc corrosion, also known as “wet storage stain” or “white rust.” White rust is the result of electrolytic reaction which occurs within the steel sheets when water exists without oxygen. The red rust occurs when the zinc coating completely breaks off the back of the steel substrate. These challenges have continuously shortened the lifespan and also impact on the cost of replacement of the sheets [١٠].

Moreover, corrosion of galvanized steel sheet can occur via chemical or electrochemical reaction [١١]. Destruction by electrochemical corrosion takes place via electrolyte action over the sheet metal. The conductive electrolyte solution such as saline or acidic solution can result in different forms of corrosion such as uniform, pitting or erosion of the zinc coated layer of the galvanized steel due to the passage of current from the anodic to the cathodic area. The fall of acidic rain on galvanized roofing sheet can be highly destructive. Acid rain is a product of the atmospheric reaction of Sulphur dioxide and nitrogen oxides with oxygen in the air to form sulphuric acid (H_2SO_4) and nitric acid (HNO) with pH of ٥ or less, which falls on the roof as rain, snow or dust. Sulphur dioxide comes majorly from smelters and power plants use for coal burning. Flaring of gas, automobile exhaust and bush burning are the chief sources of atmospheric pollution that result in acid rain. Because an electrolyte is a requirement for corrosion, roofing sheets tend to corrode, wherever acid rainwater and/or condensation cannot flow off or becomes trapped [١٢]. However, Galvanized steel sheets can be corrosion free for a very long time if used in suitable environments. Galvanized roofing sheets can last for ١٥-١٨ years in rural regions and ٣-٨ years in areas of industrial locations especially in the Niger delta region of Nigeria [١٣, ١٤]. This is an indication that the galvanized sheets have greater service life compared to bare uncoated steel sheets. Weather resistance test has shown clearly that galvanized steel sheets are ٥-٣٠ times slower than that of steel sheets [١٥].

There are numerous applications that have necessitated the use of galvanized steel due to their formability. Although the major attraction for the choice of galvanized steel have been on the ground of corrosion resistance ability. However, zinc-coated steel sheets with better corrosion resistance with high degree of formability can be achieved if the processing parameters such as the zinc bath composition are controlled. [١٦] used the results of tensile test and simulated experiment to evaluate steel sheet formability. Two important parameters of the sheet; work hardening anisotropy and exponent coefficient can be determined using tensile test. These two parameters are criteria against these parameters thinning and necking during plastic deformation, respectively. More so, the study carried out by [١٧] provided an insight into the crack propagation and fracture behaviour of galvanized steel sheet. The initiation of Cracks in galvanized coatings were discovered to take place near the interface of the steel coating layer as a result of thermal stresses which eventually propagates towards the exterior layer of the International Conference on Engineering for Sustainable World coating. However, the susceptibility of the galvanized coatings layer to crack propagation due to thermal stress can be minimized by increasing the coating thickness [١٨].

Generally, coating of steel substrate is commonly utilized to prevent degradation in contaminated atmosphere [١٩]. However, coatings of steel with only zinc have been discovered not to be as effective as the inorganic and organic coated galvanized steel sheet [٢٠]. They were found to possess unique metallurgical features and better corrosion resistance in under a destructive weather condition. In the same vein, Galvalume coated steel sheets (steel coated

with some percentage of Al-Zn) have also been to exhibit better mechanical and electrochemical properties [٢١] such as yield, tensile strengths, lower total elongation and corrosion resistance compared to galvanized steel sheets. Galvalume coated steel sheet was also discovered to retain it appearance at a higher temperature range compare to galvanized steel sheets [٢٢]. More so, comparative study of corrosion behaviour of galvanized steel carried out by [٢٣] revealed that galvanized steel roofing sheet failed in a simulated carbonate and chloride environments. This assertion and the work of other researchers instigate a search for better, alternative or improved roofing materials especially in industrial area where chloride or carbonate contamination is possible. Recently, the use of organically and inorganically coated galvanized steel products in a wide variety of industries has grown dramatically due to growing requirements on performance [٢٤]. From the assertion made by [٢٥] materials used for roofing required essential properties such as formability, good corrosion and high-quality appearance. However, environmental friendliness of material is becoming essential. Development of ٥٥٪ Al–Zn alloy coated steel sheet with organic composite coating suppresses the progress of corrosion and surface cracks prominent with the roof made of zinc or Al-Zn coated steel sheet. The organic composite coatings instinctively form a protective film which was able to inhibit the triggered corrosion mechanism in the steel under severe condition such as acidic rain or presences of dissolved salt. More so, the mixture of a pigment of the phosphate type with a calcium containing pigment produced