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Corrosion in Agriculture Instruments and Equipments : Reasons and Solutions.

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- **Abstract-**

Corrosion is universal problem and makes losses in all sectors in global economies. Agricultural sector is one of those highly impacted sectors due to corrosion. The Corrosion or rust constantly affect working and lifespan of the agricultural equipment and instruments. It is a problem that must be addressed and treated as soon as possible to avoid severe accidents and economical losses. But, the corrosion problems in agricultural equipment occurs in many ways as it has diversified conditions and environments.

In order to create a solution for any agricultural equipment, one must evaluate their particular needs. Today diverse and complex equipment is used in agriculture, together with chemical and biological products which are frequently corrosive and by nature, mostly agricultural activities are outdoors, exposed to various environmental elements and conditions. All this makes corrosion a key reason in agriculture, yet it is generally not given the importance it deserves. Fertilizers, Silage, Herbicides and pesticides, Slurries and manures, etc contains corrosive contents which leads to Corrosion in Agriculture equipment and machinery. This paper contains the reasons which are present for the corrosion occurring due to actions of these agricultural chemicals and their convenient and inexpensive solutions to farmers.

- **Keywords-** Corrosion, Agriculture, Corrosion inhibition, Rust, Equipment, Instruments, Fertilizers, Pesticides, Silage, Herbicides.

- **Introduction-**

Agriculture is the basic sector of all major economies in the world. Major Industries are dependent on the agricultural sector. As many other businesses are highly depending on the agricultural activities. Many instruments and equipments are major need of agriculture. So, facing corrosion of these instruments and equipments is one of the major issues Infront of farmers as it directly impacts economically and also reduces the life span of the instruments and equipments. Soil is an essential element of the earth's ecology; living would be nearly impossible without it. It contains an integrated system of organic and inorganic matter recycling, making it a natural growing medium for plants. Organic and inorganic materials are included. This soil also affects the oxidation of materials that come into direct contact with it. In agriculture many instruments and equipment are in continuous contact with soil in all seasons like summer, rainy and winter. So, it has higher chances of getting corroded. Corrosion occurs when materials deteriorate due to chemical interactions with their environment. Corrosion has a wide range of impacts. These have far more serious consequences for the safe, reliable, and efficient operation of equipment or structures than just losing a mass of metal. Corrosion can also apply to the deterioration of polymeric materials, concrete, and wood, but it most commonly relates to metals. Iron (typically steel) is the most extensively used metal, and the following section focuses on its corrosion. Corrosion has a wide range of consequences, and the effects on the safe, efficient, and profitable operation of equipment or structures are frequently more severe than the loss of a quantity of metal. Even if the amount of metal lost is minimal, failures of various kinds and the need for costly replacements may arise. [1,2]

Many factors like Environment, Chemicals, Fertilizers, Pesticides, Slurries, etc are majorly impacting the corrosion in agricultural instruments and types of equipment.

- **Some of the most serious consequences of corrosion: -**

1. Metal thickness reduction causes mechanical strength loss and structural failure or disintegration. Very significant weakening can occur when metal is lost in concentrated zones, resulting in a crack.
2. People's hazards or injuries associated with structural failure as well as breakdown (e.g. parts of instruments, screws, bolts, blades, etc.).
3. Waste of time in the availability of profile-making industrial equipment.
4. Reduced value of goods due to deterioration of appearance.
5. Contamination of fluids in vessels and pipes (e.g. beer goes cloudy when small quantities of heavy metals are released by corrosion).
6. Perforation of vessels and pipes allowing the escape of their contents and possible harm to the surroundings. For example, a leaky domestic radiator can cause expensive damage to carpets and decorations, while corrosive seawater may enter the boilers of a power station if the condenser tubes get perforated.
7. Loss of technically important surface properties of a metallic component. These could include frictional and bearing properties, ease of fluid flow over a pipe surface, the electrical conductivity of contacts, surface reflectivity, or heat transfer across a surface.
8. Mechanical damage to valves, pumps, etc, or blockage of pipes by solid corrosion products.
9. Added complexity and expense of equipment, which needs to be designed to withstand a certain amount of corrosion, and to allow corroded components to be conveniently replaced. [3-4]

Corrosion, on the other hand, is one of the most serious issues in agricultural instruments and equipment. Most manufacturers don't think about it. This issue has a significant impact on the survivability of agricultural equipment and instruments. Corrosion in agricultural instruments and equipment is influenced by a variety of factors. In this paper, we will focus on the chemical effects of corrosion on agricultural machinery.

 Factors responsible for Corrosion in Equipments-

Corrosion is one of the worst enemies of farm machinery and infrastructure. When corrosion is occurring, staining and distortion of metal surfaces are observable. Corrosion develops and degrades surrounding materials if left unattended. Many tractors and trucks are made of thick steel that can resist corrosion for a long time, but corrosion can attack it and damage it completely. At the conference of 'American Trucking Associations' Technology and Maintenance Council, one manager described rust-through on axle carriers that had gotten so bad that axle shafts interior had begun to corrode as well. This occurred on a tractor which was only very few years old at the time. According to Makanjuloa Oki and Paul Anawe's "A Review of Agricultural Industries," the agriculture sector is extremely susceptible to corrosion. Chemicals used in agriculture, such as acid preservatives, fertilisers, and manure, are all common causes of corrosion. According to the authors, fertilizers comprising a nitrogenous solution of ammonium nitrate and urea readily react with steel, even though the reaction is strong at welds and bolt holes. Phosphate solutions including ammonium phosphate are now less reactive toward steel, according to the same study, because they generate a phosphate passive layer that shields the underlying substrate. Because of variation in environmental and site conditions, each corrosion situation is different. To minimize corrosion damage, pay attention to what factors are all within the control. Corrosion isn't only an aesthetic concern; it also has major consequences for equipment's performance and survivability. Corrosion's most important effect is the degradation of metal components. Metal surfaces that are constantly exposed to moisture are much more prone to undergo corrosion damage. Moisture-induced corrosion can cause holes and cracking in essential wheel components. The wheel can become unusable if left unattended.

- **CORROSION BY AGRICULTURAL CHEMICALS –**

Fertilizers, grain and silage preservatives, pesticides, disease and weed management, and specific acid compounds used for cleaning milking equipment are just only few examples of chemicals regularly utilized in agriculture. Farm waste products and sludge have a character for being extremely corrosive. Acid preservatives, additives, specific fertilisers, and manures/slurries are also among the chemicals which cause the most damage to farming equipment and instruments. Acid cleaning solutions can be used in conjunction with environmentally preferable and biodegradable corrosion inhibitors to minimize their serious consequences of corrosion. [5-10]. Variable types of fertilisers have various proportions of corrosivity. Corrosiveness is evaluated by decomposition or reactions that produce aggressive compounds such as ammonia or hydrogen sulphide, especially where chloride ions, such as potassium or ammonium chloride, are present or where acidic environments exist. Ammonium nitrates and di-hydrogen ammonium phosphate, for example, are known to trigger corrosion damage via hydrolysis to acids, resulting in a pH decline. Compound liquid fertilisers' corrosiveness may be influenced by the ratio of necessary plant nutrients. The effect is most recognisable in fertiliser solutions containing approximately 15% nitrogen, especially when half of the free nitrogen comes through urea and half through ammonium nitrate.[11]

Fertilisers containing nitrogenous solutions of ammonium nitrate and urea react slowly with steels, according to a study, and the reaction accelerated at welds and bolt holes. Welded steels suffer from alloying component degradation in the heat affected zones (HAZ), and bolt holes include crevices where corrosion will be largely caused. Phosphate solutions containing ammonium phosphate are much less aggressive towards steel, generating a phosphate passive layer that protects the underlying substrate, according to the same study. There is very less or absolutely zero rusting when fertilisers are dry. However, mostly because their hygroscopic nature, they are sensitive to absorbing moisture and becoming corrosive. Fertilisers are becoming hygroscopic at a certain relative humidity, and the estimate for ammonium nitrate is 60%, making the compound very corrosive because it turns into liquid at that low relative humidity. [12] Some another phosphates typically absorb moisture when the RH is more than 90%. Fertilisers cake whenever it come into contact with moisture, increasing their abrasive characteristics dramatically. It is recommended that steel be galvanised to improve corrosion resistance. Fertiliser chemicals are much more aggressive for corrosion towards mild steels if compared with galvanised steels, according to tests.[13]

In the first year of exposure, corrosion rate values for 63 percent saturated ammonium nitrate solution are all around 250 mm for galvanised steel and 1,250 mm for mild steel. As long as proper surface cleaning, preparation, and coating are done, carbon steel is a low-cost alternative for fertiliser storage. In studies performed over a three-year period, type 304 stainless steel was observed to be the most beneficial for liquid fertiliser service. For Type 304 stainless steel, carbon steel, and 5052 aluminium, penetration values reported for tanks exposed to commercial liquid fertilisers for almost 2.5 years are in the range of 0.253, 282, and 132 μm, respectively. Good equipment design and improved maintenance and cleaning can help control the beginning and continuation of corrosion caused by fertiliser solutions. In addition, using inhibitors with fertilisers while storing, transport, and spraying helps to avoid deterioration. In the absence of urea, sulphur compounds such as thiourea, ammonium thiocyanate, and 2-mercapto benzothiazole are shown to be capable of inhibiting for mild steel subjected to a mixture containing ammonium nitrate, ammonia, and water. Polyphosphates like sodium polyphosphate and dibasic ammonium phosphate have shown potential for treating aqueous ammonium nitrate/ammonia/urea. By interacting with orthophosphate to develop a complex salt, free ammonia can minimise the inhibitory effects of the compound orthophosphate. [7] Furthermore, there is a vast supply of renewable plant-based inhibitors that are readily available for usage in agricultural applications. Organic acids created during the ensilage process can lead tower silos to cause corrosion. Whole crop maize silage ferments quickly, resulting in acidic byproducts with pH concentration as low as 3.6, which are extremely corrosive to silos' internals. [12] In a similar manner, secondary fermentation occurs when lactic acid, a stronger acid, is combined with air, resulting in silage that is primarily butyric acid and has a higher pH value. However, because temperatures within silos are typically higher than those outside, corrosion rates inside silos are typically higher than that on the external walls. This makes sense because every 10°C increase in temperature doubles reaction rates, including corrosion of metals.

Over the years, formic acid has now been implemented to prevent mould and bacteria from growing on stored grains. Various aliphatic carboxylic acids, such as propionic acid, are being used in the previously. Because the contact time for acids on equipment, such as spreaders and shredders, is typically short, mild steel corrosion rates are generally low. Propionic acids are extremely corrosive; however, by taking the proper measures, such as effectively eliminating acid-treated grain from the silo after usage, rinsing with water, and avoiding contact of treated grains with unprotected equipment, damage can be minimized. Acid-treated grains are less susceptible to corrosion during storage, with the essential caution being to avoid concentration in local places such as crevices or even where stationary pools of liquid might easily accumulate. [14] Metals suffer from asymmetrical oxygenated corrosion in such crevices, which is hazardous to them. The problem of paint-stripping properties associated with organic acid additives can be contained by the modification of their compositions. The development of a complex by introducing a cation to an organic acid, for example, renders it inefficient as a paint stripper. Others have noted that silos made from aluminum have a serviceability of over ten years, whereas enamelled steel is preferred for its simplicity in maintenance and cleaning. [15,16] Plastic coats and enamelled materials are prone to cracking, which can lead to the formation of crevices, which can lead to crevice corrosion.

When galvanised steel comes in to the contact with silage fluids and slurries, which are generally acidic, it corrodes immediately. Aluminium is the most popular metal for making storage vessel, next after galvanised steel and mild steel. [16] Because silage out from bottom of the silo seems to have a consistency similar to chipboard, equipment used to transport and unload it can lead to corrosion. Concrete is especially vulnerable to abrasion and acid damage because acids are widely recognized to react with lime, causing the concrete to become friable. As a result, the concrete begins to crack and eventually spall, trying to expose the internal structure to the environment. Acid-resistant plastics, chlorinated rubber, and epoxy-based coatings will also provide alternatives to concrete as floor coverings in agricultural environments.

- **Corrosion due to Slurries/Manures and its solution-**

With the animal domestication that were previously hunted in the wild, animal husbandry has increased exponentially. Grasscutters, rabbits, and rising demand for cow's milk, goats, and other related species have all contributed to increased in associated manure and waste management issues. As a result, manufacturers are paying close attention to equipment and associated handling devices in order to develop materials that will cope with the rapid increase in waste creation. Slurries are dung and pee combinations that are composted with litter (often straw or wood shavings) to create farm yard manure. Farm yard manure (FYM) ferments to generate moisture, ammonia, and carbon dioxide, which, when combined with naturally excreted chlorides from animals, form the most corrosive component of slurries and farm yard manures. Steel structures and poorly maintained agricultural materials and instruments are very corrosive. Choice of materials and prevention of crevice conditions in the designing phase play a role in preventing gradual corrosion damage such as machinery seizures. Galvanized steel is not particularly useful for some manures, particularly those generated from poultry and livestock, as per the findings. [13] However, for livestock floors, manufacturers still use galvanised steel or concrete. Test results suggest that galvanised metal thickness losses are close to 0.1 mm/year in piglets served copper compounds. This could be due to the local deposit/galvanic corrosion effect. It has been found that when silage effluent and slurry are mixed, a harmful composition of hydrogen sulphide gas may occur, encouraging the production of corrosive acids below deposits.

- **Corrosion by Herbicides and Pesticides and its Solutions-**

Chemicals for crop protection have grown dramatically in the last decade. Herbicides and insecticides have both enhanced corrosion at almost the same timeframe. This is especially visible in some situations, such as when hazardous species aggregate in particular locations. Copper-bearing fluids, such as the Bordeaux combination, which is made up of copper sulphate, water, and lime, are quite aggressive to aluminium, zinc, and galvanised steel. This may be particularly hazardous to newly galvanised structures. The use of copper-bearing fluids causes a considerable rise in 'zinc drip,' according to evidence from glasshouse structures. Local copper deposits are believed to enhance anodic dissolution of zinc in a compatible electrolyte, resulting in the observed "zinc drip." Within a nine-month period, serious waterline attack on steel drums containing aqueous TCA, sodium trichloroacetate-weed-killer has been observed, with heavier attacks on aluminium, galvanised steel, various brasses, and copper, while tinned steel and molybdenum-containing stainless-steel Type 316 were more resistant, and should essentially be the preferred choice in the fight against corrosion. Common weed killers, like as nitro-phenolics, have been linked to the corrosion of steel spraying equipment; however, restricted oils and greases have been shown to prevent waterline corrosion caused by differential aeration corrosion. Even though use of mild dichromate solution as an inhibitor has been successfully accomplished in corrosion protection caused by furfurals and similar chemicals, they have been linked to cancer and are extremely harmful to the environment.

Several protocols have limited its use in most industries. Chlordane, DDT in salt water, and sodium arsenite are some other pesticides and weed killers that corrode metals. For usage with herbicides and pesticides, stainless steel seems to have the best corrosion resistance, although aluminium and its alloys have performed moderately. Insecticides mixed in fuel oils, on the other hand, are observed to be much less aggressive since the solvents are petroleum-based and can coat metal surfaces with a thin coating, acting as inhibitors.

- **Corrosion in Milk processing plants and it's solution-**

In the dairy business, stainless steels are widely used. Corrosion is expected to be low and infrequent in this area. However, unique issues with cleaning and sanitation of machinery and equipment may occur, requiring the use of steel structures to protect them from milk wastes. Lactic acid, for example, can corrode 1.25 mm of steel in less than a year. Most metals involved with dairy industry instrumentation are susceptible to corrosive agents including chlorine, which including sodium hypochlorite disinfectant. Stress corrosion cracking is determined by the combined actions of stress and chlorides in situations where stainless steel is used, especially at temperatures around 70°C [2, 17], and its usage should be prohibited in the presence of caustic solutions within such a temperature range. Furthermore, phosphoric acid should not be used to remove scale or milk stone from aluminum-based equipment, and tin surfaces should never be overtreated to prevent tarnishing, which could discolour dairy products.

- **Corrosion In High-Risk Prone Areas and Its Solutions-**

Corrosion impact to buildings and infrastructure is equal to affect to machinery and equipment, according to a survey conducted of farmers and horticulturists. Metals like galvanised constructions and sheeting, some animal buildings – particularly piggeries – and systems that handle fertilisers and slurries, according to evidence, are high-risk regions where chemicals, often in conjunction with wear, can have a considerable impact.

- **Structures and Buildings-**

When the shielding zinc coating on galvanised structures is destroyed by acids, salty conditions, or any strong alkali, corrosion occurs. This is significant since galvanised sheets in rural regions can stay more than 30 years, whereas in a very polluted, industrial location, where acid rains are blamed for corrosion, the life span can be as short as five to ten years [18]. Aggressive soils, such as peat soils or marshes containing sulphate and chloride, or acid conditions, on the other hand, lead galvanised steel to corrode rapidly than it might at ground level in some constructions. Galvanized steel is also unable to resist the heavy condensation that is frequent in farm structures. Buildings located in coastal or other extremely corrosive environments are frequently advised to be painted. Calcium orthoplumbate alkyd primers with a matching alkyd top-coat are consistently easier to put on galvanised steel, where they have confirmed advantageous in minimising corrosion ravages. Because animal homes are frequently contaminated with ammonia, it is normally advised that the roof be built of double sheeting and that adequate aeration with adequate air openings must be maintained. [15] Copper-containing alloys should be avoided in material selection, while corrosion-resistant materials lacking protective coatings are the most basic designs targeted at decreasing condensation effects under roof surfaces. Gases, dust, and stink will be removed from a well-ventilated piggery, while air temperature and relative humidity will really be maintained. Furthermore, extra heat and moisture will be minimised, ensuring proper oxygen levels. To maximise ventilation, naturally ventilated shelters should be spaced by five times their height [19].

Fixtures and fasteners for structures and equipment should be used with attention to minimize crevice corrosion as metals/alloys come into contact with wood, especially if coated with preservatives including copper, mercury, or fluorides in moist circumstances. When copper and mercury are short-circuited, the anodic, more reactive metals, such as aluminium or steel, will cause corrosion preferentially as a result of galvanic corrosion. Metals in touch with wood can be protected by using an appropriate tape or bituminous layer to isolate the region, or by soaking the metal in lanolin or tallow prior to installation. Some woods are naturally tough and can withstand a variety of conditions, including contact with the surface or other moist materials. Jarrah and teak can survive for over 50 years, but other woods like chestnut, pine, and cedar can only last for 20 years. The majority of red wood used mostly for glasshouses in Europe is preserved and protected with preservative to reduce the risk of decaying. [20] When timbers are not protected with a preservative, it is suggested that they be painted; however, some paints, such as emulsion, are harmful to plant development and therefore should be resisted. Furthermore, vapours released during wood seasoning are corrosive and erode surrounding metals even when they are not in touch in poorly ventilated areas. This is widespread in trees like oak and sweet chestnut, and it should be managed to avoid when used in conjunction with metallic building surfaces.

Strong chemicals from poultry and pig husbandry can result in the degradation of farm fences, which can last up to 14 years on average. According to Loto and coworkers, galvanised steel has a longer life duration over wood and mild steel for fencing and gates. [13] This is also widely recognized that zinc used in cereal farms with a lot of lime and chemical sprays is more highly susceptible to attacks. This could be because zinc is anodic to mild steel, and the zinc particles will just protect mild steels in their near vicinity, leaving wider unprotected areas exposed to corrosion, resulting in uneven corrosion patterns. Gutters may deteriorate unexpectedly due to poor care or installation in inconvenient locations. Sloped guttering is preferred to prevent premature failures by reducing the generation of silt deposits and preventing the collection of pools of stationary liquid, which are most often acidic solutions from cleaning methods.

- **Equipment and Instruments-**

Equipment that handles chemicals, particularly artificial fertilisers and slurries, should be highly considered because they are the most prone to corrosion. To this aim, proper equipment maintenance and care should be conducted after each usage and during off-season storage. Corrosion can occur in numerous of ways, including the seizing of equipment and moving parts, as well as gradual unexpected leakages. Differential aeration causes crevice corrosion in poorly drained parts, joints, and other areas in agricultural establishments. In this situation, corrosion can be efficiently handled by appropriate maintenance, which should be reinforced with the use of inhibited greases and oils for temporary protection, as well as waterproofing. While it may be more cost effective to utilise more anticorrosive alloys and metals for agricultural equipment, some polymers are not too weak for parts of the equipment. Many agricultural conditions are found to be favourable for nylon, polypropylene, and acrylonitrile butadiene styrene (ABS). [21] Galvanised steels are more resistant to the impacts of agricultural residues from livestock than mild steels, according to corrosion experiments. [13, 22]

• Conclusion-

To avoid severe corrosion effects on machinery and equipment, appropriate cleaning and partial corrosion protection with inhibited oils and greases must be applied prior to storage in a well-assessed facility. Agricultural sites should be located away from extremely polluted industrial and salt-laden coastal locations; differing environments cause varied corrosion rates on construction materials. Static situations should be avoided, and the both external and internal faces of buildings and structures must be carefully protected with environmentally friendly paints and coatings. Designs that encourage condensation should also be avoided. Because the agricultural or farming surroundings is harsh on machinery and facilities, they must be protected on a regular basis from water, fertilisers, cow faeces, and pesticides. As a result, proven and thoroughly tested corrosion prevention procedures should be used while being in use as well as stored during seasons. In agricultural enterprises, proper maintenance is critical for reducing corrosion's detrimental effects.

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