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AN INVESTIGATION INTO THE ENVIRONMENTAL IMPACTS OF ATMOSPHERIC CORROSION OF BUILDING MATERIALS

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ABSTRACT

Corrosion is an electromechanical process where the metals corrode. In the above journal an insight into what is corrosion, the process involved in it, the various forms of it are part of the subject matter under consideration. In the midst of this, the environmental effects of corrosion on building materials is illustrated in a detailed manner and analysis of the measures which can be adopted to reduce corrosion to a minimum level is also part of the study process. In the end an overall summary is depicted with a glance on the possible opportunities which could be adopted in the mechanism of corrosion control.

Index Terms— Corrosion, Building Material, Environment, Corrosive.

I. INTRODUCTION

Corrosion is an electromechanical reaction which is based on the universal laws of nature. In fact all metallic structures corrode and the key fact is how fast they corrode [1].

Corrosion happens to be natural process. All natural process have a tendency to cling on to the lowest possible energy sources. Steel happens to be a man made substance produced by iron oxide. The energy added in the refining process is unstable. When produced with a conducive environment, steel will release this energy and return to the natural stage of iron ore. In fact when immersed in an electrolyte which could be soil, water these metals produce a current which forces the ores to leave the surface. The rate of current flow determines the life of the structure. In fact one ampere of current consumes approxiametely 20 pounds of iron every year.

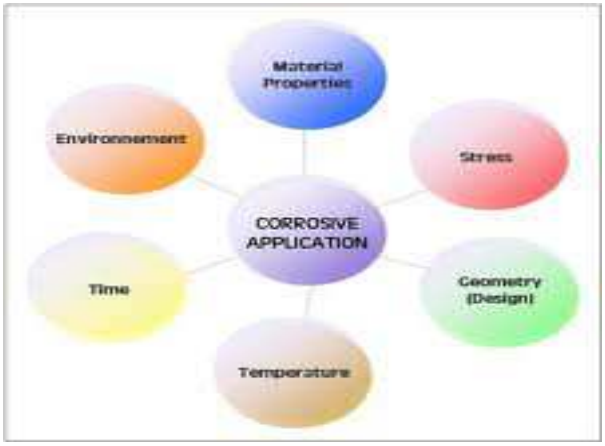

Figure 1: Corrosive Application Process

II. INTRODUCTION TO CORROSION

The job of a corrosion engineer is to slow down as well as halt the process of corrosio. Some of the techniques available in this regard are material selection, inhibitors, coatings as well as cathodic protection. Material corrosion can also arise if the metal is exposed to water, oxygen as well as other agents. This can result in loss of structural integrity or degradation of the surface appearance.

III. WHAT IS CORROSION?

Corrosion is the deterioration of a metal as a result of the chemical reactions between it and the surrounding environment. The type of metal and the environmental conditions, particularly the gases which are in contact with the metal determine the rate and form of deterioration. It could be referred as a natural process on all counts. Historically the word corrode is derived from the Latin word "corrodere" which literally means "yawn to pieces". On a general tone the definition of corrosion could be something which eats or wears away gradually. The environment plays a very important role in the corrosion process which may be influenced by a number of factors. The factors may be physical (solid, liquid or gas) chemical process (combinations and constituents) and temperature.

Corrosion is the destructive attack of a metal by an electromechanical as well as chemical reaction with the environment. In fact deterioration by physical causes cannot be called corrosion; instead it could be described as erosion along with wear and tear. In certain cases chemical attacks means physical deterioration. It needs to be understood than non metals are not included in corrosion as plastics may crack, granite may erode. This cannot be referred to as corrosion in any way. In hindsight when corrosion occurs there needs to be a chemical attack on the metals. As corrosion involves chemical change one must be familiar with the principles of chemistry to understand the corrosion reactions. Three major reasons could be attributed for the importance of corrosion which could be safety, conversation as well as economics [2].

To reduce the economic impacts of corrosion, engineers along with the scientists aim to reduce the economic losses resulting from the corrosion of tanks, pipes etc. On the other hand the process of corrosion can hamper the safety equipment in use. A typical example in this regard would be airplane components. In fact loss of any metal by corrosion is not only a waste of the metal, but the energy involved in it also. In addition to this the human efforts involved in fabrication as well as producing the metal also goes down the drain as well.

So it is quite clear when the term corrosion is mentioned it technically means a combination between a metal as well as an environment. In fact the corrosive behaviour of the metal cannot be ascertained unless the exposure to the environment so much. It is necessary to identify natural as well as unnatural combinations in this regard as well. Some of the natural combinations would be lead in water, nickel in caustic environments as the interaction between the metal and the environment does not lead to corrosive problems. On the other side of the coin unnatural combinations are the ones which result in corrosion problems. Some of the examples in this regard would be copper in ammonia solutions and lead with wine.

IV. AN OVERVIEW OF TYPES OF CORROSION

A wide spectrum of problems are encountered in the industry of today as a result of combination of materials, process as well as the environment in which they operate. Corrosion does not have immediate impact on a metal, but it affects the strength as well as the mechanical process of it and it may pave way for serious problems to come, particularly if the deterioration of critical components is concerned [3]. The environment plays a huge role in the corrosion process as the severity of the corrosion process varies from place to place.

The corrosion resistance of a material is specific to a number of factors which include composition, change in the metallurgical heat treatment, the micorstructural phases present as well as the design pattern [4]. In fact corrosion can occur in different

forms. Normally three different forms are used for corrosion which are

- Mechanism of corrosion- The process involves electromechanical as well as the chemical reactions.
- Nature of the corrodent- Traditionally corrosion can be classified as wet or dry. For wet corrosion liquid as well as moisture may be required and dry corrosion involves reaction with the high temperature gases.
- Appearance of the corroded material- it tends to be a uniform process and the pattern of corrosion of the metal all over the surface tends to be same. In the case it is localized, and then only small areas tend to be effected.
- Classification by appearance- this process is useful in case of failure analysis which is based on identifying forms of corrosion by virtual observation. This can be done by magnification as well as with the naked eye. Some other forms of corrosion can be observed by observing the appearance of the corroded material. They are Generalized corrosion (happens to be well distributed and lowest form of attack against the metal with little or no localized penetration) It occurs in environments where proper control mechanisms are in place. Pitting corrosion (also termed as under deposit corrosion. In most cases pitting extends over the entire surface creating a very irregular as well as very rough surface level and are most common in areas where they are incomplete deposits of dirt as well as oxides) Galvanic corrosion(an localised and aggressive form of corrosion due to electromechanical reaction often found between two or dissimilar metals in an electrically conducive environment) Microbiologically influenced corrosion(happens to be most severe as well as threatening form of corrosion to HVAC pipe systems) It can be caused by the presence of microbiological agents under specific environmental conditions.) Erosion Corrosion (Due to mechanical wear and tear this is the gradual and selective deterioration of a metal surface and is commonly found in areas where water changes direction) [5].

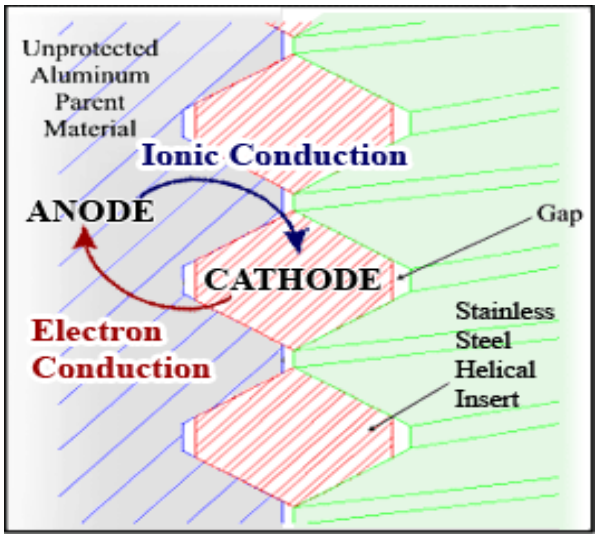

Figure 2: Galvanizing corrosion

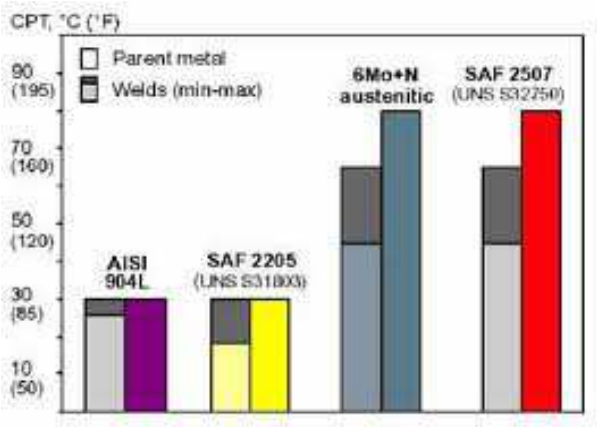

Figure 3: Pitting corrosion

Figure 4: Uniform corrosion

It needs to be understood that all these forms of corrosion are really distinct from each other. On practical terms it is observed that in a particular metal more than one method of corrosion may be adopted.

V. ENVIRONMENTAL IMPACTS CAUSED BY CORROSION

The environmental effects can usually be identified by the presence of corrosion damage or within the growing cracks or corrosion products on the fracture services [6]. The effects of corrosion may be direct as well as indirect in nature. The corrosion of the steel reinforcing bar in concrete can proceed out of sight all of a sudden and may damage a portion of the highway. In addition to these damages to buildings, structures can also be felt resulting in endangering safety as well as repair work. An example in recent times would be the sudden collapse of the corrosion fatigue over the Ohio River at Point Pleasant in the year 1967 which resulted in the loss of 46 innocent lives.

In the aircraft structures stress corrosion is another form of damage found. To put it in right perspective it is an environment induced mechanism. The current procedure is to develop crack growth rate which is to be used in safety limit calculations in wet as well as humid environment. The crack growth rates in addition to being sensitive in the exposed environment can also be dependent on other factors like frequency (National Research Council, n.d.). Stress erosion cracking is particularly a dangerous form of environmental attack which will create opportunities for the nucleus to evolve as well as crack. Other than the profound impact of the SEC process the environment may integrate or enhance the fatigue process and this creates corrosion sites. The results will be pits as well as surface roughness will develop and accelerate the crack of the nucleation process.

Corrosion problems can be pretty complex with small amount of impurities. This may cause significant change in the behaviour of a particular alloy [6]. Other than this the most dangerous environmental impact of corrosion is that it occurs in major industrial plants. Typical examples in this regard would be electrical power plants as well the chemical processing plants. Things can reach extreme consequences that a plant may even shut down. Some other major consequences could be contamination of the product; loss of efficiency as well as damages to the adjacent product placed behind the corrosive material. The impact could be social also like safety, health as well as depletion of natural resources. On the safety aspect it could be sudden release of a toxic product and on the health perspective it could be pollution from the escaped product. In hindsight the appearance of the corroded material is not at all pleasing to the eye.

Corrosion of metals caused the US economy almost $ 300 billion in prices per year at the current prices. Research points to the fact that the automotive sector had the greatest anti corrosion effect in terms of a single industry.

Table: Cost of metallic corrosion in the United States

Billions of U.S. dollars

Industry	1975	1995
All industries		
Total	82.0	296.0
Avoidable	33.0	104.0
Motor vehicles		
Total	31.4	94.0
Avoidable	23.1	65.0
Aircraft		
Total	3.0	13.0
Avoidable	0.6	3.0
Other industries		
Total	47.6	189.0
Avoidable	9.3	36.0

Source: Economic Effects of Metallic Corrosion in the United States, Battelle Columbus Laboratories and the National Institute of Standards and Technology (NIST), 1978, and Battelle estimates.

VI. HOW CAN CORROSION BE CONTROLLED?

Effective corrosion is determined by a combination of a couple of methods. The corrosion control

should be considered at a design stage of the given facility or system [8].

The methods selected must be appropriate for the type of materials used. They are no materials which are resistant to corrosion. They must be matched to the environment which they will encounter in service.

In generic terms there are five major methods of corrosion control. There are depicted below

- **Material selection-** Each and every metal as well as alloy may have unique as well as high resistant corrosive behaviour. Some of the examples of such type of metals may be sodium as well as potassium
- **Coatings** – for corrosive metals could be further segregated into two major forms in the form of metallic as well as non metallic. Whatever be the type of coating the intent tends to be the same.
- **Inhibitors** – The process can be pretty complex of sorts. They can be embedded in a protective coating or a premier of the coating. The use of it is more favoured in closed systems where the concentration of it can be readily maintained
- **Catholic protection** – The process tends to suppress the corrosive current that causes damage in the corrosion cell and restricts the flow of current to the metal. In the overall context the corrosion or metal dissolution is prevented.
- **Design** – The application of the design principles may reduce the corrosion problems and reduce the time and cost involved in corrosion repair as well as maintenance.

In addition to this another method of corrosion control which is often neglected is modifying the operating environment. Some of the mechanisms in this regard would be around a buried structure selective backfilling, in power plants or in the engine cooling plants using corrosive inhibitors, modifying the existing structures to provide ample draining opportunities are some of the methods taken for corrosion control. In the midst of all this the best form of action could be taken during the design stages and in certain cases after the system is build, action could be taken through modifying the environment as well. The key factor in this regard is the identification as well the characterisation of corrosion problems at an early stage so that corrective action could be taken.

No matter whatever training is provided with regards to the aspect of corrosion control, the onus is on the corrosion engineer to ensure that all the proper mechanisms of the design system are in place. Education is an important process in corrosion control which integrates the technology into the design process happens to be an important method for corrosion control. Quiet often it is found that engineering schools which are responsible for design does not emphasize corrosion control at all [9].

VII. CONCLUSION

All said and done from the analysis till now, the fact emerges that corrosion though a natural process is dependent to a great extent on the environment in which it operates. The impacts of corrosion can be direct as well as indirect in nature. Lot of time and effort as well as costs are involved in the corrosion process. So the urgent need of the hour is to take proper steps in reducing the corrosion levels.

On the other side of the coin the massive costs of corrosion may provide opportunities for the suppliers, manufactures as well as suppliers. The opportunities exist to reduce the cost of corrosion and the risks of failure along with the possibility of developing new markets. In a way it implies to implement a programme based on the philosophy of savings. The cost of corrosion savings tend to vary from industries to industries and the key point to note here is that in most of the industries substantial savings are being achieved. Both the process as well as the products can be analysed to identify the areas where corrosion failures can occur. Once identified preventive measures can be taken in the shortest time frame.

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