GENERAL INTRODUCTION
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Corrosion may be defined as destruction of metals by direct chemical or electrochemical reaction with the environment. In natural environment a metal like iron is not stable and reverts to a more stable form such as an iron oxide. Ores, as found in nature, consist of such metallic compounds. Thermodynamically, a metal such as iron possesses the tendency to revert to the combined condition. Corrosion is a natural spontaneous process which may be retarded but can never be completely stopped. The surface of the metal is never uniform and the attack of corrosion develops along grainboundaries or other lines of weakness. The corrosion product mainly consists of oxides, carbonates and sulphides. With the increasing use of metals and the fast depletion of sources of some of the common metals like copper, zinc, tin etc., corrosion has become a problem of increasing importance. Although studies in corrosion are more than a hundred years old, perhaps the first comprehensive study was started at Cambridge in 1923 by U.R. Evans and his collaborators. "An Introduction to Metallic Corrosion" and the larger book "The Corrosion and Oxidation of Metals: Scientific Principles and Practical Applications" by U.R. Evans and "Corrosion: Causes and Prevention" by F.N. Speller were perhaps the first set of books which systematically presented the problem of corrosion and its prevention. The present account is mainly taken from these publications. In the years 1931-1939 the
electric currents flowing over the surface of metal corroding in salt solutions were investigated by B.R. Evans and his collaborators at Cambridge including Bannister, Hoar, Thornhill and Agar. In 1938 an American Coordinating Committee on corrosion was organized. In 1945 National Association of Corrosion Engineers was organized. The electrochemical nature of passivity was studied by W.J. Müller at Vienna. As early as 1928, work was begun in Soviet Union on production of synthetic inhibitors. At present, work on corrosion is extensively carried out all over the world by a number of workers including U.R. Evans (England), H.H. Uhlig (U.S.A.), F.N. Speller (U.S.A.), I.N. Putilova (U.S.S.R.), F.C. Porter (England), J.C. Hudson (England), J.E.C. Mayne (England), and Eurof Davies (England).

The systematic work on corrosion in India was initiated by the Council of Scientific and Industrial Research (C.S.I.R.). Under its auspices, a meeting of corrosion workers was held in July 1961 at Calcutta when some of the workers including Dr. B. Sanyal, Defence Research Laboratory, Kanpur, Dr. T. Banerjee, National Metallurgical Laboratory, Jamshedpur and Dr. A.M. Trivedi, M.G. Science Institute, Gujarat University, Ahmedabad, met. At this meeting a systematic programme for studying corrosion was initiated. The 6th meeting was held in January 1967 at Ahmedabad. The C.S.I.R. under its metal committee sponsors research schemes for studies on various aspects of corrosion. In India the work on corrosion is carried
out by National Metallurgical Laboratory, Jamshedpur, Defence Research Laboratory, Kanpur, Defence Research Laboratory, Hyderabad, Central Electrochemical Research Institute, Karaikudi (Madras), Naval Research Laboratory, Bombay, Indian Institute of Science, Bangalore, Central Salt and Marine Chemicals Research Institute, Bhavnagar, and Chemistry Department, University School of Sciences, Gujarat University, Ahmedabad. At present, work on corrosion is conducted under various committees which meet every year. The work on corrosion is divided in the following sub-committees (i) Inorganic surface coatings (ii) Atmospheric corrosion (iii) Fundamentals of corrosion (iv) Industrial corrosion and service failures and corrosion in chemical Industry (v) Inhibition and cathodic protection, and (vi) Marine corrosion. The corrosion Advisory Bureau finances researches on corrosion by awarding Junior Research and Senior Research Fellowships and some nominal grants for contingency. The present work was carried out under a C.S.I.R. scheme entitled, "Corrosion Studies in Saline Atmosphere and Investigation on Incrustation corrosion in Pipes carrying Potable Water in Gujarat."

At Ahmedabad work on corrosion was started in 1954, when a systematic study on corrosion of brass was undertaken. A number of papers have been published in various journals like "Journal of Indian Chemical Society", Calcutta, "Journal of Scientific and Industrial Research", New Delhi and "Werkstoffe und Korrosion", Weinheim, Bergstr. W. Germany.
The present work may be divided into following parts:

1. Studies on Incrustation of pipes carrying potable water.
2. Studies on corrosion of Aluminium in supply water and its inhibition.
3. Studies on Atmospheric corrosion at selected sites in Gujarat.

STUDIES ON THE INCRUSTATION OF PIPES CARRYING POTABLE WATER

Formation of crust in condenser tubes and boilers and its prevention has been studied by a large number of workers. Incrustation formation in boilers may cut down efficiency as the scale has a very low thermal efficiency. External treatment of boiler feed water has been well known and may consist of softening by sodium-zeolite process, partial neutralization with sulphuric acid, etc.

Frederick Straub studied the prevention of scale formation in steam boilers by employing various organic and inorganic salts. Use of phosphates in water conditioning has been discussed by Schwartz and Munter. Inhibition of scale formation has been studied by Diebes and Jessen who employed various chemicals as inhibitors.

In the Gujarat University Campus the choking of pipes by incrustation has been a perennial problem. The crust mainly consists of calcium carbonate, magnesium hydroxide and small
amounts of iron oxide, silica etc. One may control the problem of crust formation by (a) Inducing water to form crust in a special reservoir before it enters the pipe for potable water, (b) Inhibit crust formation or induce the change in such a manner that the crust may be fluffy so that it would be easy to wash it away by flooding with water. It would have been a great advantage if hard crust as formed in working condition, may be developed by a quicker process. Unfortunately inspite of a number of attempts, a quick method of forming hard crust in pipes could not be developed in the laboratory. One may accelerate deposition of salts from hard water by heating it or by suitable chemical amendments. All such attempts, however, resulted in fluffy deposits. For inhibition of crust formation by the chemical amendments, a large number of chemicals such as sodium citrate, EDTA, sodium hexametaphosphate (calgon), sodium tartrate, ammonium citrate etc. as well as their mixtures were tried. It was found out that calgon, ammonium citrate and EDTA were most effective. However, processes employing these chemicals may not be economically viable as the cost of the chemicals in the amounts required is prohibitive.

**CORROSION OF ALUMINIUM IN SUPPLY WATER AND ITS INHIBITION**

Aluminium is acquiring increasing importance in the National Economy of India. Bauxite occurs at many places in India. It occurs at Kohlapur (Maharashtra), Belgaum (Mysore), Kapadwanj and Jamnagar (Gujarat), Salem (Madras) and at some
places in Bihar Province. At present, aluminium is manufactured in India by a number of agencies, both government as well as private, including Hindustan Aluminium Corporation, Renukoot, (U.P.), and Mettur, (Madras), Indian Aluminium Company, Belgaum (Mysore) and private companies at Koyna (Maharashtra) and Korba (Madhya Pradesh), Asansol (West Bengal), Hirakund (Orissa) etc. The production of aluminium in 1968 was about 1,80,000 tonnes. It is proposed to increase production to 36,8000 tonnes by 1971. Aluminium has practically replaced copper for telegraphic cables. Formerly household utensils of brass were popular all over India. Supplies of brass, however, are decreasing rapidly. Brass is being replaced by stainless steel for the richer section of the community and by aluminium for most of the other population. Household cooking vessels are generally made of aluminium. It was decided to study corrosion of aluminium in supply water, both in stagnant and in slowly moving conditions. Commercially available aluminium was used for experimental work. Coupons of aluminium were suspended in polythene tubs wherein water was allowed to flow continuously at a slow rate. In stagnant condition, the coupons were suspended in beakers containing water. The specimens were suspended for different periods up to ten months. Porter and Hadden have studied the corrosion of aluminium in supply waters, both in stagnant and in slowly moving conditions. They have concluded that the corrosive attack was most severe in the hard water, the typical form
of attack being deep pits covered by corrosion products. Eurof Davies has explained the initiation of pits and their subsequent development with time in the case of aluminium in synthetic waters. In the present investigation an attempt was made to study the effect of moderately hard supply water on the corrosion of commercially pure aluminium in stagnant as well as in slowly moving conditions. It was found that running water may cause severe corrosion with development of pits and holes. On addition of various inhibitors the corrosion process may be retarded. The supply water contains only traces of copper, in stagnant condition practically less pits are formed. On adding copper salts pit formation is enhanced. In synthetic waters containing artificial mixtures of sodium carbonate, sodium bicarbonate and sodium chloride etc. pits are formed even in absence of minute quantities of copper salts provided both bicarbonate and chloride ions are present. A number of inhibitors were tried. It was found that potassium chromate, benzylamine, ammonium vanadate and gelatin are excellent inhibitors. Galvanostatic measurements were made and the mechanism of corrosion and inhibition is interpreted in view of the various experimental observations.

**ATMOSPHERIC CORROSION AT SELECTED SITES IN GUJARAT**

Atmospheric corrosion of metals is generally correlated
with relative humidity, pollution of atmosphere and weather conditions including rainfall and temperature. Following two sites were selected for study: (i) Ahmedabad - Industrial city with semi arid climate. The location of the exposure site is very near to a locomotive-shed and in a compound of a textile mill (ii) Bulsar - humid, rural atmosphere with higher annual rainfall. Monthly corrosion rates of mild steel and zinc have been determined. Salinity and sulphur trioxide content at both sites were also measured.

Above indicates the chief lines of investigation. In the following chapters a detailed account is given along with the study of some additional aspects of the problem. Chapter first deals with studies on Incrustation of pipes carrying Potable Water. Corrosion of Aluminium in supply water and its inhibition is treated in the second chapter. The chapter third is concerned with studies on Atmospheric corrosion. This is followed by Summary. References are given at the end of each chapter. Whenever original references were not available information was obtained either from Chemical Abstracts or from standard textbooks.
REFERENCES


