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Review for the monograph by Alec Groysman "Corrosion in Systems for Storage and Transportation of Petroleum Products and Biofuels"

The book appears quite relevant for two reasons:

1. Fuels are used in almost any part of the world where at least minimum signs of civilization exist. They is usually represented by various petroleum products (biofuels are more rare) and have to be stored and transported in some way.
2. Corrosion problems occur everywhere, but the cost of possible problems due to corrosion is much greater in the case of fuel, since it usually results in leakage, which in turn can give rise to environment pollution and may lead to explosion or fire.

Thus, storage and transportation of petroleum products and biofuels (hereinafter referred to as PPs and BFs) are areas of high risks, where corrosion is one of the most significant but least studied risk factors. Metal structures used for the storage and transportation of PPs and BFs are mainly made of carbon steels. Though it may be surprising for non-experts, check specimens exposed to PPs and BFs often show corrosion damage, *i.e.*, the problem does exist. As an alternative, it is possible to use polymer/composite materials in systems for storage and transportation of PPs and BFs. However, they are also subject to adverse effects when exposed to PPs and BFs because their properties can change, this in turn leading to increased risks of PP and BF leakage with potential negative consequences.

The book summarizes the large practical experience of A. Groysman and reviews the existing literature and reference data concerning corrosion of construction materials in PP and BF environments and corrosion monitoring methods.

The book consists of 10 chapters covering all aspects of corrosion in systems for transportation and storage of PPs and BFs. Each section contains a brief abstract, references to literature sources, and a list of recommended literature. The availability of numerous references to earlier author's publications indicates his considerable practical experience underlying the book. The standard structure of each chapter makes the book convenient for reading and allows it to be used also as a reference because it contains an Index and Appendix covering a number of topics, such as:

- Properties of crude oils according to API classification;
- Components of crude oils and petroleum products;
- Chemical composition of petroleum products;
- Corrosivity of organic compounds contained in oils and petroleum products toward metals and polymers.

A drawback, not of the book itself but of the edition, is that the Contents do not include the names of all Appendices and their subsections.

The first section describes the physicochemical properties and corrosiveness of crude oils and petroleum products. Chapters 2–4 describing the issues listed below can be of particular interest:

– Action and uses of fuel additives;
– Additives for prevention of oil-ash and cold-end corrosion in boilers;
– Additives to biofuels, including biodiesel;
– Risks and benefits in the use of fuel additives.

Chapter 5 describes the corrosion of metal structures and equipment exposed to petroleum products. The general corrosion concept and corrosion types are described. The section abounds in examples, photographic images of real corrosion damage, and drawings. Corrosion mechanisms in petroleum products are explained and reference data are given on the most characteristic indicator of the corrosivity of petroleum products, *i.e.*, electric conductivity. Microbial contaminants and the contribution of microorganisms to the corrosion of metals in PPs and BFs are described for biofuels. Special subsections in Chapter 5 describe the specifics of corrosion processes in biofuels, soils, atmosphere, in oil storage tanks, including corrosion under heat insulation, and the methods of corrosion protection under heat insulation.

Chapter 6 deals with resistance of polymers to the action of PPs and BFs because polymers are also used, along with metals, in the transportation and storage of PPs and BFs. The permeability of polymers to PPs and BFs and their resistance to oxidants and aromatic hydrocarbons are considered. The aggressiveness of alcohols and BFs to polymers is also shown.

Chapters 7 and 8 appear to be the most interesting part for practical applications.

Chapter 7 deals with corrosion prevention and control in systems containing PPs and BFs. It contains the following information:

– Choice of corrosion-resistant materials, including the possible use of metals and alloys (stainless steel and aluminum alloys). References are made to materials choice in accordance with API standards 620, 650, as well as stainless steels of the 304 and 316 series. It is shown what steels and alloys are suitable for manufacturing objects used for storage and transportation of PPs and BFs, *e.g.*, tanks, pontoons, floating and fixed roofs, *etc*.
– Use of anticorrosion coatings for corrosion protection in various PP and BF types, such as gasoline, naphtha, crude oil, *etc*. Furthermore, protective coating systems for outer surfaces of objects are described, including metal coatings. Recommendations are given for selection of all types of coatings, with consideration for the specifics of the objects, compatibility with PPs and BFs. The corresponding test methods are described.
– Cathodic protection in systems for transportation and storage of PPs and BFs from inside and outside corrosion.

– Use of corrosion inhibitors for protection from inside corrosion in liquid and vaporized PPs and BFs.
– Antibacterial treatment.
– Combined methods of corrosion protection.

Furthermore, Chapter 7 describes a solution to corrosion problems in secondary containment and double bottom equipment, as well as in underground storage tanks.

Corrosion management is impossible without systems for corrosion monitoring and diagnostics of the technical condition of equipment. Chapter 8 gives a review of existing systems for nondestructive testing of the technical condition of equipment for transportation and storage of PPs and BFs and provides a brief description of these systems and their applications:

– for identification of various defects by ultrasonic flaw detection, acoustic emission, and magnetic and electromagnetic measurements,
– for corrosion rate measurements, *e.g.*, by gravimetric and electric resistance methods.

It was suggested to identify the predominant corrosion mechanisms and manage corrosion by controlling:

– the environment corrosivity, based on the key indicators (pH, Cl^-, SO_4^{2-}, O_2, CO_2, H_2S, NH_3, suspended matter, bacteria, *etc*.) and the ionic composition of the aqueous phase in PPs and BFs,
– residual content of chemical reagents, *e.g*., corrosion inhibitors, oxygen scavengers, various neutralizers, *etc*.
– operation parameters of equipment for transportation and storage of PPs and BFs, *i.e.*, temperature, flow rate, pressure, and condensation temperature.

Measurement of the above parameters in corrosion control systems makes it possible to estimate the corrosion situation and the presence of corrosion products on metal surfaces that may distort the measurement results, and to identify the particular measurement methods that allow one to obtain valid results.

In addition to the traditional methods for corrosion monitoring and control, it is suggested to use systems for the measurement of the metal surface condition in contact with a corrosive environment by electrochemical methods. Since the use of electrochemical methods directly in PP and BF environments for inside corrosion monitoring is limited, a list of alternative techniques is presented using scanning electron microscopes and other microscopes.

Continuous (“on-line”) corrosion monitoring is recommended in justified situations where corrosion risks are due to local corrosion and the consequences of probable failures and incidents are unacceptable. The electric resistance method and its related methods are considered most suitable for “on-line” measurements. Methods of monitoring and

diagnostics of structures and protective systems are described in the context of equipment for the storage and transportation of PPs and BFs.

The most efficient methods for pipelines include in-line inspection using various thickness metering techniques, monitoring the condition of inside coatings, presence of water accumulations and other factors that are risky for equipment integrity. A special subsection deals with tank diagnostics.

Outside corrosion is the leading risk factor in violation of integrity of equipment for the storage and transportation of PPs and BFs. Section 8 describes methods for monitoring cathodic protection and condition of outside insulation by intense measurements of potentials and stray currents (CIPS and DCVG).

The reviewed monograph "Corrosion in Systems for Storage and Transportation of Petroleum Products and Biofuels" by A. Groysman contains, in addition to the rather comprehensive information on the topic, almost as in a reference edition, also very high-quality illustrations, drawings and diagrams. Because of that, the book is also understandable for experts in areas beyond corrosion problems. The availability of the special Chapter 9 describing various cases of corrosion and corrosion-related failures of equipment for PP and BF storage and transportation, as well as chapter 10 devoted to the history of additives to PPs and BFs, make the book useful for a broad circle of readers, from focused professionals in corrosion to engineers responsible for the safe operation of equipment for the storage and transportation of PPs and BFs, as well as for students specialized in these fields.

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