

Using Digital Twin And AI To Predict Atmospheric Corrosion - A Smart Tool For Decision Makers

Otavio Correa, Jorge Seleme Mariano;
Vidya Technology
Av. Comendador Franco, 1341
Curitiba, Paraná
Brazil

ABSTRACT

This paper focuses on reviewing and offering a solution to manage the complex atmospheric corrosion process and its protection within industrial plants such as Oil & Gas, Petrochemicals, Pulp and Paper, and Mining. A review of the main protective coating failure mechanisms, as well as corrosion evaluation methods, are presented. Our objective is to gather the main parameters for a maintenance/inspection management tool, by developing a field data collection processing that feeds a digital model to predict coating failure and to enhance time, costs, and performance of asset integrity management activities. The development of a software is discussed, bringing a view on how to merge the Industry 4.0 technologies such as Digital Twins, Artificial Intelligence, Cloud services, and Mobile concepts to deploy predictive models. Advances in the platform showed ways to outline optimized inspection and maintenance plans, using condition data. It was possible to develop tools to predict costs, workforce and other variables to be considered for protective coating management. Finally, after carrying out all the necessary calculations for the activities mentioned above, the authors present how the technology can deliver other management information such as budget, productivity, the number of paintings done and/or future paintings followed for decision-makers to evaluate optimized scenarios.

Key words: coating, industrial painting, inspection, maintenance, industry 4.0, digital twin, artificial intelligence, prediction, software, management.

INTRODUCTION

The Brazilian cost of corrosion was estimated at 3% of the GPD in 2018, that percentage is equivalent to approximately \$US 49 billion, according to an ABRACO⁽¹⁾ journal released in 2020.¹ It is estimated that from this cost \$US 19 billion could have been saved through anticorrosive actions. In another research conducted by the EPRI⁽²⁾ the results showed that at least 22% of corrosion costs could be avoided through adequate mitigating actions.²

¹ Associação Brasileira de Corrosão, Av. Venezuela, 27 - Sl. 412/418 - Centro - Rio de Janeiro

² Electric Power Research Institute, 3420 Hillview Avenue, Palo Alto, California 94304

© 2022 Association for Materials Protection and Performance (AMPP). All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise) without the prior written permission of AMPP.

Positions and opinions advanced in this work are those of the author(s) and not necessarily those of AMPP. Responsibility for the content of the work lies solely with the author(s).

In terms of the integrity of process plant assets, one of the biggest causes of damage is corrosion, which, according to NACE, represents a global annual cost of \$US 2.5 trillion, or 3.4% of global GDP.³ A large part of this cost relates to the industrial sector and a significant part relates to atmospheric corrosion and the costs of protecting assets. It is estimated that up to 50% of the cost of corrosion is related to protection against atmospheric corrosion, Schweitzer.⁴

The most used method for protecting industrial assets against atmospheric corrosion is painting or coating. Its function is to create a protective layer on the surface of the substrate that isolates it from the factors that cause corrosion.

In an industrial environment, the maintenance of industrial paint is a challenging task. Numerous factors such as the environment's corrosive atmospheres, the varying painting systems, and the size of the painted area are some of the factors that make this task difficult to manage.

This work proposes an approach that involves the use of digital technologies to improve the management of painted assets, such as the inspection and maintenance of industrial painting. It also proposes the use of a Digital Twin platform introducing subsidies for operators to adopt more efficient management techniques. Also, it explains how the concept of cloud computing can be utilized for the management of painted assets. It shows how this method can help minimize the complexity of the task by processing computational models.

BIBLIOGRAPHIC SURVEY

Atmospheric Corrosion

Atmospheric Corrosion is a complex process, ruled by electrochemistry and physics processes at a thin layer over the surface of the material with dynamic kineticity of different parameters that influence corrosion process.⁴ The main factors that influence atmospheric corrosion according to Schweitzer are:

- i. Time or humidity cycle;
- ii. Air contaminants;
- iii. Temperature;
- iv. Others factors.

One way found by engineers to specify materials and protection systems against atmospheric corrosion is the corrosion classification at aggressivity grades. A standard to classify atmospheric corrosion is ISO 9223-2012.⁵

Industrial Painting and Coating Failure

Knowing that adhesion is the main coating characteristic, the procedure of surface preparation is very crucial. In addition, to each base material type, a different preparation method is necessary. To steel, countless surface preparation techniques, recoating application, inspection methods, and quality control are able and must be properly specified to each situation by a qualified professional.

Even so, for diverse causes, the coated systems fail at some point, and at some moment it can compromise the substrate. A study conducted by Mark Weston *apud* shows part failures arising nearly 46% at the painted system to application errors.⁶

One of the most widely applied techniques to protect metallic equipment and structures against atmospheric corrosion is painting or coating. Covering the metal works when the outer layer is adherent to substrate or metal base, the mechanical and chemical resistance to hold to severe weather, mechanical shocks, and chemical agents in the environment. Therefore, they simply prevent the permeability of those corrosion agents mentioned above, such as humidity and/or contaminants.⁴

Industry 4.0

In this section, we will highlight Industry 4.0 main concepts with the intention to find specific points that can be used for asset integrity management and for industrial painting maintenance. Industry 4.0 or also called Fourth Industrial Revolution is in the current trend of automatization of technologic application, communication and data exchange to the industrial process through concepts of Cyber-physical systems, Internet of Things (IoT), and Cloud Computing. The objective is to digitalize the production process creating a virtual model of intelligent factories. Cyber-physical systems and sensors capable of IoT integrated to the factory virtual model comprehend and monitor the operation in real-time. Cloud Computing, processing math models, algorithms, and AI can determine patterns able to optimize actions and decisions, co-operating to human activities in a productive environment ⁷. The term Industry 4.0 came from a German's government project of promoting computational modeling in the manufacturing sector. ⁷ The basics principles of Industry 4.0 are:

- i. Virtualization
- ii. Decentralization
- iii. Modularity
- iv. Real-time operating capacity
- v. Interoperability
- vi. Orientation to services

These concepts are well widespread in the production industry process in many sectors. However, in other sectors, a long way to implementation still needs to be crossed.⁸ It is possible to expect that applying technologies from Industry 4.0 some evolution in the sector of Maintenance and Integrity Asset Management happens.

Digital Twin

Daily is increasing the concept of the digital twin technology, since the popularity of the industry 4.0, companies are doing movements to become more digitized for a reason that it is clear now. The economic improvements created by the digital process are real. Digital Twin technology is defined by a constant flow of data between a virtual model and a real one. A Digital Twin platform is built through stacks of multiple technologies in different levels which are enhanced by the combination of Artificial Intelligence and IoT sensors. These stacks are composed of simulations, analytics, operational context, data contextualization, and 3D models. The feeding of information within the platform allows it to gather the necessary information to applications throughout the multiple Product Lifecycle Management (PLM) phases of an asset, plant, or operation. The collection of information in real facilities can be aided with the employment of new technologies, for instance, lasers, drones, and high-level data processing computers which are getting cheaper, positively contributing to the task of mapping a complex facility in a 3D model. The digital twin could be also defined as a digital platform linked to the behavior and performance in the past and in real-time following a key process that helps to optimize the business performance, in our case the key process is atmospheric corrosion. In industry 4.0 conception sensors, artificial intelligence, and 3D models are linked to the digital twin which is a possible tool to manage and predict a key industrial process. According to Parrot the digital twin is able to identify intolerable deviations from ideal conditions through any of the many dimensions that the key process could be acting on.⁹ That deviation is an identified opportunity to optimize the process, or the digital twin logic has an error; or is an opportunity to save costs, improve the quality or obtain better efficiency.

The observed deviation at the digital model may result in action at the real facility. An opportunity at the real model can be done sooner, accurately, and precisely, helping to fix and correct the asset if that is the case before a high consequent event. The tool to predict and manage the atmospheric

corrosion developed is completely aligned to the digital twin concept, which will be demonstrated further in this paper.



Figure 1: Example of a Digital Twin

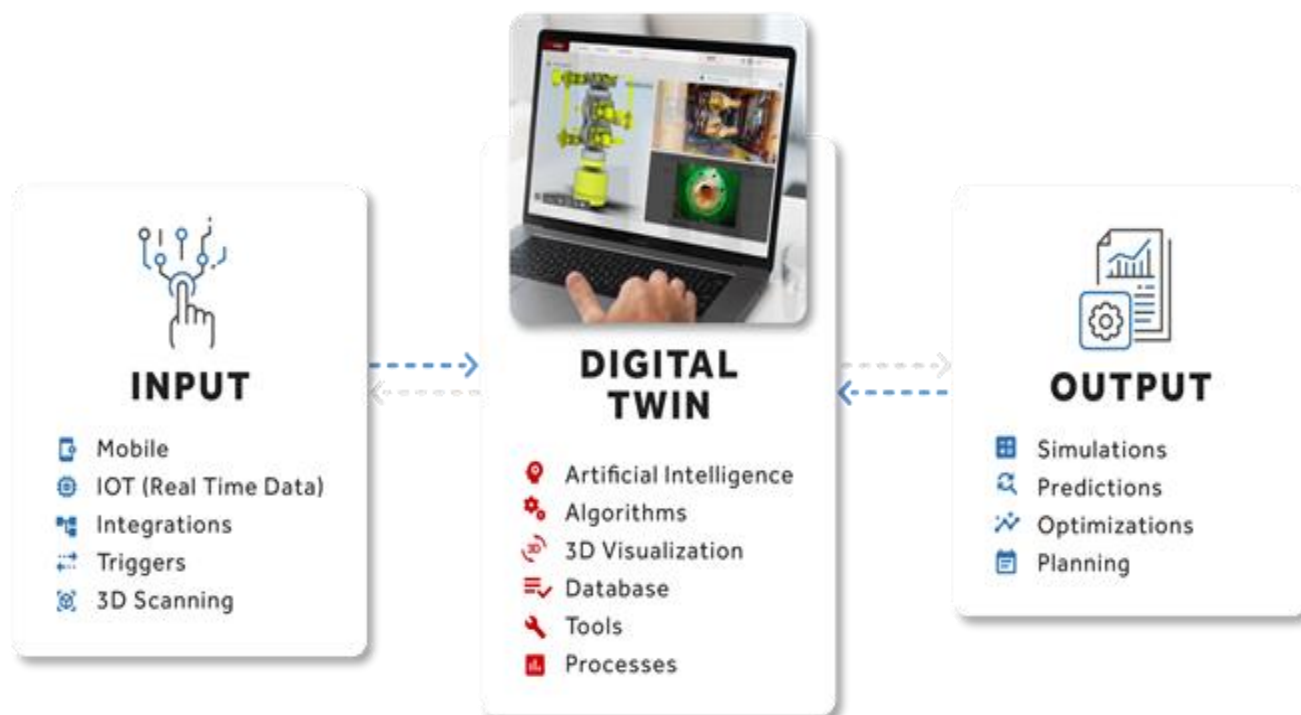


Figure 2: Representation of the input, output, and data processing scheme used by the digital twin platform