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Incorporation of Artificial Intelligence in Corrosion Engineering Technology

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Editorial

Corrosion [1] engineering and the successive technology developed from it has been dependent on controlled laboratory testing, experimental investigations and long-term field observations. Although this methodology has been successfully employed until now and has been fruitful. However, this has been achievable on the expense of logistics such as excessive time consumption, huge amounts of research funds and inability to always assess the unpredictable nature of corrosion. Sometimes the results of corrosion investigations are not even repeatable and reproducible with the same accuracy. The process of selecting the materials for corrosion protection and durability of infrastructure have been limited in their capability to fulfil the needs of complexities in the modern world. In the recent past, artificial intelligence (AI) [2] has evolved as a very useful tool to transform the above said track into an alternate route to investigate, estimate, predict and control the corrosion phenomena with super-fast speed and accuracy. Use of artificial intelligence in corrosion studies has served as an extraordinary tool to transform the experience-based practice into data driven corrosion modelling, prediction and protection. Incorporation of AI in corrosion engineering and technology has been most effective for modeling and prediction management [3]. The past conventional modeling techniques relied upon the finite element models based on simplified numerical assumptions and limited experimental data sets. Those techniques were unable to take care of the complex material and environmental behaviours. It was difficult to incorporate the vast number of variables and their combinations through the traditional methodologies. However, by the use of artificial intelligence techniques such as ensemble models (EM) [4], machine learning (ML), deep learning (DL) [5], artificial neural networks (ANN) [6], support vector machines (SVM) [7] etc. it has been possible to model and predict the non-linear behavior of corrosion [8-9] with far more accuracy and reliability. AI has helped to understand the corrosion mechanisms in a better way through the efficient data acquisition. Thus, enabling the possibility of predicting the corrosion rates with higher reliability especially for the varying corrosive environments.

Artificial intelligence has been particularly useful in the design and selection of corrosion engineering materials and resulting technologies. It has narrowed the wide range of possible material types, variables and candidates for limited number of targeted testings. Instead of carrying out expensive trial and error testing, AI has now provided cheap alternate ways to reach the outcome with fewer final verification tests. This will lead to the development of new engineering technologies for production of corrosion resistant materials including new and novel corrosion protection coatings, alloys and corrosion inhibitors for aggressive corrosive environments [10-16]. Another field that is being very efficiently benefited from AI is nano-engineering and nano-technology. AI has made it possible to analyse anti-corrosion materials at the nano-scale resulting in much better understanding of corrosion problem at a multi-scale level. Thus, resulting in the development of improved nano-engineered corrosion prevention materials, nano-coatings and nano-sensors. Another field of corrosion engineering and technology that has been immensely benefitted from artificial intelligence is the corrosion management (inspection and monitoring). Artificial intelligence has enabled the use of intelligent and smart corrosion sensors in electro-chemical monitoring systems and non-destructive techniques. This has resulted in the availability of huge data volume which was not possible with the conventional ways. This has made AI tools even stronger as they are data-driven resulting in better corrosion management of infrastructure by automatically detecting the corrosion-based damage through the visual inspection images, ultrasonic signaling and data from the electrochemical noise. All this when combined with the real time and space domains makes it possible to detect the damage earlier. Thus, reducing the possibilities of unexpected corrosion destruction. Use of digital twins under the umbrella of artificial intelligence makes it possible to monitor the corrosion of real structures without even being actually constructed.

Having said all the above, AI still imposes some challenges. All the corrosion controlling schemes governed by the artificial intelligence are dependent on the data used to train them. The quality of data, its representativeness, standardization, correctness, reliability all are important for accurate AI corrosion predictions. Corrosion itself being unpredictable in nature generates contradicting results and discussion from different researchers and can confuse the AI tools in making wise decisions. This all can result in wrong interpretations and misleading the AI users [17]. It is important to correlate the corrosion engineering and technology with data science accurately so that the AI results can be obtained precisely and accurately. All this can be done by the application of AI tools effectively and responsibly by cross-checking with the human interface. Concluding all above it can be said that the use of AI in corrosion engineering and technology is redefining its understanding, mechanisms, modeling, prediction, assessment, material development, monitoring, mitigation and protection [18]. It can be said that the corrosion management has become far more intelligent by the use of AI predictive modeling, enhanced corrosion inspection methodologies and intelligent corrosion maintenance strategies. AI has made the conventional corrosion engineering and technology far more self-dependable and automated. Need of the hour is to incorporate AI with fundamental corrosion science effectively as the field moves ahead with judicial use of AI which will surely improve the corrosion prone systems making them more durable, safe and sustainable for a better world in the future.

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