Influence of a Porous Corrosion Product Layer on the Corrosion Phenomenon of Carbon Steel Pipelines

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Abstract

Assessing the severity of the internal corrosion of structures is of paramount importance in the oil & gas industry. Modelling and simulation of this process proved to be key techniques to understand its mechanism and the main factors influencing its severity [1-4].

Considerable effort has been deployed to implement an adequate electrochemical process of the corrosion phenomenon [5-12]. However, in our knowledge, except [13-15], the influence of transport phenomenon trough a porous corrosion product layer (CPL) on the corrosion rate has not been studied extensively yet.

The transport phenomenon can influence the corrosion rate significantly by either limiting or accelerating the cathodic contribution. In this paper the general corrosion of a carbon steel under a porous CPL of siderite is studied and the influence of the transport phenomenon is examined using COMSOL Multiphysics ®. A diagram of the process is presented in Figure 1. In this paper, it is assumed that the CPL is composed solely of siderite and that the very nature of the CPL does not play a role on the corrosion rate.

A 1-D numerical model studying general corrosion under a porous CPL and accounting for chemical evolution in the electrolyte is presented. The electrochemical processes and the corresponding kinetics data implemented are the same as in Nesic et al. [3, 5-6]. Then, it is shown that the CPL's porosity and effective diffusion through the CPL play an important role on the evolution of the chemistry near to the metal surface and consequently on the corrosion rate of the carbon steel.

This model constitutes a first step and can be used for further development in order to assess the effect of either, a competitive diffusion trough a CPL or a conductive CPL, on the corrosion phenomenon. In fact, the transport phenomenon can play a fundamental role beyond the simple fact of limiting or accelerating the cathodic contribution. It is suggested that the transport from and/or to the steel bare to and/or from the "bulk" solution could greatly influence the protectiveness of a corrosion product layer and consequently the corrosion rate of carbon steels [13-15]. Finally, the electrochemical behavior of the CPL [16-17] could also increase the delocalization of the cathodic reaction all along the CPL leading to a significant increase of the corrosion rate [17].

Figures used in the abstract

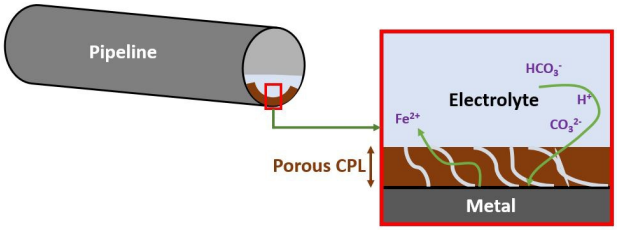

Figure 1: Schematic representation of a porous corrosion product layer (CPL) formed on a carbon steel pipeline.