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Fouling detection in buried water pipelines by observation of the scattered electromagnetic field

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The electromagnetic scattered field by a buried pipeline is calculated by means of frequency-domain numerical simulations and by making use of the scattered-field formulation. The pipeline, supposed to be used for water conveyance, is modeled as a cylindrical shell made of poly-vinyl chloride (PVC) material buried in a wall or pavement composed of cement with very low losses and filled with water. In order to make the model simpler, the pipeline is supposed running parallel to the air-cement interface. To excite the model, a linearly-polarized plane wave impinging normally on the above-mentioned interface is adopted. We consider two different polarizations in order to determine the most useful in terms of scattered-field sensitivity. Moreover, a preliminary frequency sweep allows us to choose the most suitable operating frequency depending on the dimensions of the pipeline cross-section. All the three components of the scattered field are monitored along a line just above the interface. The electromagnetic properties of the materials employed in this study are present in the literature and, since a frequency-domain technique is adopted, no further approximation is needed. Once the ideal problem has been studied, we further complicate the model by introducing two fouling scenarios due to limestone formation on the pipeline walls. In the first case, the fouling is deposited at the bottom of the pipeline when the water pressure is low enough and the second one considers the fouling to deposit on the entire internal perimeter of the pipeline's cross-section by forming an additional limestone cylindrical layer. The results obtained in these cases are compared with those of the initial problem with the goal of determining the scattered field dependency on the fouling geometrical characteristics. One of the practical applications in the field of Civil Engineering of this study may be the use of ground penetrating radar (GPR) techniques to monitor the fouling conditions of water pipelines without the need to intervene destructively in the structure.

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