Numerical studies on abrasion of decommissioned pipeline polymer coatings

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KEYWORDS: *Decommissioned pipelines; coatings; abrasion; finite element analysis.*

Polymers and polymer-based coatings are widely applied on pipelines exposed to abrasive environments, due to their low density, cost-effectiveness, mechanical reliability, and excellent corrosion resistance. Given the extensive use of polymer coatings in the oil and gas industry, especially as protection against the corrosion of subsea pipelines, an understanding of the long-term degradation of the polymer coatings is important for assessing the potential release of polymer waste into marine environment. Therefore, a practical model is required to evaluate abrasion due to interaction between polymer coating on pipelines and seabed sand particles. The primary objective of this study is to identify the dominant mechanisms and to develop a numerical framework capable of predicting the abrasion response of aged polymer coatings exposed to seabed sand particles.

In the present study a spherical indenter is employed to represent the sand particles. The analytical solution for a spherical contact follows Hertzian contact theory and distinguishes three deformation regimes—elastic, elastic–plastic, and fully plastic - based on the magnitude of the applied normal force. The proposed numerical model focuses on the elastic–plastic and plastic regimes by systematically varying the applied normal load.

Previous studies using the Finite Element Method (FEM) have demonstrated that the abrasion resistance and damage modes of polymer coatings are strongly correlated with their elastic–plastic properties and the associated contact conditions when a single hard spherical asperity slides across the surface [1], [2]. In the current study, finite element analysis is carried out to quantify the abrasion of polymer coating due to a hard spherical particle. The material nonlinearity is accounted for by using experimentally measured stress – strain response of the polymer. Consideration of multi-passes of the particle on the polymer surface enables the assessment of the evolution of the material loss due to increasing abrasion.

The results showed that the ratio of the shear or sliding force to the applied normal force is a linear function of the normalized normal force for a perfectly plastic polymer coating material, while the ratio is a quadratic function of normalized normal force for a strain hardening polymer coating material. An empirical model for the wear rate is developed which was found to be in good agreement with existing data from literature.

ACKNOWLEDGEMENT: This research is funded by Chevron through its Anchor Partnership with the UK National Decommissioning Centre (NDC).

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