Fracture Properties of an Insulation Coating Used in Deep Offshore Oil Pipelines

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Abstract: The study focused on investigating the fracture properties using the four point bending test of the multilayered insulation coating system used in deep-water oil pipeline. During the test, crack-mouth-opening displacement (CMOD) was monitored and used to develop the fracture resistance relationship. The initial stress intensity factor for the polypropylene insulation was 4.4 MPa $m^{0.5}$.

1. Introduction:

With the rapid increase of the petroleum consumption around the world, the oil exploration has shifted from onshore to offshore, further to deep-sea and ultra deepwater (MMS, 2004). The deepwater production system has semi-submersible platforms and other floating drilling facilities. Through flowlines, the oil and gas can be pumped from nearby subsea wells back to the subsea production facilities, thus forming complex networks (Cousins, 2001). Therefore, the deepwater system requires long flowlines which are able to tolerate the high pressure from the ocean depth and currents.

The design of oil pipelines becomes critical and challenging, because deeper and colder waters, approximately close to freezing point, generate issues with paraffin, hydrate and solids accumulation (Cousins, 2001). The external insulation coating system and pipe-in-pipe (PIP) configuration are used to prevent hydrate formation and paraffin buildup in deep-water oil production (Chin et al. 1999). The defect in insulation may reduce the normal oil production and increase the production cost.

2. Objectives:

The overall objective was to characterize fracture properties of the insulation coating using the four point bending test and Crack Mouth Opening Displacement (CMOD) measurement.

3. Materials and Method

In this study, four point bending test was used to investigate the fracture behavior of the insulation material. Resistance fracture toughness was determined based on the crack mouth opening displacement measurement (Vipulanandan and Mebarkia 1993). The experimental set up is shown in Fig. 11. CMOD and deflection were monitored during the loading and unloading of notched specimens.

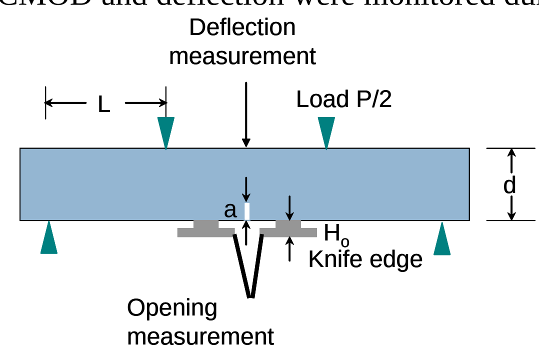
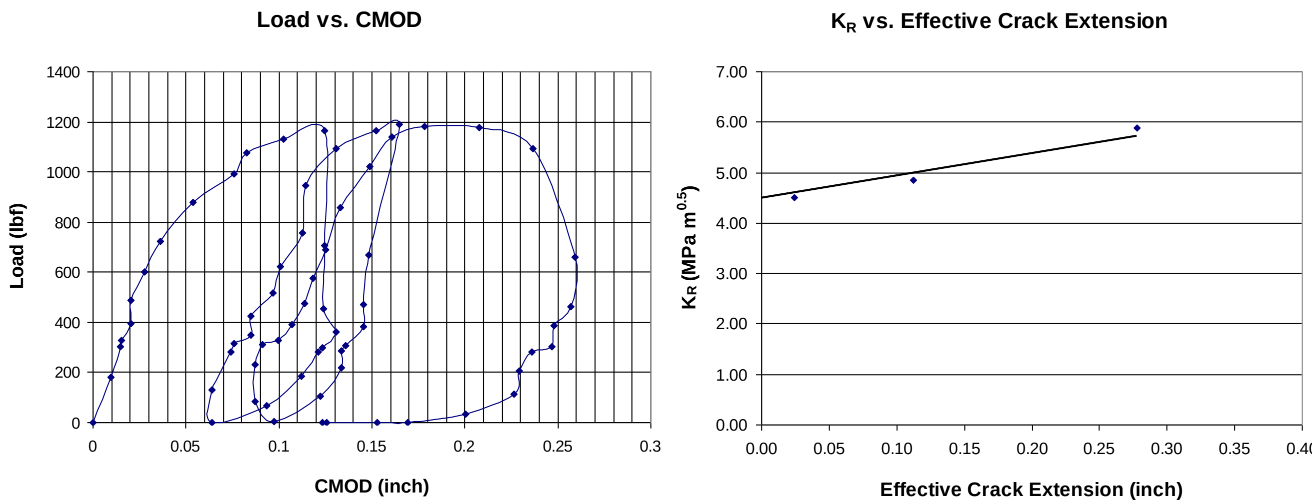


Fig.11. Four point bending test

4. Experimental Results:



(a) (b)

Fig.12. Load-unload test on the specimen with notch cut to the foam layer.

Three loops of load-unload were conducted to the specimen with an initial notch-to-depth ratio of 37%. Based on the loading and unloading, $CMOD^e_o$ and $CMOD^e$ were obtained. Resistance fracture toughness and effective crack extension were calculated based on CMOD method (Dharmarajan and Vipulanandan 1991). As shown in Fig.12. (b), the K_R-Δa relationship was linear and represented as follows

$$K_R = K_o + \rho \cdot \Delta a \qquad (1)$$

where K_0, and ρ are parameters that are obtained from least square fit of the data. The K_0 for the foam layer was 4.4 MPa√m and the ρ value was 5.4 MPa $m^{-0.5}$.

5. Conclusions

Crack was initiated and propagated in the foam layer. K_0 for this layer was 4.4 MPa√m (4004 psi√in.) and value for ρ was 5.4 MPa $m^{-0.5}$ (125 psi $in.^{-0.5}$).

6. Acknowledgements:

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7. References:

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