Characterizing Insulation Coating for Oil Pipelines Using the Impact Resonance (IR) Method

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Abstract: The study focused on the characterization of the multilayered insulation coating system of deep-water oil pipeline using the Impact Resonance Method. Time domain and natural frequency information were both collected and analyzed. The damping ratio was determined using various analytical methods.

1. Introduction:

With the rapidly 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 pipeline 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 pipe-in-pipe (PIP) configuration is used to prevent hydrate formation and paraffin buildup in deep-water oil production. The defect in insulation may reduce the normal oil production and increase the production cost.

In this study, impact resonance method (IR), and the time domain and frequency domain information were collected by Digital Signal Analyzer. Damping ratio was calculated using the Logarithmic Decrement Method and Half-power Bandwidth Method. Young's modulus and Poisson's ratio were determined using the natural frequency.

2. Objectives:

The overall objective was to characterize the insulation coating using the impact resonance method.

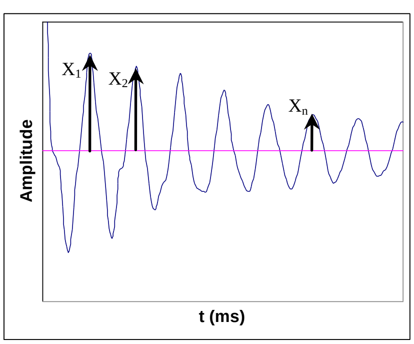

Fig.1. Logarithmic Decrement Method.

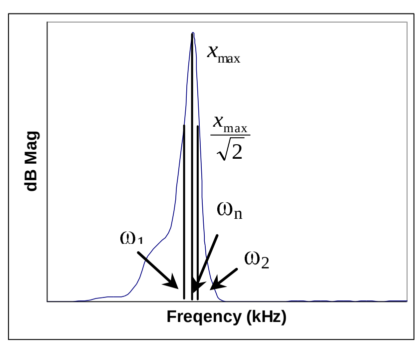

Fig.2. Half-power Bandwidth Method

In log decrement method, the loss factor and damping ratio can be calculated using Eqn (1) and (2). In half-power bandwidth method, the damping ratio can be determined using Eqn (3).

$$\text{Loss factor } \delta = \frac{1}{n}\ln\left|\frac{x_1}{x_{n+1}}\right| \quad (1)$$

$$\text{Damping ratio } \xi = \frac{\delta}{\sqrt{4\pi^2 + \delta^2}} \quad (2)$$

$$\text{Damping ratio } 2\xi = \frac{\omega_2 - \omega_1}{\omega_n} \quad (3)$$

3. Materials and Methods:

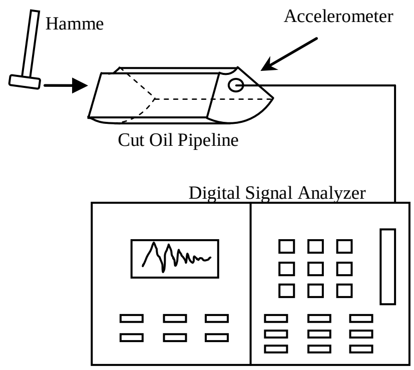

Fig.3. Impact Resonace Test Setup (Longitudinal)

4. Experimental Results:

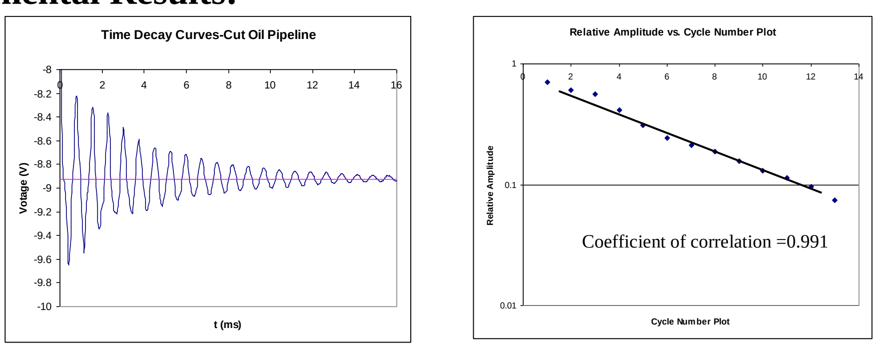

Fig.5. Free Vibration Decay Curves and Frequency Domain of Cut Oil Pipeline.

5. Conclusion

For the insulation coating material, damping ratio was 2.98% using log decrement and 4.29% using Half-power Bandwidth.

6. Acknowledgements:

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7. References:

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2. Cousins, E.T (2001). “Deepwater Subsea Liquid/gas Separation Process under Live Oil Production Conditions in the Gulf of Mexico”, “Technical Progress Report—Annual—September 30, 2000-September 30, 2001”, Conoco, Inc. Houston, TX