

FACULTY OF SCIENCE AND ENGINEERING

Vanessa Bullock, Mechanical Engineering Undergraduate

Vortex induced vibrations in subsea pipelines

Biography

- Fourth year mechanical engineering student
 - Vibration
 - Noise
 - Fluid flow
 - Materials selection and corrosion
- Asset and maintenance engineer at BP Kwinana Refinery
- Woodside graduate program 2014
- Interest in subsea technology



Overview of Presentation

- Free span pipelines
- History of designing for vortex induced vibrations
- Why study vortex induced vibration?
- Methods for predicting vortex induced vibrations
- Vortex shedding patterns
- Experimental apparatus
- Experimental results
- Findings and Future works



Free Span Pipelines

Span Length (L):

10 to 100 times pipeline diameter (D)

Seabed separation (e):

2 to 3 times pipeline diameter (D)







History of designing for VIV





Why study vortex induced vibrations?

- Cook Inlet in Alaska which was developed in early 1960s experienced 14 failures during 1965 to 1976 due to VIV
- Ping Hu Pipeline in East China Sea failed in two locations during 2000 due to VIV





Approximation methods for predicting VIV

Fluid flow over a cylinder

Resonance



$$f_n \approx f_s$$

 $f_{n1} = 2\pi \sqrt{\frac{k}{m}} \qquad f_s = \frac{St \cdot U}{D}$

r

r





Vortex shedding

- Occurs at Reynolds Numbers above 40
- VIV occurs for reduced velocities roughly 5 8 m/s

$$V_R = \frac{U}{f_{n1} \cdot D}$$

 Size of amplitude dependant on damping properties of materials





Vortex shedding patterns





Experimental Apparatus





Polyvinylchloride Pipe



Polyethylene Pipe



Curtin University



Curtin University





Findings and future works

DNV RP-F105 states:

4.4.6 $\psi_{proxi,onset}$ is a correction factor accounting for the seabed proximity:

$$\psi_{proxi,onset} = \begin{cases} \frac{1}{5} \left(4 + 1.25 \frac{e}{D}\right) & for \frac{e}{D} < 0.8 \\ 1 & else \end{cases}$$

- Meaning that the onset of VIV should be suppressed for gap ratios smaller than 0.8
- The study shows that this is not always the case:
 - PVC pipe shows amplitudes of oscillations for the 0.5 Gap Ratio, 0.8 Gap Ratio and 1.0 Gap Ratio similar to that of the 5.0 Gap Ratio
 - PE pipe shows amplitudes of oscillations similar to that of 5.0 Gap Ratios for 0.8 and 0.5 Gap Ratio
- Further investigation is needed into this cut off value
- Varied results for the 1.5 Gap Ratio PE pipe



Questions or comments?



Reference List

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- 3. C. H. K. Williamson and A. Roshko, "Vortex formation in the wake of an oscillating cylinder," *Journal of Fluids and Structures,* vol. 2, pp. 355-381, 7// 1988.
- R. D. Blevins, "Vibration of Structures induced by Fluid Flow " in *Harris' Shock and Vibration Handbook*, A. G. P. a. T. L. Paez, Ed., Sixth ed New York: McGraw-Hill, 2010, p. 19.
- 5. O. Frileiv, "Effectiveness of Spanning and VIV Mitigation for Subsea Pipelines," in *Technology Assessment & Research (TA&R) Program*, Anchorage, AK, 2005, p. 76.

