Proceedings of the Seventeenth (2007) International Offshore and Polar Engineering Conference
Lisbon, Portugal, July 1-6, 2007

ISBN 978-1-880653-68-5; ISBN 1-880653-68-0(Set); ISSN 1098-6189 (Set)

Characteristics of an Encased Gas Transportation Pipeline in Offshore Application

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ABSTRACT

When gas pipelines go through oceans or rivers, according to KOGAS (Korea Gas Corporation) design criteria, buried pipes are encased in concrete due to heavy water pressure and sudden impacts. Especially, the submarine pipes for HVL (High Volatility Liquid) in the deep-seabed are recommended to be encased in assistant structures. This study includes the behavior of pipelines encased in rectangular concrete which suffer from external pressure according to the depth, as well as the inner pressure generated by fluid inside. Based on classical theory of elasticity, the interface stress for the steel-concrete composite pipeline was defined using results from a FEM analysis. Investigations were done on local deformities of the diameter at each part of the pipelines. After calculation the local deformed diameter by using an existing equation for computing the stress in double walled cylinders, which considers the internal and soil pressure, the rate of diameter change is determined. The results were then compared with the behavior of the pipeline encased in rectangular concrete. Through this study, it was verified that pipelines encased in rectangular concrete are about 50% more effective in stress reduction than pipelines without any complementary structure and almost all the external loads are supported by concrete encasement. This study is an elementary part of the research for a new efficient integrity estimation method of concrete-covered submarine pipelines. With this result, the basic design element needed in designing submarine pipelines with protective structure was found.

KEY WORDS: pipeline, encased, encasement, submarine buried, local deformed diameter

INTRODUCTION

Lifeline systems have fundamental maintenance problems because almost all lifelines are buried underground, or located offshore or in rivers, making access difficult. In addition, damage to a buried lifeline structure can result in the shutdown of the entire system as well as enormous economic and social losses instantly. Currently, stability in design of submarine pipelines is critical issues in the field of offshore and coastal engineering. One of the basic factors of designing submarine pipeline is an interaction between buried pipelines and erodible seabed. The seabed instability around pipes has to be taken into account in the designing process. According to scour depth, the pipeline is exposed to various loads and unexpected impacts by floating matters. However, it is hard to monitor the integrity of the submarine pipelines and burial conditions under the water. Due to difficulties in the approach for maintenance, complementary structures are needed to be constructed outside of pipelines to protect against unexpected loads when designing submarine pipelines. However, no research has been done about each design criteria for encased pipelines or the relationship of stress distribution between pipelines and additional protective structure. Moreover, the estimation of stress occurring to buried pipelines due to internal and external pressure has difficulties for the design of energy transportation pipelines. Typically, to insure the safety of gas transportation pipelines, KOGAS uses rectangular concrete structures when the pipeline is installed offshore.

ANALYTICAL SOLUTION OF DOUBLE WALL PIPELINE

If properly designed, a system of multiple walled conduits resists relatively large pressures more efficiently.

THICK-WALLED CYLINDER

Circular cylinders are usually divided into thick-walled and thin-walled cylinder classification. A thin-walled cylinder is defined as one in which the hoop stress may, within certain prescribed limits, be regarded as constant to its wall thickness. From the stress development equation of thick walled cylinders, equations for thin-walled cylinder can be derived. The following expressions for the hoop stress can be applied to thick-walled cylinders for each internal pressure (Eq.1) and external pressure (Eq.2).

$$\sigma_h = \frac{P_i(r^2 - 2ab)}{rt} \quad (1)$$

$$\sigma_h = -\frac{P_o(r^2 - 2ab)}{rt} \quad (2)$$