

Burst Capacity Solutions for Submarine Pipeline with Long Corrosion Defects

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ABSTRACT

Based on the elastic-plastic, large-deformation finite element method, the failure behaviour and burst capacity of submarine pipeline with long longitudinal corrosion defects exposed to internal pressure are studied. The effect of corrosion length and corrosion location on burst capacity is discussed as well. From the FE results, a set of limit solutions are proposed to predict failure pressure of submarine pipeline made of X60 steel with long longitudinal corrosion defects. The burst capacities predicted by the proposed solutions are compared with the results from laboratory tests and various assessment methods. Consequently, it is concluded that solutions proposed in this paper are in extremely good agreement with the experimental data and give more accurate predictions than the existing assessing methods.

KEY WORDS: Submarine pipeline; long corrosion defects; failure behavior; burst capacity.

INTRODUCTION

Offshore pipelines, which are the arteries of the oil and gas industry, have been widely used as one of the most economical ways of transmitting oil and gas from an inlet point, typically an offshore platform or an onshore compressor station, to an outlet point, typically another offshore platform or an onshore receiver station. Due to the harsh marine environment, the damage of pipeline is inevitable which may result in not only economical loss but also severe environmental pollution characterized by (MMS, 1995). Long corrosion is a potential damage pattern of offshore pipelines. According to ASME B31G corrosion length beyond $\sqrt{20Dt}$ is defined as long corrosion defects. Long internal corrosion defects usually appear at the bottom of pipeline around the 6 O'clock position due to the media transporting characteristics, while long external corrosion defects usually occur near the damage part of protective coatings. Intensive researches have been conducted on the failure mechanism and safety evaluation of corroded offshore pipelines. For example, Freire et al. (2006) performed nine burst tests of API X60 pipeline with simulated external long corrosion defects subjected to internal pressure only. Several codes have been established for evaluating the residual strength of corroded pipelines. Among existing codes, the ASME B31G code (ASME, 1991) is still the

most widely used code. However, the B31G code usually obtains over conservative results especially for high strength pipeline. On basis of B31G method Kiefner and Vieth (1989) developed 0.85dl method (Modified ASME B31G) by introducing new bulging factor and material flow stress. The modified B31G method improves the prediction accuracy of burst capacity to a certain extent. Based on full scale tests and finite element analysis DNV and BG technology jointly developed a uniform guideline DNV RP-F101 (DNV, 2000; Bjornoy, 2001) for assessing corrosion defects in pipelines. Recently, a group of solutions for calculating burst capacity of corroded pipeline with X65 pipe steel are proposed by Choi et al. (2003). The regression equations were only derived from short corrosion burst data, and need to be validated for other grade of pipeline. On the base of 0.85dl equations new equations naming RPA method were submitted to predict burst strength of corroded pipeline by Benjamin and Andrade (2003) and verified by finite element analysis. However, the estimation is still conservative, especially for shallow corrosion defects (Andrade and Benjamin 2004).

This paper carried out a detailed numerical study of the failure behavior and burst capacity of pipeline with internal and external long corrosion defects based on elastic-plastic, large deformation finite element analysis. From the FE analysis results a group of regression equations were proposed for estimating burst capacity of pipeline with long axial corrosion defects.

BURST CAPACITY FOR CORRODED PIPELINE

Several assessment methods and criteria of corroded pipeline under internal pressure are available. Among them five most widely used methods are introduced in this paper, namely, ASME B31G method, 0.85dl method (Modified B31G method), DNV RP-F101, RPA method and regression equations derived by Choi et al.

Burst Capacity Equations of ASME B31G

For $L \leq \sqrt{20Dt}$

$$P_c = 1.1\sigma_y \frac{2t}{D} \left[\frac{1 - (2/3)(d/t)}{1 - (2/3)(d/t)M^{-1}} \right] \quad (1)$$

where