A Review on Implementation of Buckle Arrestors for Offshore Pipelines

Suraj[1], Praveen kumar[2], S R Ramesh[3] and Dr. T V Mallesh[4]

[1]PG student, Department of Civil Engineering, SSIT, Tumkur-Karnataka, India

[2]Assistant Professor, Department of Civil Engineering, SSIT, Tumkur-Karnataka, India

[3]Professor,Department of Civil Engineering, SSIT, Tumkur-Karnataka, India

[4]Professor & Head, Department of Civil Engineering, SSIT, Tumkur-Karnataka, India

Abstract: -*Offshore asset infrastructures (subsea pipelines, platforms, risers, jacket structures) are usually subjected to deterioration to a large extent. This growing degradation is recognized as "ageing" process. This ageing situation has become significantly important for the offshore oil and gas and the renewable energy industries because many assets within these sectors are beyond their original life expectancy. It is needed for these assets, some of which have passed their design life, to continue being utilized but with minimal human, environmental and economic risks.Structural damageincluding dent, metal loss and crack is identified and efforts are made to summaries critical damage factorssuch as dent length and crack depth. Furthermore, research and prediction methods on pipe residualultimate strength in terms of experimental tests, numerical simulations and analytical predictions are summarized and discussed.The latest research progress on residual ultimate strength of metallic pipelines with structural damage ispresented through literature survey. This research highlights the challenges to overcome effect of lateral and upheaval buckling using different stiffeners*

INTRODUCTION

The oceans of planet Earth have been the medium in which life first appeared and later exploited by men for transportation and fisheries activities. These traditional uses of oceans, however, have expanded to include the exploitation of hydrocarbons (petroleum) below the sea bed as early as 1850s, when the first exploration drilling was carried out from over a few feet (69 ft) of water in California. That was the beginning of the oil industry. Other early discoveries of oil were later observed in Pakistan (1886), Peru (1869), India (1890) and Dutch East Indies (1893) (Hassan, 2008). The development of the Gulf of Mexico as an offshore area started in1930s with oil first being produced in 1938 from a timber platform in 14 ft of water. The offshore industry began a technically more challenging phase when the North Sea was first explored as a potential offshore area in the early 1960s (Patel, 1995). Since then the pace of oil exploration and production in shallow water has gradually increased to deep-water with the exploration phase started in 1975 while production began twenty years later. The deep-water industry defines deep-water as depth at +3000 ft (900 m) while ultra-deep-water as +7000 ft (2100 m). The exploration of deep-water at present day is approximately approaching 10,200 ft (3100 m) and production at 8000 ft (2400 m) (Nergaard, 2005)

LITERATURE REVIEW

A Literature Survey is carried out on the designof Buckle Arrestors with special interest.

1. Marina V. Craveiro and Alfredo Gay Neto have done research on buckling of pipelines. The

objective of the study is to analyse the instability of pipelines due to internal pressure and experiencing different boundary conditions. Finite element software is used for nonlinear analysis. The study presents comparisons between critical forces and post-buckling configurations for the different boundary conditions, imperfections, load types and analysis methods considered. This study concludes that the equivalence in results between the distinct approaches depends on the nature of boundary conditions.

2. Olav Fyrileiv and Leif Collberg made an attempt to study the influence of pressure in pipelines design. They also further studied about theeffective axial force concept on offshore pipeline design in general and in DNV codes (in particular). This study gives an introduction to the concept of effective axial force. Further explains how this concept is applied in modern offshore pipeline design.

3. Rita G. Toscano, Luciano Mantovano, Andrea Assanelli,Pablo Amenta, Daniel Johnson, Roberto Charreauand Eduardo Dvorkin have done research on Collapse arrestors. Deepwater pipelinesnormally subjected to external pressure and bending fail due to structural collapse when the external loading exceeds thepipes collapse limit surface. After steelpipeline collapses, the collapse is restrained to the collapse initiation section or it propagates along the pipeline. Therefore, it is necessary tobuild in the pipeline periodic reinforcements, to act as arrestors for the collapse propagation. In this study, comparison of the numerical and experimental results for external pressure load is done and validated.

4. Rita G. Toscano, Chris M. Timms, Eduardo N. Dvorkin and Duane D. Degeers have done research on the design of ultra-deep water pipelines. This study presents the results of a nil-scale test programand finite element analyses performed on seamless steel line pipe samples intended for ultra-Deepwater applications. The work involved obtaining full-scale test data and further enhancing existing finite element analysis models to accuratelypredict the collapse and post-collapse response of ultra-Deepwater pipelines.

5. D. DeGeer, C. Timms, J. Wolodko, M. Yarmuch, R. Preston and D MacKinnon have done study on Medgaz pipeline, its current state of development, the installation challenges that necessitated the buckling assessments and some of the work performed throughout the study, including full scale tests, finite element analyses, and regression analyses. Collapse and critical bending strain predictive equations were developed and are also presented and are compared to other well-known collapse and critical bending strain equations.

6. Bjorn Fallqvist has done research on collapse behaviour of pipes by the use of finite element modelling. Existing analytical expressions for collapse were evaluated and especially the one used in DNV-OS-F101 was decidedto be studied in comparisonwith FE-model results.The results seemed to indicate that the transition between the elastic and plastic range of the material stress-strain curve was of great importance. The results were discussed in the context of the different collapse-related parameters defined beforehand and some concluding remarks were made on possible further work related to these findings.

7. Andrea P, Assanelli, Rita G, Toscano, Daniel H. Johnson andEduardo N. Dvorkinhave done a research on collapsebehaviour of steel pipes. Experimental/numerical techniques implemented toinvestigate the collapse behaviour of steel pipes are presented. The discussion of the experimentaltechniques includes the description of the facilities for performing external pressure collapse testsand the description of an imperfections measuring system. The numerical techniques include 2Dand 3D finite element models.

8. J. G. A. Croll presented a paper, which shows how the analysis of minimum, quasi-static and buckle propagation pressures for subsea pipelines may be exactly formulated in terms of the characteristics of ring collapse. simple mechanistic approach to ring collapse is described which enables the rational incorporation of the effects of material strain hardening. Analysis offers the potential for future design of pipelines being at once more rationally and parametrically complete and yet compact and simple to apply.

9. Kyriakides and C.D. Babcock have done investigation to understand the dynamics ofa propagating buckle and to find a basis for designing efficient and effectivearrestingdevices.Quasistaticbuckle arrest experimentswerecarried out to determine the parametric dependence of the pressure at which slowly propagating buckles penetrate thearrestors.

10. SteliosKyriakidesand Charles Babcock have suggested a new buckle arrestor design in this following paper. It is comprised of rod tightlywoundaround the pipe to form a number of turns.Theends of the rod areweldedin order to secureit in place. Its maincharacteristicis that itcan be used in continuous pipelayingmethods(e.g., reel pipelaying). It can also beused inthe case of pipes coatedwithconcretewhereit can beinserted into the concrete.Experimentshave shown that its efficiencyiscomparable to otherarrestors. Anempiricalexpression for the arrestorefficiencyis presented.

11. Rita G. Toscano, Luciano Mantovano and Eduardo N. Dvorkin performed several experimental tests and made a comparison between finite element results and experimental results for full-scale collapse tests under external pressure, external pressure followed by bending and bending followed by external pressure. The test program was performed at C-FER Technologies (C-FER), in Canada, using TENARIS steel seamless pipes. while the finite element analyses were performed by CINI, in Argentina, using the general-purpose finite element codeADINA. The numerical /experimentalcomparisons reported in this paper demonstrate a very good agreement between the finite element predictions and the laboratory observations.

12. Luciano O. Mantovano, Pablo Amenta, Roberto Charreau, Daniel Johnson, Andrea, Assanelli and Rita GToscano have developed finite element models using shell elements, for the calculation of cross over pressures and their experimental validation for seamless steel pipes. Numericaland experimental results that are obtained for the two cases are compared and results showsthe agreement between them, cross-over pressure and cross-over mechanism, isexcellent.

13. Carl G. Langne has developed Empirical relationshipsfor the design ofboth integral ring and grouted sleeve arrestors, forming the basis of a simple and straightforward design procedure. Studies carried on the progress on design of buckle arrestors ormore precisely collapse arrestors for deepwater pipelines.

14. T.D.Park and SKayriakides have presented a report on study of effectiveness of integral buckle arrestors for offshore pipelines. A series of full scale experiments were conducted where the pressure at which buckles propagating quasi-statically crossed arrestors ofvarious lengths and thicknesses was established. The model was subsequently used to extend the experimental parametric study of arrestor efficiency. Some limiting values of the parameters were established from the results and several design recommendations are made.

15. Rita G. Toscano and Eduardo N. Dvorkin have developed finite element modelsto predict the collapse and collapse propagation of seamless steel pipes under external pressure and bending.The validation of these models was performed comparing the numericalresults with experimental results obtained at CFER (Edmonton, Canada) and for the pre-collapse and post-collapse regimes. Finally, the validated finite element models are used to perform parametric analyses that provide useful data for pipeline engineers on the effect of different geometrical parameters on crossover pressure.

16. Rita G. Toscano and Eduardo NDvorkin have done studies on the finite element models which were developed using the MITC4 shell element, large displacements / large rotations formulation and an elasto plastic material model. The effect on the collapse pressure and on the collapse propagation pressure of the pipes initial imperfections such as ovality, eccentricity and residual stresses is investigated.

CONCLUSION

This paper has covered research on the residual ultimate strength of offshore metallic pipelines based on a literaturereview. It has revealed that such research is still within theengineering interest, especially when the pipes suffering fromstructural damage.Influential parametersin terms of pipe load, installation process and material that affect the ultimate strength of pipes are categorized. Structural damage including dent, metal loss and crack is identified in this paper. Furthermore, research and prediction methods on pipe residual ultimate strength in terms of experimental tests, numerical simulations and analytical predictions are summarized and discussed. Specific details on how to introduce, simplify and simulate structural damage are presented and discussed.

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