The Effect of Inner Steel Hull Flexibility on the Responses of the LNG Containment System No.96 under Static Loads

A. Arswendy(1)         Oddgeir Liasjoe(1)                Torgeir Moan(1,2)
(1)  Department of Marine Technology, Norwegian University of Science and Technology (NTNU), Trondheim - Norway
(2)  Centre for Ship and Ocean Structures (CeSOS), NTNU, Trondheim - Norway

ABSTRACT

Stress analyses of LNG containment system (LCS) No.96 have been conducted with the main objective of studying the effect of inner steel hull flexibility on the response of LCS No.96. Therefore, two global FE models of LCS No.96 were created with rigid and flexible inner steel hull support using combined shell and solid elements. In this study, elastic material properties are used. The studied responses are the static stress distributions of LCS No.96, eigen buckling modes and values, as well as their nonlinear geometrical behaviour of the LCS structure with imperfections introduced.

It was found that the static stress distribution in the upper part of the primary box is not affected by the flexibility in the inner steel hull which supports the LCS No.96. The responses of the lower part of the primary box down to the mastic ropes are influenced by the response of inner steel hull. The first buckling modes of model are bending modes of its secondary bulkheads. The model of LCS NO.96 that accounts for the flexibility of inner steel hull create lower eigenbuckling values than one with rigid support. Imperfections are introduced to the buckled bulkhead based on the eigenmodes with maximum initial displacements of 1%, 10% and 50% of the bulkhead thickness. The stress distributions before and after the LCS No.96 loss of stiffness are studied.

KEYWORDS: LNG containment system NO.96, flexible inner steel hull support, stress distributions, eigenbuckling analysis, nonlinear geometry behaviour.

INTRODUCTION

LNG containment system No.96 consists of two plywood boxes which are called the primary and secondary boxes. The boxes are filled with expanded perlite. The primary box is secured by means of the primary couplers which are fixed to the secondary coupler assembly. The secondary box is laid and supported by the inner hull through load bearing mastic ropes and fixed by means of the secondary coupler anchored to the inner hull as can be seen in Fig. 1 (GTT, 2009).

The support of the LNG containment system by the inner steel hull has a major effect on the responses of the LCS. Arswendy and Moan (2006) investigated the effect of the flexibility of the inner hull support on the static and the dynamic response of the LCS Mark III. The further study of the LCS Mark III was reported by Graczcyk and Moan (2009). The guidance notes which are issued by classification societies acknowledged the importance of inner hull support on the response of LNG containment system (DNV, 2006, ABS, 2006 and LR, 2009). Therefore, a rational design procedure of the LNG containment system required a direct calculation especially to study the effect of the flexibility of the inner hull on the stress as well as the strength assessments of LCS No.96.

In this study the effect of the flexible steel hull on the stresses of LCS No.96 is investigated by means of finite element (FE) methods. The stresses are observed for the components which are needed for the strength assessments of LCS No.96 such as the bending of primary cover plate, the compressive stress in the intersection region between the primary and secondary bulkheads, and the buckling of bulkheads. The effects of flexible steel hull support on LCS No.96 on eigen buckling values and modes are also reported, as well as their post buckling behaviour. Furthermore, the effect of imperfection to the buckling behaviour of LCS No.96 is highlighted.

Fig. 1. Artist impression of LNG containment system NO.96 (www.gtt.fr, 2009)