Comparison of different models for the fatigue analysis of details subject to side shell intermittent wetting effect

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Abstract

The influence of the side shell intermittent wetting on the fatigue life of ships longitudinal stiffeners is well known, and it has been the subject of many studies. Different models have been developed in order to take this nonlinear effect into account in the ships and offshore units fatigue strength evaluation procedures. However, these models have been built considering the sea pressure as the only source of stress cycles in the fatigue details, while in most cases the stress induced by the intermittent pressure is combined with other contributions, such as hull girder bending. The accuracy of the intermittent wetting effect models is somehow questionable in this context of combined fatigue loads.

This paper presents the validation of current fatigue evaluation methods accounting for the intermittent wetting effect. Spectral analysis using a stochastic linearization is compared with the nonlinear time domain simulation, considered as the reference model.

In order to compare the different intermittent wetting models and assess their accuracy versus the reference model, numerical applications are done for 18 transverse sections of six container carriers, taking into account the actual relative influence of the different types of loads. The fatigue damages predicted by the current models are compared with the fatigue damage provided by the reference model.

Keywords

Fatigue damage; intermittent wetting; ship structures; side shell; time domain analysis; spectral analysis.

Introduction

Side shell longitudinal stiffeners in the area affected by the intermittent wetting at the mean waterline of ships are known to be prone to fatigue problems. The load causing this type of fatigue damage is mainly the local wave pressure which is, in this case, a non-linear load due to the alternately dry and wet surface. Measured sea pressure time history, as shown in Fig. 1 from (Van der Cammen, 2004), is a truncated signal in the area of intermittent wetting (Pressure P1) whereas in the permanently wetted area, the pressure (Pressure P2) is a non-truncated signal.

The intermittent wetting effect has been studied for a long time. Cramer, E.H. & al (1993) proposed a closed form fatigue damage expression for longitudinal stiffeners connections considering exclusively the wave pressure load, assumed to be a function of the relative wave elevation. Friis Hansen, P. & al (1995) studied the fatigue damage in the side shells of ships under the combined effect of hull girder loads and non-linear local wave pressure loads at mean water line. As the stress response is a non-linear function of the wave height, they didn’t use the spectral procedure and solved the load combination problem by the application of a regular wave model.

Fig. 1: Sea Pressure Time History Inside and Outside the Intermittent Wetting Area.

For practical reasons spectral fatigue analysis (SFA) is the preferred procedure for fatigue direct calculation in the industry, so methods for taking intermittent wetting effect into account in SFA have been developed (eg. Det Norske Veritas / Bureau Veritas (2004) ). In this paper, advanced intermittent wetting models dedicated to spectral fatigue analysis are presented. They consist in a corrective pressure term added to the hydrodynamic linear pressure. This pressure correction is determined in such a way that the fatigue damages induced by the linearized pressure and by the non-linear pressure are identical.

These intermittent wetting models are then compared with the non-linear time domain simulation considered as the reference model, in order to verify and compare their accuracy. These models have been built considering the sea pressure as the only source of stress cycles in the fatigue details while in most cases the stress induced by the intermittent pressure is combined with other contributions such as hull girder bending. Therefore, their accuracy is also to be checked in case of combined fatigue loads. The intermittent wetting models are vali-