Transfer of Non-Linear Seakeeping Loads to FEM Model Using Quasi Static Approach

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ABSTRACT

This paper presents a methodology to transfer the non-linear time domain seakeeping loads to the 3D structural finite element method (FEM) model. The presented approach ensures that the loading and accelerations of the seakeeping and FEM calculation is almost identical. The applied accelerations and forces at the FEM model ensures a well balanced structural model.

KEY WORDS: non-linear, seakeeping, structure, loading and response

INTRODUCTION

To be able to investigate the local response of the ship structure in waves it is necessary to transfer the seakeeping loading to a 3D structural model of the structure. The usual approach is to transfer the linear frequency domain seakeeping loads calculated by a hydrodynamic boundary element method (BEM) to the structural finite element method (FEM) model.

The transfer of the hydrodynamic loading to the structural model is not trivial. The meshes used for the BEM and FEM models are normally quite different. A common approach is to interpolate the total hydrodynamic pressure to the FEM mesh. This interpolation will cause some inaccuracies in the loading. An other problem is the accelerations of the FEM model. The accelerations should fully balance the applied pressure loading to avoid additional stress by the support reactions. Supports or constrained nodes are necessary for solving the quasi static structural problem. Reaction forces can easily be avoided by using the “relieve acceleration” in the FEM package. The FEM-packages will calculate the accelerations needed to fully balance the loading. But there may be a difference between these “relieve” accelerations and the original seakeeping motions. If so, there will be also a discrepancy between loading and accelerations because the hydrodynamic forces are based on the motions.

The approach presented in (Malenica et al., 2008) ensures that the linear hydrodynamic loading is consistently transferred to the FEM model. In this approach the hydrodynamic boundary value problem (BVP) is solved using the hydrodynamic mesh, but interpolation is avoided by integrating the potentials over the FEM mesh. The equation of motions are solved using these coefficients and the mass distribution of the FEM model. The resulting loading can directly be transferred to the FEM model without any interpolation. The calculated accelerations balance the hydrodynamic loads fully which ensures that the support reaction are negligible. The forces and accelerations at the structural model are very close to the results of the normal seakeeping calculation.

Linear seakeeping analyse can be utilised as long the wave height remains small. For calculation of the structural response in extreme sea states it is necessary to utilize non-linear time domain seakeeping theory and transfer these non-linear loads to the structural model.

In this paper we present an approach to transfer the loading from a time domain seakeeping program with non-linear load components to the FEM model. The approach as presented in (Malenica et al., 2008) is extended for the time domain with non-linear load components. The presented method ensures that both the seakeeping forces and accelerations are consistently transfered to the FEM model.

STRUCTURAL AND HYDRO MODELS

The starting point for the calculation is the FEM model. The FEM model should have the correct mass distribution, this is normally achieved by adding additional masses and/or increased density to account for equipment and cargo weights. The mass distribution of the structural model will be used for the seakeeping calculations.

The elements that represents the ship’s outer hull are extracted from the FEM model and will be used for all remaining steps. The BEM mesh is created based on the FEM model. The first step is creating, in longitudinal directions, many transversal sections, see figure 1. These sections are created by making a cut trough the FEM mesh. Knuckle points, like the skeg, are preserved and the remaining section is smoothed. The next step is to balance the structural model in still water. The draft and trim are obtained using an iterative procedure. The BEM mesh is created us-