Summary of the dissertation

Influence of the numerical modelling methods on dispersions and errors of analysis results in chosen marine machines and structures

Summary

A ship is a special device, operating independently on the sea, in extremely harsh conditions. Therefore, safety, durability, and vibration requirements are always a top priority when designing and manufacturing ships to reduce the risk of accidents that may cause damage to people and cargo. The basic question always raises how to design the details of marine machines and structures to meet basic safety criteria in different working conditions and environments. Initially, the solution to the problems of strength endurance, vibration was based on trial and error. But in recent times, the maritime field has been rapidly developing, structures are becoming more complex, and previous experience is no longer sufficient. In shipbuilding, classification societies have been established to form sets of rules - an empirical relationship that determines the extreme values of the main parameters of the structure. Almost parallel to the development of methods of analysis based on empirical relationships, progress is being made on the in-depth understanding of the physics of the phenomena we are interested in and the development of the mathematical description of these phenomena. The model of a device is described using a mathematical model that is usually simplified and saved using computerized procedures. The numerical modelling method is widely applied, but the degree of reliability, the effect of errors and the dispersion of the analysis results is unknown in detail for marine structures. In the dissertation the sources of calculation errors and the size of results desperations were considered of the modelling marine objects.

The basic method for reducing analysis error and dispersion is the use of correlation and mutual support between the numerical modelling method and the measurement method. In the doctoral thesis, the causes of computational errors and dispersion results are considered, depending on the model of the chosen marine machines and structures. Methods to minimize them are also analysed. The influence of computational conditions such as boundary conditions, density of meshing, type of finite elements, etc. on calculation imperfections are considered. The assessments are based on a comparison between results obtained from a numerical model and results obtained based on a number of empirical formulas verified by measurement methods. Based on the obtained results, the author asserts that the thesis has solved some initial contents of the thesis as follows:

1. Mathematical models of the small basic parts that make up the hull and superstructure such as beams, thin plates, stiffened plates has built. Analysis of selected structures takes into account factors that may cause errors and dispersion in calculations such as boundary conditions, density and finite element type to be applied. The structures are also calculated and analysed in two cases of liquid contact and non-liquid contact. The results obtained are compared with the results from some experience formulas and verified by a measurement method based on the measurements performed in the laboratory of Gdynia Maritime University.

2. Building the mathematical model for two container vessels of different sizes: an average container ship of 2000 TEU and a large container ship of 11400 TEU. One of the most important parameters analysed is the ship's vibration. Global vibrations of the entire hull and local vibrations of the superstructure and main engine body are determined. The results obtained by numerical models are compared with the empirical formulas given by Brown and F. M. Lewis and F. H. Todd and some other authors. Since then, confirming the accuracy and advantages of the numerical modelling method based on the finite element method, the ability to applied numerical modelling methods to other structures in the maritime field. The reliability and confidence of engineering calculations was improved when applying numerical modelling methods for structural calculations and analysis.
3. Finally, the author has applied the numerical modelling method to the ship's propulsion system. The mathematical models for the ship's propulsion system with many different assumptions are built, choosing the most optimal ship propulsion model. Determined (point 2) stiffness of ship hull is used as the boundary conditions of power transmission system. Apply the most optimal mathematical model of the ship propulsion system to analyse and align the shaft line of the typical ship propulsion system. Static and dynamic calculations analysis of the propulsion system are carried out and compared with allowed values.

In the world's marine literature, there are a number of works confirming the occurrence of high errors and dispersions of computational analysis and measurement tests. Particularly the legitimacy of using numerical calculations seems to be limited due to their low level of confidence. The author has developed a number of calculation methods that allow a rational reduction of the levels of calculation errors, to an acceptable level while limiting the workload of numerical analysis. Within the dissertation obtained the following results:

1. The impact of calculation assumptions on errors and dispersion of analysis results in individual types of analyses (static, normal modes, forced vibrations) was estimated.
2. An optimal methodology for carrying out computational analyzes using the finite element method was developed for the ship's hull structure (including its superstructure and main engine body), taking into account the purpose of the calculations (static strength calculations, vibration analysis, thermal calculations, etc.).
3. An optimal methodology for conducting calculations using the finite element method was developed for the ship's power transmission system, taking into account the purpose of the calculations.
4. The developed calculation methods were verified by comparing them with experimental tests of selected elements of ship systems, together with determining the levels of measurement dispersions.

The author has proved that it is possible to limit dispersions and errors in numerical modelling of the marine structures and machines to an acceptable level and consistent with empirical research.