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Automatic FE modeler using stiffener-based mesh generation algorithm for ship structural analysis

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Abstract

Shipbuilding industries have started to employ 3D CAD systems to integrate all design and production processes by achieving seamless data transfer and data sharing. The emerging 3D CAD system brings a considerable change in FE analysis field. The availability of 3D geometry increased the recognition of the need for developing automatic FE modeling system consequently.

However, general automatic mesh algorithms developed by academic research field have a limitation. The difficulty in satisfying lots of line constraints and the absence of proper idealization of 3D geometry entities defined in CAD system hinders directly employing the general mesh algorithms.

In this research, an automatic FE modeling system has been developed for cargo hold FE modeling and whole ship FE modeling. The basic concept of the algorithm is to decompose surfaces using stiffener lines into subregions and generate mesh using a rule established based on FE modeling practice of ship structure. Since the decomposed subregions take simple polygon, they can be easily transformed into elements by decomposing the polygon according to the rule defined considering the shape of the polygon and mesh seed on its perimeter. The algorithm is also designed to treat appropriate geometry idealizations for bracket-type surface and stiffener connections. The idealization process is also completely customized based on FE modeling practice. The validity of the developed system is verified through illustrative examples.

Keywords: Automatic FE mesh generation; Stiffener-based mesh generation algorithm; Geometry idealization

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1. Introduction

Ship design work includes a wide range of design works; hull design and steel outfitting, electric outfitting, machinery outfitting, production drawings and so on. These design works have been performed in different CAD systems and there have been serious troubles in transferring the model data from one CAD system to another.

The integration into a single 3D CAD system requires exhaustive work and an investment of huge amount of money and time to cover the extensive design work. This has delayed the introduction of 3D CAD system into shipbuilding industries differently from any other engineering fields. The introduction of 3D CAD system is also expected to change the situation of FE analysis field. FE modeling takes an advantage of 3D geometry model by transferring it from 3D CAD system to FE preprocessor. Moreover, in FE modeling, there is a tendency of achieving a higher accuracy by reducing the mesh size, which eventually increases FE modeling time. On the contrary, rapid growth in computer performance has reduced the solving time, which accounts for a small portion of the FEM analysis time. This changing situation has encouraged to develop automatic FE modeling algorithm, which has emerged as an important issue in today's analysis engineering environment.

Since long time, analysis engineers in shipbuilding industry have constructed FE model manually while referring to only printed drawings. At most, 2D drawing data from 2D CAD system is imported to FE preprocessor and referred in manual modeling after it is reassembled as a 3D model in these days. If this manual work is replaced with automatic process, analysis and design time can be drastically reduced. In addition, a shortened analysis time gives scope for a more innovative/superior design by making it earlier, to reflect analysis results on design amid a tight ship design schedule.

Automatic FE modeling system for ship structural modeling needs a sufficient consideration of ship structure's characteristics. The development includes a new algorithm, named Stiffener-Based Mesh Generation. Its basic concept is that stiffener lines are used in decomposing surface into smaller polygon-type regions and the regions are divided into elements and smaller regions according to templates established by mesh generation practice of ship FE analysis fields. The algorithm is also designed to treat geometry idealization process which is completely tailored to the practice. The system can generate whole-ship coarse mesh model and cargo hold fine mesh model for tanker, container ship, and LNG carrier. This is expected to enhance the efficiency by drastically cutting down routine and simple FE meshing work.

Meanwhile, due to the increasing request of ship owners and classification societies for direct FE analysis, almost the same structural analysis has been repeatedly performed for examining cargo hold strength or whole-ship global strength. This has induced great concern in developing user-friendly environ ment for typical FE analysis to guarantee consistent result and to shorten analysis time.

Samsung Heavy Industries has developed integrated systems for cargo hold analysis and whole-ship analysis. The systems include all subsystems ranging from importing geometry model to generating a final report. Figs. 1 and 2 depict the organization of two systems.