

# 論文の要旨

題目

A Study on Modularization and Arrangement of Ship Piping System  
in Consideration of Series Ships

(シリーズ船を考慮した船舶配管システムのモジュール化と配置設計に関する研究)

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Presently, the market competition in the ship building industry has become exceedingly intense, and to compete in the global market, shipbuilders are required to produce ships that are more efficient and constructed in relatively short turnaround times-periods between order placement and delivery. This necessitates the development of new methods such as building series ships, design optimization, and modularization concepts. This study presents a design optimization approach based on the modularization concept for engine room design. The characteristics of the proposed method are as follows: piping systems, employed in multiple bulk carrier series ships, of different sizes are focused on. The cost and weight of these systems and the similarity and common features of the concerned modules and arrangements are considered. The piping system design process is divided into two stages—module definition and arrangement design.

Modularization involves the grouping of parts with strong dependency into a single group. In the previous research, modularization in piping design is implemented for each ship. Therefore, the modularization process is repeated due to the design of new ship type. However, based on the modularization concept developed in the automobile industry, the modularization is changing. the modularization concept is being employed in relation to the overall optimization of vehicles in the automobile industry. Consider the example of Nissan Motors' Common Module Family, which is a modular architecture concept that can be applied to a variety of different vehicles. As such, it enables the efficient design and manufacture of models such as small cars, sedans, and SUVs, simply by altering the combination of engine compartment, cockpit, and front and rear underbodies as modular units. The adoption of this type of approach to modularization provides an opportunity to enhance the design of engine rooms in shipbuilding.

In this study, the modularization is generated using the DSM concept. Since the target ship of this study is various series ships, with several additional equipment in certain ship, therefore the modularization should be separated between common equipment and optional equipment. The output of this process is in the form of a common module for ships belonging to various series types and an optional module that can be used for any particular ship. The modularization requirements are as follows.

- Modules should be defined for a single ship, a single series of ships, or for multiple series of ships.
- Based on an owner's requirements, both the common and optional modules should be sufficiently flexible to changes in capacity and size with no need for a change in module configuration.
- It should be possible to use a combination of common and optional modules to obtain a new ship type based on the owner requirements.

- To effectively utilize the modularization concept, complex connections should be included in the module. Therefore, the total number of connections between the individual modules should be minimized.

The next important stage of this study is create the optimized module arrangement. In the piping design, module arrangement design of the part in engine room deals with the selection of the most appropriate and effective arrangements that will allow a greater working efficiency. Developing module arrangement is an important step because of the impact of the layout on the operation, repair, and maintenance. Because of the complex and precise nature of the module arrangement layout, the optimization procedures such heuristic, neural network, genetic algorithm is needed.

Following the arrangement definition process, the defined modules are arranged inside the engine room. This process has been termed as the module arrangement problem. Some points should be considered, such as:

- The arrangements of three series ships were executed simultaneously. This provides the flexibility to consider various options at once.
- In the aforementioned case, the design space becomes relatively large; moreover, it is difficult to obtain an optimum solution in a limited time when the positions of the modules are directly considered as design valuables. Therefore, the decks within the engine room and individual modules were divided into meshes.
- Various constraints such as the space requirement for maintenance, area for fixed components, etc. should be considered.
- Similarity of arrangements should be considered for a single ship, series ships, and for various types of series ships.
- Pipe costs should be minimized with respect to the pipe length, diameter, material, etc.

This study presents a new piping system arrangement with respect to series of ships in line with the modularization concept. Thus, the design and layout of the piping arrangement were first divided into two stages—module definition and module arrangement. The DSM method was adopted in order to define an effective module that offers commonality of usage across different ships. Furthermore, an optimization system was developed to determine the module arrangement using a genetic algorithm in order to obtain exceptionally similar module-arrangement patterns for ships belonging to various series types, with specific consideration given to piping cost and similarity. The proposed concept is used in an actual ship design process and its effectiveness is evaluated.