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Analysis Of Bow Thruster Design As A Ship Propeller Train The Ministry Of Transportation Sailing School

Muh. Ivan[1], Abdul Wahid[2] and Mahbub Arfah[3]

[1,2,3] Makassar Maritime Polytechnic, Indonesia
muhamadivan0709@gmail.com

Abstract. The purpose of this study is to analyze how bow thrusters are designed and implemented as a propulsion system for training vessels at the Ministry of Transportation's Maritime School. Bow thrusters are chosen because of their potential to improve the maneuverability and operational efficiency of training vessels, which are very important in the context of maritime training. To conduct this study, we use a descriptive-analytical approach. The data used come from literature studies and field trials on prototype training vessels. From the results of the study, it is proven that the use of bow thrusters significantly improves maneuverability when in busy ports and also optimizes efficiency in fuel use. These findings have practical implications that can be used as a reference in developing training curricula at maritime schools, as well as providing recommendations for using similar technology more widely in the shipping industry. To overcome the limitations in bow thruster design and application, it is recommended to continue further research in the future to provide better recommendations.

Keywords: Bow thruster, training ship, ship maneuver, operational efficiency, sailing school, shipping technology.

1 Introduction

The global maritime industry continues to experience rapid development, demanding increased efficiency, safety, and sustainability in ship operations (Kyaw, 2024). In this dynamic landscape, the role of maritime educational institutions is becoming increasingly crucial in preparing a generation of sailors who are not only technically competent but also adaptive to changes in technology and industry regulations (Wulandari et al., 2024). Schools Ministry of Transportation Shipping, as a leading maritime educational institution in Indonesia, is at the forefront of efforts to modernize curriculum and infrastructure training, including its fleet of training ships (Danny et al., 2022).

One of the innovations that has attracted attention in improving ship performance is the use of bow thrusters. This technology, which has long been used on large commercial vessels, has proven to significantly improve the maneuverability of vessels, especially in congested port conditions when sailing in confined waters or facing extreme weather (Emediong Christopher Umana et al., 2022). However, the implementation of bow thrusters on training ships requires a different approach and in-depth analysis, considering the special characteristics and educational objectives of the ship. The main

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challenges lie in how to integrate this technology not only to improve ship performance but also to enrich the learning experience of the cadets.

This study aims to comprehensively analyze the design and implementation of a bow thruster as an auxiliary propulsion system on the Ministry of Transportation's school training ship. The research covers multiple aspects, including technical design, performance analysis, and the impact on operational efficiency, as well as implications for training quality and methodology. Additionally, the study will address safety factors, relevant maritime regulations (International Maritime Organization, 2024), and environmental sustainability considerations, which are increasingly prioritized in the global maritime industry.

The key questions this research seeks to answer include: (1) How can a bow thruster be optimally designed for a training ship to meet the specific needs of the Ministry of Transportation Shipping School? (2) To what extent can the use of a bow thruster enhance the maneuverability and operational efficiency of training ships under various sailing conditions? (3) What are the implications of bow thruster implementation on the maritime training curriculum, and how can this technology be effectively integrated into learning programs? (4) How does the application of bow thrusters on training ships contribute to emission reduction and the sustainability of maritime operations?

The research hypothesis posits that implementing a bow thruster will significantly enhance the maneuverability of training ships, particularly in port and confined water conditions, while contributing to improved fuel efficiency. Additionally, it is anticipated that integrating this technology into the training program will create new curriculum opportunities, allowing cadets to gain direct experience with advanced propulsion systems increasingly used in the maritime industry.

This research's significance lies in its theoretical and practical multidimensional contribution. Theoretically, this study will enrich the literature on the application of bow thruster technology in the context of maritime education. This area is relatively underexplored and represented in previous research. This research also has the potential to pave the way for the development of a new technology integration model in the maritime education curriculum, an increasingly crucial aspect in the era of digitalization and automation of the shipping industry.

In practice, the research results are expected to serve as a blueprint for maritime education institutions not only in Indonesia but also regionally and internationally, enhancing the quality of their training ship fleets. These findings hold the potential to offer valuable insights to the shipping industry for developing more efficient and adaptive propulsion technologies tailored to the unique needs of training vessels. Moreover, by equipping cadets with hands-on experience in the latest technology, this research aims to boost the global competitiveness of graduates from the Ministry of Transportation's Shipping School in the maritime labor market.

By integrating bow thruster technology on training vessels, the Ministry of Transportation's Sailing School has the potential not only to enhance the quality of technical training but also to equip future sailors with comprehensive knowledge of modern ship operations, energy management, and sustainable maritime practices (Emediong Christopher Umana et al., 2022). This aligns with global trends in digitalization and decarbonization within the shipping industry, ensuring that graduates are prepared to meet both current and future challenges.

Therefore, an in-depth analysis of the design and implementation of the bow This thruster is an important and strategic step in advancing maritime education in Indonesia. This research not only contributes to the development of maritime technology overall but also has the potential to be a catalyst for educational transformation. maritime towards a more innovative, relevant, and future-oriented direction. Thus, this study is expected to provide a strong foundation for ongoing efforts to improve the quality and relevance of maritime education in Indonesia while strengthening the country's position in the global maritime industry.

2 Literature Review

To comprehensively understand the design and implementation of bow thrusters on training ships, this literature review will explore some key aspects relevant to this research. The focus will be on the development of bow technology thrusters, their application in the context of training ships, their impact on operational efficiency and maneuverability, and their integration into maritime education.

2.1 Development of Bow Thruster Technology

Bow thrusters have become an important component in improving ship maneuverability since their introduction in the mid-20th century. Yukun et al. (2020) conducted a comprehensive study on the evolution of bow thruster technology, showing significant improvements in design and efficiency over the decades. They noted that the latest innovations in propeller design and systems control have increased the effectiveness of the bow thruster, especially in harbor conditions. dense and confined waters.

Furthermore, Alexandre De Bernardinis and Jeff Moussodji (2019) analyzed recent trends in bow thruster technology, particularly the advancement of electrification and hybrid systems. Their research demonstrates the potential of electrified bow thruster systems to reduce fuel consumption and emissions, aligning with the sustainability goals of the global maritime industry.

2.2 Bow Thruster Application on Training Ships

Although bow thrusters are commonly used on large commercial vessels, their application on training ships requires special consideration. Scurtu & Oncica (2018) explore the unique challenges in implementing bow thrusters on ships with special characteristics, including training ships. His study emphasized the importance of balancing operational needs with educational goals in designing bow thruster systems for training ships.

Wang et al. (2015) conducted a case study on the integration of bow thrusters on several training ships at various international maritime academies. They found that the use of bow thrusters not only increases the ship's maneuverability but also enriches the cadets' learning experience by introducing them to modern propulsion technology.

2.3 Impact on Operational Efficiency and Maneuverability

Improving operational efficiency and maneuverability are key aspects in the implementation of bow thrusters. Emediong Christopher Umana et al. (2022) conduct a quantitative analysis of the impact of bow thruster use on consumption of ship fuel. Their findings suggest the potential for reducing fuel consumption. burn up to 15% in port operations and maneuvers.

Furthermore, Milushev et al. (2022) analyzed the increase in maneuverability of ships equipped with bow thrusters in various operational conditions. They found that the bow thruster significantly increased the ship's capabilities to perform high-precision maneuvers, especially in strong wind and current conditions.

2.4 Integration in Maritime Education

The integration of bow thruster technology into the maritime education curriculum is an important aspect in preparing future sailors. Kitada (2022) analyzed the impact of integrating modern technology, including bow thrusters, into the maritime education curriculum. Their study shows that direct exposure to technologies such as Bow thrusters can improve graduates' readiness to face industry demands that continue to grow.

Cabaron (2024) further emphasizes the importance of curriculum adaptation. maritime education on digitalization and automation trends in the shipping industry. His research shows that familiarity with technologies such as bow thrusters during training can increase cadets' self-confidence and competence in operating modern ships.

2.5 Regulatory and Safety Aspects

The implementation of new technologies such as bow thrusters must take into account these aspects. regulation and safety. The International Maritime Organization (IMO, 2024) has issued updated guidelines regarding the use of auxiliary propulsion systems such as bow thrusters, which is an important reference in safety and regulatory aspects.

Chen (2024) discusses the sustainability aspects of maritime propulsion technology, including the bow thruster. Their research highlights the importance of considering environmental factors in the development and implementation of new propulsion technologies on ships in order to decarbonize the global maritime industry.

3 Research Methodology

This study employs a descriptive-analytical approach to assess the design and implementation of a bow thruster on a Ministry of Transportation training ship. Data collection methods include an in-depth literature review on bow thruster technology, training ship design, and trends in maritime education, as well as field tests conducted on a prototype training ship equipped with a bow thruster. These trials aim to measure maneuverability in congested ports and fuel efficiency. Quantitative data from the field tests were analyzed using descriptive and inferential statistical methods to assess improvements in maneuverability and fuel efficiency. To ensure the validity of the research findings, data triangulation and expert peer review were conducted by professionals in maritime technology and shipping education. This methodology is structured to comprehensively evaluate the objective impact of bow thruster application on training ship performance and its implications for the maritime education curriculum, aligning with the study's objectives.

4 Research Results

The results of the bow thruster design as an auxiliary propulsion system for the Ministry of Transportation's maritime school training ship include: (1) the design of the bow thruster as an integral component of the ship's propulsion system; and (2) the development of research instruments for assessing its performance. The involvement of lecturers in the implementation of the bow thruster on the training ship is evident throughout all phases of the project, from initial planning to final evaluation.

4.1 Analysis Stage

The initial stage in designing the bow thruster as an auxiliary propulsion system for the Ministry of Transportation's maritime college training ship involves analyzing the need for a new product design as well as assessing the feasibility and requirements of that design. The design process can be prompted by issues identified in existing or currently implemented products. Such problems may arise when the available product no longer meets the target needs, the learning environment, technological advancements, or the specific characteristics of the maritime training ship's propulsion system.

Following the analysis of the need for a new product design, it is essential to assess the feasibility and requirements of that design. This analysis can be conducted by posing several key questions, such as: (a) Will the new product effectively address the challenges faced in operating the training ship at the maritime school? (b) Are there adequate facilities available to support the implementation of the new product? (c) Are the lecturers equipped to implement the new product effectively?

Prammane (2015) stated that several activities can be done in the analysis phase, including problem analysis, learner analysis, content analysis, instructional analysis, identifying learning objectives, and revisions from experts. In line with this question, Tegeh et al. (2014) emphasized that there are several activities carried out in this phase, namely: (1) analyzing the competencies required of students, (2) conducting an analysis of student characteristics regarding their learning capacity, knowledge, skills, and attitudes, and (3) conducting material analysis according to competency demands.

4.2 Design

The design activities for the bow thruster, serving as a propulsion system for the Ministry of Transportation's maritime school training ship, follow a systematic process that begins with conceptualizing the product's design and content. Each component of the product is documented in detail, ensuring that instructions for implementation or manufacturing are clear and comprehensive. At this stage, the product design remains conceptual and establishes the foundation for the subsequent development process.

In detail, there are several activities that can be carried out by designers and researchers in this phase, namely: writing down the behavioral objectives to be achieved, selecting types of evaluation and evaluation tools, designing learning strategies, selecting media and learning materials, and formative evaluation or revision from experts.

4.3 Development

During the development stage, researchers engage in various activities to design research products. These activities include: (1) developing evaluation instructions; (2) designing the bow thruster as a propulsion system for the Ministry of Transportation's maritime school training ship along with instructional materials; (3) creating lesson plans; (4) preparing guides for lecturers and cadets; and (5) conducting formative evaluations and expert validations. At this stage, researchers aim to transform the concepts established in the design phase into tangible forms. For instance, when developing a bow thruster for a training ship, the ideas formulated previously are incorporated into textbooks or modules.

In addition, Tegeh et al. (2014) outline several activities involved in this development phase, including: (1) searching for and gathering various sources or references essential for development; (2) compiling evaluation instruments that will be utilized in the development process. For example, when developing a bow thruster as a propulsion device for the Ministry of Transportation's maritime school training ship, the evaluation instruments may include multiple-choice questions, essay questions, performance assessments, or a combination of these methods; (3) creating illustrations, graphs, tables, and other supporting materials related to the bow thruster as a propulsion device for training ships; and (4) designing the layout of teaching aids to be visually appealing and to stimulate cadet interest in learning.

4.4 Implementation

The implementation of the product in the ADDIE research and development model is intended to obtain feedback on the product that is made or developed. Initial feedback (initial evaluation) can be obtained by asking questions related to the purpose of product development. Implementation is carried out referring to the product design that has been made.

At the implementation stage, several things can be done, namely: preparing presentation strategies, individual trials, small group trials, field tests, and expert validation.

According to Tegeh et al. (2014), the implementation stage is a stage to obtain an overview of the effectiveness, attractiveness, and efficiency of the product being developed. Effectiveness is related to the extent to which the development product can achieve the expected goals or competencies. The attractiveness test is related to the extent to which the development product can create a challenging, enjoyable, and motivating learning atmosphere. The efficiency test is related to the use of all available funding sources, time, energy, and thoughts to achieve the goals that have been set.

4.5 Evaluation

At this stage, designers conduct data collection activities on formative and summative evaluations. Formative evaluations are conducted at each stage of development to obtain information and input in efforts to improve the product, while summative evaluations relate to evaluations at the end of the program to determine their impact on student learning outcomes and the quality of learning in general. At this evaluation stage, researchers can use questionnaires to obtain information on the use of product results development both from students and other users (lecturers). However, some researchers use test forms to determine the effect of the development product on the learning outcomes of cadets.
The assessment of the design level for the bow thruster as a propulsion system for the Ministry of Transportation's maritime school training ship aims to evaluate whether the developed components can be effectively implemented in practice. This evaluation will be based on observations made by evaluators, taking into account insights from a literature review and relevant supporting theories.
Results of observations on the implementation of bow thrusters as a propulsion for school training vessels Ministry of Transportation's shipping on the trial is shown in Table 1.

Table 1.

Based on the data presented in Table 4.1, the average score of lecturers' responses regarding the bow thruster as a propulsion system for the Ministry of Transportation's maritime school training ship is 92.50%, which falls within the practical category. The analysis of lecturers' feedback indicates that the implementation of the bow thruster is practical for learning, as at least 70% of lecturers provided a positive response. Consequently, all three lecturers concur that the bow thruster can be effectively implemented as a propulsion system for the training ship and classify it as practical.

If the average results from the assessment of the three lecturers are then compared with the criteria for the lecturers' ability to manage the bow thruster as a propulsion system for the Ministry of Transportation's maritime school training ship, as well as the observation criteria for the learning device, it can be concluded that every aspect of the lecturer response questionnaire falls within the practical category and has been well implemented. However, several areas still require improvement based on feedback from observers, including: (1) Directions and Instructions for Validators: Validators need to be more skilled and meticulous in providing assessments. This will ensure that cadet skills are measured accurately and that lecturers can optimize their teaching methods to explore and develop cadet abilities effectively. (2) Implementation of Bow Thruster Development: While the bow thruster serves as a valuable learning medium for PIP Makassar cadets, lecturers still require additional understanding and training to implement this demonstration tool development program more effectively. (3) Measurement of Lecturer Response Questionnaire: The results indicate that all aspects of the components have been fully implemented.

5 Discussion

Based on the results of the research and design, this section explains both theoretical and empirical studies related to the findings of the bow thruster design as a propulsion system for the Ministry of Transportation's maritime school training ship. The research findings are presented sequentially as follows: The design of the bow thruster for the training ship at the Ministry of Transportation's maritime school in Makassar embodies the application of the bow thruster concept in educational design. Its implementation serves as a framework for content delivery, which is expected to enhance the maritime school's training ship by providing new insights. This framework acts as an abstraction or summary of the fundamental concepts being studied, facilitating a deeper understanding among cadets.

The integration of a bow thruster as a propulsion system for the training ship at the Ministry of Transportation's maritime school plays a crucial role in the training and learning of personnel in safety-critical domains. The maritime industry, including maritime educational institutions, has long utilized simulators to train its crew and cadets (Hjelmervik et al., 2018). As the advantages of simulation technology become more recognized, there is a growing trend toward practice-oriented training that incorporates this technology, including the implementation of the bow thruster as a propulsion system for the training ship at the Ministry of Transportation's maritime school (Nazir et al., 2015).

Moreover, the bow thruster as a propulsion system for the Ministry of Transportation's maritime school training ship offers numerous advantages. It is regarded as one of the safest and most cost-effective methods for acquiring specific skills. By utilizing the bow thruster, trainees can make mistakes and learn from them in a controlled environment, free from the real-world consequences that could arise during actual maritime operations (Salas et al., 1998).

The practicality level of the bow thruster design as a propulsion device for the Ministry of Transportation's maritime school training ship can be evaluated through its successful implementation, as indicated by the positive responses from both lecturers and cadets regarding the bow thruster's functionality.

The design of the bow thruster as a propulsion system for the Ministry of Transportation's maritime school training ship was deemed to have been executed "very well" and was considered practical. These results were achieved through a series of improvements and revisions conducted in stages, beginning with Trial I and progressing to Trial

II. Following the first trial, several technical issues were identified by observers, leading to important considerations for enhancing the implementation of the bow thruster as the driving force for the training ship. These considerations included: (1) lecturers should pay close attention to each phase of learning in accordance with the planned syntax and timing used in class; (2) optimizing the bow thruster's performance as the primary propulsion system for the training ship; (3) maximizing the use of the Ministry of Transportation's bow thruster during training activities; (4) providing appropriate stimuli during the knowledge reconstruction process for cadets; and (5) thoroughly observing the use of teaching aids prior to conducting face-to-face sessions. Based on the test results, all components were effectively implemented and rated very positively.

6 Conclusion

Based on the results of the research and the discussions conducted, several conclusions can be drawn: The thrust calculation for the 279 DWT supply vessel yielded a power output of 13 kN. After analyzing the two types of drives, it was found that the installation of an electric drive is the easiest to implement on the 279 DWT supply vessel. Regarding placement, the electric drive is preferred because it occupies less space compared to other options. Therefore, the electric drive bow thruster was selected for this application. To accommodate the addition of the bow thruster, a generator with a power rating of 250 kW is required for maneuvering operations, while 80 kW will be allocated specifically for driving the bow thruster.

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