

Advancing Nuclear Power Integration in Shipbuilding and Marine Industries through Classification Society(KR) Initiatives

Minjae Jung^{a*}, Minho An^a, Sangsoo Kim^a, Hyunchul Dong^b, Youngsuk Kim^b,
Naval Business Center, Korean Register., 36, Myeongji ocean city 9-ro, Gangseo-gu, Busan, Republic of Korea
^{*}Corresponding author: mjjung@krs.co.kr

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1. Introduction

The shipbuilding/maritime industry is facing new challenges in the era of achieving carbon neutrality, ensuring energy security, and driving economic growth. Last year, the International Maritime Organization (IMO) announced a plan to achieve carbon neutrality for maritime vessels by reducing greenhouse gas emissions by 50% compared to 2008 levels by 2050[1]. In response, the shipbuilding/maritime sector is actively discussing various possibilities for the use of carbon-free nuclear energy sources to strengthen international decarbonization regulations. In this context, the value of SMRs(Small Modular Reactors) is being emphasized. Nuclear energy has faced difficulties in commercialization for maritime applications, such as ship fuel, due to safety, geopolitical security, and economic constraints over an extended period. However, research into developing SMRs with excellent safety features is actively underway, driven by the economic advantage of enabling fuel-free ship operations and increasing operating speeds.

In this connection, the shipbuilding and nuclear sectors are becoming closely integrated with the growing interest in nuclear propulsion strategies. Therefore, this paper aims to introduce the current research status and directions for practical integration of the shipbuilding/maritime industry and the nuclear field by classification societies that provide comprehensive technical services to the shipbuilding industry.

2. KR service on the nuclear power

Korean Register (KR) is the internationally recognized classification society in the Republic of Korea. It aims to ensure the safety of life and property at sea by providing technical services in various fields such as ship inspection, digitalization, environmental certification, and naval architecture in over 60 countries worldwide. In order to fulfill the collective obligation of achieving carbon neutrality in maritime vessels, the Korean Register has completed the development of environmentally friendly ship-related regulations, guidelines, and guides as shown in Table 1. Additionally, KR is engaged in the following tasks to apply nuclear technology in the shipbuilding sector.

Table I: Status of KR Rule/Guideline/Guide Development and Approval

1	Development and Approval of Environmentally Friendly Ship Rules/Guidelines/Guides
2	Development and Approval of Standards for Ship Hydrogen Fuel Cell Systems under the "Ship Safety Law"
3	Development and Approval of Ship Classification Rules for LPG/Ammonia/Methanol/Ethanol-powered Ships
4	"Ship Safety Law" Standards for LPG-powered Vessels
5	Development and Approval of Standards for Ship Hydrogen Fuel Cell Systems under the Ship Safety Law

In February 2023, the Korean Register organized a conference themed "Small Nuclear Reactors for Ships and Green Hydrogen Production" to address the global reinforcement of carbon-neutral regulations. During this event, the technological status of small nuclear reactors for ships was shared, aiming to contribute to the international strengthening of carbon-neutral policies.

Nuclear power embodies environmentally friendly characteristics, playing a significant role in mitigating climate change, and offering advantages in high-density energy generation, transportation, and storage. Among these aspects, SMRs stand out due to their safety features, capacity for small-scale power generation, and adaptability for diverse applications. [2]

The conference provided a platform for sharing insights on nuclear technology, leveraging presentations and discussions by experts in the field. The primary objective was to conduct a comprehensive assessment of the feasibility of SMR-powered ships and the potential use of SMRs in maritime green hydrogen production facilities. Additionally, the conference aimed to identify pathways for further advancements in these domains, contributing to the ongoing development of environmentally sustainable maritime technologies.

Amid the emphasis on decarbonization as part of achieving carbon neutrality, the value of SMRs is

gaining prominence due to the enhancement of national energy security [3]. Globally, among the more than 80 different types of SMRs developed, pressurized water reactor (PWR) technology, validated by its application in large-scale nuclear power plants, has become predominant.

In addition, discussions across various industries have covered diverse topics related to SMRs technology development, including molten salt reactor technology. Further details can be found in Table 2.

Table 2: Discussion Topics on SMRs for Ship Propulsion and Integrated Green Hydrogen Production:

Discussion Topics	
1	Global Trends in Small Modular Reactor (SMR) Technology Development (by Director Lee, Korea Atomic Energy Research Institute)
2	Current State and Future of Molten Salt Reactor Technology (by Dr. Kim, Korea Atomic Energy Research Institute)
3	Development Status and Prospects of Ship-based SMR Technology (by Dr. Lee, Hyundai Heavy Industries, and Dr. Kim, Samsung Heavy Industries)
4	Strategy for the Development of High-Efficiency and High-Stability Water Electrolysis Green Hydrogen Production System Linked with SMRs (by Dr. Im and Dr. Lee, Korea Institute of Industrial Technology)
5	Directions for the Advancement of Water Electrolysis Technology for Maritime Green Hydrogen Production (by Director Kang, Jiphyllus Corporation)



Fig. 1. Hosting a Conference on Integrating SMRs with Green Hydrogen Production for Ships

Secondly, the Korean Register is actively engaged in research related to maritime nuclear technology and the development of eco-friendly energy production plants. In this regard, the organization is conducting research to

analyze "Nuclear Power Generation and Eco-Friendly Fuel Production" technologies suitable for floating offshore plants. Korean Register is actively participating in research and development efforts aimed at analyzing the technology and contributing to the localization and commercialization of key technologies.

Thirdly, based on nuclear-powered ship safety regulations and application guidelines, the Korean Register published the "Report on Nuclear-Powered Ships" in 2022. In line with this effort, the organization aims to establish safety standards for the commercialization of offshore nuclear power plants

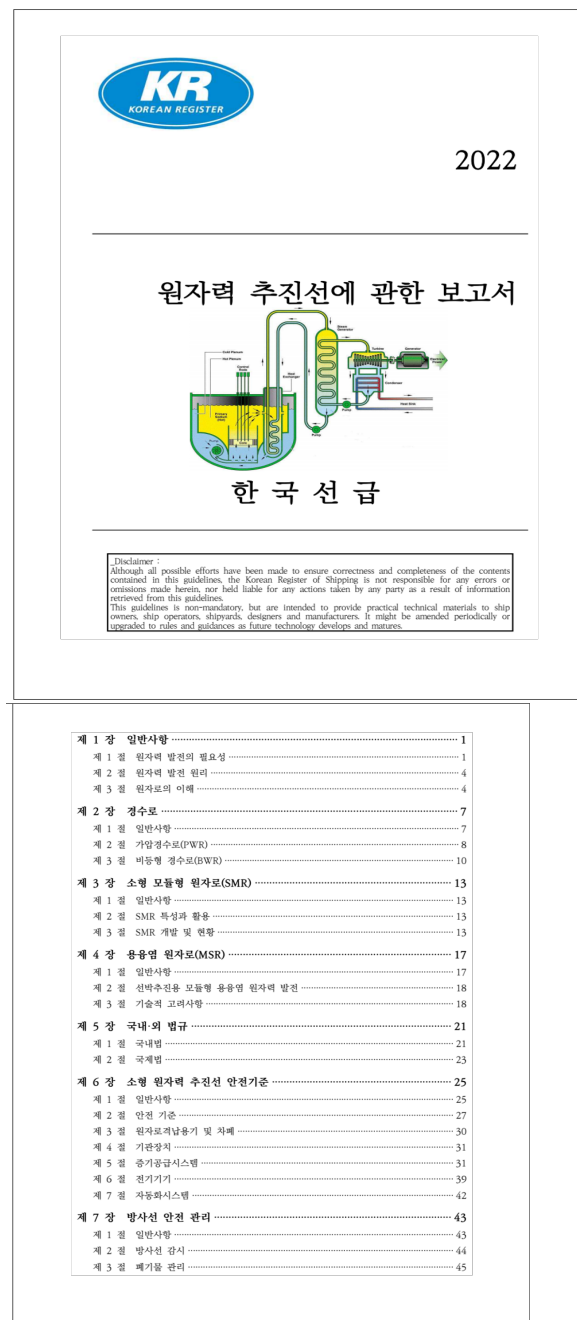


Fig. 2. The "Report on Nuclear-Powered Ships" by KR
 This report covers topics such as safety regulations, application guidelines, and considerations for the commercialization of nuclear-powered ships. It serves as a comprehensive resource for understanding the challenges, opportunities, and safety measures associated with nuclear propulsion in maritime transportation.

Fourthly, as a maritime inspection organization, the Korean Register has been continuously nurturing the capability to inspect nuclear-powered submarines, both domestically and internationally. In this effort, the organization has acquired the internationally recognized ANI (Authorized Nuclear Inspector) certification for four individuals. Additionally, the Korean Register is dedicated to fostering expertise through consistent human resource development, organizational enhancement, and procedural development to support the certification of nuclear technology for submarine propulsion systems. This proactive approach is a testament to the organization's commitment to maintaining a high level of competency in inspecting and ensuring the safety of nuclear-powered submarines.



Fig.3. ANI(Authorized Nuclear Inspector)Certificate

3. Conclusions

In accordance with policies aimed at achieving carbon neutrality in maritime vessels, the shipbuilding industry is actively engaging in the nuclear sector. As a crucial element in establishing an eco-friendly maritime energy ecosystem, Maritime SMRs are considered essential. Various countries are promoting support measures for the development of SMRs tailored to their respective environmental conditions. Additionally, efforts are underway to develop proprietary SMR models that align with national goals and circumstances. The integration of maritime SMRs plays a pivotal role in realizing carbon-neutral marine transportation and fostering a sustainable maritime energy landscape.

Leveraging its advanced nuclear supply chain and research and development capabilities, Korea has embarked on the development of 'Innovative SMRs'. The government is strategically focusing on continuous support and

the consolidation of capacities at the national level. While nuclear-powered ships have undergone substantial technological validation, there are still numerous challenges to address in terms of international consensus and commercialization for their application in commercial vessels.

To address these challenges, the Korean Register aims to contribute to the commercialization of nuclear propulsion systems by consistently updating and researching safety regulations and application guidelines through ongoing technical collaboration within the nuclear industry.

Despite the existing challenges, Korea's leadership in nuclear technology and its collaboration efforts are paving the way for the successful integration of nuclear propulsion systems into maritime vessels.

For floating nuclear reactors, it is anticipated that certification by classification societies for power generation vessel design will be a key step towards domestic production and commercialization efforts for maritime applications. Given that commercial vessels traverse various countries, the need for a universally recognized regulatory and licensing system is evident. Consequently, it is deemed essential to establish a comprehensive government approval framework and classification rules for land and maritime integrated systems through collaboration among key domestic nuclear-related institutions and task forces.

Furthermore, safety assessment outcomes are pivotal core requirements for the licensing and classification approval of nuclear-powered vessels. Thus, the development of safety evaluation methods and procedures suitable for maritime environments by classification societies is of utmost importance.

In addition, to ensure the inspection and safety assessment of military nuclear-powered vessels, acquiring inspection technologies in the relevant field and fostering nuclear expertise are vital. This effort will enable classification societies to play a crucial role in fostering smooth collaboration between the shipbuilding industry and the nuclear sector, yielding positive outcomes for both fields.

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