International Journal of Advanced Smart Convergence Vol.10 No.2 15-20 (2021)
http://dx.doi.org/10.7236/IJASC.2021.10.2.15

IJASC 21-2-3

Design of Air-Lifted Seawater Propulsion System (ALSP) for Ecoships' Auxiliary Propulsion 1

Jae-hyuk Lee

Associate professor, Department of Deep Ocean Water, KyungDong University, Korea
jhlee@kduniv.ac.kr

Abstract

We constructed an air-lifted seawater propulsion system for decreasing fuel consumption of the ships. The system has a form of pipes which can be easily installed on the sides of the ship. Seawater mixed with air, will rise along within the pipe, and will be discharged downward. If the directions of inlet / outlet of the pipe are designed properly, a propulsive energy can be obtained. We tested the system with a model ship in Jangsa port at Sokcho-city with a water depth of 2.5 meters. The system was supplied regulated air at 6 bars during the 3 tests. The model ship was moving forward at a rate of 0.18 meters per second. In case of large ships equipped zfrom clean energy.

Keywords: *Air-lifted Seawater Propulsion, Auxiliary Propulsion, Ecoships, Air Storage by Solar Power*

1. Introduction

In order to cope with climate change and reduce air pollution in the ocean, the International Maritime Organization(IMO) has announced that the 'Energy Efficiency Design Index for new ships(EEDI)' of newly built ships be reduced by 30% by 2025, and recently, it has announced that it will sanction vessels with inefficient grades from 2025 by strengthening 'Existing ships' Energy Efficiency Index (EEXI)' of existing vessels. The existing EEXI uses the same calculation formula as the EEDI applied to newly built ships, and classifies ships into five levels of A~E. The ships in lower 2nd class of D and E that do not meet the energy efficiency standards will be regulated in the third year if no alternatives are available, and the speed of the ship will be lowered through power limit. Most of the new vessels ordered after 2014 follow the EEDI standard, but most of the vessels ordered before that do not meet this standard [1].

Since EEDI is determined by the CO_2 conversion factor and fuel consumption of the fuel used by the vessel, it is necessary to reduce the fuel consumption rate by changing the fuel or remodeling the vessel [2]. Recently, air lubrication method is proposed to reduce the amount of fuel consumption, reducing friction with seawater by generating bubbles at the bottom of a ship [3].

Manuscript Received: March. 27, 2021 / Revised: April. 2, 2021 / Accepted: April. 7, 2021
Corresponding Author : jhlee@kduniv.ac.kr
Tel: +82-33-639-0263, Fax: +82-33-639-0339
Associate Professor, Department of Deep Ocean Water, Kyung Dong University, Korea

In this paper, for reducing fuel consumtion, we propose and design an air-lifted seawater propulsion system, and evaluate its performance by conducting experiments with a model ship.

2. Principle of Auxiliary Propulsion using Air Lift

When air is injected into water, the density of air-water mixture decreases, and the mixture rises upward direction, which is widely known as air-lift [4] [5]. We have succeeded in a previous experiment in which seawater at a depth of 10 m is pulled up to a height of 1.5 meters above the sea (Figure 1). Air has been compressed by solar power and injected at 6 bar regulator. The water lifting rate was 100 liters per second. The solar panels were cooled by devices using convectional phenomena [6].

Figure 1. Air-lift experiment at the 10m deep sea water

By changing the angles of the inlet and outlet from the vertical direction to the horizontal direction, seawater will be released in the stern direction of the ship, and can be utilized as an auxiliary propulsion power (Figure 2 and 3). Since the waterline of the ship varies depending on the loading amounts of the cargo, it is efficient to obtain the optimal propulsion power by varying the height of the outlet.

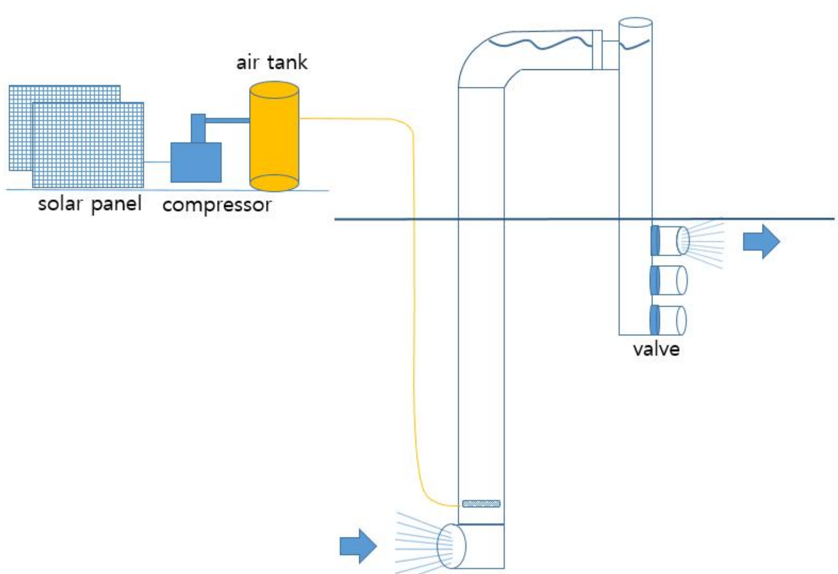

Figure 2. Conceptual design of propulsion

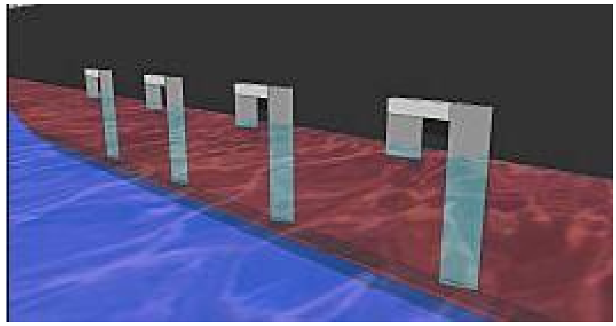

Figure 3. Conceptual diagram of multiple propulsion systems, installed on the side of ship

3. Design and Experiment of the System

By adjusting the angles of the inlet and outlet, the seawater is sucked in from the bow side and discharged to the stern side, we have designed an auxiliary propulsion system, that utilizes suction and expulsive forces as bidirectional propulsion power. (Figure 4)

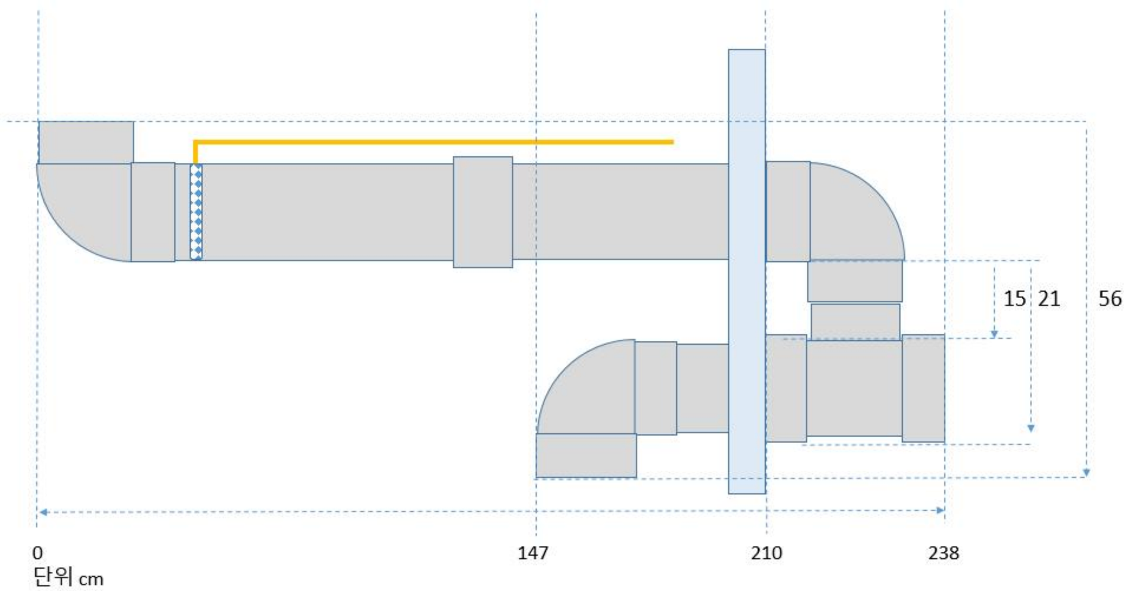

Figure 4. Design diagram of the experimental system

A model ship made of a highly-compressed polystyrene(thickness 50 mm) which is used for buoyancy in octopus fishing. We cut the polystyrene panel into a piece with dimension of 1400 mm long x 700mm wide x 50mm thick, cut into an isosceles triangle at a point of 700 mm to obtain a shape of ship. We determined the center of gravity to be a point from distance 525 mm, and drilled two holes there; the diameter of the first hole was made to fit a PVC pipe with an inner diameter of 125 mm. The position of the second hole was made to match the length of the elbow-T connection hole to be mounted on the top.

We constructed the propulsion system with pipes, each with a length of 1000 mm and an inner diameter of 125 mm, to be used as an absorbent pipe, and installed a circular tube at the end for ejecting air. The drain pipe has a length of 400 mm and an inner diameter of 125 mm, and a right angle connector is also installed at the end as showed in Figure 5.

(a)

(b)

Figure 5. Model ship and propulsion system
(a) bottom view (b) side view

We conducted marine experiments at Jangsa port in Sokcho-city, Gangwon-do. The average sea depth within the port is 2.5 meters.

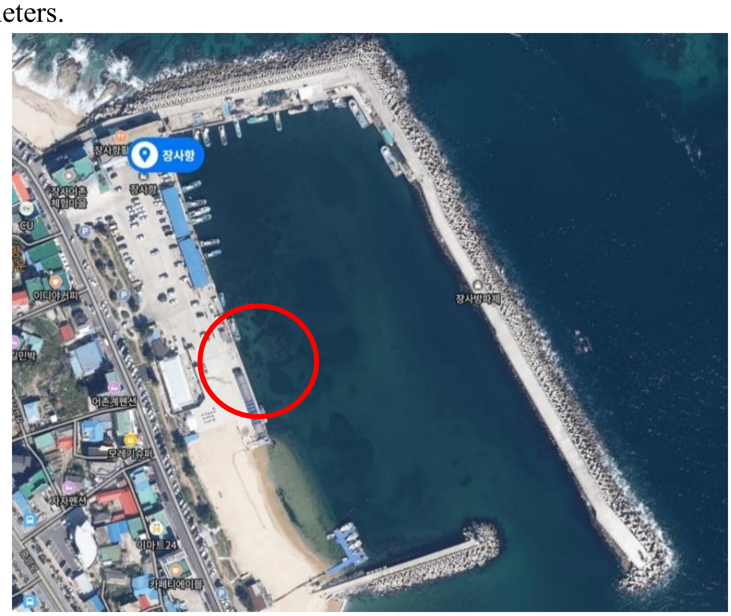

Figure 6. Experimental place (labeling the place by red circle)

We charged a scuba diving air cylinder (11 liters) at a pressure of 200 bars, and used a regulator of 6 bars in order to inject a constant air into the system.

In order to measure the propulsion performance of the system, we measured moving speed by recording time of moving along the preset 10m distance. We have conducted the marine experiment three times; the experimental scene and experimental results are shown in Figure 7 and Table 1, respectively.

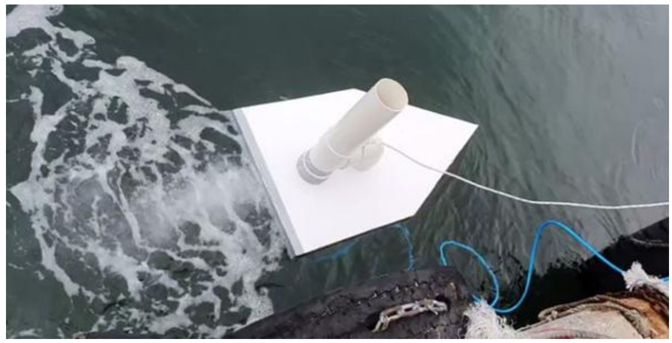

Figure 7. Experimental Scene

Table 1. Experimental result of system

No. of Experiment	Time for Moving 10m	Velocity
1st	53 seconds	0.1887 m/s
2nd	55 seconds	0.1818 m/s
3rd	56 seconds	0.1786 m/s

The model ship moved 10 meters in 54.67 seconds averagely, so the average speed was 0.1829 m/s. Although the height of the system is 2.38 meters, the net height of the falling water was only 0.28 meters, so it is judged that the moving speed is not fast. The water head of water falling distance is determined by the depth of the water, the internal diameter of the pipe, and the amount of the injection air; depth is the most important limiting factor among them [5]. When a ship larger than this experiment such as a container ship fully loaded, the difference between the waterline and the bottom of ship is more than 10 meters, the height of falling water will be increased and the moving speed will be larger.

In an additional experiment, we directly pumped a stream of air into the sea, by attaching an air hose to the outlet of the model ship, however, the model ship did not move at all. It was found that the directly ejected air did not function as a driving force to move the model ship forward, because the air floated to the surface by buoyancy.

In the experiment we used an air-tank precharged. If a ship will use solar panels for compressing air, then it is expected that the auxiliary propulsion power can be obtained from clean energy and also expected that the ship can reduce the fuel consumption rate.

4. Conclusion

In order to prepare the ship regulations enacted by the International Maritime Organization, it is necessary to reduce the amount of fuel consumption. In this study, we designed and experimented an auxiliary propulsion system using air-lifted seawater. The auxiliary propulsion system has the form of the pipes attached to the outer wall of the ship. When air is pumped through the lower side of the pipe, seawater rises above the surface due to the density difference. And when the seawater, attracted by gravity, is released and falls downward, a propulsion power is obtained by the potential energy of the seawater. We designed an auxiliary propulsion system on a model ship. From results of experiments at the Jangsa port with depth of 2.5 meters, it was found that the system was moving forward at a speed of 0.18 meters per second. In the experiment we used regulated air stored in tank. If a ship will use solar panels for compressing air, then it is expected that the auxiliary propulsion power can be obtained from clean energy and also expected that the ship can reduce the fuel consumption rate.

References

[1] IMO the 75th Proceegings of Marine Environmental Protection Committee; November 16, 2020. "https://imokorea.org/board/board.asp?B_ID=conference_result&ty=view&page=1&bandstart=1&find type= &findstr=&idx=4340&ii=11"

[2] T. A. Tran, "Calculation and Assessing the EEDI Index in the Field of Ship Energy Efficiency for M/V Jules Garnier," *Journal of Marine Science,* Vol. 6, pp.212, 2016 DOI: https://doi.org/10.4172/2155-9910.1000212

[3] S. M. Ha, "A Study on Resistance Reduction and Air Lubrication Characteristics in accordance with Air Injection Variable of Ship Air Lubrication System," Master Thesis, Department of Naval Architecture and Ocean Engineering, Pusan National University, February, 2019 [UCI] I804:21016000000138374

[4] F. S. A. Taleb and J. A. Al-Jarrah "Experimental Study of an Air Lift Pump," *Engineering, Technology & Applied Science Research* Vol. 7, No. 3, 1676-1680, 2017 DOI: https://doi.org/10.48084/etasr.1207

[5] B. R. Elbing, S. Mäkiharju, A. Wiggins, M. Perlin, D. R. Dowling and S. L. Ceccio, "On the scaling of air layer drag reduction," *Journal of Fluid Mechanics*, Vol. 717, pp. 484 – 513, 2013 DOI: https://doi.org/ 10.1017/jfm.2012.588

[6] J. Lee, "Design of solar cell cooling system using convection phenomena," *International Journal of Advanced Smart Convergence,* Vol.9 No.2 123-128, 2020 DOI: http://doi.org/10.7236/IJASC.2020. 9.2.123