Study of Advanced Technology to Reduce Fuel Oil Consumption (FOC)Using Air Lubricating System (ALS) in Vessel

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1. ABSTRACT

An air lubricating system (ALS) is a technology used primarily in maritime vessels to reduce friction of the vessels hull in the sea water hence, enhancing fuel economy and reduce emission the system works by generating and injecting a layer of air bubbles besides the hull's surface, creating a thin, insulating layer those minimizes direct contact to the water and the vessels hull. This air layer significantly decreases hydrodynamic drag, let the vessel to pass more effective in the water. The system typically includes components like compressors, air distribution units, and control systems to manage the generation and flow of air bubbles. By reducing friction air lubricating systems can lead to substantial fuel savings and lower operational costs, contributing to more sustainable maritime operation.

Keywords: Air Lubricating System (ALS), Silverstream technology, Mitsubishi Technology, Air Layer Energy Saving System (ALES), MAN 8L32/44CR Engine

2. INTRODUCTION

2-1 Air Injection Unit:

In this strategically placed along the hull, especially at the bottom. They release a controlled flow of air, forming a carpet of micro-bubbles that coats the hull surface.

2-2 Bubble Formation and eject: The injected air forms small bubbles that spread through the hull, it creating a thin air coating that minimizes direct contact with the hull and sea water. The even separation of bubbles is crucial for maintaining an effective lubricating layer.

2-3 Hull Design and Modifications: The hull of ships equipped with air lubrication systems may be designed or modified to optimize the effectiveness of the air layer. This includes shaping the hull to ensure that bubbles are evenly distributed and maintained during the ship's operation.

2-4 Control and Monitoring Systems: Sensors and control systems monitor the bubble layer and adjust the air flow as necessary to maintain optimal lubrication under varying sea conditions and speeds.

3- Functional analysis of air injection unit

The air lubricating system (ALS) in ships is a cutting-edge technology aimed at enhancing maritime efficiency by reducing hydrodynamic drag into the ship's hull and sea water. This system introduces a controlled coating of air bubbles beneath the hull, which acts as a lubricant, thereby minimizing resistance as the ship moves through the water.

This solution has emerged as a significant idea of the marine industry, where fuel economy and environmental impact are major concerns. By decreasing the frictional resistance, an air lubricating system helps in lowering fuel usage, decreasing the construct cost, and cutting down on co2 emission

The ALS is particularly relevant in the context of increasingly stringent environmental regulations and the rising costs of marine fuel. As the industry seeks sustainable solutions to meet these challenges, the adoption of air lubricating systems offers a promising pathway to achieving greater fuel efficiency and reducing the carbon footprint of maritime operations. This introduction of ALS represents solution make global shipping more environmentally and economically sustainable.

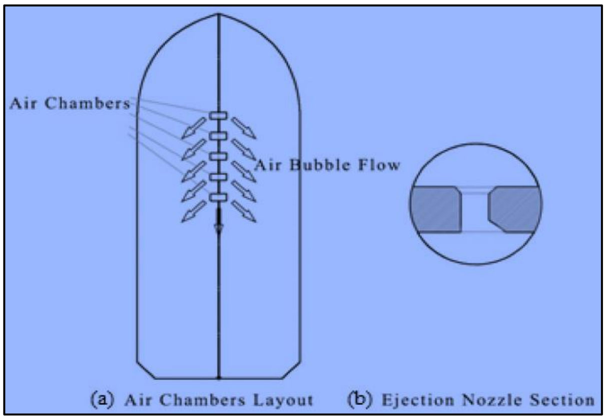

Figure-1 An image of an air lubrication method

An air ejects in air blow-off portion mounted on the bottom of the hull and the air bubbles flow covers the bottom of the hull

3.1 Bubble Drag Reduction

It is the best solution of ship's hull which breaks down into micro-bubbles, around 0.1 mm. By adding bubbles to a liquid, the density of the liquid decreases and hence the Reynolds number decreases they are some example Mitsubishi Air Lubrication (MALS), Silverstream Systems. Air Layer Energy Saving System (ALESS),

We should emphasize the importance of the injection zones and the injector design. Many companies have created various formations and types of injectors, and this topic demands further 3D computation research in order to optimize the air injection and the bubble generator Figure 2 and Figure 3 show the injection fabrication that was chosen by Silverstream Technology [17] and Mitsubishi Heavy Industries [5].

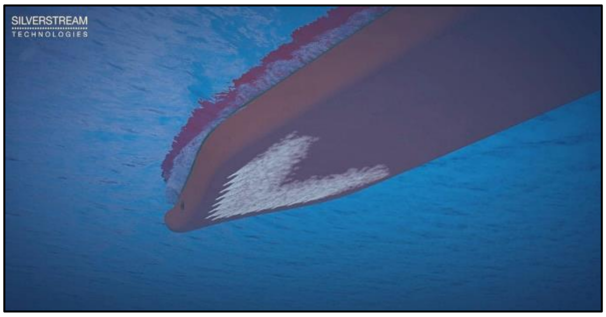

Figure 2. Silverstream technologies arrow formation

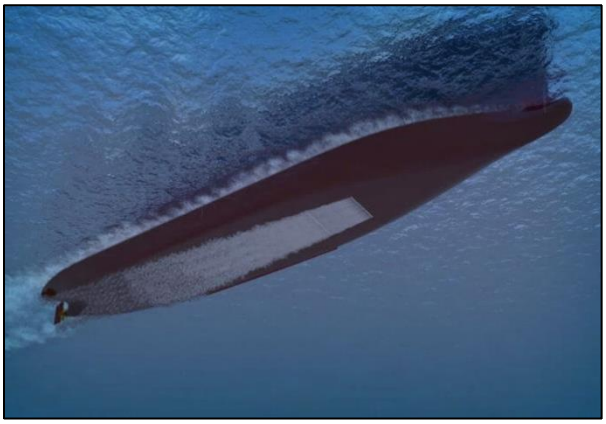

Figure 3. Double curtain formation of Mitsubishi industry

3-2 The chamber outline

A water line pipe is fitted to the upper portion of the arena, where its fitted point is offset by 200 mm away from the centre of the arena. On the lower portion of the arena are installed sixteen small apertures from which air is blown off.

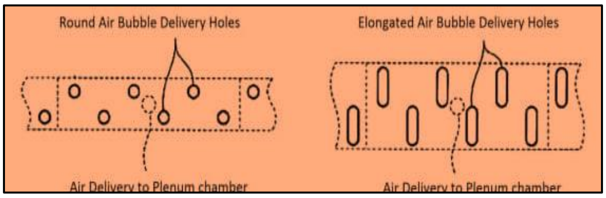

Figure 4. shows an overview photograph of the chamber. A communication pipe connected to the air supply pipe is connected to the top part of the chamber, where it is Attach point is offset by 200mm the centre of the chamber. There are sixteen small holes in the lower part of the chamber through which air comes out.

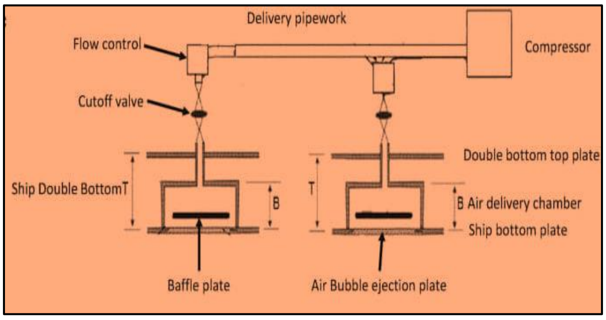

Figure 5. Air blow-off condition (underwater)

A picture of the air blow-off condition with the chamber placed under water

3.2 Flow velocity distribution test in the air

As shown in Figure 6 is a single pipe, the air blow-off rates from the various holes in the arena grow unbalanced. To correct this phenomenon, baffle boards are installed in the chambers to equalize the air flow. Figure 5 shows the measurements of flow velocity distribution in the case of with baffle board and no baffle board. The tests were conducted in the air. Model6531 was used to measure flow velocity. In the case of "no baffle board," the peak flow velocity occurred around the hole before supply air pipe so all the air can blow away at this point, causing flow velocity distribution to be unequal. In the case of "with baffle board", the flow velocity distribution appeared to be equalized in the longitudinal direction Room

3-4 Underwater air blow-off condition measurement

A model with small holes in the bottom was placed in a water tank. Air flow conditions from the respective holes were observed by an underwater camera. Figure 5 shows the experiment conditions

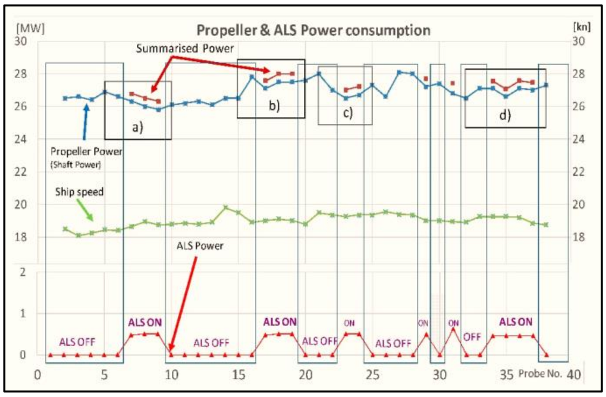

Figure 6. A comparative chart of the flow-velocity distribution through the orifices of the chamber blown out

In the case of NO BAFFLE BOARD, the peak flow velocity occurs at the number nine and number nine and number ten apertures and in the case of WITH BAFFEL BOARD, the flow velocities are equalized

3-5 A picture of the air blow-off condition from the apertures (horizontal condition)

Figure 7. A picture of the air blow-off condition from the aperture (horizontal condition)

When the chamber is placed longitudinally a picture of the air flow position is visible from the corresponding aperture Horizontal, taken by an underwater camera. With the chamber being kept exactly horizontal longitudinally, the air blowing into the water is collected at the bottom of chamber, so as to avoid air accumulation The chamber is tilted laterally by ten degrees for exit. Accordingly, when the chamber is kept longitudinally horizontal, air passes uniformly left in the 16 holes

4–Mock-up Model of Air Lubrication System

Figure 9 shows the piping diagram. Air discharged from blowers is temporarily stored in 16 pipes are fitted to the head tank are piped to the air pipes are fitted in the lower of the hull. An air supply pipe is each connected to one chamber (air chamber).

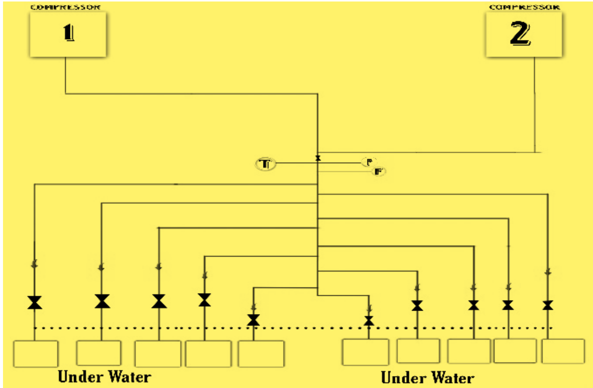

Figure 9. A simple pipe diagram of the air lubrication system (ALS)

Air discharged from two set of compressors is connected in large diameter pipe and then is distributed to fifteen branch pipes to be delivered to air chamber mounted on the bottom of the hull

4-1 Representation of an integrated system in ship

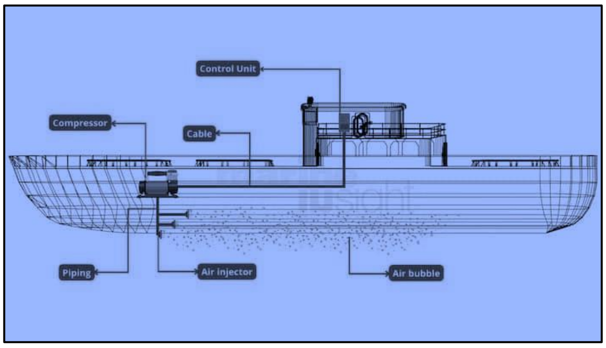

Figure 10. It presents the main parts of that synthesize the total air lubrication system. The operation is controlled in the automation room, there we can set the variables and check the system in real time

4-2 Suitable compressor type and piping

Compressors use atmospheric air and deliver it through piping systems to air release units. A main pipe distributes the compressed air into smaller pipes, which end up at injectors. This compresoor, takes 160 kW, weighs around 2 tons, and provides the pipe system with maximum 27.8 m3/min of compressed air. The compressor is also seawater cooled.

Figure 11. (a) Ingersoll Rand Suitable Compressor

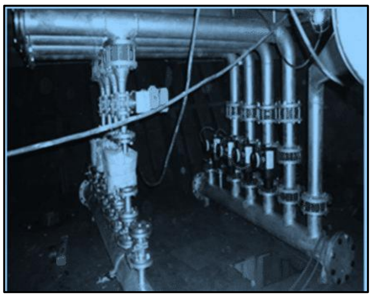

Figure 12. (b) Piping system

4-3 Simulation of the flow seawater and bubbles

A streamline animation snapshot explains the procedure, as the small air pieces (blue colour) are mixed with the passing seawater flow (yellow colour) at the air-lubricating areas. The move from left to right, indicate the ship travels in the left direction of the flowing field.

4-4 Engine features and fuel consumption

An MAN 8L32/44CR engine is a 13000kw power output and 600RPM

Table 1. Outline of the engine being tested

Engine Model	MAN 8L32/44CR
Configuration	8 cylinders in line
Power output	13,000 kw (13MW)
Bore	320mm
Stroke	440mm
RPM	600 RPM
Displacement	11.32 Liters per cylinder
Mean effective pressure	25.8 bar
Compression ratio	15:1
Fuel type	Heavy fuel oil (HFO) Diesel oil (DO)
Weight	155 tons without AE
Dimensions (L×W×H)	8meters×3meter×4meter

4-5 Calculate the fuel consumption of this engine

Let's the MAN 8L32/44CR engine consumes around **200 tons** of fuel per day without air lubrication. In this estimate of the engine reduce the 10% of the fuel. 10% savings: 20tons/day

5-CONCLUSION

- The air lubrication system (ALS) in a ship's hull is an innovative technology designed to enhance the vessel's fuel efficiency and reduce environmental impact. By injecting a layer of air bubbles along the hull, the system effectively reduces frictional resistance to the hull and the water.

- The primary advantage of ALS is the reduction of hull resistance, which lowers the amount of engine power required to maintain a given speed. This improvement in fuel efficiency can lead to significant savings in fuel consumption, making the system economically beneficial over time. The decrease in fuel consumption directly translates to a reduction in CO_2 emissions, supporting efforts to meet stringent international regulations on greenhouse gas emissions in the maritime industry. The technology contributes to more sustainable shipping operations. Although the initial installation of an ALS may involve capital costs, the long-term savings from reduced fuel consumption can offset these costs, making it a financially viable investment.

- Additionally, it may help ship operators avoid penalties related to environmental regulations. ALS can be adapted to various types of vessels and operating conditions. Its performance can be optimized based on the ship's speed, load, and sea conditions, ensuring consistent benefits across different voyages.

- The ALS requires regular maintenance to ensure optimal performance. However, when properly maintained, the system is reliable and can consistently deliver the expected reductions in fuel consumption and emissions.