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ARMADA
TECHNOLOGIES

2nd Generation Passive Air Lubrication

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Armada Technologies is an affiliate of the EcoOne® Marine Technologies Group

1st vs. 2nd GENERATION AIR LUBRICATION SYSTEMS

Air lubrication has a long history, dating back to the 19th century when it was first patented as a way of reducing drag friction between ships and water. Fast-forward over a hundred years and modern technology is again peeling back the layers of this concept and and exploring ways in which air lubrication can reduce drag resistance on ships' hulls for better energy efficiency.

1st Generation: Pioneer Hull Air Lubrication Systems

In 2018, the IMO published a list of various energy saving strategies that could be used toward reducing GHG emissions. The list included hull air lubrication, a technology which has been the subject of much discussion for almost 20 years.

The development and implementation of this technology has not been without its challenges. The experiences of shipowners have not been entirely positive with regard to the real-world performance of first-generation air lubrication systems (ALSs). Problems identified have included:

- Excessive power demands, as a result of the need to continuously run a number of compressors
- The space requirements, for the compressors, coupled with excessive vibration and noise
- System installation is challenging
- System operation is highly technical
- The system's efficacy can be affected by speed, draft and weather and may not function as desired or indeed at all
- Progressive pressure-build and 'burping' with cavity-based ALSs can restrict functionality, especially on deep draft vessels
- Market-available ALSs have claimed a potential fuel savings of 5 – 10 %, but research shows actual savings to be far lower, sometimes as low as 0 %!

2nd Generation: Armada's Revolutionary 'Passive' Air Lubrication System

In direct response to shipowner's feedback, the original Armada concept was premised on the goal of taking the compressors out of the loop since they are the biggest 'pain point' when it comes to ALSs. This led Armada's team of engineers to develop PALS - a second-generation, compressor-less air lubrication system that also incorporates significant improvements and enhancements over first-generation systems.

Armada's 'passive air lubrication system' (PALS), utilizes the forward motion of the ship to provide the motive force for the process. This means that the required equipment is limited to blowers plus some small capacity water pumps when operating in sub-optimal conditions. As a result, Armada's PALS requires much less power to achieve an optimal operation whilst offering far greater control over a wide range of operating conditions. Benefits are:

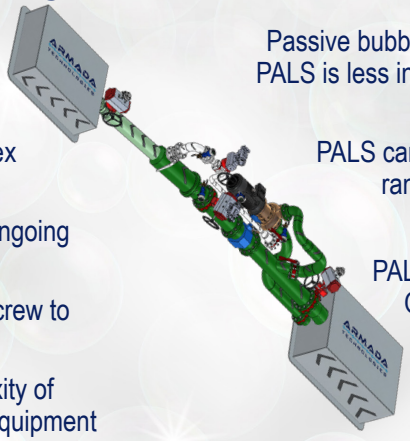
- Greater energy efficiency offering decreased emissions
- Easy operation, no additional crew needed to run PALS
- No issues with compressors creating excessive vibration and noise
- Less maintenance, inspections and overhauls
- Smaller installation footprint, less intrusive to the vessel and can be retrofit within a standard dry dock
- Optimal drag reduction is aligned to the ship type, prevailing speed, draft and even weather conditions
- System performance is more consistent, across a wide range of operating conditions and vessel configurations
- Potential double-digit net fuel savings is achievable

CURRENT MARKET AVAILABLE ALS

- Active bubble generation method represents a parasitic load – limiting net fuel savings
- System is cumbersome and complex to install
- System requires a high degree of ongoing maintenance and intervention
- Systems can require an additional crew to maintain air compressors
- System is expensive given complexity of installation and reliance on active equipment

PALS Key Differentiators

ARMADA TECHNOLOGIES



- Passive bubble generation increases net fuel savings PALS is less intrusive to install and can be fitted within a standard dry dock window
- PALS can tune system output to a much broader range of operating conditions with ongoing optimisation via machine learning
- PALS has a significantly reduced CAPEX & OPEX given the smaller capacity pumps and blowers, compared to heavy duty air compressors

OWNER BENEFIT SUMMARY
ARMADA PALS



BACKGROUND

The global fleet comprises a wide range of vessel types that operate at different speeds and drafts (laden and unladen) and with a diverse range of hull forms. Therefore, so it's not surprising that the first-generation ALSs, based upon older compressor-driven technology, are not always able to deliver significant benefits to the shipowner.

THE CHALLENGE

Bulk Carriers / Tankers

These ships typically steam at relatively slower speeds in the region of 12-15 knots. They have a full form and are designed with large beam and operating drafts. The ships have a high component of frictional resistance and for that reason should be ideal candidates for ALS. This has not proven to be the case however, because the result of the deep draft is that these vessels experience significant hydrostatic pressure on the bottom plating of the hull. In first-generation ALS this is where air is injected into the vessel boundary layer, and so the systems may suffer from a 'build and belch' phenomena instead of providing a smooth progressive injection of lubricating bubbles. The vessel may also experience an intermittent surging motion as the waves of air propagate along the length of the hull. Additionally, vessels of these types will require a significant number of outlets to ensure an even distribution of air across the bottom plating. Taken together these challenges can result in both high CAPEX and OPEX for first-generation ALSs used in these applications.

LNG / Container

These ships can often steam at relatively high speeds. The higher speed results in significant daily fuel consumption and so an ALS should offer the opportunity for a good solution here. However, the wide speed range and significant variance between laden and unladen draft makes the optimisation of a first-generation ALS in these applications very difficult. In addition, the high speed operation requires the ALS to deliver a very high volume of air in order to continuously replenish the air cavities under the ship. This puts a significant demand on the system's air compressors and so the power requirements for first-generation ALSs in these applications can be very high.

Ferry / Cruise

These ships are also typically full form and can travel at relatively high speed. Draft is pretty much consistent throughout their operating cycles between ports. Transit legs are usually short so an ALS must be able to deliver optimal performance consistently.

Given the high speed operations of these vessels they will rely on a large volume of air delivery for the continuous replenishment of air cavities under the ship. This puts a significant demand on the system air compressors and so the power requirements for first-generation ALSs in these applications can be very high.

THE ARMADA SOLUTION

The Armada PALS solution completely removes the need for compressors for all ship types. Instead, PALS adopts a venturi sub-mechanism to entrain the air. This mechanism has no moving parts and so allows for a significant reduction in CAPEX and OPEX costs.

For high-speed vessels, PALS decouples the ship speed from system lubricity, in doing so ship speed has no effect on the net energy required to generate bubbles prior to injection.

For LNG / Container ships, 100% of the air injection process takes place within the double bottom of the vessel making a PALS installation significantly less disruptive and achievable in a shorter dry docking window.

PALS takes the system water inboard of the vessel and creates a refined 'premixture' of air/water prior to re-injection under the vessel. For slower speed vessels, this ensures a smooth and progressive displacement of the existing boundary layer rather than simply blasting air through it as first-generation systems may do. The prevailing local hydrostatic pressure actually supports the injection of the reduced viscosity system water, pinning it within the boundary layer and eliminating the 'build and belch' phenomena associated with first-generation cavity-based ALSs.

“We are standing on the shoulders of the academics and engineers who came before us in air lubrication technology. But I think that there is a significant scope for improvement and we have accepted the challenge to bring Armada’s PALS to the next level with the potential for double-digit net fuel savings on an ongoing basis.”

– Alex Routledge, Armada CEO

Armada PALS, *the new ground-breaking ALS technology to watch out for!*

It needs repeating because it so important — there are NO compressors used with Armada’s PALS. That’s because they’re expensive, spatially inefficient, require significant maintenance, can create excessive vibration and noise and most importantly consumes large amounts of power, thereby significantly reducing operating costs, improving consistency of performance across a wide range of operating conditions and offering genuine OPEX savings for owners/operators.

In addition, the simpler nature of PALS makes for quicker, easier installation within a tight dry docking window.

PALS Reliability: State-of-the-art innovation and outcomes

In September 2022, Armada’s PALS was tested in the Hydrodynamic & Cavitation Tunnel (HYKAT) of HSVA, one of the world’s leading cavitation testing facilities. Testing results showed a stable, well engaged and high-quality rigid carpet of aerated water in the boundary layer and significant on-plate reduction.

The Armada team documented a drag reduction ‘sweet spot’ that could be targeted where two identified hydrodynamic phenomena were effectively balanced within each and every operating condition.

Armada’s passive bubble generation method increases fuel efficiency while providing greater scalability than ever before — making it a perfect air lubrication solution for fleets of all sizes.

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