Improving Ship Performance with Air Lubrication Achievements and Challenges

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2nd LEC Sustainable Shipping Technologies Forum
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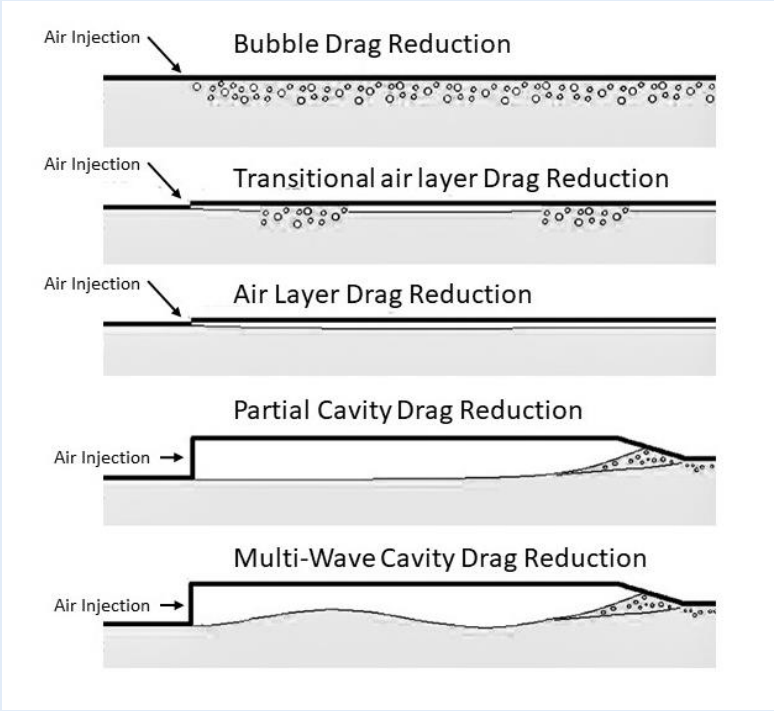
INTRODUCTION

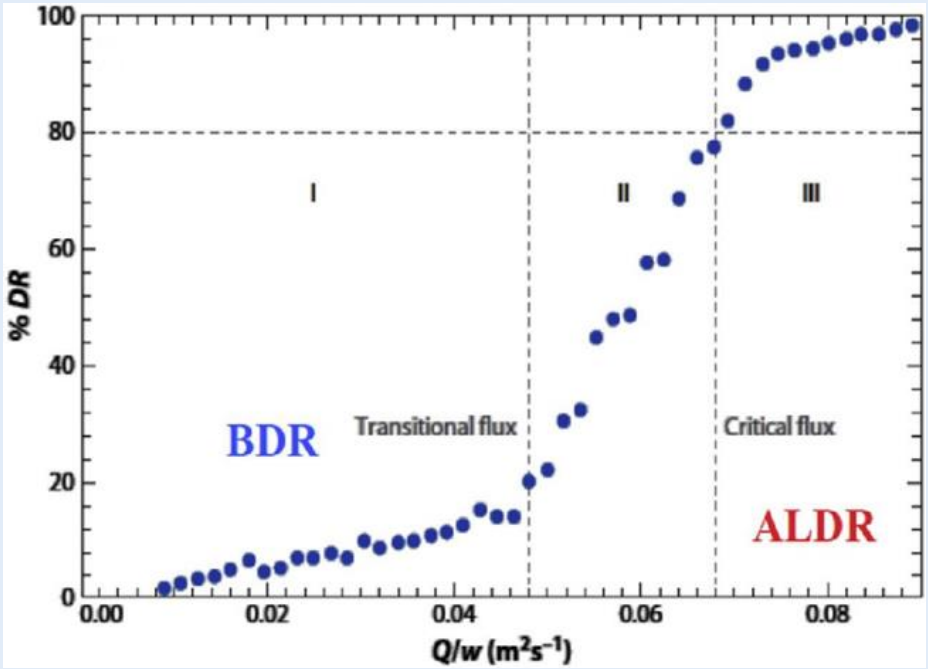
- Air Lubrication is a phenomena that can be used to reduce friction drag on a ship hull
- Air is injected as bubbles, or at higher volume to form a sheet or fill a cavity
- The potential drag reduction varies from around 5% to as much as 30% depending on the mechanism used and the vessel type it is applied to



Note that bubbles and sheets are not normally constrained by keels or fences on a ship bottom. A cavity requires the bottom to be specially formed

Mechanisms

- Air micro bubbles (BDR) follow the boundary layer
- The transitional flux, area II can be turbulent
- Air at higher volume forms a sheet under the boundary layer (ALDR)
- Air at sufficient volume to fill a cavity (ACDR), is above *Q/w* about 0.1

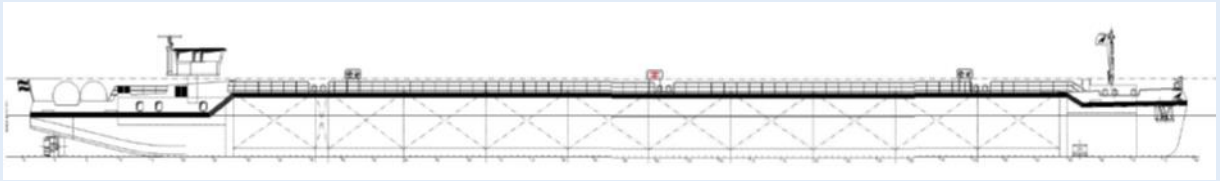


The behaviour of an air stream under a hull will be dependent on vessel speed as well as the hull geometry. Normally therefore an air lubrication system will be tuned to the hull and have an optimum speed

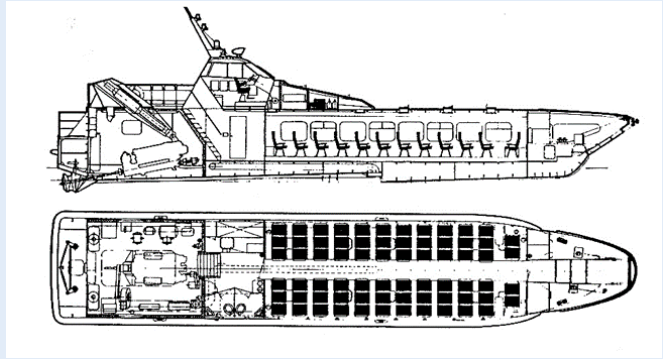
APPLICATION of MECHANISMS

- Bubbling and sheet
  - under surface of large ships
  - power and emissions reduction

- Sheet and shallow cavity
  - very long canal and river barges
  - power and emissions reduction



- Cavity
  - high-speed craft
  - power reduction
  - motions improvement



Bubble, layer, and cavity coverage of a vessel immersed area will be portion of total immersed area, so savings have a limit. Given that the achievements so far have been significant.

LARGE SHIPS - 1

Developments for oceangoing ships have focused micro bubble lubrication aiming at simpler systems and drag reduction in range of 5 to 8% and air layer lubrication aiming at up to 10% overall reduction

The key companies that have researched and commercialised systems are:

- ❑ Mitsubishi Heavy Industries Shipbuilding (MHI)
- ❑ Samsung Shipbuilding (SSI)
- ❑ Foreship
- ❑ Silverstream

- o MHI and SSI have developed air layer systems they deploy on ships they build
- o Foreship is a Naval Architecture practise based in Finland. They deliver a patented microbubble system package for retrofit or new build ships
- o Silverstream is a specialist marine practise based in UK who deliver their own patented microbubble system as an installation package for retrofit or new build ships

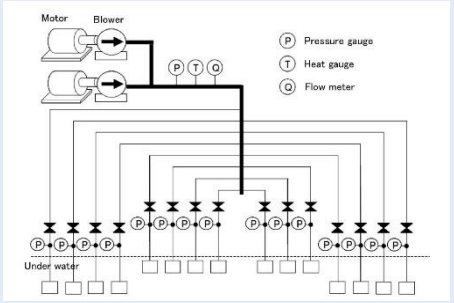
There is a balance between installed power, system complexity, and drag reduction. Ship-owners are normally after the simplest, lowest cost, and lowest maintenance system possible

LARGE SHIPS - 2

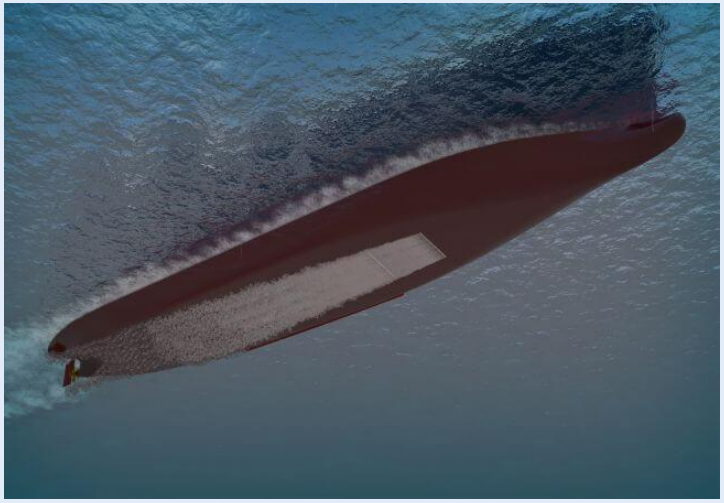
- MHI

MHI carried out model testing and a series of full scale trials with large module carrier vessels and a ferry before gaining fully commercial orders for its system on car carrier, Aries Leader, and two Aida cruise vessels

MHI patented system uses compressed air delivered to distribution boxes close to the bow and generate an expanding air layer covering most of the bottom. Drag reduction is in the region 8 to 10%



LARGE SHIPS - 3



- Samsung

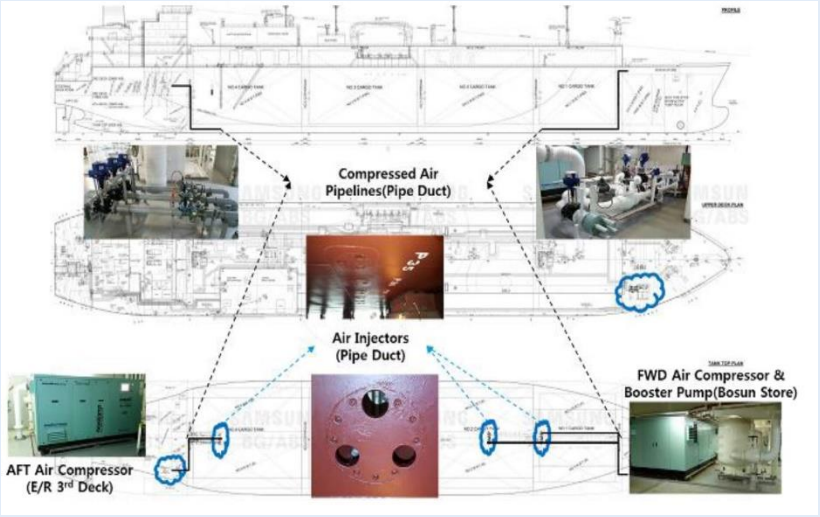
Samsung have developed another compressed air system aiming towards air layer lubrication.

The company carried out a substantial model test programme in house, and followed this with installation on two of their own ‘module delivery’ vessels carrying ship modules from China to Korea

Following these successful proof of concept projects they now supply their ‘Saver Air’ as an option for their LNG Carriers and other designs

The system injects air through plenum chambers on the hull bottom centreline.

Overall power savings are in the range between 5 and 10%



LARGE SHIPS - 4

- Foreship

Foreship developed their own patented system after a completing CFD and model testing.

They supply complete design and procurement packages for ship owners to use with their selected builders.

Their main clients so far are cruise ship owners. The system saves over 5% in powering, emissions reduction, and the bubble carpet acts as a noise and vibration damper.

Performance has been calibrated across several ship installations at all stages of a voyage and different seastates

The Foreship system is a compressed air delivery to hull bottom distribution units that may be just at the bow, or at other locations along the hull bottom centreline.

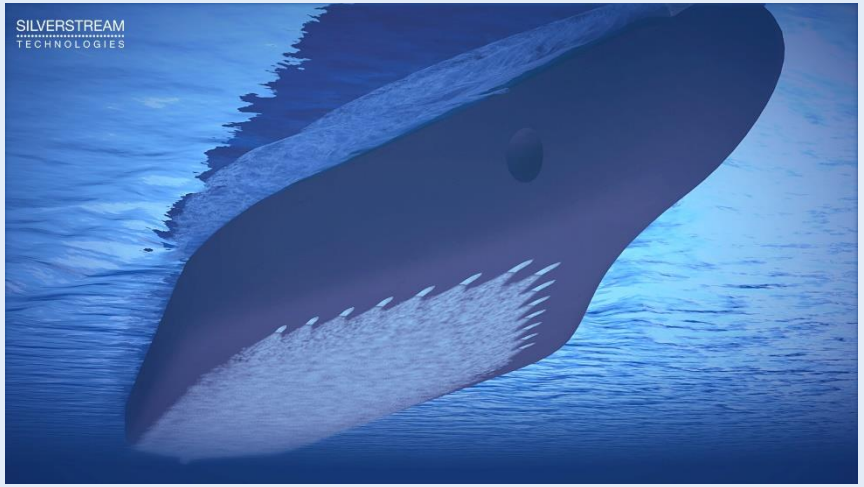
Volume and pressure is controlled so that the Kelvin Helmholtz effect optimally maintains boundary layer mixing and ensures BLR over the whole length of the ship

LARGE SHIPS - 5

- Silverstream

A specialist UK company delivering design and hardware packages to shipbuilders and ship-owners for retrofit or new-build

The system is a patented BDR system with air delivery optimised by use of the Kelvin Helmholtz effect



Air delivery is through an array of individually installed plenum chambers allowing optimisation to a hull underside.

Full scale trials including with Lloyds Register have verified the drag and power savings at reliably above 5%. Installed system power is very low

The system has been installed on cruise ships and is currently being fitted to a new class of 8 RoRo ships for Grimaldi

INLAND SHIPPING - 1

- Russian shipyards for Volga/Don and other markets

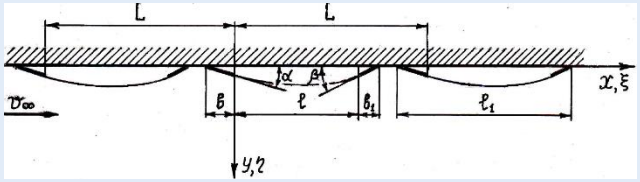
Research has been ongoing in Russia since the 1970's on 'partial cavity' drag reduction for coastal and inland shipping.

Work has included analytical studies, much model testing, and construction of prototypes and some commercial vessels

Due to the High L/B of this type of vessel the focus has been on installation of a series of cavities lengthwise each fed with low air volume so that the lower surface forms a parabola

Drag and power savings well above 10% have been achieved

The cavity means that the vessel has significant structural changes to the hull bottom



INLAND SHIPPING - 2

- Damen

Damen have completed studies, model testing, and prototype construction of an air cavity barge with LNG powering

Trials have demonstrated as high as 15% saving at typical transit speeds from the Air Cavity system

The hull bottom structural arrangement is innovative. Air feed is to each of the cavities along the length

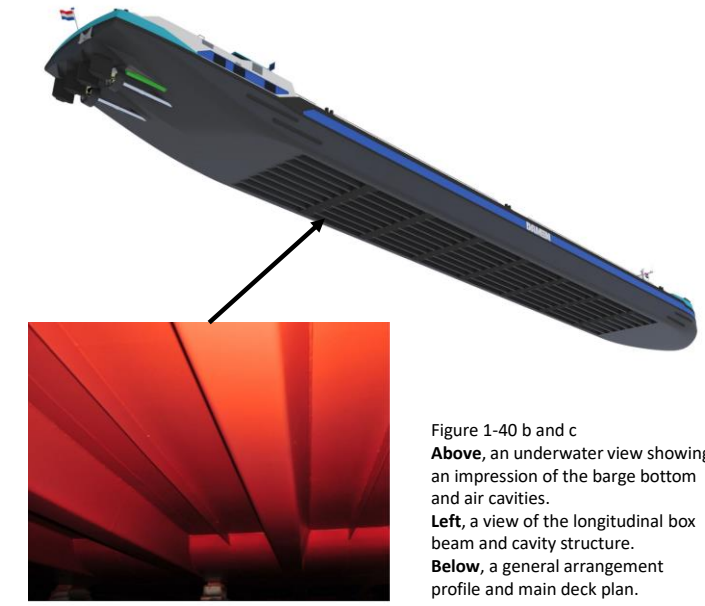
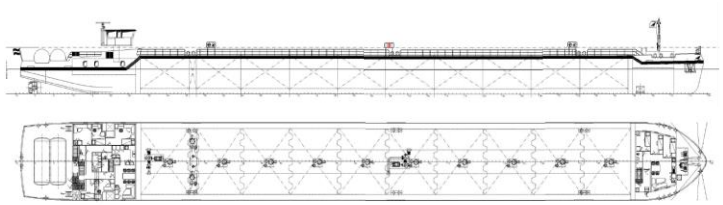


Figure 1-40 b and c
Above, an underwater view showing an impression of the barge bottom and air cavities.
Left, a view of the longitudinal box beam and cavity structure.
Below, a general arrangement profile and main deck plan.



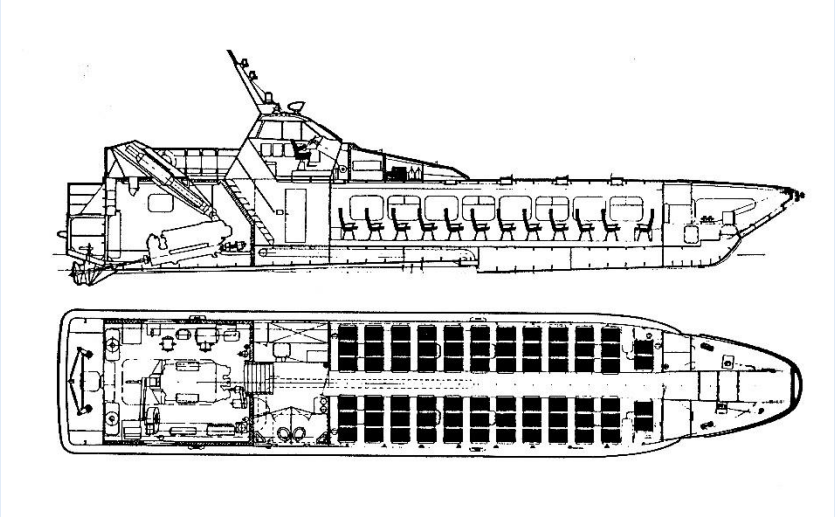
HIGH SPEED CRAFT - 1

- Russian shipyards and designers

Russia has lead the way for fast air cavity craft

Their approach is a forward planing surface and a cavity in aft 60% or so of length

They have had success with both passenger ferries and fast landing craft up to 240t displacement



The Russian design utilises the forward cavity step to minimise air volume needed to maintain the cavity at planing speed

Drag savings up to 30% have been achieved compared to planing hull, and the ride in a seaway is much softer

HIGH SPEED CRAFT - 2

- ESI / Tuco Marine

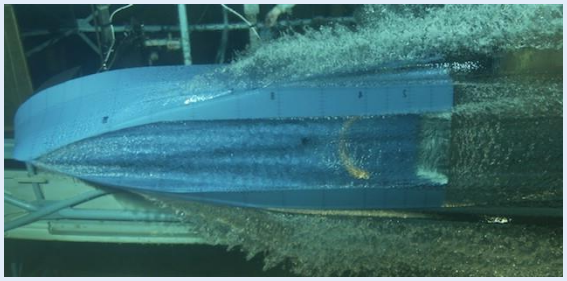
Effect Ships International have been developing air cavity craft for two decades. They gained EU and Norwegian R&D funds for energy saving fast craft.

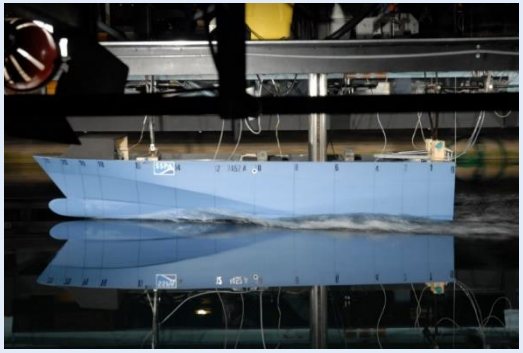
Following model Testing at SSPA, Goteborg a prototype was built and demonstrated over 30% savings in powering, and a very comfortable ride

The configuration is a cavity under most of the hull with thin deadrise side walls, air feed at bow and amidships and a hinged stern seal

Airflow and ‘cushion’ power is relatively low.

ESI teamed up with TUCO Marine in Denmark to develop a coastal utility craft after the success of the prototype.





HIGH SPEED CRAFT - 3

- BBGreen

Since 2014 ESI have worked on another EU sponsored project within the Horizon 2020 programme aimed at green shipping

BBGreen is the worlds first battery electric high speed passenger ferry.

The project has faced and overcome many technology challenges as it has been completed during a rapid development phase for electric powering of marine craft

The ferry has successfully performed service proving operations in Stockholm in 2018

Since then technology has become available that enables faster battery charging and longer range between charges

BBGreen Highlights

LOA	20 m
BOA	6 m
Passengers	80
Service Speed	30 knots
Propulsion	2 x 300 kW
Lift System	1 x 80 kW
Batteries	200 kWh prototype

SESX Marine Technology are the successor to SES Europe and are now developing new designs using the basic air cavity concept while implementing technology available today for green powering.

TECHNOLOGY STATUS AND CHALLENGES

Physical mechanisms understanding and simulation

- Air Lubrication behaviour under a hull is very complex
- CFD is a great help but only part of the solution
- There is much still to learn to optimise with a particular ship:
  - Interaction with hull geometry
  - Interaction with the seaway and motions

Moving into the market

Large vessels

Energy saving is now key to also minimise emissions
Moving to becoming a base case option
and so … Market expansion

Air Cavity Fast Craft

Development of zero emission vessels
Understanding the potential market
Market building

Enablers

EU development funds
Environmental regulations
Industry appetite