



Airships of the sea

Naval architecture: Blasting a cushion of air bubbles under a moving vessel's hull can reduce its fuel consumption

IF YOU blow a lot of air bubbles under a ship, and keep them coming, "good things will happen", says Steven Ceccio, an expert on bubbles at the University of Michigan's mechanical-engineering department in Ann Arbor. When air is pumped rapidly out of small holes in a ship's hull, the swarming bubbles will quickly join together and coat the hull with a layer of air a centimetre or two thick. This reduces drag, because air offers far less resistance than water.

As the ship moves forward, the layer of air slides back and out from under the hull. But blowing more bubbles to replenish it does not require much energy, so fuel savings of 5-10% are within reach, says Dr Ceccio. He studies air-lubrication systems, as the field is known, for the American navy, even though warships generally have v-shaped hulls, which facilitate fast travel but are unfriendly to bubbles. Almost all cargo vessels, by contrast, have flat bottoms, which allow a larger volume to be kept buoyant for a given amount of hull metal. Bubbles work well on these and, since the cost of fuel is often more than half of a cargo ship's total operating expenses, the potential savings are huge.

Bubbles are wont to slip past the edges even of flat hulls, but efforts to hold them in place are paying off, says Uwe Hollenbach of the Hamburg Ship Model Basin, a facility that tests new naval technologies. One trick is to trap the blanket of air between two ridges that protrude a few centimetres downward from the port and starboard edges of the hull. Another is to

Fluid defences

Military technology: Body armour can be made lighter and stronger by incorporating an unusual sort of liquid into its design

ASUIT of armour that is lightweight and flexible, yet capable of absorbing the impact of a bullet, is an idea that seems to come from the future. For many years researchers have been investigating designs that might be able to provide such protection by incorporating liquids. BAE Systems, a British defence contractor, seems close to turning such "liquid armour" into reality.

In recent tests at the company's Advanced Technology Centre in Bristol, a special liquid has been used to construct a material that is thinner than normal body armour and yet is able to stop a low-velocity bullet. Work is now under way to see if it can also stop more powerful bullets. If these tests are successful, liquid armour could furnish soldiers with protective clothing that is more comfortable and less cumbersome than existing body armour, and provides them with greater protection.

Liquid armour relies on the properties of materials called shear-thickening fluids. The molecules in such liquids are closely packed but loosely arranged. The material behaves like a liquid in normal conditions, and is able to flow. If subjected to pressure, though, the molecules lock together and behave like a solid. The gooey substance produced by mixing cornstarch with a little water is a

commonplace example of such a material. This flows like a liquid when poured yet, if hit with a spoon, reacts like a solid.

Researchers at the University of Delaware developed shear-thickening fluids for use in liquid armour almost ten years ago. Several military laboratories and defence firms have worked on them since then. Among them was Armour Holdings, an American company that BAE took over in 2007.

The fluid that Armour Holdings developed is a liquid polymer containing nano-engineered particles of silica, though BAE is coy about the details of what it is using. The new armour is not pure liquid, of course. Rather, the fluid is sandwiched between layers of Kevlar, a high-strength polymer commonly employed in protective gear. When the sandwich is struck by a bullet, the locking together of the molecules in the fluid spreads the load across a wide area, allowing the material to absorb more of the impact. It also distorts less than conventional body armour when it is hit. That means it is less likely to cause serious injury by deflecting inward.

Standard body-armour contains around 30 layers of Kevlar. The material being tested by BAE has only ten Kevlar layers. BAE therefore thinks it may be possible to build body-protection suits that are only around half as thick as existing ones, but still able to offer greater protection. Soldiers would find that a welcome relief.

shape the vessel's stern in a way that stops air being sucked into the propeller, where it would reduce thrust by lessening the propeller's grip on the water. It is also possible to design hulls that include air-trapping recesses a couple of metres deep.

Damen Shipyards Group, a Dutch firm that builds more than 150 ships a year, has found that such cavities cut fuel consumption by about 15% on a 60-metre ship that carries cargo on rivers. Tests at MARIN, a naval-engineering institute based in Wageningen, also in the Netherlands, suggest air cavities can reduce a big ship's fuel costs by as much as 20%. Damen, meanwhile, estimates that the air-lubrication system will increase the cost of building a 110-metre cargo ship by only about 5%. It expects production to begin early next year, and plans to license designs to other shipbuilders soon thereafter.

As yet, few shipping companies have

adopted air lubrication, in spite of results like these. That is partly because shipbuilding in general has slumped along with global trade. It takes years for a new ship to be designed and built, and investment in such a thin market can appear risky. Retrofitting ships with air-lubrication kits, rather than building them from scratch, is much cheaper, says Katia Kardash, boss of the DK Group, a naval-engineering company in Rotterdam.

The firm's retrofit product, Air Cavity System (ACS), went on sale this year. It can be built into the bottom of a container ship in two weeks during regular dry-dock maintenance. Some tests indicate ACS could provide fuel savings of 15%. Ms Kardash says that even with DK's more conservative estimate of 7-10%, an investment in ACS will be recouped in 18-30 months. Might a new generation of airships soon be ready for launch? ■