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'Why Ships (and Pedalos) Float'

The holiday season draws to an end - but while navigating a yacht through a limpid sea or piloting a 'pedalo' round the point in search of family adventure the thought might have occurred - why does this craft keep its distance above the seabed?

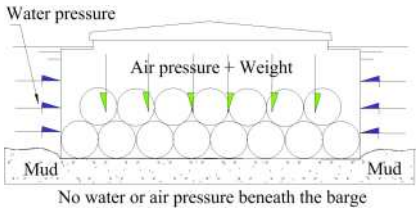
The stock answer to this question is 'a ship floats because it displaces its own weight in water'. It is true that a floating ship, dinghy or pedalo, does displace a mass of water equivalent to it own weight and all the cargo, kids, beer cans – and bikes – it might happen to carry. But this oft recited fact masks a deeper and more interesting reason for a ship either floating or not floating.

Some years ago I was involved in a dispute concerning a Thames barge loaded with steel coil. Having completed loading, the craft was taken off its berth and put to anchor in the stream. Within a few hours the ebb tide left the barge high and dry on soft river mud. Inevitably, the tide returned and covered the mud. It was expected that the barge would lift and float at its original draught, at which it could be towed down-river.

But shore observers became concerned when water rose up the sides beyond the original draught marks. Concern turned to dismay when the barge refused to float and water rose higher and higher. Thames tides have a range of about seven metres and on the particular day the rise was more than sufficient to immerse the hatchcover. At that stage the undamaged and as yet internally dry barge was sitting on the riverbed completely submerged in water of still increasing depth. At the next low water the barge was uncovered, but of course by then the interior was flooded and much damage was done to the steel cargo.

Arguments passed to and fro between the parties. Surveyors for the cargo interests 'proved' that by the time water had risen up to the original draught marks the barge was displacing its own weight of water and therefore – in accordance with the 'Principle of Archimedes' – the barge should have floated. That it did not float was taken as certain evidence that it had been damaged by the stevedores or holed by debris buried in the river mud. But neither proposition was correct.

The barge had a flat bottom and vertical sides and ends. Pressed firmly onto the mud by the weight of cargo the air was squeezed out from beneath the entire bottom area. As the tide returning tide progressed water crept up the vertical ends and sides but was unable to flow beneath the barge. The increasing depth of water pressed on the hull but no 'lift' or flotation was generated. Soon, the barge displaced far more than its own weight in water but this was still not sufficient to overcome the forces holding it onto the mud – the so-called 'suction effect' had taken hold.

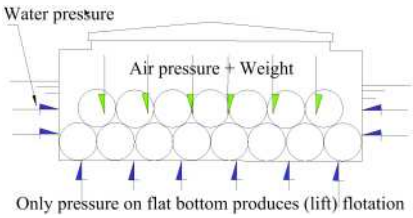


No water or air pressure beneath the barge

Atmospheric pressure equates to about 1Bar (10^5 N/m^2). Therefore, every square metre of the barge flat bottom was subject to an atmospheric force of about 10.2ton. As the barge measured about 30 x 11m the total weight of air pressing it onto the mud was almost 3,400tons. By comparison, the fully loaded displacement of the craft was only about 1,000ton.

A tremendous force arising from air pressure is always present. But this is normally completely balanced because it acts on the water surface and is thus transmitted through the water and acts with equal force all around a floating hull.

Buoyancy, the lifting force which keeps a ship or any other body afloat, is not derived from displacement but from water pressure. The barge eventually displaced much more than its own weight of water but it did not float on the tide because water pressure (and its intrinsic component of atmospheric pressure) could not access the underside flat bottom. Although the vertical sides and ends were subject to combined water and air pressure this acted only inward (horizontally) and had no upward component with which to overcome the weight of the barge and the pressure of air pushing on the inside bottom.



Only pressure on flat bottom produces (lift) flotation

Archimedes only applies to freely floating bodies. While it offers a convenient and reliable means of relating the weight of a ship to its draught it needs to be fully understood if errors are not to occur.

This series of occasional Technical Notes is intended as a service to the enlightened lay reader to explain marine engineering issues which are topical or which appear from time to time as issues in maritime disputes.

Alex Sinclair is an independent consulting marine engineer with over 28 years experience of casualty investigation, arbitration and litigation. A full CV is available at www.ajsinclair.com.

Next time: Stainless Steel, how it works – and some popular misconceptions.

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