Propeller Propulsion

Though propellers were first fitted on ships in the 1830s, it was really the Wright brothers who began serious optimization of their design because of their critical need for lightweight and efficient propellers for their pioneering airplanes. Like the wings of an aircraft, propeller blades are most effective when they have a high aspect ratio, that is to say they are long and thin as exemplified by the aircraft propeller in Figure 1 (left). However, as with wings, structural limitations demand greater strength and this constraint is particularly severe for marine propellers which, to be sufficient strong and rugged, must have blades of much smaller aspect ratio as exemplified by Figure 1 (right). Thus the design of a propeller is influenced by

Figure 1: Left: Old style aircraft propeller. Right: Ship propeller

many factors including the required thrust and structural strength. The blade angles decrease with radius so that the lift produced is distributed over the length of the blade (since the incident velocity increases with radius) rather than being focussed at the tip. Moreover the flow at the blade tip is often of critical importance. On aircraft propellers it is the source of much noise and so the tip is sometimes completely unloaded (zero design incidence angle) in order to minimize the noise. With marine propellers, cavitation (see Figure 2) often occurs first at the tip and, as with aircraft propellers, the tip is unloaded to minimize this deleterious effect (see section (Mfb)). Indeed, as a result of cavitation and structural constraints, marine propellers come in a wide variety of different shapes as illustrated by Figure 3. Sometimes ducted propellers such as that in Figure 3 (right) are used to improve performance but their susceptibility to damage can be a vulnerability.

Both aircraft and marine propellers also come in a variety of numbers of blades, anywhere from two to six or more. However, with larger numbers of blades the effect of the wake of one blade on the following blade can significantly reduce performance. Furthermore, both ships and planes can have a number of propellers. Though the modern trend in both instances is toward the fewest practical number of propellers

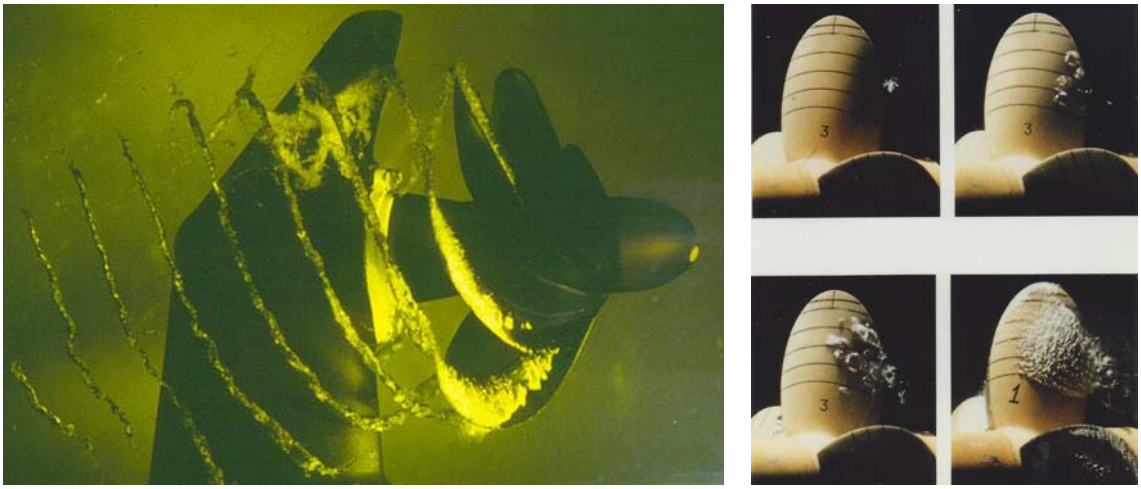

Figure 2: Examples of cavitation on marine propellers.

Figure 3: Left: Five different marine propeller designs. Right: Ducted marine propeller.

(namely one), ships are sometimes equipped with three and commercial passenger aircraft have at least two for safety reasons.