Introduction to Propellers

Figure 1: Left: Hamilton Standard 54H60 propeller on US Navy plane. Right: A typical high aspect ratio propeller, AP156-hi.

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 propellers in Figure 1. However, as with wings, structural limitations demand greater strength and this constraint is particularly severe for marine propellers which, to be sufficiently strong and rugged, must have blades of much smaller aspect ratio as exemplified by Figure 2. As described in the following section, the design of a propeller is influenced by many factors that include not only the required thrust and structural strength but also the vulnerability and susceptibility to damage.

Propellers, most notably marine propellers, feature in a variety of historical contexts as illustrated in Figures 3 and 4. One critical design choice is the number of blades; as seen in these figures, the typical number ranges from three to six. Three blades often lead to excessive vibration. Four or five are most frequently the best choice. Smaller aspect ratio blades are often needed for structural reasons (as discussed elsewhere) and this can lead to excessive hydrodynamic interaction between the blades when the number is above five. The swept and rounded blade shapes are preferable since these are less susceptible to cavitation; sharp corners are not recommended since these tend to promote intense vortices that promote cavitation. The three propeller configuration deployed on the Titanic (Figure 3) leads to excessive interference between the propellers and is rarely used in modern times.

As discussed in another section, cavitation damage, noise and vibration is a serious problems for ship propellers. Often these are made of bronze (figure 2) or even stainless steel which are less susceptible to cavitation damage. Sometime just the leading edges are made of stainless steel. The cavitation problem is never completely avoided and hence the need for regular propeller maintenance and replacement.

Figure 2: Left: Five different marine propeller designs. Right: 85 ton, bronze marine propeller.

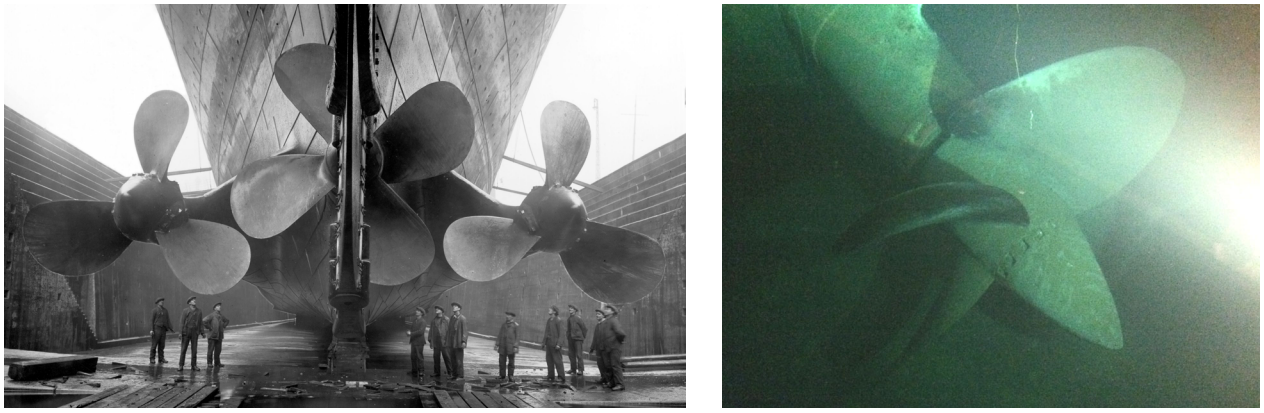

Figure 3: Left: The three propellers on the Titanic. Right: Propeller on the Queen Mary.

Figure 4: Left: Propellers on the salvaged U-boat, U-584.