

Unbalanced rudder – historically, this type of rudder was used on larger ships, but the design has been superseded by the semi-balanced rudder, which gives greater manoeuvrability.



Figure 1.4 Unbalanced rudder

Semi-balanced rudder – this is a combination of balanced and unbalanced and a proportion (around 20%) of the rudder is in front of the stock. It is often found on ships that have two propellers.



Figure 1.5 Semi-balanced rudder

Flap rudder – the trailing edge of this type of rudder has a variable flap, which provides an increased rudder angle at the tip, increasing manoeuvrability, particularly at slow speeds.



Figure 1.6 Flap rudder

Schilling/fishtail rudder – the rudder plate is shaped like a fishtail, with a flat plate welded to the top and bottom. This deflects and holds the flow of water from the propeller into the rudder body, with no spill off the top or bottom, which would result in a drop in 'lift'.

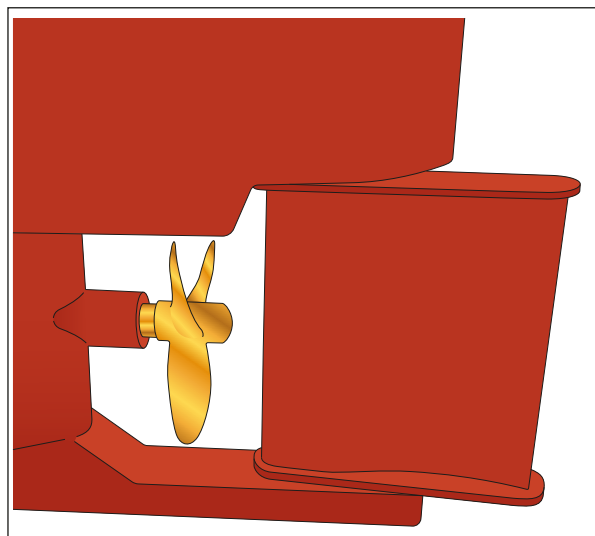


Figure 1.7 Schilling rudder

1.4 Propellers

As the propeller rotates, it accelerates the water passing through it, which creates higher water pressure behind the propeller and lower pressure in front of it. This creates thrust, which forces the ship forward into the negative pressure. The faster the propeller rotates, the more thrust is created. The propeller shaft creates the torque (energy) required to rotate the propeller blades. The number and design of the propeller blades influence how much water is displaced as they turn.

Each propeller blade is designed in a particular shape to promote the flow of water down and then through it. The forward or leading edge of the propeller refers to the edge that cuts through the water or makes contact first. The trailing edge is the aft section of the propeller where the water leaves the blade. The profile of the blade may be either flat/straight or progressive. A flat propeller blade is uniform in thickness, while a progressive blade becomes thicker towards the trailing edge.

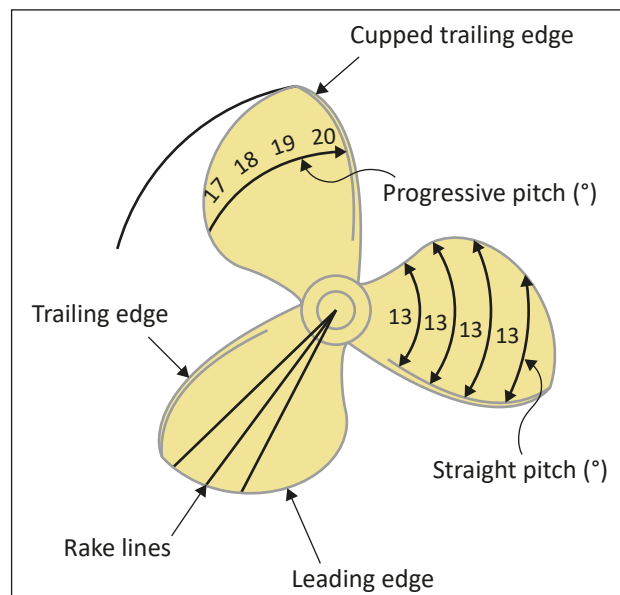


Figure 1.8 Parts of a propeller

As most propellers are designed for creating forward movement, there is less thrust created when operating astern due to the profile of the blades, ie the trailing edge becomes the leading edge.

Ship propellers may have between three to five blades. Propeller efficiency is higher with a minimum number of blades. However, as ship size increases, more blades are required to withstand the larger forces imposed during operation. Additional blades also give better holding power in rough seas and reduced vibration and have better strength and durability.

The dimension of the propeller depends on the type of ship and the following factors:

- The design draught of the ship
- stern construction and design of the ship
- distance requirement between the tip of the blade and the hull of the ship
- operating conditions of that kind of ship, eg tankers and bulk carriers have a large difference between their loaded vs ballast sailing draught, while passenger ships and container ships do not. Propeller size tends to be smaller on tankers and bulk carriers so that, when in ballast, the propeller remains underwater.

There are two main types of propellers: fixed pitch and variable pitch.

1.4.1 Fixed pitch

The propeller blades are fixed to the hub of the propeller and remain at the same angle/pitch during rotation. These propellers are usually made from a copper alloy and tend to be fitted to ships that do not require great manoeuvrability, such as tankers and bulk carriers.

A fixed pitch propeller is robust and reliable and requires little maintenance, and is also more cost-effective than a controllable pitch propeller.

1.4.2 Variable (controllable) pitch



Figure 1.9 Variable pitch propeller

A variable pitch propeller is not made up of one solid piece of metal like a fixed pitch propeller but has individual blades that can be moved simultaneously through an arc to change the angle of pitch.

In normal operation, it resembles a fixed pitch propeller and provides an equivalent level of thrust. However, the variations of pitch angle provide greater thrust control. Pitch is said to be 'positive' when moving ahead, 'negative' when moving astern and 'zero' when the ship is stopped.



Figure 1.10 Close-up of a variable pitch propeller showing how each blade can change its pitch

The angle of pitch and the speed of the ship's engine are often linked, meaning that for a certain angle of pitch the ship will make a set speed. However, on some ship types, the rotation of the propeller blades remains constant and it is the angle of the blades not the rotation of the propeller that provides the required thrust, ie the propeller blades are constantly turning and, by changing the pitch angle of the blades, you can introduce thrust and therefore speed.

Advantages:

- Quick changes in speed can be obtained by altering (inverting) the pitch of the blades, rather than having to stop the propeller and then set it to rotate astern like a fixed pitch propeller
- there is no limit to the number of ahead and astern movements, unlike slow starting engines using a fixed pitch propeller
- there is no minimum (idle) speed when the engine is set to ahead, as the pitch of the blades can counteract the turning of the propeller
- if a blade becomes damaged, it can be removed and replaced easily. Under the same circumstances, a fixed pitch propeller would require a whole new propeller.

Disadvantages:

- At 'zero' pitch, with the propeller continuing to rotate in front of the rudder, the water disturbance over the rudder makes the ship difficult to control at slow speeds
- the mechanism for controlling the propeller blades is expensive and complex to build and maintain, when compared with a fixed pitch propeller.

1.4.3 Ducted propeller (Kort nozzle)

A ducted propeller, also known as a Kort nozzle, is a propeller fitted within a non-rotating shroud that directs water through the propeller. This increases the velocity of the water, reducing the water pressure and in turn lowering the thrust and torque of the propeller. However, simultaneously, a circulation occurs, resulting in an inward aimed force that has a forward thrusting component. This thrust is larger than the thrust reduction of the propeller, meaning there is a net gain for the efficiency when compared with a non-ducted propeller.

However, the side effect of this design is that the shroud around the propeller adds drag, which increases with speed. Kort nozzles lose their advantage over unshrouded propellers at around 10 knots, whereby the drag outweighs the increase in speed.

This type of propeller is mainly used on tugs, small coastal ships and fishing trawlers, as these ships do not regularly achieve speeds higher than 10 knots, so the drag of the shroud is negligible. They can also be fitted on ice class ships to protect the propeller blades from floating ice.

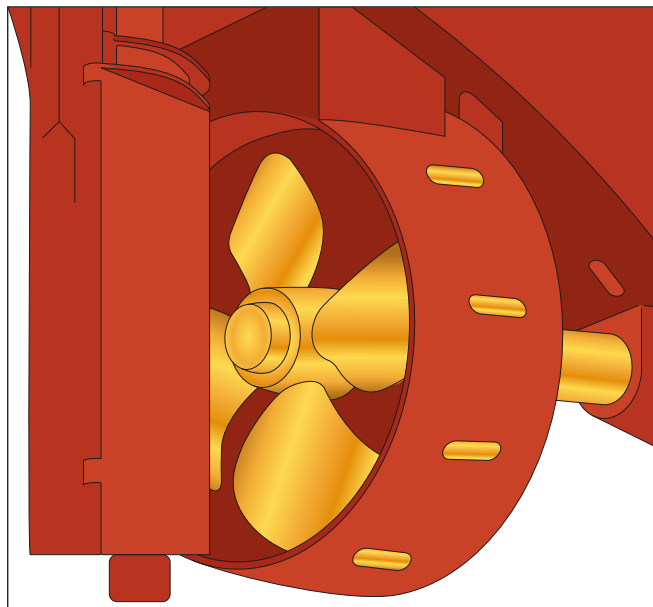


Figure 1.11 Kort nozzle