Ship Propulsion :

Geometry of Screw Propeller

A screw propeller consist of a number of blade attached to a hub or boss. The boss is fitted to the propeller shaft through which the power of the propulsion machinery of the ship is transmitted to the propeller.
When this power is delivered to the propeller, a turning moment or torque Q is applied making the propeller revolve about its axis with a speed (revolution rate) n thereby producing an axial force or thrust T, causing the propeller to move forward with respect to the surrounding medium (H_2O) at a speed of advance V_A.

The units of these quantities in the SI unit system are:

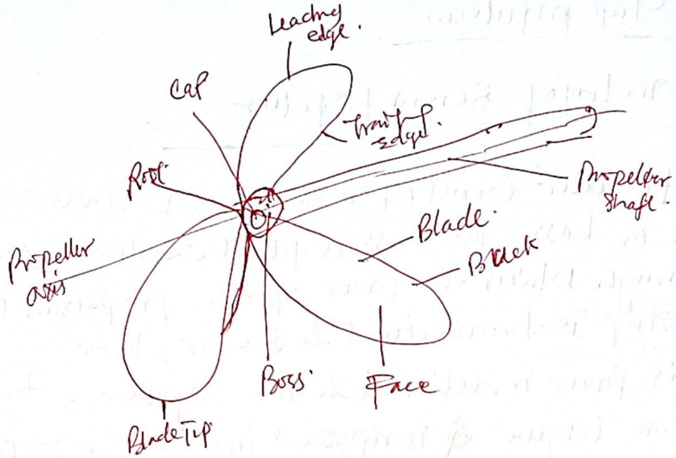
Q = Newton-meters.

n = Revolutions per second.

T = Newtons.

V_A = meters per second.

The rate of Revolution of a propeller is often expressed in terms of revolutions per minute (rpm) and the speed of advance in knots. (1 knot = 0.5144 m/s).



The point on the propeller blade furthest from the axis of revolution is called the blade tip. The blade is attached to the propeller boss at the root. The surface of the blade that one would see when standing behind the ship and looking at the propeller fitted at the stern is called the face of the propeller blade. The opposite surface of the blade is called its back.

A propeller that revolves in the clockwise direction (viewed from aft) when propelling the ship forward is called a right hand propeller. If the propeller turns anti-clockwise when driving the ship ahead, the propeller is left handed.

The edge of the propeller blade which leads the blade in its revolution when the ship is being driven forward is called the leading edge. The other edge is the trailing edge.

When a propeller revolves about its axis, the blade tips trace out a circle. The diameter of this circle is the propeller diameter D. The number of propeller blade is denoted by Z. The face of the propeller blade either forms a part of a helicoidal or screw surface or is defined with respect to it; hence the name "screw propeller".

A helicoidal surface is formed when a line revolves about an axis while simultaneously advancing along it. A point on the line generate a 3-D curve called a helix. The distance that the line advances along the axis in one revolution is called the pitch of the helicoidal surface.

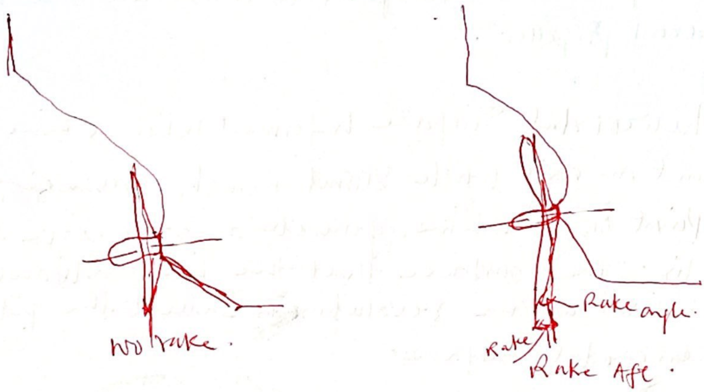
The pitch of the helicoidal surface which defines the surface of a propeller blade is called the pitch P of the propeller.

RAKE AND SKEW

If the line generating the helicoidal surface is perpendicular to the axis about which it rotates when advancing along it, the helicoidal surface and the propeller blade defined by it are said to have **NO Rake**.

If, however, the generating line is inclined by an angle ε to normal then the propeller has a rake angle ε. The axial distance b/w points on the generating lines at the blade tip and at the propeller axis is the Rake.

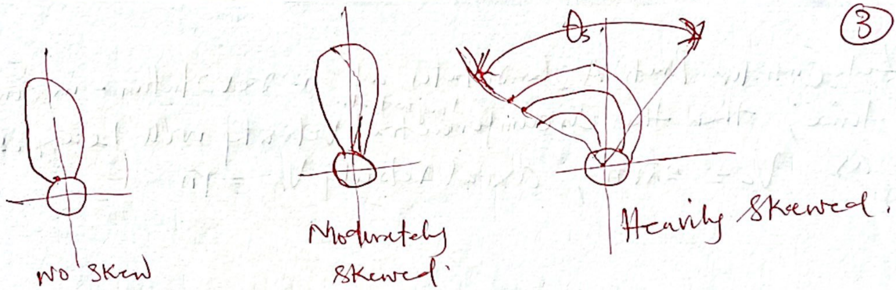
Note Propeller blades are sometimes raked at angles up to 15 degrees to increase the clearance (space) b/w the propeller blade and the hull of the ship.



Consider the lines obtained by joining the midpoints b/w the leading and trailing edges of a blade at different radii from the axis. If this lines is straight and passes through the axis of the propeller, the propeller blades have no skew.

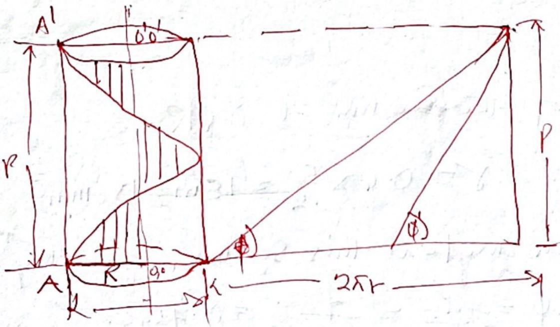
The lines joining the midpoints curves towards the trailing edge, resulting in a propeller whose blades ~~are~~ are skewed back. Skew is adopted to reduce vibrations. Some modern propeller designs have heavily skewed blades. The angle θ_s b/w the straight line joining the centre and the propeller to the midpoints at the ~~blade tip~~ root and a line joining the centre and the midpoint at the blade tip is a measure of skew.

Scanned with CamScanner



Geometry of Screw Propeller :

As stated earlier, a screw propeller may be considered as a helical surface, or helicoidal surface, on rotation screws its way through the water, driving water aft and the ship forward.



If the distance of the point A from the axis OO' is r, then the circumferential distance travelled by the point in one revolution will be 2πr. The distance travelled in the same time is called the pitch of the helix and it is denoted by p.

Let consider Point, A to rotates at n revolution in unit time; then the tangential Circumferential Velocity will be expressed as $V_c = 2\pi r n$; axial Velocity $V_A = Pn$

Example 1.

In a propeller of 5.0m diameter and 4.0m pitch, radial lines from the leading and trailing edge of the section at 0.6R make angle of 42.2 and 28.1 degrees with the reference plane through the propeller axis. Determine the width of the expanded blade outline of 0.6R.

Soln.

Given Data

The radius of the section at 0.6R.

$$r = 0.6 \times 5/2 = 1.5m = 158mm.$$

The pitch angle at this section is given by.

$$\tan\phi = \frac{P}{2\pi r} = \frac{4}{2\pi \cdot 1.5} = 0.4244; \quad \cos\phi = 0.9205$$

$$\cancel{\cos\phi}\ \theta = \tan^{-1}(0.4244) = 22.997^\circ$$

$\theta = 22.997$

Leading Angle $-\theta_L = 42.2^\circ$, trailing Angle $= \theta_T = 28.1^\circ$

Scanned with CamScanner

The width of the expanded outline at 0.6R is

$$C = \frac{r(\theta_L + \theta_T)}{\cos\phi}$$

θ_L and θ_T are the radius.

$$C = \left[\frac{1500\left(\frac{42.2 + 28.1}{57.3}\right)}{0.9205}\right]$$

$$\boxed{C = 1999.2\,mm}$$