

2 FORCES ACTING ON THE MANOEUVRING SHIP

2.1 Longitudinal and rotational motion

When the ship is moving on straight course – longitudinal motion - at constant speed there are two forces acting – thrust of the propeller and resistance of the water. They are equal and act in opposite directions (fig. 2.1a).

Pure rotational motion with no forward speed could be executed by using stern and bow thrusters acting in opposite directions. Ship then turns around the pivot point located approximately amidships (fig. 2.1b).

Turning at speed could be executed by using rudder. When moving ahead the ship rotates around the pivot point located in the front part of the ship. When moving astern, the pivot point is close to the stern (fig. 2.1c).

Sideway motion could be executed by using bow and stern thrusters acting in the same direction (fig. 2.1d). Similarly, tugs pushing at bow and astern may create similar forces.

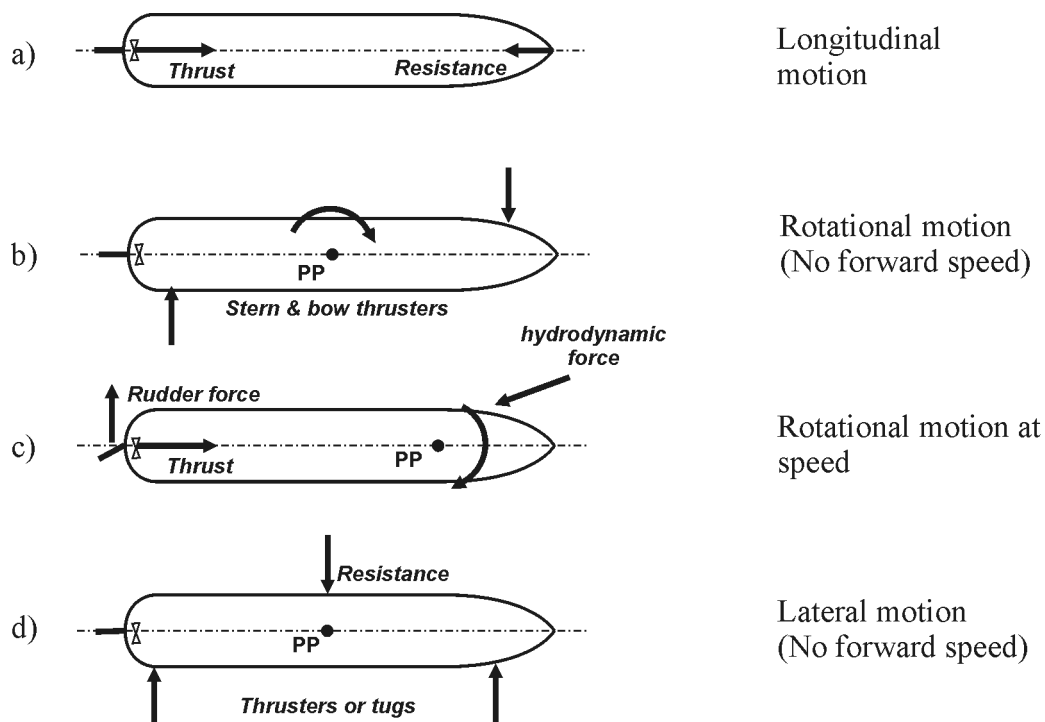


Fig. 2-1

When the ship is moving headway, the centre of lateral resistance is moving forward. Bow thruster (or tug) is less effective, because it is pushing against greater opposite force. This also creates rotational motion. (Fig. 2-2). When the ship is moving sternway, the opposing effect is created and the stern thruster (or tug) is less effective.

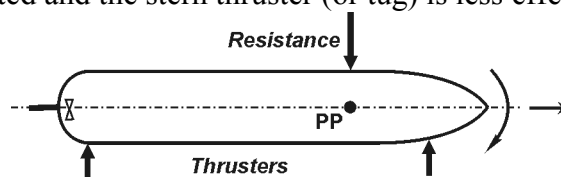


Fig. 2-2

2.2 The pivot point

Pivot Point “PP” is the point around which the ship rotates – it is the point of application of the hydrodynamic forces acting on the ship’s hull.

With no forward speed, pivot point coincides with the centre of gravity that is approximately amidships.

When the ship is making headway, pivot point moves forward.

When the ship is making sternway, pivot point moves aft (Fig. 2.3).

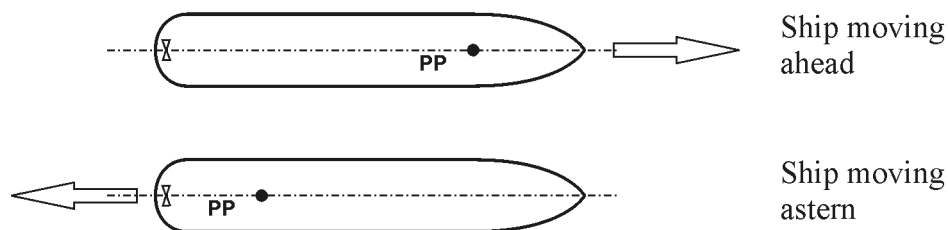


Fig. 2-3

Position of the pivot point depends on the form of the hull. Its position when moving ahead is between $(0.12 \text{ to } 0.25) L$ from the bow. In full-bodied ships, pivot point is closer to the bow, in slender ships farther from the bow (fig. 2.4).

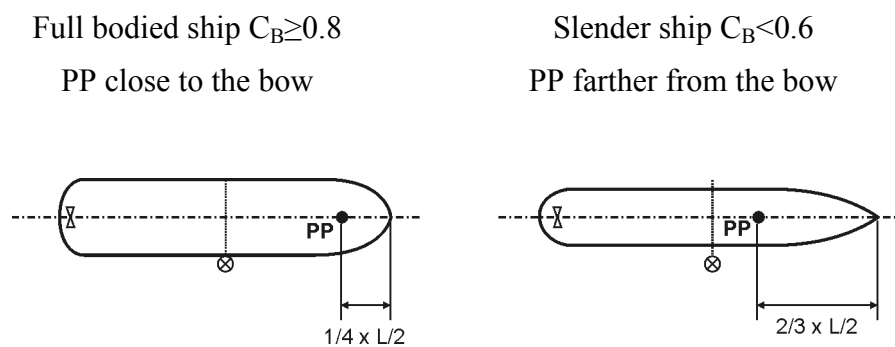


Fig. 2-4

The position of pivot point is very important from the point of manoeuvring. If it is close to the bow, the ship has better turning ability (smaller turning circle). (See chapter 3).

2.3 Transverse thrust of the propeller

In single-screw ships the turning propeller creates non-symmetrical pressure field at ship's stern. The pressure difference created on both sides causes that transverse force is induced that is called transverse thrust of the propeller.

If the propeller is right handed, then when making headway, transverse thrust is directed to starboard, when making sternway, it is directed to port (fig. 2.5).

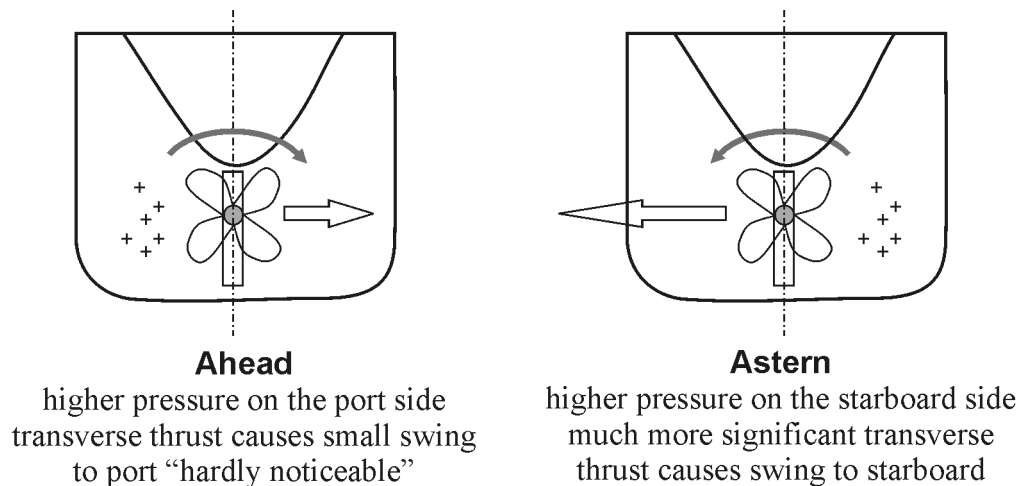


Fig. 2-5

With left-handed propeller, the situation is reversed.

- When ahead motion: transverse thrust to port;
- When astern motion: transverse thrust to starboard.

Generally, transverse thrust is small when making ahead, much larger when making astern.

Simple formula for calculation of transverse thrust when making astern:

Roughly: Transverse thrust $T_T = (0.05 \text{ to } 0.10) \cdot \frac{P_A}{100}$

Where: P_A = astern power of the ship (in shp).

Example: Main engine power:	$P=20000$ shp
Assuming engine power available:	$P_A= 60\% P =12000$
Transverse thrust according to formula:	$T_T= 12$ tons

2.4 Effect of the transverse thrust of the propeller

The effect of the transverse thrust of the propeller is much more significant when making sternway than when making headway (fig. 2.6).

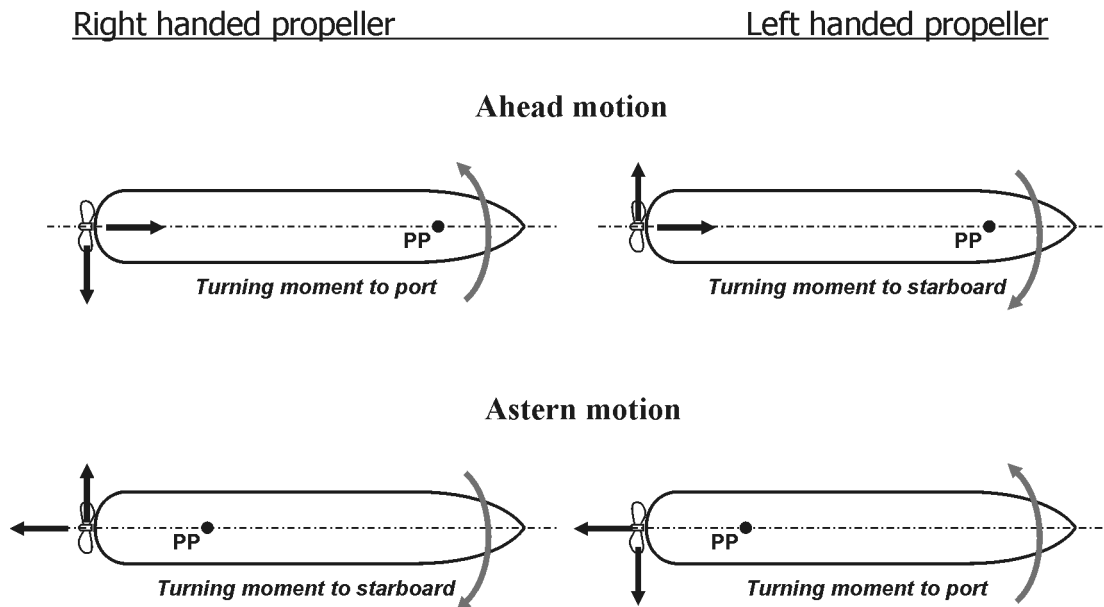


Fig. 2-6

Swing due to transverse thrust of the propeller in ahead and astern motion:

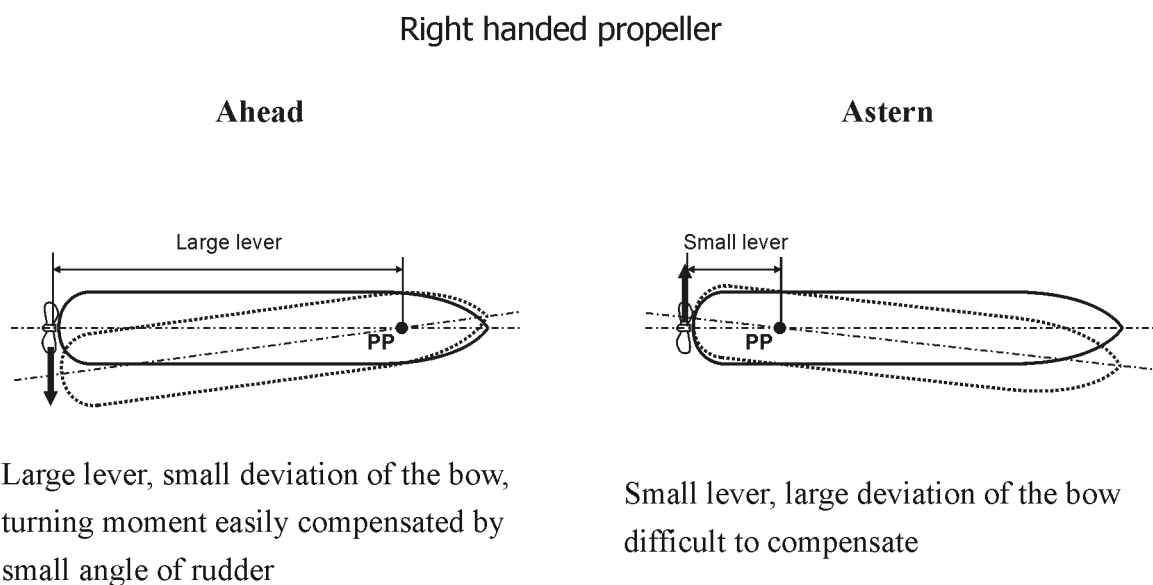


Fig. 2-7

2.5 Forces acting on the ship when turning

When the ship is making a turn, then apart of the propeller thrust and water resistance, also rudder force and transverse hydrodynamic force are active.

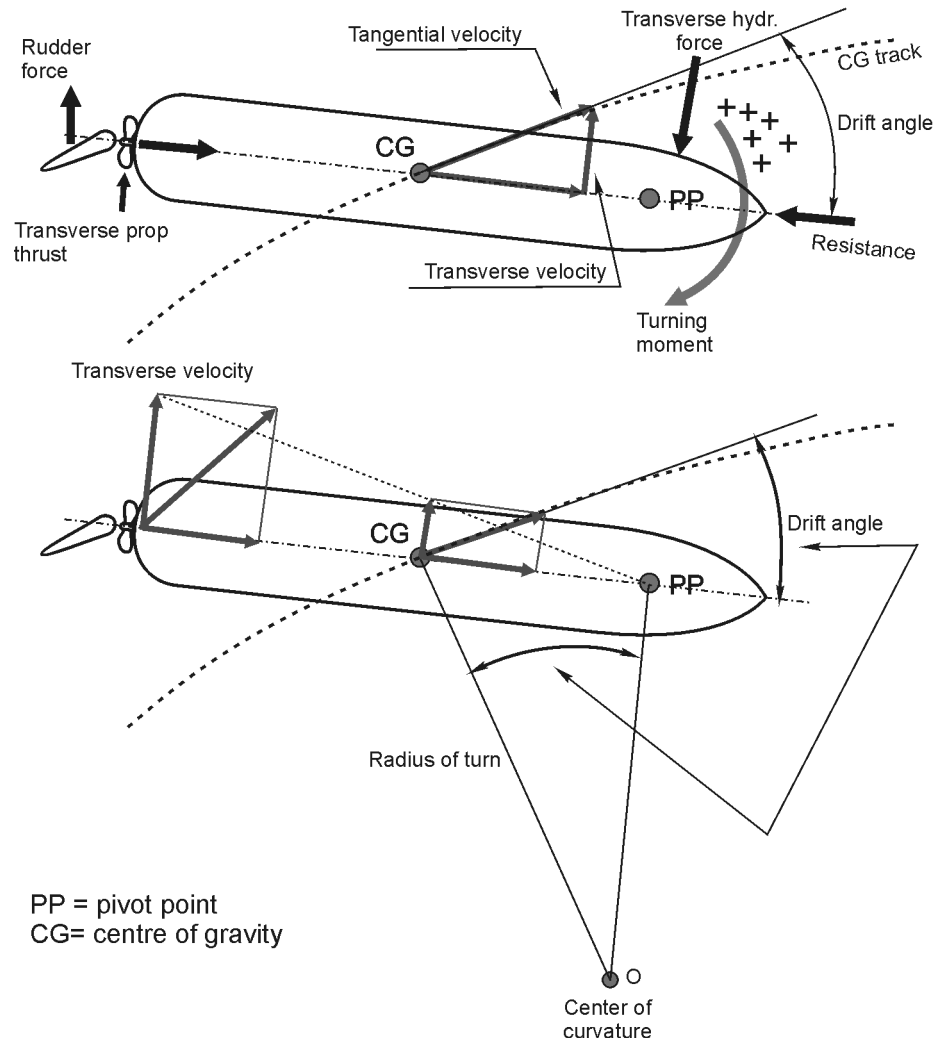


Fig. 2-8

Ship is moving along the curvilinear path with the centre at point **O**. The distance between the centre of curvature and the centre of gravity of the ship is radius of instantaneous turn.

Ship's centreplane deviates from the tangent to the path of the centre of gravity by the drift angle. The line perpendicular to the ship's centreplane through the centre of rotation, marks pivot point (**PP**). At this point, there is no transverse velocity in turning; for people on board it appears that the ship rotates around this point (Fig. 2.8). Transverse velocity is greatest at stern.