

Propeller diameter and pitch, influence on the optimum propeller speed

In general, the larger the propeller diameter D , the lower is the optimum propeller speed and the kW required for a certain design draught and ship speed, see curve D in the figure below.

The maximum possible propeller diameter depends on the given design draught of the ship, and the clearance needed between the propeller and the aft body hull and the keel.

The example shown in the figure is an 80,000 dwt crude oil tanker with a design draught of 12.2 m and a design speed of 14.5 knots.

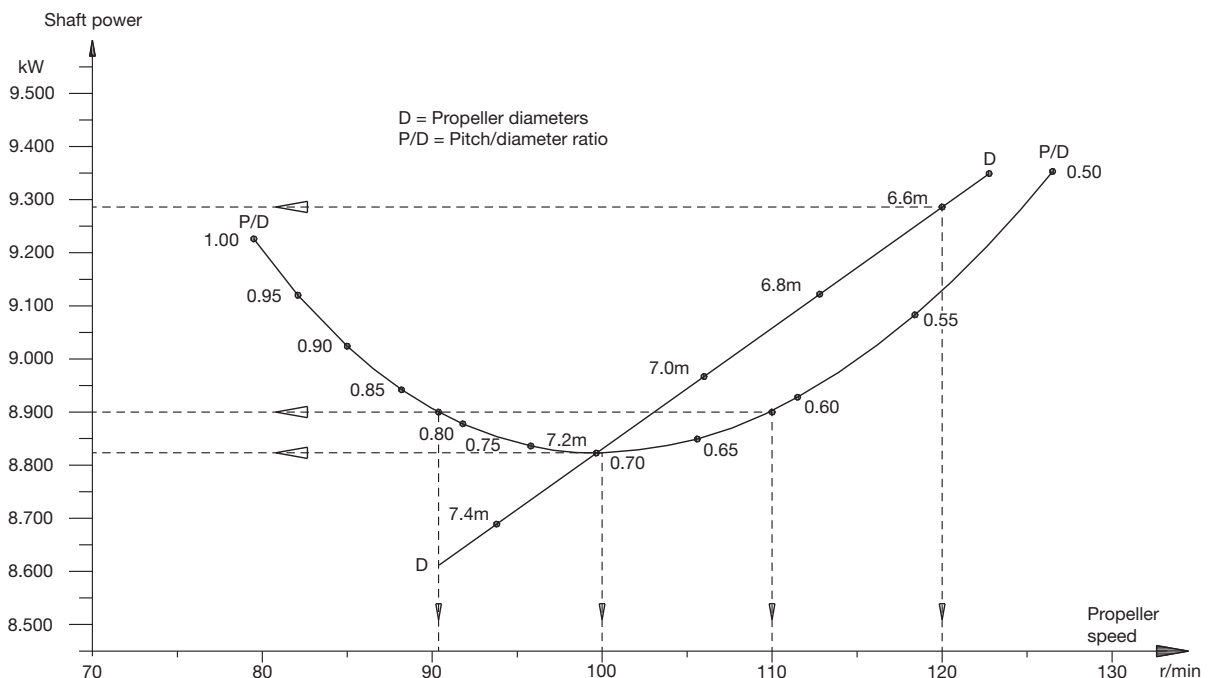
When the propeller diameter D is increased from 6.6 m to 7.2 m, the power demand is reduced from about 9,290 kW to 8,820 kW, and the optimum propeller speed is reduced from 120 r/min to 100 r/min, corresponding to the constant ship speed coefficient $\alpha = 0.28$ (see definition of α in Section 2.02, page 2).

Once a propeller diameter of maximum 7.2 m has been chosen, the corresponding optimum pitch in this point is given for the design speed of 14.5 knots, i.e. $P/D = 0.70$.

However, if the optimum propeller speed of 100 r/min does not suit the preferred / selected main engine speed, a change of pitch away from optimum will only cause a relatively small extra power demand, keeping the same maximum propeller diameter:

- going from 100 to 110 r/min ($P/D = 0.62$) requires 8,900 kW i.e. an extra power demand of 80 kW.
- going from 100 to 91 r/min ($P/D = 0.81$) requires 8,900 kW i.e. an extra power demand of 80 kW.

In both cases the extra power demand is only of 0.9%, and the corresponding 'equal speed curves' are $\alpha = +0.1$ and $\alpha = -0.1$, respectively, so there is a certain interval of propeller speeds in which the 'power penalty' is very limited.



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Fig. 2.02.01: Influence of diameter and pitch on propeller design

Constant ship speed lines

The constant ship speed lines α , are shown at the very top of Fig. 2.02.02. These lines indicate the power required at various propeller speeds to keep the same ship speed provided an optimum pitch diameter ratio is used at any given speed, taking into consideration the total propulsion efficiency.

Normally, if propellers with optimum pitch are used, the following relation between necessary power and propeller speed can be assumed:

$$P_2 = P_1 \times (n_2/n_1)^\alpha$$

where:

P = Propulsion power

n = Propeller speed, and

α = the constant ship speed coefficient.

For any combination of power and speed, each point on lines parallel to the ship speed lines gives the same ship speed.

When such a constant ship speed line is drawn into the layout diagram through a specified pro-

pulsion MCR point 'MP₁', selected in the layout area and parallel to one of the α -lines, another specified propulsion MCR point 'MP₂' upon this line can be chosen to give the ship the same speed for the new combination of engine power and speed.

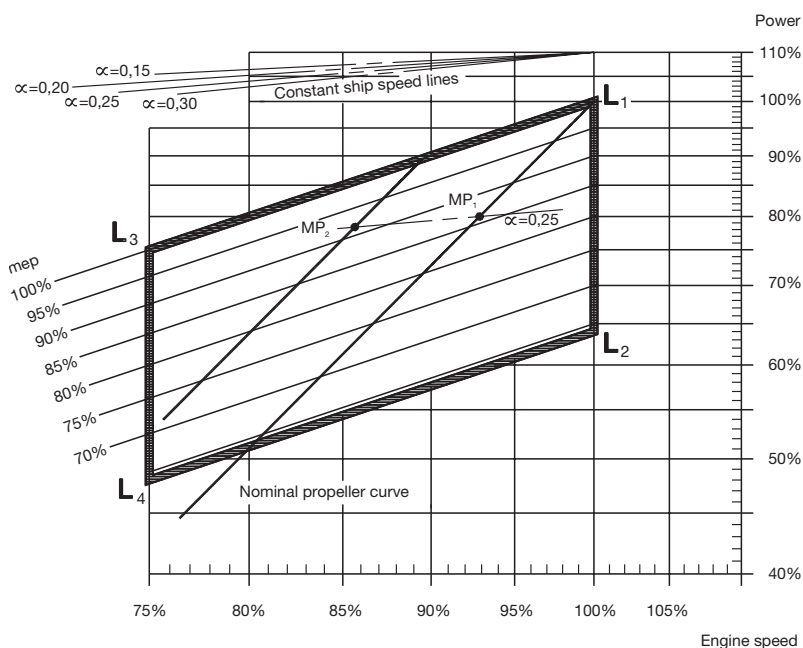
Fig. 2.02.02 shows an example of the required power speed point MP₁, through which a constant ship speed curve $\alpha = 0.25$ is drawn, obtaining point MP₂ with a lower engine power and a lower engine speed but achieving the same ship speed.

Provided the optimum pitch is used for a given propeller diameter the following data applies when changing the propeller diameter:

for general cargo, bulk carriers and tankers
 $\alpha = 0.25 - 0.30$

and for reefers and container vessels
 $\alpha = 0.15 - 0.25$

When changing the propeller speed by changing the pitch, the α constant will be different, see above.



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Fig. 2.02.02: Layout diagram and constant ship speed lines