Naval Architecture 3102
Proportions

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Ships Proportions

- From the aspect of choosing appropriate main dimensions, ships divide into three main categories:

  I. The deadweight carrier
  II. The capacity carrier
  III. The linear dimension ship

The Deadweight Carrier

- The deadweight carrier is distinguished by the fact that its dimensions are determined by the equation:

$$\Delta = C_b \, L \, B \, T \times 1{\cdot}025 \, (1 + s) = W_D + W_L$$

L	=	Length BP in metres
B	=	Breadth mld. in metres
T	=	Load draught in metres
C_b	=	Moulded block coefficient at draught T on Length BP
Δ	=	Full displacement in tonnes
s	=	Shell, stern and appendages displacement expressed as a fraction of the moulded displacement
W_D	=	full deadweight in tonnes
W_L	=	lightship weight in tonnes

The Deadweight Carrier

- In the case of a deadweight carrier T is the maximum draught permitted by the geometric freeboard for the ship‘s dimensions and construction.
- The equation does not involve the depth of the ship, except in so far as it is implicit in the draught.

The Deadweight Carrier

- A small increase in scantlings, a small reduction in bulkhead spacing and a few alterations in construction details may be sufficient to enable a particular value of T to be obtained with a reduced depth D with the resulting design having a reduced cargo capacity and stowage rate.

Solution of Cubic Equation for the Deadweight Carrier

- This equations involves three dimensions and the block coefficient C_b (which has a complex relationship with the speed and length of the ship) is readily solved by assuming three ship lengths and associating with each of these an appropriate beam, draught and block coefficient to obtain a displacement.
- If the lightship weight is then calculated for each ship and subtracted from the displacement, three values of deadweight are obtained.

Solution of Cubic Equation for the Deadweight Carrier

- If these are then plotted on a base of length, the required ship's length can be read against the specified deadweight.

The Capacity Carrier

$$V_h = C_{b_D} L B D^1 = \frac{(V_r - V_u)}{(1 - S)} + V_m$$

- For the volume carrier the dimensions are determined by the equations:

D^1 = Capacity Depth in metres

$D^1 = D + c_m + s_m$

D = Depth moulded in metres

c_m = Mean camber in metres = 2/3c for parabolic camber

s_m = Mean sheer in metres = 1/6 $(s_f + s_a)$ for parabolic sheer

C_{b_D} = Block coefficient at the moulded depth

V_h = total volume in m^3 of the ship below the upper deck, and between perpendiculars.

V_r = Total cargo capacity (m^3) required.

V_u = Cargo capacity (m^3) available above the upper deck

S = Deduction for structure in cargo space expressed as a proportion of the moulded volume of these spaces.

V_m = Volume required for machinery, tanks etc. within the volume V_h

The Capacity Carrier

- In this equation, it is significant to note the absence of the draught T as a factor, although it is implicit as a second order term in the difference between the value of C_{bD} and the value of C_b at draught T which is established by the form required to suit the speed length ratio of the ship.

The Linear Dimension Ship

- The linear dimension ship is distinguished by the fact that its dimensions are primarily fixed by considerations other than those of deadweight or of volume.
- An example is the St. Lawrence Seaway ship where the beam limit of 22.86 m can lead to a very long slim ship with a high L/D value and for which the economic advantages of carrying a large deadweight or capacity of cargo through the canal offsets the penalties resulting from constructing a ship whose proportions are not economic for other services.
- The Panama Canal exercises a similar influence with a beam limit of about 32.2 m and a draught limit of about 13 m depending on season.

The Linear Dimension Ship

- The distortion from normal ship proportions has not been as great as that caused by the St. Lawrence Seaway locks, but there is the same trend.
- In addition to ships influenced by external factors: there are a number of ship types whose dimensions are determined primarily by the unit size of the cargo they carry.
- Container ships are probably the most obvious example. For this type of ship the beam and depth are the first dimensions to be fixed, determining the number of containers which can be carried in the midship section of the ship, and the length of the ship is then adjusted to accommodate the total numbers.

The Linear Dimension Ship

- As there is within limits, an optimum length/beam relationship, steps develop in the numbers of containers for which optimum ships can be designed.
- The breadths of car ferries and of train ferries are similarly tailored to accommodate a number of lanes of vehicles, with the result that there are fairly distinct steps in the beam of ships of those types.
- As each beam value is associated with appropriate values of depth and length there tends to be optimum and non-optimum car numbers.

DIMENSIONS, DISPLACEMENT AND FORM

There are six dimensional relationships linking the four main ship dimensions of L, B, D and T: and it is necessary to use three of these in order to solve the previous equations.

- The relationships are:

$$
\begin{aligned}
B &= f(L) \qquad & D &= f(L) \\
D &= f(B) \qquad & T &= f(L) \\
T &= f(D) \qquad & T &= f(B)
\end{aligned}
$$