Propulsion Trends in Bulk Carriers

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The demand for raw materials like coal, steel, copper, etc., has increased considerably since the turn of the millennium, especially in consequence of globalisation and the great demand for raw materials in China, owing to the economic growth in this large country. This means that the Chinese industry, among others, is absorbing large quantities of iron ore and other bulk cargoes.

The bulk carrier market, therefore, is very attractive, which caused a boost in newbuildings until the latest economy crisis in 2008. Since then, bulk carrier orders in a short period have been declining, but are now picking up again.

The optimum propeller speed is changing as well, steadily becoming lower, because the larger the propeller diameter that can be used for a ship, the actual propeller power and pertaining speed requirement will be correspondingly lower, and the lower the propulsion power demand per ton bulk transported.

These factors have an influence on which main engine type should be selected/installed as the prime mover, and also on the size of the bulk carrier to be built.

Recent development steps have made it possible to offer solutions which will enable significantly lower transportation costs for bulk carriers as outlined in the following.

One of the goals in the marine industry today is to reduce the impact of CO₂ emissions from ships and, therefore, to reduce the fuel consumption for the propulsion of ships to the widest possible extent at any load.

This also means that the inherent design CO₂ index of a new ship, the so-called Energy Efficiency Design Index (EEDI), will be reduced.

In the future, this drive may probably result in operation at lower than normal service ship speeds compared to earlier, resulting in reduced propulsion power utilisation. However, it still seems to be unchanged.

A more technically advanced development drive is to optimise the aftbody and hull lines of the ship, including bulbous bow, also considering operation in ballast condition. This makes it possible to install propellers with a larger propeller diameter, thereby, obtaining higher propeller efficiency, but at a reduced optimum propeller speed, i.e. using less power for the same ship speed. As the two-stroke main engine is directly coupled with the propeller, the introduction of the latest MAN B&W ultra long stroke G engine types meets this trend of installing large propellers in the bulk carriers which may reduce the ship’s fuel consumption. Therefore, today bulk carriers are often ordered with a G engine type as prime mover.
Market development

Definition of a bulk carrier

A bulk cargo is defined as loose cargo that is loaded directly into a ship’s hold, rather than in barrels, bags, containers, etc., and is usually homogeneous and capable of being loaded by gravity. This paper describes the dry-bulk carrier type, normally just known as bulk carrier or bulker.

Bulk carriers were developed in the 1950s and are one of the three dominating merchant ship types together with tankers and container vessels. Today, bulk carriers comprise about 43% of the world fleet in tonnage terms.

Bulk carrier sizes and classes

Small < 10,000 dwt
Handysize 10,000-35,000 dwt
Handymax 35,000-55,000 dwt
Panamax 55,000-80,000 dwt
Capesize 80,000-200,000 dwt
Large Capesize 200,000-300,000 dwt
VLBC >300,000 dwt (VLBC = Very Large Bulk Carrier)

Average ship particulars as a function of ship size

Average design ship speed, \( V_{des} \)

In Fig. 1, the average ship speed \( V_{des} \) used for design of the propulsion system and valid for the design draught \( D_{des} \) of the ship, is shown as a function of the ship size.

Fig. 1 also shows that today the average design ship speed – except for Small and Handysize bulk carriers – is generally higher than or equal to 14.5 knots. The trend shown for large Capesize and VLBC shows an even higher selected design ship speed.

In general, the selected design ship speed today seems not to be lower than before the economy crisis in 2008-2009. The reason is probably that shipowners still wish to operate the ships at a high ship speed, if needed, but in normal service on reduced ship speeds. Thus, many ships are today installed with main engines prepared for efficient low load operation at reduced ship speeds.

Major design parameters and propulsion power demand of average bulk carriers

Major propeller and engine parameters

In general, the highest possible propulsive efficiency required to provide a given ship speed is obtained with the largest possible propeller diameter \( d \), in combination with the corresponding, optimum pitch/diameter ratio \( p/d \).

As an example, this is illustrated for a 205,000 dwt large capsize bulk carrier with a service ship speed of 14.7 knots, see the black curve in Fig. 2. The needed propulsion SMCR (Specified Maximum Continuous Rating) power and speed is shown for a given optimum propeller diameter \( d \) and \( p/d \) ratio.

According to the black curve, the existing propeller diameter of 8.3 m may have the optimum pitch/diameter ratio of 0.71, and the lowest possible SMCR shaft power of about 17,700 kW at about 88 r/min.

The black curve shows that if a bigger propeller diameter of for example 9.3 m is possible, the necessary SMCR shaft power will be reduced to about 16,700 kW at about 70 r/min, i.e. the bigger the propeller, the lower the optimum propeller speed.

If the pitch for example for the diameter of 8.8 m is changed, the propulsive efficiency will be reduced, i.e. the necessary SMCR shaft power will increase, see the red curve. The red curve also shows that propulsion-wise it will always be an advantage to choose the largest possible propeller diameter, even though the optimum pitch/diameter ratio would involve a too low propeller speed (in relation to the required main engine speed). Thus, when using a somewhat lower pitch/diameter ratio, compared with the optimum ratio, the propeller/engine speed may be increased and will only cause a minor extra power increase.

The efficiency of a two-stroke main engine particularly depends on the ratio of the maximum (firing) pressure and the mean effective pressure. The higher the ratio, the higher the engine efficiency, i.e. the lower the Specific Fuel Oil Consumption (SFOC). Therefore, today the main engine may often be derated.

Furthermore, the higher the stroke/bore ratio of a two-stroke engine, the higher the engine efficiency.

This means, for example, that an ultra long stroke engine type, as the G70ME-C9, may have a higher efficiency compared with a shorter stroke engine type, like a super long stroke S70ME-C8.

The application of new propeller design technologies may also motivate use of main engines with lower rpm. Thus, for the same propeller diameter, these propeller types can demonstrate an up to 4% improved overall efficiency gain at the same or a slightly lower propeller speed. This is valid for propellers with Kappel technology available at MAN Diesel & Turbo, Frederikshavn, Denmark.

Furthermore, due to lower emitted pressure impulses, the Kappel propeller requires less tip clearance that can be utilised for installing an even larger propeller diameter, resulting in a further increase of the propeller efficiency.

Hence, with such a propeller type, the advantage of the new lowspeed G engine types can also be utilised even though a larger propeller cannot be accommodated.

Average propulsion power demand

Based on the already described average ship particulars and ship speeds for bulk carriers built or contracted during the period of 2000–2013 with due consideration of the latest ones contracted, we have made a power prediction calculation (Holtrop & Mennen’s Method) for such bulk carriers in various sizes from 5,000 dwt up to 400,000 dwt.

For all cases, we have assumed a sea margin of
15% and an engine margin of 10%, i.e. a service rating of 90% SMCR, including 15% sea margin.

The average ship particulars used are, basically, referring to standard single side bulk carriers, but the SMCR power demand found may, as a good guidance, also be used for double side bulk carriers, by referring to a slightly higher deadweight tonnage than valid for the single side hull design. For example, a 54,000 dwt double side hull design could be corresponding to an about 55,000 dwt single side hull design.

The graph in Fig. 3 shows the above-mentioned table figures of the specified engine MCR (SMCR) power needed for propulsion of an average bulk carrier. The SMCR power curves valid for the future -1.0 knot lower compared to the average design ship speed are also shown.

**Propulsion power demand of average bulk carriers as a function of ship speed**

When the required ship speed is changed, the required SMCR power will change too, as mentioned above, and other main engine options could be selected. This trend – with the average ship particulars and average ship speed as the basis – is shown in detail in Figs. 4-6. See also the description below giving the results of the main engine selection for the different classes of bulk carriers.

If for a required ship speed, the needed nominal MCR power for a given main engine is too high, it is possible to derate the engine, i.e. using an SMCR power lower than the nominal MCR power, which involves a lower specific fuel consumption of the engine.

Considering the high fuel price and the EEDI demands, it is today normal practice to select a derated main engine in order to get an SFOC as low as possible.

**Small and Handysize bulk carriers**

For Small and Handysize bulk carriers, see Fig. 4, the selection of main engines is not so distinct as for the large bulk carrier classes. Some owners and yards might prefer four-stroke engines, while others prefer and specify two-stroke engines. For the larger bulk carrier classes, the selection of main engine is, as mentioned, more uniform.
Handymax and Panamax bulk carriers

The main engines most often selected for Handymax bulk carriers, see Fig. 5, are the 5 and 6S50MEC8/ME-B9, with the 6/7S50MEB9 and 6/7G50ME-C9 types being the optimum choice for meeting the power demand of all Handymax bulk carriers sailing up to 15.0 knots in service.

The main engines used for Panamax bulk carriers, see Fig. 5, are mainly the 5/6G60ME-C9, 6/7G50ME-C9 and the 7S50MEB9 and 7G50ME-C9 types being the optimum choice for meeting the power demand for nearly all Panamax bulk carriers sailing up to 15 knots in service.

Capesize, Large Capesize and VLBC bulk carriers and examples of EEDI

Today, in particular the 6S60MEC8, 6G60ME-C9 and 5/6S70MEC8 and 5/6G70ME-C9 engines are used for propulsion of the Capesize bulk carriers, see Fig. 6.

For large Capesize, it is particularly the 6G70ME-C9 which is of interest. For VLBCs, the 7S80ME-C9 and 7G80ME-C9 engine types are almost exclusively used as the main engine today, see Fig. 6.

As an example, the influence of the ship speed on the EEDI is shown in Figs. 7 and 8, valid for 205,000 dwt Large Capesize bulk carrier with the design ship speed of 14.7 kn and 14.0 kn, respectively. The influence of the propeller diameter and the corresponding main engine types are also shown. Fig. 7 shows that for the design ship speed of 14.7 knots, the two 6G70ME-C9 cases are the only ones to meet the 2015 reference EEDI.

For the reduced design ship speed of 14.0 knots, see Fig. 8. With the G70ME-C9 engines, it will now be possible to meet the 2020 reference EEDI figure without further optimisation of hull and/ or propeller.

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