New Engine Control Technology for Improved Ship Acceleration

Passage of the barred speed range increasingly important in modern shipping

Developments in ship and engine design driven by the general desire for lower fuel consumption and the introduction of the energy efficiency design index (EEDI) have resulted in some ships being too slow to pass the barred speed range (BSR). A too slow passage of the BSR can have negative consequences for shaft lifetime and ship manoeuvring.

MAN Diesel & Turbo began R&D work due to the reports of too-slow passage of the BSR and has led to significant progress in terms of understanding and assuring sufficient engine and propeller acceleration, particularly with respect to quick passage of the BSR. It has been found that the following parameters influence the ability to pass the BSR quickly:

1. the position of the barred speed range in relation to the SMCR rpm
2. the propeller light running margin
3. the degree of heavy running of the propeller in the bollard pull condition
4. the dynamic torque capability of the engine.

A design value has been developed to evaluate the combined effect of the first three points mentioned above. It has been named the BSR power margin. By using the BSR power margin in the vessel design phase, it is possible to design a vessel for quick passage of the BSR. The definition and the use of the BSR power margin are described in this paper.

With respect to point 4 above (the dynamic torque capability of the engine), a new dynamic limiter function (DLF) has been developed for the ME-C engine. DLF is an engine control system upgrade, which increases the torque that the engine can develop for up to 30 minutes, and it therefore reduces the time for passing the BSR. It is available in two versions:

- "DLF Standard" which significantly reduces the time for passing BSR and can be retrofitted without renewing torsional vibration measurements, if the engine control system version is not too old for this.
- "DLF Full" which can further reduce the time for passing the BSR. DLF Full may, or may not, increase torsional vibration stress levels, if the class requirement is to force DLF "always on" during the verification sweep test. The use of DLF Full is therefore, so far, subject to confirmation of acceptable stress levels. For new vessels such confirmation is performed during sea trials. For existing vessels, retrofit of DLF Full requires renewal of the torsional vibration measurements.

DLF increases the torque available from the engine for up to 30 minutes, but it does not increase the torque that the engine can continuously deliver. A sufficient propeller light running margin is still needed to achieve sufficient engine power and vessel speed in long lasting heavy conditions such as:

- heavy weather
- shallow or otherwise restricted waters
- ice.

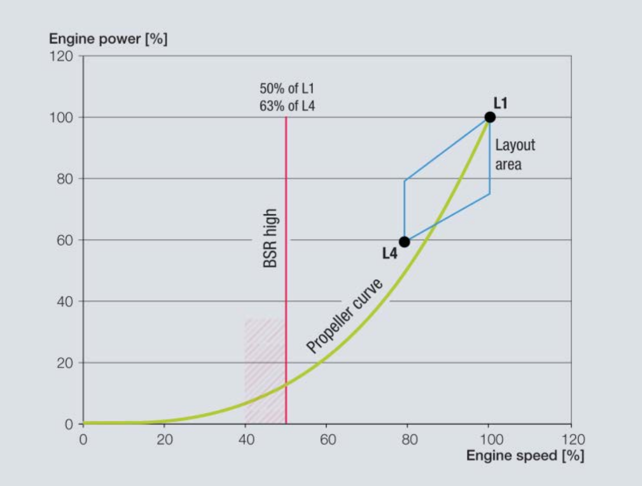

Fig. 1: General focus on fuel economy and the introduction of the EEO/ have led to reductions in engine power. Engine SMCR is increasingly selected near the L 4 rating instead of the L1 rating. Because the rated speed is then lower, this often results in the BSR being placed higher in relation to the layout point: 50% of L1 rpm is 63% of L4 rpm

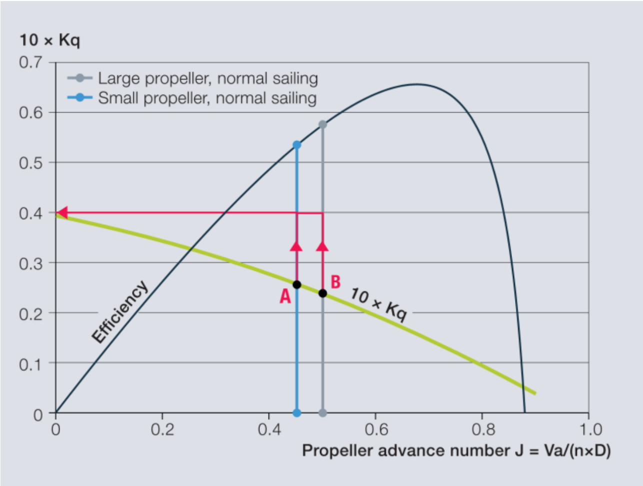

Fig. 2: Plot of open water propeller characteristics, showing propeller efficiency and torque coefficient (KO) for a 84-50 propeller with a PIO ratio of 0.8. It can be seen how the relative increase in the torque coefficient when moving from normal sailing to bollard pull (J=O) is larger for the large propeller (B) than for the small propeller (A)

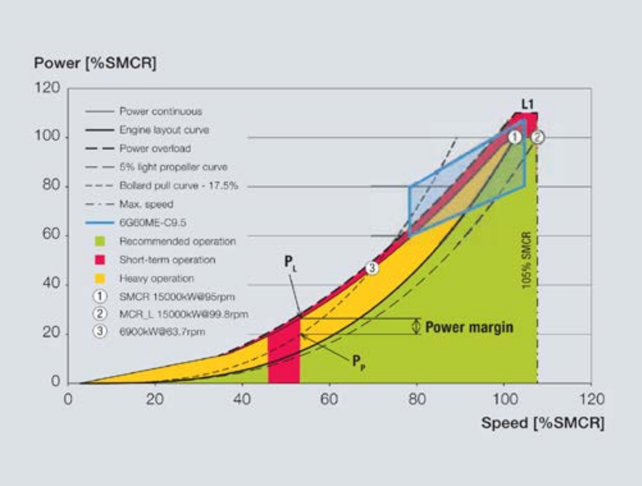

Fig. 3: MAN B&W engine load diagram with indication of a barred speed range (red), the required propeller power at the upper end of the BSR in the bollard pull condition (Pp) and the available power surplus for propeller acceleration (PL-Pp). The diagram has power on the Y-axis, but at a given rpm power is proportional to torque. The BSR power margin is 33% in this case

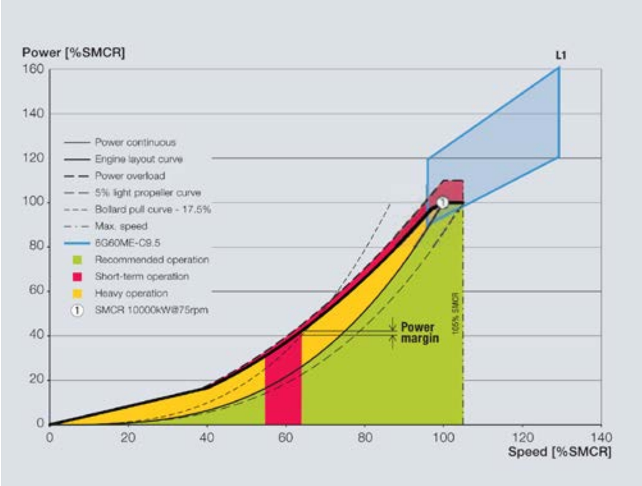

Fig. 4: MAN B&W engine load diagram with indication of a barred speed range (red) and the barred speed range power margin. The BSR power margin is 5% in this case. This layout is likely to result in slow passage of the BSR

Through the use of the BSR power margin in the vessel design phase and, if required, by applying DLF Standard or DLF Full to the MAN B&W ME-C engine, it is now possible to make sure that a vessel will exhibit quick passage of the BSR.

Test results

The DLF development was completed with testing on board a number of vessels that had experienced acceleration issues. Some of the main results including the effect on torsional vibrations are presented in the following.

Barred speed range passing time

DLF was applied with success on a Kamsarmax bulk carrier in the final phase of DLF development (test vessel 4). Fig. 8 shows how the BSR passing time was significantly reduced on this vessel.

DLF Roll-Out

DLF is not applied to all engines immediately in order to gain experience with the system before it is applied as a standard feature across the entire engine range. In general, DLF Standard is applied. If sea trials show that a higher dynamic torque is needed, DLF Full can be applied to the extent that the engine and torsional vibrations permit.

ME-C

Before engine shop test

DLF is now the standard on new 5 and 6-cylinder engines. 5 and 6-cylinder engines have been chosen because they have the highest placed BSR relative to SMCR rpm, and this is where we have seen cases with slow passage of the BSR. Before shop test, DLF is applied free of charge.

DLF can be applied on engines with more than six cylinders if it is considered necessary. This is evaluated on a case-by-case basis.

After engine shop test

Depending on the engine control computer hardware installed, it may be possible to retrofit DLF to engines already delivered. Retrofit requires that a service engineer attends the vessel, and a cost is therefore associated. Contact PrimeServ for further details.

ME-B

The ME-B engine has a different engine control system than the ME-C, and DLF has not yet been developed for ME-B. The ME-B engine does not have fully flexible exhaust valve timing, so the effect of DLF on ME-B must be expected to be smaller than for ME-C. Nevertheless, DLF is expected to be able to provide significant acceleration improvement also for ME-B, and DLF will therefore be developed for ME-B also.

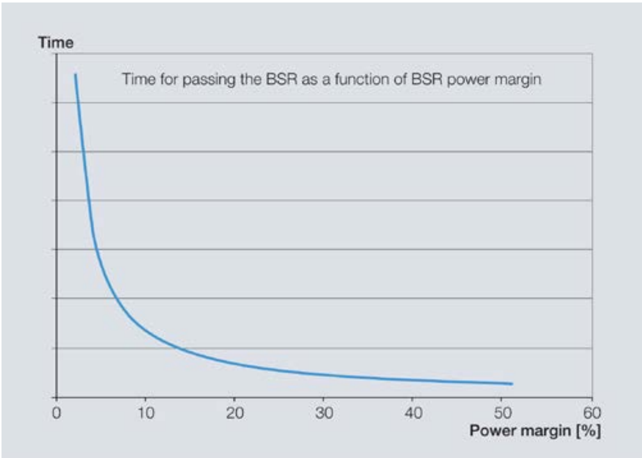

Fig. 5: Time for passing the BSR is dependent on the BSR power margin. Below about 10%, the passage time quickly increases

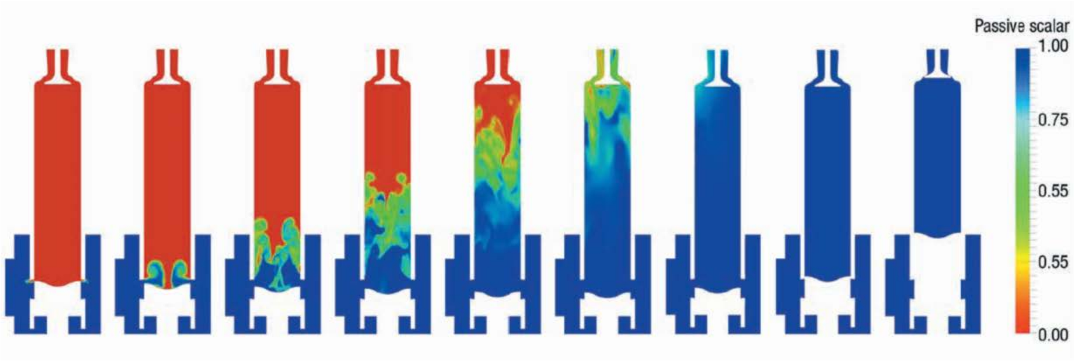

Fig. 6: CFO simulations showing the degree of scavenging of the cylinder. Red colour is exhaust gas. Blue is scavenge air

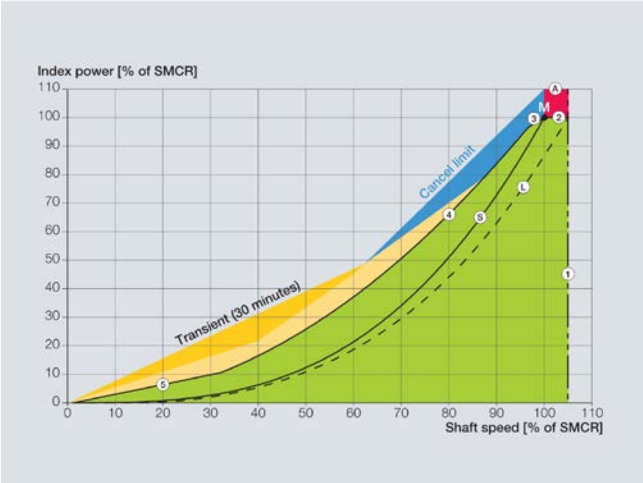

Fig. 7: Traditional and DLF limiters. The area indicated with "Transient (30 minutes)" shows the change in fuel index, shown as power, that becomes available due to DLF. The area indicated with "Increase limit" shows the power that becomes available when using the traditional increase limit button, which is still available and which is working independently of DLF

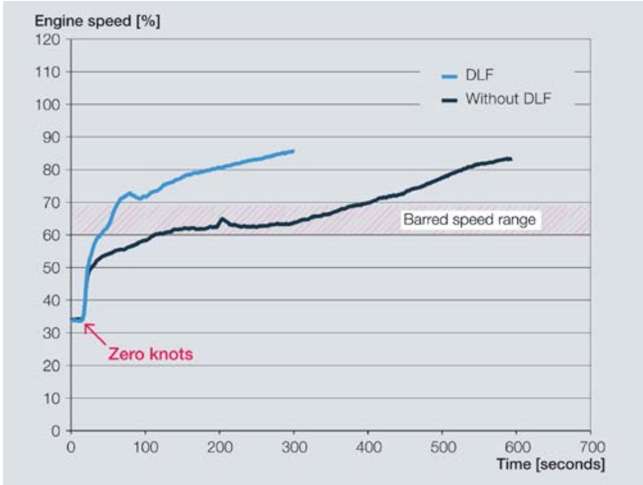

Fig. 8: Test vessel 4 (82,000 dwt bulk carrier). Acceleration with a highly placed barred speed range ending at 69% of SMCR speed. Results are shown with and without DLF Standard. Vessel is going astern with the engine in dead slow ahead until zero knots is reached, then the handle is put to navigational full

Source: DIESELFACTS 2/2016
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