MAN Diesel & Turbo

MAERSK

More versatile operation while assuring compliance with regulation

The marine industry is constantly looking into methods for reducing costs and environmental impact. During the later years focus on lower ship speeds has increased significantly. There are several reasons for this increased focus, among others the slowdown in global trade and a strong focus on reducing green house gas emissions.

Emissions from marine diesel engines on large oceangoing vessels are regulated in the MARPOL Annex VI regulation developed in the International Maritime Organisation, IMO. In this regulation emissions of NOx are regulated, and a certificate for compliance with the regulation is issued for every engine, based on test bed verification measurements. Changes in engine adjustments may lead to violation of emission regulation compliance if not handled properly.

Under the *Green Ship of the Future* umbrella, Maersk and MAN Diesel & Turbo has initiated the *Dual/Multi MCR Certification* project[1], seeking to improve engine low load performance without compromising the emission certification of the engine.

Marine engines operating at low speeds

A typical two-stroke low speed diesel main engine for vessel propulsion is optimised for a certain operation range. The range is traditionally in the upper region of the load range, normally at 80% to 85% of full load. This is similar to all other engine types.

Engines directly coupled to the propeller have a lot of advantages, but also has additional challenges when low ship speeds are required. A large reduction in engine power is required for a smaller reduction of ship speed. For one example, a reduction in ship speed from 25 to 21 knots would require 50% less engine power.

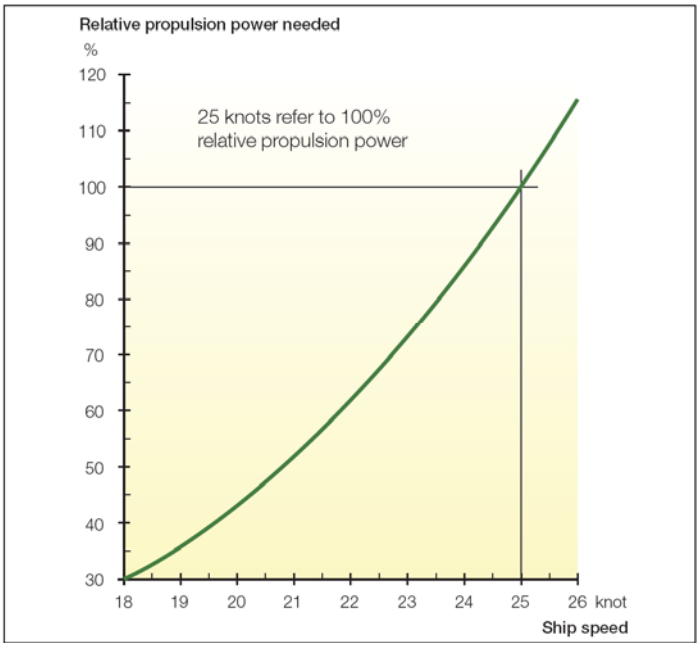

Figure 1. Relative propulsion power needed for a large container vessel

Options for more versatile engines

A range of options for assuring safe and optimal methods for operating engines at low loads have been investigated. Some are now included as standard options in the newly released MAN Diesel & Turbo marine diesel engine programme. Options such as Variable Geometry Turbochargers, Exhaust Gas Bypass and Engine Control Tuning. For most of the options they can be applied at the design stage and certified on test bed, or retrofit and certified onboard following standardised procedures.

- ECT: Engine Control Tuning
- VT: Variable Turbine Area
- EGB: Exhaust Gas Bypass

SFOC optimised load range	Tuning methods	SFOC Change [g/kWh]				
		35%	50%	65%	80%	100%
High load (85–100%)	Standard L_1 engine	3.5	–1	–3.5	–3.5	0
Part load (50-85%)	ECT	2.5	–2	–4.5	–4.5	3
	VT	0.5	–4	–6.5	–4.5	0.5
	EGB	0.5	–4	–6.5	–4.5	1.5
Low load (25-70%)	ECT	1	–3.5	–6	–3.5	1.5
	VT	–1.5	–6	–8.5	–3.5	0.5
	EGB	–1.5	–6	–8.5	–3.5	1.5

Table 1. MAN B&W Tier II standard engine tuning options, and their influence on fuel oil consumption[2]

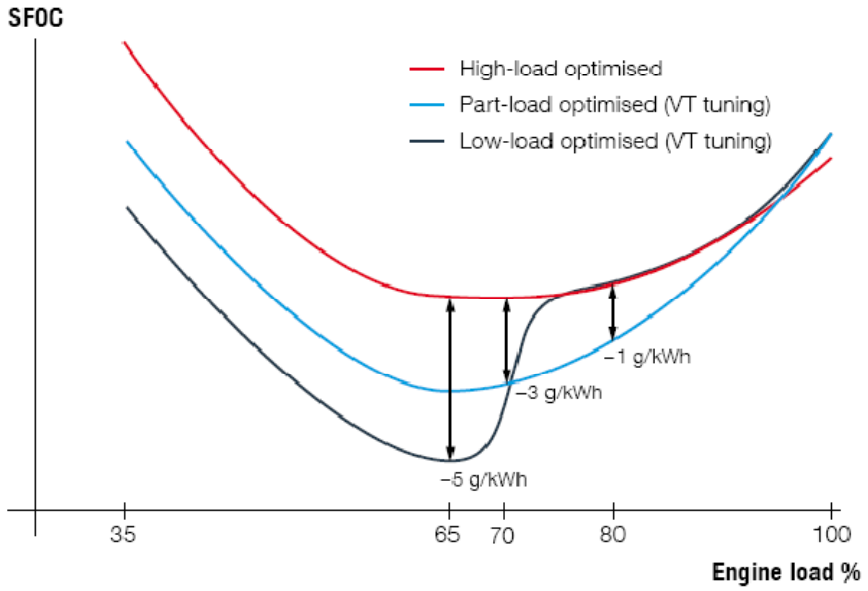

Figure 2. Fuel oil consumption (SFOC) in different optimisation modes

For some versions of Engine Control Tuning, a more complex certification procedure may be necessary in order to get the maximum benefit of the options offered. This we call dual MCR certification.

Dual MCR certification

As mentioned previously the application of dual MCR certification may be beneficial in some circumstances. In case a ship is to be operated in two different operations patterns for prolonged periods, certification of the engine in two different engine setups may result in a significantly improved fuel economy and resulting reduced CO_2 emissions. As an example, the two different engine setups may be defined using Engine Control Tuning.

In Engine Control Tuning the flexibility of ME and ME-C engines is utilised for setting up engine control parameters in different conditions, aimed at either a low load, part load or high load optimised engine.

In case of dual MCR certification, complete certifications of two different optimisation modes are performed. Essentially this means that two individual NOx Technical Files are prepared and approved. When the ship is delivered, an initial survey of the engine in one optimisation mode is performed, and a Engine International Air Pollution Prevention (EIAPP) certificate is issued, based on the NOx Technical File and Survey for that optimisation mode. At a later stage when operation in the other optimisation mode is required, the engine is reconfigured, and a new initial survey is performed and a new EIAPP certificate for the engine is issued.

The two optimisation mode may be for same Maximum Continuous Rating (MCR) of the engine. However, to utilise the full benefit of the offered optimisation possibilities, two different MCR may be wished.

Turbocharger cut-out

In addition to Exhaust Gas Bypass, Variable Turbine Area and Engine Control Tuning an option for improved low load operation is Turbocharger cut-out.

A MAN B&W two-stroke low speed engine is able to run continuously at loads as low as 10%. However, in order to have full benefit of the low load operation, a range of retrofits may be applied.

For multi-turbocharger engines, turbocharger cut-out can be utilised when operation at low loads.

When one turbocharger is cut-out, the turbochargers remaining in service will be operating at a more optimal point resulting in higher efficiency, and the scavenging air pressure will increase. The results of the increased scavenge air pressure are increased cylinder compression and maximum combustion pressure, which is beneficial for fuel oil consumption and the overall engine condition.

In order to have the full benefit of the turbocharger cut-out and still maintain engine flexibility MAN Diesel & Turbo has developed a system for turbocharger cut-out using a system of swing gate valves in combination with an automatic control and safety system[3].

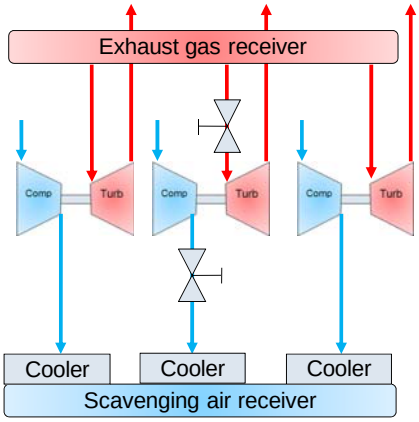

Figure 3. Diagram of a turbocharger cut-out installation on an engine equipped with three turbochargers.

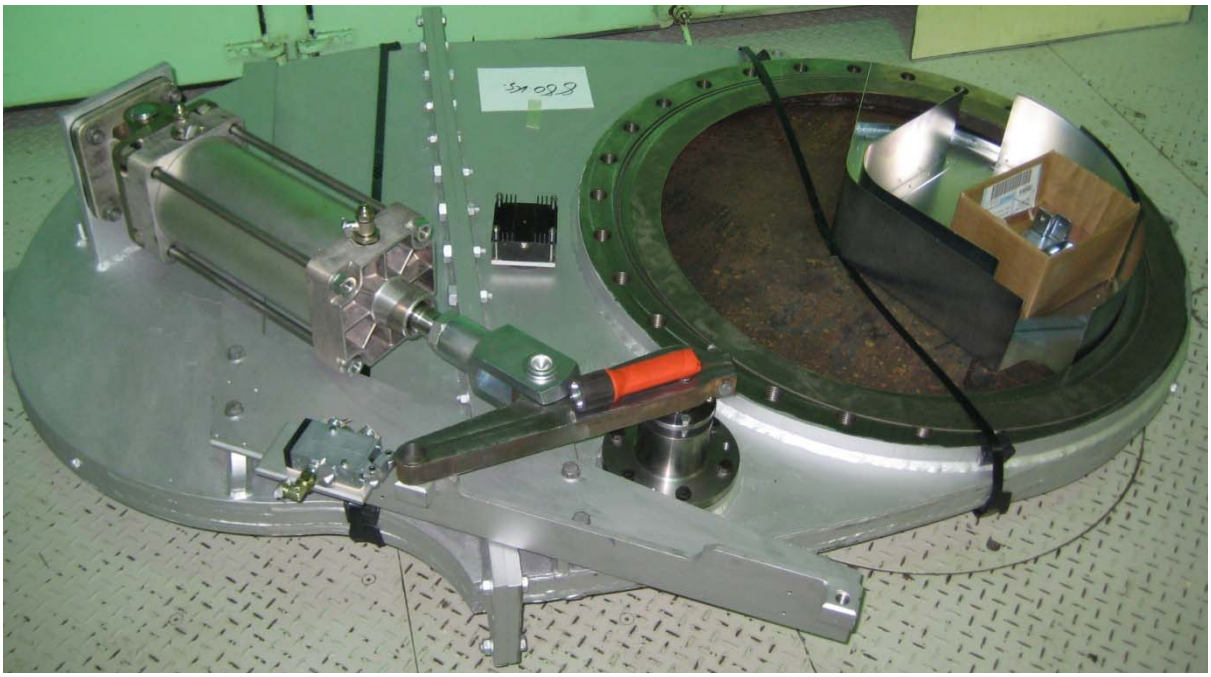

Figure 4. Cut-out valve

Certification of turbocharger cut out

Two main paths for assuring compliance with IMO regulation in case of turbocharger cut-out application has been developed.

1. Verification of compliance through onboard emission measurements.
2. Utilisation of measurement results and documentation from selected test engines, the so-called “Common Documentation” procedure.

Depending on the actual engine configuration type, one of the two methods can be used for documenting compliance with emission regulation when retrofitting turbocharger cut out. The later is the most economically optional option, but not always possible.

Several emission measurements have been performed onboard using the onboard measurement path. The Common Documentation has been used for documentation of turbocharger cut-out on more than 90 of the largest container vessels.

Installation onboard Maersk Line vessels

The MAN B&W main engine on the large container vessel Maersk Salalah was the first engine retrofitted with a swing gate turbocharger cut-out system. The system was installed, tested and verified for emission regulation compliance autumn 2009. The system has been operating since then.

Figure 5. 12K98ME main engine on Maersk Salalah. An insulated swing gate valve for turbocharger cut-out installed between the exhaust gas receiver and the turbine side on one of the three turbochargers.

Status and future

A strong market demand due to the situation in the shipping industry has lead to the development of methods for improved versatile operation of low speed diesel engines.

Standardised methods are part of the newly released product portfolio from engine manufactures.

Dual MCR certification of selected engines are underway, providing the ability of the operator to utilise the full benefit of the different tuning methods available for two-stroke low speed diesel engines.

Turbocharger cut-out has been implemented on MAN B&W two-stroke low speed engines.

As these changes influence emission characteristics of an engine, solutions for assuring compliance with the emission regulation are required. Through one of the Green Ship of the Future projects, the cooperation between Maersk and MAN Diesel & Turbo, has resulted in new procedures for assuring compliance with emission regulation.

The results have been utilised in the application of turbocharger cut-out to a large number of very large diesel engines. A 3% reduction in fuel oil consumption and CO_2 emissions is achieved through application of turbocharger cut-out. All though the fuel saving is a small fraction, the saved fuel and reduced CO_2 emissions accumulates to substantial amounts, due to the size of the affected propulsion power plants.

[1] http://www.greenship.org/fpublic/greenship/dokumenter/GSF%20brochure%20-%20maga/Enkeltsider%20af%20projektartiklerne/p9%20Lower%20ship%20speeds%20within%20certification.pdf

[2] MAN Diesel & Turbo: Marine Engine IMO Tier II Programme 3rd edition 2010

[3] http://www.mandieselturbo.com/1014924/Press/Press-Releases/Trade-Press-Releases/Turbochargers/Turbocharger-cut-out-retrofit-solution-attracts-massive-interest.html