Exhaust gas for power generation – How efficient are state-of-the-art methods?

Thomas S. Knudsen
MAN Diesel A/S, Copenhagen/Denmark

Introduction

This paper will present the development of the MAN B&W two-stroke engines within the field of utilisation of exhaust gas energy. The system described is called TES: Thermo-Efficiency-System.

TES Applications

For the large bore diesel engine, a diesel combined cycle plant set-up has up to now been based on a standard design and, thereby, also standard performance of the diesel engine, leaving the Waste Heat Recovery (WHR) to boiler and steam turbine producers. Such a setup has, of course, contributed to improvement of the total efficiency of the combined plant, but not necessarily secured the best possible utilisation of fuel.
The overall task could, however, be redefined in searching not the optimal solution for the individual machines (engine, turbocharger, power turbine, boiler and steam turbine) but as a combined optimum for the total process. The main success criterion is optimal efficiency (i.e. reduction of fuel consumption and thereby the emission of CO_2) of the system as a whole, however, with consideration of side effects such as emissions from the system.
Simple system calculations for two-stroke engine plants clearly indicate that a reduction of the scavenge air amount, and thereby increase of exhaust gas temperature level, which leads to a minor reduced efficiency of the diesel engine itself, at the same time creates remarkable potential for increased power output on both power turbines and steam turbines. The above-mentioned potential compensates the reduction of diesel engine efficiency with surplus. Accordingly the objectives are as follows:

- By calculation and test, to encircle the level of reduced air flow through the engine where thermodynamic parameters (performance), heat load on the combustion components, i.e. piston, exhaust valve, liner and cover, are not jeopardising the reliability of the diesel engine.
- To develop the principles and investigate, by calculations, different variants of combined systems starting in the above-mentioned results of the calculations and engine test. The variants of combined systems consist of the engine as a core element, boilers, power turbine (TCS) and steam turbine – all called Thermo Efficiency Systems (TES). Also variants of TES systems combined with Scavenge Air Moisturising (SAM) systems are evaluated; as such systems will probably be applied on future engines due to expected new NO_x emission regulations, as well as for economical reasons of engine production.

The influence of the TES system on the engine has been simulated on a 10K98MC engine. The measured temperatures of the combustion chamber confirm that TES can be introduced in service without hesitation, when combined with the use of slide fuel valves. All temperatures are within a range where we have good service results.

Conclusion

Methods exist to increase the efficiency of the prime mover. The payback time of such systems are typically 5-6 years with current oil prices. However, due to the current hot market for ships it is logistically difficult to implement. It is therefore recommendable to include the possibility of a TES system at an early stage of the project.

After graduating in mechanical engineering from the Technical University of Denmark in 1980 Thomas S. Knudsen

obtained his doctor's degree in solid mechanics at the same university in 1983. He started his professional career with MAN B&W Diesel A/S in Copenhagen in 1983 where he still is employed. After various managerial positions he today act as Senior Vice President of the low speed business unit.