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Design and first application of a 2-stage turbocharging system for a medium-speed diesel engine

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Abstract: It is obvious that strong reductions in nitrogen oxides (NO_x) and carbon dioxide (CO_2) are required for combustion engines in the near future. One efficient means to achieve both targets is to apply Miller valve timing. However advanced Miller timing requires strongly increased charge air pressure. The best concept for achieving this is 2-stage turbocharging, which gives more or less unlimited boost pressure with a high efficiency level.

Earlier 2-stage turbocharging feasibility tests on Wärtsilä 20 engine, reported in CIMAC 2007, confirmed the performance expectations put on advanced Miller timing and 2-stage turbocharging. Used hardware was however suitable for test purposes only, not for serial production. Parts of the turbocharging unit were located ”off-the- engine”, which can not be regarded as the optimum production solution, merely a mediocre compromise. After the test on Wärtsilä 20 attention was directed to create a production standard design for a larger size Wärtsilä engine.

Design targets:

- All turbocharging modules/components preferably located on the engine
- Maintain excellent engine dynamic properties
- Maintain compact engine dimensions simultaneously maintaining a good serviceability
- Include necessary controls (air/exhaust gas/cooling water) in the above mentioned dimensions
- Necessary valve timing controls included in the design

Achieving the design targets is challenging especially considering the fact that 2-stage turbocharging in practise doubles the amount of turbocharging system components.

Design work was supported with extensive optimisation using detailed FE-calculations, taking into consideration especially the strongly increased internal pressure. Flow channels were optimised by means of latest CFD tools. To ensure proper and easy manufacturing the design, especially castings, was reviewed and finalised in co-operation with suppliers.

This paper presents the design project aiming at the optimum 2-stage turbocharging system for a medium-speed diesel engine. Additionally operation and performance experiences are summarised. Testing experiences are covering assembly and operational feedback of the 2-stage turbocharging system specific components.