



Turbocharging

Augsburg,
07/06/2010

MAN Diesel & Turbo Introduces Two-Stage Turbocharging with New TCX Generation

TCX features compact architecture and low-pressure ratio-optimised flow components

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Development of the next generation of large-bore diesel engines has the reduction of exhaust emissions as a primary target. Reducing engine emissions through internal measures is achieved by increasing the mean effective pressure. This requires high charge-air pressures but cannot be achieved through single-stage turbocharging. However, two-stage turbocharging enables the charge-air pressure to be increased substantially while simultaneously reducing exhaust emissions, despite the increased specific engine output. MAN Diesel & Turbo is now ready to bring two-stage turbocharging to the market with the introduction of its TCX generation.

Two-stage turbocharging

Two-stage turbocharging systems consist of two turbochargers of different size connected in series. The exhaust gas coming from the engine drives the turbine of the smaller, high-pressure turbocharger (the first stage) which in turn drives the turbine of the larger, low-pressure turbocharger (the second stage). The low-pressure turbocharger's compressor draws in ambient air and sends it via an intermediate cooler to the high-pressure turbocharger's compressor. Here, the air is compressed once again and, via a further charge-air cooler, sent to the engine. The system adapts to varying operating conditions either through controlled turbine bypass or by variable nozzle rings (VTA). Two-stage compressors also have bypasses designed to suppress compressor surging.

The demands placed on the individual turbochargers in the high- and low-pressure stages vary considerably from each other. The high-pressure stage is charged by the full exhaust, however only receives a comparably low air volume (of previously compressed air) from the low-pressure stage. For this reason the high-pressure stage employs a smaller compressor. In contrast, the conditions for the low-pressure stage



are similar to those encountered in single-stage turbocharging though at lower pressure ratios.

The TCX series

With the new TCX Series, MAN Diesel & Turbo has developed a new generation of turbochargers especially aimed at two-stage turbocharging. The TCX series is based on the proven design philosophy of the TCA/TCR-series with uncooled casings and durable plain bearings. While the well-known TCA/TCR series use axial and radial turbines respectively, the new TCX-series employs a novel, diagonal turbine that is ideally suited to the lower-pressure ratios.

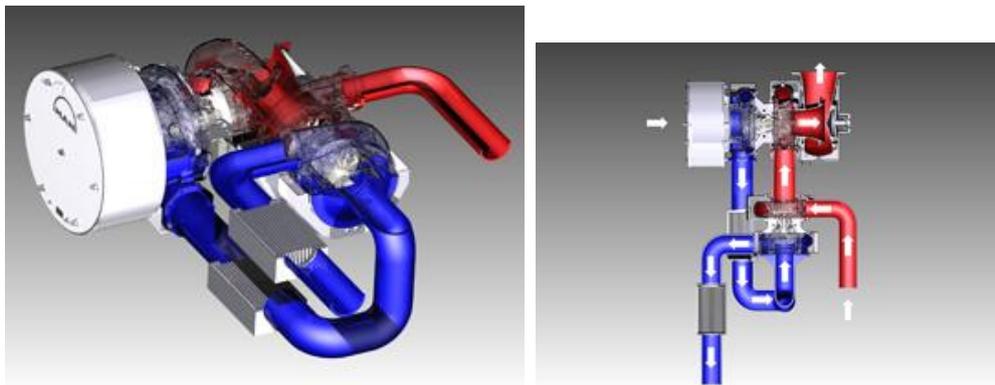
The lower-pressure ratios affect flow-ducting components as well as bearings and casings. Especially at the high-pressure level, increased thrust forces are imposed on the bearing system. Also the sealing air used for turbine shaft sealing is adjusted to suit the changed pressure levels. Furthermore, the tightness of all turbocharger casings must be ensured because of the higher pressures in the higher-pressure turbocharging stage.

Challenges

Two-stage turbocharging poses a number of challenges not exclusively related to turbochargers but also to the implementation of the engine's charging system. Besides the space and piping requirements that an additional turbocharger stage requires, an optimised intercooler is also included. In response to this, MAN Diesel & Turbo has delivered a compact solution where the turbochargers are arranged at 90° to each other (see illustration below).

In comparison to single-stage turbochargers, the TCX series incorporates characteristic features especially suited for lower-pressure ratios per stage:

- optimised component characteristics at low-pressure ratios
- the use of pressure-ratio reduction for the benefit of air capacity increase
- the use of pressure-ratio reduction for the benefit of dynamic behaviour
- compactness in order to minimise additional space (and weight) requirements for the two-stage turbocharger system including intercoolers
- matching of compressor and turbine capacities to accommodate low-pressure ratios
- wider application ranges per turbocharger size



Two-stage turbocharging with intermediate cooler (simplified illustration)

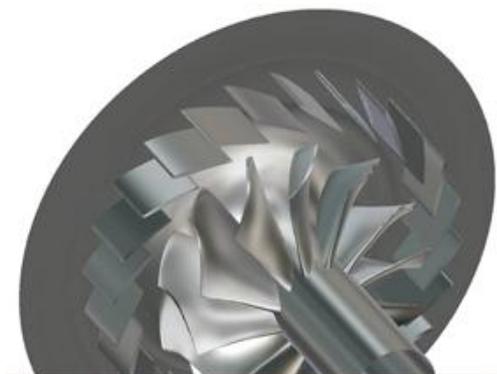


Illustration of the novel, diagonal turbine of the new TCX-series turbocharger optimised for low-pressure ratios



Model showing the compact architecture of two-stage turbocharging with intermediate cooling

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MAN Diesel & Turbo

MAN Diesel & Turbo SE, based in Augsburg, Germany, is the world's leading provider of large-bore diesel engines and turbomachinery for marine and stationary applications. It designs two-stroke and four-stroke engines that are manufactured both by the company and by its licensees. The engines have power outputs ranging from 47 kW to 87 MW. MAN Diesel & Turbo also designs and manufactures gas turbines of up to 50 MW, steam turbines of up to 150 MW and compressors with volume flows of up to 1.5 million m³/h and pressure levels of up to 1,000 bar. The product range is rounded off by turbochargers, CP propellers, gas engines and chemical reactors. MAN Diesel & Turbo's range of goods also includes complete marine propulsion systems, turbomachinery units for the oil & gas as well as the process industries and turnkey power plants. Customers receive worldwide after-sales services marketed under the MAN PrimeServ brand. The company employs around 12,500 staff at over 100 international sites, primarily in Germany, Denmark, France, Switzerland, the Czech Republic, Italy, India and China. MAN Diesel & Turbo is a company of the Power Engineering business area of MAN SE which is listed on the DAX share index of the 30 leading companies in Germany.

Ref. No.: 6510-0183