Power2 leading the way in two-stage turbocharging

Second-generation Power2® can be used for the entire power range of large medium-speed engines

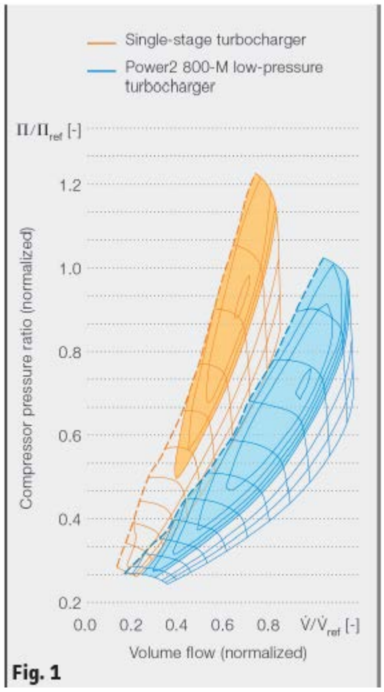
Power2. Service friendliness for optimal economic performance.

ABB Turbocharging began presenting to customers Power2 800-M, the second generation of its two-stage turbocharging system Power2. Offering considerable improvements in engine efficiency and reductions in emissions that go far beyond any single-stage system, even exceeding the high expectations, Power2 in its second generation represents the next step in two-stage turbocharging for large medium-speed engines. A portfolio with four different frame sizes is planned for second-generation Power2, two more than for the first-generation Power2 that has been on the market since 2010.

Two-stage turbocharging is a key technology that facilitates a reduction in both fuel consumption and emissions while helping to increase engine power density. With pressures of up to 12 bar and turbocharging efficiencies over 75%, second-generation Power2 leverages the full potential of extreme Miller cycles to minimize NOx reduction and fuel consumption.

Optimum performance

Power2's high efficiency comes as a result of its sophisticated design, which was always planned as a dedicated two-stage turbocharging solution. Its compressor and turbine stages make a special contribution in this regard.



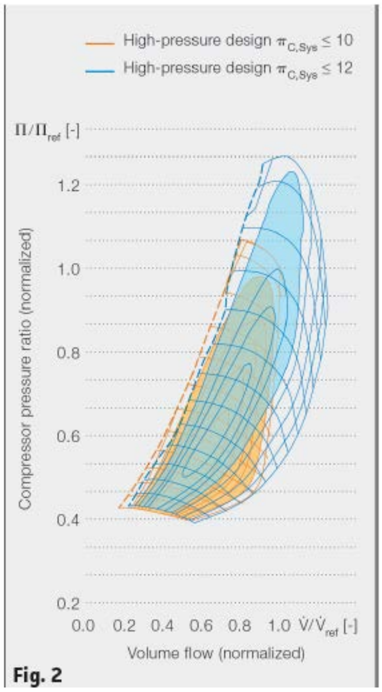


Fig. 1: Compressor performance maps of a single-stage turbocharger (A100-M) and Power2 800-M low-pressure turbocharger at equal impeller wheel diameter.

Fig. 2: Compressor performance maps of thePower2 800-M high-pressure turbocharger.

Two-stage turbocharging implies specific requirements having to be met by the thermodynamic components that differ from those of single-stage systems. Pressure ratios of compressors and turbines in low- and high-pressure turbochargers of two-stage systems are generally different to those of components in single-stage turbochargers. **Fig. 1** shows this difference by comparing the compressor maps of a single-stage design and the Power2 low-pressure stage design for the same impeller wheel diameter. With respect to flow areas, differences in fluid density resulting from specific temperatures and pressures in the high- and low-pressure stages need to be considered. In addition, performance maps of compressors and turbines need to be matched perfectly in order to allow unrestricted engine operation over the entire load range.

The high-pressure turbocharger features two compressor stage variants, which are specified according to the desired overall pressure ratio. The compressor stage known from the first generation yields optimum performance for applications with pressure ratios up to $\pi C = 10$. For pressure ratios up to $\pi C = 12$, an entirely new high-pressure compressor stage design has been developed. Both stages have been optimized, focusing on the compressor map width and efficiency at their specific operating range. Performance maps of both stages are presented in **Fig. 2**. Both stages operate at an efficiency level of up to 84% at design pressure ratio.

Axial turbines will be used for both the low- and the high-pressure stage. The turbine stage designs take into account the diverging needs of the high- and low-pressure sides. These result from different temperature levels and flow area requirements.

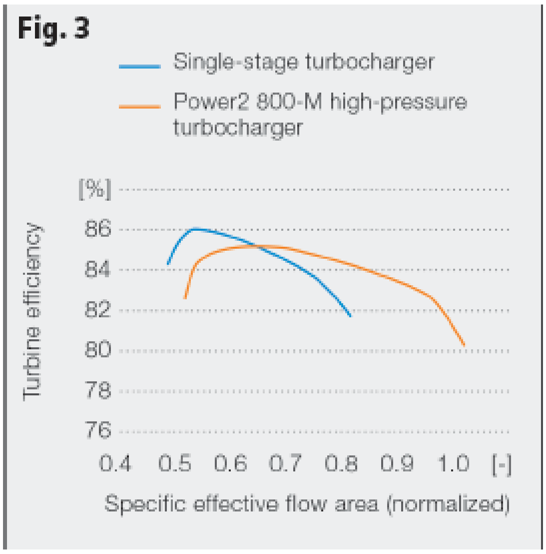


Fig. 3: Turbine efficiency vs. specific effective flow area of a single-stage turbocharger and Power2 800-M high-pressure turbocharger.

The axial turbine design for the high-pressure turbocharger combines the advantages of high specific volume flow (**Fig. 3**), excellent efficiency even at part load and good acceleration behavior due to low mass moment of inertia.

The requirements for the low-pressure turbine stage also differ significantly from those for single-stage turbines. The required range of specific volume flows in the case of the low-pressure turbine is shifted toward a lower level than for single-stage turbines (**Fig. 4**). Consequently, this lower requirement has been exploited in the design of the new low-pressure turbine stage to gain higher stage efficiency.

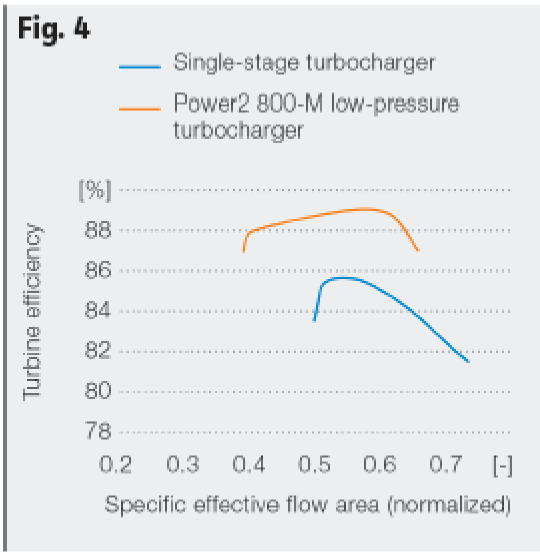


Fig. 4: Turbine efficiency vs. specific effective flow area of a single-stage turbocharger and Power2 800-M low-pressure turbocharger.

In addition to the compressor and turbine design, the design framework around these components needs to be considered to achieve optimum system performance. Therefore, the design of the flow channels and subsystems has been optimized specifically during development of the new turbochargers.

Focus on minimal service downtime

Engine availability is a key factor for achieving optimal economic performance. Consequently, the time required for service work needs to be reduced to a minimum. In the case of two-stage turbocharging, this aspect becomes even more important as there are double the number of turbochargers to be serviced. During development of the new turbocharger generation, service friendliness has been considered from the very beginning. The designated goal was to reduce service time of the complete two-stage system to below the reference value of current single-stage turbochargers.

For the second generation turbo-chargers the proven cartridge concept has been enhanced in order to further reduce service time. The idea behind the extractable cartridge is a turbocharger which has an outer shell, consisting of compressor casing and gas casings, and a cartridge group which contains the entire interior of the turbocharger. In order to exchange the cartridge during service, only the air inlet casing together with the insert wall of the compressor needs to be removed. All other interfaces to the engine, such as oil connections, air outlet flange connection, gas inlet and gas outlet flange connections, remain untouched. Furthermore, there is no need to remove the insulation of the turbocharger anymore, since only the flange connection of the air inlet needs to be accessed during service (Fig. 5).

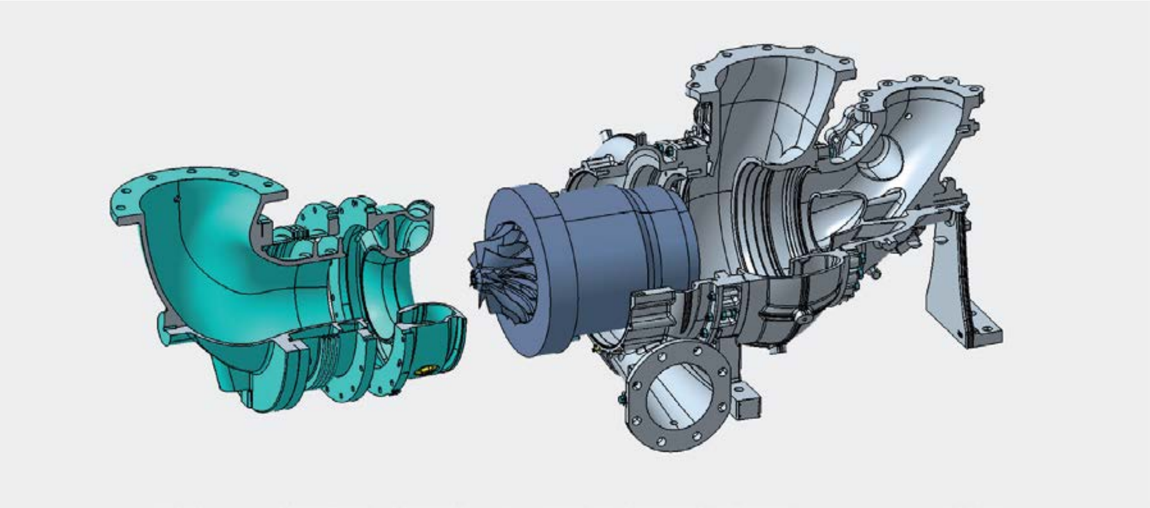


Fig. 5: Power2 800-M high-pressure turbocharger with extractable cartridge.

Conclusion

Demand for highly efficient engines with high power density and low operating costs that comply with today's emission requirements is driving the development of new turbocharging solutions. Second-generation Power2 represents an optimized technology enabling engine designs that fulfill all these requirements at once. The entire system has been designed and optimized for the specific needs of two-stage turbocharging. With pressure ratios of up to 12 and turbo-charging efficiencies beyond 75%, Power2 enables full exploitation of the advantages of two-stage turbocharging. Ease of service has been especially considered in the design. With the new extractable cartridge, service downtime has been minimized, which increases engine availability. The Power2 800-M series provides a two-stage turbocharging solution for the entire range of large medium-speed engines.

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