Concepts NREC

The Experts in Turbomachinery

Case Study

Volvo uses RITAL™ for Turbocharged Engine Simulations

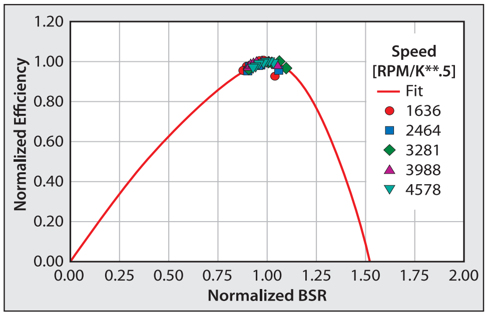
Automotive OEM Volvo needed to simulate the performance of a turbocharged piston engine to evaluate new turbocharger designs. They used RITAL™ turbine calculation code to predict the performance of their new designs. This allowed the engineers at Volvo to produce and store good calibrations and extrapolations which could be used on other projects using the same turbine.

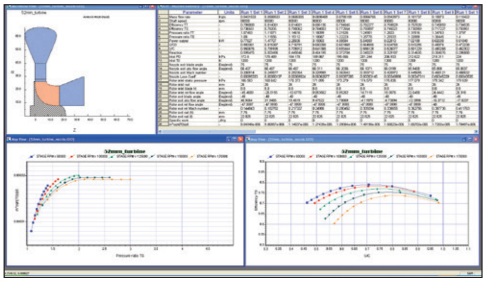
In recent years, there has been a rapid increase in the volume of turbocharged engines used in passenger cars and other types of vehicles. The primary reasons for turbocharging both diesel and gasoline engines are the current trend of "downsizing" to smaller engines to meet emission legislation demands – especially for diesels – and increasing the charge pressure to preserve vehicle performance.

Volvo Cars of Sweden designs engines for their own vehicles (as well as for the complete range of Ford products) and is currently developing new turbocharged engine designs. However, simulating the performance of a turbocharged piston engine has always been a challenge, because the turbocharger sets all the boundary conditions exclusively to the piston engine. Therefore, an error in the turbocharger performance prediction has a great impact on the simulation of engine output.

These difficulties are mostly the result of limited data used by the simulation program that has to extrapolate performance without knowing how the turbine is designed. The data received from hot gas stands (most commonly used to measure turbocharger performance) only provide about 25% of the performance information required.

To successfully match simulation and test results,





Volvo Cars used RITAL™ turbine calculation code to simulate turbocharged engine performance.

the designer has to vary correction factors for the efficiency and blade speed ratio (BSR) curves. Achieving settings that match a steady-state solution works quite well, but matching the transient behavior is much more difficult, because it is unclear whether the correction factors should stay the same over the complete simulation register. The

Volvo uses RITAL™ for Turbocharged Engine Simulations, continued

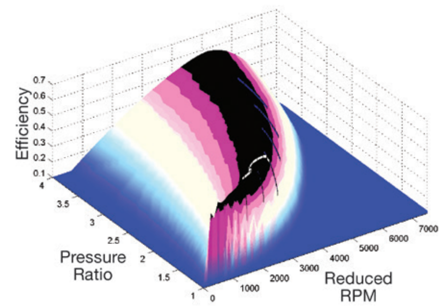
default extrapolation method is purely a numerical extrapolation of data comprised of efficiency fit versus blade speed ratio. As shown (upper right), all the test data are located in a very small band and then extrapolated over a wide range with a single curve. Designers of radial turbines are aware that there is a speed dependency in the characteristics, and ideally there should be an individual curve for each speed. With the limited information that is normally available, a single curve is the best estimate that can be made.

A better solution is to bypass the internal, simplified postprocessing method in the engine simulation code, and instead, use Concepts NREC RITAL turbine calculation code. Volvo Cars has used this method to achieve one simulation model working in both transient and steady-state operation.

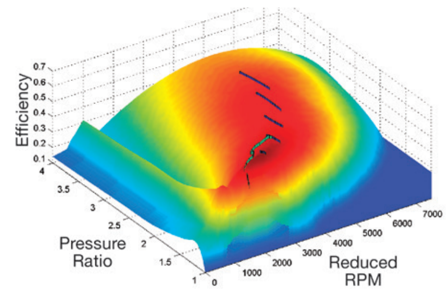
The two graphs (at right) are examples of the extrapolated turbine performance plotted as a surface including speed dependency. Although the scales of the graphs are identical, the different shape of the extrapolated efficiency produced by RITAL is clearly evident.

The ability to produce a good calibration and extrapolation in RITAL has proven crucial for Volvo Cars. When one turbine model has been completed, the extrapolated map is stored for future use in other projects.

This provides a quick and good up-front simulation for the next project using the same turbine, and considerably reduces the number of iterations and time required for different turbochargers in both simulation and testing. And Volvo Cars has also found the turbine knowledge and understanding gained through time well spent, for good turbine modeling in RITAL, is helpful in detailed discussions with their turbo suppliers.



Turbine data extrapolated by the engine simulation code



Turbine data extrapolated by RITAL™

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