Scania AG

CASE STUDY

Scania Uses Software and Detailed Testing Together for Tailor-Made Turbocharger Development

Founded in 1891, Swedish company Scania AG is one of the world's leading manufacturers of heavy commercial vehicles, buses, coaches, and engines for both marine and industrial applications. Scania is known for its focus on safety, efficiency, and sustainability. Because overall engine efficiency is directly related to turbocharger efficiency, the company has invested heavily in tools and capabilities for tailor-made turbocharger development. In order to enable rapid generation of new hardware, Scania takes a modular approach to turbocharger development. By making the various components "plug-and-play," engineers can generate valuable trade-off curves cost-effectively (see Figure 1). Note that the turbine inlet is generally twin-scroll for dual exhaust system application.

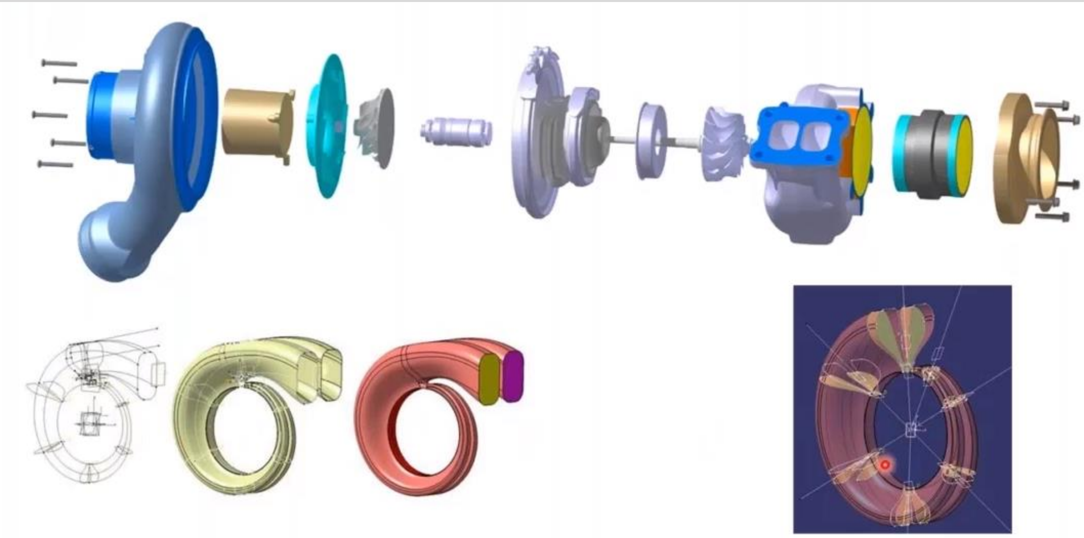


Figure 1: Scania modular turbocharger development approach

Scania's design philosophy is to use the best software tools combined with the best laboratory testing and equipment, thereby ensuring accuracy in simulation and maximizing its value. Unified testing of the full turbocharger is performed in an onsite laboratory with dual combustion chambers feeding both sides of the twin scroll. Detailed measurements of velocities, pressure, and temperature are made throughout the compressor stage with minimally invasive Kiel probes. The multiplicity of measurements allows an understanding of the physics driving the performance, as well as comparison with simulation results by location.

The Scania turbocharger system design approach involves three looping processes, as shown in Figure 2. In addition, it is critical to couple turbocharger simulation with full engine simulation. The top inner loop is where compressor and turbine component design start, using Concepts NREC tools. 1D preliminary design (COMPAL for compressors, RITAL for radial turbines) uses the desired design point conditions to develop hub and shroud shapes. Given diffuser and scroll/volute parameters, these preliminary designs can be evaluated off-design and input parameters adjusted to make improvements. Then, a default 3D bladed geometry is automatically created in AxCent, where 2D analysis tools can provide more information on impeller performance and blade shapes can be manipulated to investigate the impacts. TurboFEA can then be used to evaluate stresses and vibrational modes and TurboLink can create computational fluid dynamics (CFD) meshes and launch and post-process Cadence's OMNIS Turbo Standard all from within the familiar AxCent user interface. After evaluating CFD-predicted performance maps together with full engine simulation, Scania may then go back to COMPAL and RITAL to make further modifications, possibly looping this manual process a couple of times until there is satisfaction with performance.

Embedded Design Process

Tools used:

COMPAL, RITAL, AxCent, TurboFEA, OMNIS Turbo, TurboOPTII

Result:

Validated design and analysis toolset that links to full engine simulation and laboratory testing process

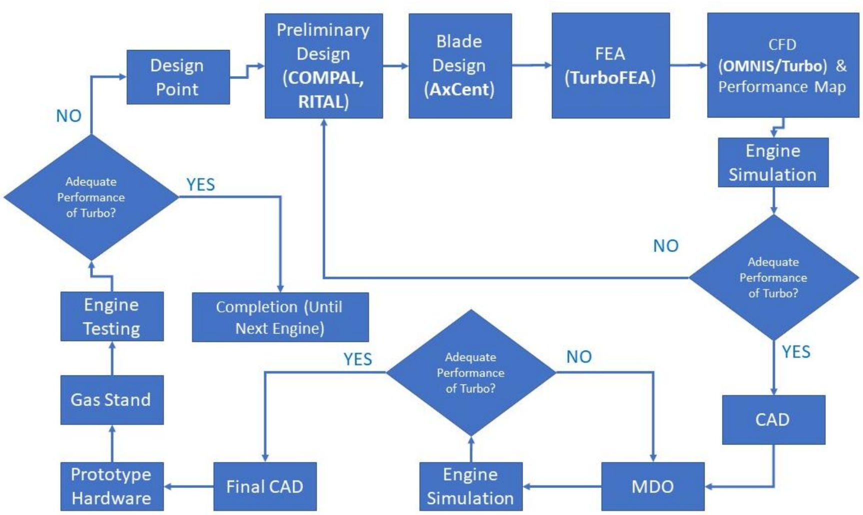
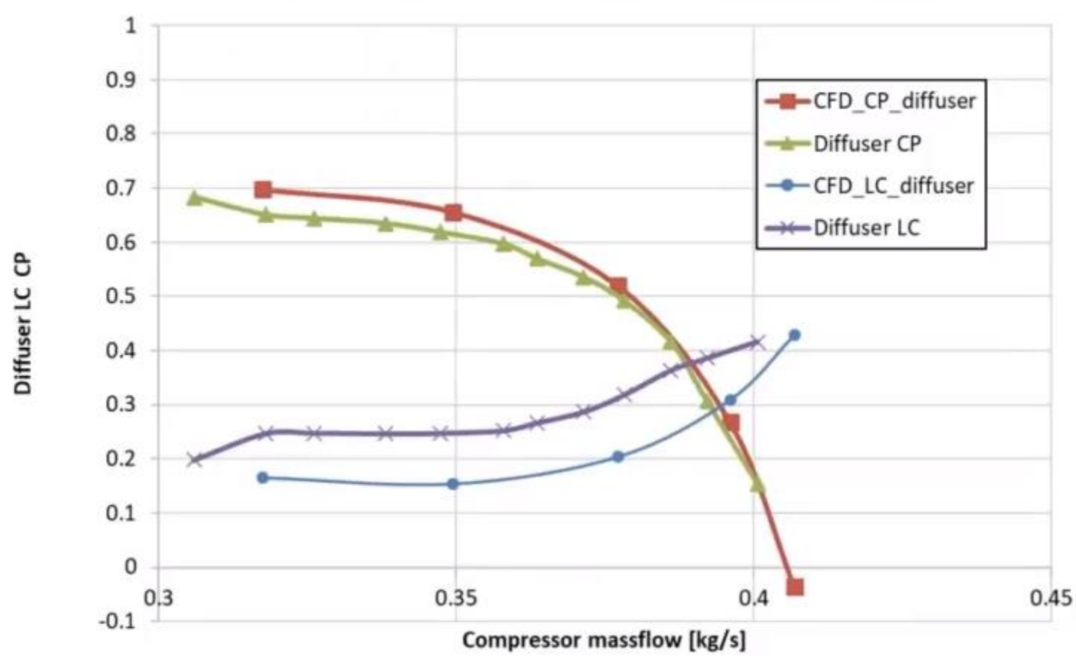


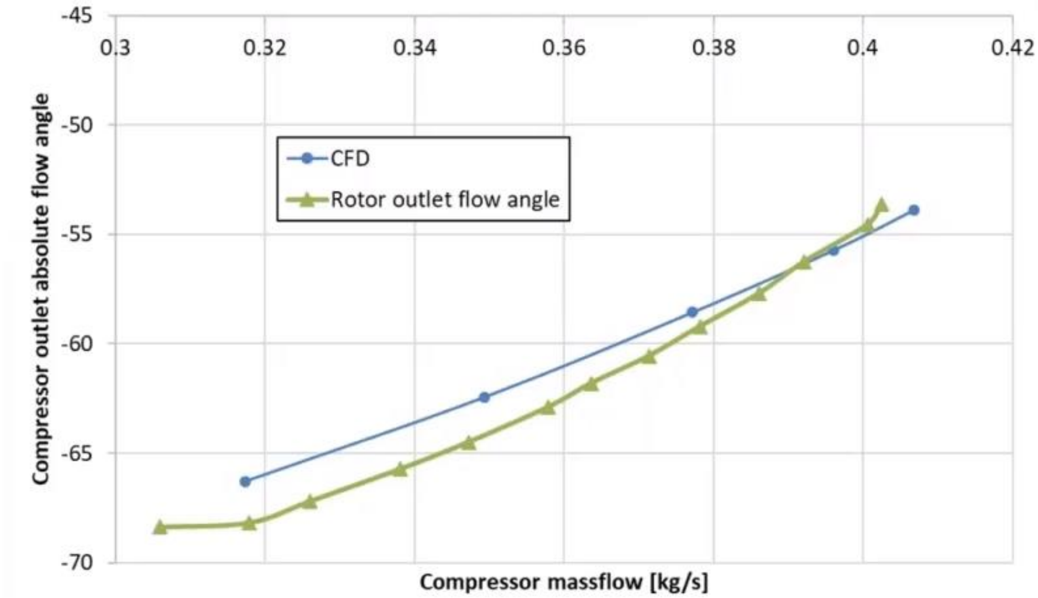
Figure 2: Scania turbocharger system design loops

After developing detailed CAD (computer-aided design) models, some further multi-disciplinary design optimization is performed along with further coupling to full engine simulation and possible additional modifications. Once this “final” design is found to adequately perform with the engine by simulation, prototype hardware is quickly developed and the unified turbine and compressor are tested on a gas stand first. Eventually, the prototype hardware is incorporated into full engine testing. If any areas of concern arise with the full engine testing, then the design point may be re-evaluated, and another round of ground-up design may be undertaken, using the knowledge gained throughout the rest of the process.

An important byproduct of this design process is the capability to validate the simulation tools. Figure 3 shows comparisons of (a) diffuser loss coefficient and pressure coefficient and (b) impeller discharge flow angle as a function of compressor mass flow. These results provide confidence in the simulation-driven product development approach on which Scania has embarked, yielding a return on investment by allowing for heavier reliance on modeling and design loops with fewer testing loops.



a) Diffuser pressure coefficient (CP) and loss coefficient and loss coefficient (LC) versus mass flow



b) Compressor impeller flow angle versus mass flow

Figure 3: Comparison of CFD results to gas stand measurements

With reduced carbon footprints becoming ever more important, Scania will be relying even more on simulation to fit turbocharger design to specific engines and applications, incorporating design optimization even more deeply into this process.