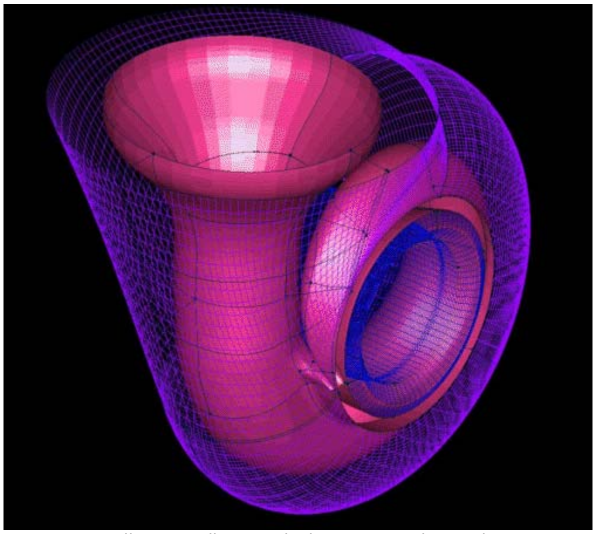
Computer Simulation Advanced Design for Gas Turbine Engines



Engineers at Rolls Royce Allison made this transition duct grid using Gridgen.

Computer simulation helped Allison engineers improve the efficiency of a new gas turbine engine by helping to optimize and validate the transition duct design between the compressor, combustor, and turbine. Scroll transitions, shaped like tubas, were evaluated for industrial gas turbine engines in the 1970s but abandoned because of the difficulty in achieving good temperature, mass and velocity distribution within the complex scroll geometry. Allison revived this concept for its new generation of low NOx power generation turbines and used the latest simulation technology to optimize critical flow parameters. The engineers used Gridgen to generate a 3D multiple block, structured grid of the complex scroll geometry and computational fluid dynamics (CFD) software modeled flow around the exterior and through the interior of the scroll.

In 1995, the U.S. Department of Energy signed an $82.5 million agreement with Allison to develop a new family of turbine engines for electrical power generation that will provide reduced emissions and lower operating costs as well as increased fuel flexibility. Allison is infusing into the Advanced Turbine System (ATS) program many of the technologies that have been developed by the company under a wide array of military and commercial turbine engine programs.

A critical factor in the design of the ATS industrial engine, and virtually every other industrial gas turbine engine, is the transition duct from the combustor to the turbine. Allison chose to develop a scroll shaped transition duct, which looks like a tuba or a snail shell.

Gridgen allowed Allison engineers to break the scroll's geometry into contiguous sub-domains called blocks. They generated grids on the scroll and casing surfaces, creating faces for each block, letting the software tool fill the volume grids within the blocks. Using separate blocks for regions where the casing volume varied, in combination with arbitrary interface boundaries in the flow solver, the engineers were able to maintain the mesh at a nearly uniform density throughout the casing. In this way, they were able to achieve the accuracy they needed in the large diameter area without burdening the smaller diameter areas with an excess of elements that would slow down solution times.

The irregularity of the scroll geometry meant that the initial grid had areas of negative volume that would have made it impossible to analyze. With a conventional grid generator, Allison engineers would have been forced to modify the grid cell by cell to improve its quality, a process that would have taken weeks. Fortunately, Gridgen provides an elliptic smoother that allowed engineers to improve the quality of the mesh by automatically applying elliptic partial differential equation methods. Engineers applied smoothness, clustering and orthogonality controls to improve the mesh. In only about an hour, they had refined the grid, producing an excellent quality mesh ready for computational analysis.

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