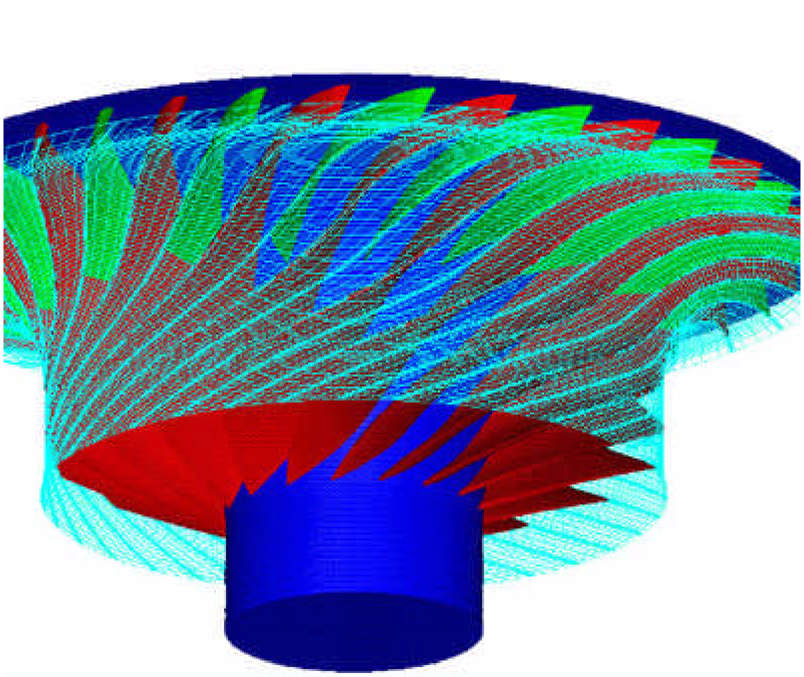
Multiphysics Code Demonstrated for Propulsion Applications

The utility of multidisciplinary analysis tools for aeropropulsion applications is being investigated at the NASA Lewis Research Center. The goal of this project is to apply Spectrum, a multiphysics code developed by Centric Engineering Systems, Inc., to simulate multidisciplinary effects in turbomachinery components. Many engineering problems today involve detailed computer analyses to predict the thermal, aerodynamic, and structural response of a mechanical system as it undergoes service loading. Analysis of aerospace structures generally requires attention in all three disciplinary areas to adequately predict component service behavior, and in many cases, the results from one discipline substantially affect the outcome of the other two. There are numerous computer codes currently available in the engineering community to perform such analyses in each of these disciplines. Many of these codes are developed and used in-house by a given organization, and many are commercially available. However, few, if any, of these codes are designed specifically for multidisciplinary analyses.

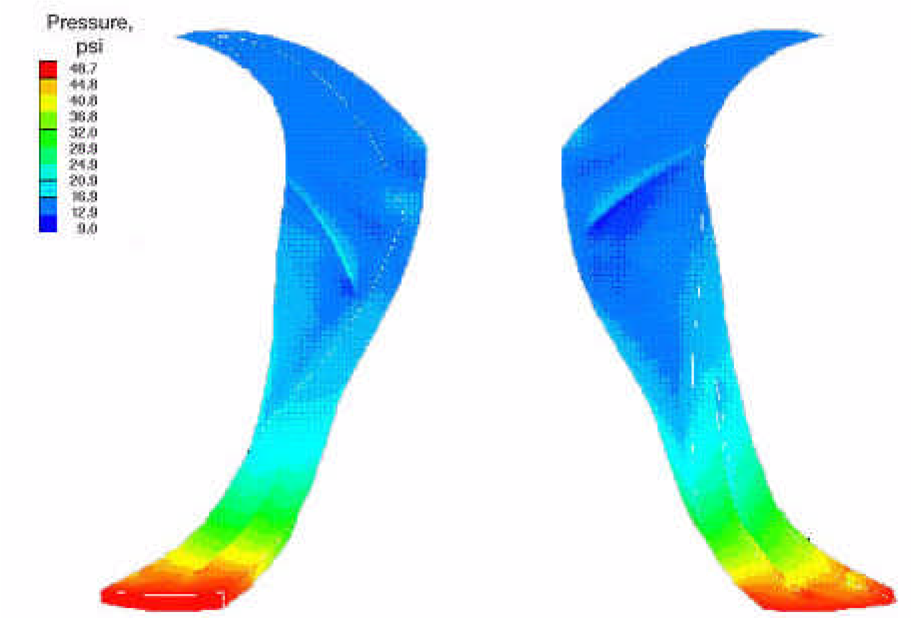
The Spectrum code has been developed for performing fully coupled fluid, thermal, and structural analyses on a mechanical system with a single simulation that accounts for all simultaneous interactions, thus eliminating the requirement for running a large number of sequential, separate, disciplinary analyses. The Spectrum code has a true multiphysics analysis capability, which improves analysis efficiency as well as accuracy.

Centric Engineering, Inc., working with a team of Lewis and AlliedSignal Engines engineers, has been evaluating Spectrum for a variety of propulsion applications including disk quenching, drum cavity flow, aeromechanical simulations, and a centrifugal compressor flow simulation.



Computational grid overlaid on geometry of centrifugal impeller.

For centrifugal compressor simulations, AlliedSignal provided a mesh of the computational domain for a cyclic symmetry sector of the main gas path for one of their production compressors. A viscous, steady, compressible flow finite element analysis was performed for the AlliedSignal centrifugal compressor. This is the first successful application of this technology to three-dimensional turbomachinery fluid flow. Centric Engineering performed the flow analyses, and results from the simulations were forwarded to AlliedSignal Engines and NASA for comparison with test data and other computational fluid dynamics (CFD) results. Deliverables included the values of the fluid pressure, velocity, temperature, density, and turbulence intensity computed by the Spectrum solver at the mesh nodes.



Pressure results for single blade passage of centrifugal impeller.

The successful application of the Spectrum multiphysics code to turbomachinery fluid flow simulations provides opportunities for performing full-system multidisciplinary simulations. Since this code already has demonstrated capabilities for thermal and structural analysis, establishing its ability to analyze turbomachinery fluids would provide a complete foundation for multidisciplinary aeropropulsion simulations. Opportunities for follow-on work include adding the back cavity flow and the solid casing to the main gas path model. In addition, several opportunities exist for accelerating the simulation run times to bring them to within acceptable design constraints.

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