

Enhancing Turbojet Engine Performance Through Compressor Redesign in AxSTREAM

Summary

Client: Technion – Israel Institute of Technology

Need: Improve compressor efficiency and pressure ratio to reduce specific fuel consumption and gas temperatures while evaluating additive manufacturing feasibility for diffuser fabrication.

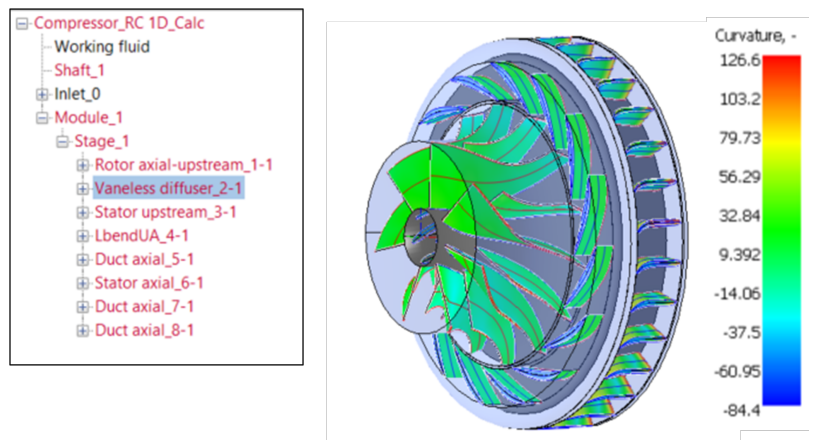
Solution: The AxSTREAM software suite was used to reconstruct and redesign the turbojet compressor system. The platform enabled preprocessing and reconstruction of the impeller and diffuser geometries, while AxSTREAM supported flow path modeling, 1D/2D streamline analysis, and complete diffuser redesign. Detailed CFD validation was performed in AxSTREAM, including additive manufacturing surface roughness modeling and advanced flow analysis. Together, these tools provided a comprehensive assessment of compressor performance across operating conditions and ensured an optimized, validated final design.

Product Requirements: The project aimed to improve overall engine efficiency by redesigning the compressor diffusers using additive manufacturing. Key objectives included increasing pressure ratio and isentropic efficiency, reducing specific fuel consumption and gas temperatures to extend engine life, evaluating surface roughness effects from additive manufacturing, and ensuring proper integration into the existing engine.

Results: The redesigned compressor achieved a higher pressure ratio and improved isentropic efficiency, with reduced flow separation and more uniform exit flow, supporting improved overall engine performance.

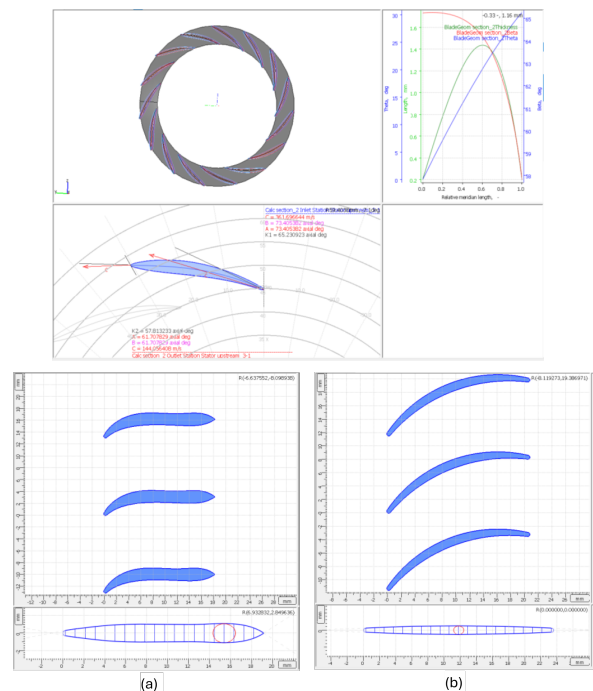
Geometry Reconstruction & Baseline Modeling

The existing compressor geometry was reconstructed in AxSTREAM using manufacturer CAD files and 3D scan data. Blade profiles, camber lines, and thickness distributions were extracted and imported into AxSTREAM, where the full centrifugal compressor architecture was defined and baseline performance maps were generated using 1D/2D streamline analysis.



Diffuser Redesign in AxSTREAM

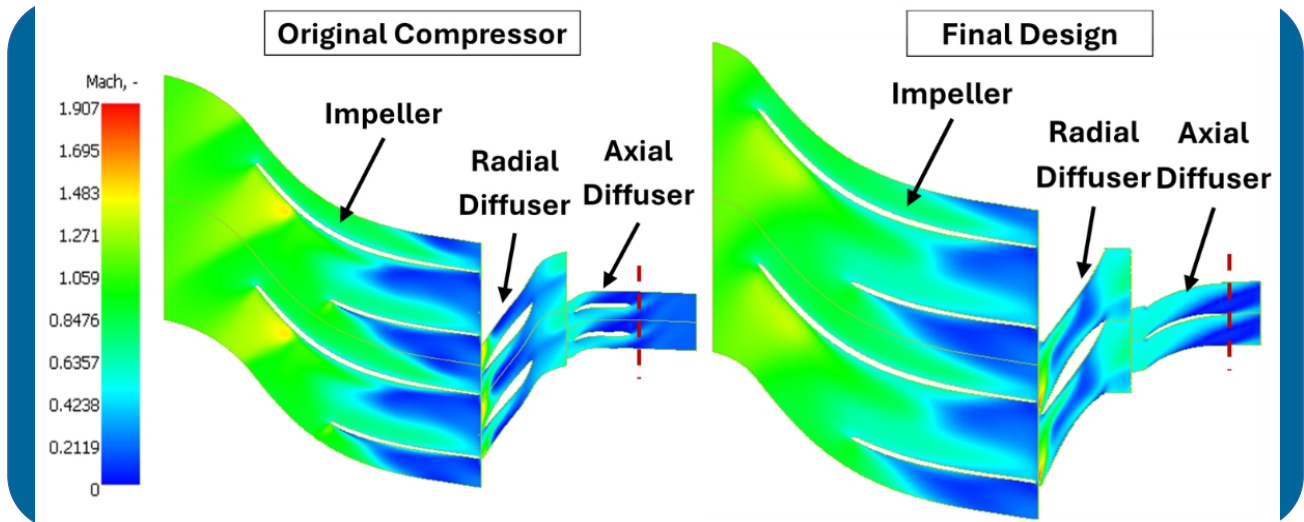
The radial and axial diffusers were completely redesigned by optimizing blade metal angles, thickness distribution, solidity, and meridional flow path geometry. AxSTREAM's radial blade design and profiler tools enabled rapid iteration using semi-empirical correlations and velocity triangle visualization to improve pressure recovery and reduce diffusion losses.



CFD Validation & Flow Analysis in AxSTREAM

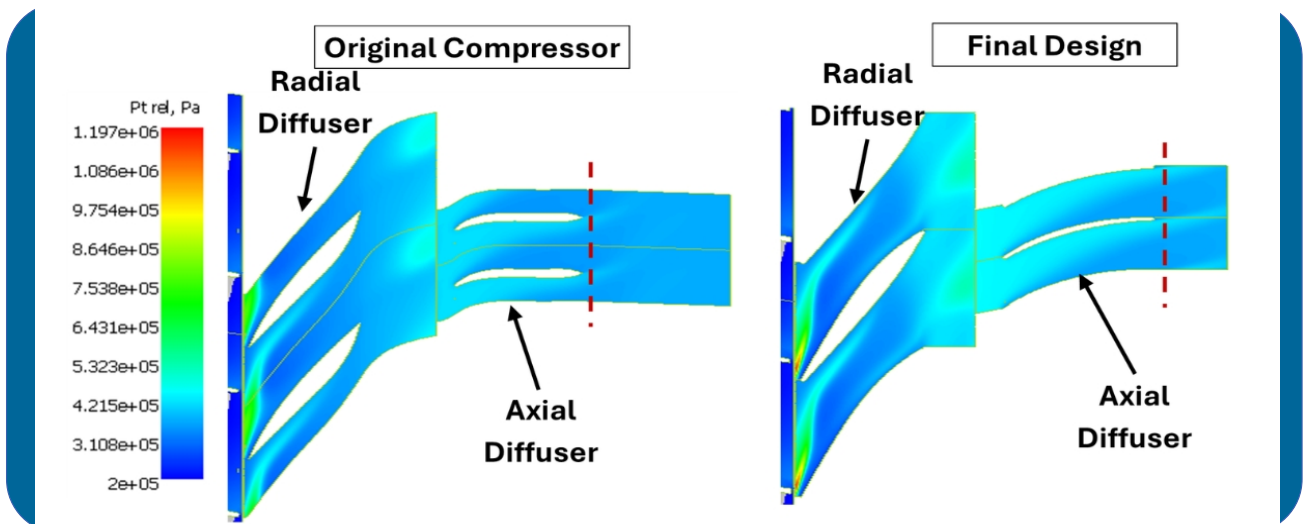
Following preliminary diffuser redesign in AxSTREAM, detailed three-dimensional CFD simulations were performed in AxSTREAM to validate aerodynamic improvements. The analysis evaluated flow separation, pressure recovery, and exit flow uniformity. Because the redesigned diffuser was intended for additive manufacturing, surface roughness effects ($R_a \approx 6 \mu\text{m}$, $\epsilon \approx 36 \mu\text{m}$) were incorporated to ensure realistic performance assessment.

Mach Number Comparison - Baseline vs. Final Design



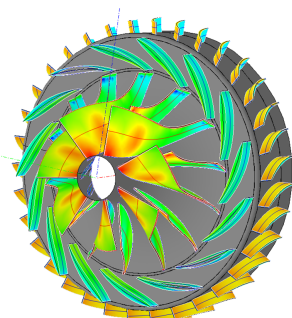
Comparison of Mach number distribution at 85% blade span. The redesigned configuration reduces high-velocity regions and delays flow separation relative to the baseline compressor.

Total Pressure Distribution - Baseline vs. Final Design



Total pressure field comparison showing improved pressure recovery and more uniform flow through both radial and axial diffusers in the final design.

Results



The redesigned compressor achieved approximately 1.5% higher isentropic efficiency and a 0.2 increase in pressure ratio. CFD results confirmed reduced flow separation, improved pressure recovery in both diffusers, and more uniform flow delivered to the combustion chamber, indicating a more stable and efficient compressor operation.