DOCTOR OF PHILOSOPHY

A MULTIDISCIPLINARY ALGORITHM FOR THE 3-D DESIGN OPTIMIZATION OF TRANSONIC AXIAL COMPRESSOR BLADES

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A new, multidisciplinary algorithm for the CFD design optimization of turbomachinery blades is presented. It departs from existing techniques in that it uses a simple, previously-developed Bezier geometry representation (BLADE-3D) that can be easily manipulated to achieve true 3-D changes in blade shape. The algorithm incorporates zero and first-order optimization techniques including sensitivity analyses and one-dimensional search methodology. It features an iterative finite element structural analysis as well as a cold shape correction procedure to ensure that the resulting blade meets steady-stress structural requirements. The process was applied to two different transonic fan designs – the Sanger rotor designed for the NPS Turbomachinery Laboratory and NASA Rotor 67, otherwise known as the 'NASA Fan.' The optimization objectives for the two designs were mass flow rate and polytropic efficiency respectively. Results for the Sanger rotor effort yielded an 8.1 % improvement in mass flow rate, a 5% improvement in total pressure ratio, and a 0.9 % increase in adiabatic efficiency. Application to the NASA Fan resulted in a 2.5 % increase in polytropic efficiency. The results validate the utility of the BLADE-3D Bezier geometry package for use in future development of automated optimization routines for turbomachinery blade design.

KEYWORDS: Design Optimization, Transonic Fan Blades, Bezier Geometry Package