CONCEPTS engineering education and technology for industry

TECHNICAL MEMORANDUM NO. 192

ADVANCED DIFFUSER PERFORMANCE FOR CENTRIFUGAL COMPRESSORS AND PUMPS

FINAL REPORT FOR THE DIFFUSER CONSORTIUM

PART 2

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EXECUTIVE SUMMARY

Part 2 of the Advanced Diffuser Performance Consortium has obtained record levels of channel diffuser, tandem airfoil diffuser, and Low Solidity Airfoil (LSA) diffuser performance. Baseline data for vaneless diffusers operating with up to 50% pinch were obtained, including pinching from either the front, back, or both sides. Remarkably high pressure ratio and efficiency were achieved for the best builds of the channel, tandem, and LSA diffusers as shown in Figures ES.1 and ES.2 with all three devices providing comparable levels. The distinguishing element was stable operating range where a particular LSA dominated the comparison, as shown in Figures ES.3 and ES.4, at moderate pressure ratios. At low pressures, the vaneless diffuser gave more range (on the choke end) but lower solidity airfoils must also be tested at these conditions. Efficiency with the LSA was substantially better than the vaneless diffuser design at all speeds (pressures). An application for a patent has been filed, relative to the LSA diffuser work.

Forty tests were conducted for 27 builds. Additionally, data from select CETI internal research and development (IRAD) work have been presented to supplement the basic consortium work. All tests were conducted in the same test rig as the majority of the Part 1 tests. The initial vaneless tests for Part 2 also utilized the original impeller from the Part 1 work; subsequently, a new impeller of substantially the same type was introduced for the remainder of Part 2 work.

Further supporting information was obtained showing that diffusers and other downstream components can interact strongly with the performance of the impeller due to an aerodynamic coupling effect. The surface upon which a pinch (passage height reduction) is applied will affect the diffuser and stage performance, and particularly choke and surge margins.

When combined with the Part 1 results, the present research provides a very thorough treatment of channel diffuser design and application issues. Trends are observed (or identified) regarding leading edge radius ratio (R_3), length-to-width ratio (L/W), and divergence angle (2θ). Good initial information is provided concerning the effective layout of low solidity airfoil diffusers.

Recommendations can also be offered for continuing investigation. Further tests of the low solidity airfoil diffuser operating at different values of chord (cascade radius ratio), lift coefficient, inlet rotor to diffuser gap, solidity, and airfoil shape should be pursued. Likewise, testing of alternate rotors and detailed traversing to establish diffuser losses may be recommended.

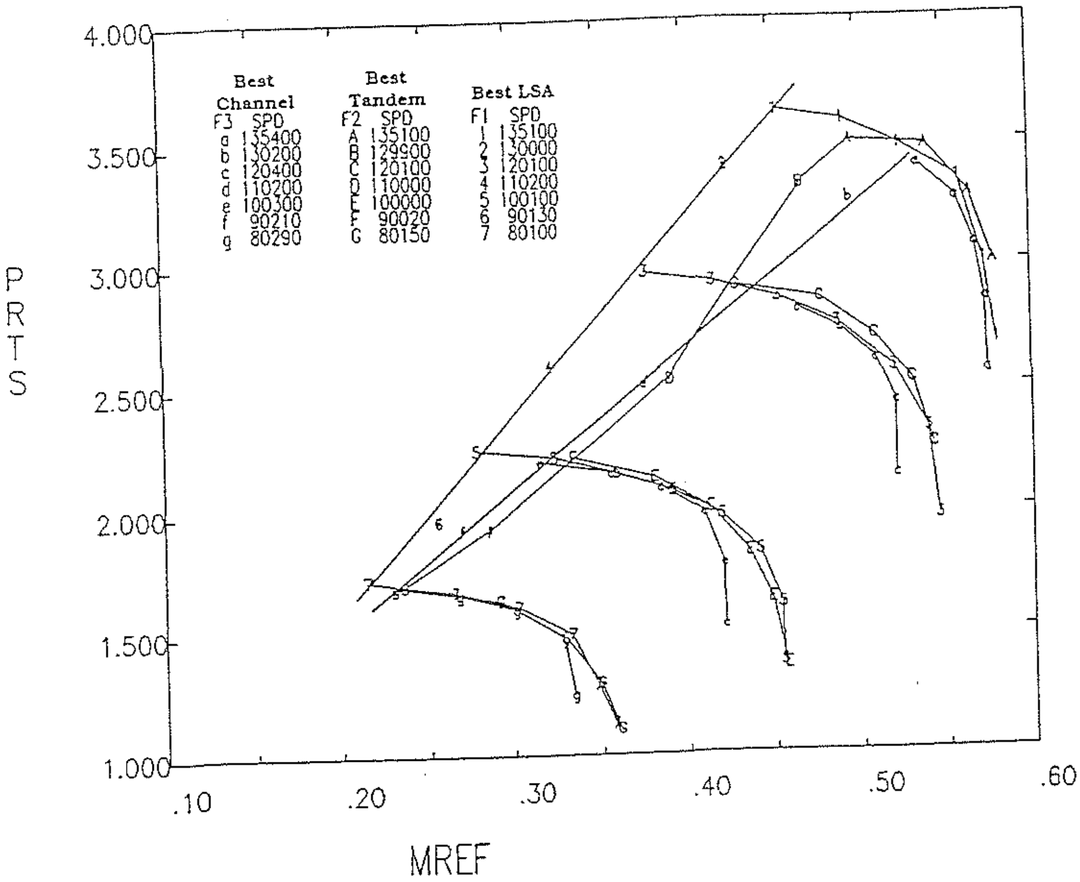

Figure ES.1

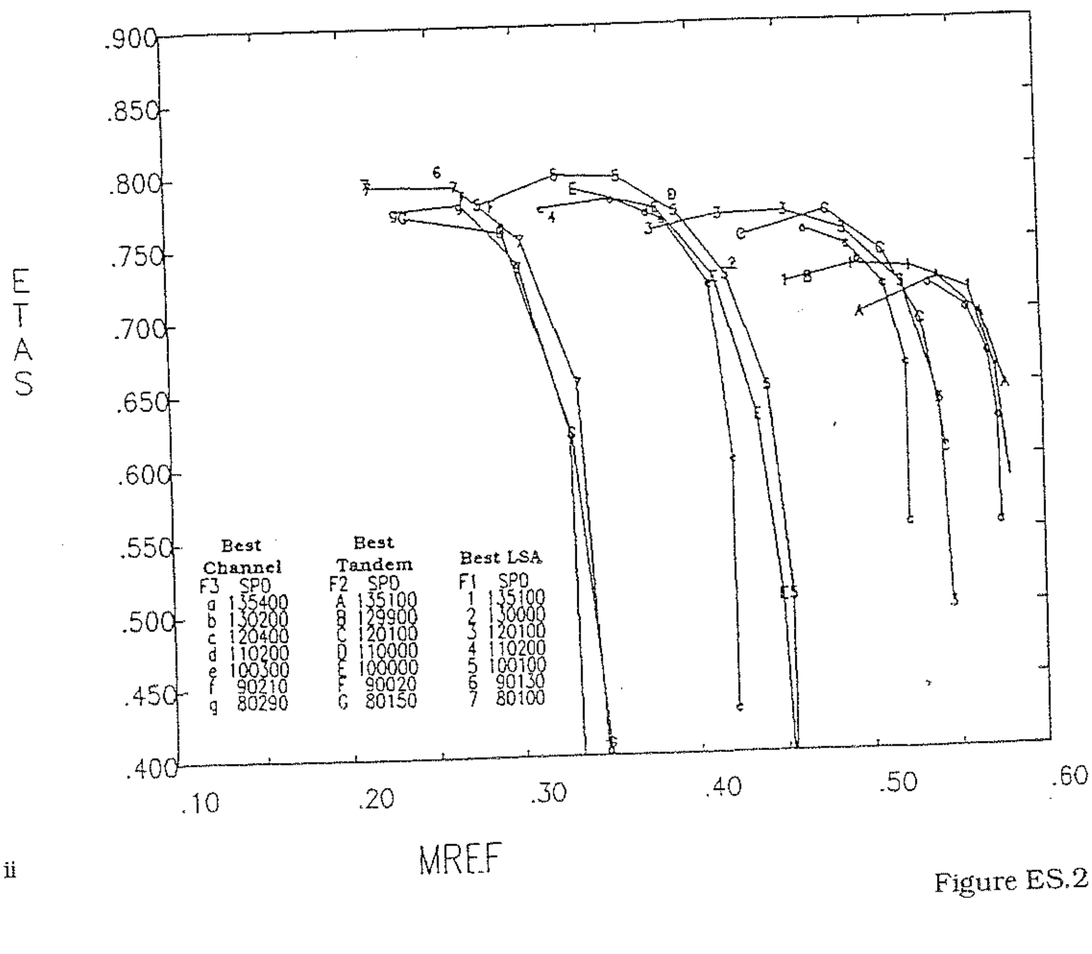

Figure ES.2

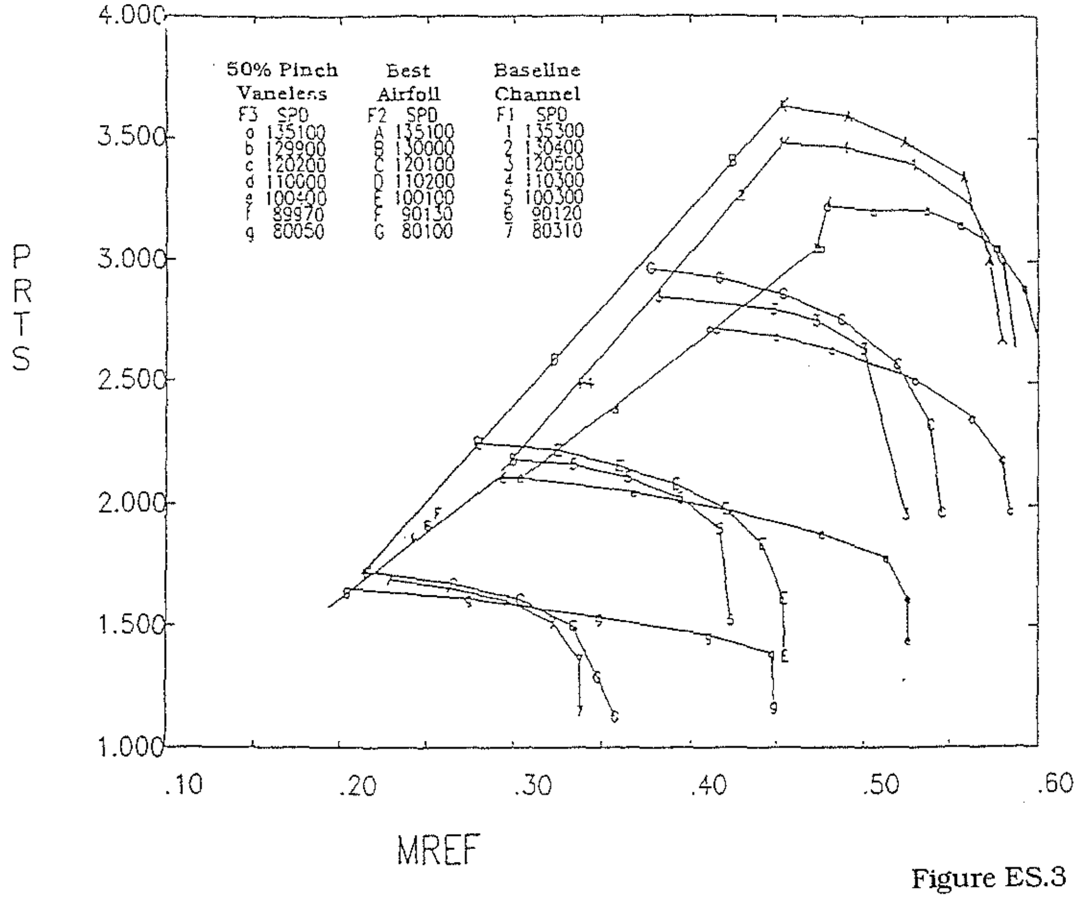

Figure ES.3

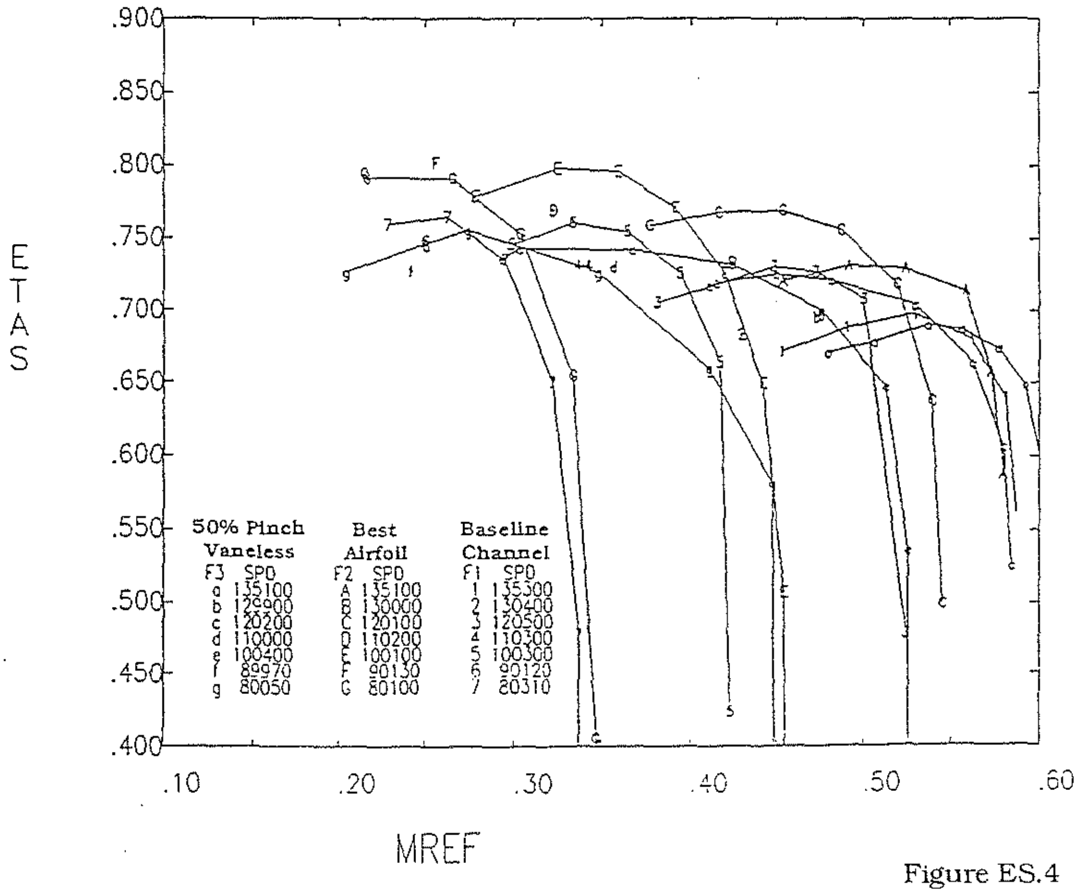

Figure ES.4