

Turbine Air-Flow Test Rig CFD Results for Test Matrix

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- Outline
 - TAFT Background
 - Design Point CFD
 - TAFT Test Plan and Test Matrix
 - CFD of Test Points
 - Conclusions



- Background
 - TAFT (Turbine Air-Flow Task) test rig
 - Based on Integrated Power-head Demonstrator program (IPD)
 - TAFT is 1.42 super-scale of IPD Lox Turbine
 - Initial CFD Simulations performed Spring 2002
 - CFD Simulations performed for design point
 - Solutions used to determine
 - Flow Environment
 - Instrumentation Locations
 - TAFT testing began Spring 2003
 - Testing will include 4 configurations
 - 13 nozzle, 17 blade geometry with “near” axial gap
 - 13 nozzle, 17 blade geometry with “far” axial gap
 - 22 nozzle, 17 blade geometry with “near” axial gap
 - 22 nozzle, 17 blade geometry with “far” axial gap



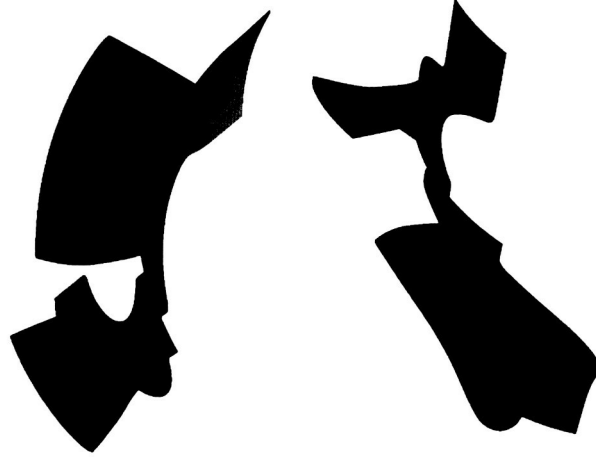
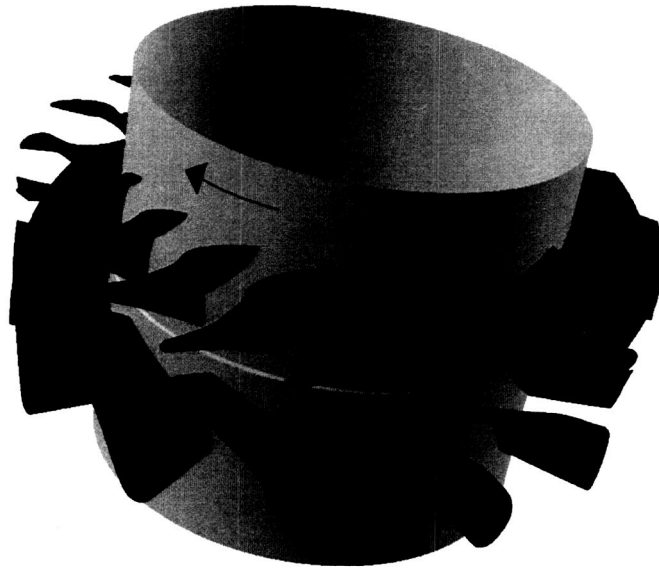
- Initial CFD Solutions

- CFD Tools

- Corgrid: Grid Generator

- Corsair: Unsteady, Parallel, Turbomachinery Analysis CFD Code

- Grid

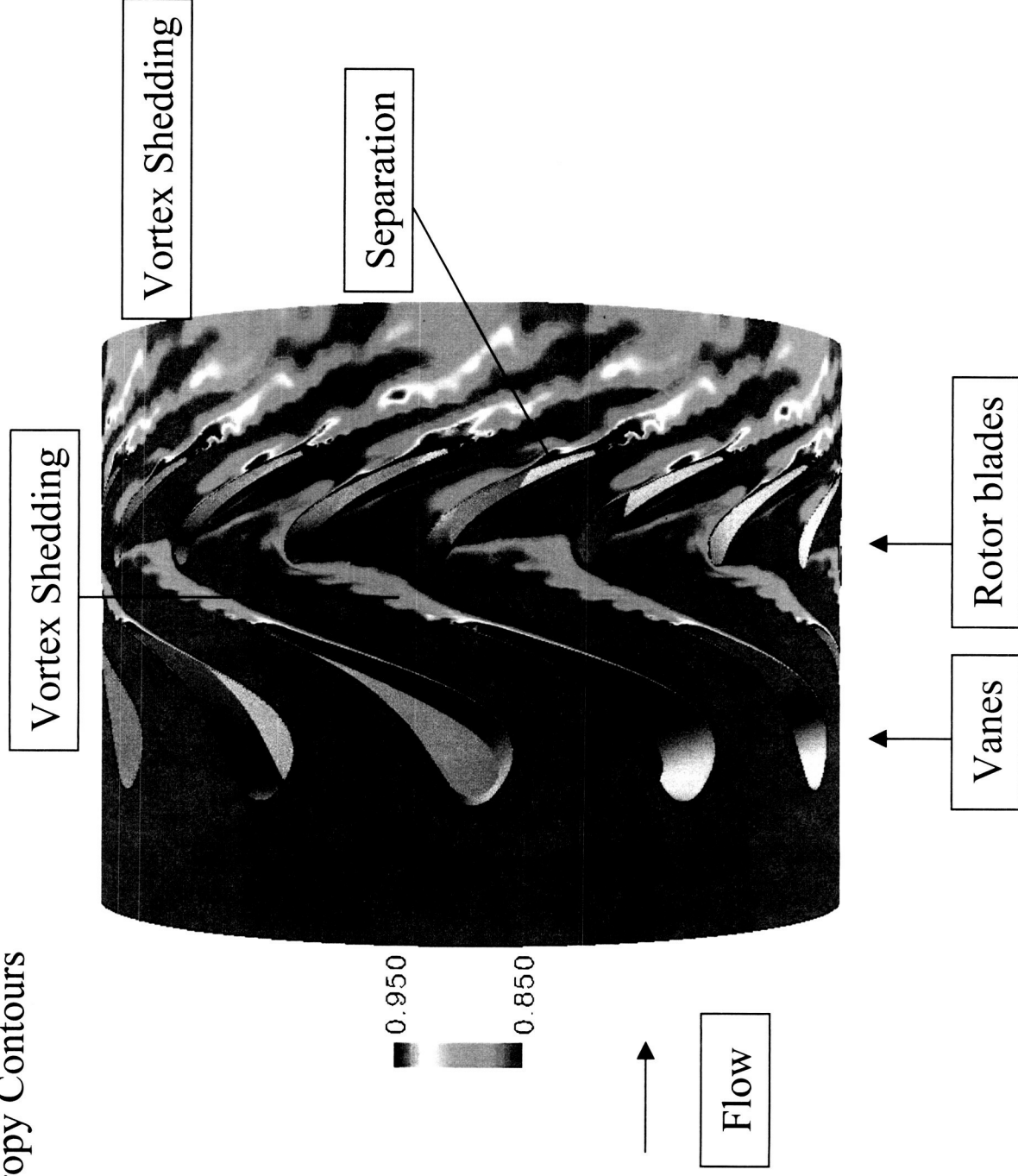


	Vane-1	Rotor-1
O-grid	181x51x41	181x51x41
H-grid	123x61x41	142x57x41
# of passages	2	3
Total grid pts	1,372,188	2,130,975



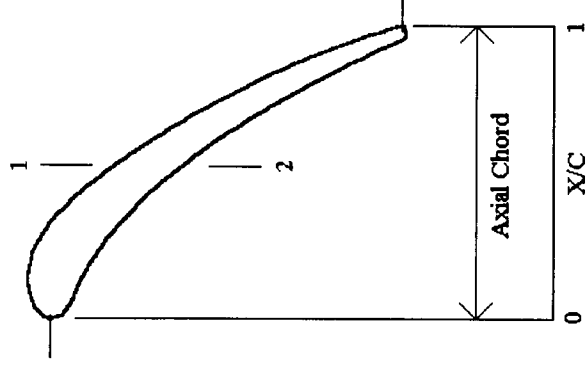
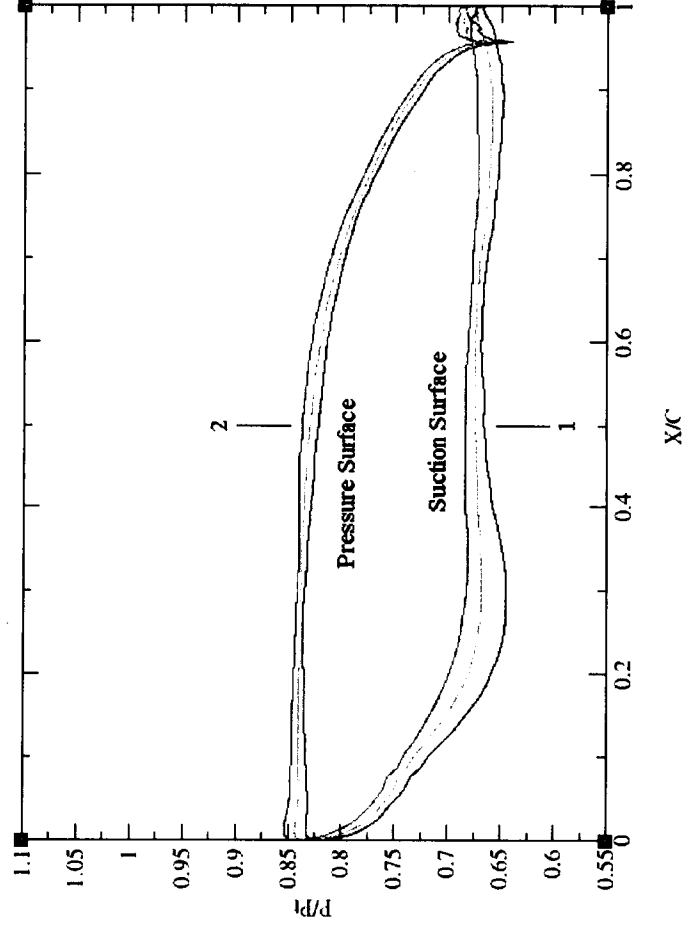
- Initial CFD Solutions

- Entropy Contours



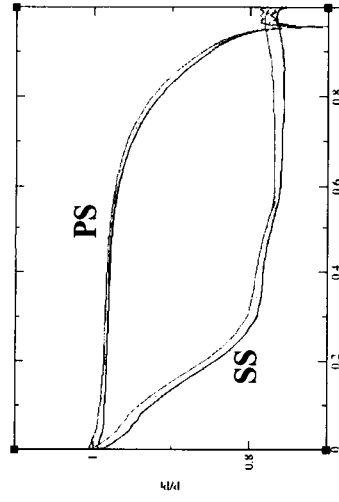
- Initial CFD Solutions

- Solutions

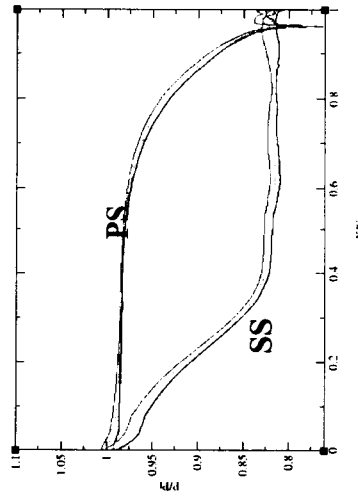


•CFD Solutions

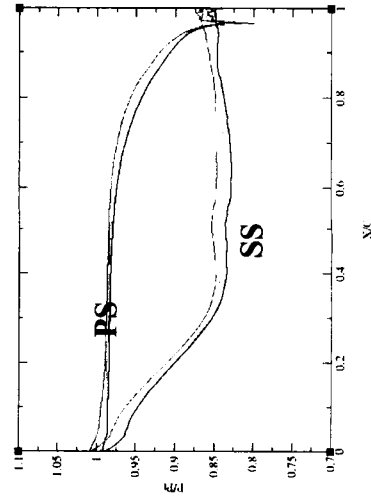
- Vane Pressure Envelopes



11% Span



50% Span



89% Span

PS : Pressure Surface

SS : Suction Surface

— Maximum

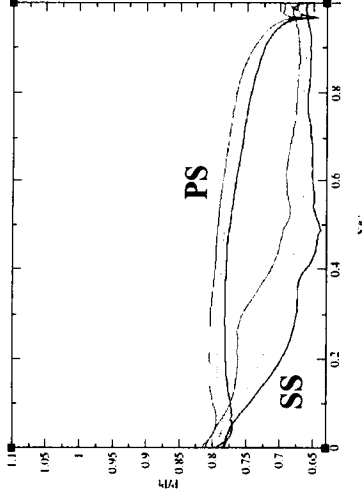
--- Time Average

... Minimum

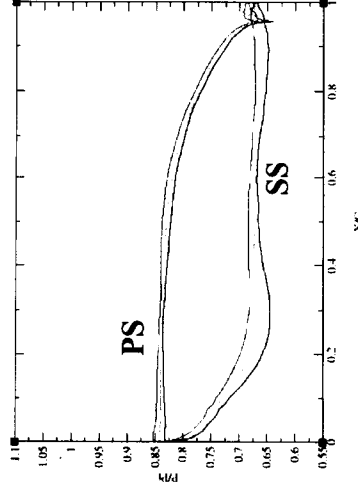


•CFD Solutions

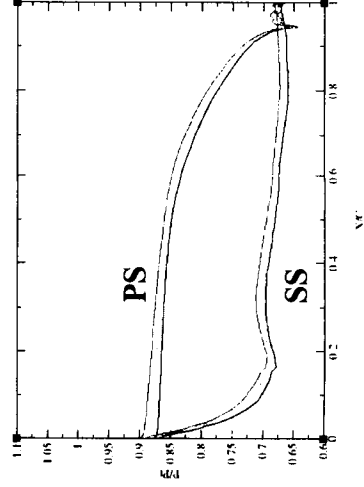
•Rotor Pressure Envelopes



11% Span



50% Span



89% Span

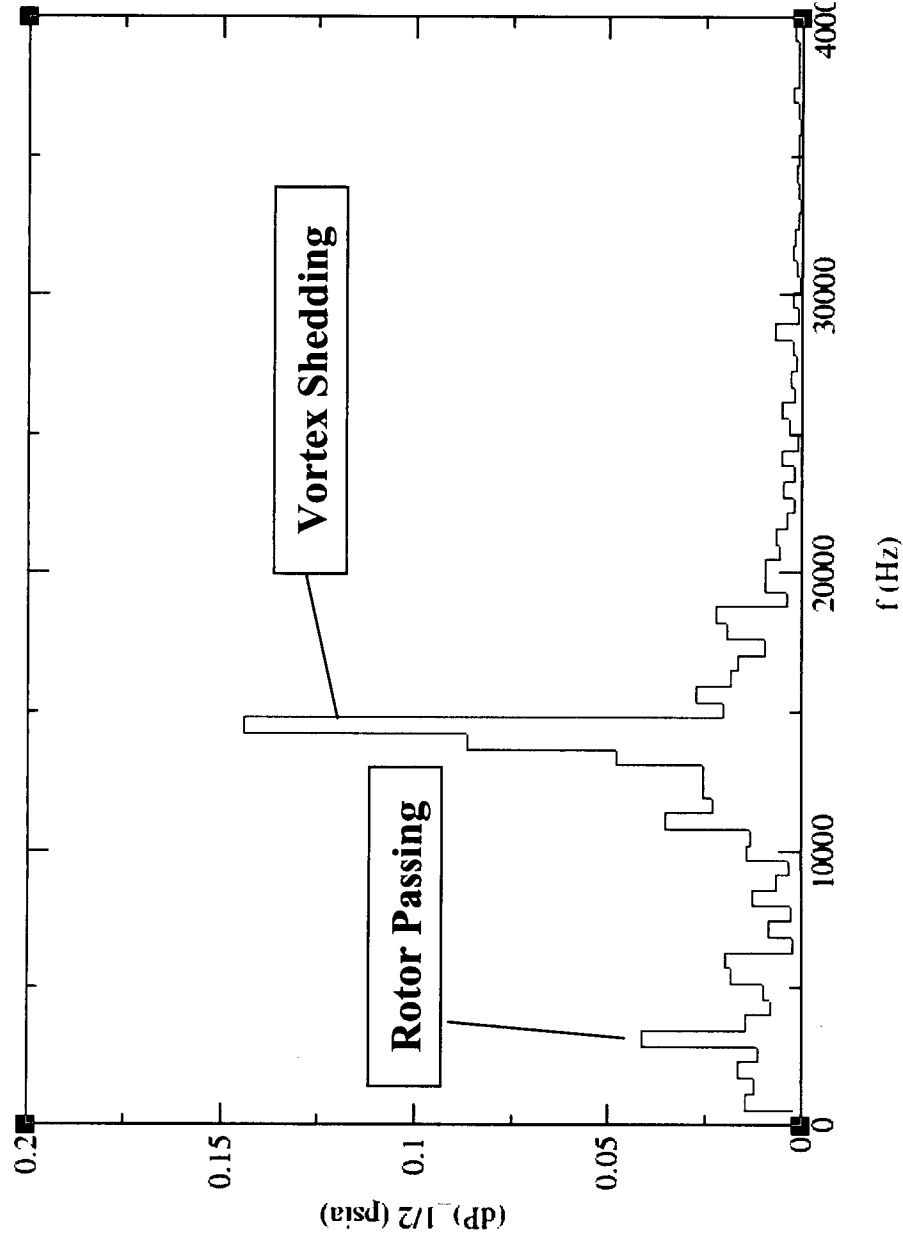
PS : Pressure Surface
SS : Suction Surface

— Maximum
— Time Average
— Minimum



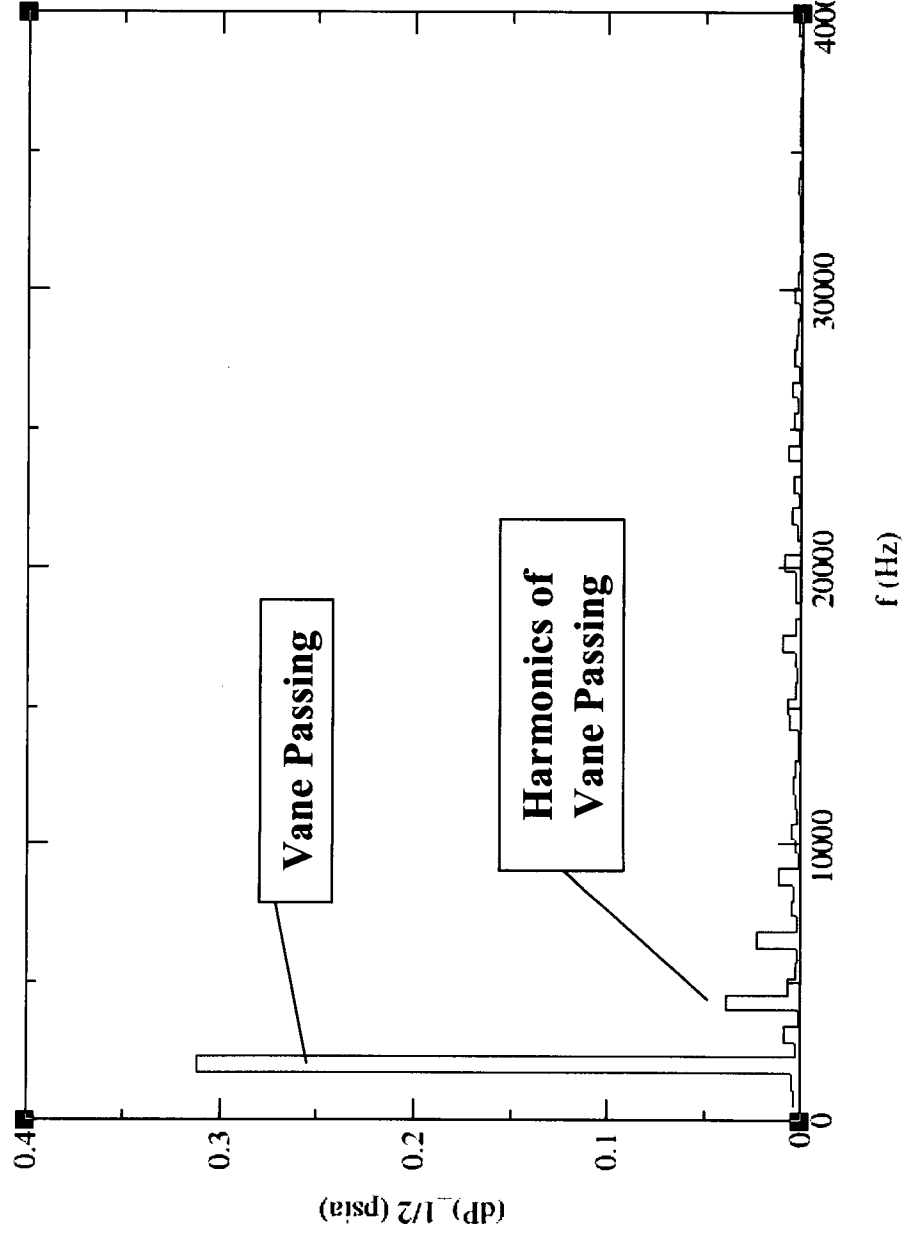
- CFD Solutions

- Vane trailing edge spectrum at mid-span



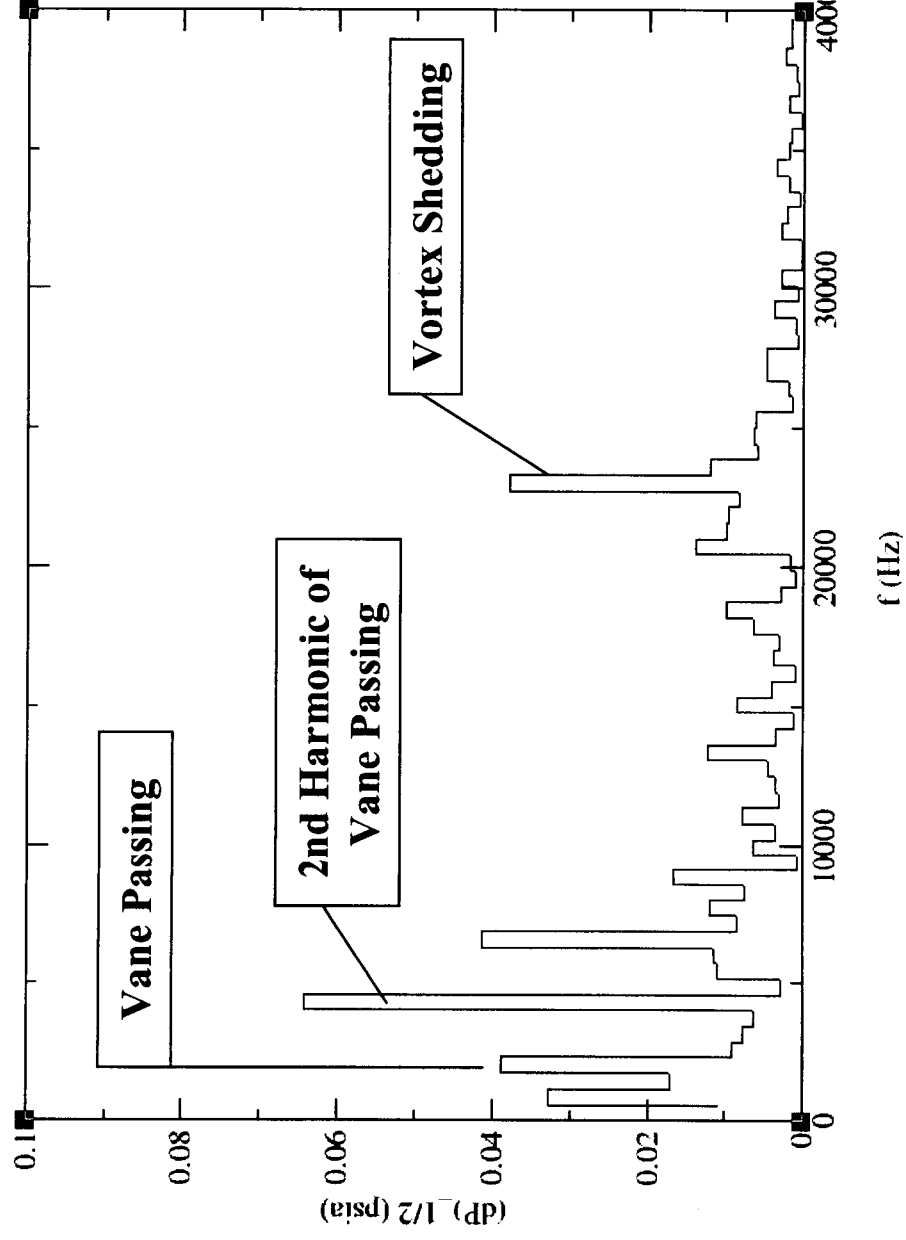
- CFD Solutions

- Rotor leading edge spectrum at mid-span

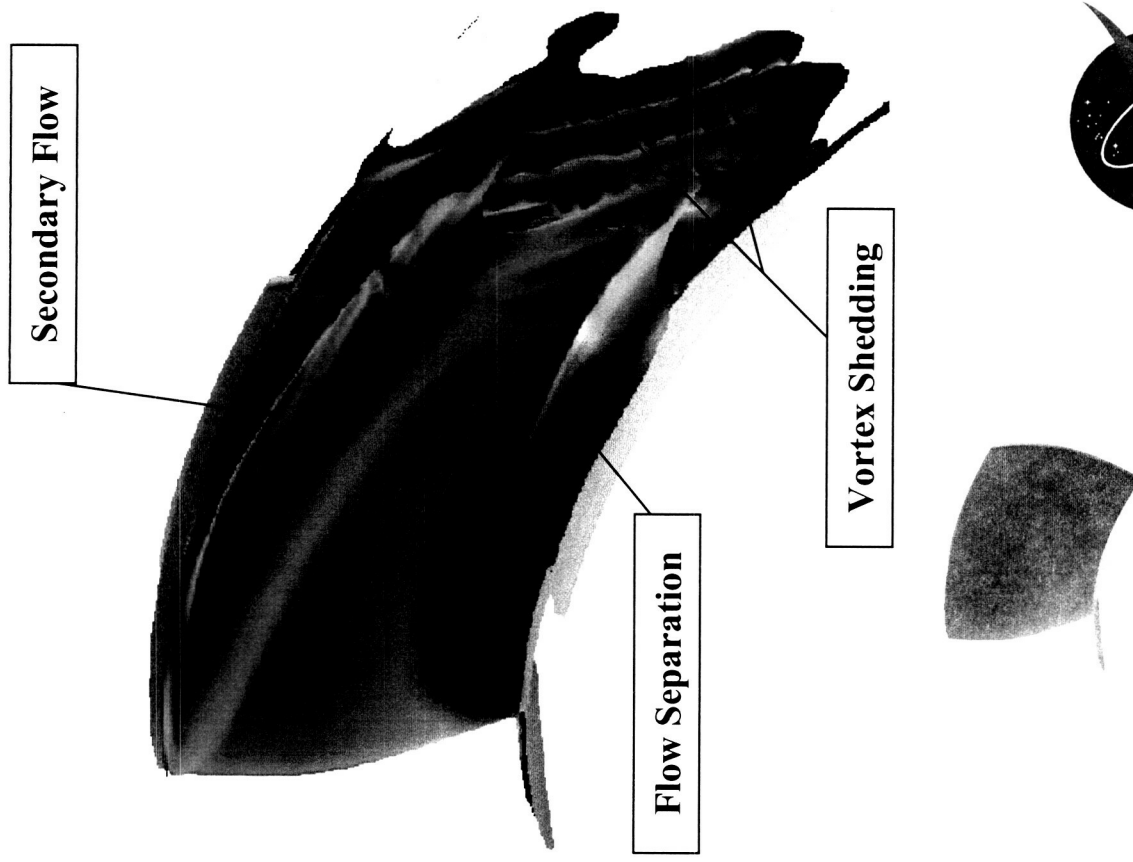
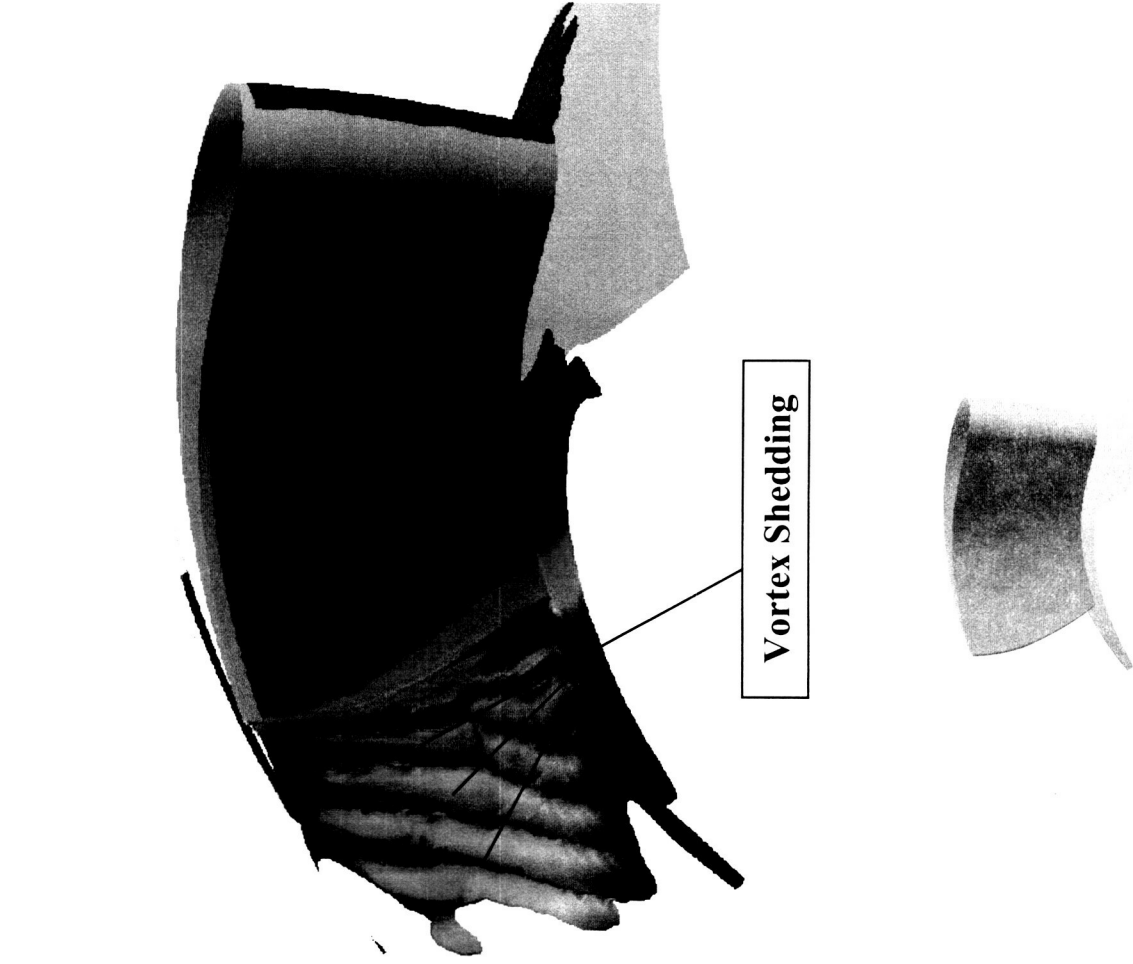


- CFD Solutions

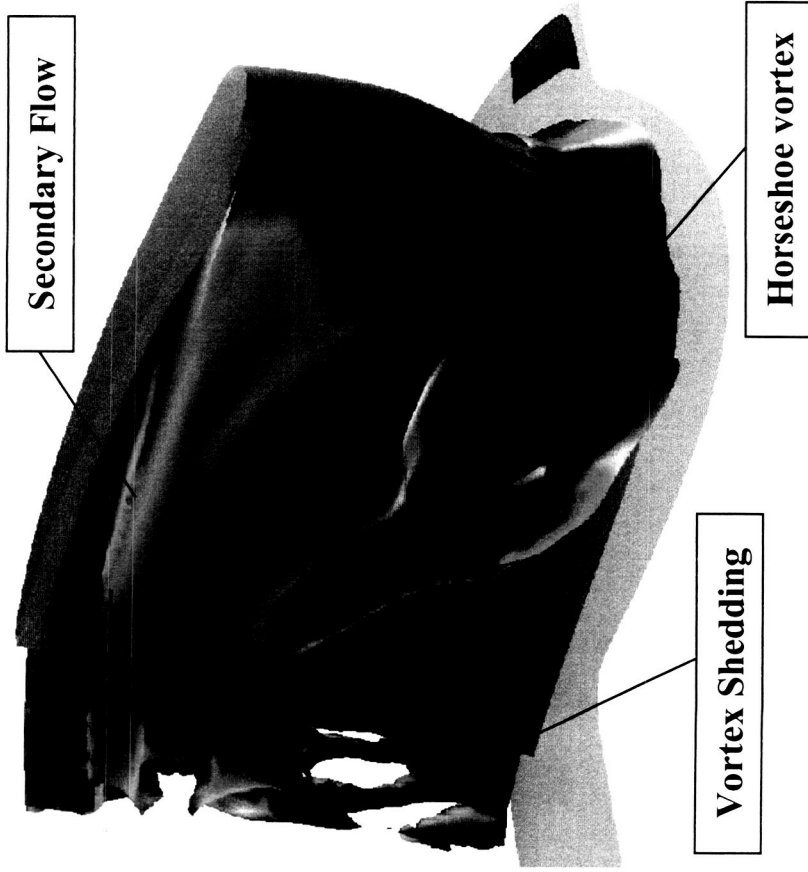
- Rotor trailing edge spectrum at mid-span



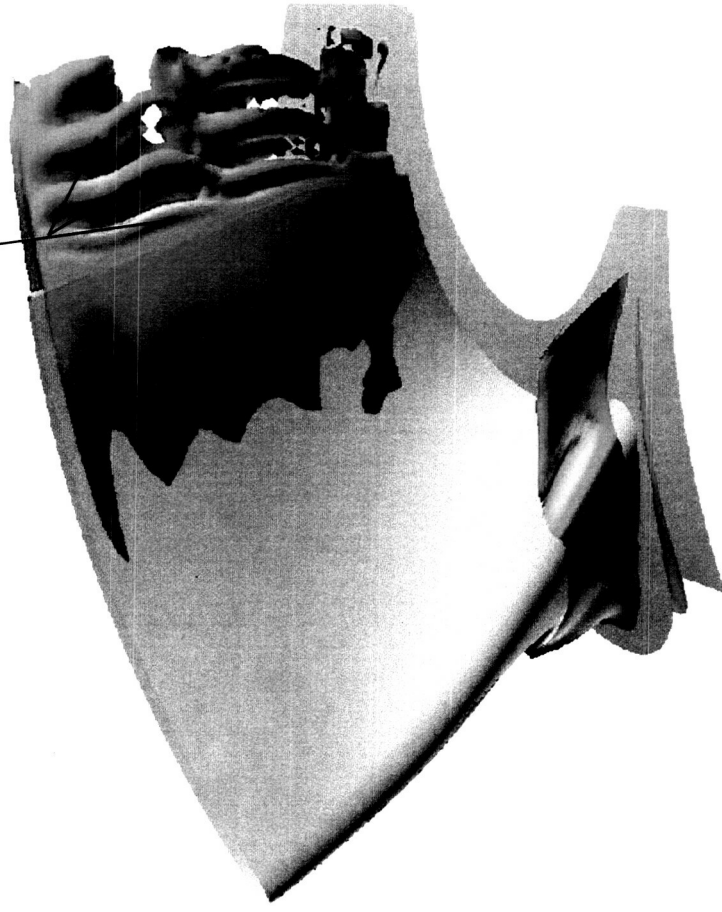
- Iso-Surfaces of Entropy for the Nozzle Vane



• Iso-Surfaces of Entropy for the Rotor

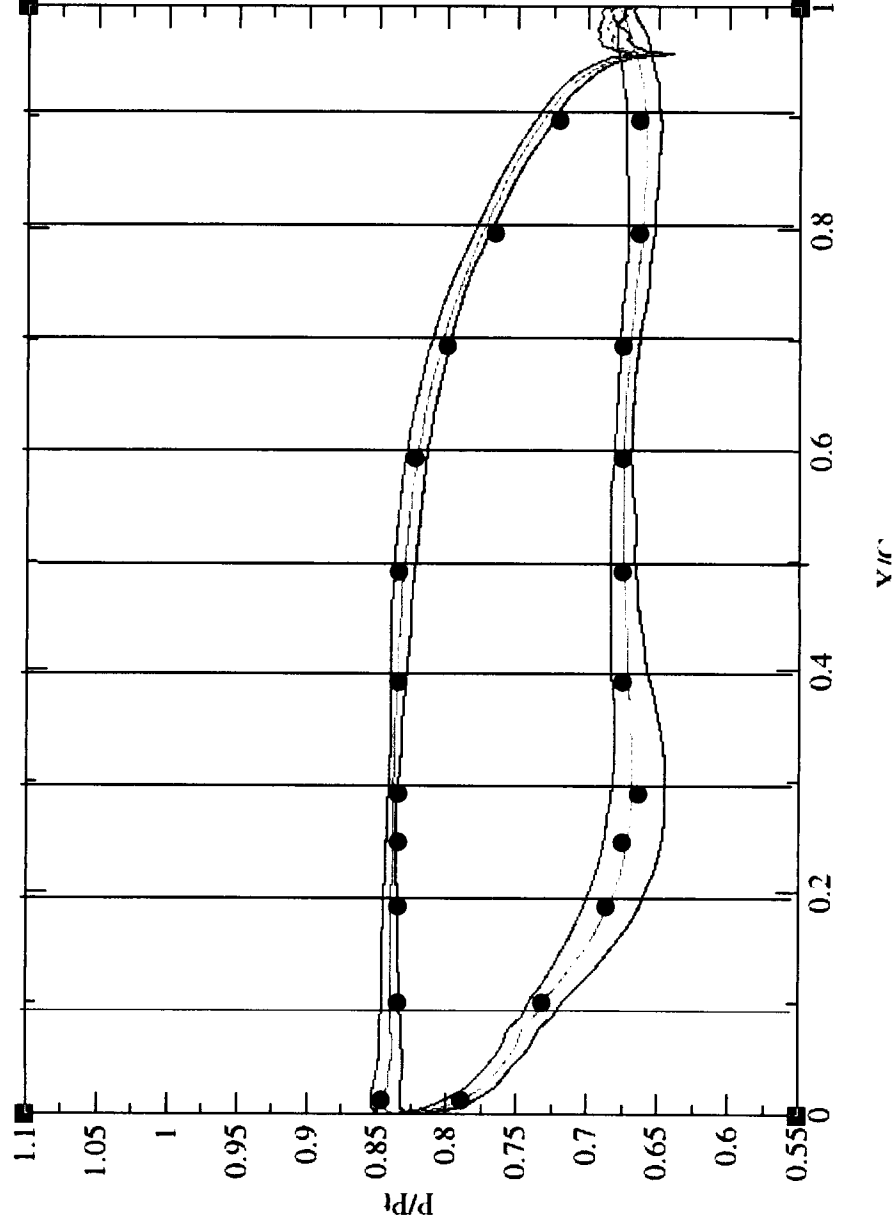


Vortex Shedding



Instrumentation Locations

- CFD to determine instrumentation locations for test



Leading edge: pressure and suction side(as close to i.e. as possible)

10% axial chord : pressure and suction side

20% axial chord : pressure and suction side

25% axial chord : pressure and suction side

30% axial chord : pressure and suction side

40% axial chord : pressure and suction side

50% axial chord : pressure and suction side

60% axial chord : pressure and suction side

70% axial chord : pressure and suction side

80% axial chord : pressure and suction side

90% axial chord : pressure and suction side

(22 Sensors total at 50%span)

Maximum
Time Average
Minimum



- TAF^T test matrix

- Taft testing began April 2003
- Testing will provide good validation database for CFD and Meanline analysis codes

TAF^T Test matrix

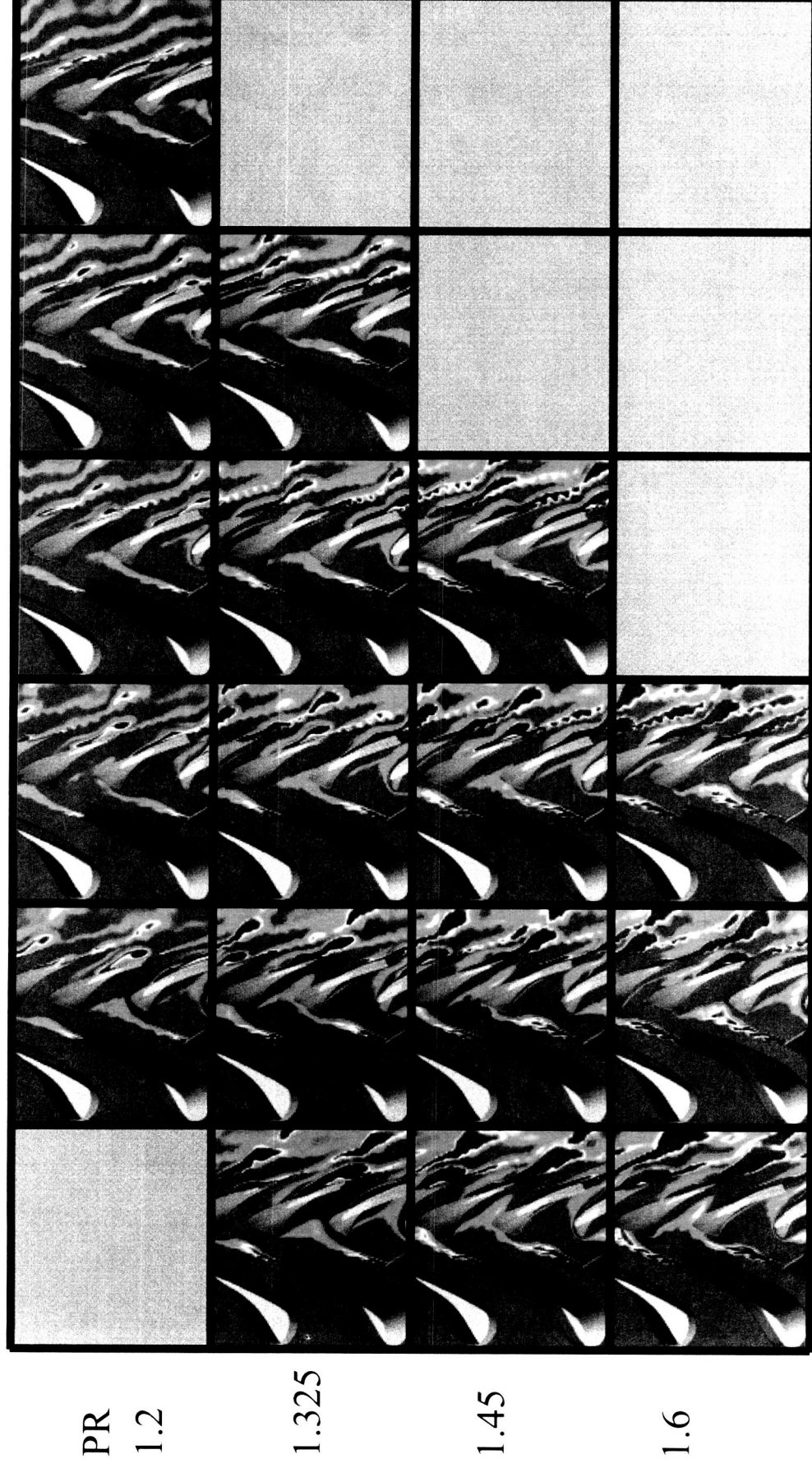
U/C0 PR	.440	.500	.579	.658	.729	.8
1.2		6122 rpm 19.31 lb/sec 124.6 ft-lb	7091 rpm 19.34 lb/sec 112.5 ft-lb	8058 rpm 19.35 lb/sec 100.1 ft-lb	8925 rpm 19.38 lb/sec 89.4 ft-lb	9794 rpm 19.46 lb/sec 79.5 ft-lb
1.325	6646 rpm 22.49 lb/sec 192.3 ft-lb	7552 rpm 22.50 lb/sec 179.0 ft-lb	8746 rpm 22.53 lb/sec 161.6 ft-lb	9939 rpm 22.56 lb/sec 143.9 ft-lb	11011 rpm 22.60 lb/sec 128.7 ft-lb	
1.45	7589 rpm 24.47 lb/sec 238.6 ft-lb	8623 rpm 24.48 lb/sec 222.2 ft-lb	9986 rpm 24.52 lb/sec 200.6 ft-lb	11348 rpm 24.56 lb/sec 178.7 ft-lb		
1.6	8476 rpm 25.97 lb/sec 282.3 ft-lb	9635 rpm 26.0 lb/sec 262.9 ft-lb	11154 rpm 26.03 lb/sec 237.3 ft-lb			



• TAFIT test matrix CFD Solutions

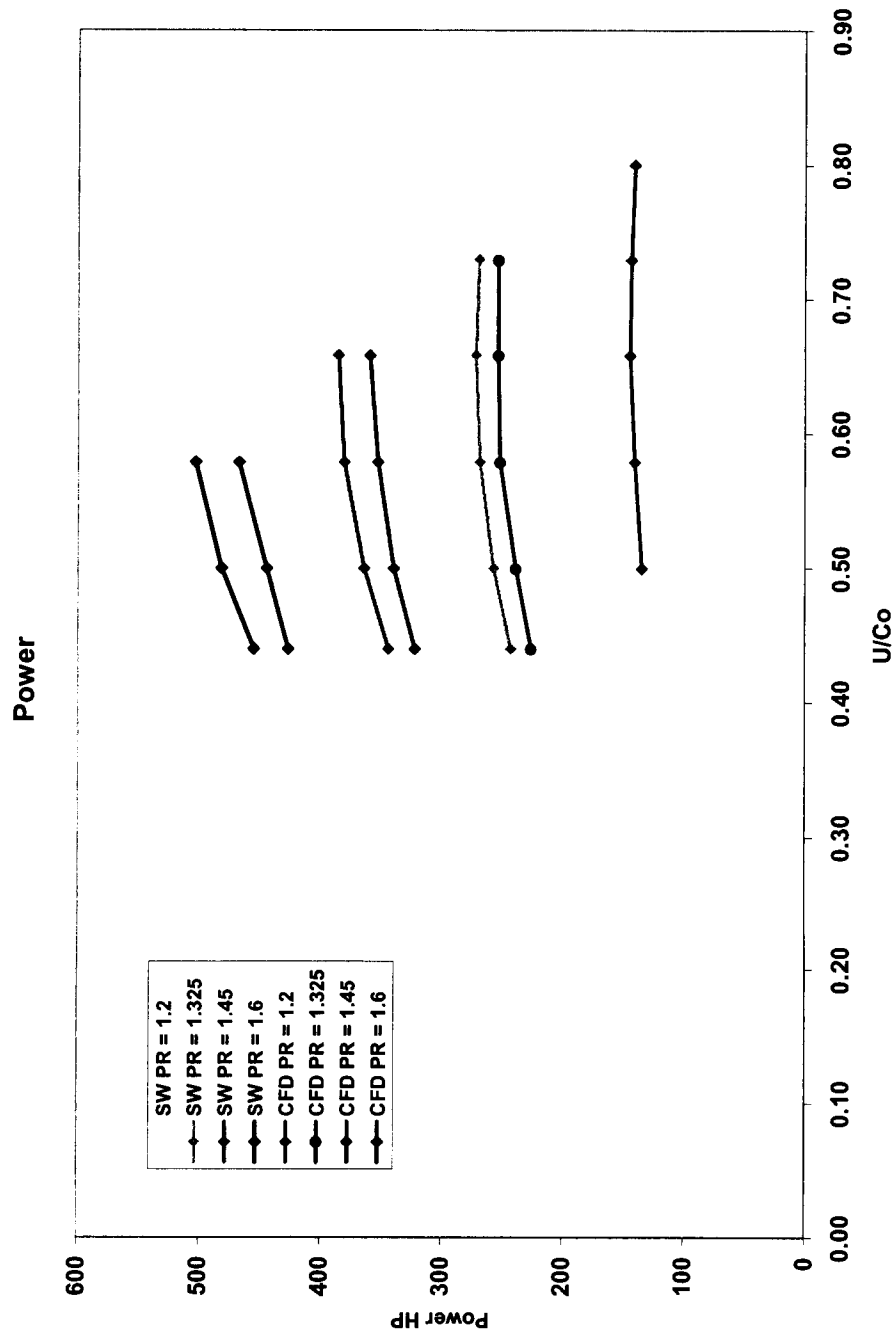
- Absolute entropy contours shown below

U/Co 0.440 0.500 0.579 0.658 0.729 0.800



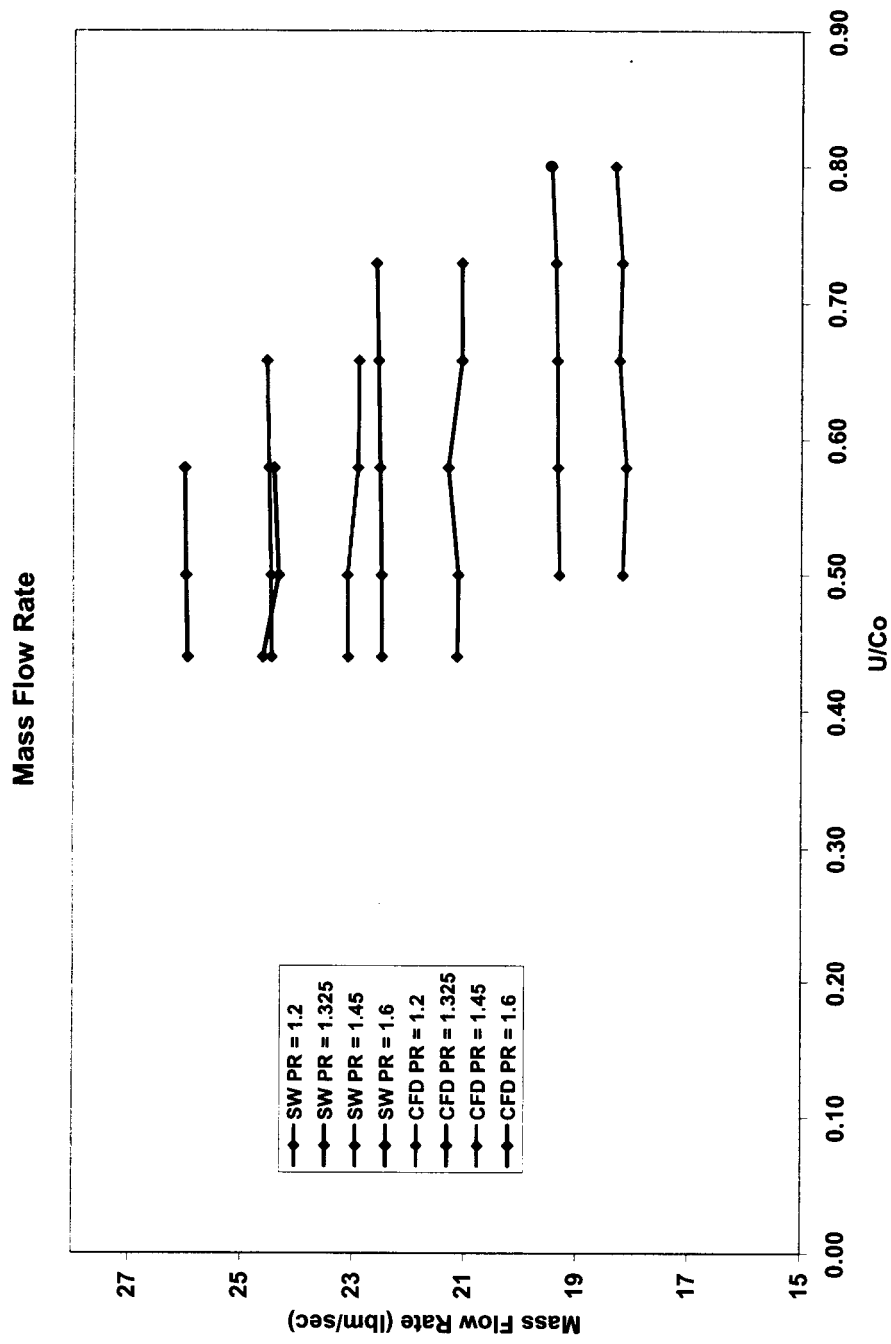
• TAFI test matrix CFD / Meanline Comparison

- Meanline XXXX



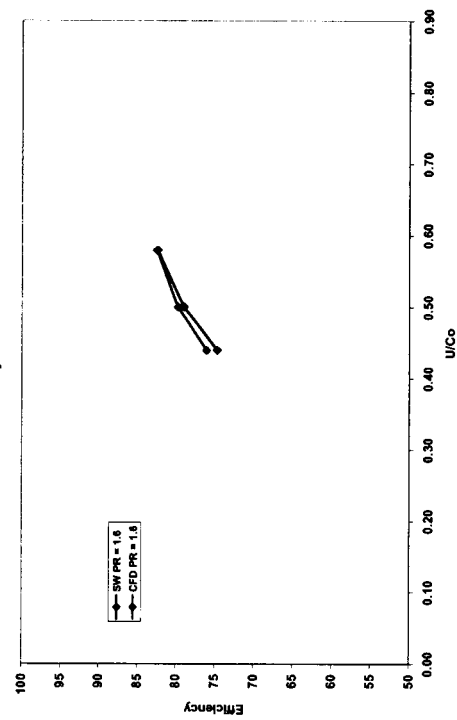
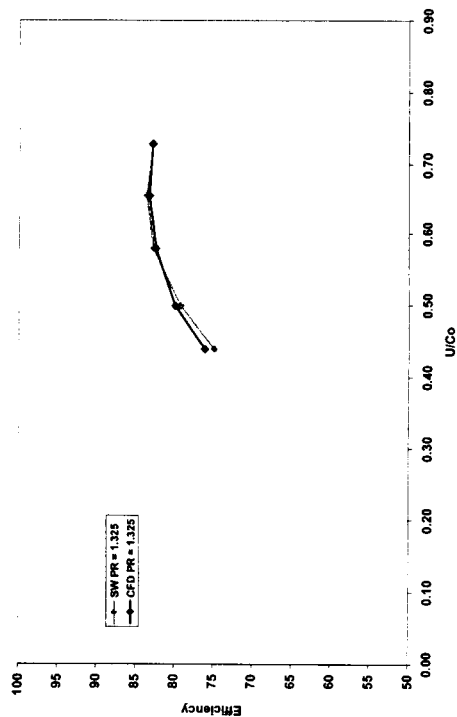
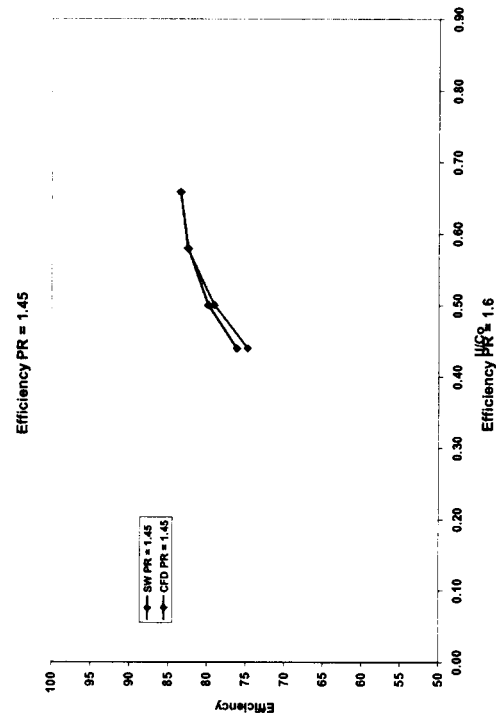
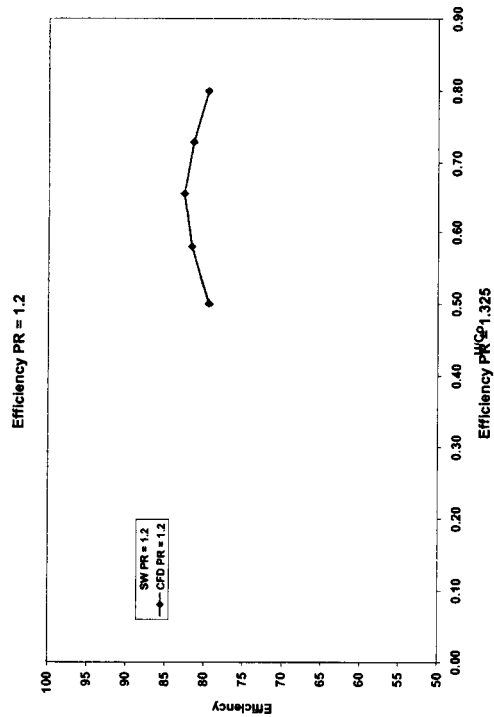
• TAFt test matrix CFD / Meanline Comparison

- Meanline XXXX



• TAF test matrix CFD / Meanline Comparison

- Meanline XXXX



- Conclusions

- Simulations Completed for 13 Vane case / Design Axial Gap
- Currently interrogating solutions
- Testing for 13 vane configuration to begin May 2003
- CFD Shows higher mass flow than meanline
- Initial testing suggests (Preliminary):
 - CFD shows the higher mass flow than Meanline and Test
 - Meanline Codes flow 3% more than Test rig
- Test will provide excellent validation / comparison tool for both CFD and Meanline analysis tools
- Final Comparisons will be presented when complete

