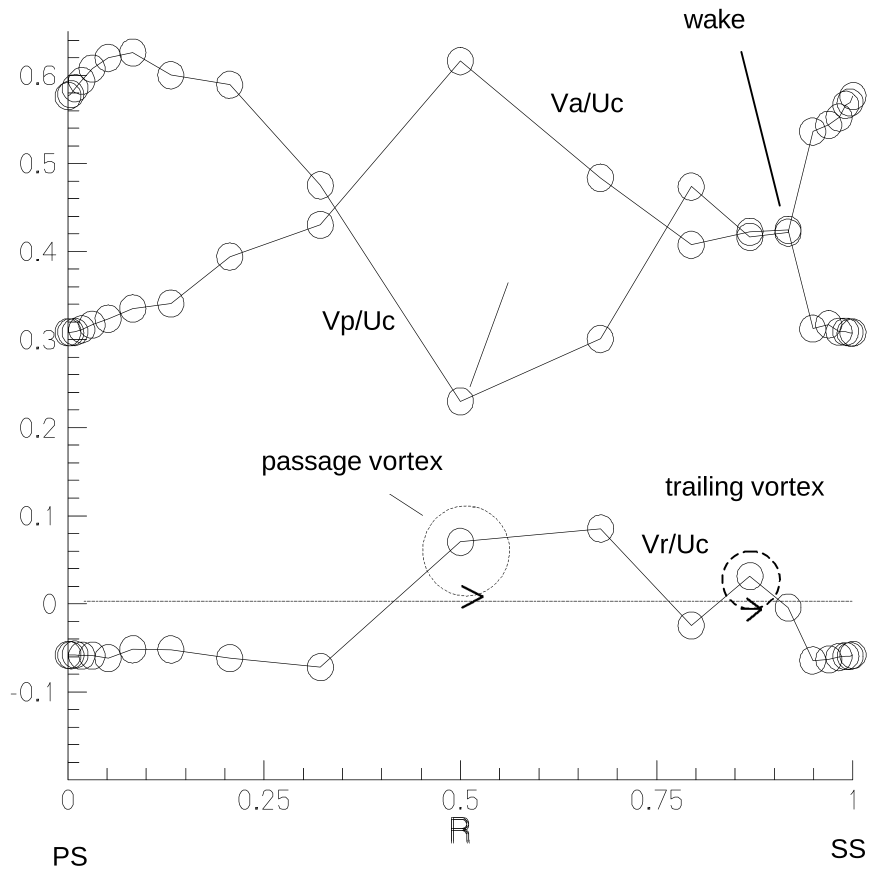
Corsini and Rispoli

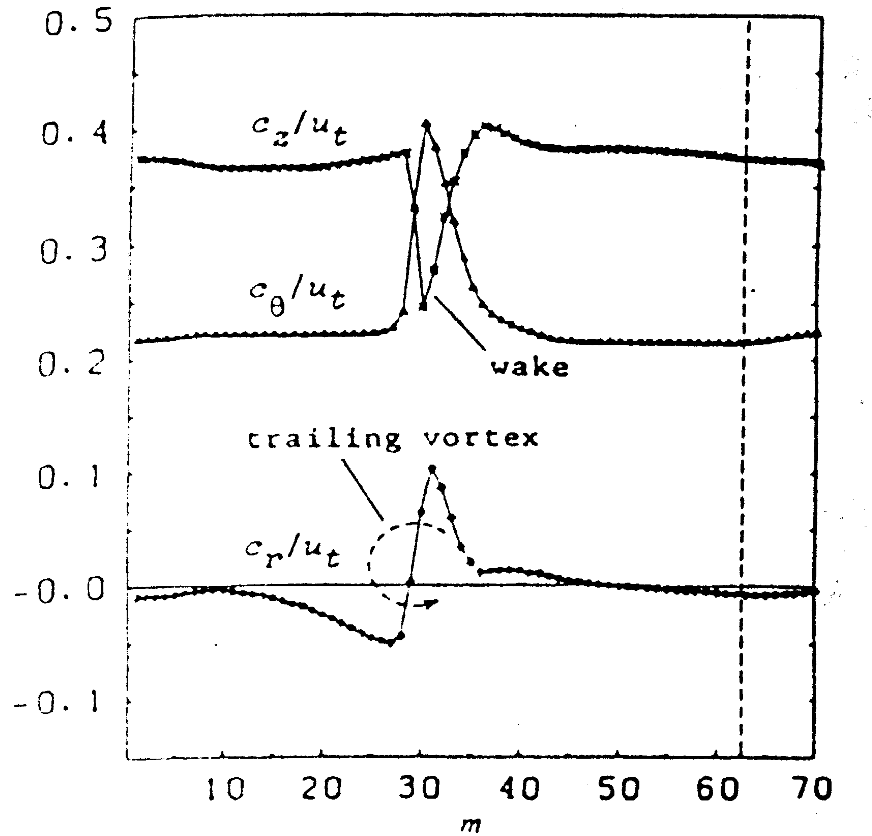
Navier-Stokes prediction obtained with XENIOS finite element code (1991) - grid 59 × 21 × 31

tip clearance $t = 1.8\%\ l_c$



Inoue and Kuroumaru free vortex rotor (1984)

tip clearance $t = 1.2\%\ l_c$



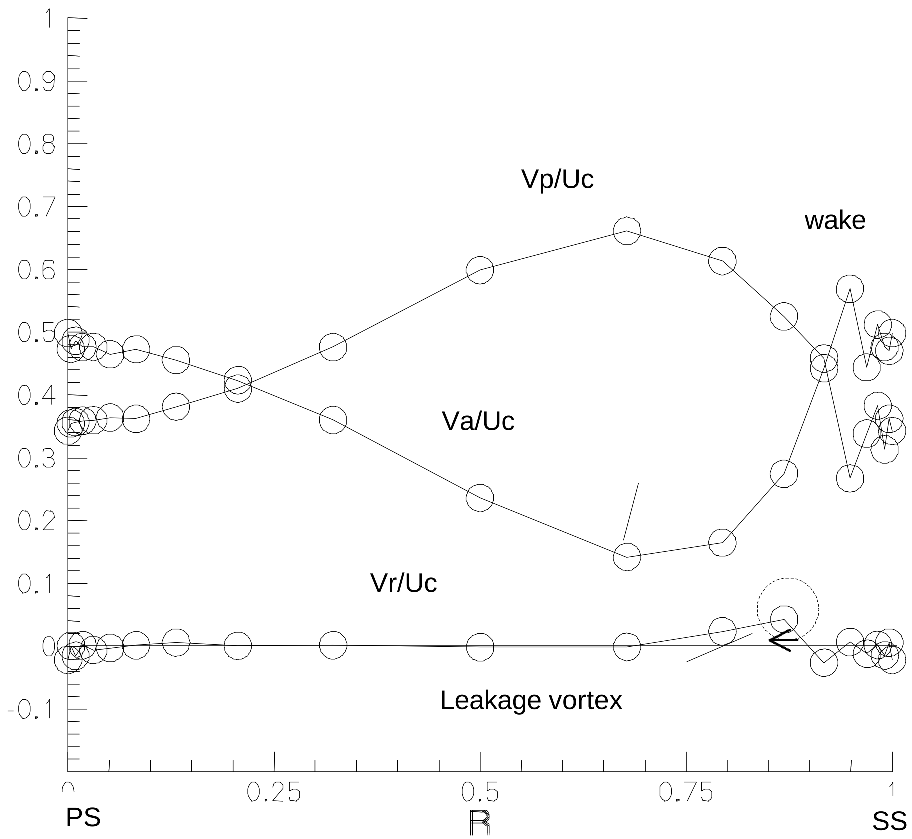
near the hub (r/r_c = 0.642)

Pitchwise distributions of ensemble average velocites

Corsini and Rispoli

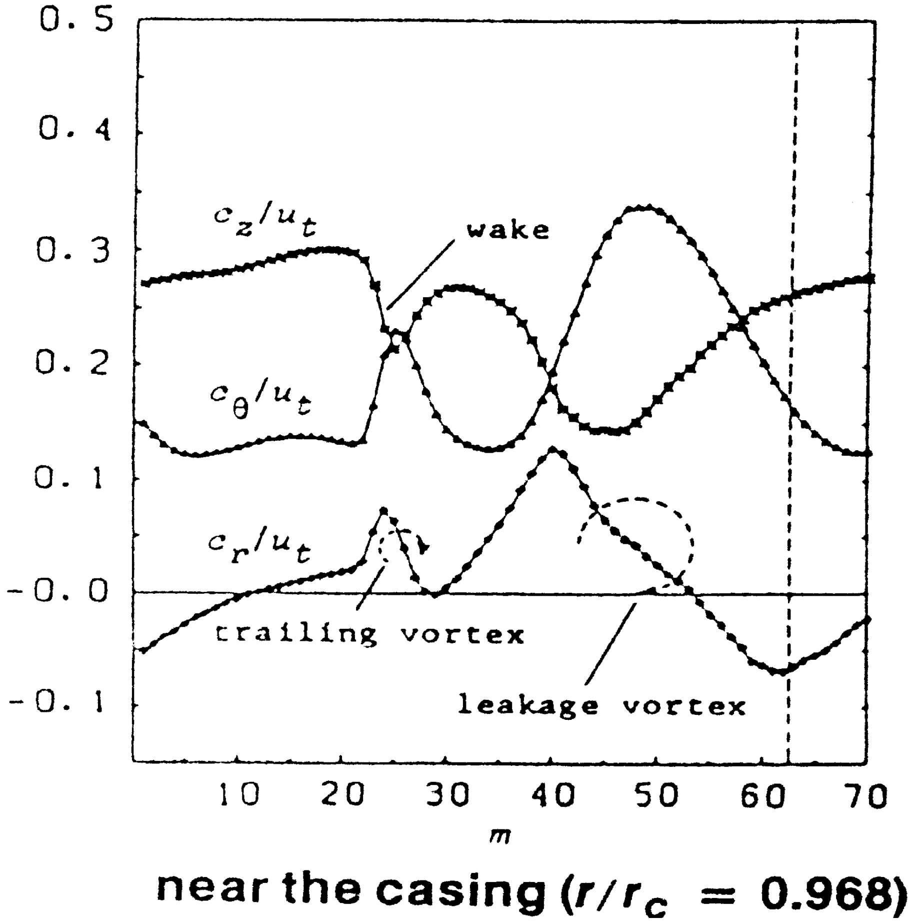
Navier-Stokes prediction obtained with XENIOS finite element code (1991) - grid $59 \times 21 \times 31$

tip clearance t = *1.8%* l_c



Inoue and Kuroumaru free vortex rotor (1984)

tip clearance t = *1.2%* l_c

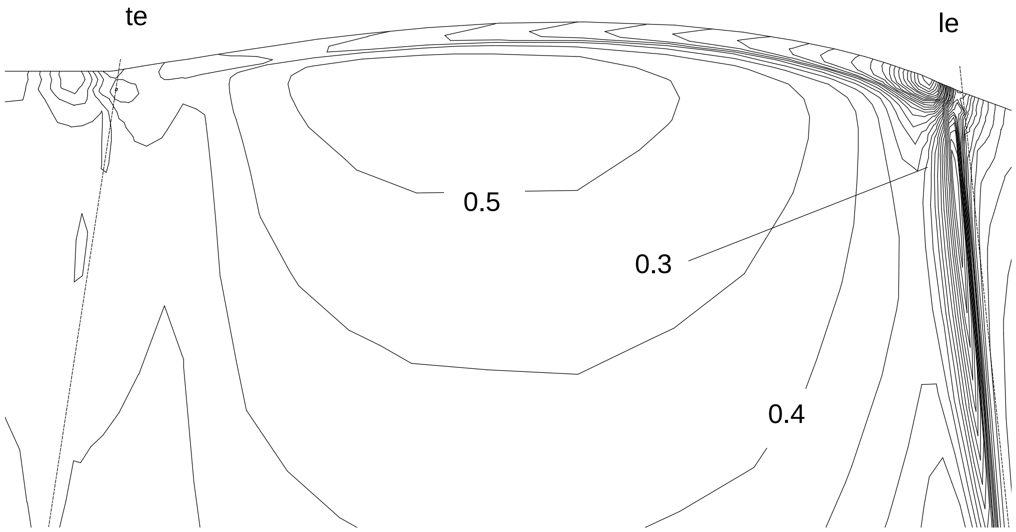


Pitchwise distributions of ensemble average velocites

Corsini and Rispoli

Navier-Stokes prediction obtained with XENIOS finite element code - grid 59 × 21 × 31

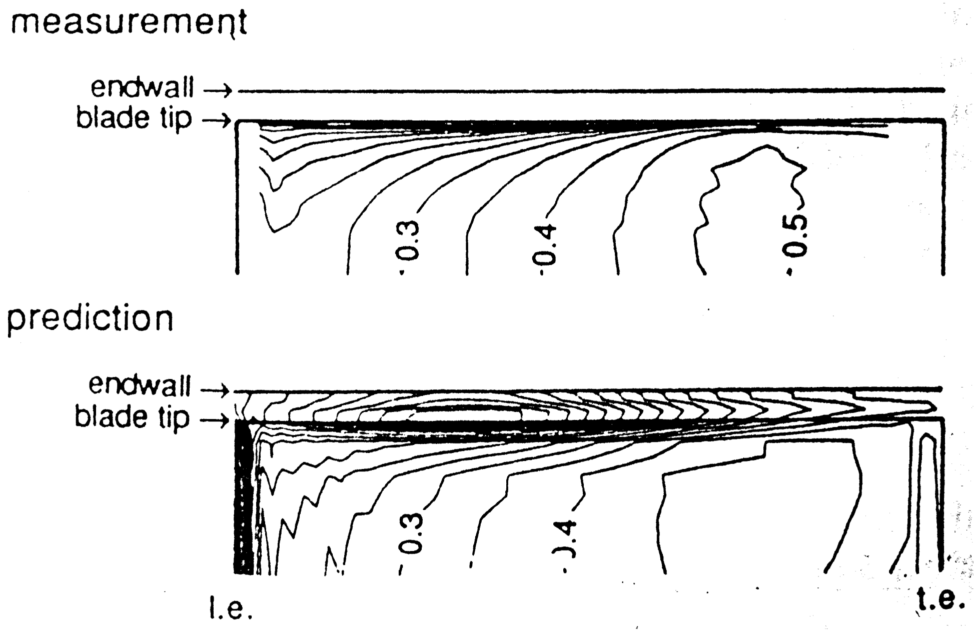
tip clearance $t = 1.8\% \, l_c$



Storer and Cumpsty linear cascade (1991)

Navier-Stokes prediction obtained with Dawes finite volume code (1987) - grid 61 × 25 × 33

tip clearance $t = 4\% \, l_c$

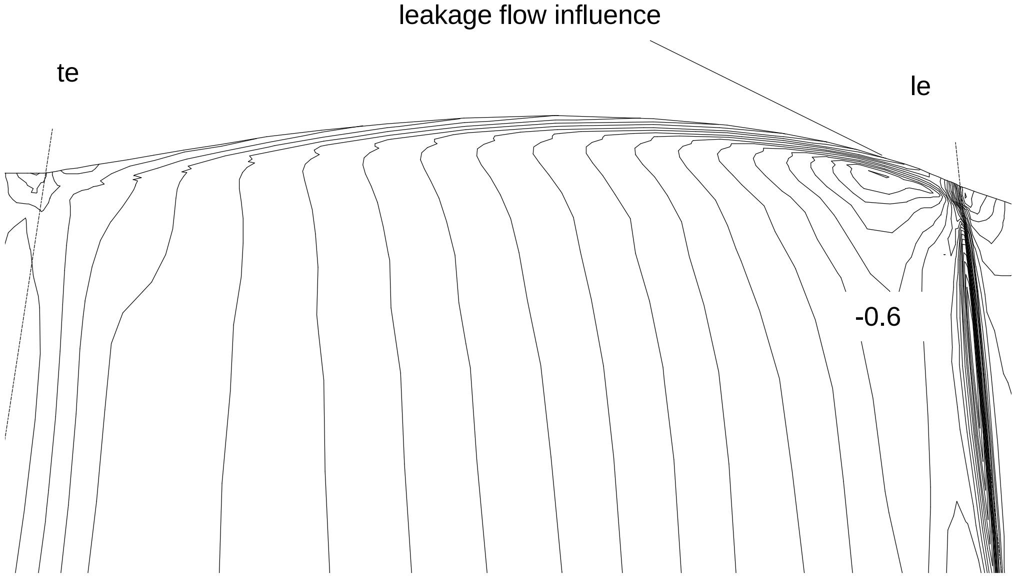


Blade surface static pressure distribution (C_p) - pressure side

Corsini and Rispoli

Navier-Stokes prediction obtained with XENIOS finite element code - grid 59 × 21 × 31

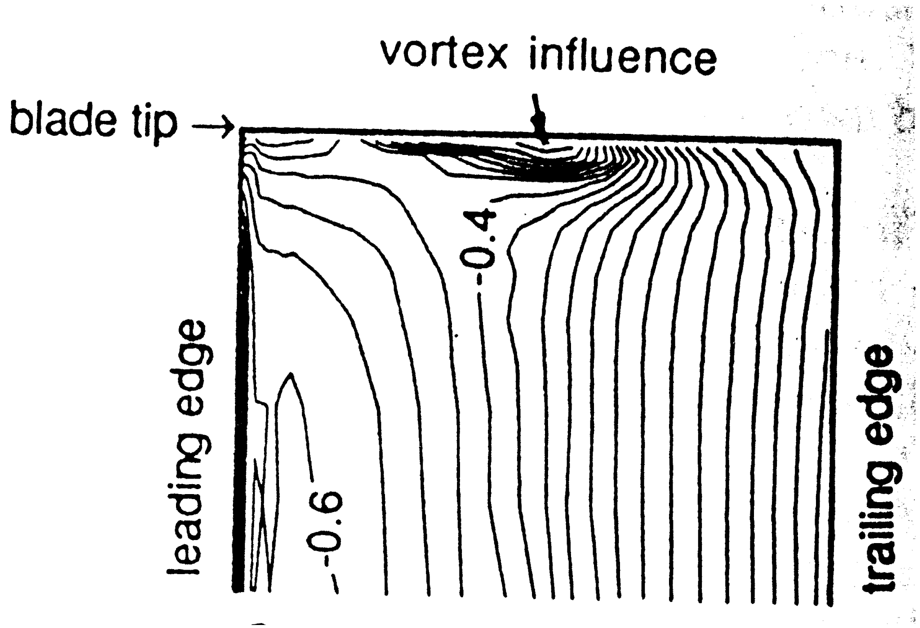
tip clearance $t = 1.8\%\ l_c$



Storer and Cumpsty linear cascade (1991)

Navier-Stokes prediction obtained with Dawes finite volume code (1987) - grid 61 × 25 × 33

tip clearance $t = 4\%\ l_c$

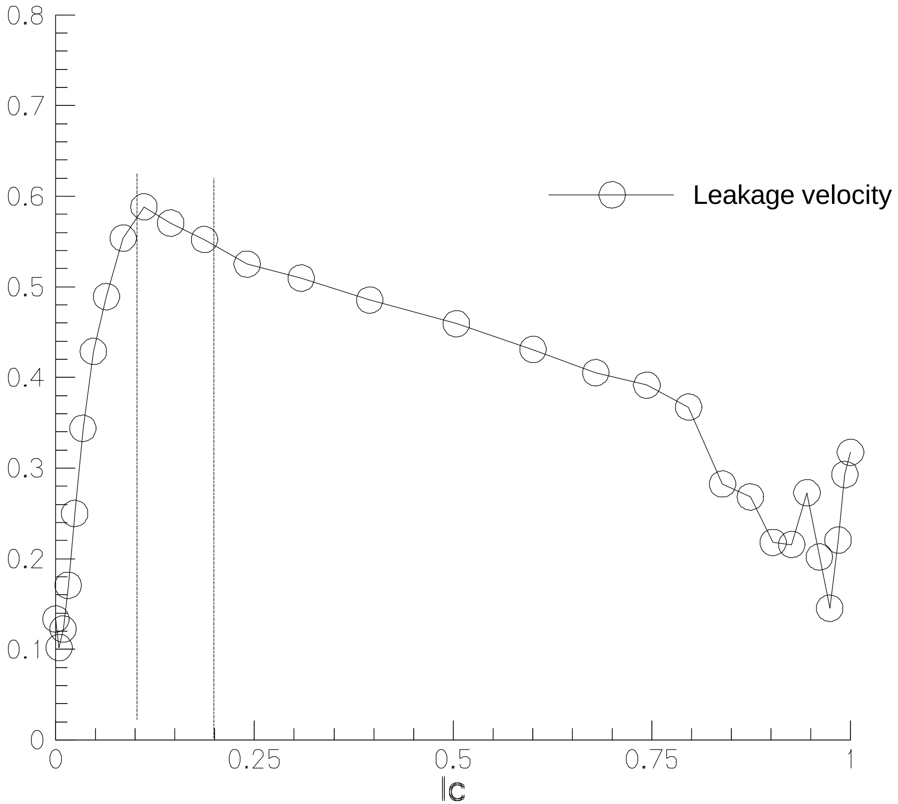


Blade surface static pressure distribution (C_p) - suction side

Corsini and Rispoli

Navier-Stokes prediction obtained with XENIOS finite element code - grid 59 × 21 × 31

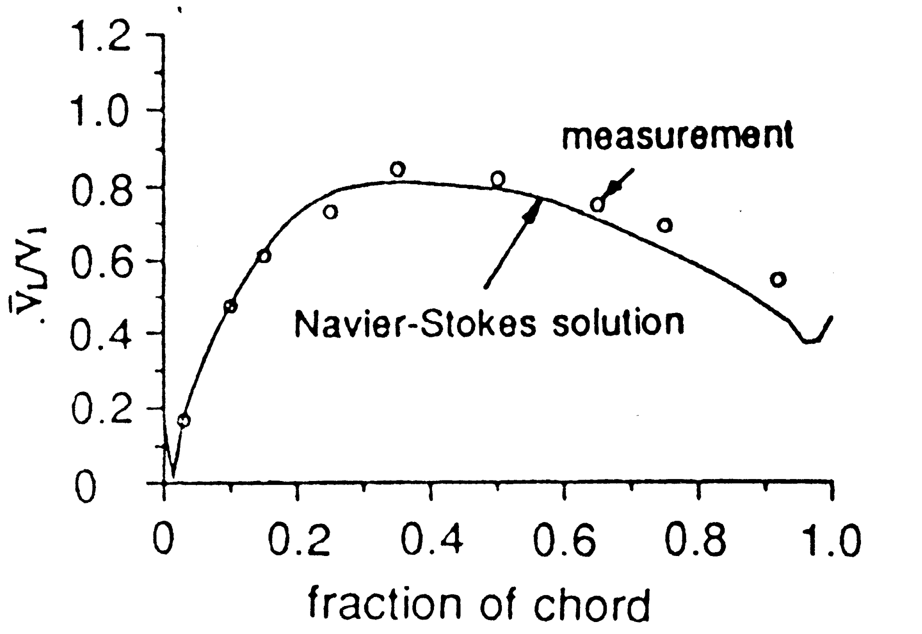
tip clearance $t = 1.8\%\ l_c$



Storer and Cumpsty linear cascade (1991)

Navier-Stokes prediction obtained with Dawes finite volume code (1987) - grid 61 × 25 × 33

tip clearance $t = 2\%\ l_c$



Chordwise distribution of averaged tip leakage flow velocity

Corsini and Rispoli

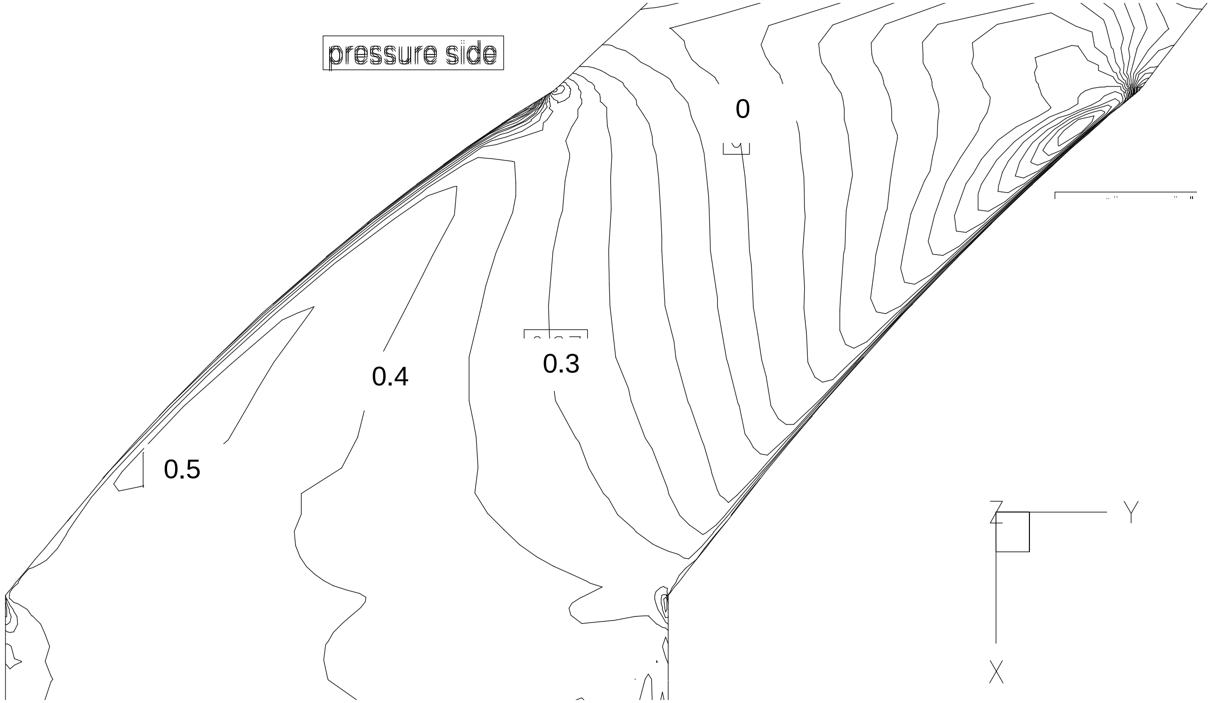
Navier-Stokes prediction obtained with XENIOS finite element code - grid $59 \times 21 \times 31$

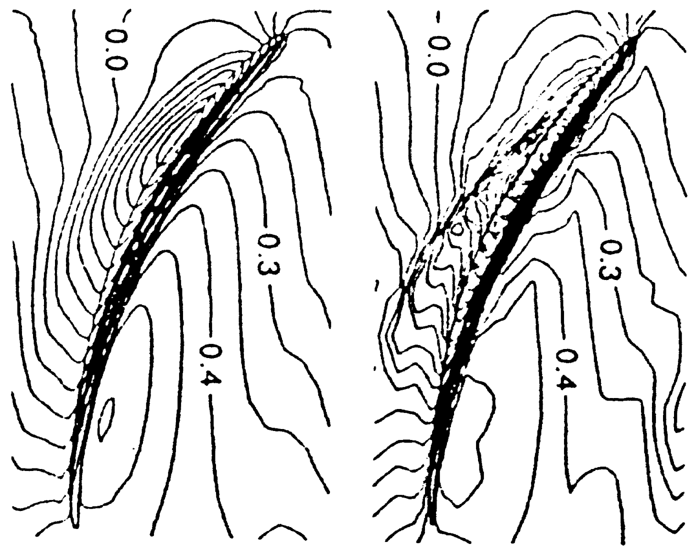
tip clearance $t = 1.8\% \, l_c$

Storer and Cumpsty linear cascade (1991)

Navier-Stokes prediction obtained with Dawes finite volume code (1987) - grid $61 \times 25 \times 33$

tip clearance $t = 2\% \, l_c$



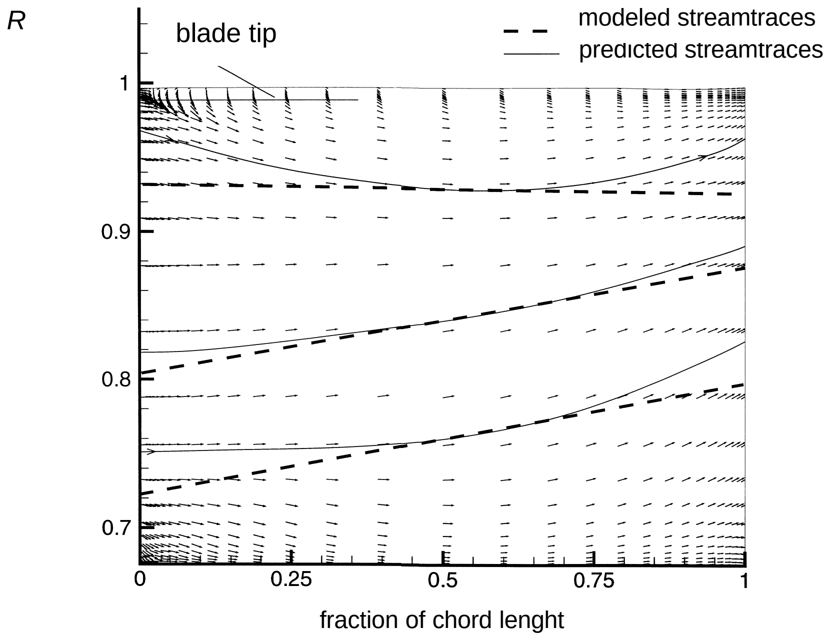


prediction measurement

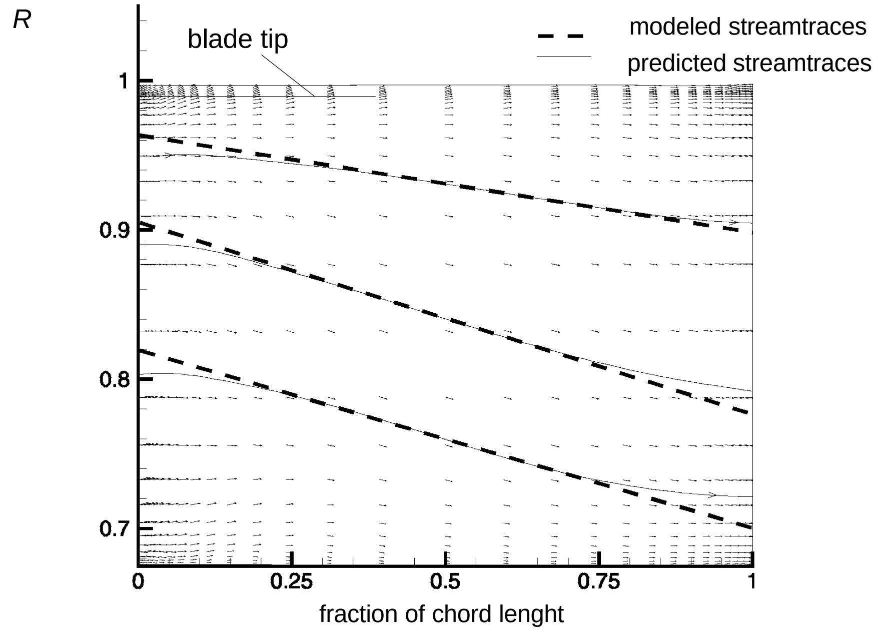
Blade surface static pressure distribution (C_p) - pressure side

CFD ORIENTED *AXIAL FAN* DESIGN IMPROVEMENT (1)

- CFD INTER-BLADE FLOW PHYSICS PREDICTION



Velocity field close to the blade suction side



Velocity field close to the blade pressure side

- Blade lift synthesized by use of “cone couple” model

  separate optimization of blade *pressure* and *suction sides*

  extend the validity of 2D cascade concept

CFD ORIENTED *AXIAL FAN* DESIGN IMPROVEMENT (2)

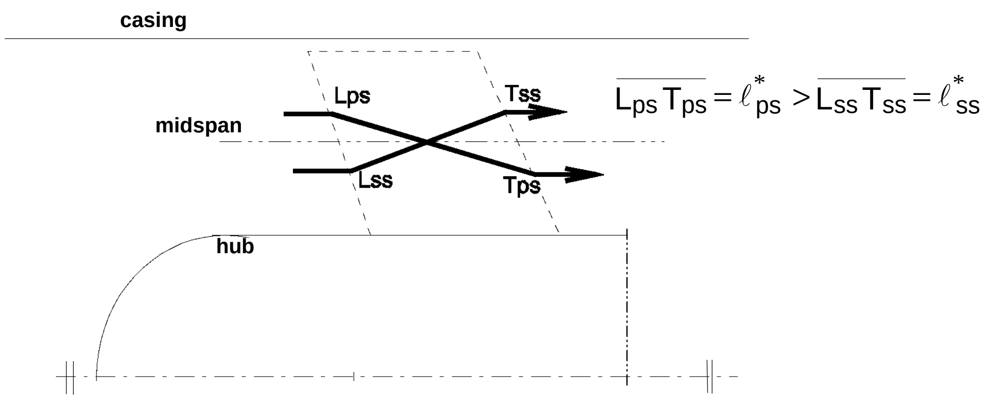
- on the basis of *computed* pitch-averaged flow

  force factor is evaluated $(\ell/t)c_\ell$

  optimum c_ℓ* is defined (Howell, 1942) ⇒ **optimum solidity values** $(\ell/t)^*$

	c_ℓ^*	$(\ell/t)c_\ell$	$(\ell/t)^*$
SS cone	0.893	1.004	1.124
PS cone	0.591	0.859	1.453

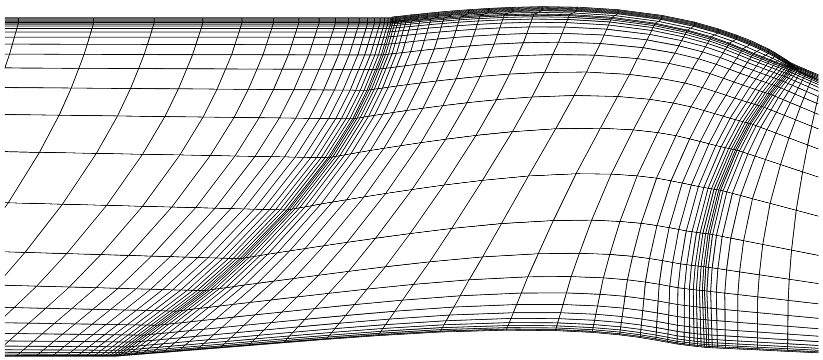
- optimized axial fan rotor geometry with *FORWARD SWEPT* blades



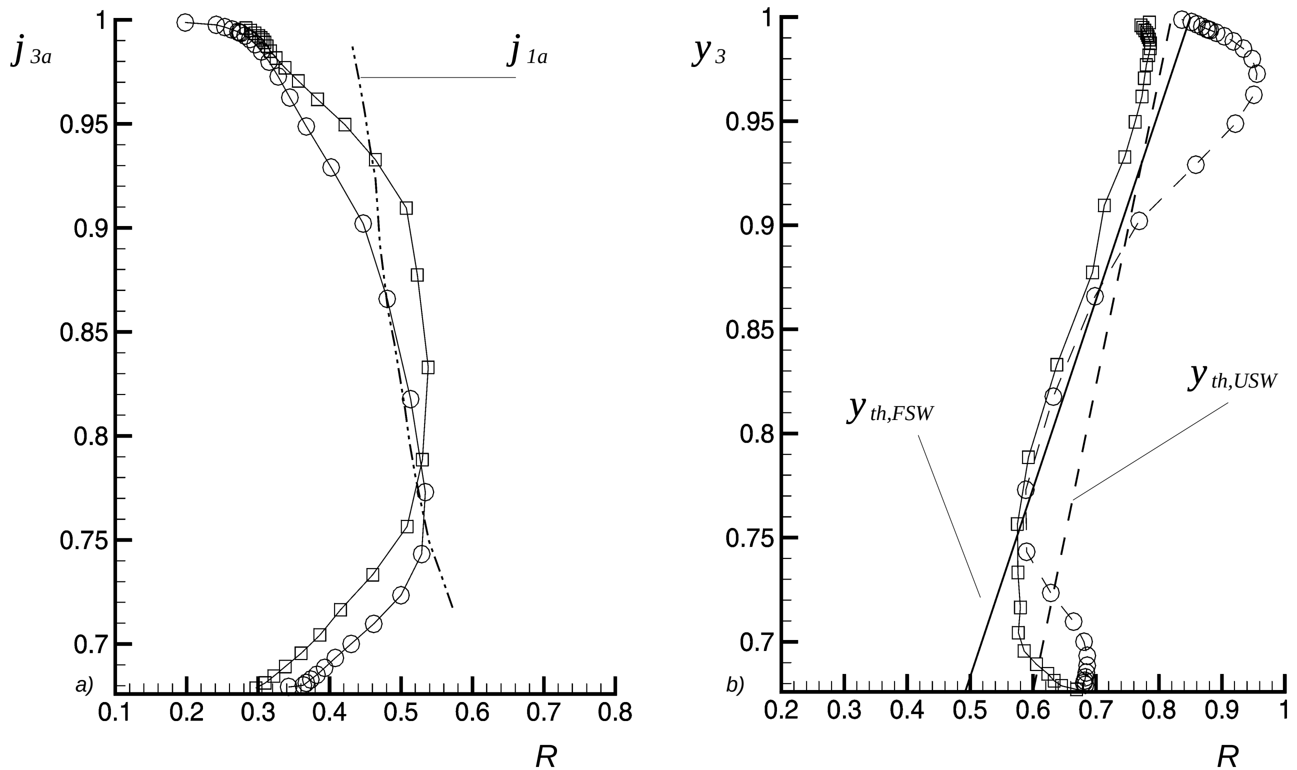
SWEPT AXIAL FAN ROTOR

- NON FREE VORTEX DESIGN
- CIRCULAR ARC *CAMBERED PLATE*

	Unswept bladed rotor			Swept bladed rotor		
blade number	12			12		
hub-to-casing diameter ratio	0.676			0.676		
tip clearance (percent span)	2 %			2 %		
flow coefficient F	0.50			0.50		
Ideal total head rise coefficient Y	0.70			0.70		
	hub	mid	tip	hub	mid	tip
blade solidity ℓ / t	1.53	1.24	1.05	1.79	1.23	1.13
forward sweep angle, deg	0	0	0	30	30	30
stagger angle, deg	47.9	42.2	38.3	56.3	43.1	37.4
camber angle, deg	27.4	23.1	19.9	35.4	25.4	20.3

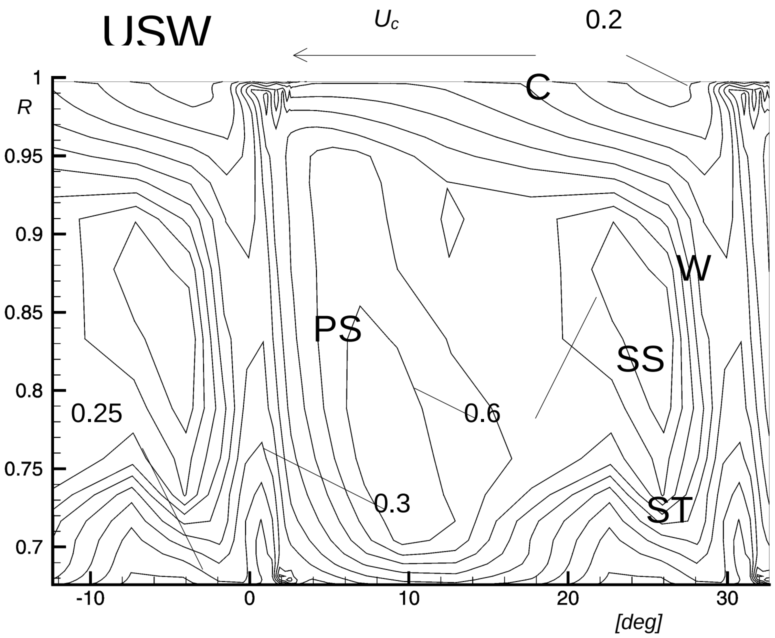


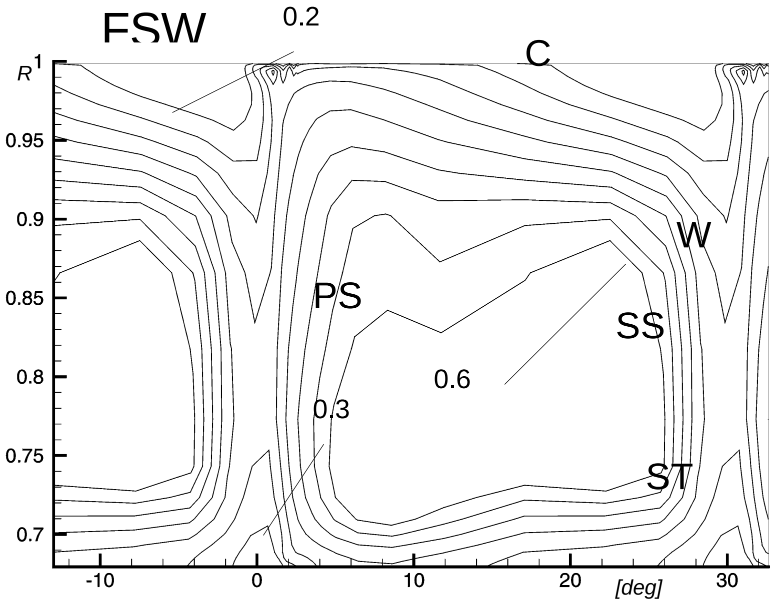
SWEPT AXIAL FAN ROTOR FLOW SURVEY (1)



Pitchwise-averaged flow data for FSW and USW rotors
(circles: FSW; squares: USW)

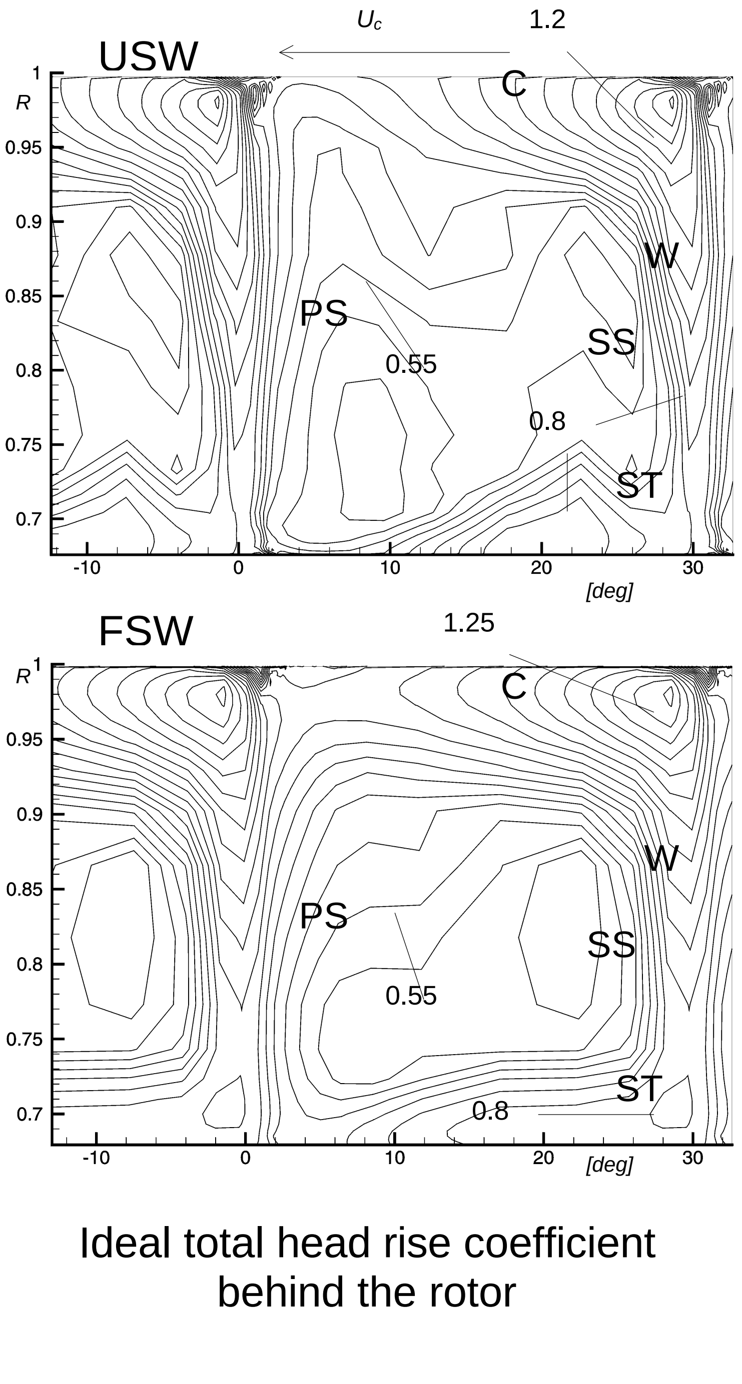
SWEPT AXIAL FAN ROTOR FLOW SURVEY (2)





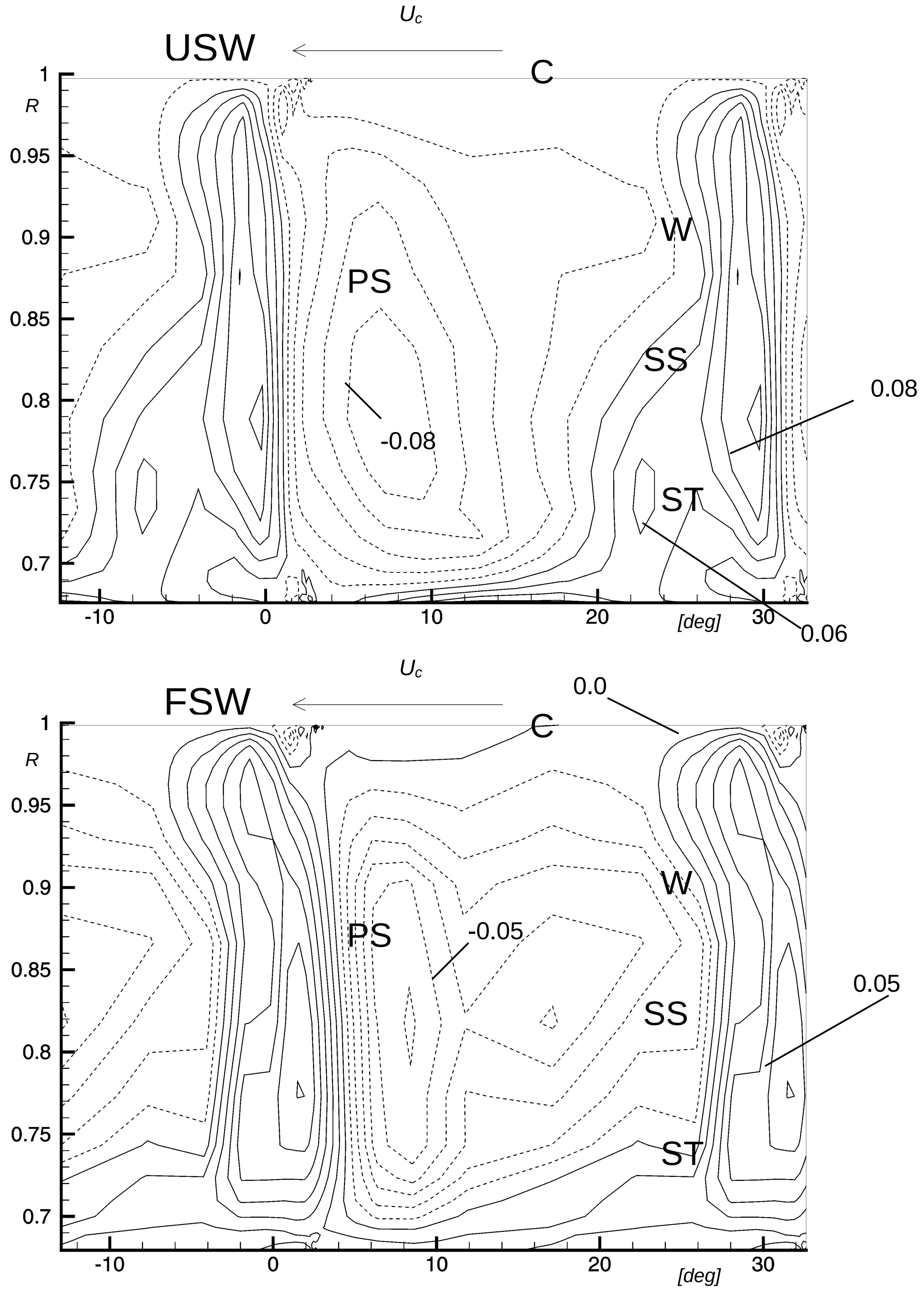
Axial flow coefficient behind the rotor

SWEPT AXIAL FAN ROTOR FLOW SURVEY (3)



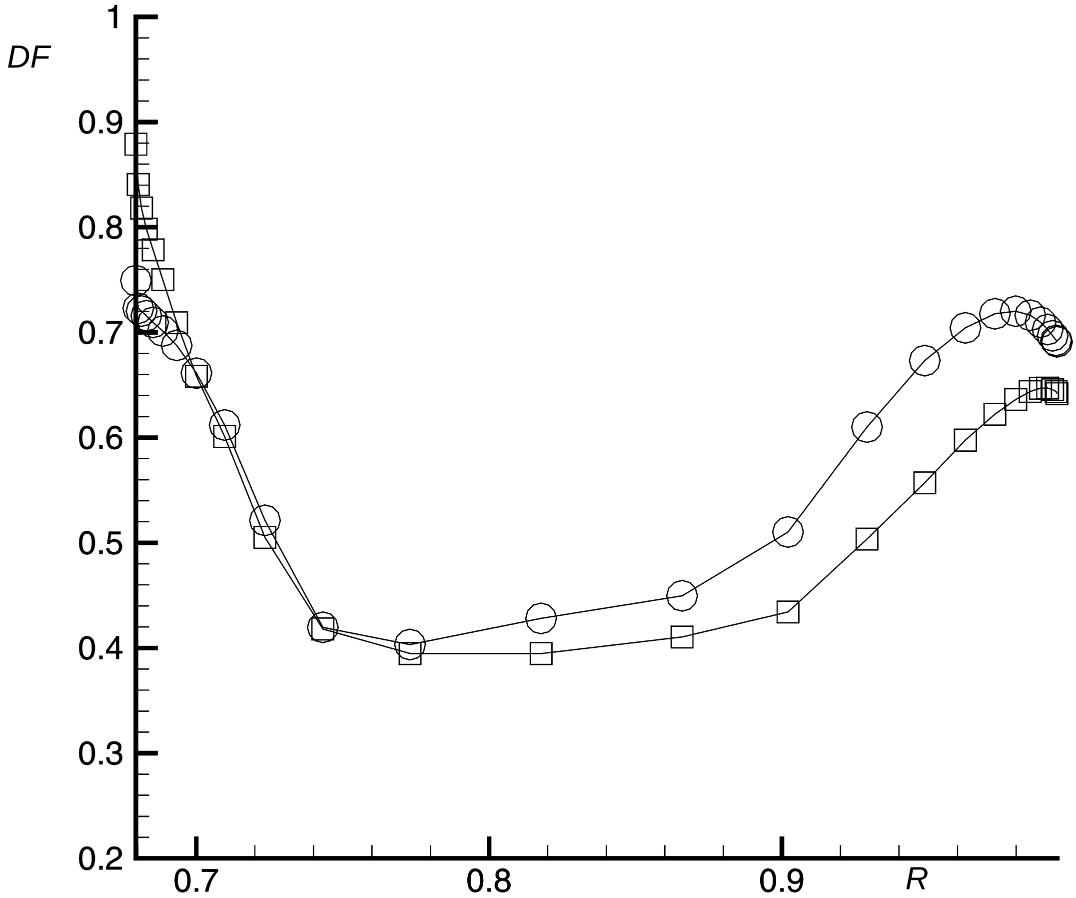
Ideal total head rise coefficient
behind the rotor

SWEPT AXIAL FAN ROTOR FLOW SURVEY (4)



radial flow coefficient
behind the rotor

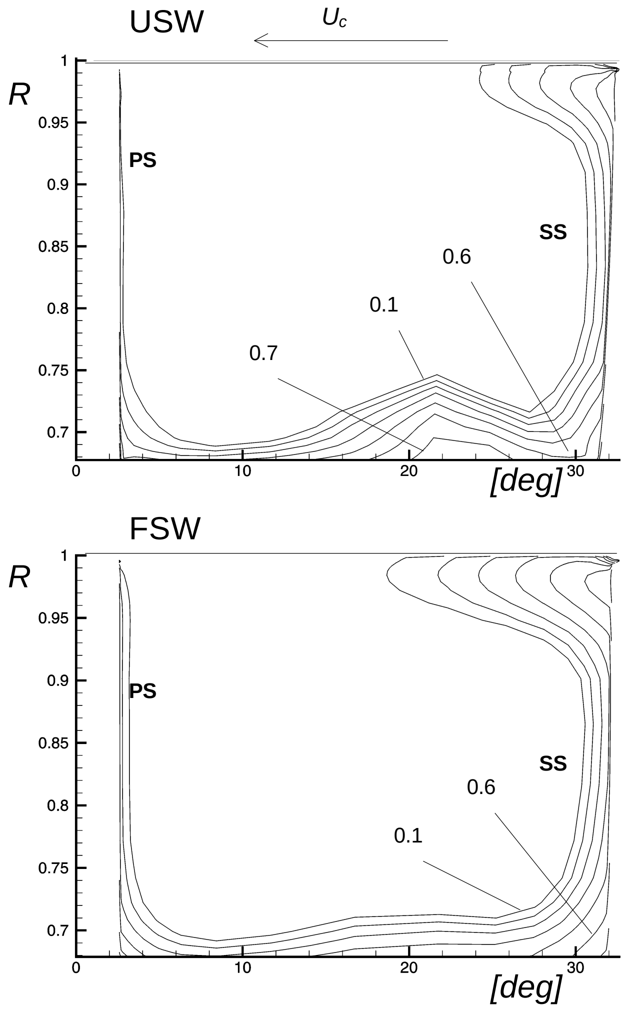
SWEPT AXIAL FAN ROTOR LOADING



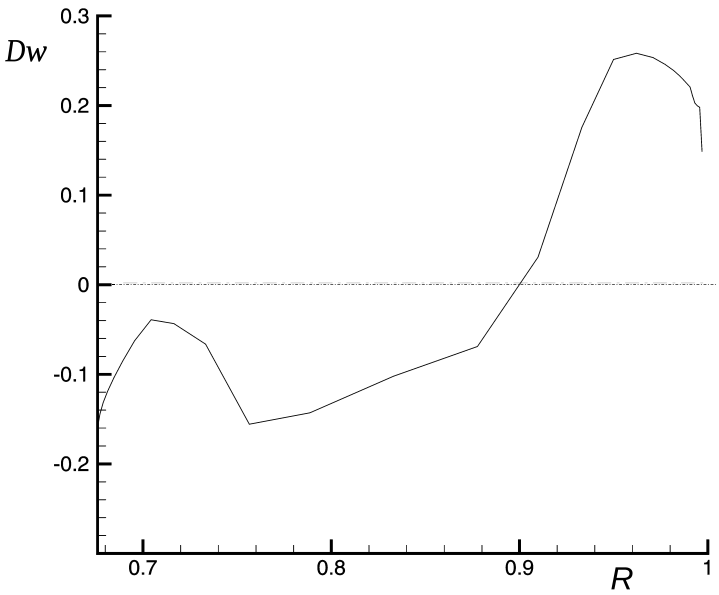
Diffusion factor profile along the span
(circles: FSW; squares: USW)

$$DF(R) = 1 - \overline{w}_{out} / \overline{w}_{in} + D\overline{w}_{p} \; / \; 2s \; \overline{w}_{in}$$

SWEPT AXIAL FAN ROTOR LOSS BEHAVIOR



Loss coefficient distribution
at *98*% blade chord

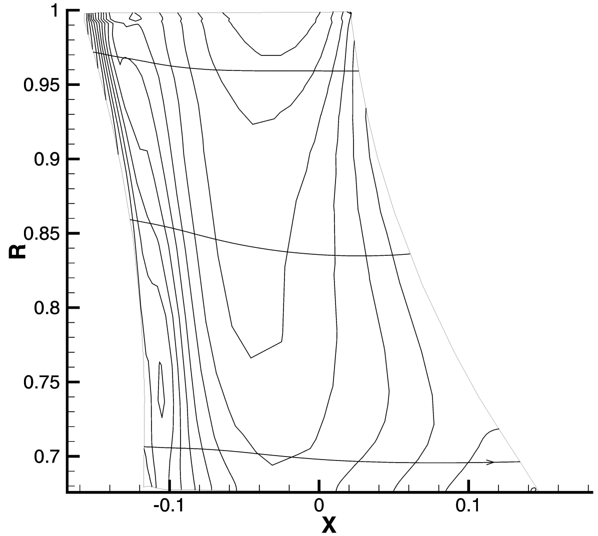


Loss improvement factor

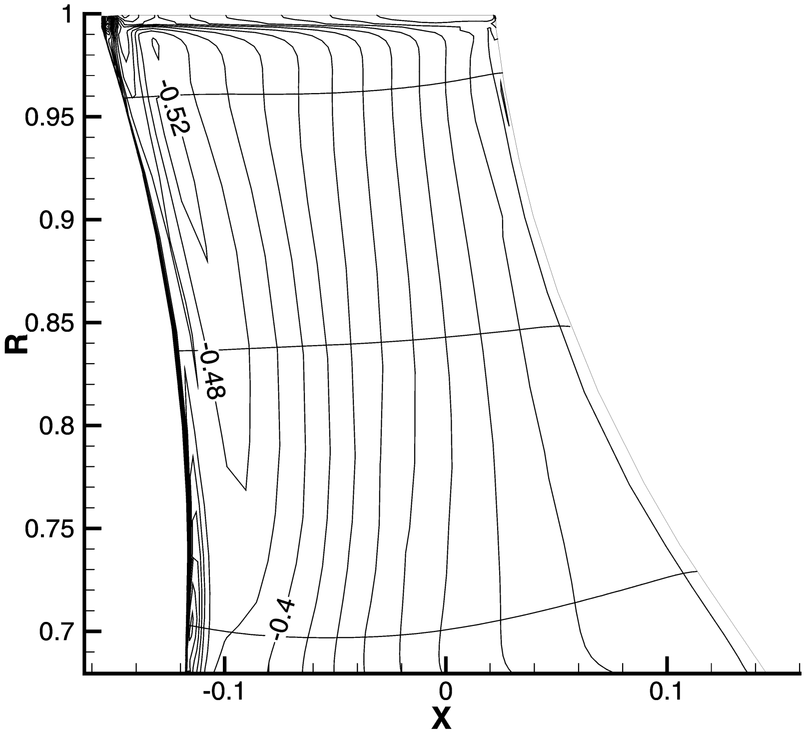
$$w = \overline{p}_{0in} - p_{0out} \Big/ 0.5\, r \overline{V}_{in}^{2}$$

$$Dw(R) = \overline{w}_{FSW} - \overline{w}_{USW} \big|_{R}$$

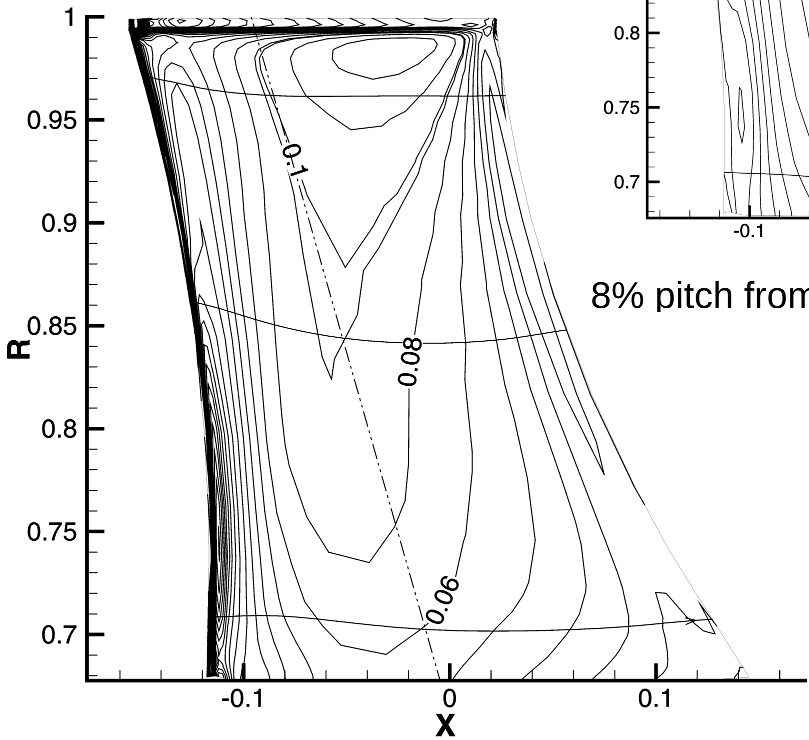
SWEPT AXIAL FAN ROTOR FLOW SURVEY (5)



8% pitch from blade pressure side



streamlines on blade suction side



streamlines on blade pressure side