SOCRATES Teaching Staff Mobility Program
2000 - 2001

Technical University of Budapest
1782
Department of Fluid Mechanics

DMA-URLS

Finite Element Method
for Turbomachinery Flows

Numerical studies on axial flow fan rotor aerodynamics

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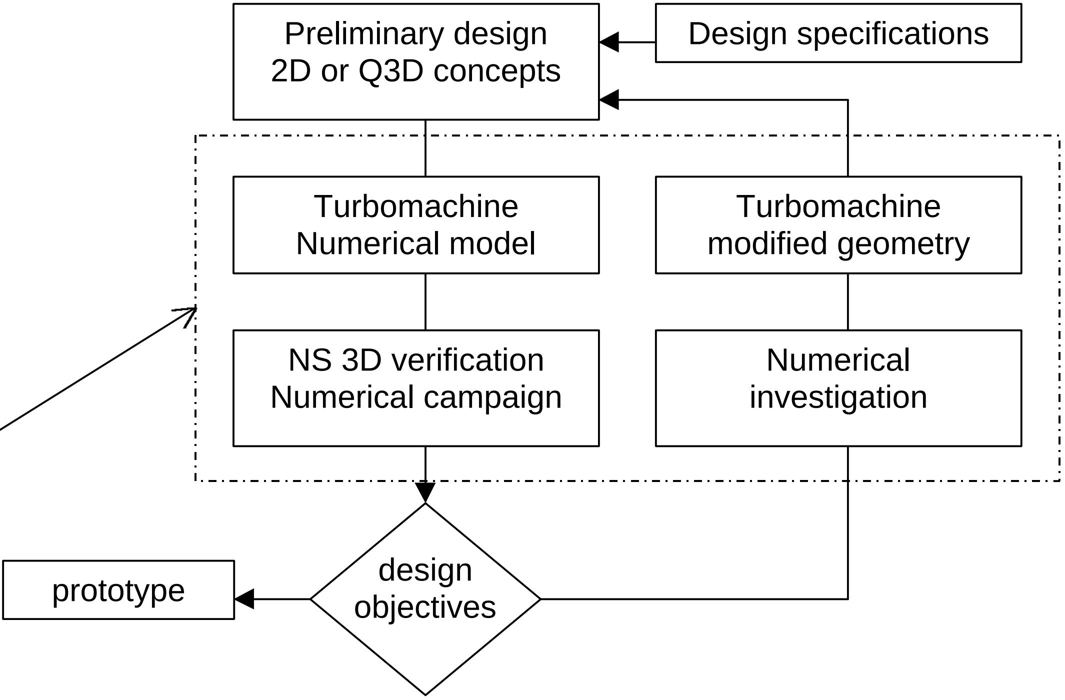
***BUDAPEST University of Technology and Economics* - 28 November 2000**

HOW CFD IMPLEMENTS TURBOMACHINERY DESIGN

- CFD INFLUENCE ON TURBOMACHINERY DESIGN



- CONCERTED EXPERIMENTAL AND NUMERICAL ANALYSIS
    - UPSTREAM/DOWNSTREAM LDA DATA COMPLEMENTED BY CFD INTERBLADE PREDICTION
    - GUIDELINES FOR IMPROVEMENT OF DESIGN METHOD ⇒ CFD BASED

TEST FAN AND EXPERIMENTAL METHOD (1)

- NON FREE VORTEX DESIGN

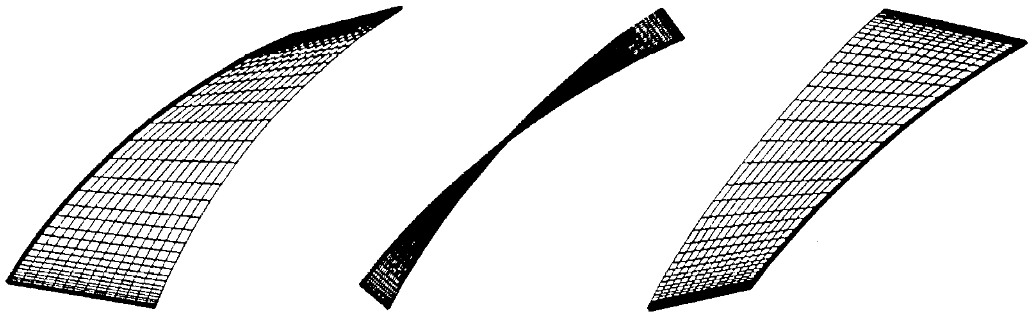
BENEFITS ⇒ HIGH TOTAL HEAD RISE
$\overline{Y}_t = 0.7$ AT $\overline{F}_D = 0.5$

DRAWBACKS ⇒ STRONGER SECONDARY FLOWS

	root	tip
r/Rc	*0.676*	*0.990*
chord (mm)	*171*	*171*
$(\ell/t)_D$	*1.534*	*1.047*
camber radius (mm)	*360.7*	*493.1*
g_D (deg)	*47.9*	*38.3*

- TEST FAN ROTOR BLADING CHARACTERISTICS

UNTAPERED CIRCULAR ARC *CAMBERED PLATE*



TEST FAN AND EXPERIMENTAL METHOD (2)

- EXPERIMENTAL FACILITY DFM@BUTE

- LDA SYSTEM (Vad and Bencze, 1996)

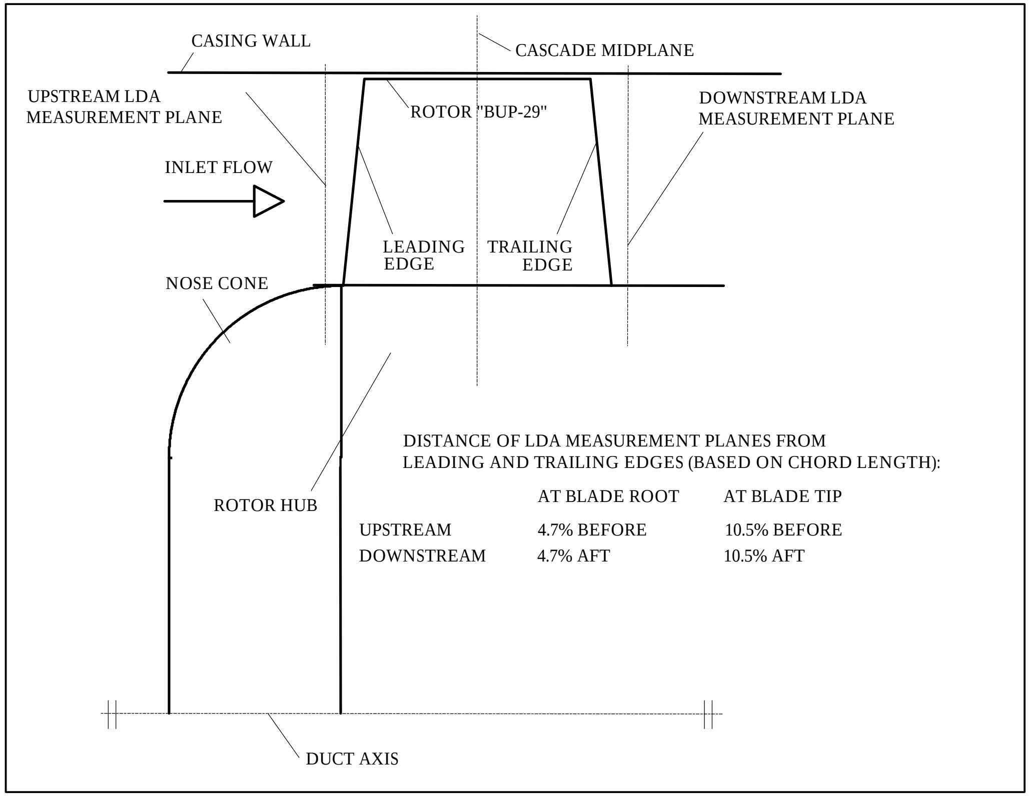
SINGLE COMPONENT EQUIPMENT

MEASUREMENT CELLS DIMENSION

3 mm ´ 5 mm ´ 1°

a r p

100 COLLECTED DATA ´ CELL



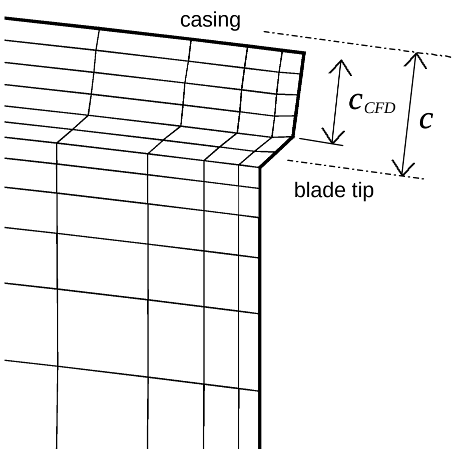
NUMERICAL MODELLING OF AXIAL FLOW FAN ROTOR (1)

- FAN GEOMETRICAL MODELS, H-GRID TOPOLOGIES

PINCHED TIP APPROXIMATION

COARSE GRID $(59 \times 21 \times 31)$, 38.409 nodes

FINE GRID $(59 \times 31 \times 41)$, 102.951 nodes



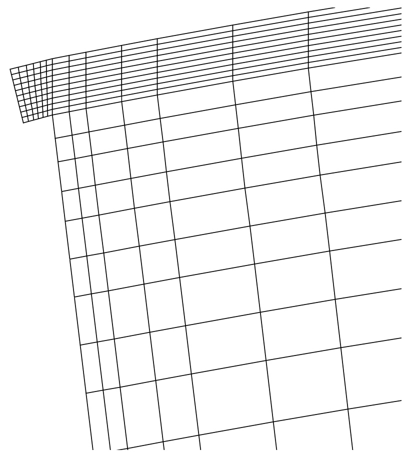
c_{CFD} = *2.2 mm*, modeled clearance

c = *3 mm*, rotor clearance
(Vad and Bencze, 1996)

EMBEDDED H-GRID

COARSE GRID $(59 \times 25 \times 37)$, 40.157 nodes

FINE GRID $(131 \times 37 \times 51)$, 247.197 nodes



3 H-grid topologies:

- inlet, bladed passage and outlet regions
- leading and trailing edges
- tip clearance region

NUMERICAL MODELLING OF AXIAL FLOW FAN ROTOR (2)

- BOUNDARY CONDITIONS

  - ♦ INFLOW — DIRICHELET CONDITIONS *VELOCITY*, k AND e

    PITCH-WISE AVERAGED LDA *VELOCITY DISTRIBUTION*

    TURBULENCE INTENSITY AXY-SIMMETRIC PROFILE (Lakshminarayana, 1982), (Vad, 1999)

  - ♦ OUTFLOW — NEUMANN CONDITIONS HOMOGENEUS (k AND e)

    AND NON HOMOGENEUS p

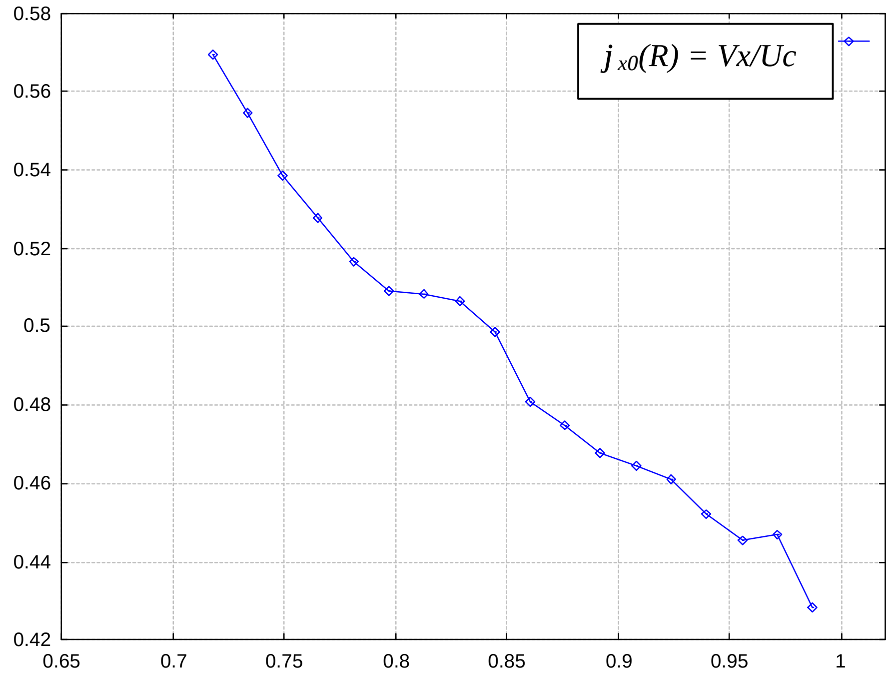
  - ♦ SOLID BOUNDS — WALL FUNCTION (WALL SHEAR STRESS, k AND ε)

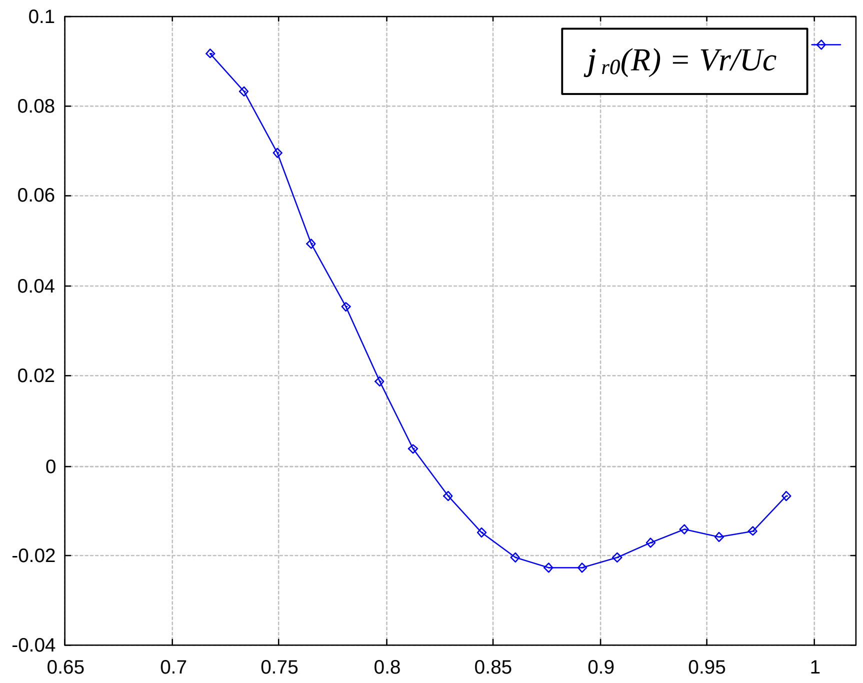
    first grid node $30 < d^{+} < 200$

  - ♦ PERIODIC BOUNDS — DEGREES OF FREEDOM EQUALITY

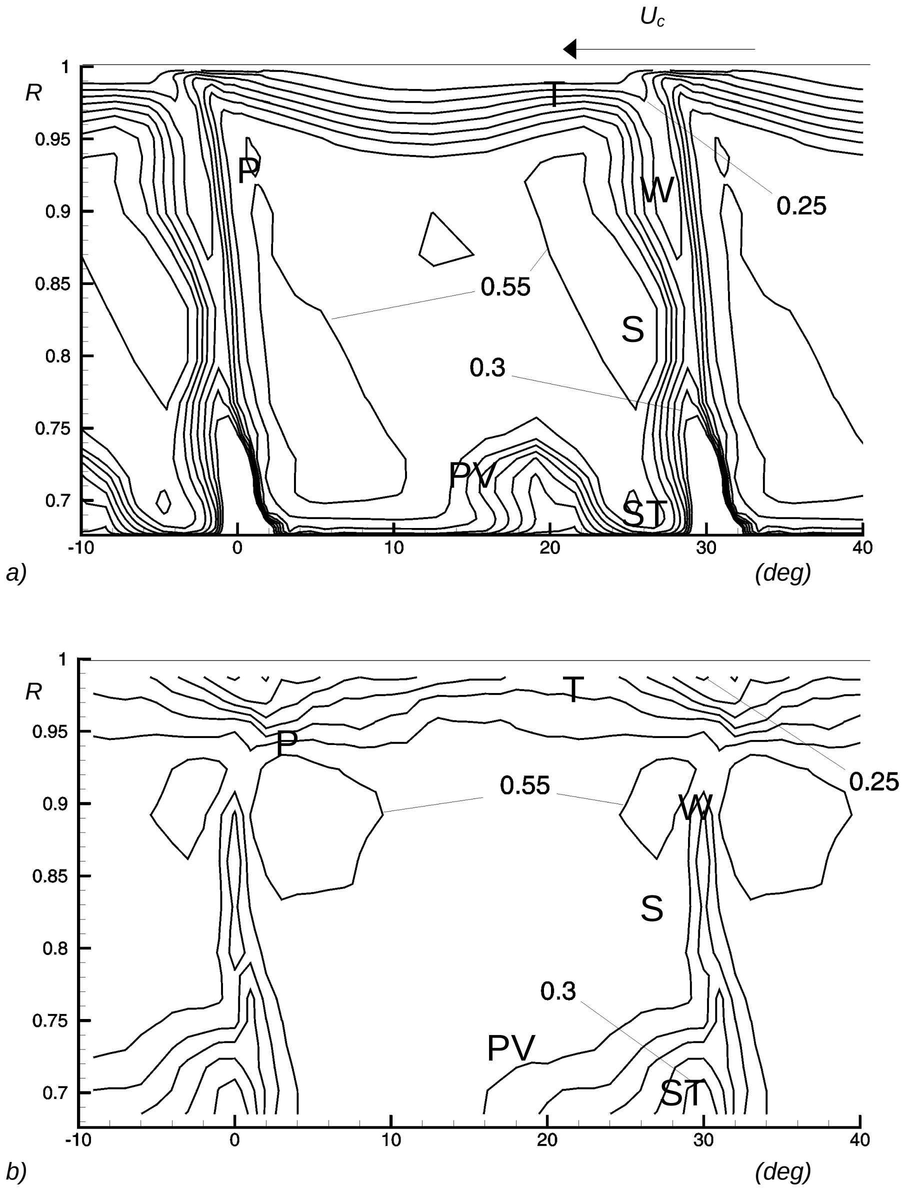
Vad and Bencze non free vortex rotor BUP29

LDA measurements

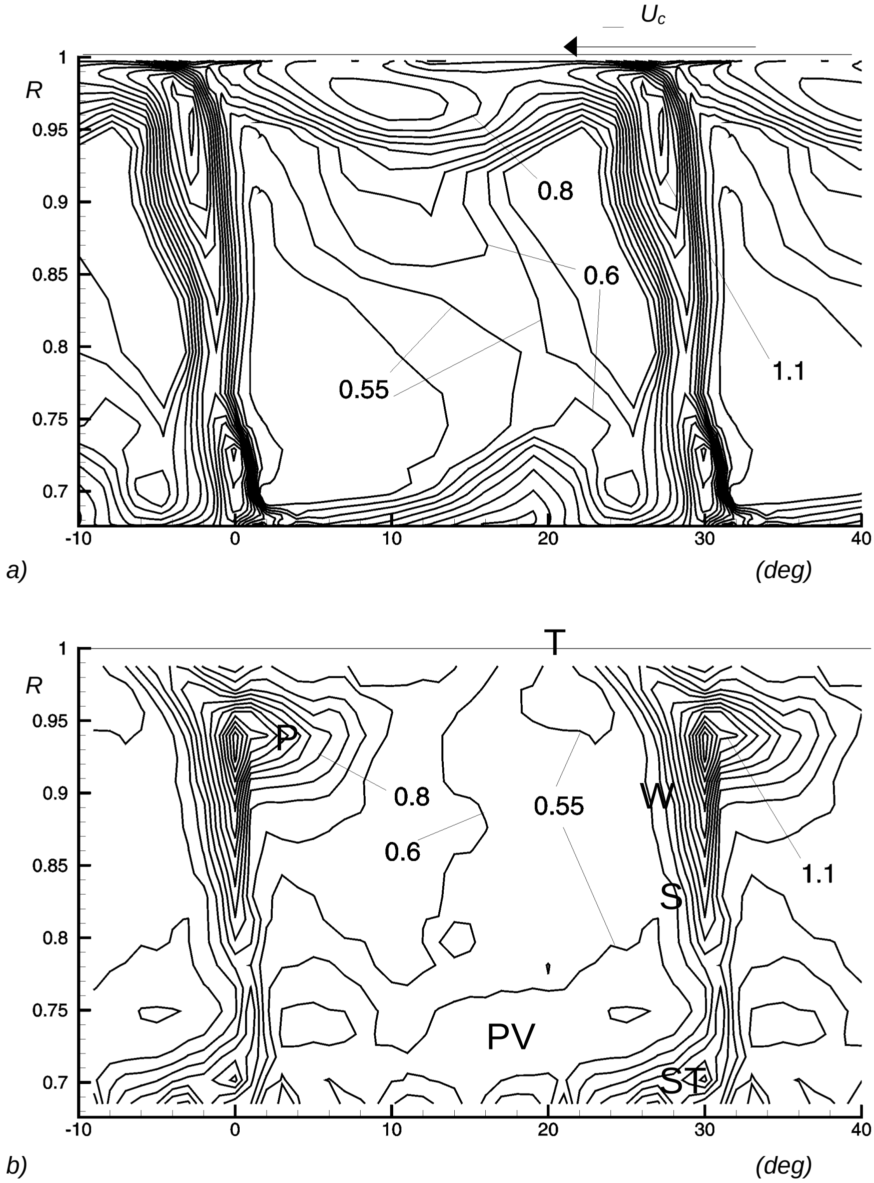




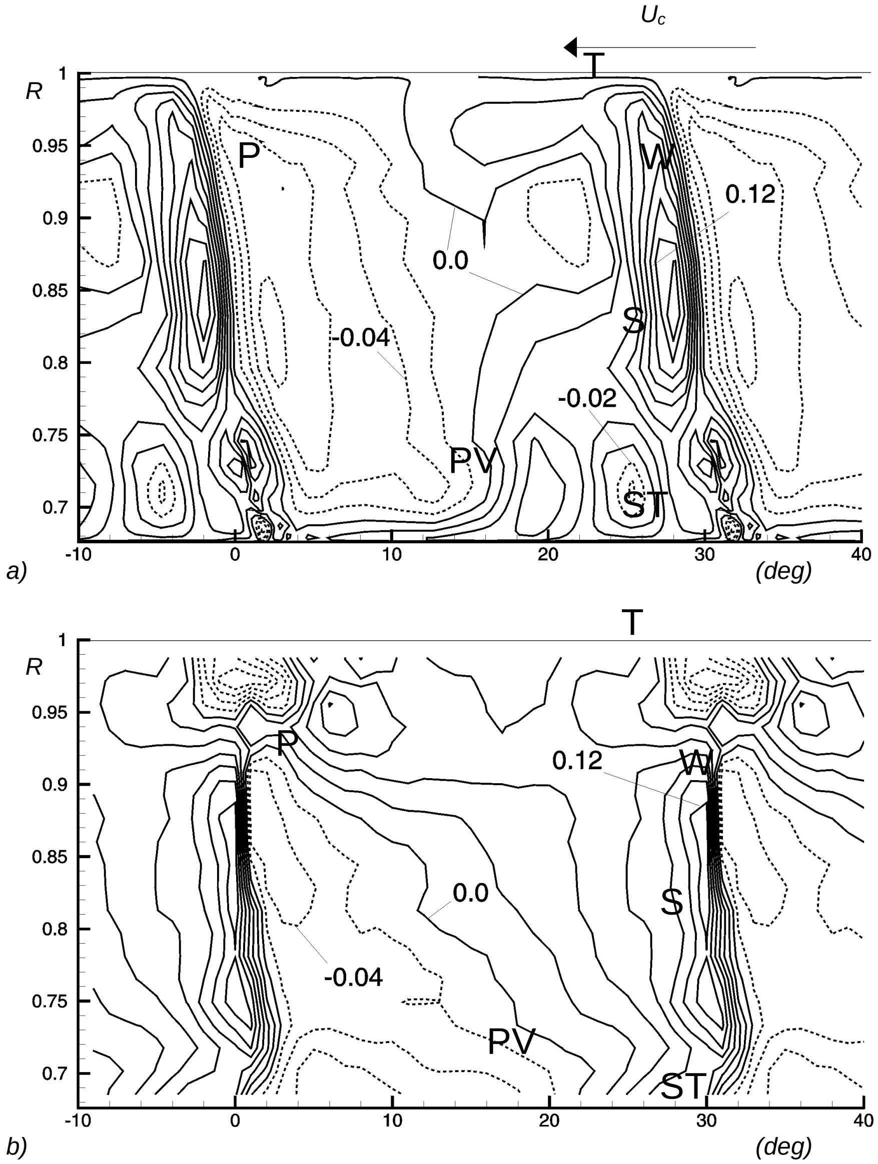
Upstream pitch-averaged axial and radial flow coefficient distributions



Axial flow coefficient (j_x) distributions behind the rotor
(a: computations, b: experiments (Vad and Bencze, 1996))



Ideal total head rise coefficient (y) distributions behind the rotor
(a: computations, b: experiments (Vad and Bencze, 1996))



Radial flow coefficient (j_r) distributions behind the rotor
(a: computations, b: experiments (Vad and Bencze, 1996))

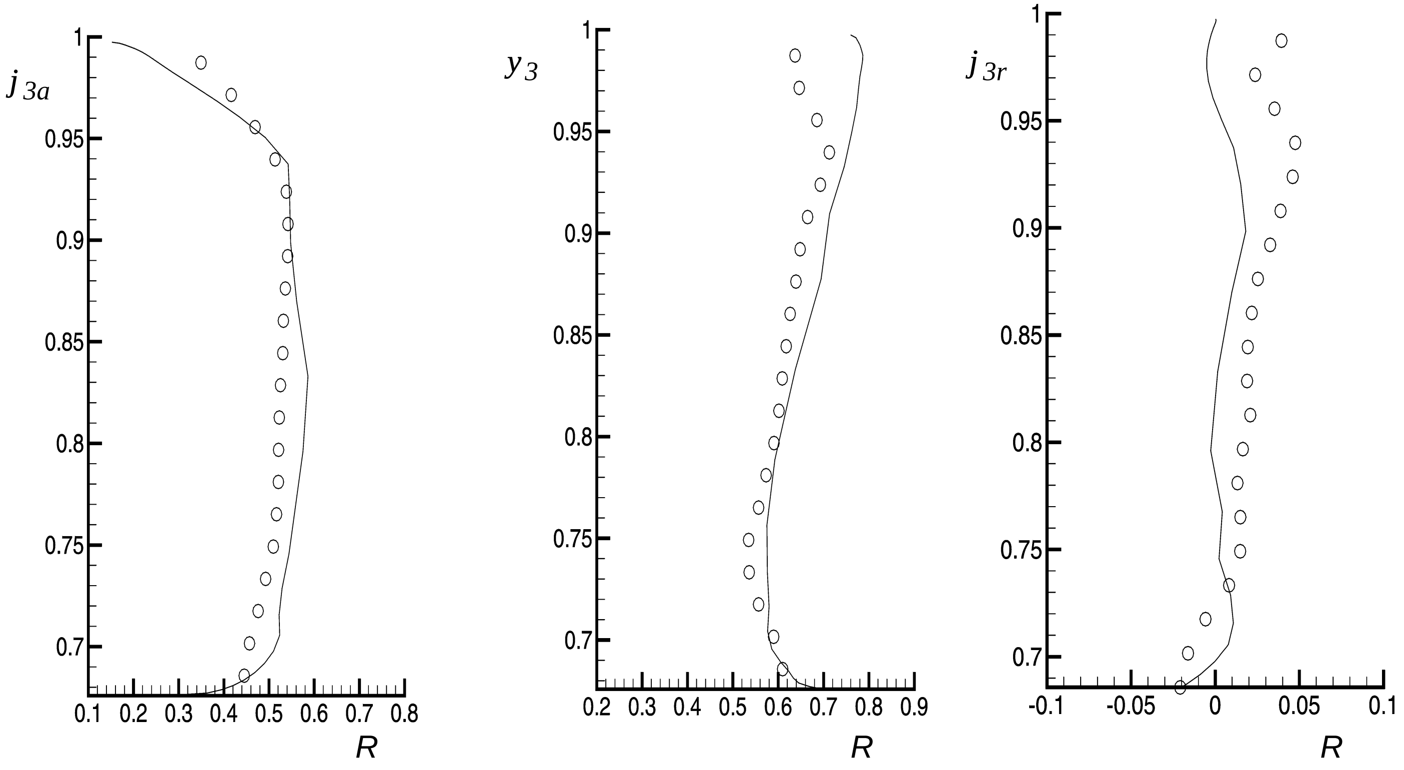
Corsini and Rispoli

Navier-Stokes prediction obtained with XENIOS finite element code - grid 81 × 31 × 41

predicted at *x = 0.05* l_c *downstream of rotor hub*

Vad and Bencze non free vortex rotor BUP29

LDA measurements



Pitchwise-averaged outlet axial flow and local ideal total head rise coefficient distributions