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Data Article

Instantaneous PIV data related to the leakage flow of a low-speed axial-flow fan with rotating shroud

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A B S T R A C T

The present paper is companion to Large-scale unsteady flow structures in the leakage flow of a low-speed axial fan with rotating shroud, Canepa et al., 2019.
Two-dimensional PIV has been used in order to investigate the leakage flow in a low-speed fan with rotating shroud at three operating conditions. The reported data are constituted by about 3000 instantaneous meridional velocity fields, which are statistically independent. Each velocity field contains 41 × 55 velocity values deployed on a rectangular grid. In order to allow taking ensemble averages of the data, each velocity field has been assigned to a 4-deg bin in the rotor reference. The data are particularly valuable, since no data of this kind and detail have been made available to the scientific community yet.

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Specifications table

Subject area	Mechanical engineering
More specific subject area	Fluid dynamics, Aeroacoustics, Turbomachinery
Type of data	Data in CSV files
How data was acquired	Particle image velocimetry (PIV) system constituted by a double-cavity Nd:Yag pulsed laser and two Dantec High Sense Mk II cameras. The Dantec Dynamic studio software [2] has been used in order to compute the instantaneous velocity field.
Data format	Formatted and unprocessed (instantaneous velocity fields from cross-correlations of pairs of images).
Experimental factors	About 3000 instantaneous velocity fields statistically independent. The corresponding angular position of the rotor is also provided.
Experimental features	Instantaneous velocity fields have been measured in the gap region of a low-speed axial-flow fan with rotating shroud employed in automotive cooling systems. Measurements are 2-D and have been performed in the meridional plane. The operating conditions have been varied by means of a test plenum based on ISO 10302 standards.
Data source location	Genoa, Italy, 44.3994704 N, 8.9637347,18 E.
Data accessibility	https://data.mendeley.com/datasets/g88vyssbs9/1
Related research article	E. Canepa, A. Cattanei, F. Mazzocut Zecchin, D. Parodi, Large-scale unsteady flow structures in the leakage flow of a low-speed axial fan with rotating shroud, Exp. Therm. Fl. Sci., 102 (2019) 1—19, [1].

Value of the data

- The database allows deepening the physics of the leakage flow in low-speed axial-flow fans, and may help developing quieter fans.
- As the instantaneous flow fields are statistically independent, the data allow testing and developing techniques for the analysis of statistically independent flow fields (e.g. proper orthogonal decomposition, conditional sampling and average, ensemble average).
- The data allow developing and testing turbulence models for turbulent flows containing periodic and non-periodic coherent structures.

1. Data

1.1. Data organization

For each operating condition, about 3000 instantaneous velocity distributions are provided together with the corresponding angular position in the rotor frame.

Each velocity distribution is related to a rectangular domain containing 41 $\times$ 55 points in the meridional plane; the axial coordinate x ranges from 3.3 mm to 73.6 mm, and the radial coordinate r ranges from 199.7 mm to 293.9 mm.

At each point the axial and the radial velocity components (v_x and v_r, respectively) are provided together with the related spatial coordinates x and r, see Fig. 1.

Data are organized in 3 directories (\DP2400, \DP3000, \FD3000) related to three operating conditions (rotational speed Ω and pressure rise coefficient $\psi = \frac{\Delta p}{0.5\rho_0 u_{tip}^2}$):

DP2400 $\rightarrow$ $\Omega = 2400$ rpm, $\psi = 0.121$, (DP, design condition).

DP3000 $\rightarrow$ $\Omega = 3000$ rpm, $\psi = 0.121$, (DP, design condition).

FD3000 $\rightarrow$ $\Omega = 3000$ rpm, $\psi = 0.0173$, (FD, free discharge condition).Where: Ω [rpm] is the rotational speed, Δp [Pa] is the pressure rise though the rotor, ρ_0 [kg/m^3] is the ambient density, and u_{tip} [m/s] is the blade speed at the tip.

Each directory contains about 3000 files sampled at about 6 Sample/s. Each file (i.e. each image or "frame"):

- Is related to a different acquisition time instant. The acquired frames are statistically independent since the flow has been undersampled; hence, the time of acquisition is useless and not reported.

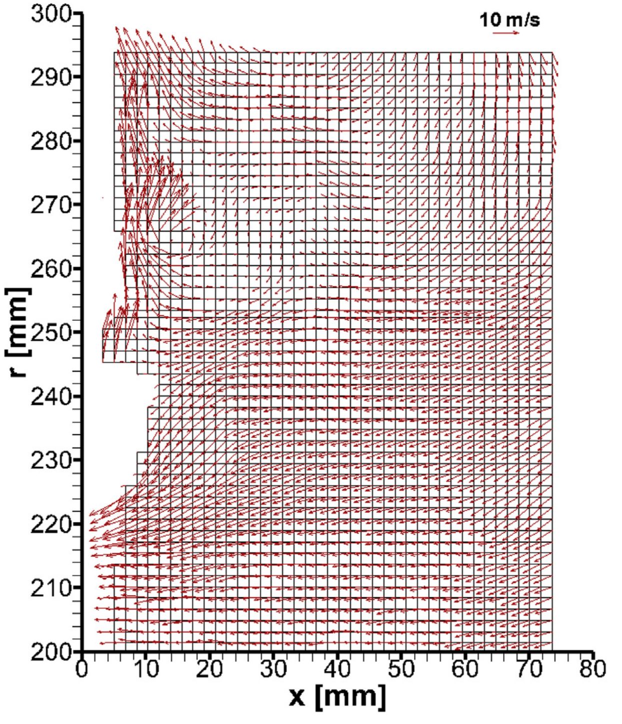

Fig. 1. Example of flow field (file DP3000_2910_90_24.csv).

The rotor angular position has been simultaneously acquired and each frame has been related to a 4-deg angular window (i.e. "bin") within one rotor revolution, resulting in 90 bins for the whole rotor, i.e. 10 windows per blade passage. Up to 33 frames per bin have been acquired. The window to which a frame is related is reported in the file name (see example below).

- Contains the instantaneous meridional components of the velocity vector (axial v_x, and radial v_r) on a rectangular domain composed of 41 $\times$ 55 grid points (spacing $\Delta x = \Delta r = 1.74$ mm).
- Each row is related to a grid point; in the columns from 1 through 4, x, r, v_x, and v_r are reported. In the 5th column an index ("check") is reported whose value may be either 0 (the grid point contain reliable data) or 1 (the reported data are unreliable due to wall reflections and/or missing seeding).

1.2. Example of data file (content of file DP3000_2910_90_24.csv)

The mesh and flow field are plotted in Fig. 1 (points where check = 1 blanked).
DP3000 → operating condition.
2910 → 2910th frame (out of 2911).
90_24 → 24th frame (out of 25) within the 90th bin (less than 33 frames have been acquired in this bin).
As an example, the 1st and the 27th rows of the file are reported in the following:
1st row: 3.2659, 199.66, − 4.5228, − 0.4048, 1.

- $x = 3.2659$ mm
- $r = 199.66$ mm
- $v_x = -4.5228$ m/s
- $v_r = -0.4048$ m/s

- check = 1 (data at this grid point are not reliable)

  27th row: 3.2659, 245.33, 1.6301, 12.049, 0.

- $x = 3.2659$ mm
- $r = 245.33$ mm
- $v_x = 1.6301$ m/s
- $v_r = 12.049$ m/s
- check = 0 (data at this grid point are reliable)

2. Experimental design, materials, and methods

Measurements have been taken on a 9-blades rotor provided with a 460-mm-diameter rotating shroud. The rotor has been mounted on a test-plenum which allows varying the operating point acting on the width of two back slots, see Fig. 2. At design conditions (DP), the flow rate is $Q = 1.174$ m^3/s and the static pressure rise is $\Delta p = p_{out} - p_0 = 388$ Pa at the rotational speed $\Omega = 3000$ r/min, i.e. the flow coefficient is $\varphi = Q/(u_{tip}\pi r_{tip}^2) = 0.098$ and the pressure coefficient is $\psi = \Delta p/(0.5\rho_0 u_{tip}^2) = 0.121$. Beyond DP conditions, the fan has been operated close to free-discharge conditions (FD), at which $\varphi = 0.164$ and $\psi = 0.0173$.

2-D PIV has been used for surveying the flow field, see Fig. 2. The scattered light has been simultaneously acquired by two Dantec High Sense Mk II cameras. The laser light sheet has been placed in front of the rotating shroud in the meridional plane. The investigated area ranges between $r = 200$ mm and $r = 295$ mm and extends up to 70 mm upstream of the rotor, see Fig. 3.

The rotor angular position related to each pair of images (the two cameras have acquired about 3000 pairs, then joined in a single image) has been simultaneously acquired. The velocity field has been computed on a 1.74 mm-step square grid by means of the Dantec Dynamic studio software, which is provided together with the PIV system. Then, the spatial cross-correlation function has been computed over interrogation areas constituted by 64 $\times$ 64-pixels with 50% overlapping. This results in a $\pm$4% instantaneous accuracy.

Deeper information on test configuration, experimental procedure, and involved physical phenomena are reported in Canepa et al. [1–4].

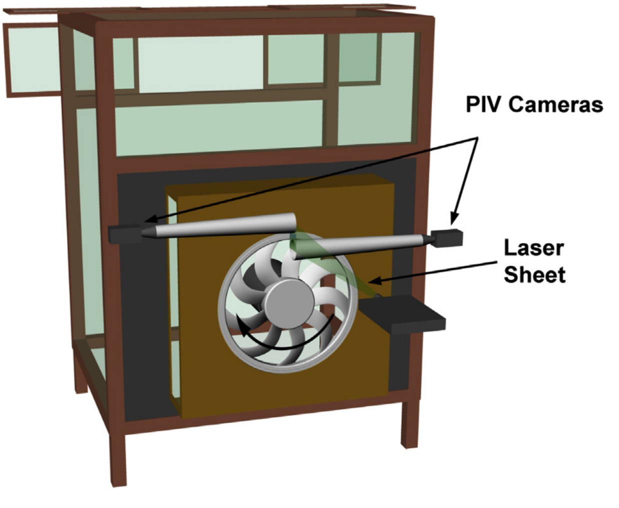

Fig. 2. The rotor and the experimental setup.

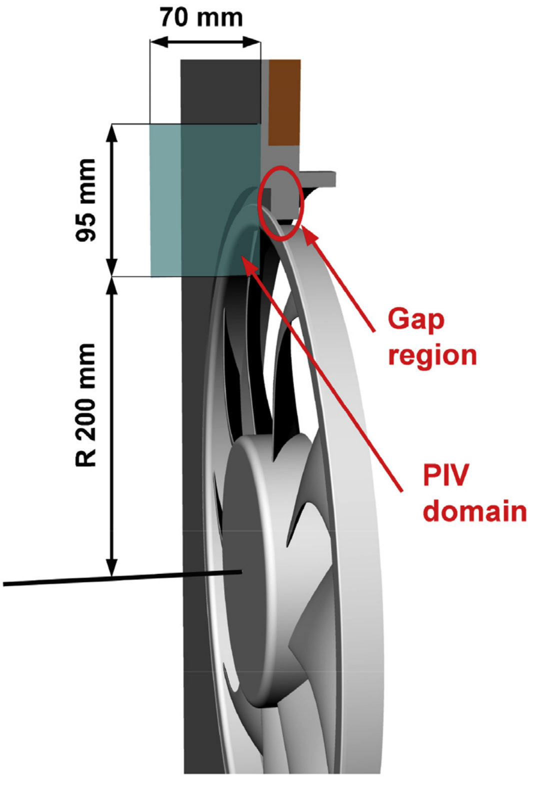

Fig. 3. The gap region and the surveyed domain.

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Transparency document

Transparency document associated with this article can be found in the online version at https://doi.org/10.1016/j.dib.2019.103895.

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