Cover Photo

Visualization of Two-dimensional Flows by a Liquid (Soap) Film Tunnel

Gharib, M. * and Beizaie, M. *

** Graduate Aeronautical Laboratories, California Institute of Technology, 1200 East California Boulevard, Pasadena, CA 91125, USA*

e-mail: mory@caltech.edu

This image represents a two-dimensional jet produced in a soap film tunnel (Gharib and Derango, Physica D, Vol.37 pp.406-416, 1989). The small variation of the film thickness results in interference patterns, thus, providing an excellent means for flow visualization. The figure shows a laminar jet (Re number = 25), but the jet fluid has a lower surface tension than the ambient fluid, which results in a large growth rate for the jet.

Journal of Visualization, Vol. 5, No. 4 (2002) 311

Visualization of Flow Structure in a Channel with Corrugated Walls by Liquid Crystals

***Zharkova, G.M.*[1], *Kovrizhina, V.N.*[1] *and Khachaturyan, V.M.*[1]**

1) *Institute of Theoretical and Applied Mechanics, Siberian Branch of the Russian Academy of Sciences, 630090 Novosibirsk, Russia*
e-mail: {Zharkova, Kovrizh, Khachat} @itam.nsc.ru

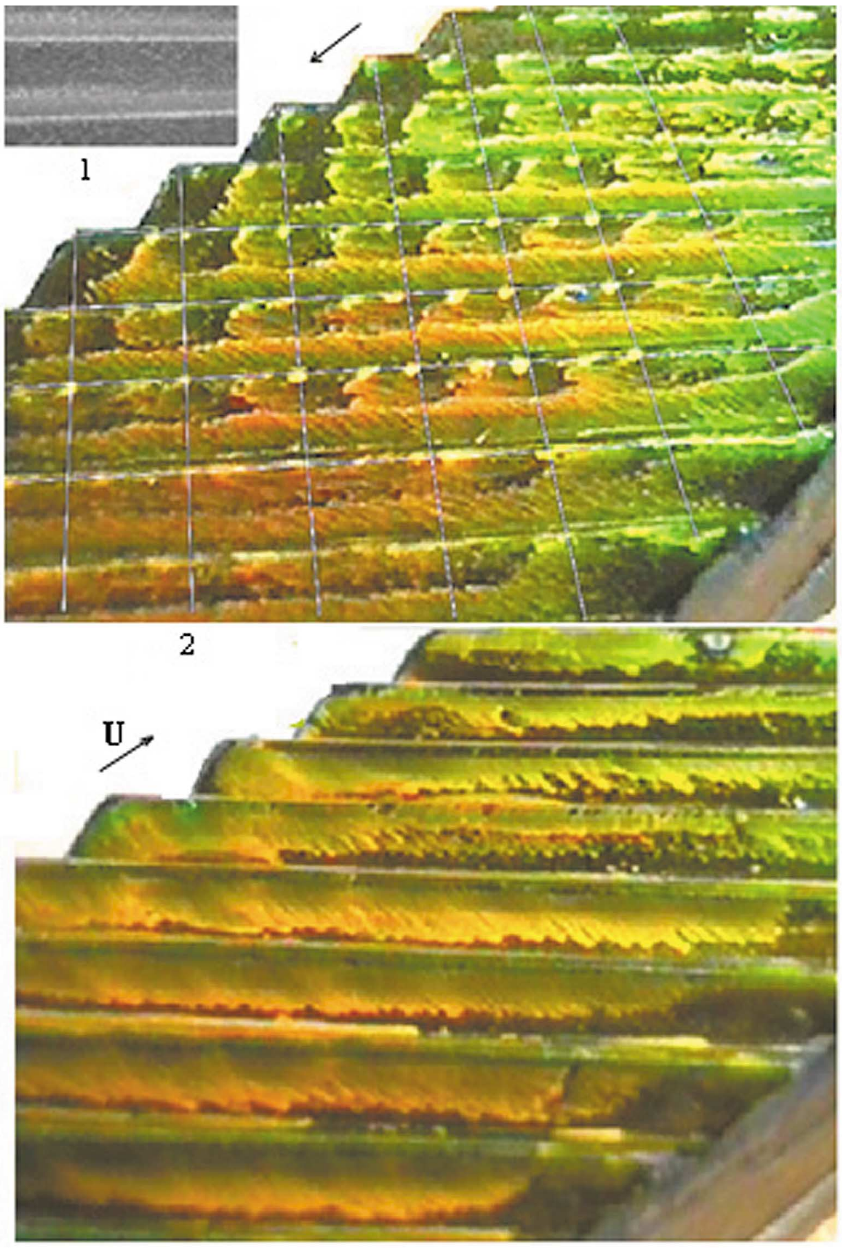


Fig. 1. Test surface with LC without flow
Fig. 2. Shear stress visualization. General view on the corrugated plate on the lee side
Fig. 3. General view on the windward side
Fig. 4. Test model and chart of the channel cell

Visualization of the shear-stress distribution on a wall of the channel formed by two corrugated sheets with opposite directed ribs is presented in figures. For the purpose, the effect of texture transition from the so-called focal-conic texture to planar texture in shear sensitive liquid crystals has been used. Corrugation angle (the twice angle between main flow direction and rib line) $\theta = 90°$, crimp angle $\varphi = 60°$, hydraulic diameter of the inner channel $d_h = 7.6$ mm and Reynolds number $Re_{dh} = 1.3\times104$.

Journal of Visualization, Vol. 5, No. 4 (2002) 312

Visualization of Twin & Kármán Vortices on the Ancient Pottery, Jomon-doki, made 4500 Years Ago

Nakayama, Y.[1], Oki, M.[2] and Aoki, K.[3]

1) *Future Technology Research Institute, Tokai University, 3-56-2 Higashi-Oizumi, Nerima-ku, Tokyo 178-0063, Japan*

2) *School of High-Technology for Human Welfare, Tokai University, Numazu-shi, Japan*

3) *School of Engineering, Tokai University, Hiratsuka-shi, Japan*

Fig.1. Joumon-doki

Fig.2. Pollen of cedar coming from cedar forest

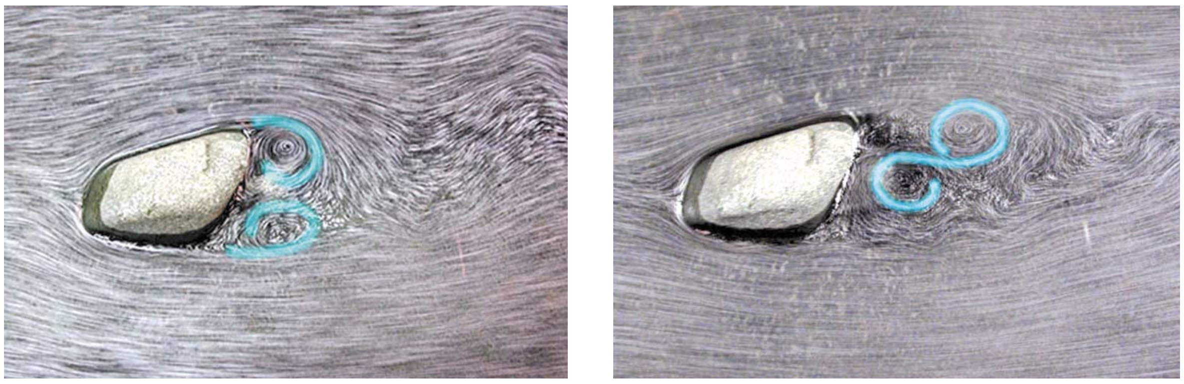


Fig.3. Twin vortex (left) and Kármán vortex (right) behind a rock of river
(Surface floating method using pollen of cedar tree and aluminum power)

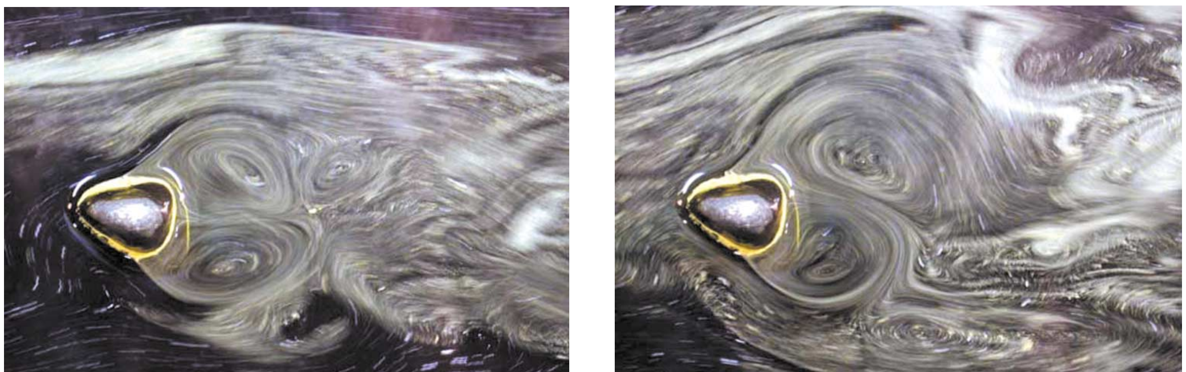


Fig.4. Twin vortex (left) and Kármán vortex (right) behind a rock of river
(Surface floating method using pollen of pine tree)

It is said that the Jomon-age in Japan began 16,000 years ago and continued till 2,500 years ago. The earthenware made in this age is called Joumon-doki. Among them, two potteries shown in Fig.1 were discovered in Niigata Prefecture and have very nice pattern. It is said that these potteries were made about 4,500 years ago. The pattern on the side wall consists of two kinds of vortex. One is so-called twin vortex each rotating in the opposite direction and the other that is observed under the twin vortex is the plastic art of Kármán vortex rotating in one direction and presenting reversal S-shaped vortex. It can be easily assumed that Jomon people watched the twin vortex and Kármán vortex created by tracers such as the pollen of the cedar (Fig. 3) and pine (Fig. 4) trees, fallen leaves and petals, and copied the pattern on the earthenware.

Journal of Visualization, Vol. 5, No. 4 (2002) 313

Three-dimensional Flow Structure around an Axial Fan

Lee, S. J.[1] *and Yoon, J. H.*[1]
1) *Pohang University of Science & Technology, Pohang 790-784, Korea*

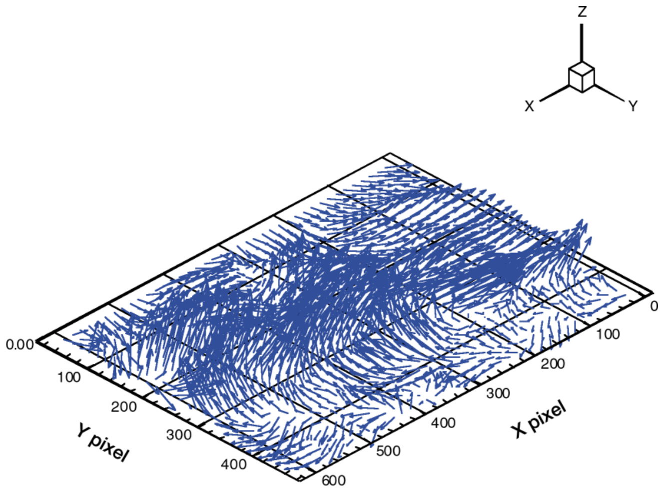



Fig.1. Axial-fan model and instantaneous velocity vectors measured by stereoscopic PIV

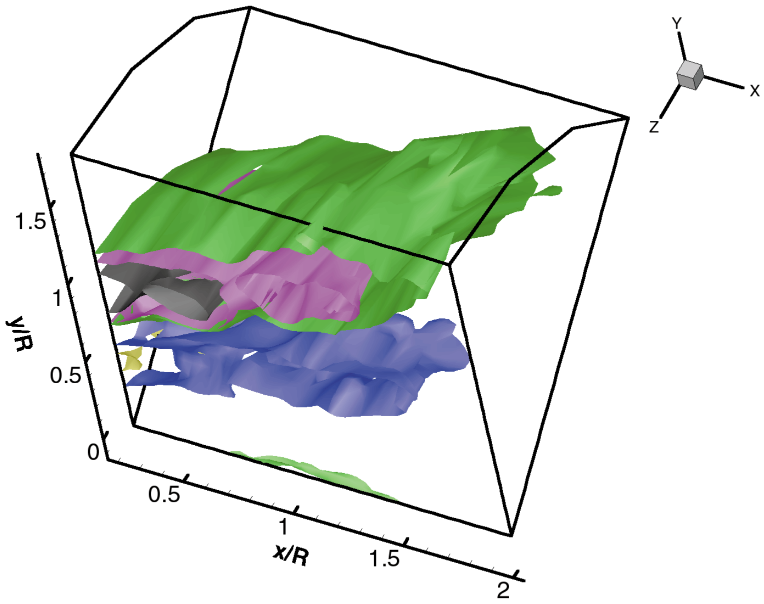


Fig.2. Three-dimensional iso-vorticity structure of spanwise vorticity ω_z

The stereoscopic PIV (particle image velocimetry) measurements were carried for an axial-fan to understand the three-dimensional (3-D) flow structure around the fan. The fan model has five forward-swept blades and its tip diameter is 50 mm. Figure. 1 shows the axial-fan tested and a typical 3-D reconstructed instantaneous velocity field measured in an axial plane just behind the axial-fan. During experiments, the fan is rotating at 180rpm. 500 instantaneous velocity fields were measured and they were ensemble averaged to obtain the phase-averaged mean flow structure.

By combining the vorticity contours measured at four consecutive phases, iso-vorticity contours having the same spanwise vorticity (ω_z) were derived. The contour plot of equi-spanwise vorticity surface is depicted in Fig. 2. It shows the quasi 3-D distribution of positive tip vortices shed from the blade tip, trailing vortices and negative vortices induced from the pressure side of fan blade. The positive tip vortices and negative vortices interact strongly in the region of $0.6<y/R<0.8$.

Journal of Visualization, Vol. 5, No. 4 (2002) 314

Large Eddy Simulation of Turbulent Flame

***Tominaga, T.*[1], *Itoh, Y.*[1], *Hirohata, M.*[1], *Kobayashi, T.*[1] *and Taniguchi, N.*[2]**

1) *Institute of Industrial Science, The University of Tokyo, 4-6-1 Komaba, Meguro, Tokyo 153-8505, Japan*
e-mail:tominaga@icebeer.iis.u-tokyo.ac.jp

2) *Information Technology, The University of Tokyo, 2-11-16 Yayoi, Bunkyo, Tokyo 113-8658, Japan*

(a) (b)

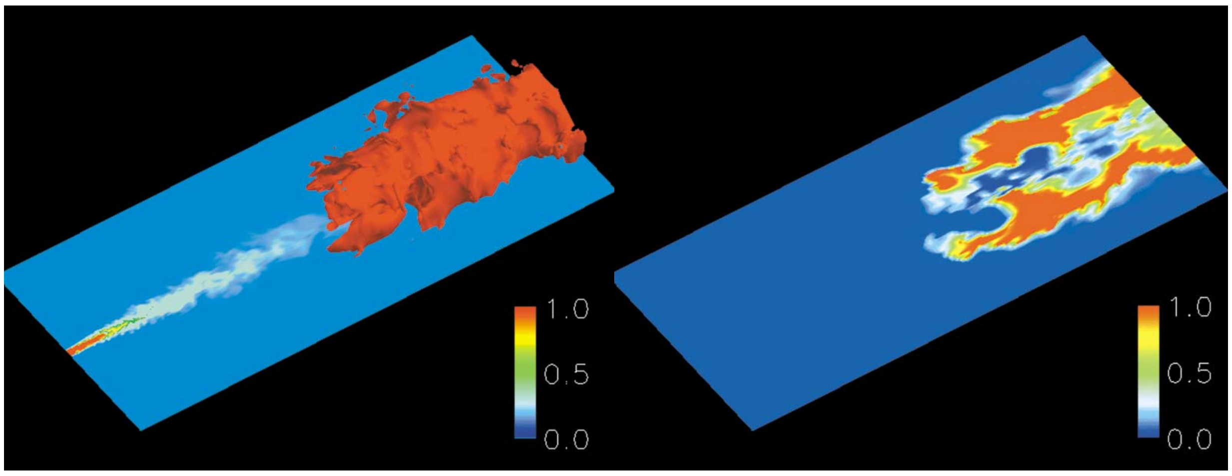


Fig.1. (a) The lifted flame front (red surface) and the mixture fraction distribution (color contour)
(b) The distribution of the scalar G

(a) (b)

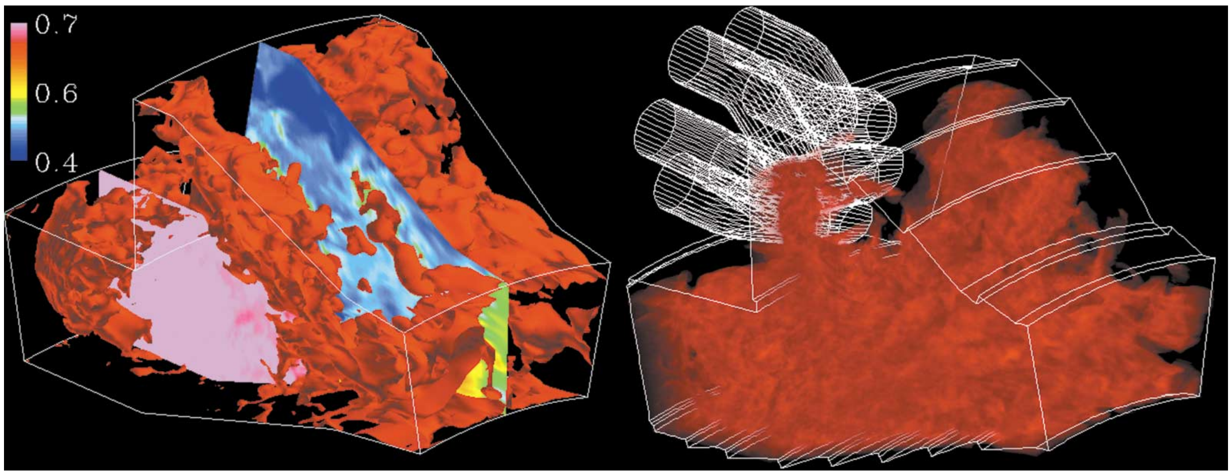


Fig.2. (a) The flame front (red surface) and the distribution of the equivalence ratio (color contour)
(b) The volume rendered flame based on the value of the scalar G

The flame front in a turbulent combustion flow field was numerically simulated using a large eddy simulation and a flamelet model. As a flamelet model, the G-equation model for a premixed combustion and the conserved scalar approach for a diffusion combustion were used respectively. Combining both equations for premixed and diffusion flame, the "2-scalar flamelet approach" was newly introduced to predict the complicated flame, such as the lifted flame and the flame propagation with non-uniform fuel ratio.

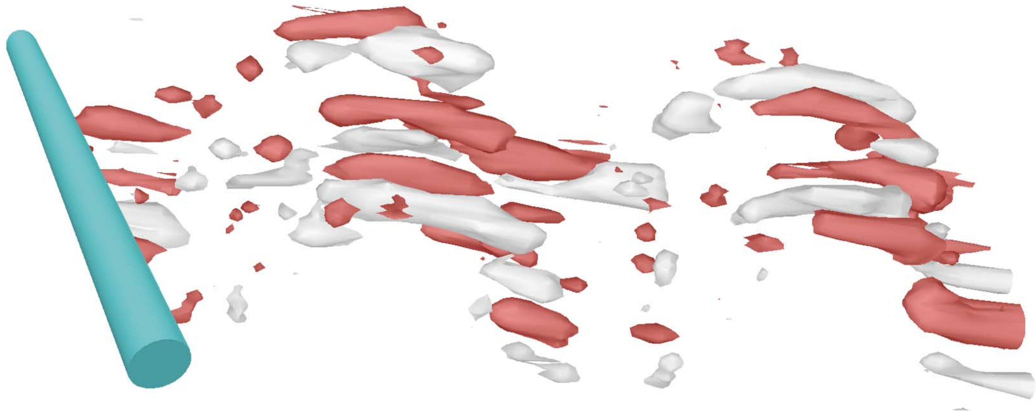
Figure 1 shows the result of the simulation for lifted flame. The mixture fraction distribution and predicted flame front are described in Fig.1(a) while the distribution of the scalar G is described in Fig.1(b).

Figure 2 shows the flame in a gas turbine combustor. In this combustor, the fuel ratio is non-uniform. Figure 2(a) shows the distribution of the equivalence ratio calculated by mixture fraction equation and the flame front calculated by the G-equation. Figure 2(b) shows the volume rendered flame based on the value of the scalar G.

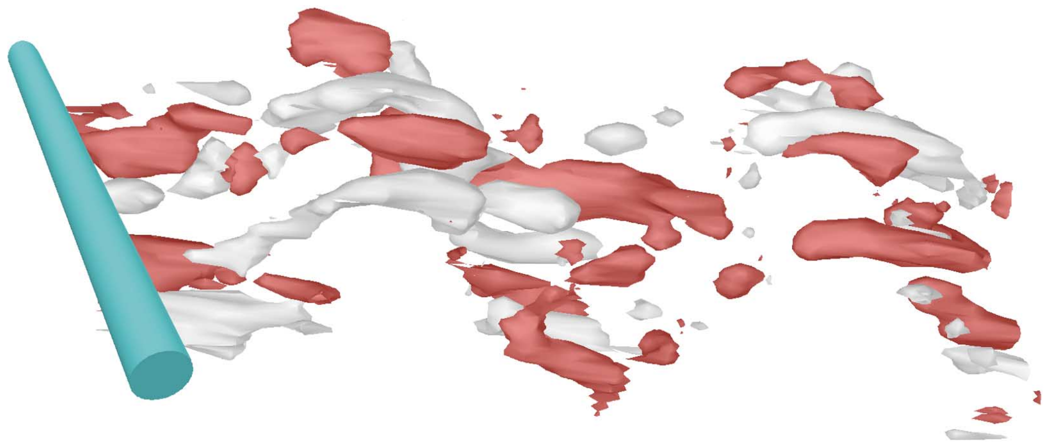
Journal of Visualization, Vol. 5, No. 4 (2002) 315

Vortex Lock-on and Spatio-temporal Evolutions of Streamwise Vortices

Sung, J.[1] ***and Yoo, J. Y.***[2]
1) *Digital Appliance Research Lab., LG Electronics, Inc., Seoul 153-802, Korea*
2) *School of Mechanical and Aerospace Engineering, Seoul National University, Seoul 151-742, Korea*



Natural shedding case, $f_o/f_n = 0$



Lock-on state, $f_o/f_n = 1.92$

These figures show the spatio-temporal representations of iso-vorticity surfaces of the streamwise vortices in the natural shedding and lock-on conditions. Successive PIV images were acquired in the streamwise plane which was located at 2.5 diameters downstream of a circular cylinder, by utilizing an image-reflecting mirror oriented at 45° far downstream. The streamwise coordinate is proportional to time. When a bluff body faces an oscillatory incident flow, a vortex lock-on may occur accompanied with an increase in fluctuating lift and drag forces. Furthermore, the present results strongly manifest the increased strength and spanwise wavelength of the streamwise vortices with lock-on.

Journal of Visualization, Vol. 5, No. 4 (2002) 316

Measurement of Vortex Structure at the Rotor Exit of Turbo-fan

***Yu-Cheong, I.*[1)]*, Kobayashi, T.*[1)]*, Saga, T.*[1)] *and Itoh, T.*[2)]**

1) *Institute of Industrial Science, The University of Tokyo, 4-6-1 Komaba, Meguro, Tokyo 153-8505, Japan*

2) *Oriental Motor Co., Ltd, Yamagata 997-0011, Japan*

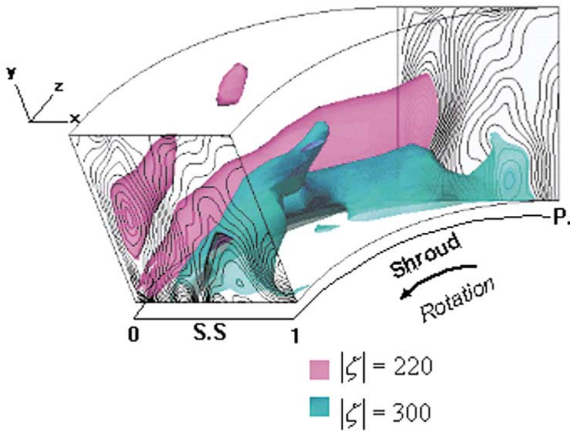
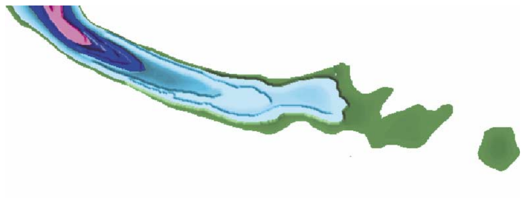
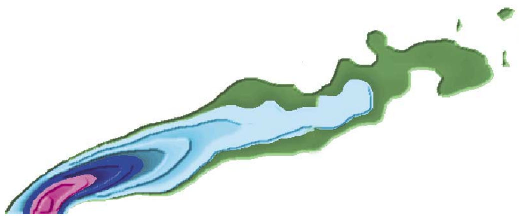


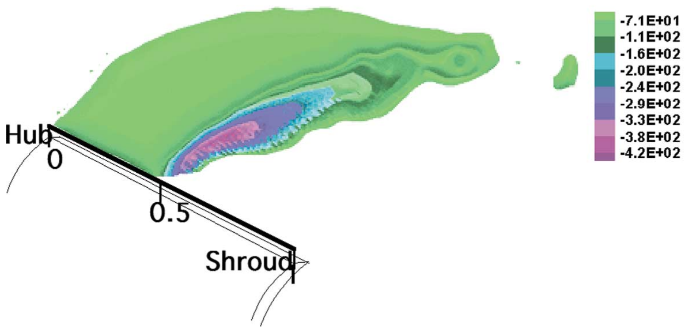
Fig.1. Shear layer vortices



(a) z/b = 0.2



(b) z/b = 0.4



(c) z/b = 0.8

Fig.2. Tip vortices across the span wise

Fig.3. Tip vortices

The tip vortices and shear layer vortices were studied experimentally by using the high resolution PIV technique. The tested turbo-fan having 11 backward-curved blades with a blade outlet angle of 45 degree was rotated at the speed of 900 rpm. The shear layer vortices (Fig. 1) were achieved by averaging 500 stereoscopic PIV measurement data made at 22 circumferential planes, which ranged from 0 degree (blade suction surface) to 32 degree (blade pressure surface). Phase average tip vortices (Fig. 2) were calculated by the 300 instantaneous PIV measurement results at every 20 planes across the span wise. The difference in the magnitude of the velocity speed at these points guarantees that the tip vortex, which is an important factor of noise, is generated around these points. At the location of (z/b = 0.4) where a distinctive difference exists in the magnitude of the velocity speed, a large scale of vortex is formed as can be seen in Fig. 3.