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Flow Characteristics of a Tip Leakage Vortex at Different Flow Rates in an Axial Flow Fan

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Key Words : Axial Flow Fan(), Rotating Hot-Wire Probe(), Tip Leakage Vortex()

Abstract

The flow characteristics in the blade passage of a low speed axial flow fan have been investigated by experimental analysis using a rotating hot-wire sensor for design and off-design operating conditions. The results show that the tip leakage vortex is moved upstream when flow rate is decreased, thus disturbing the formation of wake flow near the rotor tip. The tip leakage vortex interfaces with blade pressure surface, and results in high velocity fluctuation near the pressure surface. From the relative velocity distributions near the rotor tip, large axial velocity decay is observed at near stall condition, which results in large blockage compared to that at the design condition. Throughout the flow measurements using a quasi-orthogonal measuring points to the tip leakage vortex, it is noted that the radial position of the tip leakage vortex is distributed between 94 and 96 percent span for all flow conditions. High spectrum density due to the large fluctuation of the tip leakage vortex is observed near the blade suction surface below the frequency of 1000 Hz at near stall condition.

1.

(tip

leakage vortex)

(off-design)

(1-6) Inoue (3,7)

가

(,

. Fukano Jang⁽⁶⁾)

(leakage

jet)

가

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Table 1 Design specifications of axial fan rotor

| | |
|----------------------------|---------------|
| Flow Coefficient | 0.41 |
| Total Pressure Coefficient | 0.3 |
| Rotational Speed | 1000 rpm |
| Tip Radius | 287.5 mm |
| Hub-Tip Ratio | 0.52 |
| Chord Length at Tip | 131 mm |
| Solidity at Tip | 0.65 |
| Blade Profile | NACA65 Series |
| Number of Blade | 9 |

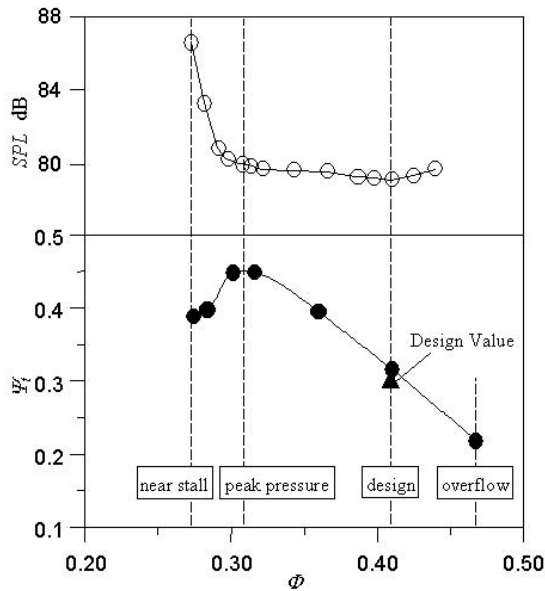


Fig. 1 Sound pressure level and total pressure rise

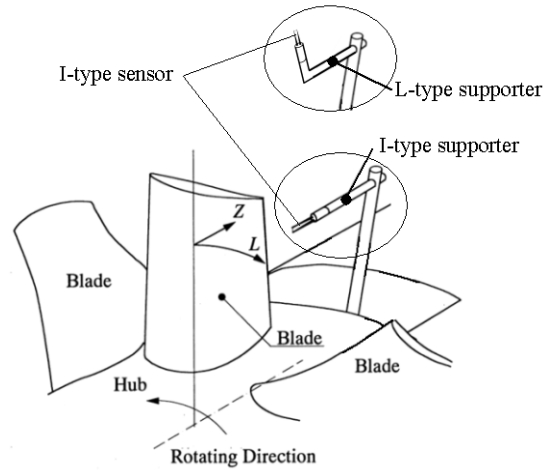


Fig. 2 Test blade measuring system

1 m
 4 가 ($\Phi = 0.28, 0.31, 0.41, 0.47$)
 ($\Phi = 0.31$)
 ($\Phi = 0.28$) 가
 I
 5 μ m

Fig. 2

2.

Table 1
 2 mm (1.5 %)
 Φ ()
 Ψ_t () 0.41
 0.3 287.5 mm
 NACA65
 Fig. 1

Fig. 2

, supporter I-type
 (trailing edge)
 가
 (Fig. 3(a)
 Fig. 2 I-
 L-type supporter
 supporter

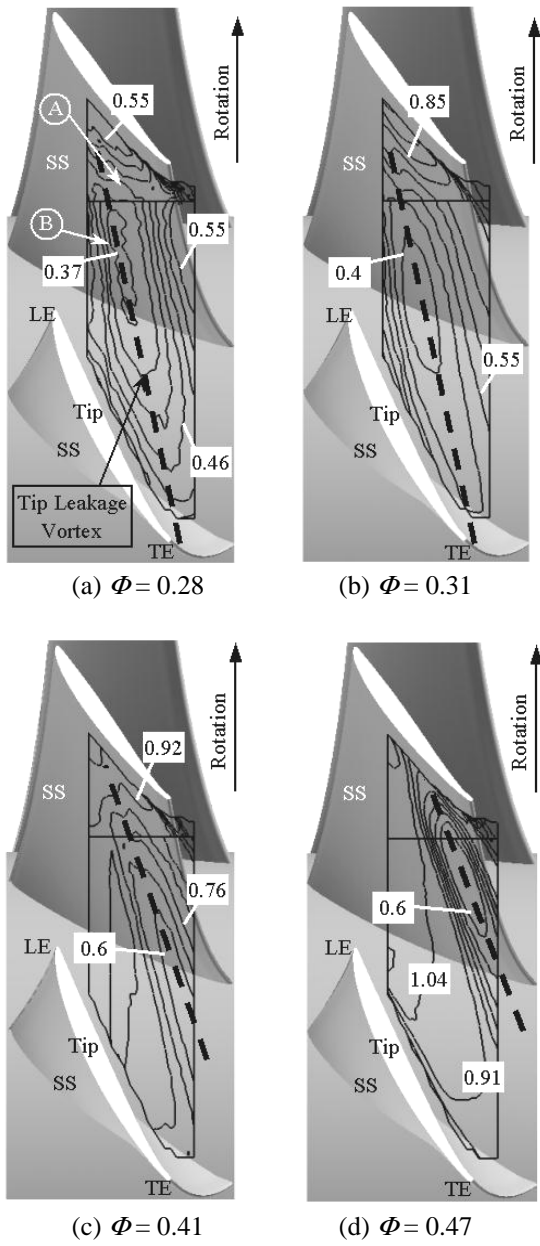


Fig. 3 Contour of relative velocity on the plane 96 percent span

3.

3.1

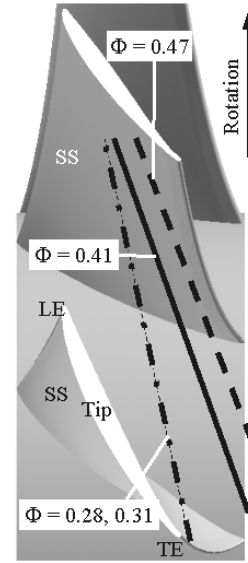


Fig. 4 Trajectory of the vortical center of the tip leakage vortex

Fig. 3 96 % 3

96%

Fig. 2 L-type supporter "A" (Fig. 3(a)) ,

I-type supporter "B" 96 % Fig. 7 , 4

76 % (255 mm) 98 % (285 mm)

27 % , 121 %

9 mm , 3 mm

Fig. 3 (velocity trough) ,

(Phi = 0.28, 0.31)

가

(Phi = 0.41)

가

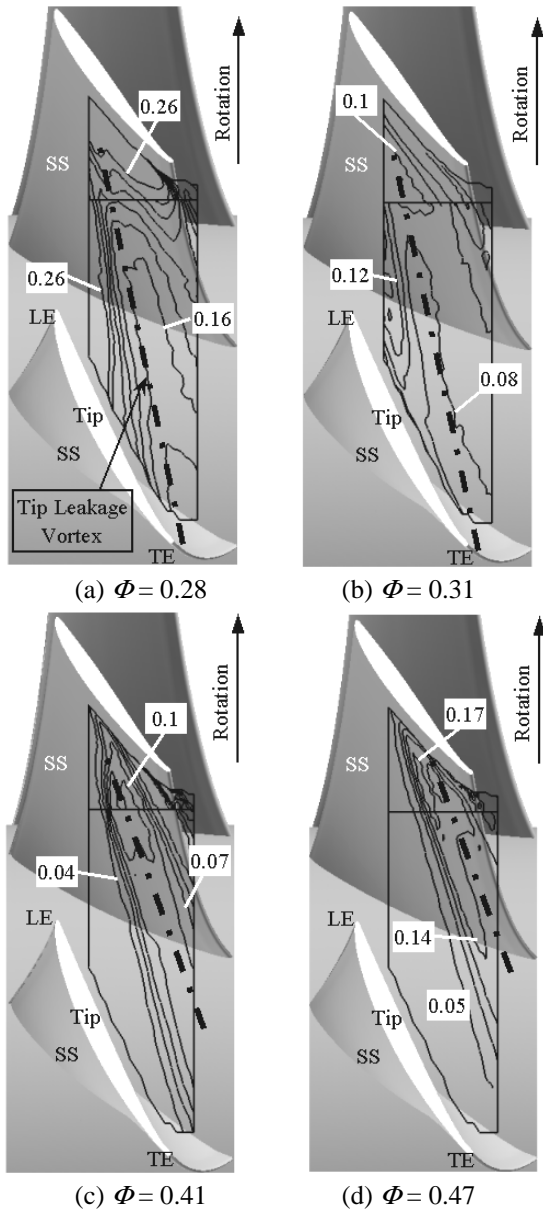


Fig. 5 Contour of velocity fluctuation on the plane 96 percent span

Fig. 4

Fig. 5
96 %

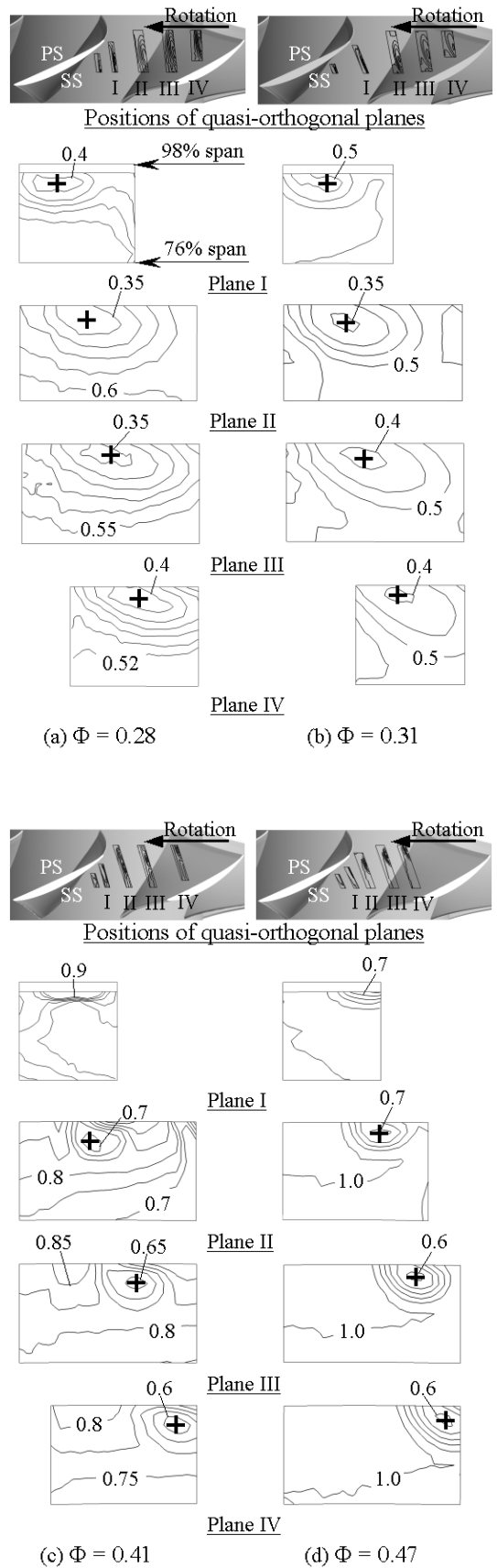


Fig. 6 Contour of relative velocity on the quasi-orthogonal plane to the tip leakage vortex

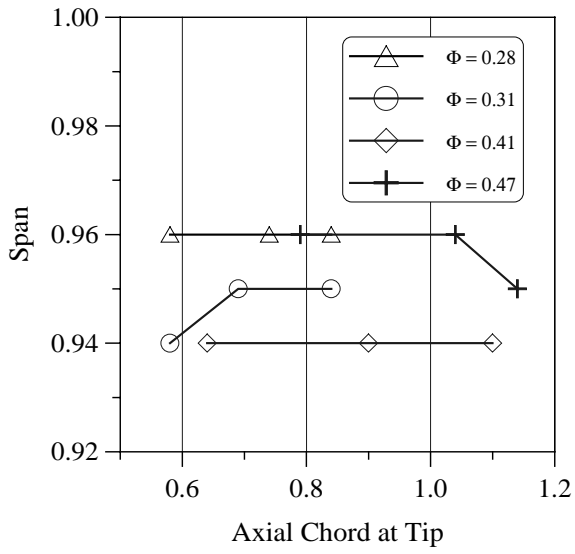


Fig. 7 Radial positions of the vortical center of a tip leakage vortex

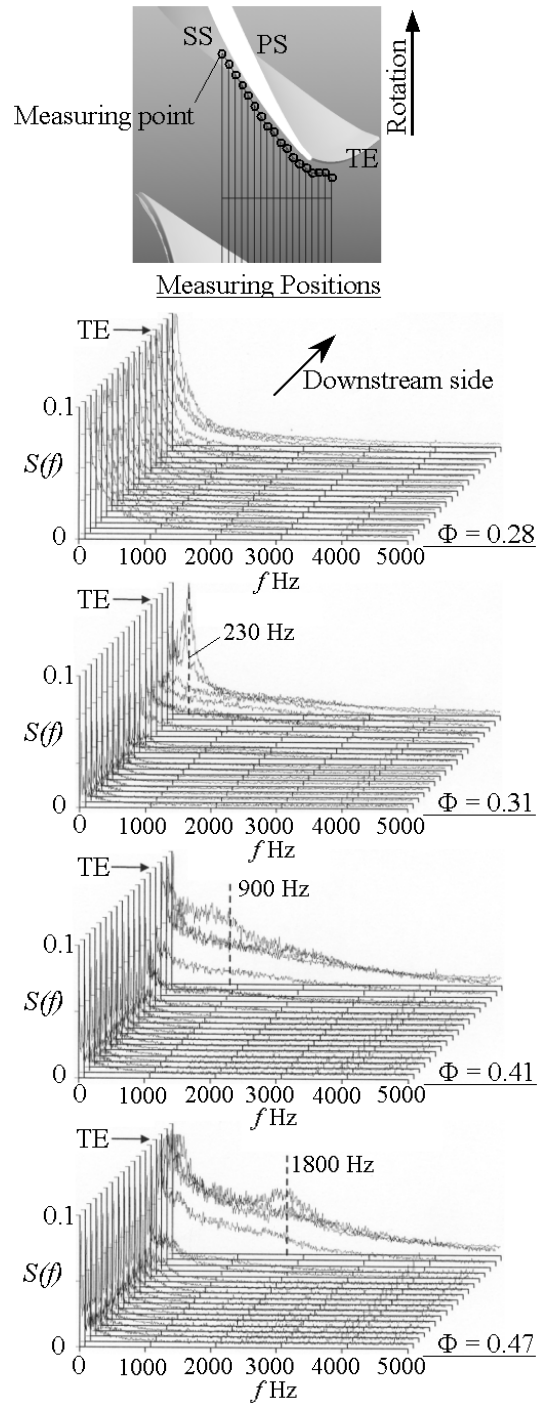


Fig. 8 Spectrum of velocity fluctuation at 85 percent span

Fig. 5

Fig. 3

. Fig. 3

가
($\Phi = 0.28, 0.31$)

가

(main flow)가

가

Fig. 1

가
($\Phi = 0.41$)

(6)
($\Phi = 0.47$)

가
. Fig. 3

가

3.2

4

“+”

Fig. 6

3

(blockage)

4.

가
 가 가
 (Fig. 6(d)) 가 ,
 80 % 가
 6(a) 75 % 가 (Fig. (1) 가

Fig. 7

(1)

(2)

(3)

(4)

(= 57.6 mm)
 "1"
 94 ~ 96 %
 95 %
 1 %
 1000 Hz
 가

3.3

Fig. 8 4 , 85 %
 “ ”

3 mm ,
 Fig. 3
 Hz ,
 Fig. 8
 ($\Phi = 0.28$) 1000 Hz
 가
 , Fig. 5(a)

($\Phi = 0.31$)
 230 Hz 가 ,
 가
 (5) , 가
 가

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