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Measurement of Flow Structure in Rod Bundle with Split Vane Spacer Grid

, ,

105

가

가 . 3 X 3 75mm
 (P/D) 1.33 . Reynolds 1.2 X 10⁵

가

, ,

Abstract

An experimental investigation of the flow structures in rod bundles with the air test model for the split vane spacer grid has been performed. Three dimensional velocity distributions and turbulent intensities over a central subchannel are measured at the Reynolds number of 1.2×10^5 by using pitot tube and hot wire anemometry. The rods were arranged in a square array with a pitch to diameter ration of 1.33. The strong cross flow appears in the gap region of central subchannel in rod bundle with split vane spacer grid. The parameters reduced from measurement, turbulent intensity, turbulent diffusion coefficient, cross flow factor and swirl factor, are consistent with the previous test results.

1.

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Westinghouse

[1], SPC

[2], KAERI

[3]

[4]

Shen[5], Yang[6],

Hejna[7], Oh[8]

Shen[5] W/D=1.27

P/D=1.375

가

LDV(Laser Doppler Anemometry)

가 가

가

Yang[6] W/D=1.35

P/D=1.49

가

LDV

10~15 D_h

가

Hejna[7] 3

가

가

가

Oh[8,9]

가

가 $5 D_h$

$5 D_h$

[10].

가 0~5 D_h

3

2.

1

Westinghouse

Siemens

가

3 X 3

100 mm

275 mm

2

300 mm X 300 mm

75 mm

가 2400 mm

1.33

Straightener 가

가

가

3

가

Velmax 8300

900 mm X 900 mm X 900 mm

가

±0.01 mm

3

TSI

TSI 100

, TSI 200 Digitizer

DAP

HP 54602B

2.4 mm

4

3

가

3 (a)

가

244

$0D_h, 1D_h, 2D_h, 3D_h, 4D_h, 5D_h$

가

3 (b)

4

, 2

2

Reynolds

Reynolds 가 1.2×10^5

:

$$Re = \frac{\bar{U} \cdot D_h}{\nu} \quad (1)$$

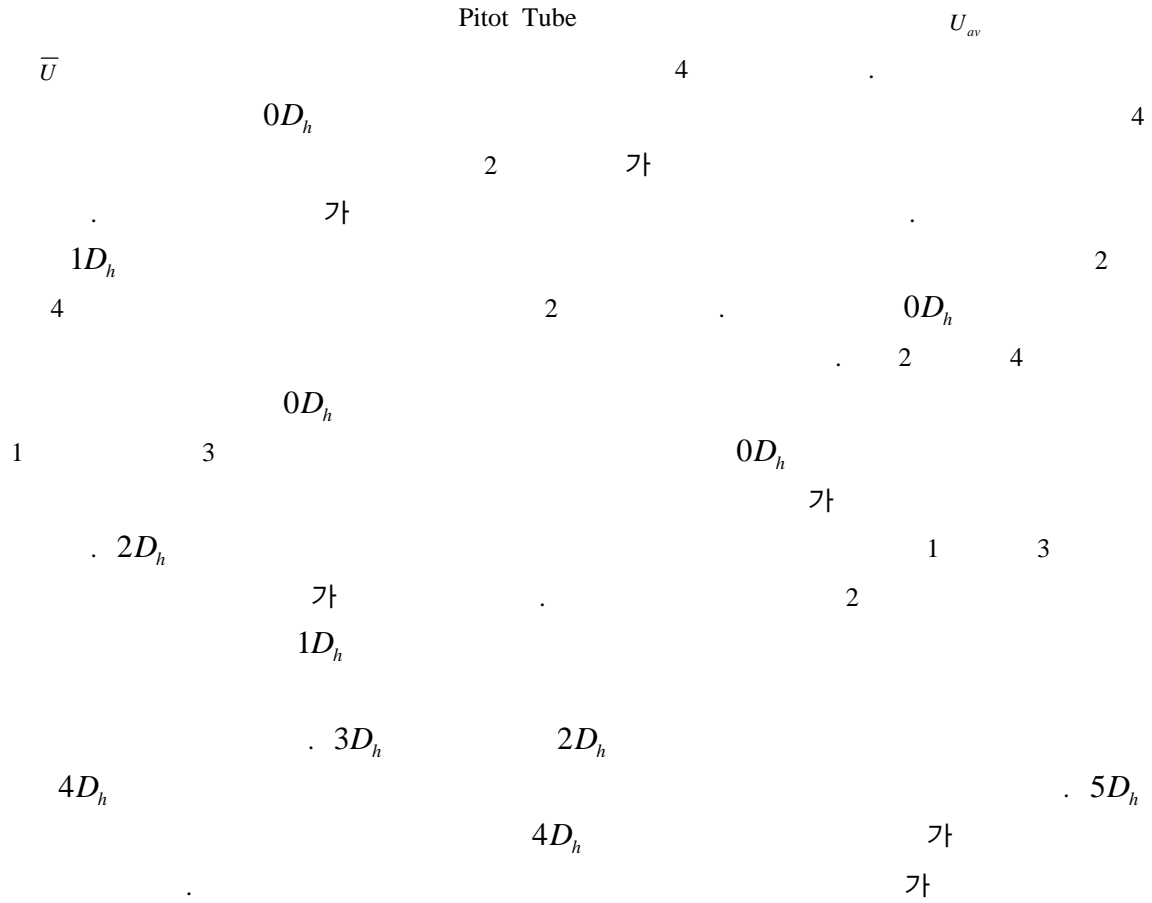
\bar{U}

, D_h

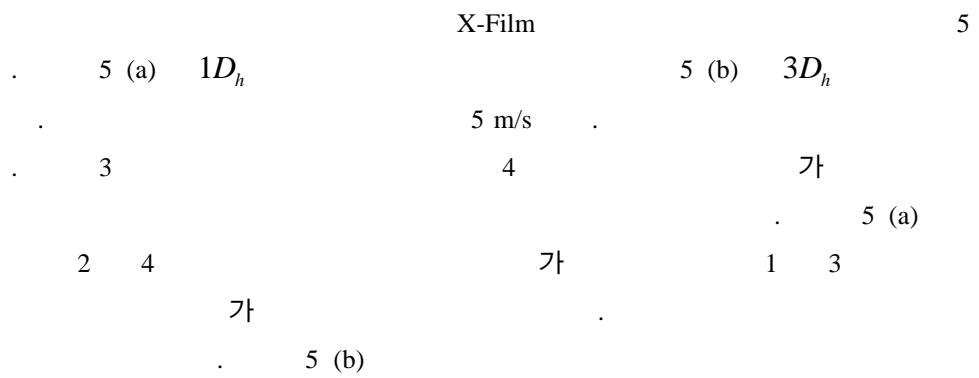
ν

3.

3.1



3.2



3.3

(2)

$$F_s = \frac{1}{p} \int \frac{|V_{lateral}|}{\bar{U}} dl \quad (2)$$

p

$|V_{lateral}|$

\bar{U}

l

6

5

6

$6D_h$

Hejna[7]

3.4

X-Film

(3)

$$I_x = \frac{u'}{\bar{U}} 100 \quad (3)$$

u'

\bar{U}

7

가

Yang[6]

Hejna[7]

3.5

가

(4)

$$F_c = \frac{1}{s} \int |V_{lateral}| dy \frac{\mathbf{d}}{\mathbf{n}_r} \quad (4)$$

(5) \mathbf{d} , \mathbf{n}_r Moeller[11]

$$\mathbf{n}_r = \mathbf{n} \frac{\text{Re} \sqrt{\mathbf{x}}}{20 \sqrt{8}} \quad (5)$$

\mathbf{n} , \mathbf{x} Blasius
 9 Hejna split vane
 가 Hejna[7]

3.6

(TDC) [7] (6)

$$TDC = \frac{1}{8 \cdot s} \int \frac{|V'|}{\bar{U}} dy \quad (6)$$

s, \bar{U} , $|V'|$
 TDC 8

TDC Hejna[7] 14%
 7
 $5D_h$ $6.2D_h$

4.

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Nomenclature

D_h	hydraulic diameter	[m]
F_s	swirl factor	
F_c	cross flow factor	
l	length along diagonal	[m]
p	diagonal distance from rod surface to rod surface	[m]
s	distance from rod surface to gap center	[m]
Re	Reynolds number ($= \frac{\rho \bar{U} D_h}{\mu}$)	
\bar{U}	subchannel average axial velocity	[m/s]
$V_{lateral}$	lateral velocity ($\sqrt{V^2 + W^2}$) perpendicular to diagonal	[m/s]
U, V, W	time averaged local velocity	[m/s]
x, y, z	coordinate	[m]
u', v', w'	turbulent fluctuations	[m/s]

Greek Symbols

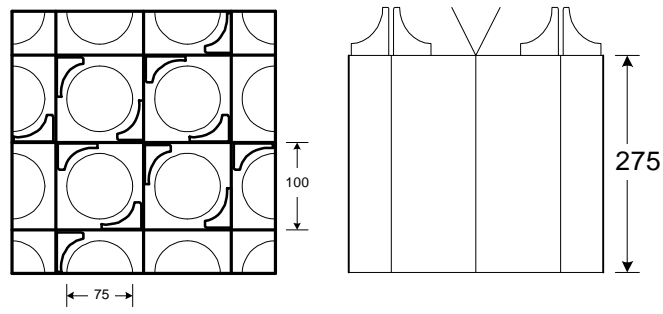
d	rod pitch
ν	kinematic viscosity
\mathbf{x}	friction factor

Subscripts

av	arithmetic bundle averaged
bulk	bulk average
r	reference

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(a) Top View (b) Side View

Figure 1. Test Spacer Grid

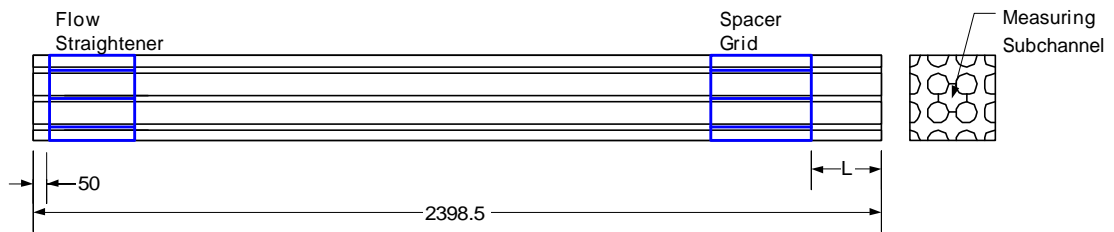
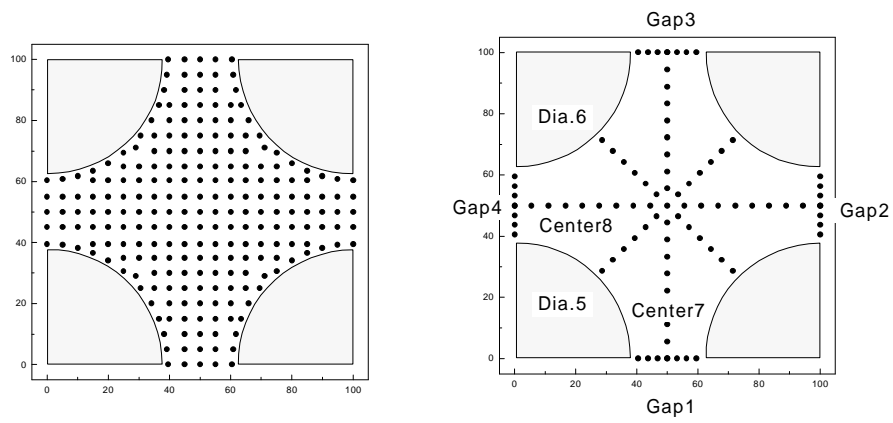


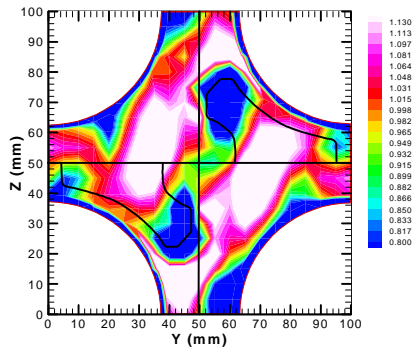
Figure 2. Test Section



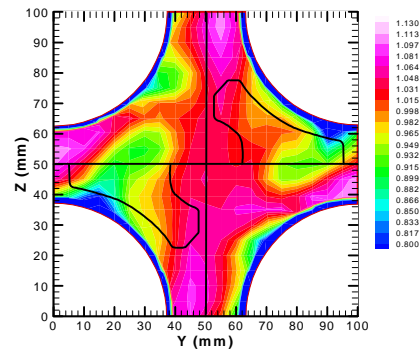
(a) Pitot Tube

(b) Hot Wire Anemometry

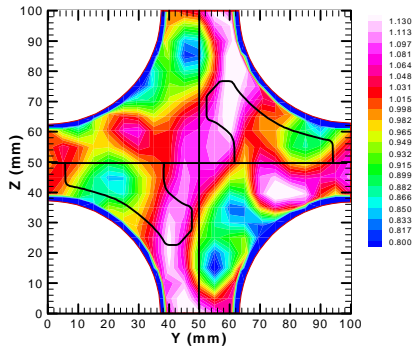
Figure 3. Measuring Points



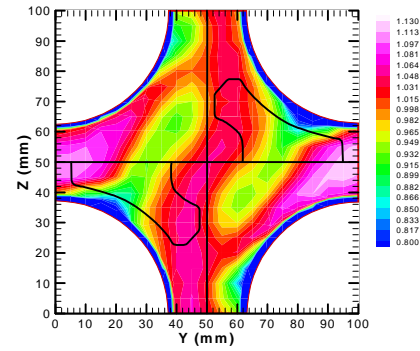
(a) $0D_h$



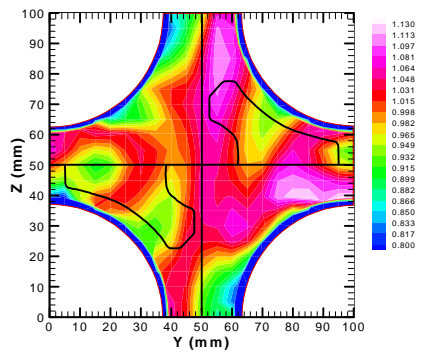
(d) $3D_h$



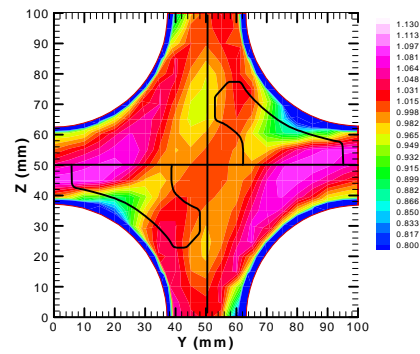
(b) $1D_h$



(e) $4D_h$

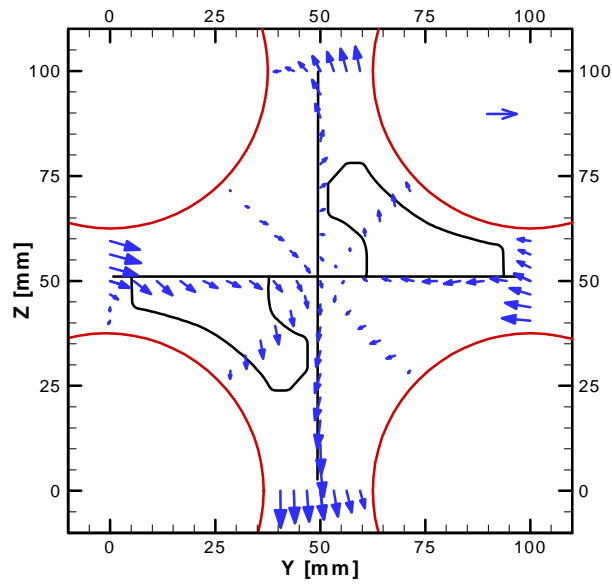


(c) $2D_h$

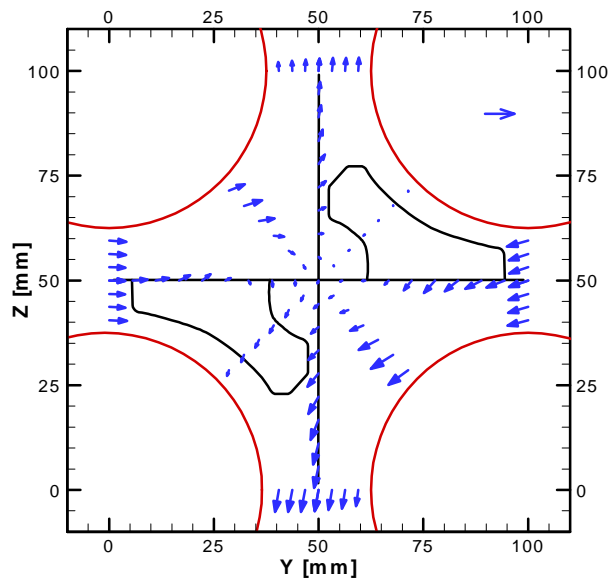


(f) $5D_h$

Figure 4. Axial Velocity Distribution



(a) $1D_h$



(c) $3D_h$

Figure 5. Lateral Velocity Distribution

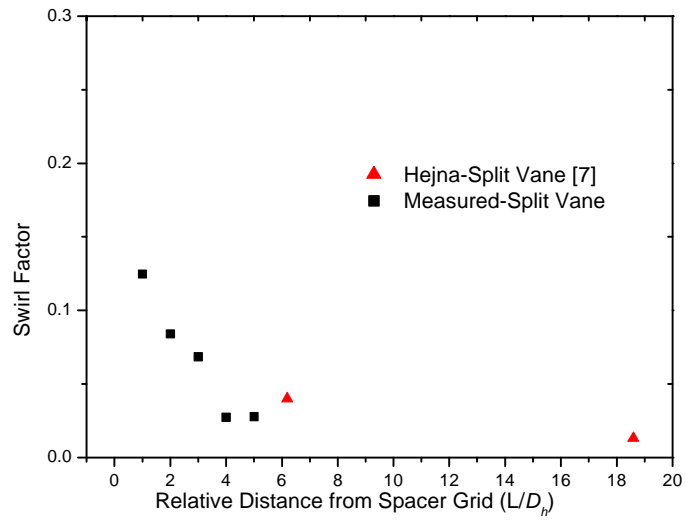


Figure 6. Swirl Factor

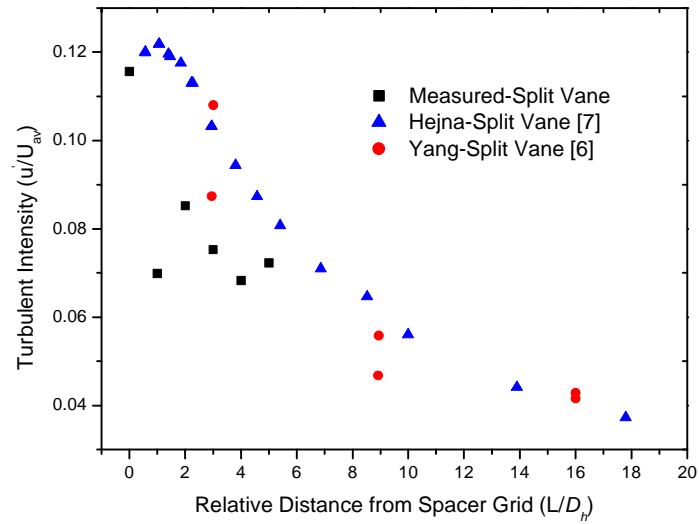


Figure 7. Axial Turbulent Intensity at Center of Subchannel in Axial Variation

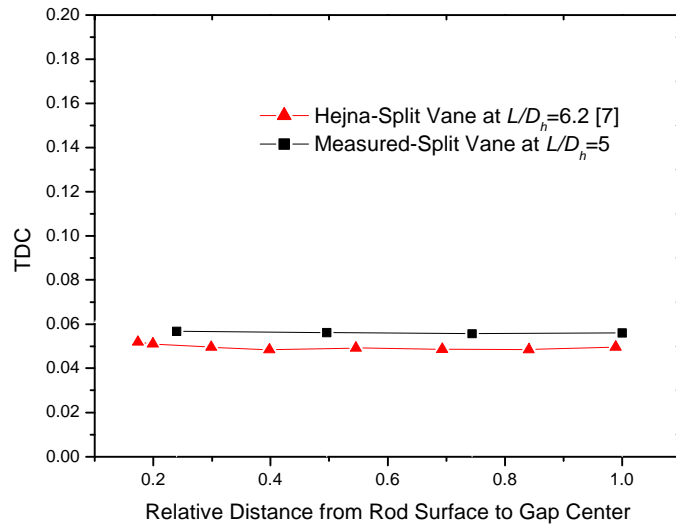


Figure 8. Turbulent Diffusion Coefficient

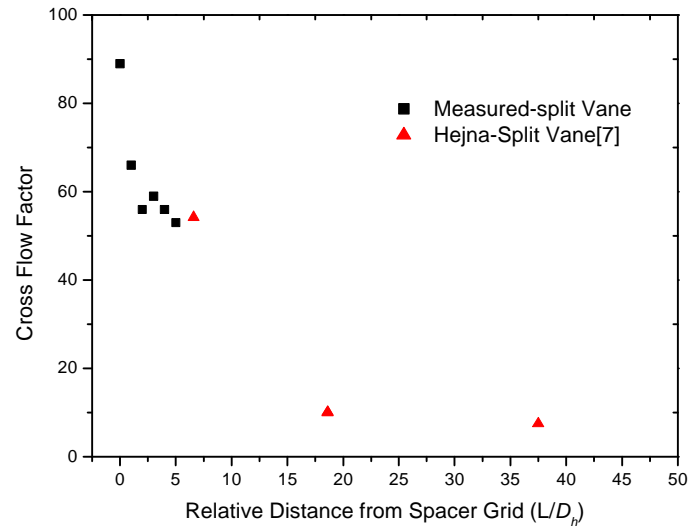


Figure 9. Cross Flow Factor in Axial Variation