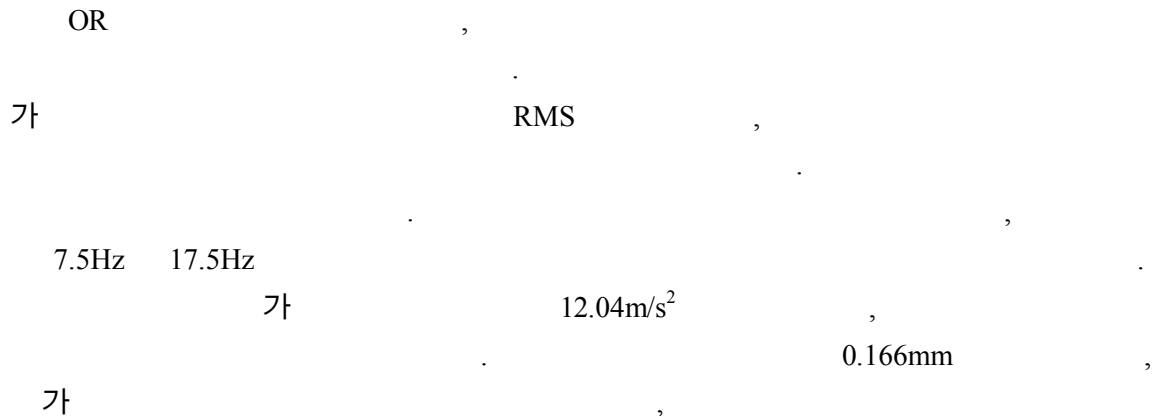


Vibration Test of an Instrumented Capsule for Fuel Irradiation Test

150

1/2



Abstract

The fluid-induced vibration level of an instrumented capsule for fuel irradiation test, which was manufactured for fuel irradiation test at the reactor core of HANARO, is investigated. For this purpose, the instrumented capsule is loaded and tested at the OR site of the HANARO design verification test facility that can simulate identical flow condition as the HANARO core. Vibration signals of the instrumented capsule subjected to various flow conditions were measured by using vibration sensors installed in the capsule. In time domain analysis, maximum amplitudes and RMS values of the measured acceleration and displacement signals are obtained. By using frequency domain analysis, frequency components of the fluid-induced vibration are analyzed. In addition, natural frequencies of the instrumented capsule are obtained by performing modal test. The frequency analysis results show that the natural frequency components near 7.5Hz and 17.5Hz are dominant. The maximum amplitude of the accelerations is found to be 12.04m/s^2 in time domain and is within the allowable limit of the HANARO reactor structure. Also, the maximum displacement amplitude was calculated as 0.166mm at the protection tube. Since these vibration levels are remarkably low, excessive vibration is not expected when the irradiation test of the instrumented capsule is to be performed at the HANARO core.

1.

1995 2 (first criticality) 8
 , , ,
 CT, IR1 IR2
 3 OR3 OR6 4 가 , 가
 ,
 ,
 ,
 가
 ,
 [1~4]. ,
 , (fluid-induced vibration)
 ,
 ,
 [5].
 , OR
 , 가 RMS(root
 mean square)
 ,
 (modal testing)

2.

,
 (fluid-induced vibration)
 ,
 (modal testing)

2.1

1/2 가 , 13 , 4
 OR 3 , 1/2

OR clamp, rod tip, bayonet, spider

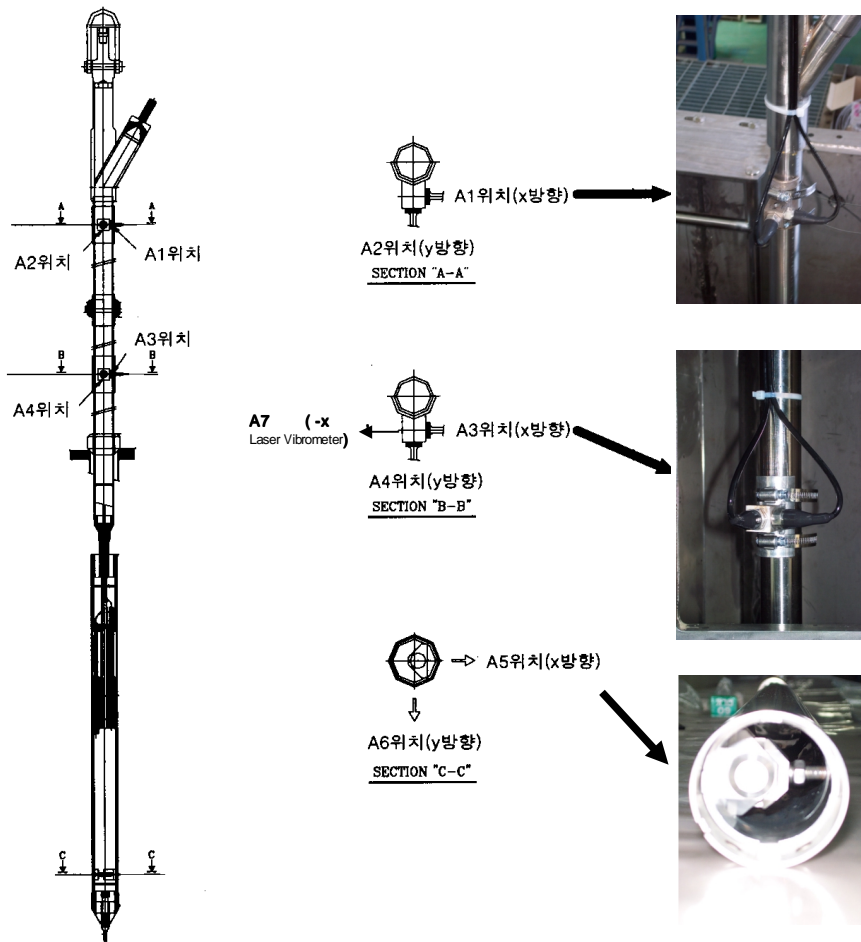
OR
 (9.49kg/s) 40% 120% 10%
 209kPa

[6].

2.2. 가

1

가



1

가

1
 (longitudinal vibration)

(lateral direction)

가
 (bending vibration)

가
 clamp
 clamp
 (A1 A2) 90°
 가
 (mounting thread) 가
 OR clamp
 OR clamp , OR
 OR
 2 가
 hose band 가
 , 가

A4) 가
 가
 90°
 2 가
 2 가 (A3
 가

2.3.

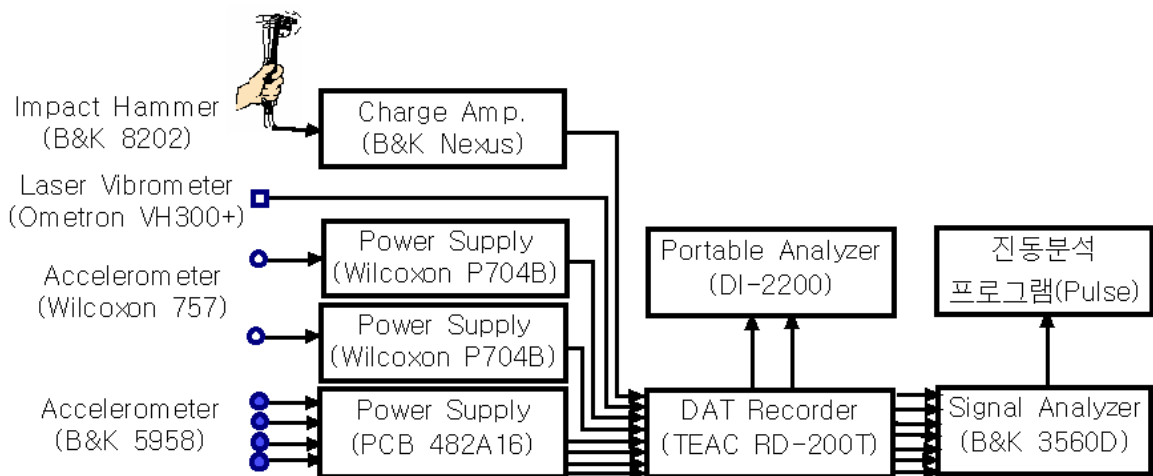
2

OR OR

2 가 (Wilcoxon 757)

4 가

(B&K 5958)



2

supply 가 , 가 가 가 power
 DAT recorder Laser Vibrometer
 (DI-2200) DAT recorder DAT recorder FFT analyzer
 (impact hammer)
 가 , 가 ,
 (force transducer) 가 가
 DAT recorder
 3
 Laser Beam
 Laser Vibrometer(Ometron VH300+) A3
 가



3 Laser Vibrometer

3.

()

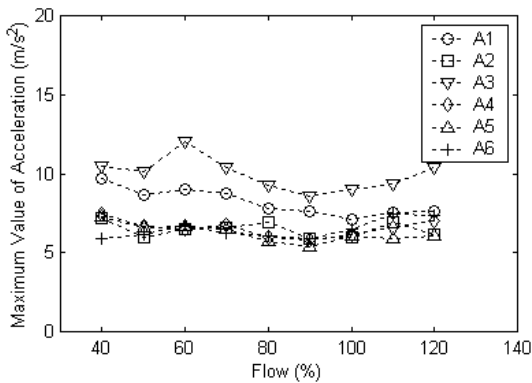
RMS(root mean square)

가

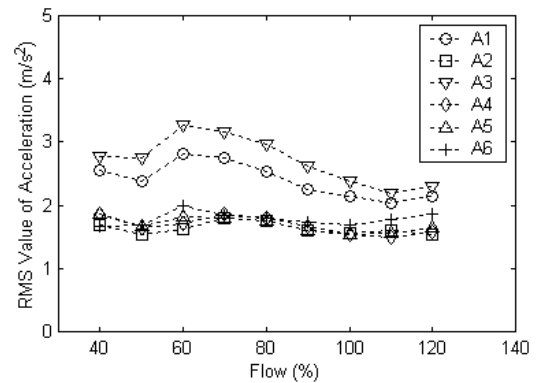
3.1.

[6] 40% 120% 10%

RMS
 4 6 가 가 , 2
 RMS
 가 4.91~12.04m/s², RMS 1.49~3.26m/s²
 가 RMS 3~4
 가 가 가

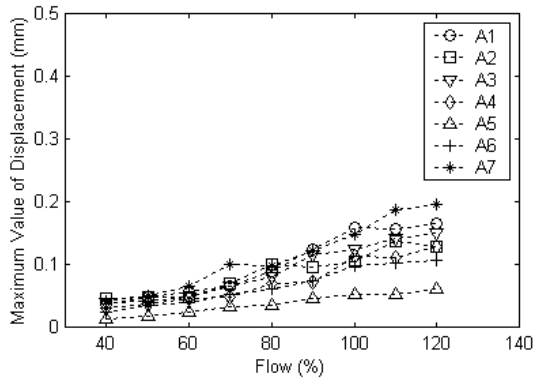


(a) 유량 변화에 따른 가속도 최대진폭의 변화

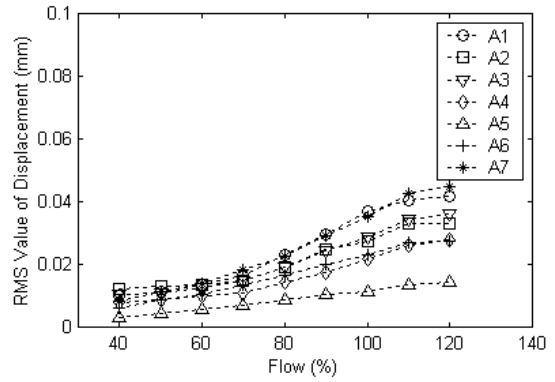


(b) 유량 변화에 따른 가속도 RMS값의 변화

4 가 RMS
 6 가 A3 12.04m/s²
 [7] 가
 x (A1 A3) 가
 y (A2 A4) 가
 OR clamp가 y
 5 40% 120% 10%
 RMS 가 가
 (1/(2πf)², f:) ,
 [8,9].
 가 (Inverse Fourier) 가



(a) 유량 변화에 따른 변위 최대진폭의 변화



(b) 유량 변화에 따른 변위 RMS값의 변화

5

RMS

5
0.003~0.042mm

A1~A6

0.012~0.166mm, RMS

(spring)

5 A7

Laser Vibrometer

x

가

A3

5

A3

A7

RMS

가

가

가

Laser Vibrometer

A3

5

가

RMS

가

가

가

A4

0.166mm

6

3.2.

OR

가

가

가

(frequency response function)[9]

6

x

(가

)

가

가

A1

A3

가

6

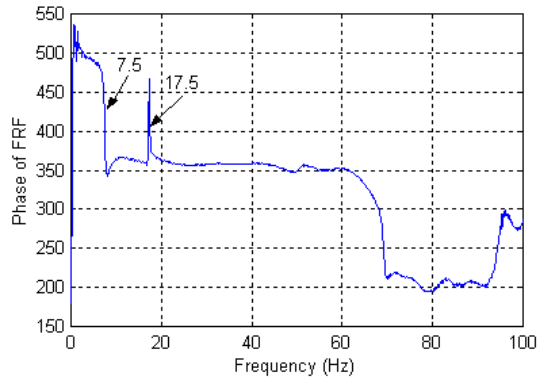
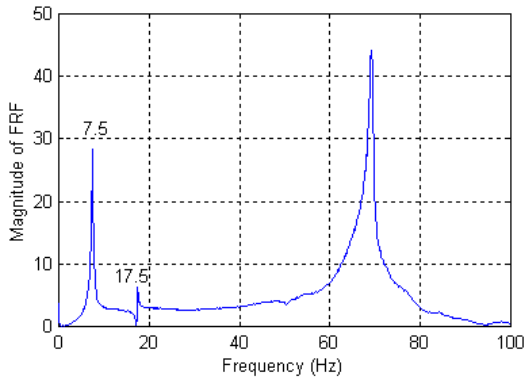
(magnitude)

가 (phase)

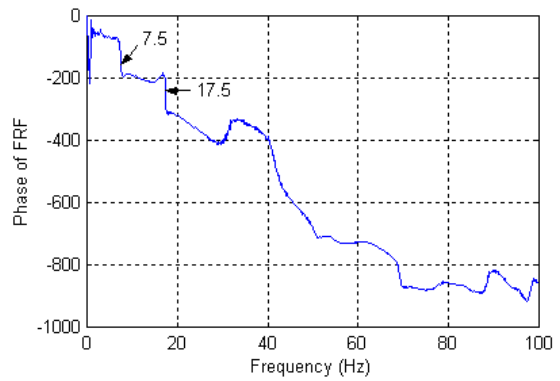
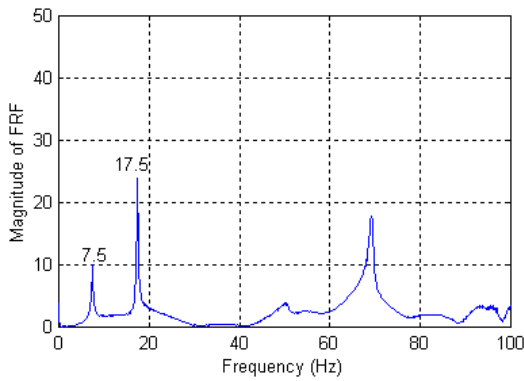
7.5Hz 17.5Hz가 x

1

2



(a) A1위치에서 구한 주파수응답함수의 크기 및 위상



(b) A3위치에서 구한 주파수응답함수의 크기 및 위상

6

(x)

7

y

가

, 가

A2 A4

가

18Hz

7

y

1

2

7.75Hz

가

, x-y

가 2 , x-y

가

OR clamp

x y

가

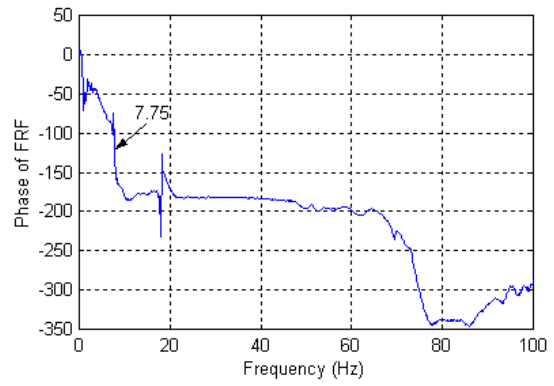
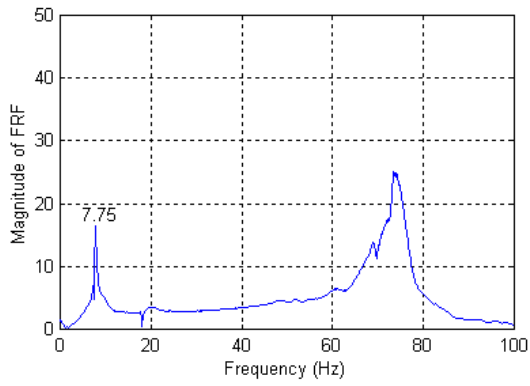
1

1

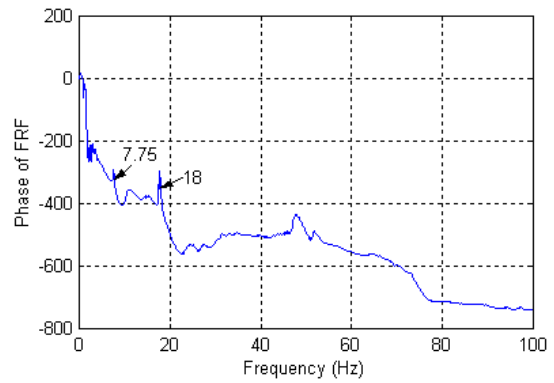
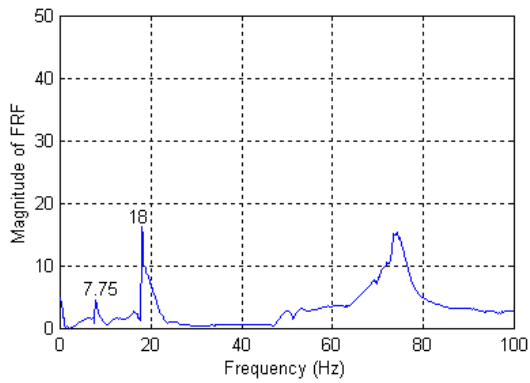
가

가

가 가
가 가



(a) A2위치에서 구한 주파수응답함수의 크기 및 위상



(b) A4위치에서 구한 주파수응답함수의 크기 및 위상

7

(y)

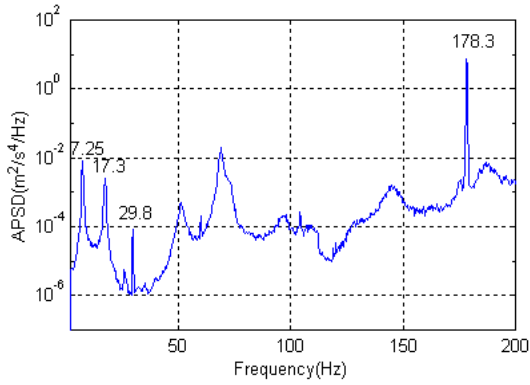
1

가	x	y	x	y
(Hz)	7.5, 17.5	7.75, 18.0	8.5, 24.0	8.75, 24.5

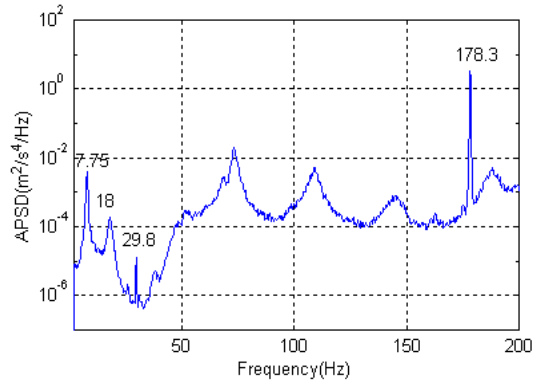
3.3.

9.49kg/s(100%)
(auto spectral density function)

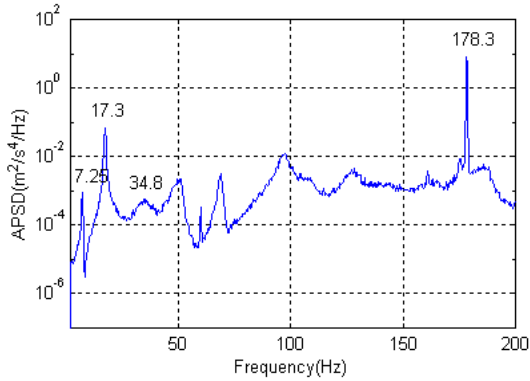
8



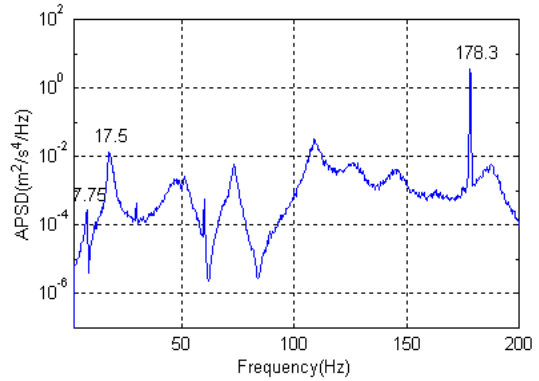
(a) A1위치 가속도신호의 자기스펙트럼밀도함수



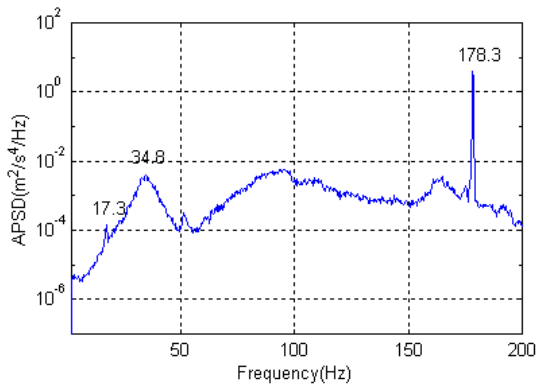
(b) A2위치 가속도신호의 자기스펙트럼밀도함수



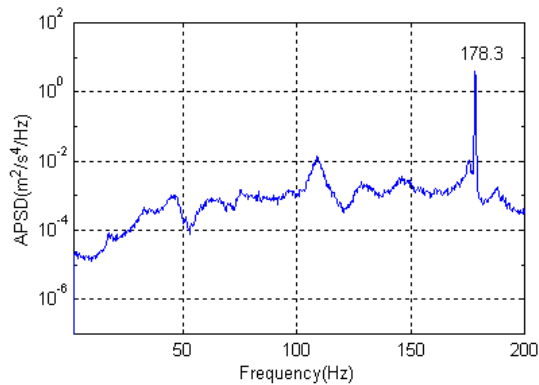
(c) A3위치 가속도신호의 자기스펙트럼밀도함수



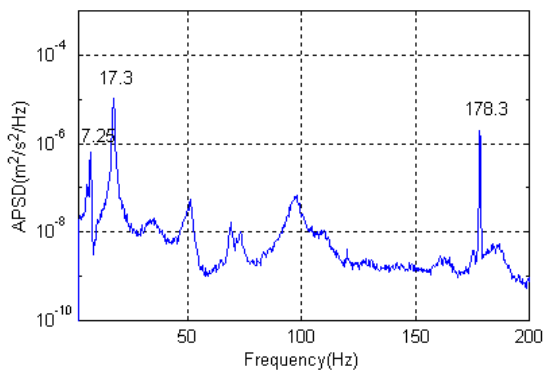
(d) A4위치 가속도신호의 자기스펙트럼밀도함수



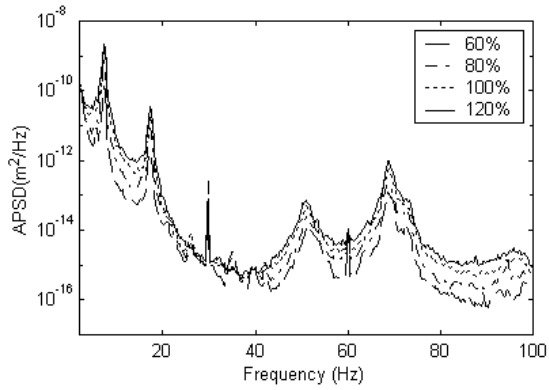
(e) A5위치 가속도신호의 자기스펙트럼밀도함수



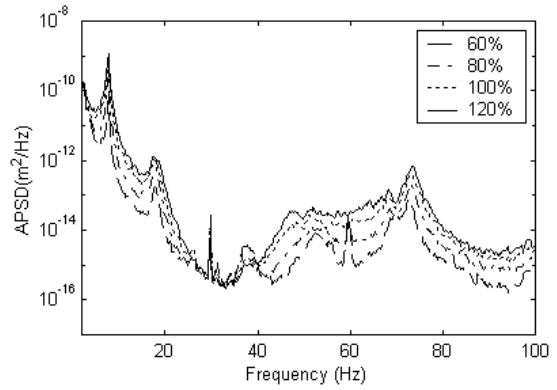
(f) A6위치 가속도신호의 자기스펙트럼밀도함수



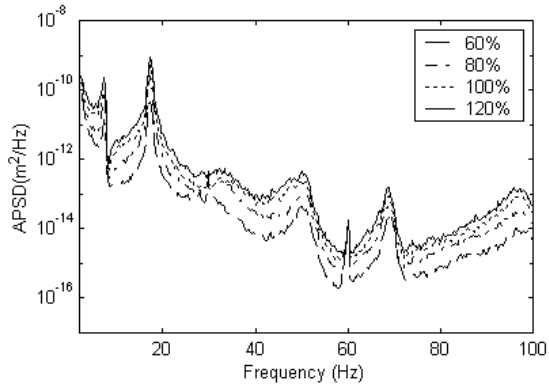
(g) A7위치 속도신호의 자기스펙트럼밀도함수



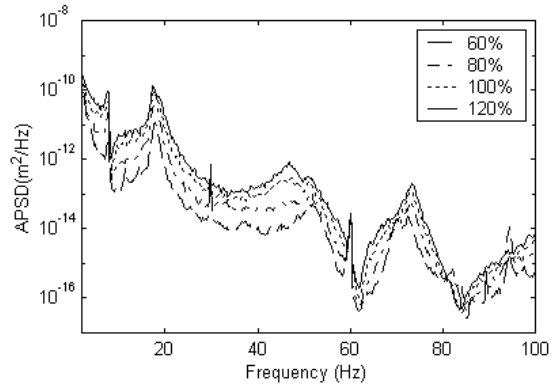
(a) A1위치 변위신호의 자기스펙트럼밀도함수



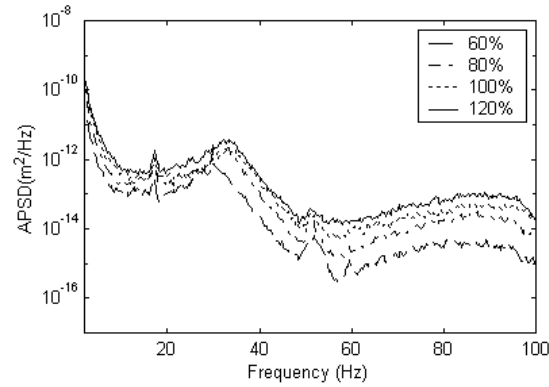
(b) A2위치 변위신호의 자기스펙트럼밀도함수



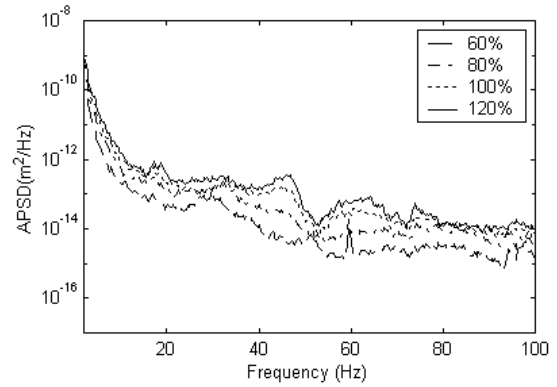
(c) A3위치 변위신호의 자기스펙트럼밀도함수



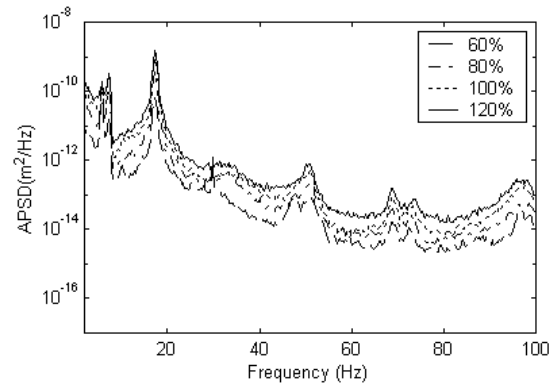
(d) A4위치 변위신호의 자기스펙트럼밀도함수



(e) A5위치 변위신호의 자기스펙트럼밀도함수



(f) A6위치 변위신호의 자기스펙트럼밀도함수



(g) A7위치 변위신호의 자기스펙트럼밀도함수

4.

- 1) 가 , RMS
가 가 .
- 2) x
7.5Hz 17.5Hz , y
7.75Hz 18Hz ,
가
- 3) 가
- 4) blade passing 178Hz 가
- 5) , 가
12.04m/s² , 가
(18.99m/s²)
- 6) 0.166mm ,
가

- [1] , “ Test Assembly ,”
, KAERI/ TR-1474/2000, , 2000.2.
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