Sampling Location in Nuclear Aerosol Stack

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1. Introduction

ANSI/HPS N13.1-1999 reported criteria of sampling location in nuclear stack to make representative sampling. The criteria of sampling location of radioactive particle are as following:

1. In velocity Profile, COV(Coefficient of Variation) shall not exceed 20% over the center region of the stack that encompasses at least 2/3 of the stack area
2. The average swirl angle shall be less than 20°
3. COV of particle concentration shall not be exceed 20% over the center region of the stack that encompasses at least 2/3 of the stack cross area
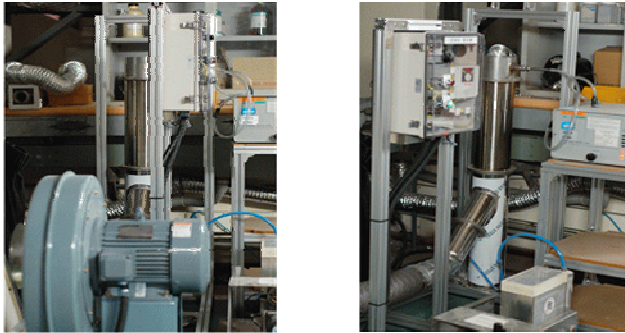

Figure 1. Experiment Apparatus

2. Simulation

Before experiment, The COV and swirl angle along the stack height were determined numerically. Using present calculation, the sampling position can be predetermined. Therefore, the sampling line from probe to detector can be minimized to reduce deposition loss. The calculation geometry was similar to that of Rodgers et al.(1996) . The disturbance occurs at the interface between rectangular duct and stack is 45°

Calculation was performed for Reynolds number of 10^5, 3×10^5 and 5×10^5 which cover normal and abnormal operating   condition of nuclear facilities. Standard k-ε model was used to include turbulent effect and flow field calculated using finite volume method.

Figure 1 shows COV as function of stack height z and, diameter of stack D. As shown in figure 2, COV decreases as height increases and COV is not significantly affected by Reynolds number.

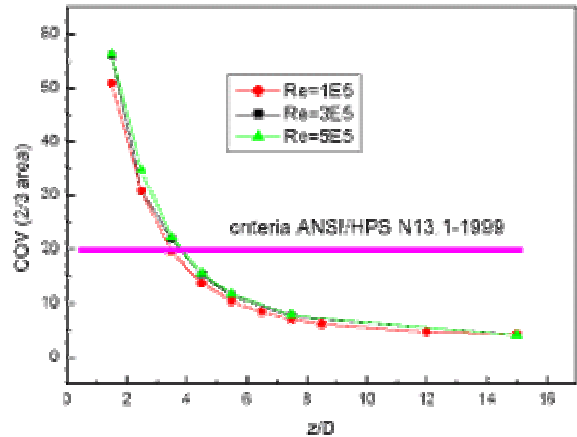[#] Chungnam Natonal University Mechanics Professor

Figure 2. COV as function of Z and D of stack

COV is satisfied the criteria at distance around 4D from the disturbance. The average swirl angle was also calculated in the same Reynolds number range. For all the cases, the average swirl angle satisfied the criteria.

3. Experiment

3-1 Velocity Profile

Figure 3 is an experiment outline of velocity measurement. Diameter of air inlet pipe is 100mm and inlet angle is 45°. Velocity was measured from 41 points
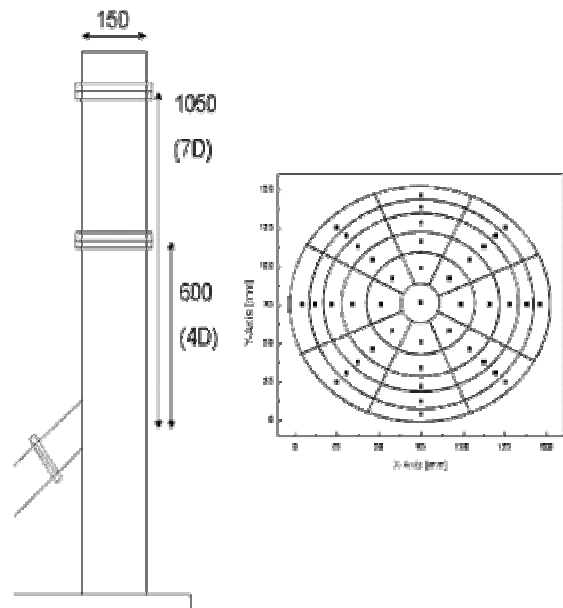

Figure 3. Measurement height and point of velocity

The COVs of velocity values at Z=4D and Z=7D are below 20%.

Table 1. The COV value of Velocity

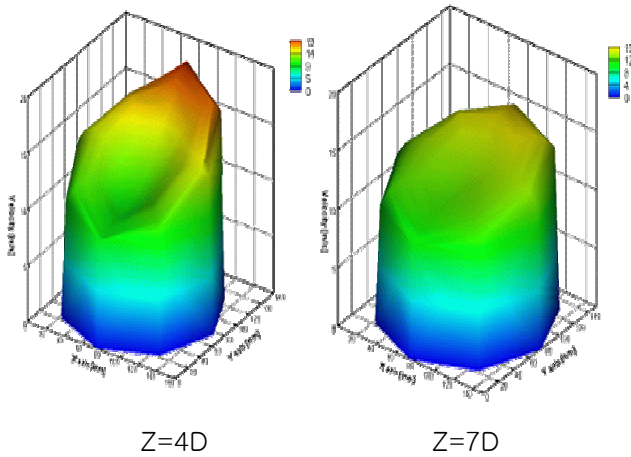| Position	COV(%)	ANSI HPS N13.1-1999
Z=4D	19.79	YES
Z=7D	11.52	YES

Z=4D   Z=7D

Figure 4. Velocity Distribution

3-2 Average swirl angle

The experiment of average swirl angle was not performed due to the absence of measurement tool.

3-3 COV of particle concentration

There are seventeen measurement points for particle concentration. Sampling nozzle manufactures according to ANSI rules. Inside diameter of the nozzle is 7.1mm and the inside diameter of sampling line 9.3mm
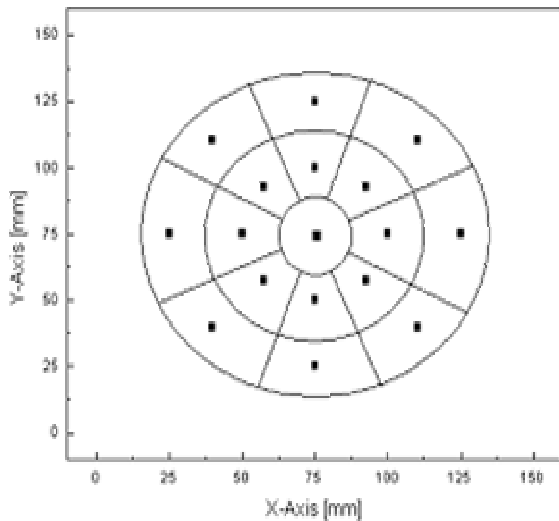

Figure 5. Measurement point of particle concentration

Figure 6. Sampling nozzle

The COV of particle concentration at z=4D, z=7D are as follows: As a result Z=4D is not appropriate as sample location

Table 2.The COV value of particle concentration

position	average concentration (particles/CC)	COV(%)	ANSI HPS N13.1-1999
Z=4D	1363.6	29.4	NO
Z=7D	1179.6	16.1	YES

4. Conclusion

From the simulation, ANSI HPS 13.1-1999 guide value(velocity COV less than 20%, particle concentration COV less than 20% , less than 20° swirl angle) is satisfied with Z=4D. But from the experiment, particle concentration COV is not satisfied at Z=4D. Therefore the appropriate location of sampling is Z >6D

REFERENCES

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[4]ANSI/HPS N13.1-1969, "Guide To Sampling Airborne radioactive materials in Nuclear Facilities, 1969