別紙４－１（課程博士（英文））

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# Abstract (Doctor)

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| Title of Thesis | Study on Hot-Smoke Behavior from A Chimney Ejecting into Turbulent Crossflow |

Approx. 800 words


This study aimed to investigate the hot-smoke dispersion behavior released from a chimney in turbulent crossflow experimentally using specially designed wind tunnel. Two turbulence generators were conducted which an artificially obtained quasi-isotropic turbulence was generated using an active turbulence generator and a rectangular grid to generate grid turbulence. A heated jet and an unheated jet with smoke were injected into the crossflow from the vertically oriented chimney installed in the test section. The chimney model was placed on the floor of the wind tunnel test section. In this study, the experimental parameters considered were temperature of the heated jet (smoke), jet ejected velocity, and cross-wind velocity. Smoke motion was captured by high-speed camera to obtain instantaneous patterns of the smoke dispersion. Six kinds of the featured patterns were clearly identified, such as bifurcated vortex tubes with and without a strong mutual interaction (Mode I and Mode II), connected hairpin-type vortices (Mode III), the mixture of the coherent and turbulent vortices (Mode IV), the meandering motion (Mode V), and downwash structure (Mode VI). These smoke patterns in the downstream field from the chimney were found to be depended on buoyancy, turbulent motion, and inertia forces. Under the quasi-isotropic turbulence, the smoke dispersion preferred to exhibit a meandering pattern (Mode V) under wide range of adopted flow velocities, which was hardly observed using the grid turbulence test device. Interestingly, as compared to the unheated jet, the meandering smoke structure with heated jet ejection was also observed even at the lower jet velocities and the higher crossflow velocities, suggesting that the buoyancy force shall play an important role on appearance of meandering motion and control the smoke dispersion. Direct smoke exposure case (Mode VI) was preferred to be observed when the quasi-isotropic turbulence was imposed, although the trend of appearance depending on the jet temperature could be predicted even using grid turbulent device. It was concluded that using grid turbulence would not be suitable to predict on the smoke dispersion problem in the actual scale. The time averaged smoke concentrations profiles were analyzed at locations along the crossflow direction, and it was revealed that the effective diffusion becomes stronger when the quasi-isotropic turbulence was imposed in the cross-wind. Further, it was confirmed that the smoke dispersion behavior can be well-characterized by the existing prediction

method based on the point source model. In addition, two patterns were observed under the condition studied in quasi-isotropic turbulence condition, such as meandering motion in downstream (Mode V) and downwash (Mode VI). The boundary of these two modes was found to be sensitive to all three parameters considered in this study, suggesting that all were similarly important to determine the boundary. The observed data were summarized in the physical plane to propose the potential scaling law of Reynolds number and jet-Froude number, and it was found that all plots were collapsed into the single line. This result suggested that the viscous effect around the chimney plays a role on the appearance of downwash pattern of the hot-smoke. This proposed scaling law worked well to describe the critical condition of the appearance of the downwash pattern under the condition studied in the present work. Moreover, the interpretation of the phenomena has been further made with the numerical approach to gain more detailed physics with the insightful understanding from scientific way for the downwash pattern, it was studied in the numerical simulation using the Fire Dynamics Simulator (FDS), Large Eddy Simulation (LES). The reason how the downwash occurs from the chimney is identified. Results shown that the downwash pattern occurred when the plume was drop down into low-pressure region in the wake of the chimney which caused by low-speed zones appear at behind of the chimney. When this appears, plume rise may be diminished, or in some cases, the effluent may be trapped in the wake and eddies of the chimney, which may result in high ground-level concentrations immediately downwind on the area.