Wind Tunnel Experiment for Predicting the Visible Plume Region from a Wet Cooling Tower
− Toward the Application of an Environmental Impact Assessment −

Background

Recently, in Japan, an independent power producer (IPP) has built thermal power plants with wet mechanical cooling towers instead of the conventional sea water-cooled system. Visible plume from the wet cooling tower produces some significant atmospheric effects, such as the reduction of visibility to air and ground, ice formation on surfaces, cloud initiation, and augmentation of precipitation. It is therefore of great importance to predict the visible plume region from the cooling tower in an environmental impact assessment. A wind tunnel experiment is considered to be one of the predominant methods, but no one has estimated the visible plume region generated from the vapor of the cooling tower.

Objectives

The objectives of this study are to develop detailed and simple methods for the wind tunnel experiments to predict the visible plume region from a wet cooling tower.

Principal Results

1. Development of a detailed method to predict the visible plume region

The diffusions of water vapor and heat emitted from the cooling tower in wind tunnel experiment are tracked using a tracer gas. The water vapor mixing ratio is estimated using the instantaneous concentration of the tracer gas, which is measured using high-response flame ionization detectors. A visible plume region is defined as all area where the instantaneous water vapor mixing ratio is larger than the instantaneous saturation water vapor mixing ratio (Figure 1). The results obtained by the present wind tunnel experiments are in good agreement with the some observations as shown in Figure 2.

2. Development of simple method to predict the visible plume region

In above method, since the instantaneous concentration must be measured, the specific measuring instrument, which is not usually applied in the present environmental impact assessment, is needed. Therefore, we experimentally introduced the approximate equation of the instantaneous high concentration, which is a function of time-averaged concentration and the spreading width, and proposed a simple method to predict the visible plume region using only time-averaged concentration. The visible plume region obtained by simple method are in good agreement with those obtained by detailed method (Figure3), and it indicates that it is possible to evaluate the visible plume region by measuring only time-averaged concentration using the normal measuring instrument.

Future Developments

We will investigate the validity of the present method for a real cooling tower that has many stacks, and aim to apply the present method to an environmental impact assessment.

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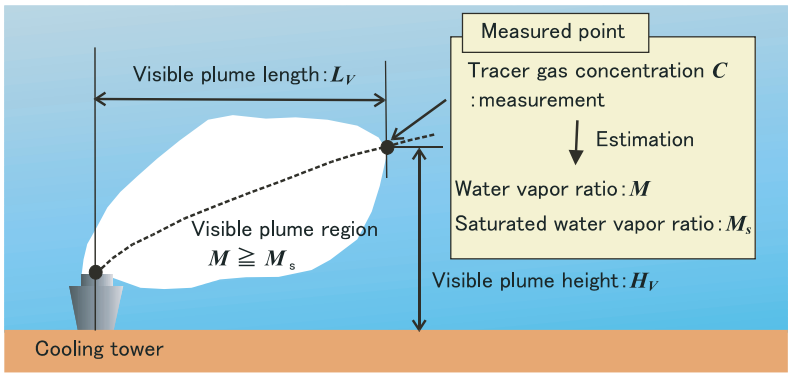
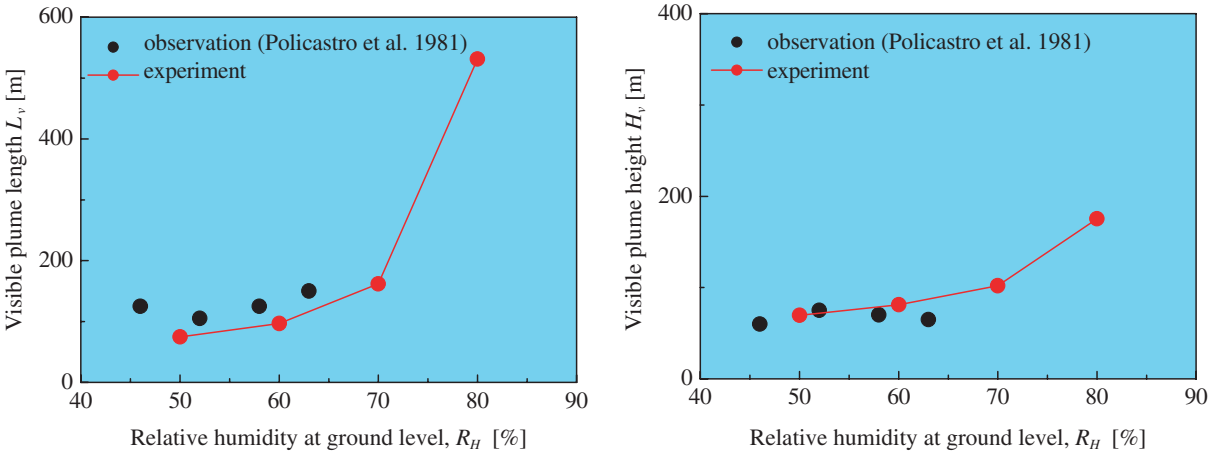
Reference

Michioka et al. Wind tunnel experiments of visible plume from a cooling tower. -Development of visible plume prediction method from a single stack- Komae Research Laboratory Rep. No. T030011 (2004)



The diffusions of water vapor emitted from a cooling tower in wind tunnel experiment are tracked using tracer gas. A visible plume region is justified as the area where the water vapor mixing ratio is larger than the saturation water vapor mixing ratio.

Fig.1 Schematic of the present method

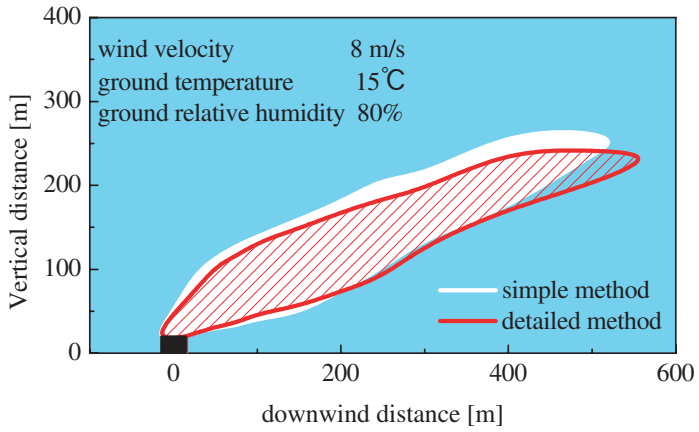


(a) Visible plume length

(b) Visible plume height

Fig.2 Comparison of observations and wind tunnel experiments

The visible plume length and height obtained by the present wind tunnel experiments are compared with some observations. Here, in the present method, since the cloud is generated at a high altitude of a few meters under a high relative humidity at the ground level, we cannot justify whether it is a visible plume from the cooling tower or a cloud. However, the present method can predict the visible plume region at low altitude, it is hence possible to estimate the reduction in visibility on elevated roads and buildings, which is very important in environmental impact assessment.



It is possible to evaluate the visible plume region by measuring only time-averaged concentration using the normal measuring instrument. Therefore, it is expected to apply the present simple method to environmental impact assessment.

Fig.3 Visible plume region (Comparison of simple and detailed methods)