Experience (12)

Estimating SO_2 Concentrations Using the Gaussian Model

Objective of the Experiment

1. Teaching students how to estimate pollutant concentrations at various distances from continuous emission stacks.
2. Helping students understand how concentrations decrease with horizontal distance.

Theoretical Part:

One of the applications of Gaussian dispersion theory is estimating the concentration of a given pollutant based on several assumptions. These assumptions include considering pollutant emissions as steady, neglecting dispersion along the mean wind direction, assuming the pollutant is chemically inert, and that particles instantly spread from high-concentration areas to low-concentration areas. The general equation for continuous source dispersion in two dimensions(x, z) is given by [6]:

$$C(x.y.z) = \frac{Q}{2\pi\, U\, \sigma_y\, \sigma_z}\, e^{\frac{-y^2}{2\sigma_y^2} - \frac{(z-H)^2}{2\sigma_z^2}}$$

Where σy and σz are the dispersion coefficients in the y and z-directions, respectively. U is the wind speed at the effective height. The concentration at ground level (i.e., z=0 and y=0) can be determined by simplifying the above equation as follows:

$$C(x.0.0) = \frac{Q}{2\pi\, U\, \sigma_y\, \sigma_z} \qquad (4\text{-}11)$$

Materials and Tools used

1. Specifications of the Dora Refinery Stack (Middle Refineries Company) with the following technical characteristics:
   - Diameter: 0.3 m
   - Actual height: 60 m
   - Temperature: 773 K
   - Fuel consumption: 720,000 m^3/month (fuel gas)

2. Automatic meteorological station.
3. Standard deviation charts for lateral and vertical dispersion coefficients, as shown in Figure (4-9).

Method of Work

1. Calculate the source strength in g/s for the Dora Refinery chimney. Use the given specifications and the methodology from Experiment 2.3 to verify the source strength.
2. Determine the wind speed at the estimated effective height using Equation (3.9) from the previous experiment.
3. Identify the atmospheric stability class using data from the meteorological station installed on the roof of the Atmospheric Sciences building, with measurements displayed on the LCD screen in the Air Pollution Laboratory.
4. Calculate the dispersion coefficients σy & σz for distances of 500 m, 1 km, and 2 km from the chimney. Use the stability class identified in step 3 and refer to the standard deviation charts in Figure (4-9).
5. Compute the concentration of SO_2 at the horizontal distances mentioned above for different transverse (y = 50, 100, 300 m) and vertical (z = 250, 300, 500 m) positions.
6. Record the results in the following table:

X (m)	σ_y (m)	σ_y (m)	Y (m)	Z (m)	C_{SO2}	$C_{SO2}(x,0,0)$
500			50	250		
1000			100	300		
10000			300	500		

7. To calculate the dilution (reduction in pollutant concentration) with horizontal distances $\frac{C_x(10000)}{C_x(1000)}$ & $\frac{C_x(1000)}{C_x(500)}$

Discussion

Q1: Calculate the pollutant concentration at ground level?

Q2: Discuss the pollutant concentration with horizontal distances?

Q3: Define the Gaussian Dispersion Theory?

Q4: Do dilution ratios have a relationship with atmospheric stability? Explain.