

The Experiment 11

Calculating the emission rate of pollutants from a single chimney

The Objective of the experiment:

Teaching students how to calculate the emission rate of any pollutant from a continuous point source, in addition to introducing them to its importance in applications of pollutant calculations within an hour or a year .

The Theoretical Part:

The pollutant emission rate is of particular importance in air pollution applications, such as the simple model, the Gauss model, climate change calculations, and so on. Emissions from stationary sources are initially divided into restricted and unconfined. Restricted emissions are those from stacks and other regular release designs that are usually the result of a specific ventilation process that draws pollutants in with fans or other engines. Unrestricted emissions are those emerging from surface ventilation openings and other gaps, which are carried by natural convection resulting from buoyancy. Determining the quantities of restricted emission is much simpler than that of unrestricted emissions. For both types of emissions, there are two important measurements, which are the concentration of the pollutant and the mass flow rate, which when calculating it is necessary to know the gas flow rate .

At the volumetric emission rate, we must correct it because both temperature and pressure have different values than in the surrounding air. Therefore, the gravitational concentrations are converted to natural units of mass per cubic meter, kg/m³, at standard conditions (temperature 20 °C and 1 atmosphere pressure) before recording them. Since pressure and temperature are unlikely to be standard, there appears a need to convert gravitational units at standard conditions. (STP) to other pressure and temperature. Under standard conditions, a volume of 1 m³ contains a certain mass of matter. When temperature and pressure change, the volume changes, but it remains containing the same mass of matter. However, the emission rate is calculated as [17]:

The volumetric gas flow rate inside the chimney in m³/s is given by:

$$E_s \left(\frac{m^3}{sec} \right) = v_s * A = v_s * \frac{\pi * D_s^2}{4} \quad (4-2)$$

Then we need to correct the flue gas flow rate to take into account the moisture content and standard conditions using the following relationship:

$$E_{s,\text{dry}} \left(\frac{\text{m}^3}{\text{sec}} \right) = E_s * \frac{273.15}{T_{\text{actual}}} * \frac{P_{\text{actual}}}{1_{\text{atm}}} (1 - \text{fraction water vapour}) \quad (4-3)$$

Where P_{actual} , T_{actual} They are the pressure and temperature inside the chimney in units of K and atmosphere. By knowing the concentration rate of a certain gas inside the chimney, we obtain the emission rate in units of g/s.

$$Q_s = E_{s,\text{dry}} \left(\frac{\text{m}^3}{\text{s}} \right) C_0 \left(\frac{\text{g}}{\text{m}^3} \right) \quad (4-4)$$

If the concentration is in ppm, the emission rate is calculated by the following equation:

$$Q_s = 4.5 * 10^{-8} * E_{s,\text{dry}} C_0 (\text{ppm}) * M_{\text{pollutant}} \quad (4-5)$$

The Materials and Tools used

1. A chimney containing two small holes.
2. Temperature measuring device.
3. Pressure measuring device.
4. Water vapor measuring device.
5. A sensor to measure the concentration of a specific gaseous pollutant.
6. Pollutant source.
7. Pull or push fan.
8. Iron tripod stand.

The Method of Work:

1. Measure the inside diameter of the chimney with a ruler.
2. Place the source of pollution on top of the iron stand, then cover them with the chimney as shown in the diagram (1-3).
3. Measure the exit velocity of pollutants (v_s).
4. Calculate the volumetric flow rate of pollutants by applying equation (4-1).

5. Through the two holes, he measured the temperature inside the chimney three times, taking the average and its pressure, while converting the temperature unit value to the kelvin.
6. Measure the water vapor content of the pollutants released.
7. Calculate the volumetric flow rate corrected for pollutants using equation (4-2).
8. Measure the concentration of the pollutant whose mixed emission is to be calculated using a fan.
9. If the unit of measurement for the pollutant is mg/m^3 , calculate its emission rate directly using equation (4-4) and substitute the $E_{s \text{ dry}}$ value calculated in step 4.
10. If the pollutant is measured in ppm, find its average molecular weight, then calculate its emission rate using equation (4-4) and replacing the $E_{s \text{ dry}}$ value calculated in step (4).

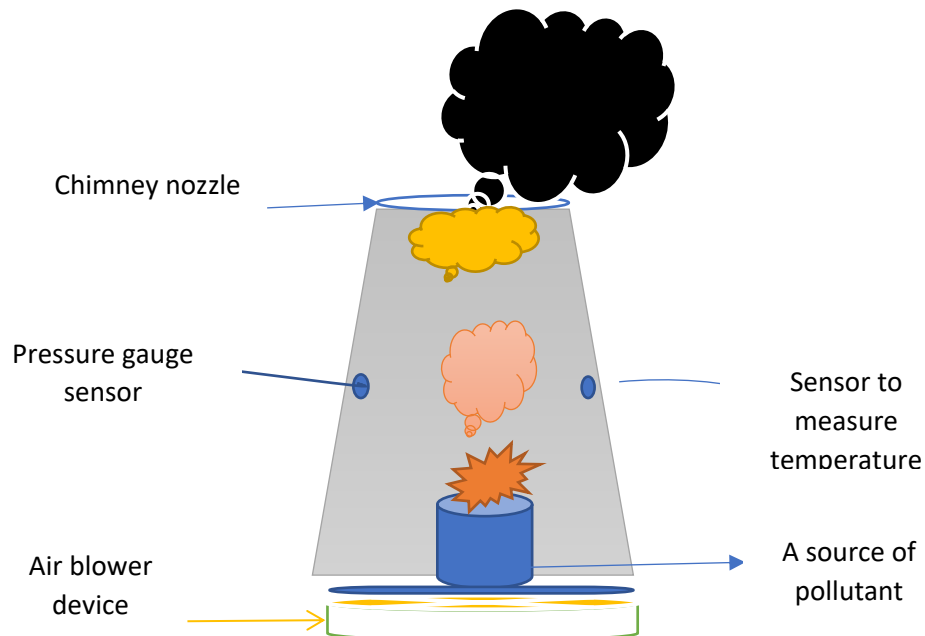


Figure (4-4): Schematic of a chimney with a single nozzle

Discussion

1. Explain how to convert the emission value used in this experiment to tons/year (Ton/year)?
2. Explain another way to calculate the emission rate?
3. Find another way to calculate the emission rate. Mention it and explain it briefly?
4. Explain how the volumetric flow rate equation (2.4) was corrected, that is, show the equation that was used in the correction?