The Tenth Experiment

Estimating the rise of polluted Blinders

The Objective of the experiment:

1. Calculate the effective rising Blinder height and determine its location above the chimney.
2. Calculate the true slope rate of the atmospheric layer above the chimney.
3. Determine and draw the shape of the blinders emerging from the chimney according to the surrounding weather conditions.

The Theoretical Part:

Studying the initial blinders rise is important in the diffusion behavior of pollutants flowing from a single chimney (point source), as the height of the blinders emerging from the chimney and entering the atmosphere determines the trace of pollutant concentrations measured near the Earth's surface. If the ascent is high, the blinders carried by the wind will travel large distances before reaching the ground, and this is followed by a decrease in ground level concentrations, as a result of the large dispersion in the blinders. Most blinders entering the air usually have either an exit velocity that lifts them upward or some degree of buoyancy resulting from differences in temperature or density with or with the surrounding air. Note Figure (6b-4). The height of the chimney ranges from 250 m to 300 m in most cases, and rarely reaches 400 m. We must not forget that the horizontal wind speed also has an effect on the blinders rise, as the high wind speed quickly discourages the blinders from rising vertically with the direction of the wind, as shown in Figure (6a-4). Although high wind speeds reduce the rise of the blinders. dispersion may not be affected due to the passage of a large volume of moving air through the source, meaning that high winds usually enhance the dispersion processes, and finally the rise of the cloud is also affected by atmospheric stability [17].

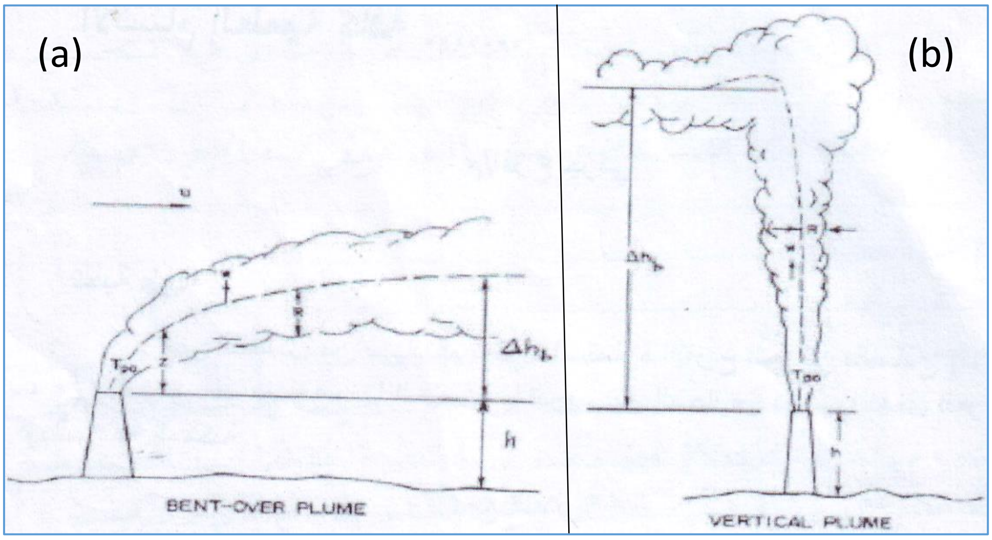

Figure (6-4): The rise of the blinders due to the temperature difference between the cloud and the ocean due to wind speed

From what was explained above, we find that atmospheric stability plays a role in the rise of blinders, and the rise height will be calculated according to it below. We assume that the spread of pollutants the moment they exit the chimney nozzle begins from an imaginary height Δh in addition to the real or natural height of the chimney, as shown in the diagram and picture in Figure (7-4). Therefore, the effective stack height (H) becomes:

$$H = h + \Delta h$$

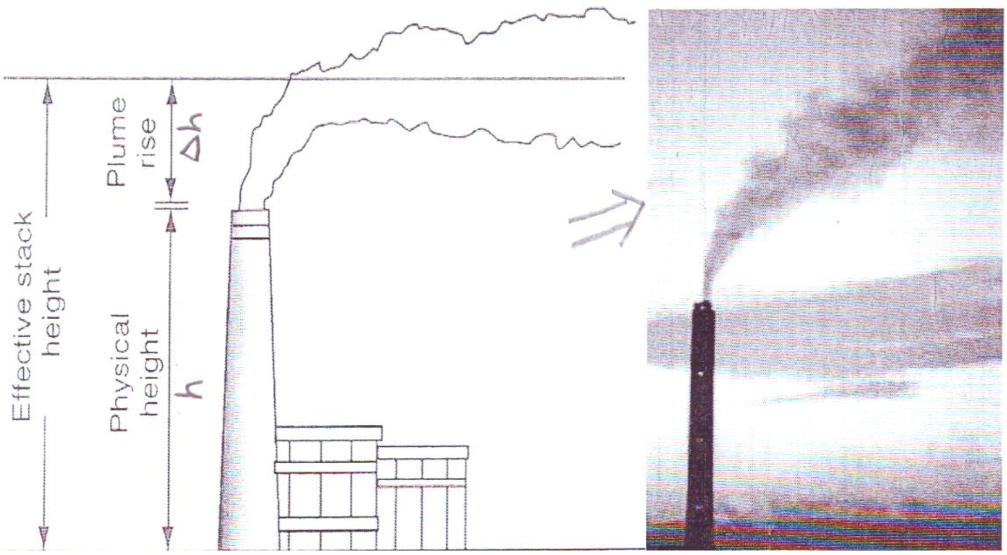

Figure 7-4: A chimney with initial specifications.

The effective boarding height depends on:

1. Temperature of emissions leaving the chimney.
2. Internal cross-sectional area of the chimney.
3. Emission speed.
4. Horizontal wind speed.
5. Vertical gradient of temperature through the dispersion and diffusion layer.

In this experiment, we will focus on calculating the effective height resulting from the rise of the blinders due to thermal buoyancy, as it prevails in most cases during the daytime, and blinders rise rarely occurs as a result of increased exit velocity.

On the wind speed by four times [6]. In any case, Δh is calculated according to the amount of movement, buoyancy, and stability according to the relationship below:

$$\Delta h = \frac{114 * S * {F_b}^{1/3}}{U_s} \qquad (4-7)$$

Where Us: the wind speed at the chimney nozzle is extracted from equation (3-1).

F_b: Primary buoyant flux in ($m^4.S^{-3}$) which is calculated from:

$$F_b = \frac{g v_s {D_s}^2}{4T_a}(T_p - T_a) \qquad (4\text{-}8)$$

Where Tp: temperature of pollutants, Ta: ambient air temperature and S: atmospheric stability factor, it is given:

$$S = 1.58 - 41.4\,\frac{\Delta\theta}{\Delta Z} \qquad (4\text{-}9)$$

Where Δθ/ΔZ: the gradient of the potential temperature in K/m, which is calculated from the chimney nozzle to the top of the cloud rise using the following relationship:

$$\frac{\Delta\theta}{\Delta T} = \left(\frac{\Delta T}{\Delta z}\right)_{actual} (K/m) + 0.0098\ (K/m) \qquad (4\text{−}10)$$

The Materials and Tools used

1. A graph paper showing only a chimney 8 m above ground level (note Figure 4-8).
2. Static chimney data: D_S=0.4 m, T_P=420 K, V_S=3 m/s.
3. Wind speed measuring device at a height of 8 m.
4. Air temperature measuring device number 2, one of which is fixed at a height of 8 m and the other at a height of 20 m, making sure to place them in a dark place to avoid the influence of sunlight.
5. Calculator with ruler.

The Method of Work:

1. Measure the wind speed at a chimney nozzle height of 5 m three times every five minutes and then calculate their average.
2. Simultaneously measure the air temperatures at heights 5 m and 20 m, three times every five minutes, and then find their rates.
3. Convert temperature values from degrees Celsius to Kelvin units.
4. Use equation (4-8) to calculate F_b.
5. Calculate the value of (ΔT/Δz) actual from T_2-T_1/Z_2-Z_1, then we substitute the value into equation (4-10) to obtain the stability factor S.
6. Calculate the value of the change in height of the blinders rise (Δh) using equation (4-7).
7. Calculate the value of the effective height of the blinders rise (H) using equation (4-6), which represents the center line of the cloud emerging from the chimney.
8. Fix the value of H on the curve and then connect it to the chimney nozzle according to the wind value: the line is curved if $U_S \geq 2$ m/s and vertical if $U_S < 1$ m/s.

9. Draw the shape of the conical blinders around the center line, where it becomes more obtuse as it moves away from the nozzle.

10. Shade the shape of the cloud Strongly near the chimney nozzle and slightly when away from the chimney, and why?

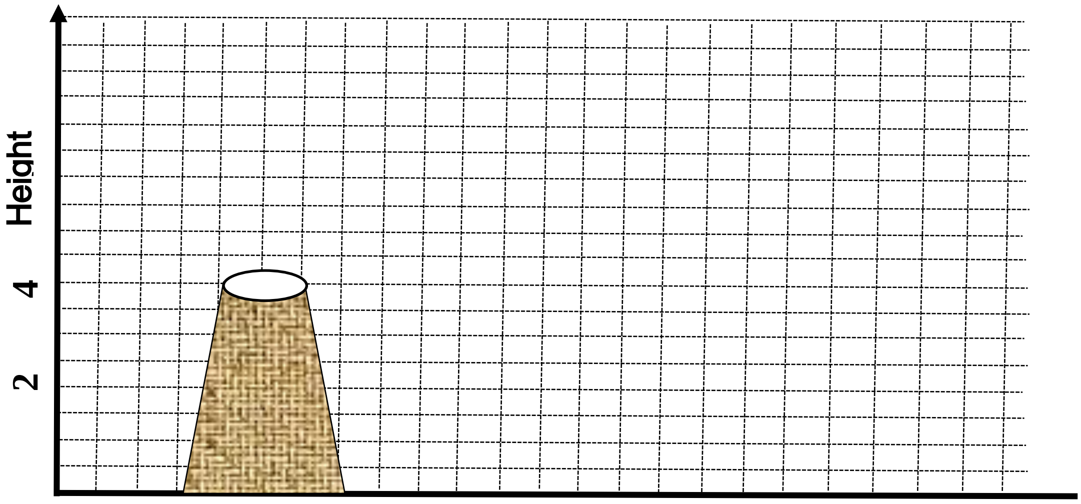

Figure (8-4): A chimney 8 m above the ground.

Discussion

1. What is the shape of the exiting blinders if the exit speed is four times greater than the wind speed?
2. Discuss your results according to the quality of atmospheric stability?
3. What type of atmospheric stability is best for the spread of pollutants based on their effects on surrounding or close to residential areas?
4. What if the surface layer was dominated by an atmospheric inversion above which was the chimney nozzle?
5. In your scientific opinion, which times of the day are best for operating stations and factories and why?