experiment (10)

Estimation of the height of polluted clouds

Objective Of the Experiment

1. Calculate the effective rising cloud height and locate it above the chimney.

2. Calculating the real slope rate of the atmospheric layer above the chimney.

3. Determine and draw the shape of the cloud emerging from the chimney, according to the surrounding conditions.

The theoretical part

The study of the rise of the primary cloud is of great importance in the spread of fluxing pollutants flowing single by one (point source), as the cloud rises out of the chimney and enters the atmosphere of the plane that carries pollutant concentrations near the surface of the earth. If it is a high rise, the cloud, due to the wind, will travel great distances before reaching the ground, and this height is in a decrease in the ground level concentrations, as a result of the large dispersion in the cloud. Most of the incoming clouds usually have either a speed of exit due to temperature differences or an increase in the surrounding air, or with both, note Figure (6b-4). The height of the chimney ranges from 250 to 300 m in most cases, and it rarely reaches 400 m. And we must not forget the horizontal wind speed also has an effect on the rise of the cloud, as the high wind speed quickly discourages the cloud from rising vertically in the direction of the wind, as shown in Figure (6a-4). Although the higher winds are usually higher during dispersal, the fugaira is also affected by atmospheric stability [17].

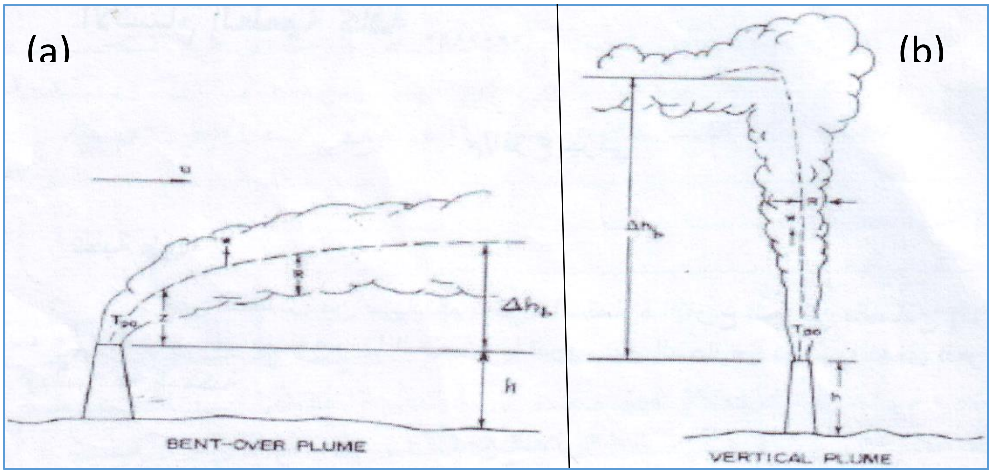

Figure (4-6): The rise of the cloud due to the temperature difference between the cloud and the ocean due to the wind speed.

From the aforementioned clarification, we find that atmospheric stability has a role in the ascent of clouds, and the ascent height will be calculated according to it. We assume that the spread of pollutants at the moment of their exit from the chimney mouth starts from an imaginary height Δh in addition to the real or natural height of the chimney as shown in the diagram and the picture in Figure (4-7). Therefore, the effective stack height (H) becomes:

$$H = h + \Delta h \qquad (6\text{-}4)$$

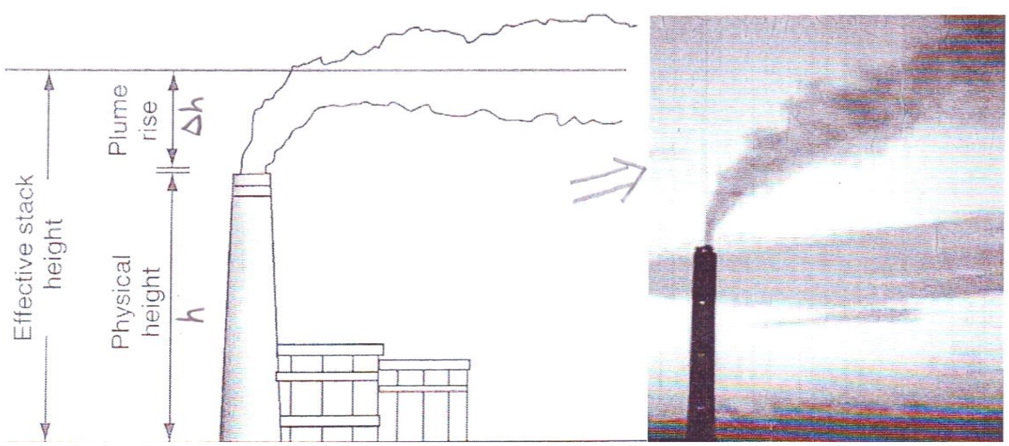

Figure (4-7): Chimney with initial specifications.

The effective climb height **H** will depend on:

1. The temperature of the emissions leaving the chimney.
2. The internal cross-sectional area of the chimney.
3. Emission velocity.
4. Horizontal wind speed.
5. The vertical gradient of temperature through the scattering and diffusion layer.

In this experiment, we will focus on calculating the effective height resulting from the rise of the cloud due to the thermal buoyancy, as it prevails in most cases during the daytime, and the rise of the cloud rarely occurs as a result of an increase in the exit speed over the wind speed by four times [6]. In any case, Δh is calculated according to the momentum, buoyancy and stability in the relation below:

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

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

F_b: the initial buoyancy flux in (m4.s-3) which is calculated from:

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

Where T_p: pollutant temperature, T_a: ambient air temperature and S: atmospheric stability factor, given:

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

where $\Delta\theta / \Delta Z$: inertial temperature gradient, steepness K / m which computes the stack mouth to top cloud height which can use the following relation:

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

Materials and tools used

1. A graphic sheet with only a chimney 8 m high above ground level (note Figure 8-4).

2. Static chimney data: DS=0.4 m, TP=420 K, VS=3 m/s.

3. An instrument measuring the wind speed at a height of 8 m.

4. Air temperature measuring device number 2, one of them is installed at a height of 8 m and the other at a height of 20 m, taking into account that they are placed under a dark place to avoid the influence of sunlight.

5. Calculator with ruler.

The method of work

1. Measure the wind speed at the height of the chimney mouth 5 m three times every five minutes and then calculate their rate.

2. Measure at the same time the air temperatures for the two altitudes of 5 m and 20 m for three times every five minutes and then find their averages.

3. Convert the temperature values from degrees Celsius to kelvin units.

4. Use equation (4-8) to calculate Facebook.

5. Calculate the value of (ΔT/Δz)_actual from T2-T1/Z2-Z1, then substitute the value into equation (4-10) to get the stability factor S.

6. Calculate the value of the change in height for the rise of the cloud (hΔ) using equation (4-7).

7. Calculate the effective cloud rise height (H) using equation (4-6), which represents the central line of the cloud exiting the chimney.

8. Fix the H value on the curve, then connect it to the chimney mouth 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 a conical nebula shape around the center line, which becomes more obtuse as it gets further from the crater.

10. Shade the shape of the cloud strongly near the mouth of the chimney and light when away from the mouth, and why?

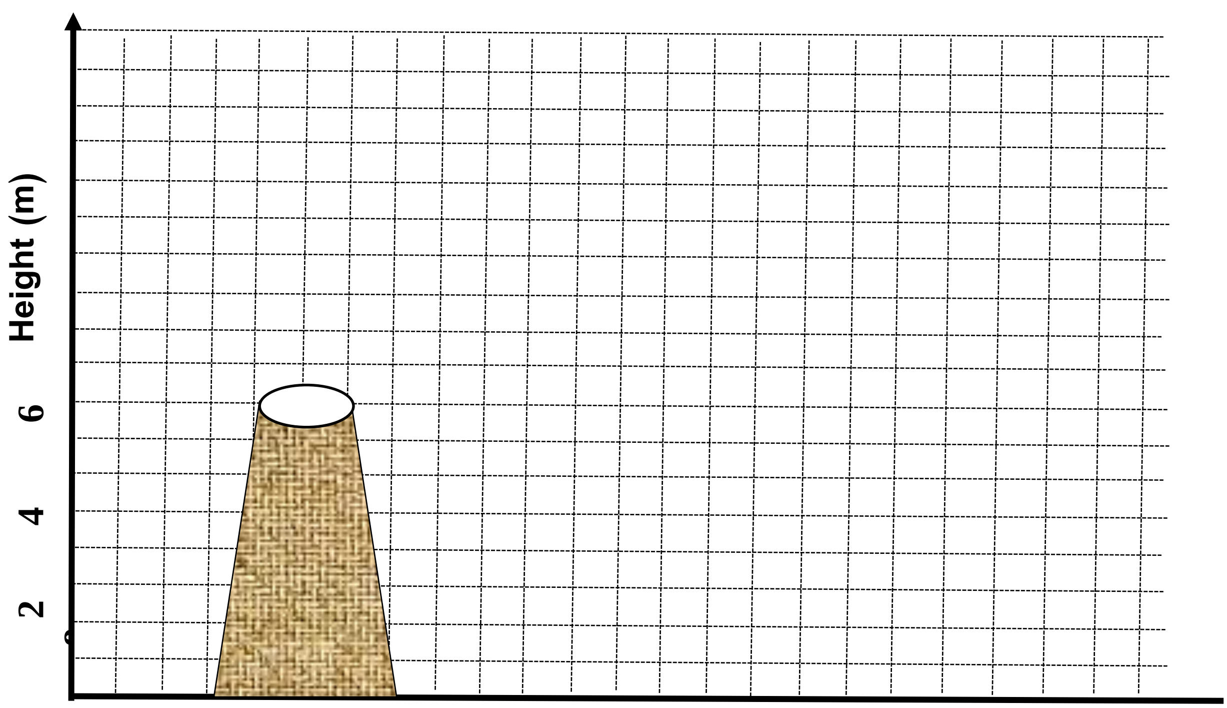

Figure (4-8): A chimney with a height of 8 m above the ground.

Discussion

Q 1: What is the shape of the emerging cloud if the exit speed is four times greater than the wind speed?

Answer:-- ----.

Q2: Discuss your results according to the quality of air stability?

Answer:-- -- --------- -- -------------------.

Q3: Which type of air stability is better for the spread of pollutants, according to their effects on the surrounding or near residential areas?

Answer:-- ----.

Q4: What if the surface layer is dominated by an atmospheric inversion with the chimney mouth above it?

Answer:-- -- --------- ------------.

Q5: In your scientific opinion, which times of the day are best for operating stations and factories, and why?

Answer:-- -- --------- ------------.