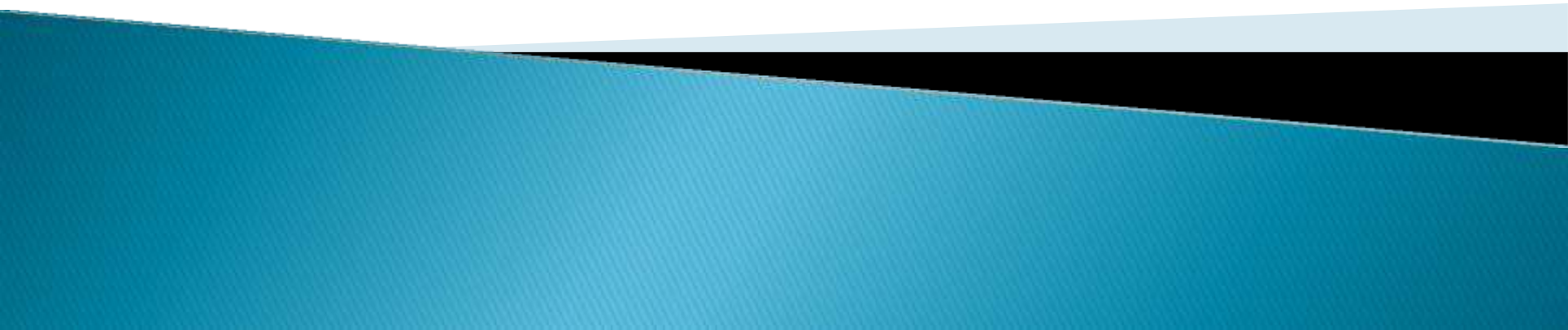


Measurements & applications of Equilibrium Moisture content, rate of drying curve

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Theory of drying:-

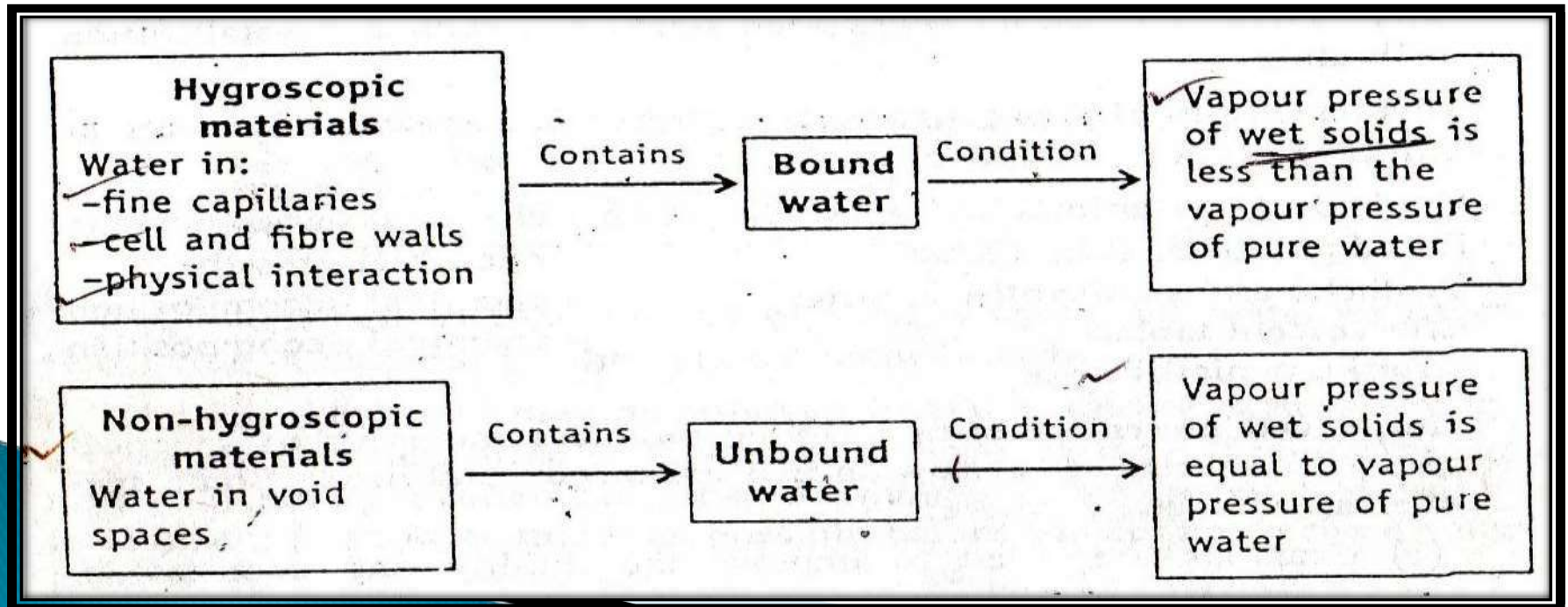
In a wet solid mass, water may be present in two forms;

1) Bound water:

Bound water is the minimum water held by the material that exerts an equilibrium vapour pressure **less than** the **pure water** at the same temperature.

2) Unbound water:

- It is the amount of water held by the material that exerts an equilibrium vapour pressure **equal** to that of **pure water** at the same temperature.
- Unbound water exists largely in the voids of solid thus in non-hygroscopic material all the liquid is unbound water.



Theory of drying can be discussed under two headings

- ▶ A) Equilibrium relationships
- ▶ B) Rate relationships

A) Equilibrium relationships:

Air of constant humidity and temperature is passed over wet material after long exposure equilibrium is reached.

□ Equilibrium moisture content (EMC):

It is amount of water which exerts vapour pressure equal to the vapour pressure of atmosphere surrounding it.

Based on the conditions of temperature and humidity solid will either lose or absorb the moisture;

1) When air is continuously passed over the solid containing moisture more than EMC then solid lose water till the EMC is reached. This phenomenon is known as Desorption.

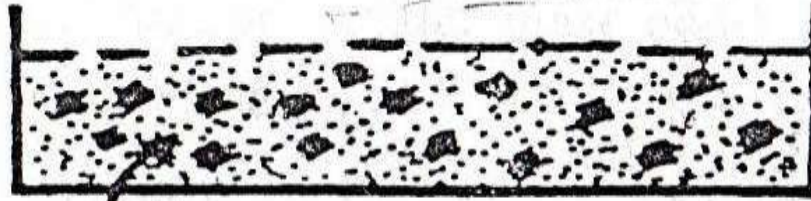
2) When air is continuously passed over the solid containing moisture less than EMC then solid absorb water till EMC is reached. This phenomenon is known as Sorption.

Moisture in solid > EMC = desorption (lose water)

Moisture in solid < EMC = sorption (gain water)

Vapour pressure of wet mass =
Vapour pressure of atmosphere

At equilibrium

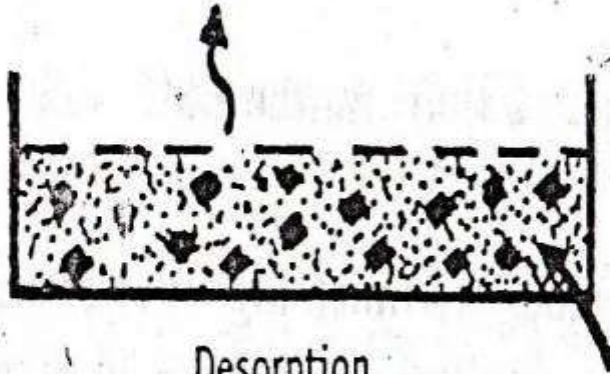


Amount of water = EMC

Wet mass

Moisture in the solid > EMC of solid

Moisture

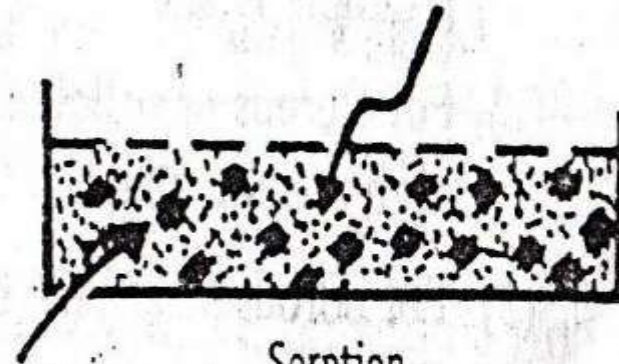


Desorption

Wet mass

Moisture in the solid < EMC of solid

Moisture



Sorption

❑ Free moisture content (FMC):

It is the amount of water that is free to evaporate from solid surface.

$$\text{FMC} = \text{Total water content} - \text{EMC}$$

B) Rate relationships:

- Rate relationship is observed by considering a simple model which mimic the conditions of a dryer. In this model wet slab of solid is considered and hot humid air is passed over it. The change in weight is determined by weighing the slab at different time interval and following calculations are made;

$$\% \text{ Loss on drying (LOD)} = \frac{\text{mass of water in sample (kg)}}{\text{total mass of wet sample (kg)}} \times 100$$

$$\% \text{ Moisture content (MC)} = \frac{\text{mass of water in sample (kg)}}{\text{mass of the dry sample (kg)}} \times 100$$

$$\text{Drying rate} = \frac{\text{weight of water in sample (kg)}}{\text{time (h)} \times \text{weight of the dry solid (kg)}}$$

- ▶ From the data obtained by the above experiment graph is plotted by taking FMC on x-axis and drying rate on y-axis.
- ▶ The curve obtained is known as **drying rate curve**.

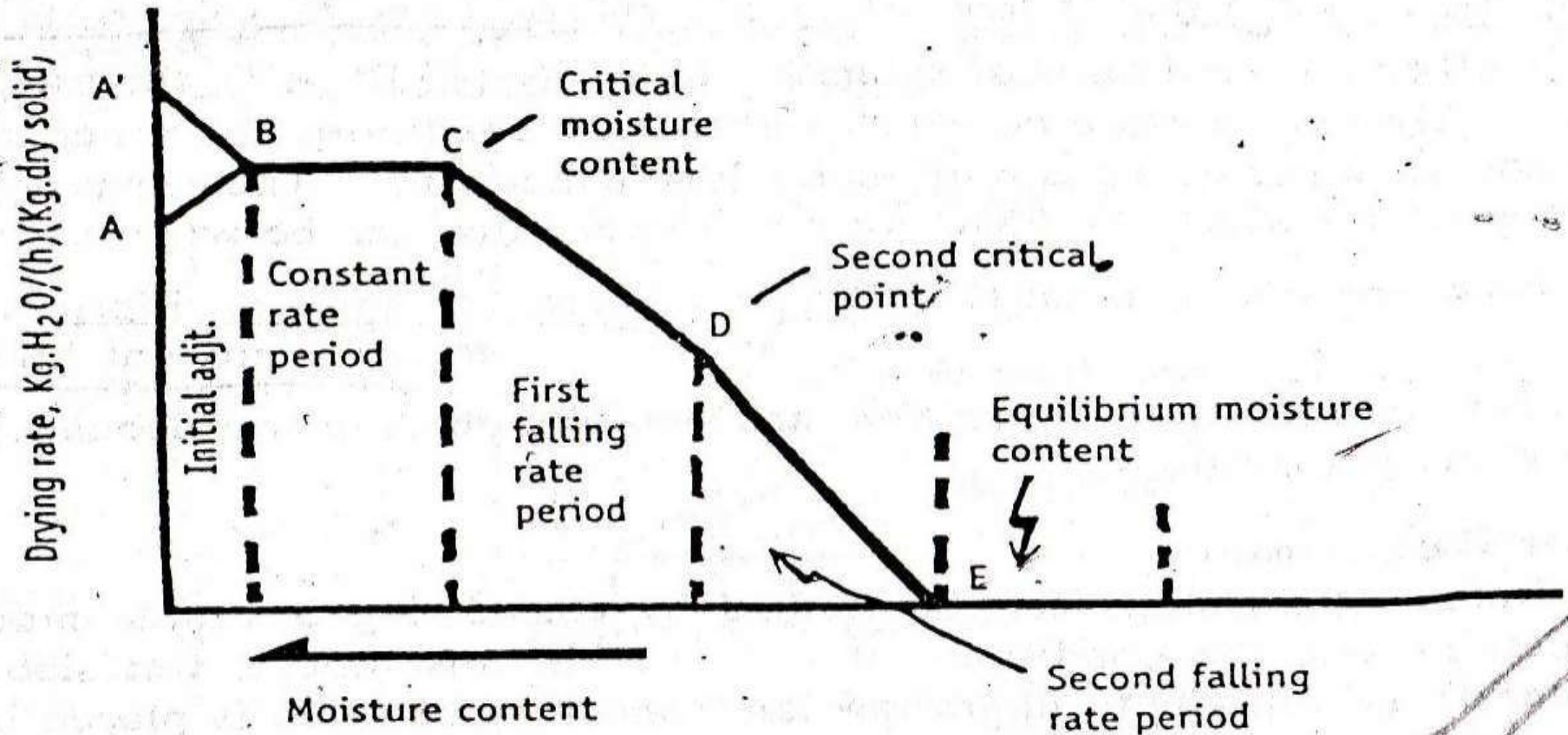
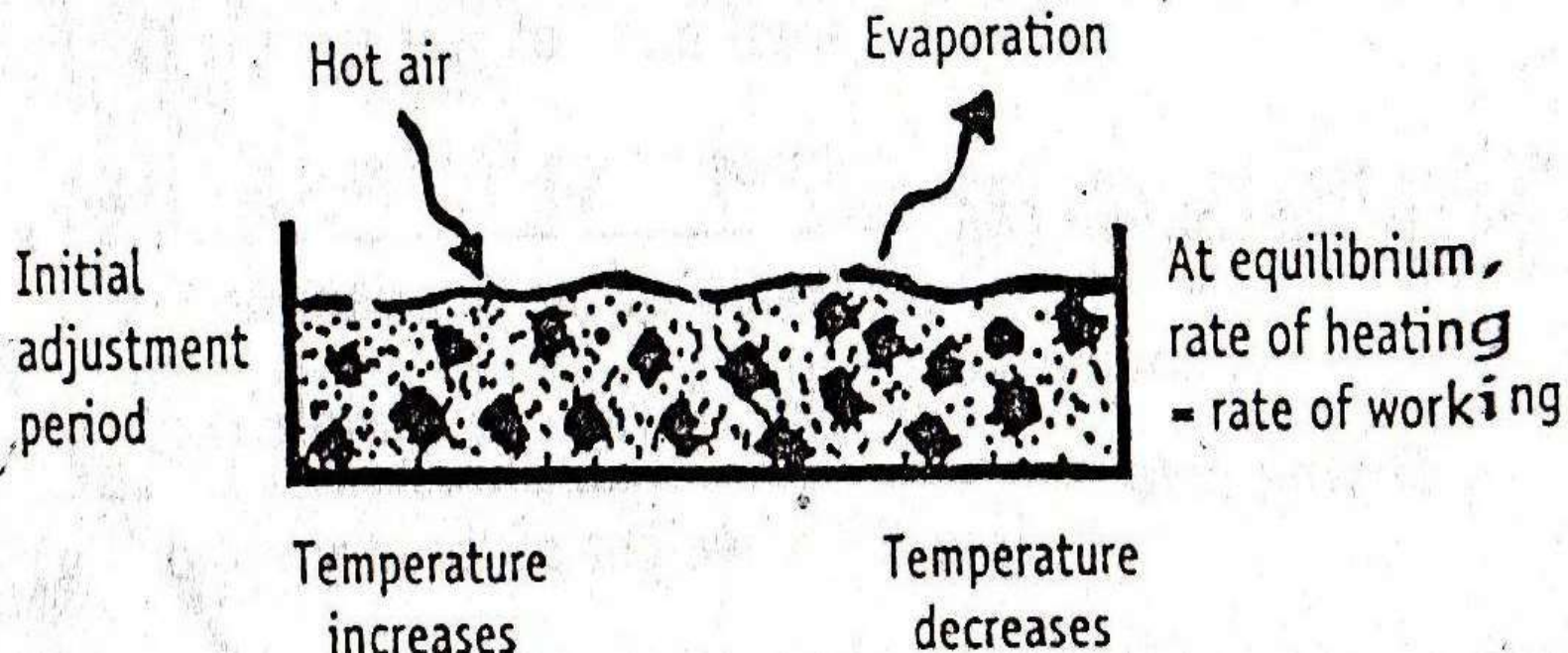
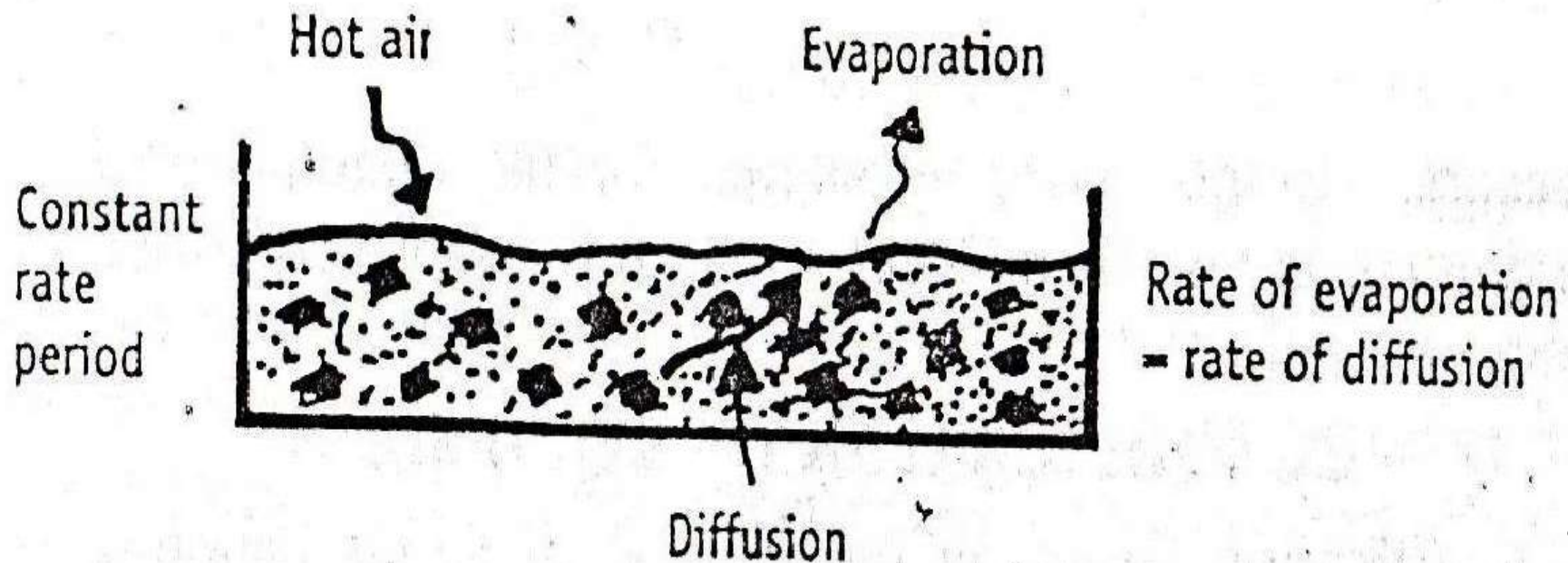


Figure 14-2. FMC curve.

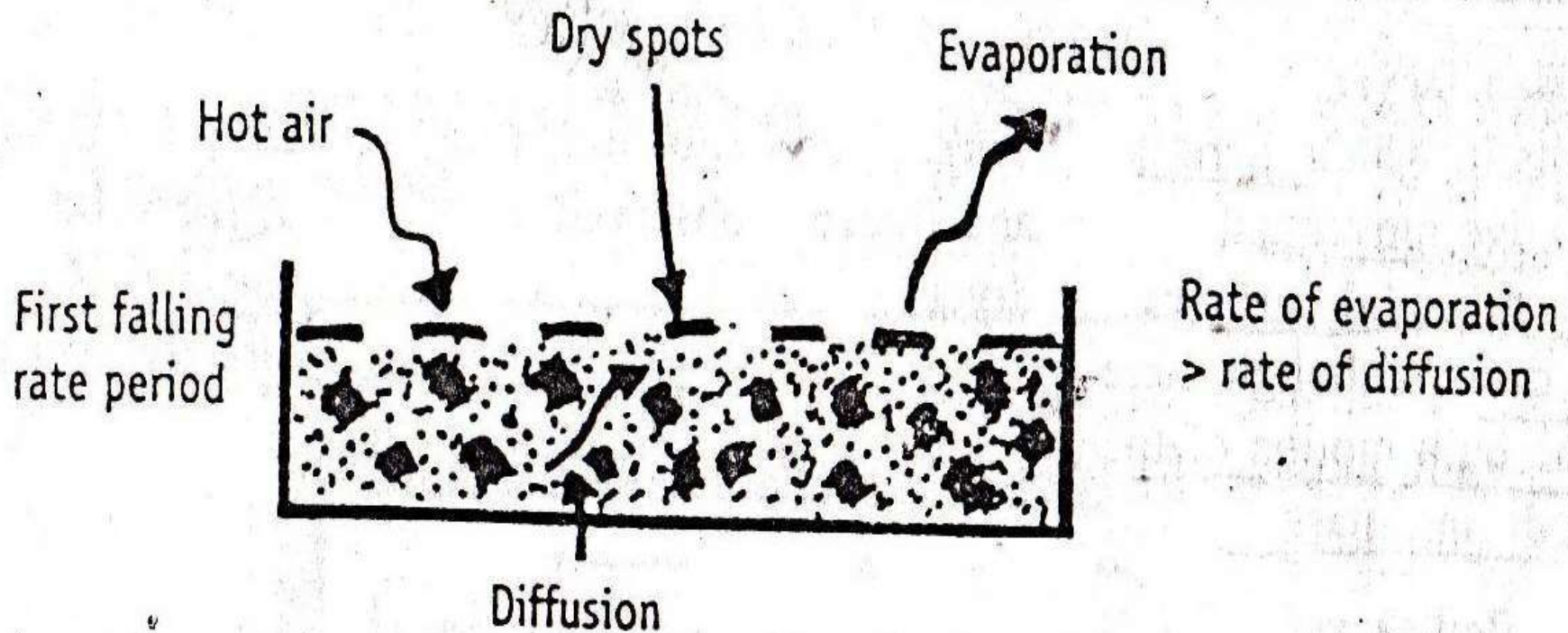
(1) The time corresponding to AB represents the *initial adjustment period*. During this period, the solids absorb heat and the temperature increases. At the same time, the moisture begins to evaporate and thus tends to cool the drying solid. After some time, the temperature stabilises (heating and cooling rates become equal). This temperature is equal to the wet bulb temperature of the drying air and is referred by the point B.



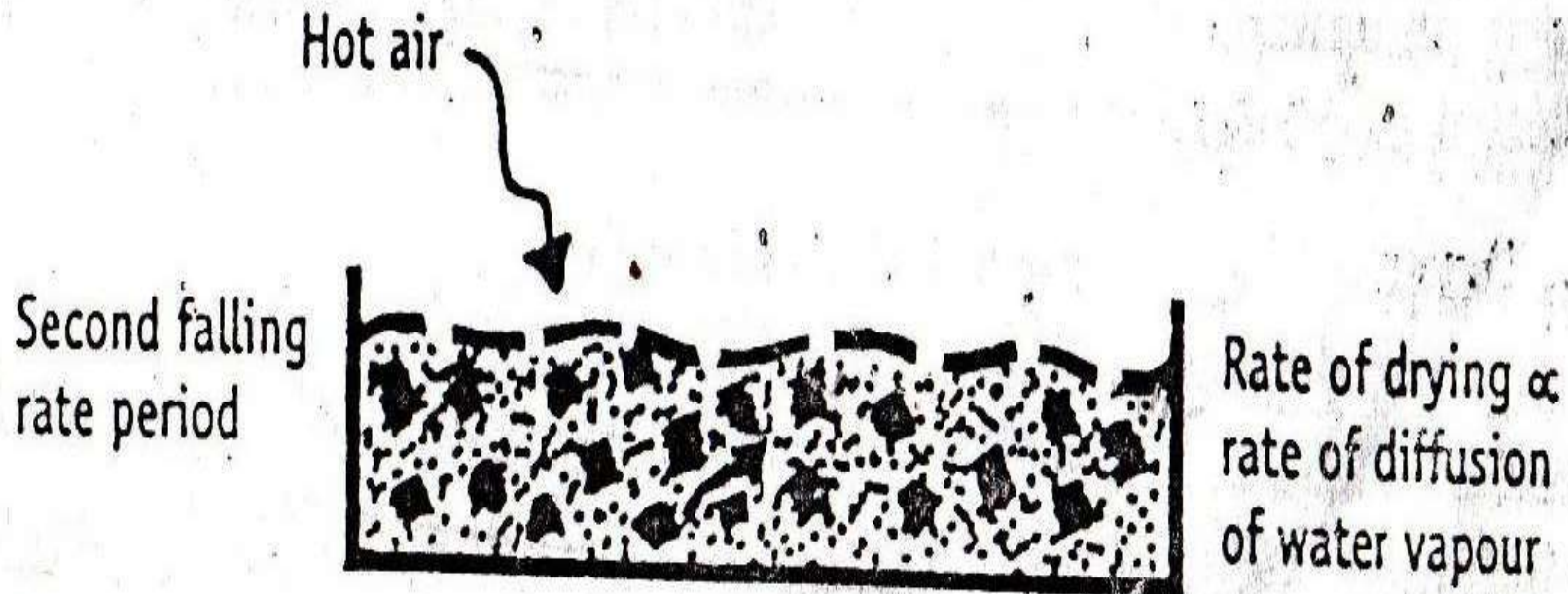
(2) The time corresponding to BC represents the *constant rate period*. The temperature remains constant and rate of drying is constant. The moisture evaporating from the surface is replaced by the water diffusing from the interior of the solid. The rate of diffusion is equal to the rate of evaporation. The moisture content at the end of constant rate (point C) is referred to as the critical moisture content (CMC).



(3) The time corresponding to CD represents the *first falling rate period* (or unsaturated surface drying). During this period, the surface water is no longer replaced at a rate fast enough to maintain a continuous film on the surface. Dry spots begin to appear and the rate of drying begins to fall off. The point D is referred to as the *second critical point*. At this point, the film of surface water is completely evaporated.



(4) The time corresponding to DE represents the *second falling rate period*. During this period, the rate of drying falls even more rapidly than the first falling rate. During this period, the rate of drying is dependent on the rate of diffusion of vapour of moisture to the surface of the solid. Point E is referred to as the *equilibrium moisture content*.



(5) Beyond E, the drying rate is equal to zero. Therefore, temperature and moisture content remain constant. Beyond, E, continued drying is waste of time and energy.

The curves may have different shapes for different levels of moisture. If the drying is carried above the level of CMC, only constant rate period occurs.

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