Homework n°01

Exercise 1 – Integrated Analysis and Design of a Drying Process

A chemical engineering plant processes hygroscopic granular solids that must be dried before storage to prevent degradation and ensure product stability.

A continuous drying unit is considered. A pilot-scale experiment was performed under controlled conditions using hot air.

Given Data

- Initial mass flow rate of wet solid: **1000 kg·h^{-1}**
- Initial moisture content: **30% (wet basis)**
- Final moisture content: **10% (wet basis)**
- Drying air temperature: **90°C**
- Drying air velocity: constant
- Atmospheric pressure operation

Experimental drying data (pilot scale):

Time (min)	Moisture content X (kg water/kg dry solid)
0	0.429
10	0.360
20	0.300
30	0.240
40	0.200
50	0.170
60	0.150

Part I – Mass Balance and Moisture Formalism

1. Convert the initial and final moisture contents from wet basis to dry basis.

2. Determine:

- Dry solid flow rate
- Water evaporated (kg·h^{-1})
- Outlet water content

Part II – Drying Mechanisms and Physical Interpretation

3. Identify the types of moisture present in the solid:

- Free moisture

- Bound moisture

4. Describe the coupled heat and mass transfer mechanisms involved:

- External convection
- Internal diffusion

Part III – Drying Kinetics and Data Exploitation

5. Plot the curve: $\boldsymbol{X = f(t)}$

6. Calculate the drying rate using: $\boldsymbol{N = -\frac{dX}{dt}}$ or $\boldsymbol{N = -\frac{X_{i+1}-X_i}{t_{i+1}-t_i}}$

(Using finite differences between experimental points)

7. Plot: $\boldsymbol{N = f(X)}$

8. Identify:

- Constant-rate period
- Falling-rate period
- Critical moisture content

9. Comment on the shape of the curve and relate it to internal transport limitations.

Part IV – Process Design and Technology Selection

10. Among the following dryers:

- Tray dryer
- Rotary dryer
- Drum dryer

Select the most suitable for this process. Justify

Recommend:

- Flow configuration (co-current or counter-current)
- Type of drying (direct or indirect)

Justify.

Part V – Transport Phenomena and Operating Parameters

11. Explain, using transport arguments:

- Why drying slows down in the falling-rate period
- Why internal diffusion becomes limiting

Homework Submission Guidelines

The homework assignment must be completed **in groups of minimum two (2) and maximum four (4) students**.

Only **one designated member per group** is allowed to submit the work on behalf of the group. Submissions must be sent to: **bouti.m@centre-univ-mila.dz**

The submitted document must clearly **include the full names of all group members**.

The deadline for submission is **Saturday, April 4, 2026**.

Any submission not complying with these instructions may not be considered.