Al-Mustaqbal University College

Chemical Engineering and Petroleum Industries

Unit Operations Lap

Experiment (2)

FORCED DRAFT TRAY DRYER

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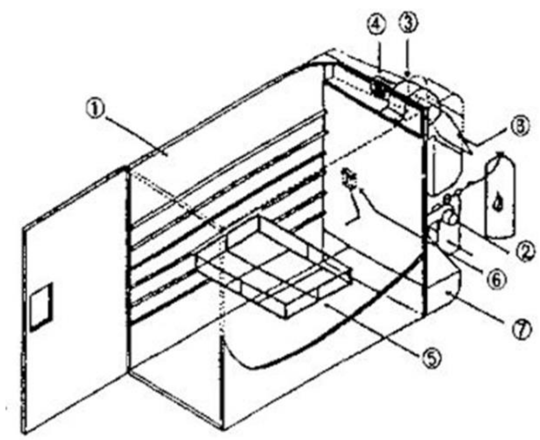
INTRODUCTION

In many cases, drying of materials is the final operation in the manufacturing process, carried out immediately prior to packaging or dispatch. Drying refers to the final removal of water, and the operation often follows evaporation, filtration or crystallization. Drying is carried out for one or more of the following reason:

- To reduce the cost of transport.
- To make a material more suitable for handling.
- To provide definite properties.
- To remove moisture this may otherwise lead to

corrosion.



1.DRYING CHAMBER

2.AIR BLOWER

3.CENTERIFUGAL FAN

4.MOTOR

5.TRAY

6.HEATER

7.ORIFICE IN THEAIR DUCT

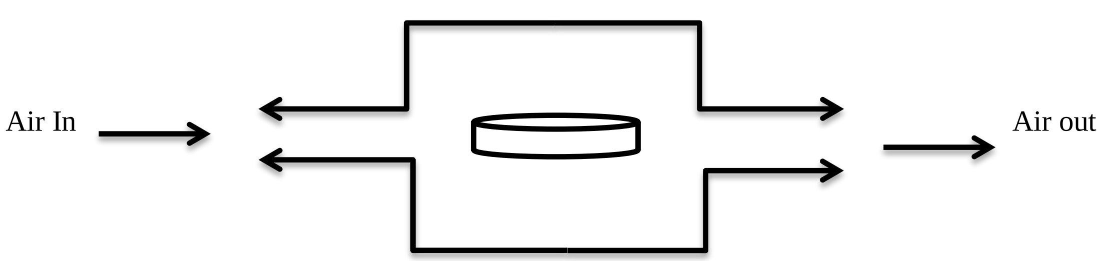
8.BALANCE

AIM

To determine the drying rate of a solid under forced draft condition and determine the critical moisture content.

DESCRIPTION

- A schematic diagram of the experimental set-up is given below:



is a wind-tunnel type tray dryer. The main components are;

- Drying chamber
- Air blower
- Heater
- Orifice in the air duct
- A tray
- Balance

The air flow is controlled by a valve in the blower outlet and its flow rate is measured by a pre-calibrated orifice meter. Thermometers are placed at the inlet and outlet of the drying chamber.

EXPERIMENTAL PROCEDURE:

- Load the pre-weighed tray with solid and record the weight of sand & tray.
- Start the blower and heater. Fix the air flow rate and let the system to achieve steady state as the air flow rate would make the temperature steady.
- When the desired conditions of temperature and air velocity are reached(in about

10-15min), remove the sample tray and put known amount of water in it to give desired initial moisture content.

- Place the tray gently in the drying chamber and start the stopwatch.
- Record the balance reading with time at about 3-5min time interval.
- Drying is assumed to be complete when at least 3 consecutive readings are unchanged.
- The temperatures at the inlet and outlet of the drying chamber and the air flow rate(manometer reading fixed across the orifice) are recorded at least three times during the course of run to give average operating conditions.
- The same steps are repeated for other runs at different operating conditions.

The range of variables may be fixed as given below: Air Flow rate = 8 to 10 cm manometric difference(with water as manometric fluid) Initial Moisture Content = 20-50% (Prepare the sample in this range of moisture content)

CALCULATION FORMULAE

Moisture content present in solid, X(kg water/kg dry solid)

X = (W-S)/S The drying rate is thus calculated from:

Moisture content present in sample, $x = \frac{\mathrm{Ws-Sd}}{\mathrm{Sd}}$ gm water/gm of dry solid.

Now plot a X V/s t on X-Y scale.

From this plot we calculate the slope = - dx/dt. Now we have the drying rate as

$N = -S\frac{dx}{dt}\frac{1}{A}$ kg/m^2.s

$N = -\frac{S}{A}\frac{\Delta X}{\Delta\theta}$

OBSERVATIONS & CALCULATIONS:

Tray diameter = 150mm

Surface Area of Solid = 0.0706 m^2

Solid dry wt. = Initial

Moisture content =

Manometric difference, R = m

$$h = R * \left(\frac{\rho m}{\rho a} - 1\right)$$

Superficial air flow rate ,G =0.61 *a_o*$\sqrt{2gh}$ * ρa Kg/m^2.s

S.No	Time θ , sec	Wt. of solid(solid+water)	X=(W-S)/S(Kg water/kg dry solid)	$N = \frac{S}{A}\frac{\Delta X}{\Delta\theta}$

Plot X Vs θ and draw a straight line through all points. Fit a second degree polynomial to the X Vs θ data and obtain the slope dX/dθ corresponding to various values of θ The drying rate is thus calculated from:

$N = -S\frac{dx}{dt}\frac{1}{A}$ kg/m^2.s

$N = -\frac{S}{A}\frac{\Delta X}{\Delta\theta}$

Plot drying rate N (kg/m2-s)Vs moisture content X (kg of water/kg of dry solid). From this plot critical moisture content (Xc) can be obtained. The experiment can be repeated at constant air flow rate and constant air temperature.

Discussion

1-How does atray dryer work?

2-How do you increase the efficiency of atry dryer?

3-Where are tray drayer used?

4- How many types of tray dryer are there?

NOMENCLATURE

A = Dying surface area, m2

G = mass velocity of gas, kg/m2-s

N = drying rate, kg/m2-s

Nc = constant drying rate, kg/m2-s

S = mass of dry solid, kg

Tg = absolute temp. of gas (dry bulb), K

X = moisture content of solid (kg of water/kg of dry solid)

Θ = time, sec P = density, kg/m3

Pm = density of manometric fluid, kg/m3

Pa = density of air, kg/m3

a0 = area of orifice, m2

W = mass of wet solid, kg