# * Exp ① Mixing of Powders

→ parameters

* Sample wt (g) sand

" Vol. AgNO₃ (mL) AgNO₃

ie Top bottom Right Left at different Time

## * Abstract (objective)

In this experiment we have① to study to process of mixing & see how the properties of ingredients – the particle size distribution as example – will affect the process. Also② [illegible] investigate the affect of mixing time, mixing speed on the state of mixing

apparatus Double cone mixer, Timer, speed controller

( Titration ← ionselective )

sand (AgNO₃)

~~AgNO₃~~ KCl

②

$$\boxed{n_{KCl} = n_{AgNO_3}} \; ⊛$$

$$m_{KCl} = n_{AgNO_3} * M_{wt}$$

①

$$n = V * 0.1$$

AgNO₃

0.1 → تركيز

$$\boxed{mL \to L} *$$

$$* \; 10^{-3}$$

$$⊛ \quad n = \frac{m}{M_{wt}}$$

$$n = \overset{M}{conc.} * Vol.$$

conc. → تركيز

$$\boxed{KCl + AgNO_3 \rightarrow AgCl\downarrow + KNO_3}$$

Mass of sand = Total weight − $m_{KCl}$

Total weight ↙ من التجربة (قراءات)

$m_{KCl}$ ↙ حسبة

$$X_{KCl} = \frac{m_{KCl}}{m_{Tot.}}$$

$$X_{sand} = 1 - X_{KCl}$$

$$X_{avg} = \frac{X_{sand_{top}} + X_{sand_{bott.}} + X_{mid}}{3}$$

$$(X - X_{avg})^2 = (X_{sand_{top}} - X_{avg})^2$$

$$(X_{sand_{bott}} - X_{avg})^2$$

$$\vdots$$

$$\Sigma (X - X_{avg})^2$$

$\boxed{Index}$ → to measure mixing

$$I_s = \frac{\sigma_e}{s} = \sqrt{\frac{\mu_p * (1-\mu_p) * (N-1)}{n * \sum_{i=1}^{N} (x_i - \bar{x})^2}}$$

N → Number of spot sampl ③

n : No. of particles in the sample

$\mu_p$ → overall fraction

by number of particles of sand in the total mix.

$$\mu_B = \frac{\#\ sand}{\#\ tot.}$$

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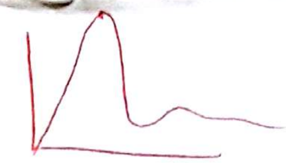
امتحانات عال ⊛

Exp ①



* hom I ↑

⊛ Mixing index variable with time in a which means that we can have high mixing capibility at Low period of time for mixing.

⊛ The mixture with homogenous component (has high mixing index), it happen at certain and optimum period of time, after this index will decreas with time

⊛ To make exp. more accuracy, increase number of sample which make the results more efficient.

⊛ (Solid) particles difficult to achieve mixing comparing with Liq & gas. (So perfect mixing maybe Not achieve)

---

⊛ Calculation

- avg. particle size (sand) $\frac{180+90}{2} = -- = 10^{-4} * -- \text{ cm}$
- 〃 〃 〃 Salt (Nacl) $\frac{180+90}{2}$
- $\rho_{sand} = --$ , $\rho_{salt} = --$

$1m = 10^6 \mu m$

$cm \rightarrow 10^4 \mu m$

$V_{sand} = \frac{\pi D^3}{6}$ قطر avg.

$V_{salt} = \frac{\pi D^3}{6} \rightarrow$ قطر

m sand mass particle $= \rho * V$

$m_{salt} = \rho * V$

**At the Beginning**

weight of sand = --

〃 〃 salt =

$\# \text{ sand particles} = \frac{\text{weight of sand}}{\text{Mass of sand part.}}$

$\# \text{ salt particles} = \frac{\text{weight of salt}}{\text{Mass of salt part}}$

Total No. of particles = # salt + # sand

$\mu_p \text{ for sand} = \frac{\# \text{ of sand}}{\text{Total particles.}}$

$\mu_p \text{ for salt} = 1 - \mu_{p\,sand}$

$I_{so} = \frac{1}{\sqrt{n_T}}$

⊛ **At time 28**

mass = 0.143

moles of Nacl = M * V (0.1) (--Vol. of $AgNO_3$) = 0.0134

mass of Nacl = n * Mw → 74.55

Mass of sand = Mass of sample (Exp.) − Mass of Nacl

$\# \text{ salt particle} = \frac{\text{Mass of salt}}{\text{Mass of salt part.}}$

$\# \text{ sand} = \frac{\text{Mass of sand}}{\text{Mass of sand particle}}$ ✓

# Total No. of particles = # sand + # salt

$X_{sand} = \frac{\# \text{ sand}}{\# \text{ total}}$

$X_{salt} = 1 - X_{sand}$

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Exp ②

# * Shell & Tube Heat Exchanger :-

* **Objective**

① To determine (calculate) the overall heat transfer coeff. ($U$) using steam on shell side & cooling water on the tube side.

② To investigate the effect of flow pattern (co-current or counter current) on the heat transfer coeff.

③ To establish energy Balance in the heat exchanger.

* مهم

**Abstract**

objective أول ال
abstract ز

Shell & Tube heat exchangers are one of the most popular types of exchanger. In this exp. we are going to calculate the overall heat transfer coeff. ($U$) using steam on Shell side & -- نفس نقطة ① ,,, Heat exchangers are typically classified according to flow arrangement,, In the parallel flow (co-current) flow, the steam & cold fluids enter at the same end, flow in same direction & Leaves at the same end. In counter current arrangement, the steam and cold fluids enter the heat exchanger at different ends & flow in opposite directions ,, Each fluid arrangement leads to different heat rates and the Calculation are different . The configuration of Shell & Tube heat Ex. in counter current flow has higher effectiveness than Co-current.

السبب ؟؟ ⇒ [ Due to log mean Temp. difference which is Larger at counter current]

---

**معلومات بشكل عام**

Ⓐ The idea of heat Exchanger is to exchange the heat between two Streams ,, So the heat is transfer from the Shell * stream which is hot * ,, to Tube Stream which is Cold

Ⓐ In our Exp. the hot stream inside the shell is water steam while Tube stream is cold water

Ⓐ Two Types of Flows inside heat Ex. → Co-current flow
→ counter current

ركزوا عليها

Ⓐ It's perferable to make Ⓐ turbulent flow through the shell, This guarantee better contact Between the shell stream and Tube stream.

Ⓐ Because the hot fluid flows through the shell, there is large amount of heat loss to environment especially when the shell isn't insulated

1)

ask, review & recieve

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تابع Exp ②

⊛ The impurities of ~~Dusts decrease~~ Dirt which covered the tubes decreases ↓ the efficiency of heat transfer ,, Because it increases the heat transfer Resistance
(also decrease the U ,, ~~and increase ... (mass flowrate of water)~~) .

* Rate of heat transfer @ counter > parallel (co current) due to log mean Temp. Differences [illegible]

* Errors
- personal
- instrumental
- in reading Temp. & P.

* The pressure drop ↑ ,, fluid flow rate ↑ [Directly proportional]

* Baffles which are filled along the shell ① increase the velocity of flow (Turbulence)
∴ Thus giving better heat transfer

25% cut

another job of baffles ② supports for tube from bending with time

⊛ $R_c$ ↑ ,, heat coeff. ↑ ,, when mass flowrate of water increases , The dirt factor decreases.

---

**Calculation**

نختار Run ، نحسب $T_{c\,avg.} = \frac{T_{in} + T_{out}}{2}$ للـ cold water

① $\rho_w$
② $C_p$
③ $\mu_w$
④ $K_w$
⑤ $P_r$

ثم الخصائص عنده
(الخصائص عند $T_{avg.}$) ⊛
$\boxed{T_c}$ *

$\rho_w = 1000$ kg/m³

⊛

* بالنسبة للـ Steam

$P_{sat} =$ ---

⊛ gauge مش (abs.) ، بطلع $T_{sat.}$ والخصائص عند $T_{sat}$ ⊛

$h_{f,g} =$
$\rho_s =$
$C_{p,s} =$
$\mu_s =$

**Parameter**
1) Inlet water Temp.
2) Outlet " "
3) Inlet steam Temp.
4) Outlet " "
6) Inlet water pressure (bar)
7) Outlet water pressure (bar)
8) Inlet steam pressure
9) Outlet steam pressure
10) cooling water Scale reading
11) flowrate of steam condense

---

شغلات بالمانيول ⊛

| | | | |
|---|---|---|---|
| Inside Tube Dia | 12 mm | No. of Tubes | 37 |
| Outside Tube Dia | 14 mm | | |
| Tube Length | 2030 mm $\boxed{2.030\ m}$ | | |

$Q_w$ ↑ ,, water flow ↓

$\boxed{R_d \uparrow \quad \text{water} \uparrow}$ *

$\Delta P$ ↑ fluid ↑

$U_c$ ↑ ↑

2)

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تابع

7.5 , 9 , 11.5 , 13 , 14.6

# (*) Calculation Exp ②

scale Reading (1.5)

$\dot{V}_w = --- = \boxed{\frac{m^3}{s}}$ جدول

$\boxed{\frac{L}{min}}$

للتحويل من $\frac{L}{m} \rightarrow \frac{m^3}{s}$

$\boxed{1 m^3 = 1000 L}$ (*)

نقسم على $\overline{\quad 60 * 1000 \quad}$

$\dot{m}_w = \dot{V}_w * \rho_w$

---

$\dot{V}_s = --- = \boxed{\frac{m3}{s}}$ جدول

$\boxed{\frac{ml}{min}}$

للتحويل من $\frac{mL}{min} \rightarrow \frac{m^3}{s}$

$1 m = 10^3 ml$

* $\boxed{1 m^3 = 10^6 ml}$

نقسم على $\overline{\quad 60 * 10^6 \quad}$

للتحويل من

$\boxed{1 m^3 = 10^6 mL}$ (*)

$\dot{m}_s = V_s * \rho_s$

$$\text{Re} = \frac{4 \dot{m}_w}{N * \pi * D_i * \mu_w}$$

N: 37 من الكتاب

$D_i$: 0.012

Diameter of inside

$< 2100$ Laminar

$$Nu = 1.86 \, Re^{\frac{1}{3}} \, pr^{\frac{1}{3}} \left(\frac{D_i}{L}\right)^{\frac{1}{3}} \left(\frac{\mu_b}{\mu_{wi}}\right)^{0.14}$$

laminar

$Nu = \frac{h.D}{K}$

$D_i \rightarrow 0.012$

$L \rightarrow 2.030$

$\mu_b \rightarrow$ bulk

$\mu_{wi} \rightarrow$ wall

[illegible] $\rightarrow$ $\mu_w \rightarrow$ water

$\mu_s \rightarrow$ steam

نجيب $h$ (heat trasfer coeff.) من $Nu = \frac{h . D}{K_w}$

$h = --$ $W/m^2.K$

$h = \frac{Nu . K}{D}$ تكتب

* Heat loss By steam $Q_s = \dot{m}_s \left(h_{fg} + \Delta T_s * C_p\right)$

$\Delta T_s \rightarrow T_{in} - T_{out}$

in out

1 – 2

دايما بنحسب إنه counter طالما لم يحدد ذلك

co-Current

out-in

$$\Delta T_{lm} = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{\Delta T_1}{\Delta T_2}\right)} = \frac{\overset{in}{(T_{s,in} - T_{w,in})} - \overset{out}{(T_{s,out} - T_{w,out})}}{\ln\left[\frac{T_{s,in} - T_{w,in}}{T_{s,out} - T_{w,out}}\right]}$$

✓ $\boxed{in - out}$ دايماً $\boxed{hot - cold}$

** ال in [illegible]

3) Counter current $\frac{(T_{s,in} - T_{w,out}) - (T_{out,s} - T_{in,w})}{\ln(\frac{-}{-})}$

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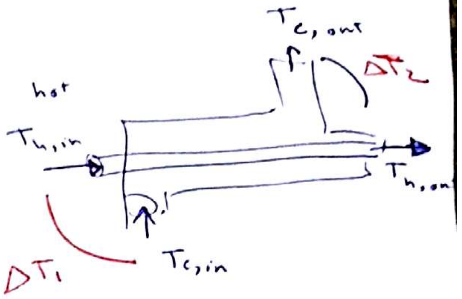
Out Dia 0.014
inner " 0.012



$$\overset{\swarrow}{Q_s} = \overset{??}{U_d} * \overset{-}{A} * \overset{-}{\Delta T_{lm}}$$

$$U_d = \frac{Q_s}{A * \Delta T_{lm}} \qquad (W/m^2.K)$$

↳ effective

↙ overall coeff. of heat transfer (Fourier's)

$$U_c = \frac{h_{io} * h_o}{h_{io} + h_o} = \frac{1}{\frac{1}{h_{io}} + \frac{D_o}{D_i h_i}}$$

$D_o$ → 0.014

clean overall heat trasfer coeff.

$h_{io}$ ↙ 8510 W/m².K

1500 Btu/hr.ft²

$D_i h_i$ ↳ heat transfer coeff.

$$h_{io} = h_i * \frac{I.D}{O.D}$$

$$R_d = \frac{U_c - U_D}{U_c * U_D}$$

Re ↑ , U ↑ , m ↑ $R_d$ ↓

$$R_d = \frac{1}{U_d} - \frac{1}{U_c}$$

↙ Dirt factor or fouling factor

( [illegible] )
mass flowrate

---

~~Another correlation~~

$$Q_w = m_w * C_{p,w} * \Delta T_w$$

heat gained By water

$$* \ \text{heat loss} \quad Q_L = Q_w - Q_s$$

$Q_w$ ↳ Heat gained By water

$Q_s$ ↳ Heat loss By steam

*
+
−
*

$$\% Q_L = \frac{Q_L}{Q_{(s)}\,ⓦ\,⊛} * 100\%$$

---

Another correlation for Nu if Flow is turbulent

$$Nu = ~~Re~~\ 0.027\, Re^{0.8}\, Pr^{\frac{1}{3}} \left(\frac{\mu_b}{\mu_w}\right)^{0.14}$$

$$Nu = \frac{h.D}{K}$$

Turbulent

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# * Exp (3) ~ Climbing Film Evaporator

Steam pressure , vacuum p
water flowrate , flowrate of process concentrated
feed inlet Temp $T_{1,1}$ , " " " condensate
Height of sensible Zone

Flowrate of steam Condensate
Temp of " "

## * Abstract (Objective) :-

1. To demonstrate the basic principles employed by climbing film evaporator.
2. To determine the effect of process parameters such as feed flowrate on the overall heat transfer coeff , V/L Ratio & economy of the climbing Film evp.
3. To investigate the two phase flow patterns at different feed flow rates. (steam & water)

purpose of evaporation → To produce concentrated solution of non-volatile solute & volatile solute

## * حكي عام *

(*) Climbing Film evaporator operated under ~~Vacuum~~ vacuum in order to Lower boiling point of the solutions , So it can be used to concentric solutions which are sensitive to high Temp.

(عكسية) (*) By increasing the feed flowrate, The rate of evaporative heat decreases as a result of the decrease in the overall heat transfer coefficient.

(طردية) (*) Increasing the feed flowrate increases the rate of sensible heat transfer & coeff. of sensible heat transfer.

طردية sensible
$Q_{loss}$ ↗

(*) Increasing the feed flowrate, increase the concentrate and the condensate flow rates.

---

$h_1 = 1.3$ Manual

$T_1$ = inlet
$T_2$ = outlet

$$T_F = \frac{T_1 + T_2}{2}$$

$P_{sat}$ = .. , $T_{sat}$

Sat. Liq. @ $T_F$

$\rho_L = 922$

$\mu_L =$

$C_p =$

$\lambda_L =$

Sat. steam at $T_{sat}$.

$\rho_s = 922$

$\mu_s =$

$C_p$

$\lambda_s =$

1atm = 1.01325 bar

$\dot{V}_{cond} = V_{feed} - V_{conc.}$ → flow rate of concentrated

0.1 −

نحوله إذا شي $\frac{L}{h} \Leftarrow \frac{}{10^3*60}$

$\dot{m}_{conc.} = \rho_L * V_{conc}$

$\dot{m}_{cond} = \rho_L * V_{cond}$

$\dot{m}_{st} = \rho_s * V_{st,conc.}$ given

$\dot{m}_{feed}$ = ~~0.00165~~ given

$$Re_{feed} = \frac{4\, \dot{m}_{feed}}{\pi * \underset{0.025}{D} * \mu_L}$$

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[illegible]

## Calculation Exp ①

$\mu$  $Ns/m^2$

$$Re_{feed} = \frac{4\dot{m}}{\pi D . \mu}$$ $< 2100$ laminar

$$Re_{steam} = \frac{4\dot{m}}{\pi \underset{0.025}{D} . \mu}$$

$$Q_{sensible} * = \left( \overset{\rho_L * V_{cond}}{\dot{m}_{cond.}} + \overset{\rho_L * \dot{V}_{conc.}}{\dot{m}_{conc.}} \right) * C_{P.L} * (T_2 - T_1)$$ $(W)$

$$\Delta T_{lm} = \frac{T_2 - T_1}{\ln \left( \frac{\overset{17}{T_s - T_1}}{\underset{111.6519}{T_s} - \underset{54}{T_2}} \right)}$$

$$\frac{(T_s - T_1) - (T_s - T_2)}{\ln \left( \frac{T_s - T_1}{T_s - T_2} \right)}$$

$$A_{sensible} = \pi \underset{0.025}{D} \, \underset{1.3}{h_1}$$

**Calandria** ✓

D= 29 mm

L = 2.7

**Steam jacket**

D = 50 mm

L = 2.6

A = 0.21

$$U_{sensible} = \frac{Q_{sensible}}{A * \Delta T_{lm}}$$

$$Q_{evap.} = \dot{m}_{cond} * \lambda_s$$ ✓

$$Q_{evap} = \underset{\text{overall evaporative heat transfer coeff.}}{U_{evap.}} * \underset{\pi \underset{0.025}{D} (\underset{2.6}{h} - \underset{1.3}{h_1})}{A_{evap.}} * (T_s - T_1)$$

$Q_e$

D = 0.025

$h_1$ = 1.3

h = 2.6

$$U_{evap} = \frac{Q_{evap.}}{A_{evap.} * (T_s - T_1)}$$ (*) (*)

$$Q_{losses} = Q_{sensible} + \overset{m_{cond} * \lambda_s}{Q_{evap.}} - (\dot{m}_{st} * \lambda_s)$$

$$Capacity = \overset{\dot{m}_{cond}}{0.000413} * (60 * 60) * \boxed{2.20462} \Rightarrow lbm/hr$$

$$Economy = \frac{\dot{m}_{cond.}}{\dot{m}_{steam}}$$

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# * Exp (4) [Concentric Tube Heat Exchanger]

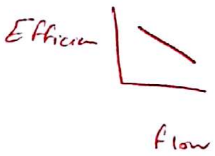
① To demonstrate the working principles of a concentric tube heat Exchanger operating under co- & counter flow arrangements.

② To demostrate the effect of hot water Temp variation, flowrate variation on the performance characterstics of a concentric Tube Heat Ex.

**Parameters** Co- current & counter

① Hotwater flowrate ($cm^3/min$)

② $T_{hot,in}$ ③ $T_{hot,out}$ , ④ $T_{cold,in}$ , ⑤ $T_{cold,out}$ .



* Co-current (parallel)

The exit Temp of the hot must be higher than exit Tep. of cold.

* counter flow

The exit temp. of the ~~hot~~ cold fluid must ~~be higher~~ been hotter than exit tmp. of hot fluid.

⇒ Energy is transferd from hot to cold

* The ratio between Temp. diff. don't change ---

* Energy removal from hot → is added to cold fluid.

↑ flow rate fluid    ↓ lower Temp. change.

⊛ higher effectiviness is prefered

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## * Calculation

$$Q = m_h * Cp_h \left(T_{hot\,in} - T_{hot\,out}\right)$$

$$\eta_{hot} = \frac{\Delta T_{hot}}{\Delta T_{max}}$$

$$\eta_{cold} = \frac{\Delta T_{cold}}{\Delta T_{max}}$$

where $\Delta T_{cold} = T_{c,out} - T_{c,in}$

$\Delta T_{hot} = T_{h,in} - T_{h,out}$

$$\boxed{\Delta T_{max} = T_{h,in} - T_{c,in}}$$

overall efficiency $\eta_{cold} + \frac{\eta_{hot}}{2}$

$$\eta_{overall} = \frac{Q_{absorbed}}{Q_{emitted}}$$

LMTD

mean Temp. difference between the two fluids

$$T_{lm} = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{\Delta T_2}{\Delta T_1}\right)}$$

(counter current)

$\Delta T_2 = T_{hot,inlet} - T_{cold,inlet}$

$\Delta T_1 = T_{hot,outlet} - T_{cold,outlet}$

Finally

$$U = \frac{Q}{\Delta T_{ln} * A}$$

overall heat transfer coeff.

$A$ 0.067

---

LMTD

Co current

$\Delta T_1 = T_{hot,in} - T_{cold\,in}$

$\Delta T_2 = T_{hot,out} - T_{cold\,out}$

Counter

$\Delta T_1 = T_{hot,in} - T_{cold,out}$

$\Delta T_2 = T_{hot\,out} - T_{cold,in}$

(*)

$$L_{MTD} = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{\Delta T_1}{\Delta T_2}\right)}$$

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*Exp(5) Heat conduction

Fourier Law (linear relationship)
→ copper
between Temp & thickness of walls
[illegible] Temp & Time is (exponential)

* Objective (Abstract):-

① To measure the temp. distribution for steady state conduction of energy through a uniform cross-section & demonstrate the effect of a change in heat input.

② To determine the thermal conductivity K of a material & the effect of temp. on thermal conductivity.

③ To measure the application of poor thermal conductors and dermine the thermal conductivity K of a poor thermal conductor.

---

ملاحظات
conclusion

(*) The value of thermal conductivity in Solid material

$$K_{Solid} > K_{Liq} > K_{gas}.$$

K inversely proportional wit ΔT & thermal conductivity (تناسب عكسي)

(*) The Temp. is proportional increasing to heat input, as well as in unsteady state until reaching the steady state, it mentions constant.

(*) The temp. huge near the electral source & less position closer to waterflow.

⇒ The thermal conductivity increasing with increase temp. and heat transfer but inverse proportional with the length of material Δx, and kind of material.

* The conduction heat transfer in this exp. occurs in linear form from the top to the bottom of the cylinder not in the radial direction

---

(*) factors that affect the rate of conduction.
① Temp. differences ΔT
② Cross Sectional Area A
③ Length (distance heat must travel) & Time.

Thermal conductivity
→ slightly depend on Temp
تعتمد على it's composition & dimensions (cross sectional area & length)
value ثابت ما تتغير اذا غيرنا ال material
يعني دخلنا حرارة أكثر او voltage [illegible]

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*Calculation :-

$$Q = -KA\frac{dT}{dx}$$

Heat (Q) = I.V = 0.057 * 54.06 = 3.a - W

$$\text{Area} = \frac{\pi D^2}{4}$$ 25 mm قطر (0.025 m) لا تنسوا = 0.000491 $m^2$

$\Delta T = T_5 - T_4 = \ominus$ °C

$\Delta X = 0.03$ m → من الكتاب 30 mm (*)

$$K = \frac{-Q \cdot \Delta X}{A \cdot \Delta T} = \ldots \; W/m \, ^\circ C$$

---

(*) It's good to calculate the value of thermal conductivity after it be steadystate

ببداية التجربة unsteady بتلاقيها لما تتغير
وباستقرار الحرارة , steady

(*) Cupper → high thermal conductivity
لذلك تستخدم household
municipal
industrial app.

⇒ Insulation of the swab is imp. → To ensure that no convection transfer which may error in the exp.

Temp. vs Time
at voltage كذا
مختلفة
3 رسمات

# * Exp(6) [Fluidized Bed heat transfer Unit]

*** Objective**

① To calculate heat transfer coefficient (h) in fluidized bed.

② To show the effect of fluid velocity on pressure drop through the fluidized bed.

**ملخص**

we increase air flow → study affect
↘ of h (heat transfer coeff.)
& pressure drop

(طردية)

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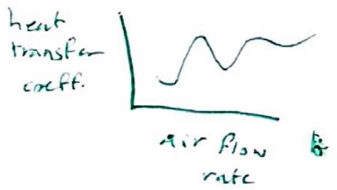
→ ① **Fixed Bed Region** : → Direct Linear Relation between ΔP & airflow (طردية)



→ ② **Transition Region** :
for intermediate flowrates, when the airflow ↑, ΔP↑ to reach maximum point and then it is starts decreasing.

→ ③ **Fluidized bed Region**:
for high flow rates, The ΔP becomes approximatly constant with the increment of air flowrate

---

ملخص when air flowrate ↑ , h ↑ (Air flow vs h)

↝ When Air flowrate ↑, ΔP ↑ and still increase ← (Air flow vs ΔP)
to reach fluidizing point then ΔP decrease then increase.

↝ The porosity of the bed when true fluidization occurs is the minimum porosity for fluidization, if the flowrate of fluid is increased the bed starts to expand & the voidage of the bed increases.

⊛ The heattransfer coeff. (h) depends :-

① Temp. diff. ΔT between the heater & the bed (inversely proportional)

② Heat transfer from the heater to the bed (directly proportional)

③ Velocity of the fluid (directly proportional)

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## * Calculation

1st run

$I = ..$ A

$V = ...$ v

$T_1 = ..$ °c

$T_2 = ...$ °c

Surface Area = 0.002 $m^2$ [ 20 $cm^2$ من السؤال ]

**Power** = current * voltage = ... W

From Newton's Law we get that :-

$$Q = h . A . \Delta T$$

قانون ال Convection

$$h = \frac{Q}{\underset{\swarrow\ 0.002}{A} . \Delta T}$$

---

## Conclusion

① when Air flow increase , The heat transfer coeff. (h) increase [directly proportional]

② when " " " , $\Delta P$ ↑ [directly proportional]

③ There's No proportion between Temp. with heat transfer coeff, and with pressure

④ Air flow increase ↑ , power increase ↑ (directly proportional)

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# Exp (7) [Jaw crusher]

→ **objective** To study the comminution behavior of different materials, using primary crusher (Jaw crusher), under vigorous condition, taking in consideration power requirements.

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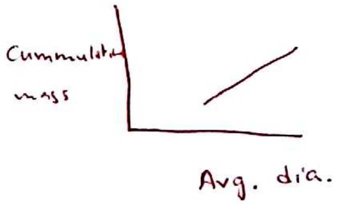
ملاحظة

increase surface Area ↑ طردي input energy

( By reducing the size)



① coarse
② intermediate
③ Fine

power ∝ crushing strength.

As initial size ↑ , Time Required for crushing ↑, feed Rates ↑

$\eta = 100\%$ ✗

↳ some power will be lost in rising the sys. Temp. → result Friction between stones & crushers.

→ size of material → 80% percent will pass → avg. dia > 1.5 mm

about 80% of product was fine

avg. dia ↑ ,, product size ↓

Errors

traces represented on the sieves from previous sieve-anlysis, during process as dust.

conc.

power ∝ particle size (proportional)

initial size ∝ Find size of product

Errors ① personal in reading → temp. → time the runs.
② exp. error → loss of heat term
③ Error in not weight

Variables

- ⊛ Initial material size.
- ⊛ jaw gap setting
- ⊛ Method of crusing

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cm

# Calculation

**Coarse**

Total ini. weight

Total final weight

$$(wt)\% = \frac{\text{weight of solid in the sieve}}{\text{Total final weight}} * 100\%$$

[illegible]

Avg Dia.

total ~~[illegible]~~ ini weigh

Time

$$\text{Mass flowrate} = \frac{\text{mass}}{\text{time}} = \frac{g}{s} \longrightarrow \text{ton/hr}$$

[illegible]

$d_{80\%}$ = ...

1 kg = 1000 g
1 ton = 100 Kg

$$\text{Power} = \text{mass flowrate} * 0.3162 * W_i * \left[\frac{1}{\sqrt{d_{80\%}}} - \frac{1}{\sqrt{d_i}}\right] = KW$$

$\frac{1}{\sqrt{L_2}}$

$W_i$ work index = 17.5 K.W hr/ton for oil shale

avg. dia of mesh ~~crusher~~ of 80%

interpolar
Dia (1.7) & (3)
70.46, 100 ع نسبة
80 [illegible]
[illegible] ]
ارسم
Dia ع Cumulative

---

## * Bond's Law [Coarse]

$$\frac{P}{\dot m} = 0.3162 \; W_i \left(\frac{1}{\sqrt{L_2}} - \frac{1}{\sqrt{L_1}}\right)$$

## * Kick's Law [intermediate]

$$\frac{P}{m} = K_e \ln \frac{L_1}{L_2}$$

## * Rittinger's Law [fine]

$$\frac{P}{m} = K_R \left(\frac{1}{L_2} - \frac{1}{L_1}\right)$$

*

$$\frac{4}{3}\pi r^3$$

$$\frac{\pi D^3}{6}$$

$$\text{vol.} = \frac{4}{3}\pi r^3$$

$$\text{vol.} = \frac{4}{3}\pi \frac{D^3}{\cancel{8}_2}$$

~~vol = $\frac{\pi D^3}{4}$~~

cylinder $\pi r^2 h$

$$\text{initial Dia} = \left(\frac{\text{particle size} * 3}{(4 * \pi)}\right)^{\frac{1}{3}} * 2 * 10 \rightarrow D_P \text{ mm}$$

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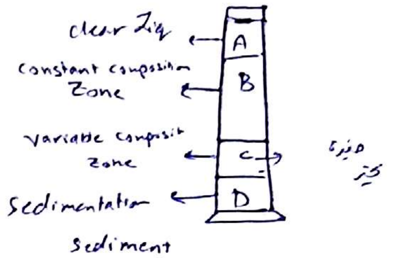
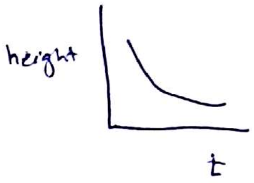
# ⊛ Exp (8)　Gravity Sedimetation

graduated cylinder ⊔ 3 ✓
with different conc.　identical

## ⊛ Objective

To demonstrate how the data obtained from batch settling tests can be used in design purposes [eg :- Thickness design]. This can be achieved through studying the settling behaviour of different materials having different properties under various process conditions.



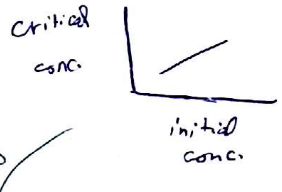


**Sedimentation** ~~State~~ process of deposition of a solid material from a state of suspension or solution in a fluid material under the force of gravity

**Clarifier** if the target was to clarify the Liq.

**Thickener** if the purpose is to thicken the solid

The unit called



✓

directly propor

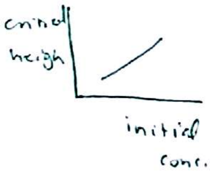
↑ initial conc

Area of thickener or clarifier ↑

✓

1) ρ (ε) (μ)
2) initial conc. of solid
3) hieight
4) partical size

| | |
|---|---|
| $C_o$ | initial conc. |
| $Z_o$ | initial height |
| $Z_L$ | critical height |
| $\theta_L$ | critical time |
| $C_L$ | critical conc. |
| Min. height | |



3 identical graduated cylinder with differen solid con.

Kynch Theory of sedimentation

critical height ↓ time ↑
when initial conc ↑

Common way to represent the sedimentation ⊛

Batch settling curve

→ personal error
Not accurat reading from cylinder

initial conc ↑
Time ↑

Rate of fall of ~~[illegible]~~ sludge ↑
conc of suspension ↓

## Calculation

For conc. 100 g/L

$C_0$ = 100 g/L = 100 Kg/m³

$Z_0$ = 19 cm = 0.19 m

From figure

$Z_L$ = 6 cm = 0.06 m

$\theta_L$ = 800 s

$V_L = \frac{Z_L}{\theta_L}$ = -- m/s

$Z_i = \underline{Z_L} + \underline{V_L \theta}$

$C_L = \frac{C_0 \, Z_0}{Z_i}$ = Kg/m³

Minimum area of thickener $3.785 * 10^{16}$ L/day

Feed conc. 200 g/L

Sludge conc. 700 g/L

$Q_0 = 3.785 * 10^{16}$ L/day = 0.0438 m³/s

$$A_{min} = Q_0 \, C_0 \left[ \frac{\frac{1}{C_L} - \frac{1}{C_u}}{V_L} \right] = \text{..} * 100 * \left[ \frac{\frac{1}{\text{...}} - \frac{1}{\text{..}}}{\text{---}} \right]$$

$= m^2$

$A_{min}$ ← min. Area of thickener to handle

can be handle before filtration, to decrease to flowrate coming into the filter hence enhance the process

g/L = Kg/m³

**Sedimentation** the process of separation of a dilute suspension of solid particles into a supernatant Liq & concentrated slurry

① initial conc. of suspension. تعتمد على

② Relative densities of fluid

③ Dimensions of settling tank

④ size of the particles.

---

* مهم

if the purpose

* to concentrate the solids

↳ it thickining

* But if the purpose is the removal of solid particles to produce clear Liq ⇒ clarification

عشان نقدر to determine the dimensions of settling tanks & it can be carried out batch wise or continuously

---

* efficiency can't reach 100%.

(why?) ⇒ Because there are tiny particles that can't be removed by settling

Less suspensions initial conc. → Less time for settling

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# Exp (9) Filter press

* **Objective** To demonstrate the basics of ① filtration & to study the effect of certain ② variables such as solid concentration in slurry and size of solid particle on the resistance to filtration.

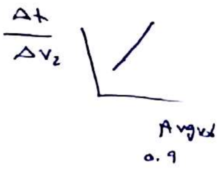
Plate & frame filter commonly used filter design.

ترادتج من الموبايل .

@ p = - -

**Conclusion**

Filtration process depends on ① the concentration of Solids in the fluid, ② particular nature of solid (size, shape), ③ fluid physical properties (viscosity, density, corrosion)



**Adv.** of filter press

① High solids content cake.

② High pressure operation is usually possible.

③ Because of its basic simplicity the filter press is versatile & may be used for a wide range of materials under varying operating conditions of cake thickness & pressure

④ It is equally suitable whether the cake or the Liq. is the main product.

**Dis**

1.2

① Noise Levels caused by feed pumps can be very high.

② It is intermittent in operation & continual dismantling is apt to cause high ~~water~~ wear on the cloths.

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## ⊛ Calculation

At $p = 0.5$ bar

$$\Delta P = \boxed{\phantom{0}} * \frac{760 \text{ mmHg}}{1.01325 \text{ bar}} = \text{---} \text{ mmHg}$$

Height 1 = 1

Time 1 = -- min

Time 2 = -- min

width = -- 14.2 cm

Length = -- 18 cm

Volume 1 = Height x width x Length ml

$\Delta t = t_2 - t_1$

Height 2 = 2

Volume 2 = $\textcircled{2} * 14.2 * 18$ -- ml

$\Delta V = V_2 - V_1$

$$\text{Avg vol.} = \frac{V_1 + V_2}{2}$$

$$\frac{\Delta t}{\Delta V} =$$

After plot between $\frac{\Delta t}{\Delta V}$ vs. Avg. V

The equation is $y = \boxed{0.0001} x + 0.202$

Slope = ---

intercept

viscosity = --

Area = 14.2 * 18 = --

Vol. = 100 cm$^3$

Resisdance of filtering medium

$m^{-1}$ [illegible]

$$\text{Intercept} = \frac{\textcircled{R} \times \mu}{\text{Area} * \Delta P} = 0.202$$

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