lab ① Exp ① (Vapor liq Equilibrium)

more volatile than toluene
less B.P

Reem

→ two volatile (n-Hexane & Toluene)

liq & vap. composition → (By Refractometer)

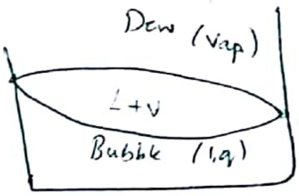
→ Necessary for efficient separation of Liquid By distillation.

	liq	vap.
n-Hexane	x	y
Toluene	$1-x$	$1-y$

* at equilb.
  vap. & liq phases will be equal
  But comp will not

activity coeff are (=) → ∴ sys. is ideal → Raoult's law

على شو تعتمد
① P
② Temp.
③ comp.



$$P_T = P_A^* x_A + P_B^* x_B$$

$T \uparrow$,, Rate of vap. $\uparrow$

Bubble → at which mix. start to bubble

$$\gamma = \frac{y_i \cdot P_T}{x_i \cdot P^{sat}}$$

activity coeff.

$$\boxed{\gamma_H = \frac{P_{tot} \cdot Y_H}{P_H * X_H}}$$

$$\gamma_T = \frac{P_{tot} \cdot Y_T}{P_T * X_T}$$

% vol

$$X_h = \frac{\frac{X_h * \rho_A}{Mwt}}{\frac{X_h * \rho_A}{Mwt} + \frac{X_{Tol} * \rho_B}{Mwt}} \quad (\text{mol }\%)$$

$$X_h + X_T = 1$$

كيفية التحويل من % Vol to % mol

$$X_T = \frac{\frac{X_T *}{Mwt}}{\frac{X_T *}{Mwt} + \frac{X_h *}{Mwt}} = \text{mol}\%$$

$$P_{tot} = P_H + P$$

$$X_H P_H \gamma_H + X_T P_T \gamma_T$$

Atoine $\log P = A - \frac{B}{T+C}$
mm Hg

Exp ① Calculation

$\hat{V}_A = \frac{1}{\rho_A} \, Mwt\,A$ hexane ↙ molar vol.

$\hat{V}_B = \frac{1}{\rho_B} \, Mwt$ Toluene

$X_B = 1 - X_A$

speed ↑
velocity ↓
P ↑

$$X_A = \frac{\dfrac{X_A \text{ (vol. fraction in liq)}}{\hat{V}_A \rightarrow \frac{Mwt}{\rho_A}}}{\dfrac{X_A}{V_A} + \dfrac{X_B}{V_B}}$$

Exp ⑤ [Compressible fluid flow]

Simple pipe — fraction losses ⇒ يعتمد على Velocity ①

V ↑ velocity ΔP ↑ $(P_0 - P_1)$ ↑
Re ↑
f ↑ due to Blasius Relation

slope = $\frac{4FL}{D}$

f ↑ , V ↑, Re ↑ quantity © $(P_0 - P_1)$

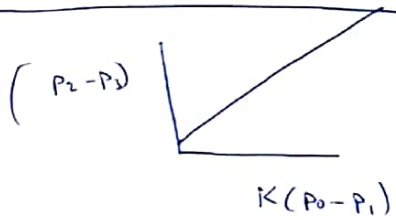
Sudden Expansion (enlargement) → ΔP & velocity طردية
ΔP & ρ طردية

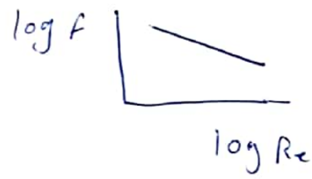
$(P_0 - P_1)$ & $(P_2 - P_3)$ ↑

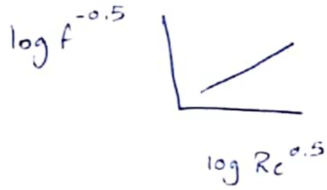
KE ↓ (V↓) P ↑ $KE = \frac{1}{2} m v^2$

(total Energy is conserved)

∴ ρ_2, ρ_3 ↑ gradually







Nozzle

increases the velocity at the begining of the process → is used for measure the flowrate

pipe طول & friction ∴ P قلّ

straight — friction loss & velocity (طردية)

$(P_0 - P_1)$ & Re (طردية)

* compressibility is affected by ΔP

$\rho = \frac{P \, Mwt}{RT}$

$P.V = n.R.T$ Ideal gas law

$P . \frac{m}{\rho} = \frac{m}{Mwt} R.T$

* $\rho = \frac{P . M_w}{RT}$

lab(1)

- Solubility curve
- tie lines

• Exp (2) (liq liq Equilibrium) → * يفصل مركبين اعتمادا على Relative solubility in two diff immiscible liquids & Similar Boiling point *

Latent heat

heat required to convert liq to vap. at atmospheric pressure

liq separation in water is to be separated using toluene in which immiscible in water & miscible in Acetone ∴ easily to be separated from Acet.

at 25°C Acetone, Toluene, Water

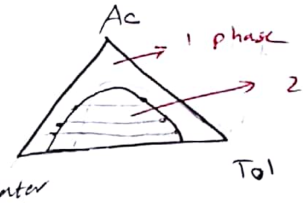
* temp. sensitive

* Acetone miscible بالاثنين

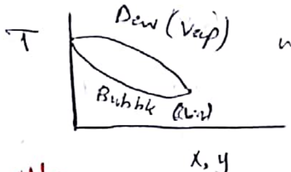
Tol. ولكن ال

Acc. مع ال mis

Water مع ال misc.



until cloud point



* mixed well

Then allowed to settle into two layers

* The composition of each layer was determined by measuring the refractive index of each one.

↓

(linearity) othmer Tobias correlation & cheacking the reliability

Extraction doesn't produce finished product لازم نعمل separate → to obtain final product

- Solution to be extracted → feed
- liquid used → Solvent.
- layer which contain solvent → extract
- 〃 〃 〃 feed → Raffinate

Two steps

① Intimate mixing or contact of the solvent with the solution to be treated, So as to transfer the solute from the solution to the solvent.

② Separation of the liq. solution phase from the liq solvent phase.

مبدأ Material dissolved in one liq. phase is transferred to a second liq phase

Extract	Raffinate
layer contain greater conc of solvent & smaller conc. of feed liq.	layer containing the greater conc. of feed liq ~~solvent~~ & smaller conc. of solvent

Agitated glass cell for liq liq equilibrium ①

Refractometer ②

(accurate Reading)

tie lines

RI ext. Raf

a → mass weight of tol.

b → 〃 〃 water

To extract the components from each other by separating them into two layers, after allowing mix. to settle down. ⇐ خليط الmixture مع بعض و نفصلهم

* Exp ② تابع *

→ Titration until (cloudiness)

* $\boxed{\text{Cloud point}}$ → at which three components in the mixture are in equilibrium
" It represents one point at ternary curve.

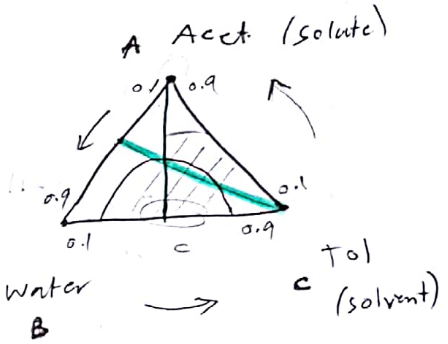
Calc.

$m = \rho * V$

mass مطلوب
for Tol, water, Aceto
ثم نجمعهم

$\boxed{\text{mass fraction } X = \frac{\text{mass}}{\text{total mass}}}$

→ titrating mixture of water & Acetone with Toluene until the cloud points & then estimate the compositions of the mixture.



→ Two phase meet at the point at which the two phases have identical compositions, at this point the tie line converage in a point & two phase become only one phase (plait point)

⊛ عودين من ال comp لما عندك من ٠ ل ١٠٠
* خطوط عودية عليه

* The direction of tie lines indicates that Acetone is more soluble ~~in~~ in Toluene that water.

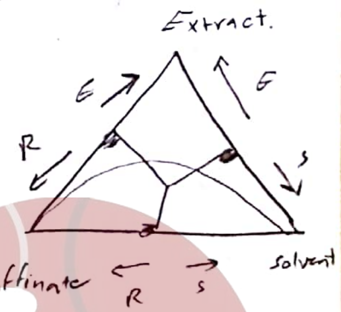
Ac. / tol.

* The Acetone is partial miscible in both toluene & water

$\boxed{\text{linearity}}$ → othmer Tobias correlation

* Refractometer → personal error (fourth last digit). → light of RI Should be stronger to ensure better Reading

* Make sure → $\boxed{\text{Extraction process}}$
(mixing & settling) ~~thake~~ take their time.

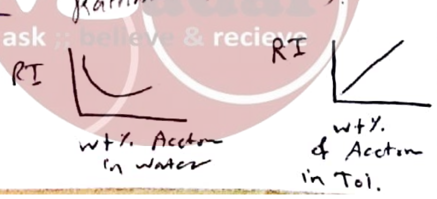


gloves ✓

settling time ↑ efficiency of the extraction ↑

* Toluene is good extractant for Acetone from water according to the area under the mutual solubility

Extract → solvent آخر
Raffinate → feed أول



* lab ① Exp ③ Reem

(Digital Joulemeter) → ① To determine the specific heat capacity of metal
② = specific latent heat of vaporization
③ efficiency of electrical motor.

* electrical energy ⇒ Joule

powers ⇒ Watt

$Q = \overset{\text{block}}{m} \cdot \overset{?}{C_p} \cdot \Delta T$

$\boxed{Q = m \cdot \lambda}$ → specific heat → ΔH_{vap} (KJ/Kg) (J/g)

water after vap.

(final weight − initial weight) → mass of water evap (g)

→ Joule meter Reading

DC & AC
(Direct & Alternative currents)

At const mass & var. voltage, Q_{out} will be const. So V↑, Q_{in}↓, η↑ (direct)

* load masses = mass of Block (lifted) + mass of handle (hanger)

Q_{out} = * work = PE (potential energy)

$= m * g * \Delta h$ (height)
kg, 9.8

$Q = m \cdot C_p \cdot \Delta T$
J/g.°C

*10 scale

C_p for Aluminum = 0.9109 J/g.°C

$\eta = \dfrac{\text{Mechanical work}}{\text{Electrical}} * 100\%$ (potential)

λ : latent heat of vaporization
(heat required to convert 1g of liq at const P)

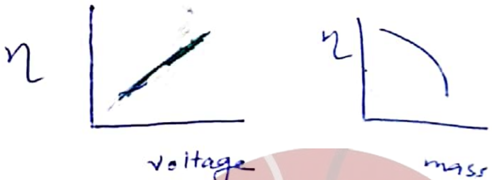
$\dfrac{m \cdot g \cdot \Delta h}{\text{Joulemeter Reading}} = \boxed{\eta = \dfrac{Q_{out}}{Q_{in}}} = m * g * \Delta h$

W, E, Joulemeter Reading

• At const. V & var. mass

* m↑, Q_{out}↑, Q_{in}↑ (more than increment of Q_{out})

η↓ (inv. Relation)



η↑ ⇒ volt.↑ (Direct Relation)

η↑ ⇒ m↓ inverse

Exp (4) Efflux Time for a Tank

lab (1)

Reem

time → pipe length & diameter

→ initial depth of liq.

من بداية التفريغ لنهاية الـ Tank] H_1

من نهاية التفريغ لنهاية الـ Tank] H_2

→ final depth of liq.

mass of mix. = mass of filled Bottle − mass of empty Bottle

$$\rho = \frac{m}{V}$$

$$Re = \frac{\rho \cdot u \cdot d}{\mu}$$

⇒ (العوامل التي تؤثر في التفريغ)

1. Tank shape
2. Tank Diameter
3. كمية المادة
4. phys. properties of material.
5. Head (length) → كل ما كان أعلى كل ما كان التفريغ أسرع

efflux time ↑ pipe length ↑

(due to friction between the fluid & pipe)

at const. dia.

efflux time ↑ when Diameter ↓

(Because at small dia pipes there is higher viscous force between the fluid & the pipe)

⇒ How to measure density & viscosity?

density → mixture using 50 ml density bottle by calculating the mass of mix. first then divide it by vol. to get density

$$\rho = \frac{m}{V_{50}}$$

viscosity → Viscometer = (physconometer)

$$A = \pi \frac{D^2}{4}$$

$$Q = \frac{V}{t_{eff.}}$$

Velocity ← $V = Q/A$

in exp 7 ← $V = \frac{w}{\rho \cdot A}$

Exp ⑥ (Determination of losses in piping sys)

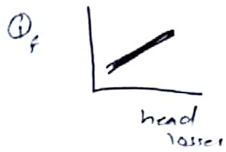
(study pressure losses due to friction)

كيف تحدث؟

friction
① Roughness of pipe
② Sudden Expansion
③ " Contraction
④ valves
⑤ Elbow fitting

تأثيرهم
(Sudden Expan., contrac., bends, gate valve, global valve)

head losses
① flow velocity
② pipe length
③ Diameter
④ Friction factor Based on
↳ Roughness of pipe & Re No. for the flow
(Degree of Roughness)



Head loss
Measure of Reduction in the total head.
Σ elevation head
velocity head
pressure head

تحدث بسبب
friction between fluid & wall pipe

• Straigh pipe

Q↑ (Vol. flowrate) → Re↑ بسبب زيادة ال velocity
→ head losses↑
f↓

* friction losses in 90° mitre
أكبر من
losses in 90 elbow

KE = 0 ∴ f high

* head losses for sudden expansion ($\frac{u^2}{2}$)
أكبر من
Sudden contraction $\frac{1}{2}\left(\frac{u^2}{2}\right)$
بسبب فرق الضغط

• Bends

Bend ↑ ,, Head losses ↓

Q↑ head losses ↑
(in 90° elbow & mitre Bend)

But friction losses will larger in 90° mitre than elbow

Valves
* Head losses for global valve
أكبر من
gate valve
due to compact geometry

Q↑ ,, head losses↑

K (loss coeff) ↓ in both

• Sudden Expan. & contraction →
head losses* لازم غير متساوي
Q↑ , head losses ↑ in Both (contra. & expantion)
Dia لازم يكون غير متساوي

$Q = \frac{m}{\rho \cdot t}$ (Vol. flowrate)

$u = Q/A$

→ 6 تابع ←

Calculation

$\Delta h = h_1 - h_2$

$Q \text{ (vol. flowrate)} = \frac{m}{\rho . t}$

$u = Q/A$, $A \to \frac{\pi D^2}{4}$

$\% Q = \frac{Q}{Q_{\text{fully opened}}}$

$K = \frac{\Delta h * 2g}{u^2}$ Gate valve / $\frac{d_2}{d_1}$

$f = \frac{\Delta h_f * d * g}{2 * L * u^2}$ Straight pipe

$\Delta h_{\text{(no losses)}} = \frac{(u_1^2 - u_2^2)}{2g}$

$\Delta h_{\text{losses (al)}} = \frac{(u_1 - u_2)^2}{2g}$

بطرحهم من بعض Δh_{loss}.

r/D

overall $\eta = \frac{W_p}{W}$

$W_p \to Q_v * (P_2 - P_1)$ (value)

W معطاة

Expect

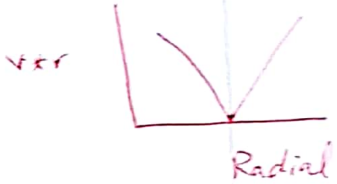
Exp (7) Pitot Tube

↳ study flow of air in tubes

velocity ✓ , vol. flowrate ✓

flow through pipes was turbulant

* velocity of flow inside the pipe is increasing when we go closer to center & dec. when we go close to the sides of the pipe



$Re = 140,000 > 2100$ ∴ turbulent flow

70,000

* ولكن شكل ال velocity profile زي تبع laminar

* Take care of pressure diff. Reading

* After sometime ⇝ fan is heated due to over work ⇒ This will affect the density of air flowing through the pipe

↳ Recommentation Turn off the fan once in while make sure the temp. is const through exp

* Calculation

orifice

mass flowrate ← $W = \rho * \text{orifice Area} * C_d * \sqrt{\frac{2\Delta P}{\rho}}$

$\rho = \frac{P \cdot Mwt}{R \cdot T}$

orifice Area $= \frac{\pi d^2}{4}$ → orifice

$\bar{v} = \frac{W}{\rho \pi R^2}$; $A = \pi R^2$

avg. veloc.

Pitot Tube

local velocity

↳ $v = \sqrt{\frac{2(P_0 - P)}{\rho}}$

W ⇒ from Simpson Rule 3/8

avg. velocity ↙ $\bar{v} = \frac{W}{\rho \cdot A}$

$Re = \frac{\rho \cdot \bar{u} \cdot D}{\mu}$

* مهم دراسة ال calc. الها بالتفصيل!

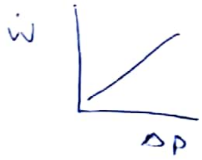
Exp ⑧ Positive Displacement Pumps characteristics

lab① Reem

أنواع pumps ✓
(Vane & piston)

Part ①
diff. p & const speed

Part ②
const p &

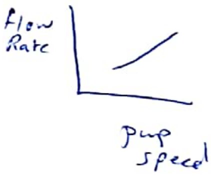


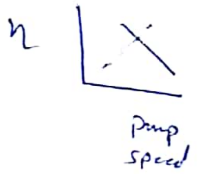
* p ↑ (velocity const)
water power ↑ at const flowrate

p↑ Vol. flowrate ↓ ,, vol. effectiviness ↓
(Bernoli's equation)

A↓

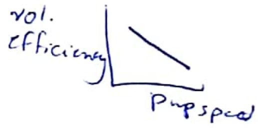
overall
$\eta = \frac{Q_v(\Delta P)}{W_p} \quad \frac{}{W}$



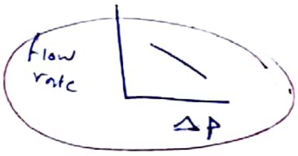


* Vane pumps are more ~~efficiencies~~ e ~~effectiv~~ efficiencies for higher Δp

Expected
$= \frac{\text{Swept vol.} * \text{flowrate}}{1000}$

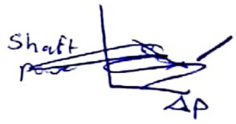


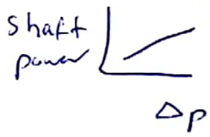
Vol. η
$= \frac{\text{Actual}}{\text{Expected}}$



* At const speed &
$\boxed{\uparrow p}$,, overall efficiency ↑
flowrate ↓
Vol. efficiencies ↓

$\frac{Q_v}{V_s * V_p} * 100$
V_s: swept vol.
V_p: speed

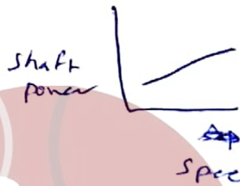




* At const p
* Vane
  V↑ (speed) , high flowrate ↑
  lower vol. eff. ↓
  V↑ (speed) ↓ overall efficiencies.
* piston
  V ↑ lower overall eff. ↓
  vol. eff. ↓
  high flowrate ↑

↙ الرسمات هون
مش قاعدة
صح
piston أو vane

⇐ العلاقات هاي
احفظ ^^

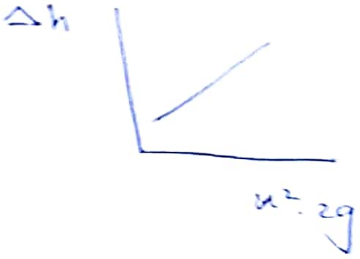


$W = \Delta p * Q_v$
overall = W_p / W
Vol. eff. $= \frac{\text{Actual}}{\text{Expected}}$
Expected $= \frac{cc/\text{Rev} * \text{speed}}{1000}$

Exp(9) (Compressible Fluid Measurement)

↳ Bernoli

$A\uparrow$, $P\uparrow$, $V\downarrow$

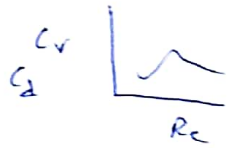


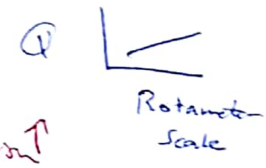
Measured flow

① orifice → أرخص economically
② venturi → Best one
③ Rotameter

Decreases energy loss due to gradual flow of fluid

$K = \frac{\Delta h * 2g}{u^2}$





$Q = \frac{m}{\rho * t}$ → vol. flowrate

simple
$(P_0 - P)\uparrow \rightarrow Re\uparrow \rightarrow friction\uparrow$

sudden
$(P_0 - P)$ & $(P_2 - P_3)\uparrow \rightarrow (\rho_2 - \rho_3)\uparrow$

$K = \frac{\Delta h * 2 * g}{u^2}$ → loss coeff

ρ & Veloc. to describe flow

When ρ is func. & Both ~~Posto~~ Position in the flow & time

Change in P & u → var. in ρ → comp. flow

if ΔP large to cause 10% or greater decrease in ΔP is considered compressible flow

$\Delta P = \rho g h \sin\theta$

* امتحان ميد سابق *

- ارسم Venturi meter + أجزاؤه
- استخدام manometer ← يقيس أي ضغط؟ → absolute P
- " barometer → atm. P
- فرق بين Dyn. & Kinematic viscosity
- فرق بين gauge & abs. P?

Reem Barakat