AIR LECTURE 9 & 10

Sizing of Particles

When dealt with powders → you sieve the particles

You take a vessels with holes in it (of a certain size).

You put the particles and start shaking it.

Using a series of sieves is a common practice done by chemical and civil engineers known as sieve analysis.

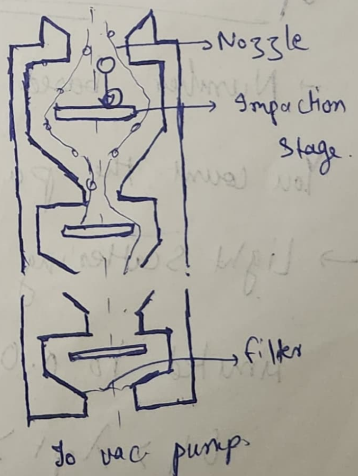
Assumption → Particle has a certain gravitational settling rate.
i.e there will be enough velocity due to gravity.

This however isn't the case for particles smaller ~~lower~~ than 100 micrometer.

Buoyancy / Drag makes sieving impractical and of no use in particles of this small size.

How do you size / count particles in nm size range?

→ Inertial Impactors (MOUDI)
Micro orifice Uniform Deposition Impactor.



Diameter of orifice becomes smaller as you go further down.

Using fluid mechanics to separate smaller & large particles.

Working of MOUDI

1) There are 3 sizes of particles. They enter from atmosphere.
2) There is a pump to create vacuum (suck atmosphere out)
3) They come in with certain velocity and hence an inertia.
4) The gas molecules (the ants) adapt to the chang caused at the impaction stage (obstruction).
5) The gas particles are forced to turn.
6) The smaller particles turns away, the larger ones are unable to turn and get stuck to the vaseline on impaction stage.
7) This process continues for every sizes of particles.
8) Now you can get histogram of data collected.

In industry, only 2 stage process, $\underbrace{\text{pm-10 \& pm-2.5}}_{\text{Particulate matter}}$

→ Used for particles (> 56 nm) and is mass based.

Optical Particle Counter (OPC's)

→ Number based (> 100 nm)

You count the particles one by one.

→ Light scattering | Extinction

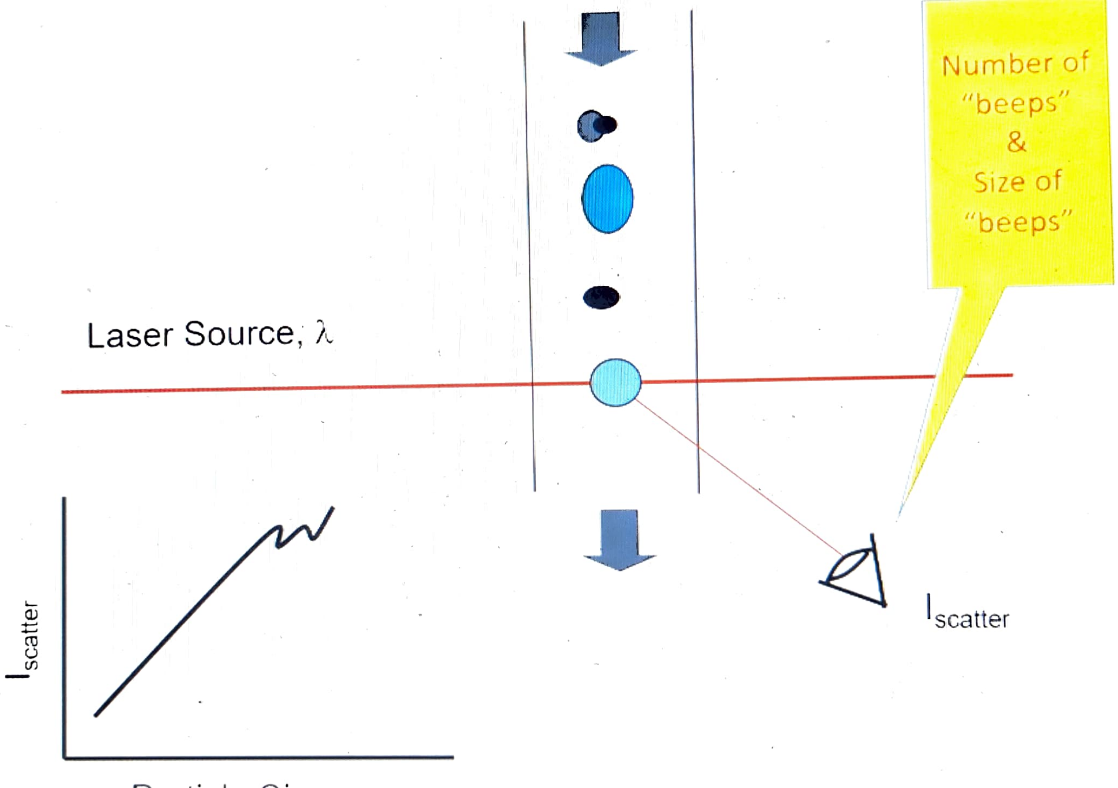
Limited to 0.09 μm.

$0.4 > \lambda_{opt} > 0.7\ \mu m$

Cloud of particles
↓
turbidity.
↓
We measure turbidity in water.

→ Aerosol → single particle

Water → Multiple particles.


Number of
"beeps"
&
Size of
"beeps"
Laser Source, λ
Iscatter
Iscatter

→ Larger the particles → larger the signal
→ Every time a particle passes, there is a beep.
Each beep is a count = size of particles.

Electrical Mobility

→ Sizing (>3nm)
→ Counting (Condensation Nuclei Counters)
→ Use an electrical field to charge particles and then you use an electric field to separate them

Working (Model 3081 Long DMA) → fig in next page.

1) You bring in the particle with a charge and you introduce them into the shell.
2) There is an electric field between the outer surface and the brown (high-voltage) rod.
3) The ~~cheng~~ charged particle moves under the influence of electric field.
4) Depending on the size, there will be a charge and depending on the charge, there will be an electrical mobility.
5) The dotted lines (can be seen faintly) are the trajectories that indicate the different size of particles that hit the central rod.
6) Below the rod, there is a small opening, which allows only one particular trajectory / size to go through.
7) With a particular electrical field (tuned electrical field), a particular size can go through the opening

Polydisperse particles → Monodisperse particles.
To change size of monodisperse particle → change voltage diff between central rod & shell

Electrical Mobility Analysers

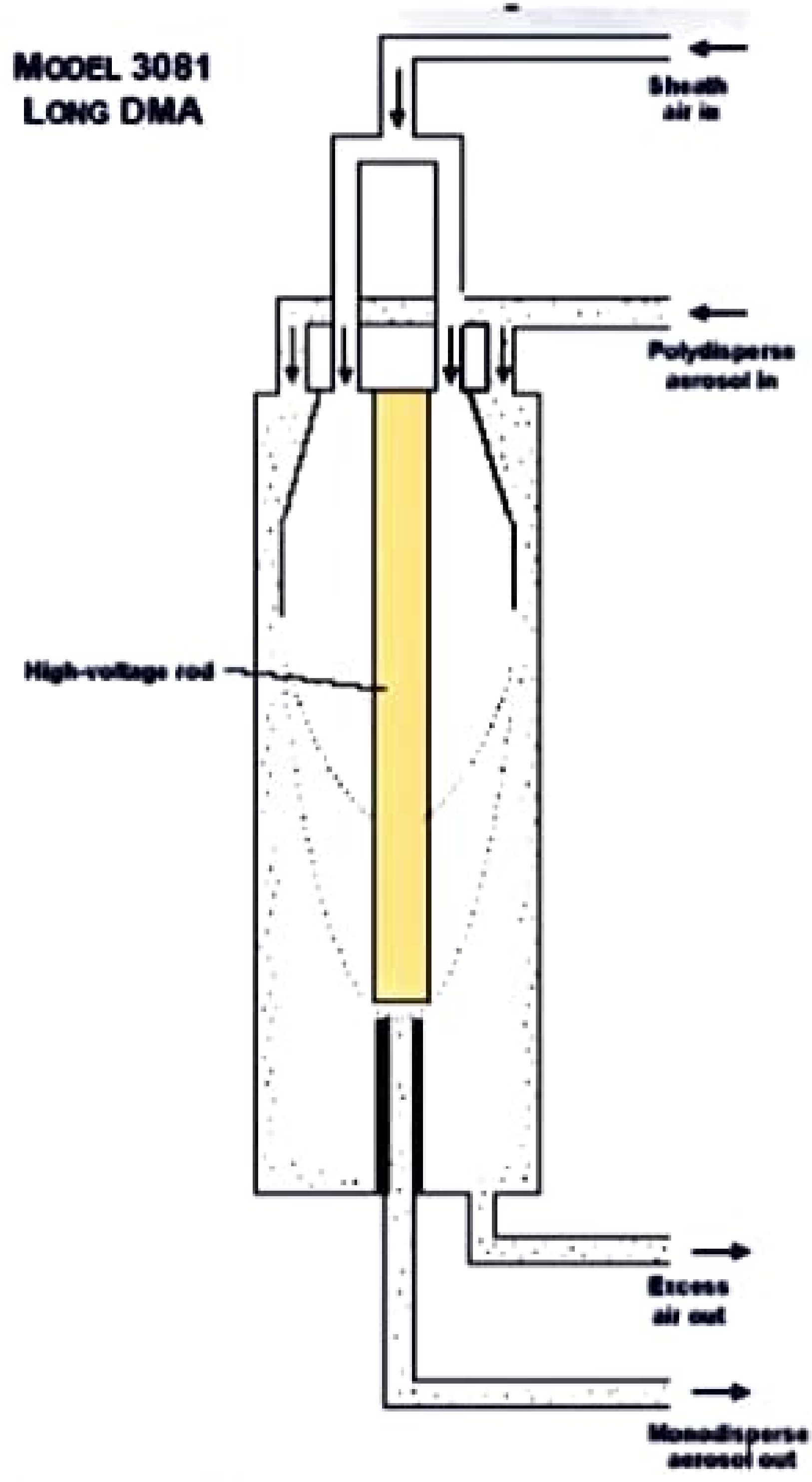
- Charge particles
- Electrical Field

SIZE

CPC

OPC in Principle – Alcohol used to grow size

Differential Mobility Analyser (For size separation using electrical mobility)



Source : TSI Inc.

Now to count the particles

↓

Condensation Particle Counter. (3 nm)

1) Pass the monodisperse particles through an area saturated with vapor/alcohol. These vapor/alcohol condenses on the small particle to create a larger particle which is optically detectable. ~~This is called scanning mobility particle sizer.~~

Scanning mobility Particle Sizer.

Combination of differential mobility analyzer (sizer) and a Counter (CPC).

Long unit has the electrical rod.

Why scanning? You scan the electric level i.e you chose electric field as per your demand.

Field Instruments

Standard sampler → High volume sampler.
(Govt used)

↓

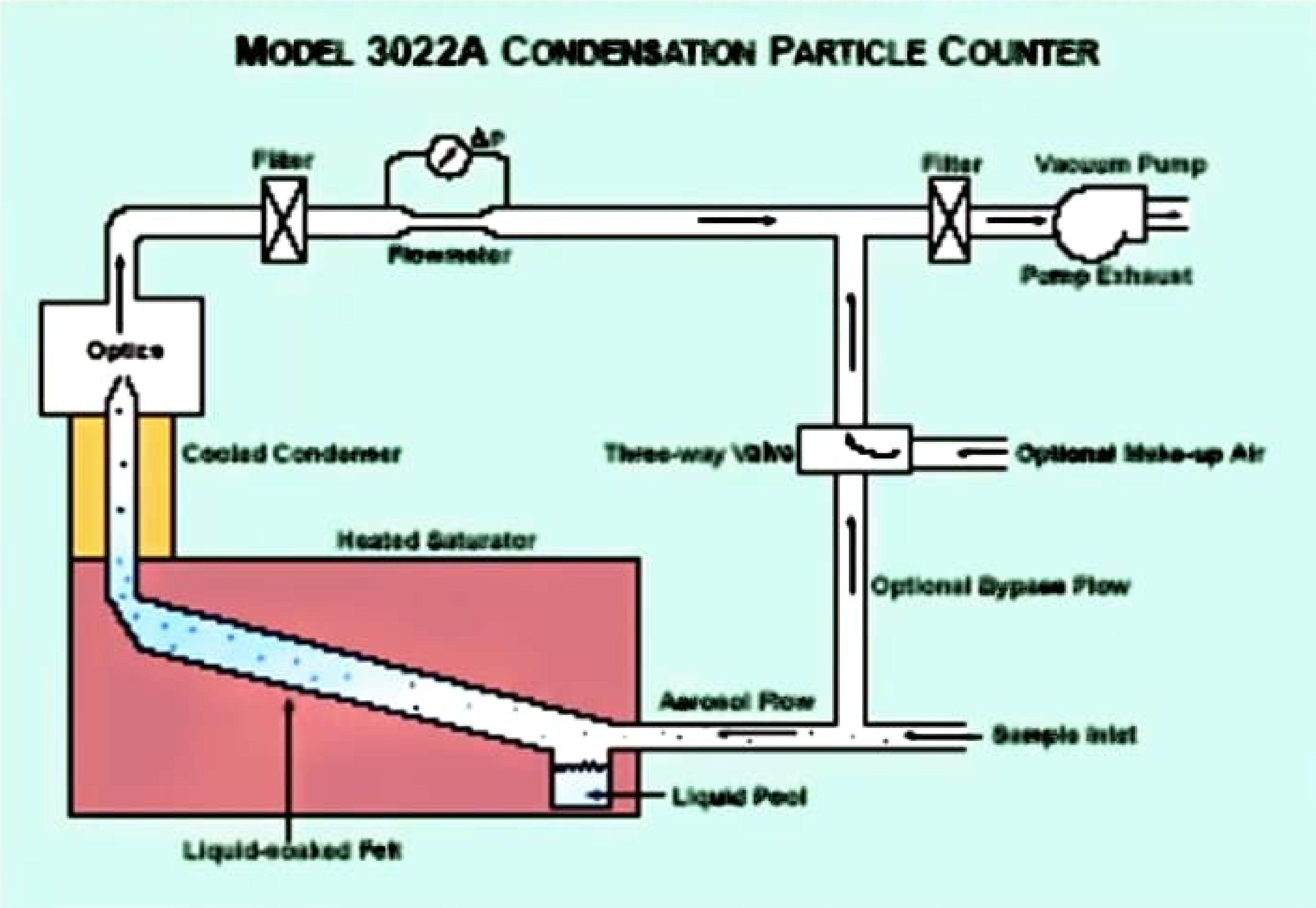
Take large volume of air & pass it through a filter which has a cyclone cutoff (removes particles > 10 µm)
So you are only collecting particles that are respirable on a filter paper. Weigh the filter paper before and after the collection of particles.

$W_{After} - W_{ini} = W_{particles}$

↓ Div by Volume

$$\frac{W_p}{V_{sample\ of\ air}}$$

Condensation Particle Counter (For growing the size separated particles and detecting them using light scattering)



Source : TSI Inc.

Scanning Mobility Particle Sizer

Field Instruments

- High Volume Samplers (~2 Lakhs)
  - Regulatory (RSPM, SOx, NOx)

→ Mini Vol Samplers (5 l instead of 1000 l)
- For places that are highly ~~poll~~ polluted.
- Principle used : Same as MOUDI

→ Dust Trak

You put an impactor at entry & measure particles less than the given size.

Measuring Gaseous Pollutants.

- Wet ~~chemistry~~ chemistry

Collect the sample → Take a solvent reagent → Bubble the air for 8-24 hrs → Bring the air back to lab → Perform standard test prototypes to measure oxygen/sulfur/nitrogen oxides.

- Electrochemical sensors (Real time)
  → Instant
  → Accurate (not as much as wet chemistry) but more feasible.

- Spectroscopy

Field Instruments

- High Volume Samplers (~2 Lakhs)
  - Regulatory (RSPM, SOx, NOx)

- Mini-vol Samplers (~5 Lakhs)
  - Regulatory (PM10, PM2.5)

Field Instruments

- High Volume Samplers (~2 Lakhs)
  - Regulatory (RSPM, SOx, NOx)
- Mini-vol Samplers (~5 Lakhs)
  - Regulatory (PM10, PM2.5)
- Dust Trak (~7 Lakhs)
  - Real time (1 minute resolution)
  - PM_x (x = 1, 2.5, 4, 10)

Measuring Gaseous Pollutants

- Wet Chemistry (8 hour averages)
- Electrochemical sensors (Real time)
- Spectroscopy (Real time)
- Standard Methods (SPCB's Analytical Labs)