# Lecture 12

## Powder Processing

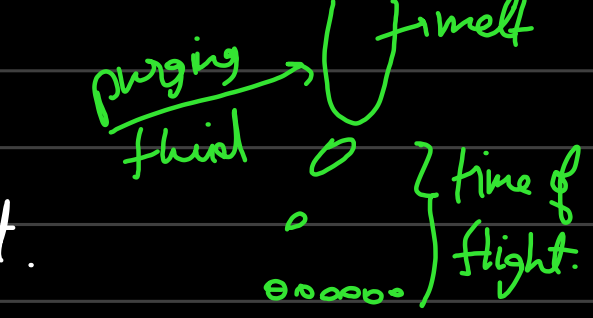
## Atomization:

↳ spherical shape particles

↳ disintegration of melt into droplets which freeze into spherical powder particles.

↳ Done in atomizer.

→ optimum time of flight.




→ for high melting temp solids, vertical atomizer required to increase time of flight.

→ Nano-size powder can also be generated.

→ production rates of 400kg/min.

→ used for metals, alloys & intermetallics.

→ Two types of atomization: (media of disintegration)

i) Gas ii) Liquid

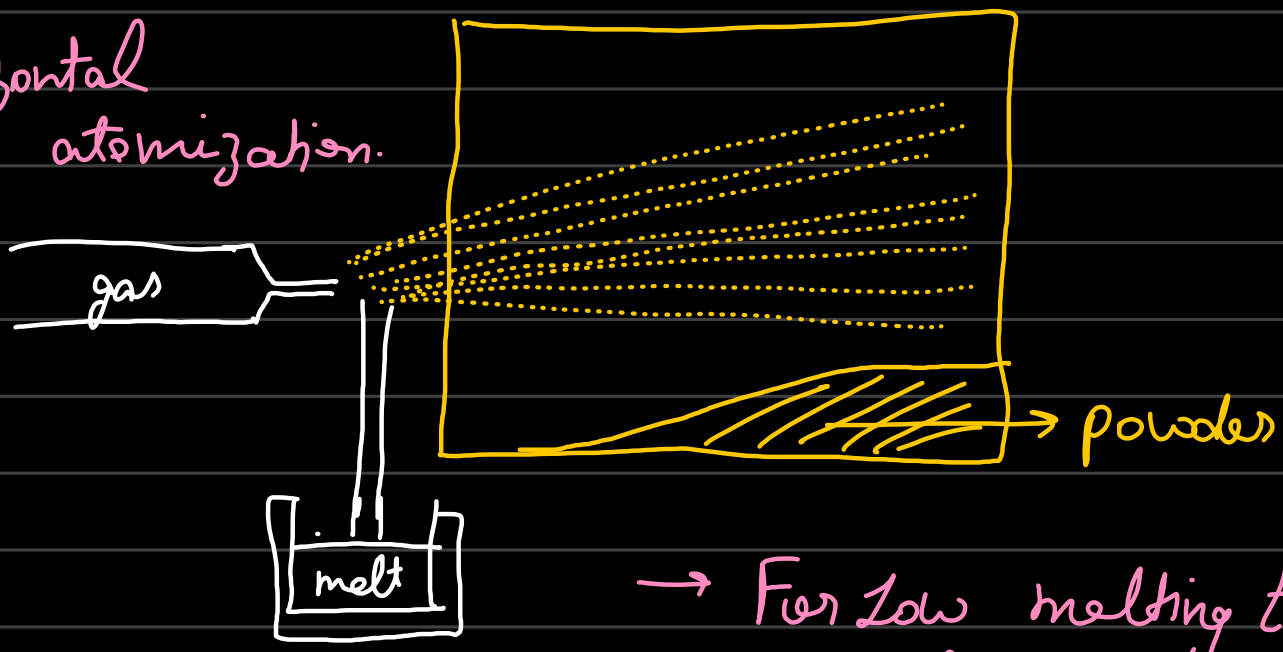
# Gas Atomization:

↳ Use of air, nitrogen, helium or Argon gas

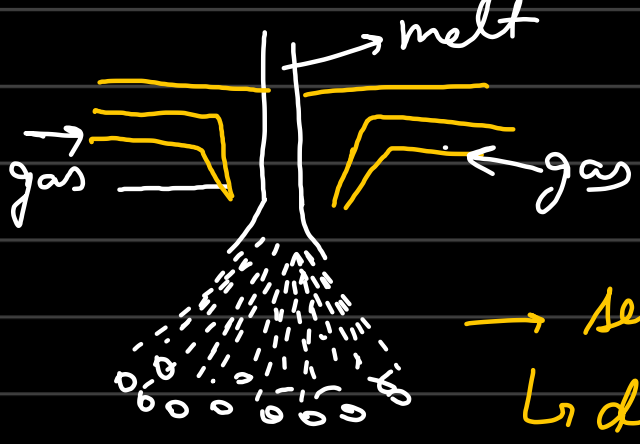
→ main idea is to deliver energy to the molten stream to form droplets.

→ Higher the energy input (high gas velocity, high temp) smaller the droplets. (high surface area / energy)

Horizontal atomization.




→ For low melting temp materials.

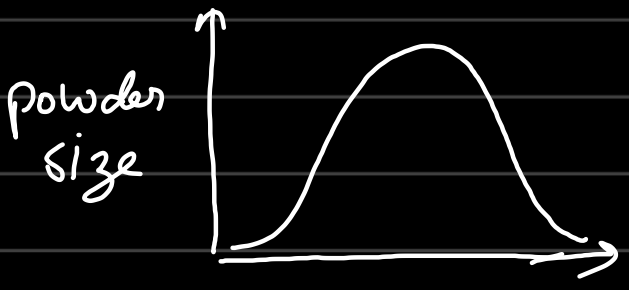



## Vertical Atomizer.

→ high temp. materials.

→ series of shape changes during flight
↳ driven by lowering of surface energy
↳ spheres not formed immediately

→ Size distribution is very wide, but mostly over 10 μm.




→ Cooling rate of the order of $10^6$ °C/s.


→ Gas pulls liquid into ligament which undergoes morphological changes.

## Mathematical relation between ligament size and sphere size.


$$N\frac{\pi D^3}{6} = \frac{\pi}{4} d^2 L$$

$$\boxed{\frac{L}{N} = \frac{2}{3}\frac{D^3}{d^2}}$$

Surface energy minimization.

$$N \pi D^2 < \pi L d$$

$$\frac{L}{N} > \frac{D^2}{d}$$

$$\frac{2}{3} \frac{D^3}{d^2} > \frac{D^2}{d}$$

$$D > \frac{3d}{2}$$

→ Empirical relation : powder size related to melt characterization.

$$D = K d \left[ 1 + \frac{M_m}{M_G} \right] \frac{\eta_m}{\eta_G We}$$

powder size.

$We$ = Weber number $= \frac{\rho_a V^2 D_L}{2 \gamma_m}$

$d$ = Melt stream dia ; $\eta_m$ = melt viscosity

$K$ = empirical const. ; $\eta_G$ = gas viscosity

$M_m$ = mass flow rate of melt stream

$M_G$ = gas flow rate of purging gas.

$V$ = Velocity of gas

$\gamma_M$ = melt surface energy

$D_L$ = ligament dia

→ Satellite particles: small spheres attaching over bigger spherical powder particles. {agglomeration}

↳ due to turbulence in gas flow.

↳ particles re-enter gas expansion zone

↳ welding of powder particles.

↳ need to maintain minimal turbulence in gas expansion zone.