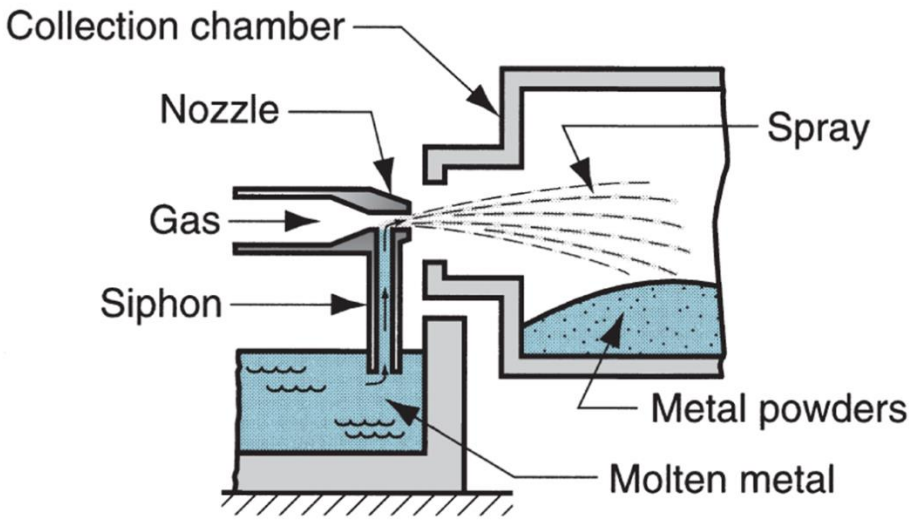
Benha University
Shoubra Faculty of Engineering
Mechanical Engineering Department

Lecture # 2

POWDER METALLURGY

متالورجيا المساحيق



Dr. Mohammed Gamil

Production of Metallic Powders

1. Atomization Method
2. Chemical reduction of particulate compounds
3. Electrolytic deposition
4. Pulverization or grinding of brittle materials
5. Thermal decomposition
6. Precipitation from solutions
7. Condensation of metal vapors

1. Atomization Method

- Suitable for comparatively less reactive metals.
- Pure metal and alloy powders
- "The break up of a liquid metal into fine droplets, typically smaller than 150μm."
- Forcing of molten metal through a small orifice and breaking up the stream by a powerful jets of compressed air, gas or water.
- High velocity gas stream flows through expansion nozzle, siphoning molten metal and spraying it into container.
- The gases used are Ar, N and He gas jet (inert gases).

Types of Atomization

- On the basis of atomization media;

i) Gas atomization

ii) Water atomization

- On the basis of kind of energy being used;

i) Vacuum atomization

ii) Rotating disc atomization

iii) Centrifugal atomization

iv) Plasma atomization

v) Ultrasonic atomization

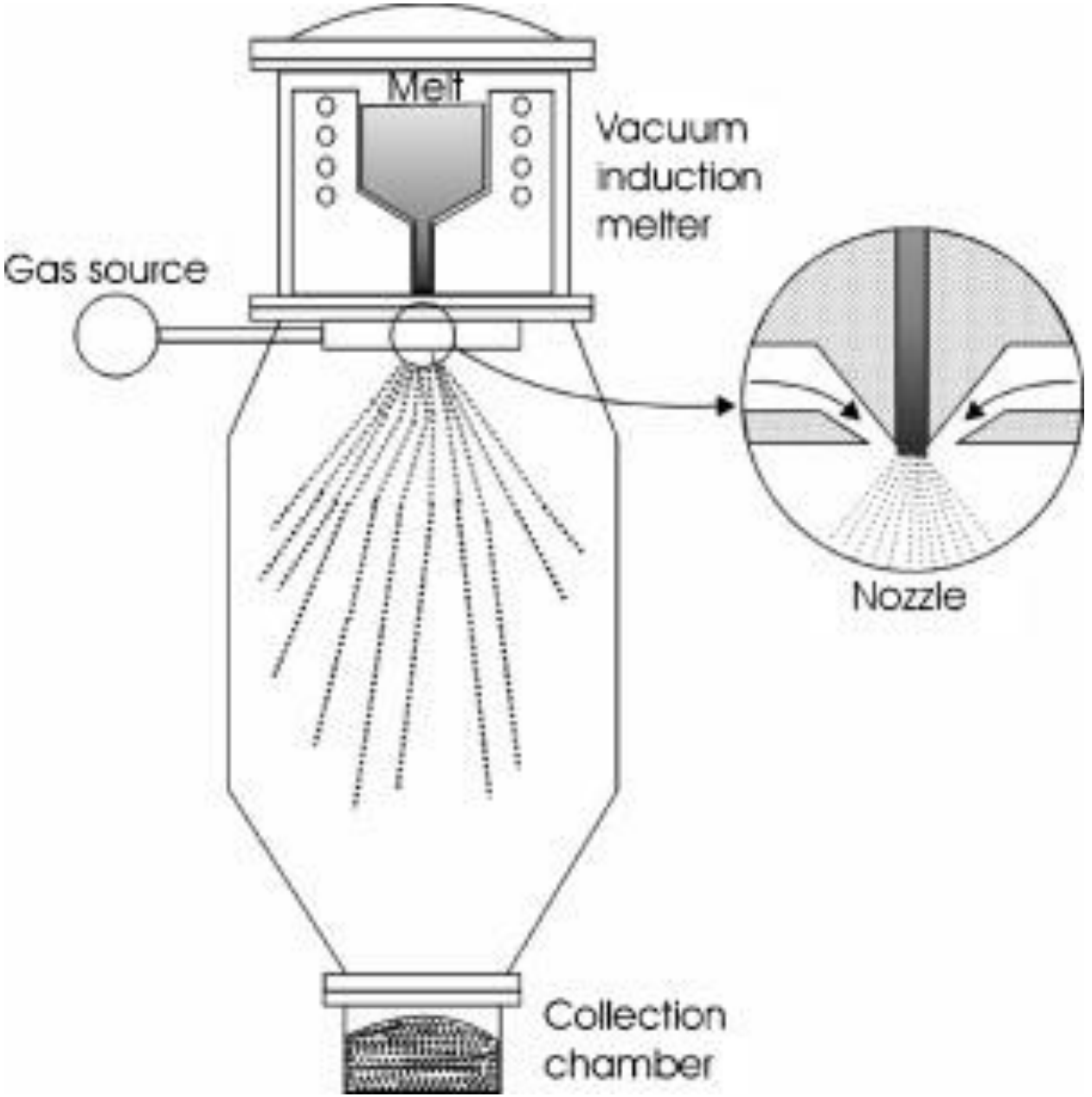
GAS ATOMIZATION

- The breakup of liquid metal stream into droplets by the impingement الإصطدامof high pressure gas. OR
- The liquid metal stream is disintegrated by rapid gas expansion out of a nozzle.

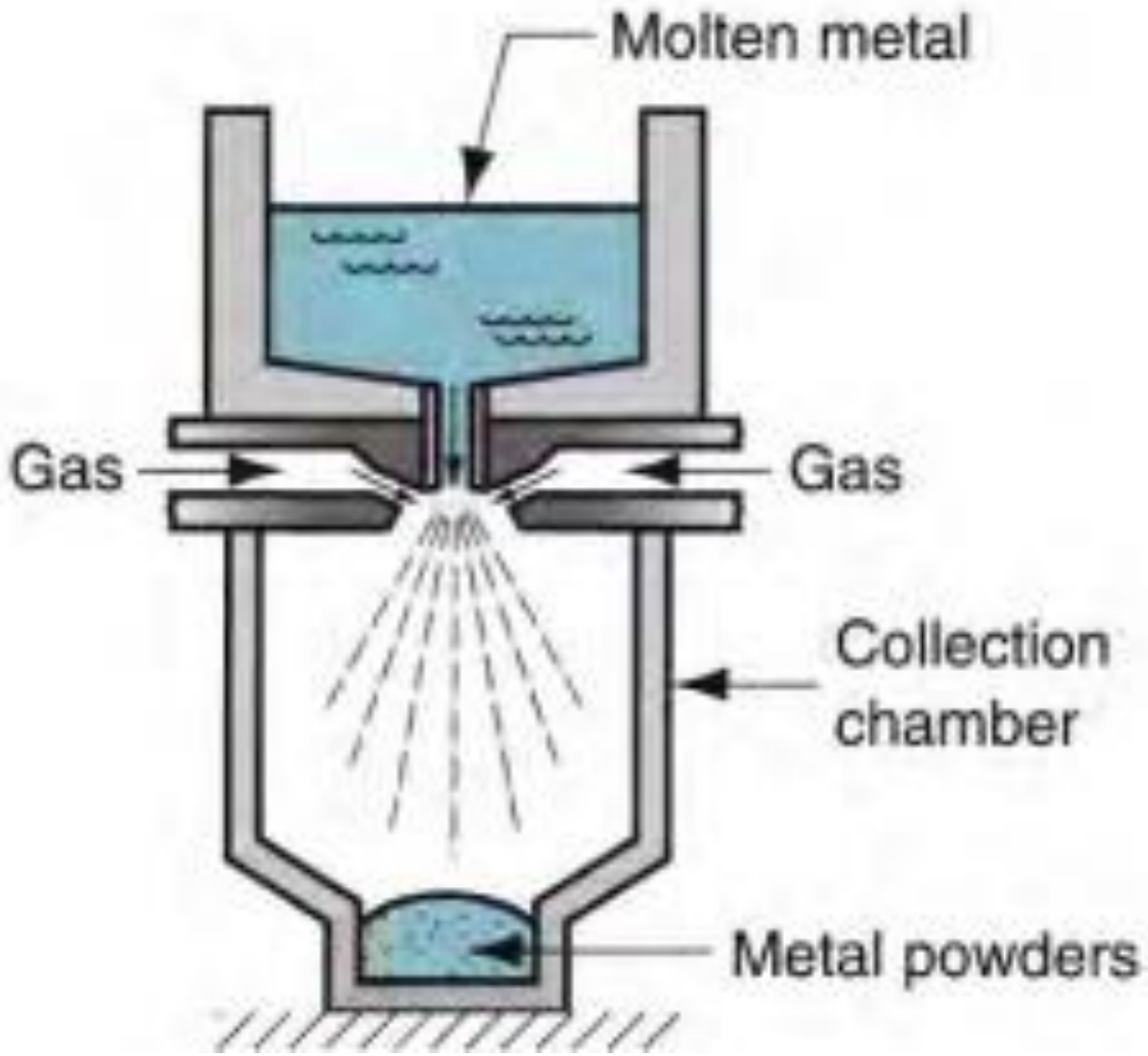
- Air, nitrogen, helium or argon

- The major components of a typical installation include:
  - A melting furnace facility
  - An atomization chamber usually 5 – 6 m high
  - A gas jet compressor net-work.

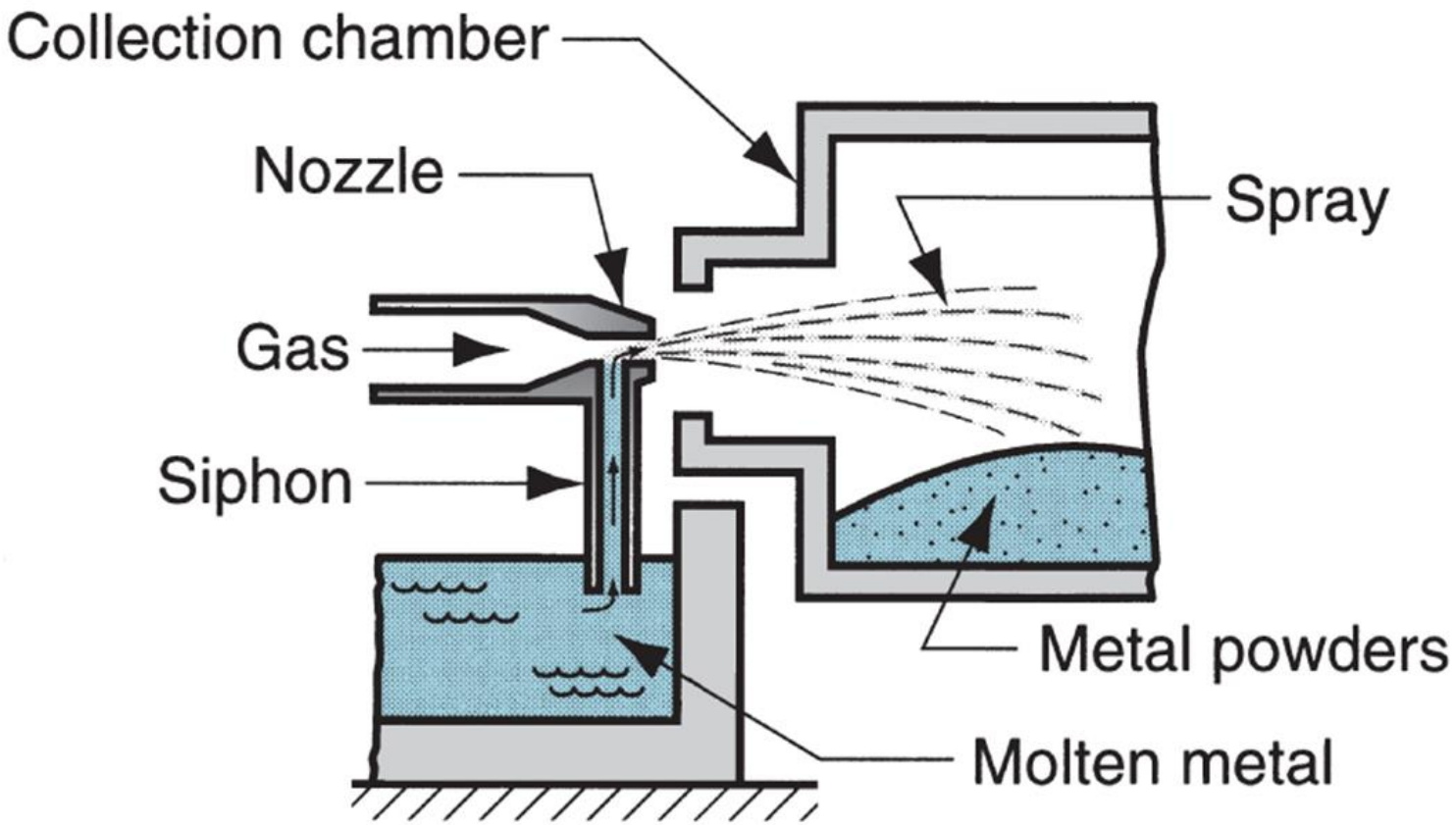
GAS ATOMIZATION



GAS ATOMIZATION



GAS ATOMIZATION



GAS ATOMIZATION

- The powder characteristics and its overall morphology depends on the following variables.
  - Degree of super heat
  - Size of stream
  - Force to disintegrate the stream/ pressure of gas
  - Viscosity of the molten metal
  - Nozzle diameter

GAS ATOMIZATION

Fine particle size is favored by:

i) High pressure of the gas/atomization fluid

ii) Low metal viscosity

iii) Low metal surface tension

iv) Degree of superheat

v) Small nozzle diameter

vi) Short metal stream

vii) Short jet length

GAS ATOMIZATION

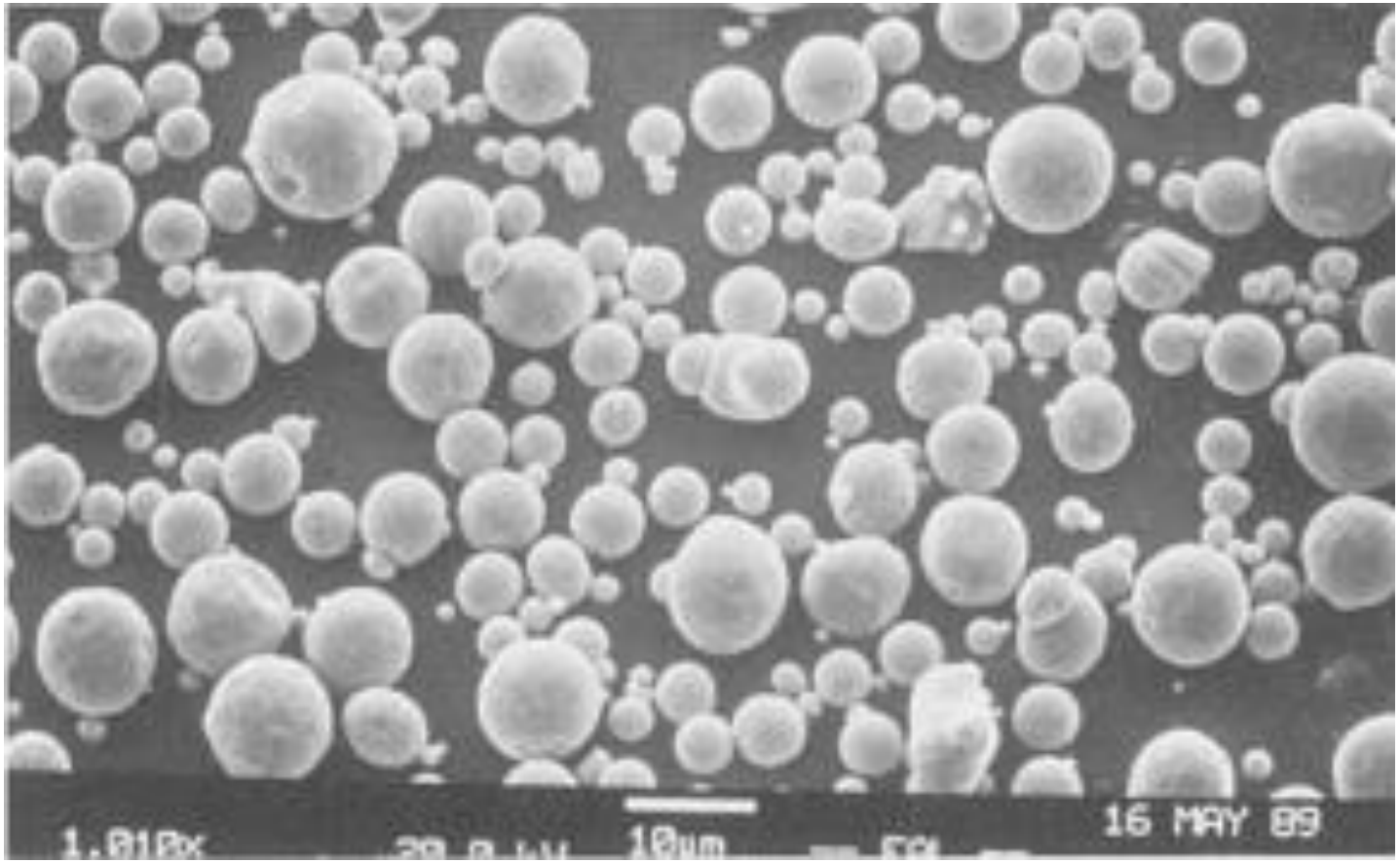
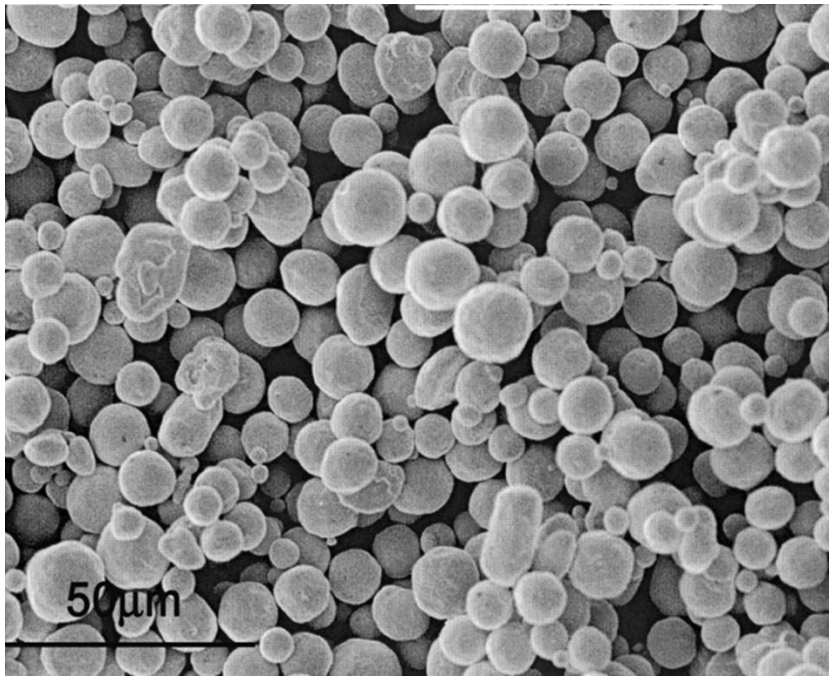
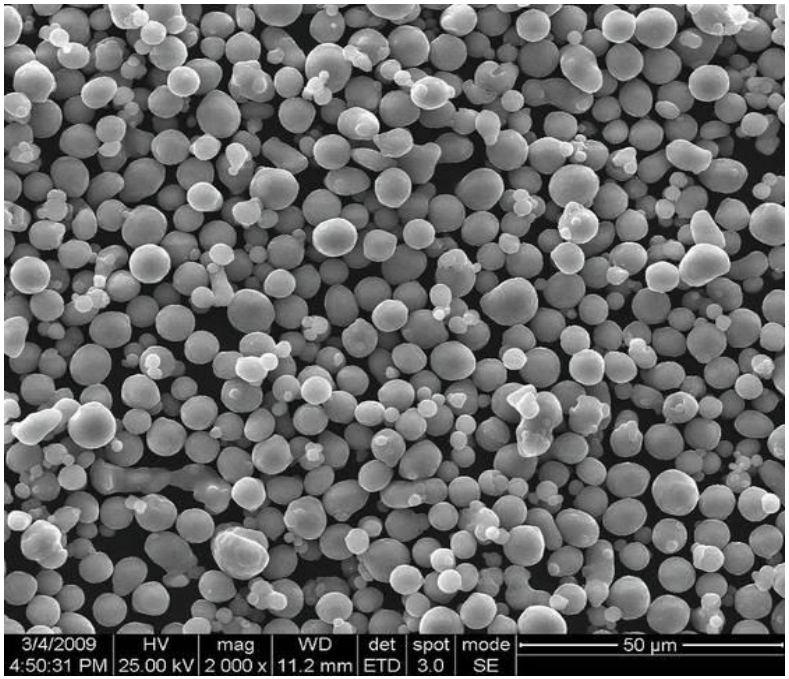
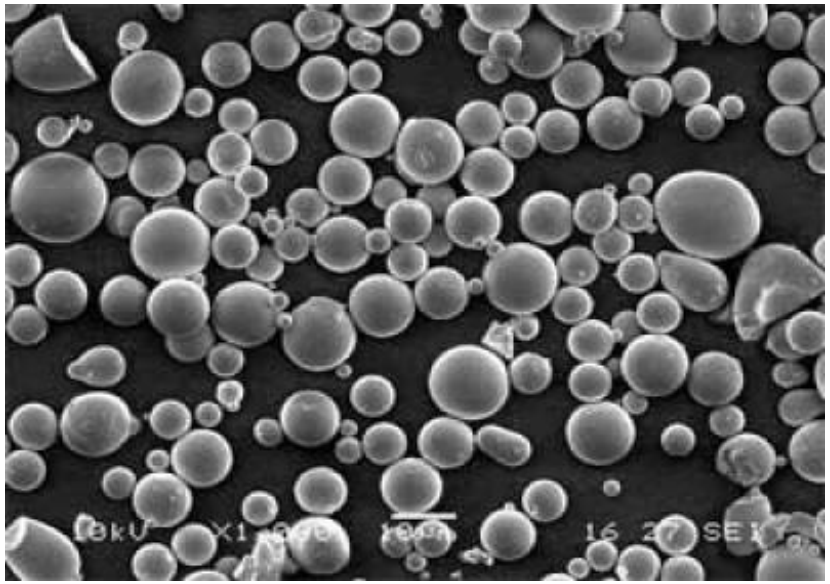


Figure: Scanning electron microscopy of 316L stainless steel gas-atomized powder.

GAS ATOMIZATION







WATER ATOMIZATION

- Melting point below 1500 ^{o}C
- Less reactive metals
- Atomization tank --- slightly smaller in height as compared to Gas Atomization Tank.
- Water is directed by a single jet, multiple jets or annular ring around the bottom nozzle of tundish.
- Rapid quenching
- Pressure of water is important
- Water has low compressibility and higher density than gas, hence the distance of the impact and the metal exit from the nozzle play less role.

- Powder shape ------- irregular
- Surface texture ---- rough with some oxidation.

  (relatively high surface oxygen contents)
- High volume and low cost production
- Microstructural characteristics ---- amorphous to fine crystalline and dendritic.
- The major components of a typical installation include;

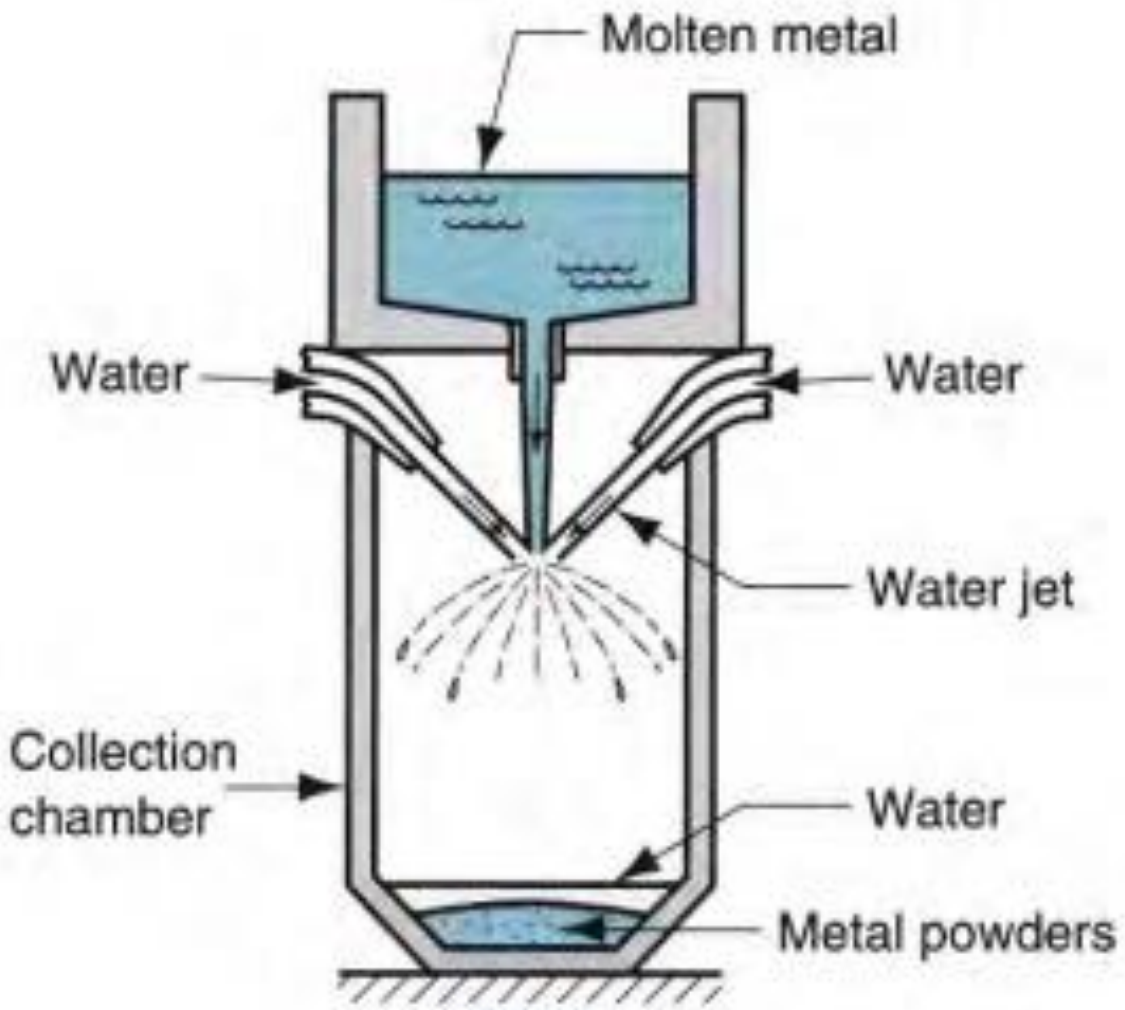
❖ A melting facility

❖ A tundish, a reservoir that supplies a uniform and controlled flow of molten metal to the tundish nozzle

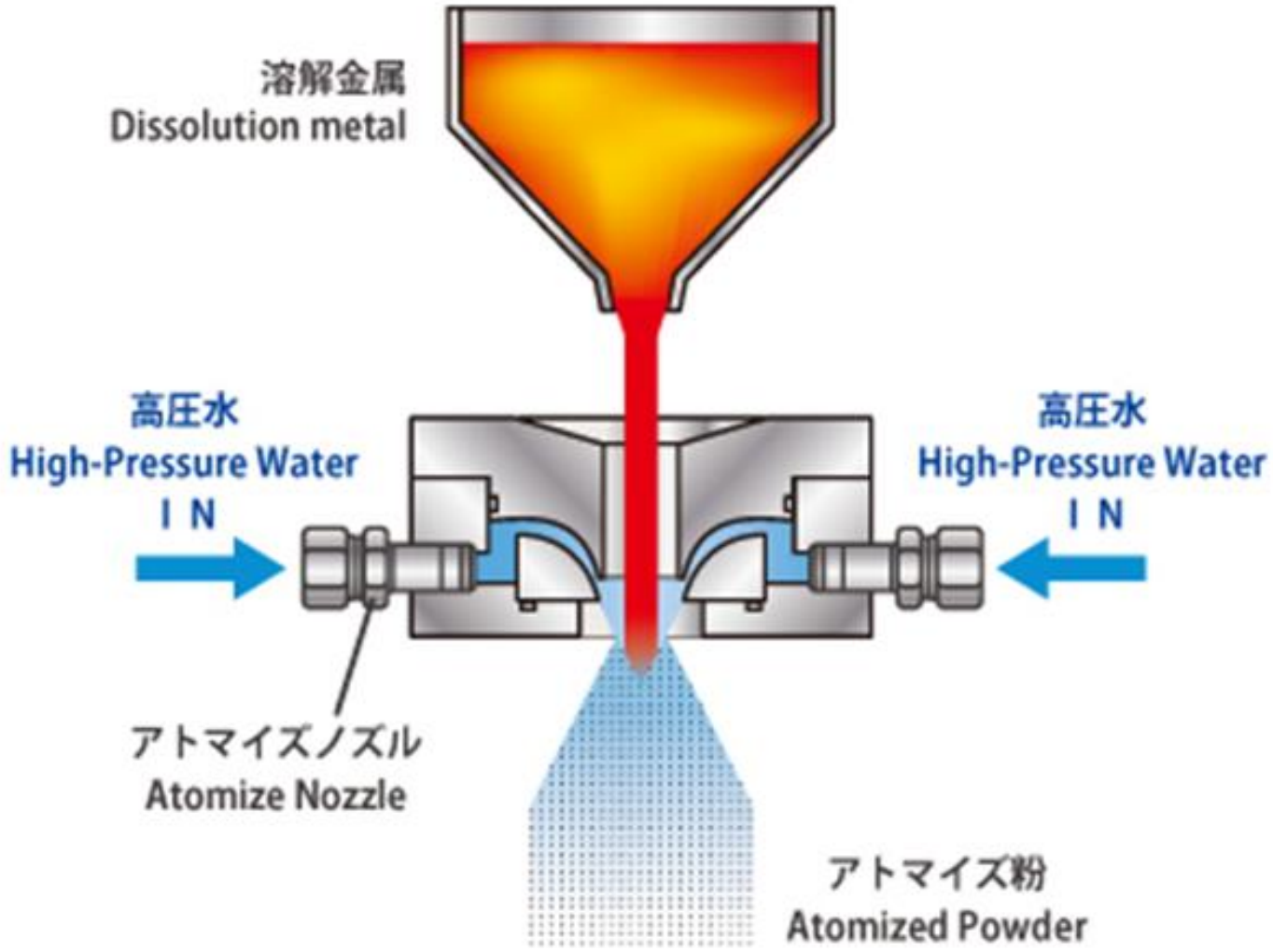
❖ An atomizing chamber

❖ Powder drying equipment

WATER ATOMIZATION



WATER ATOMIZATION



VACUUM ATOMIZATION

- When the molten metal supersaturated with gas under pressure is suddenly exposed to vacuum, the gas expands, comes out of the solution and causes liquid metal to be atomized.
- Vacuum atomizing unit consists of two main sections;

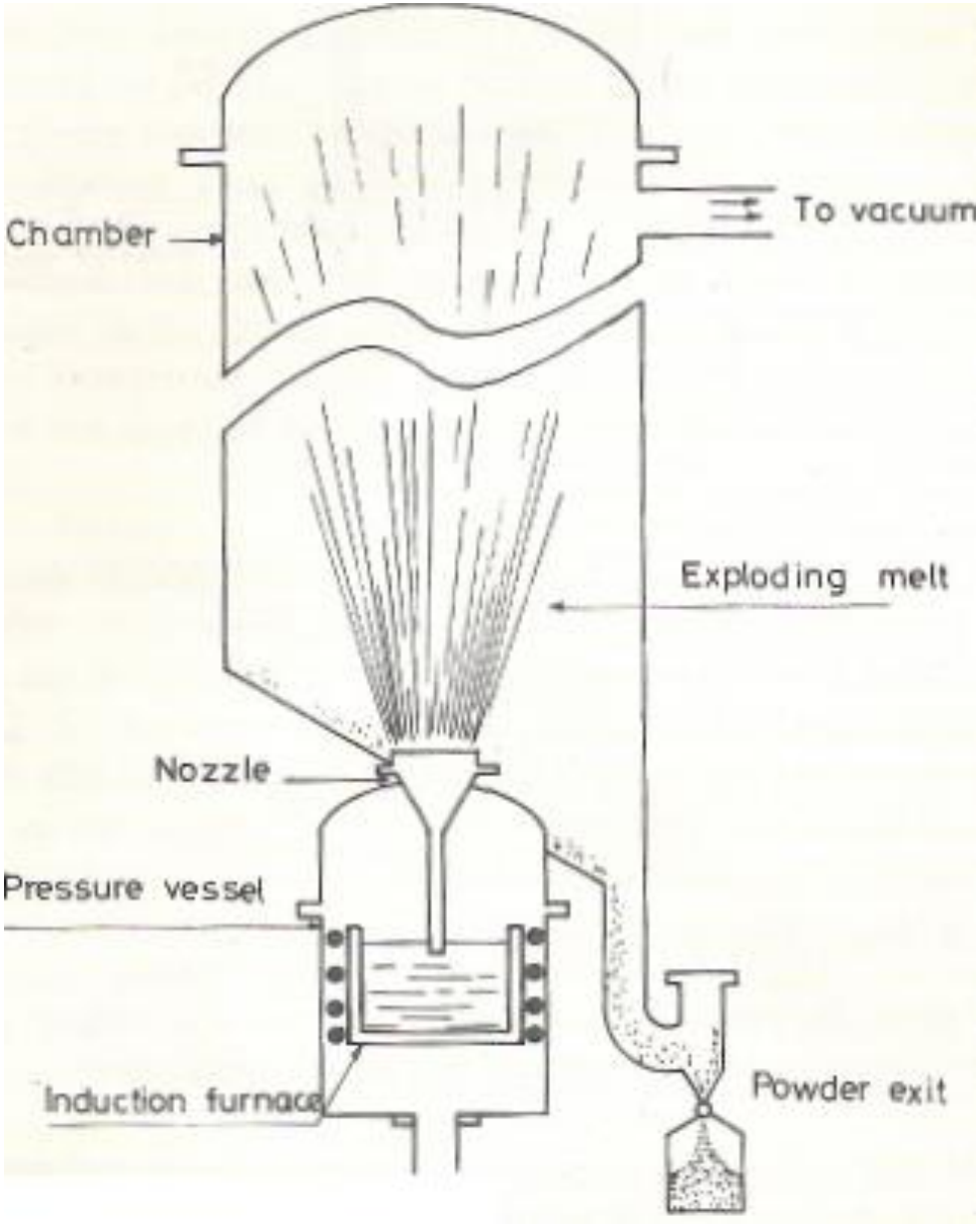
i) Lower chamber is the vacuum induction furnace for melting.

ii) Upper one is atomization chamber with powder collection chamber.

**Both chambers are vertical.

- Metals and alloys are melted

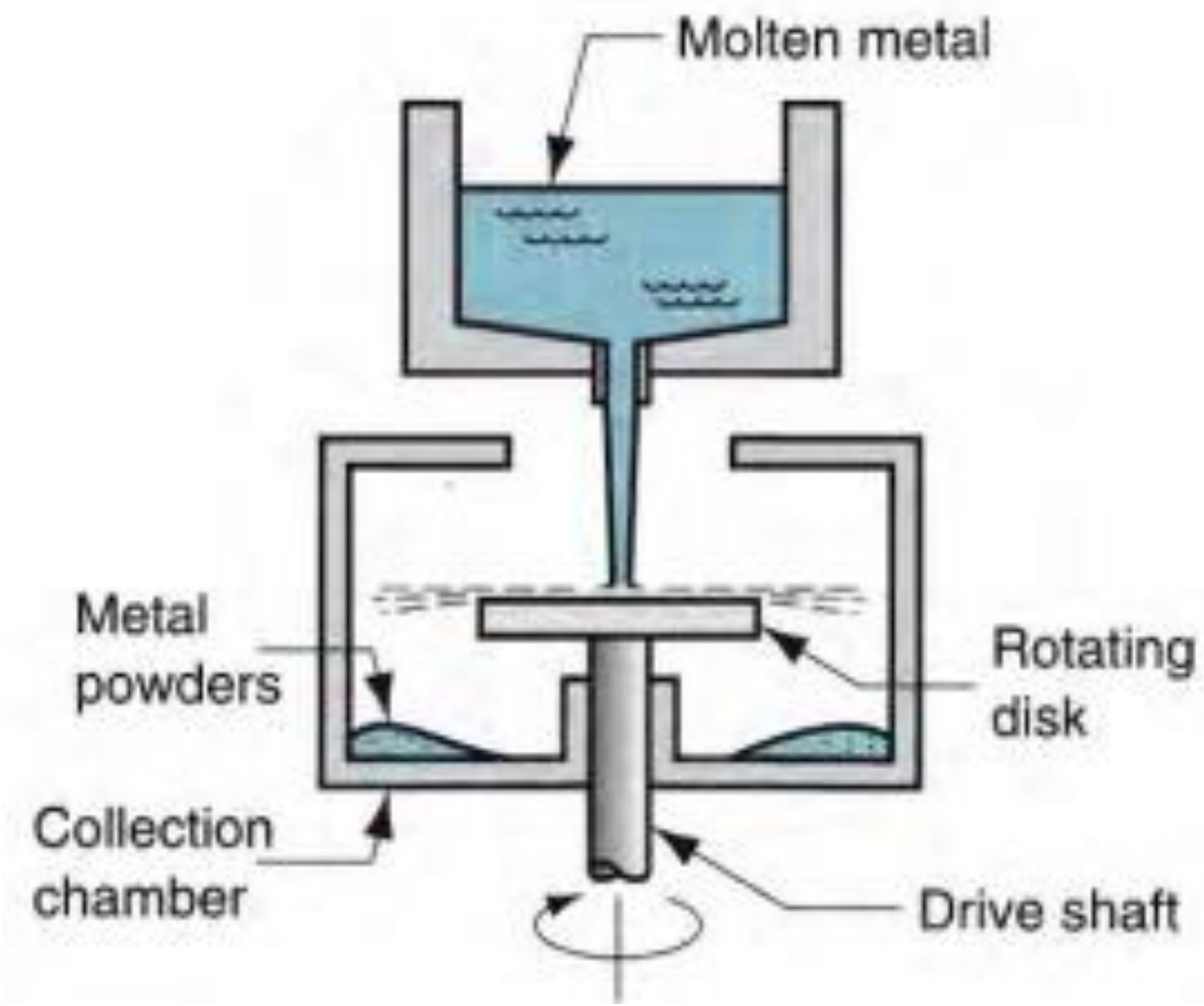
VACUUM ATOMIZATION



VACUUM ATOMIZATION

- Molten metal is saturated with soluble and non-reactive gas.
- The molten metal stream is atomized by introducing gas-saturated stream through a ceramic transfer tube and nozzle in a reduced pressure (vacuum) chamber.
- Also called "melt-explosion technique" because the high pressure stream and gas de-saturation cause the melt to literally explode into the vacuum chamber.
- The collection chamber is designed to maximize the yield, minimize contamination, and ease of cleaning.
- Powder handling ----- under inert gas or vacuum.
- Powder produced is spherical, clean and of a high purity.
- High cooling rate --- microcrystalline structure.

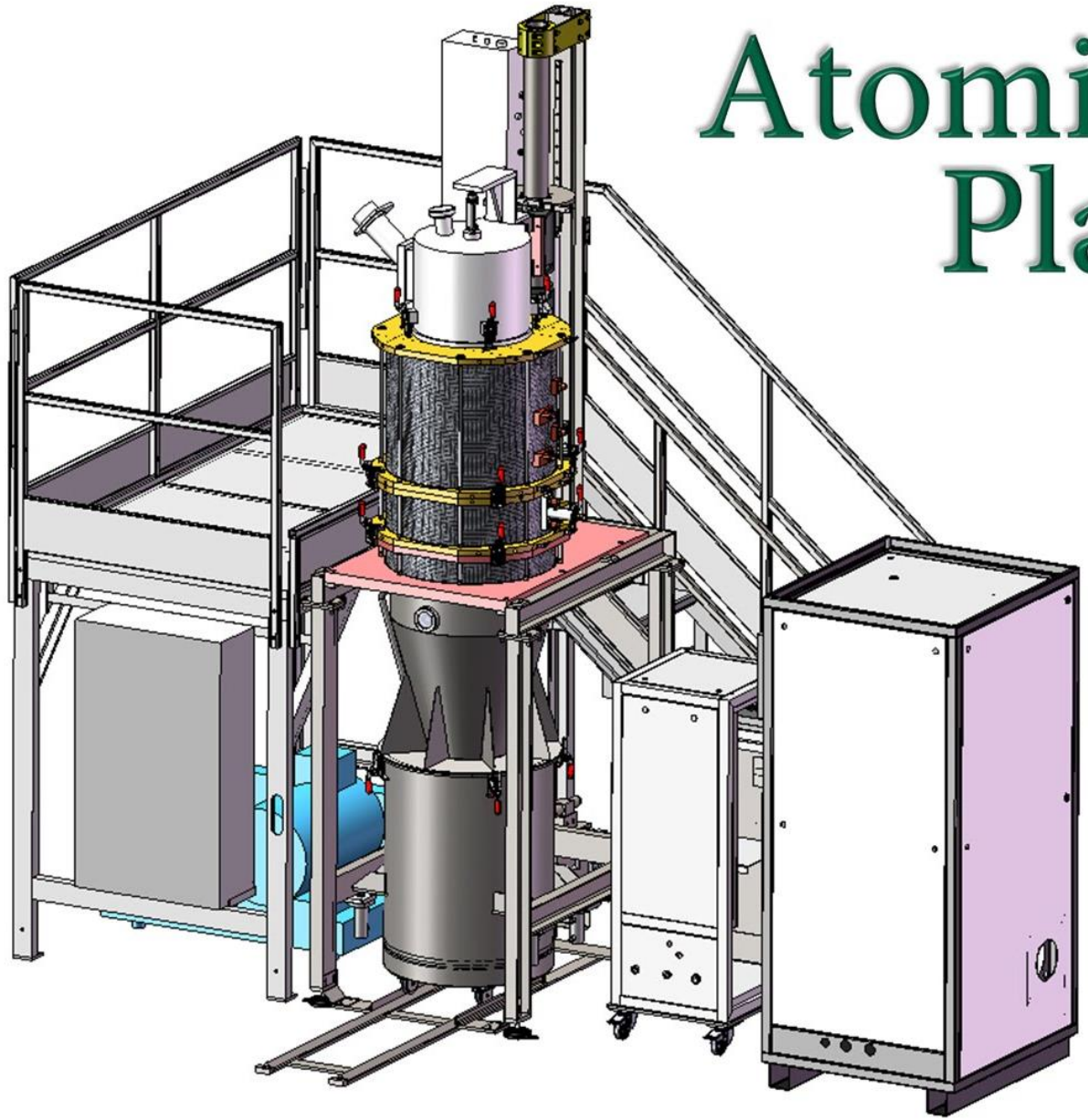
ROTATING DISC ATOMIZATION



ROTATING DISC ATOMIZATION

- Involves the impinging of a stream of molten metal onto the surface of a rapidly spinning disk.
- The liquid metal is mechanically atomized and thrown off the edges of the spinning disks.
- Generally, spherical & coarse powder
- Low melting metals
- In some cases, the disintegration إنحلال of the droplets occurs after exit from the rotating disc slit.
- Control of the opening size, provides some control of the droplet size.
- Coarse powder

Atomization Plant



GAS ATOMIZATION

Mechanism of Atomization

- **Four stages**

1st Stage:

The impingement of high velocity jets of water or gas produce sinuous waves موجات متعرج which cause disturbance in the liquid sheet.

2nd Stage:

Wave fragments شظايا موجة and ligaments الأربطة formation through shearing forces is produced by the disturbance at stage one.

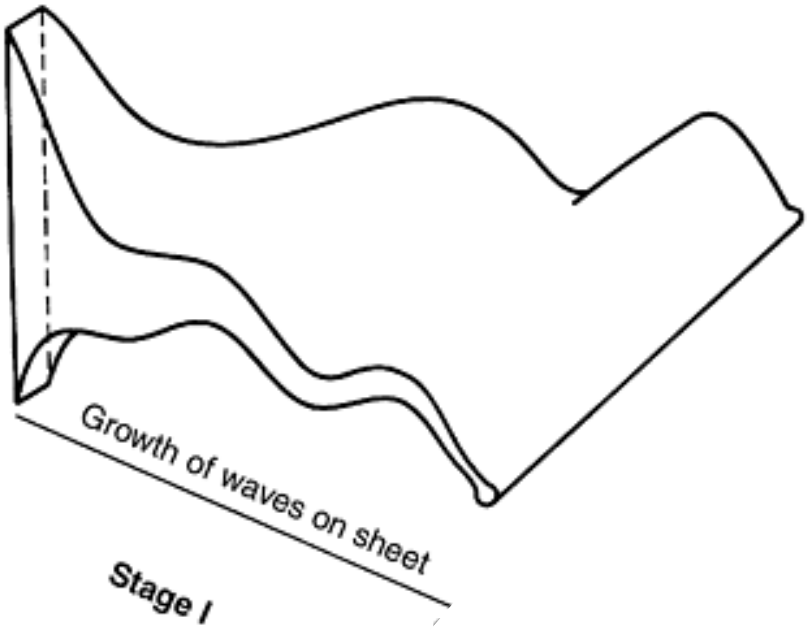
3rd Stage:

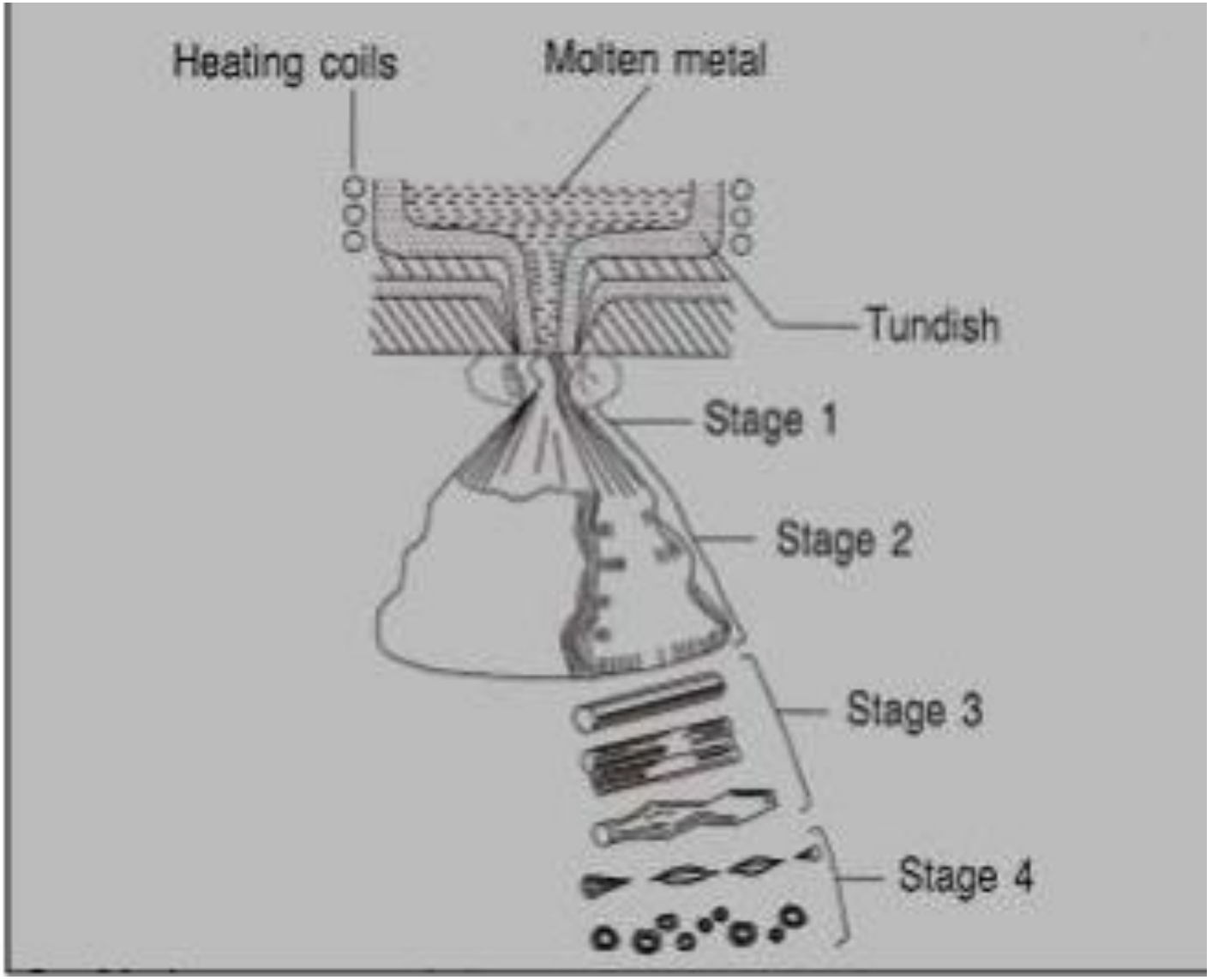
- Breakdown of ligaments into droplets ----- primary atomization.
- Regular particle shape --- high surface tension & low cooling rate.
- Irregular particle shape --- low surface tension & high cooling rate.

4th Stage:

- Further deformation and thinning of droplets and wave fragments into smaller particles occur --- secondary atomization.
- Size reduction is limited by melt viscosity, temperature and acceleration force.

Model for the disintegration of a liquid sheet by a high-velocity gas jet.




Heating coils
Molten metal
Tundish
Stage 1
Stage 2
Stage 3
Stage 4

Thank you