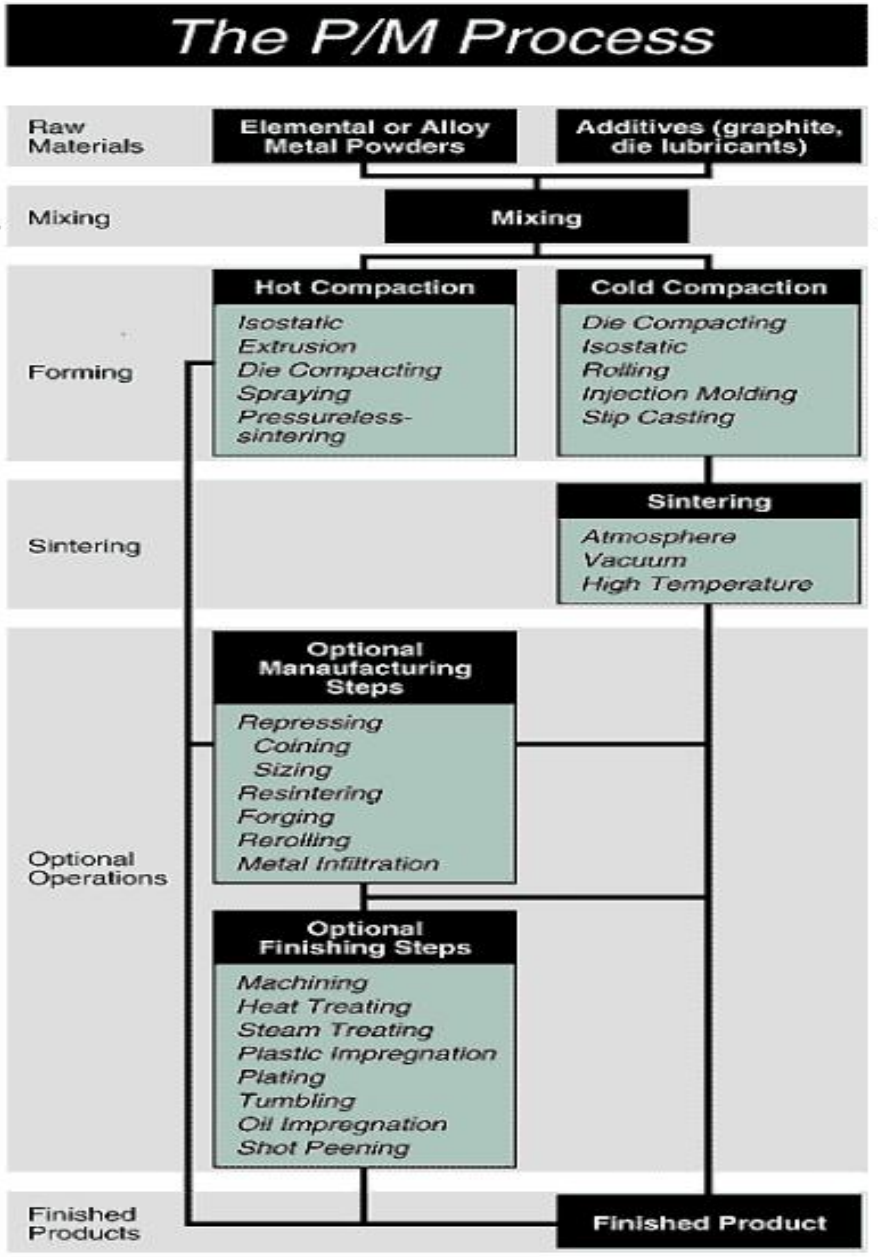
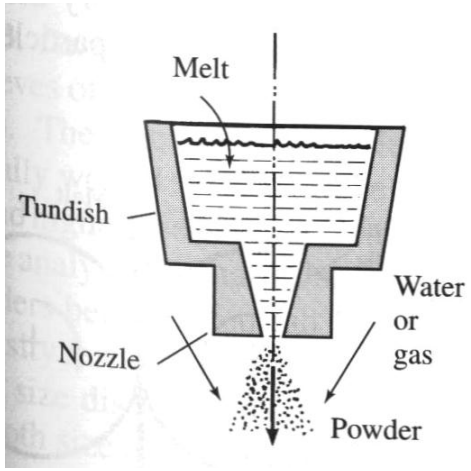
Basic P/M Steps

- Powder Production
- Raw Material
- Mixing
- Forming
- Sintering
- Optional Operation
- Finished products

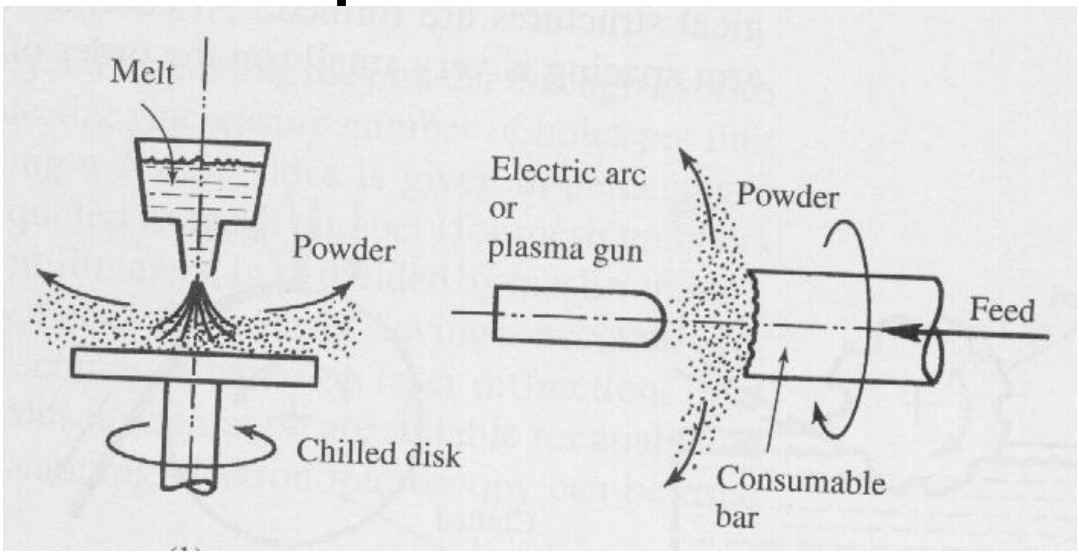


Powder Production

- **Many methods: extraction from compounds, deposition, atomization, fiber production, mechanical powder production, etc.**
- **Atomization is the dominant process**



(a)



(b) (c)

(a) Water or gas atomization; (b) Centrifugal atomization; (c) Rotating electrode

Methods of Powder Production

- **Atomization**
  - Produces a liquid-metal stream by injecting molten metal through small orifice.
  - The stream is broken up by jets of **inert gas**, **air**, or **water**.
- **Reduction**
  - Uses gases (**hydrogen and CO**) to remove oxygen from metal oxides.
- **Electrolytic deposition**
  - Utilizes aqueous solutions or fused salts.
  - Produces **purest form of metal powder**.

- **Carbonyls**
  - Are formed by letting **iron or nickel** react with **CO.**
  - The reaction products are then decomposed to iron and nickel.
- **Comminution**
  - Mechanical comminution involves crushing, milling in a ball mill.
- **Mechanical alloying (MA)**
  - Powders of two or more pure metals are mixed in a ball mill.
  - This process forms **alloy powders**

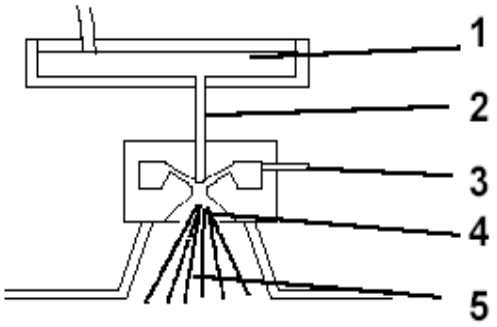
Powder Production: Water-Atomizing-Process

- **Principle**
  Atomizing the Melting by Means of Water Jet
- **Metal**
  Scrap, Iron Ore, Roll Scale
- **Factors of Influence**

↑	Water Pressure	Melting Temperature	Flowrate of the Melting
Grain Size	↓	↓	↑

- **Product**
  Pure Iron or Alloy

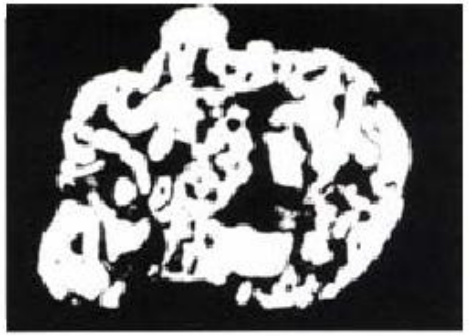
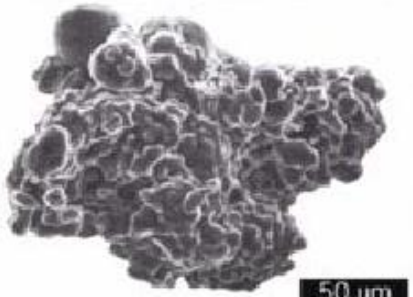
- **Principle of Water-Atomizing**



1 Foundry Ladle
2 Melting Stream
3 High Pressure Water
4 Nozzle
5 Atomized Iron Powder

source: Höganäs, EHW Thale

Particle Form and – Structure of Unalloyed Iron Powder

	Scanning Electron Microscope-Picture	Cross Section
Sponge Iron Powder NC 100.24		
Atomized Powder ASC 100.29		

source: Höganäs

Powder Production

1- Atomization

Types of atomization process

1- Water Atomization
2- Gas Atomization
3- other types

-**Atomization principles**

-**Atomization production sequence**

- Metal melting
- Over heating…….
- Melt Composition
- Melt treatment
- Sample analysis……..
- Pouring
- Dewatering
- Draying……..
- Annealing….
- Screening
- Packing (pre-alloy, premix)

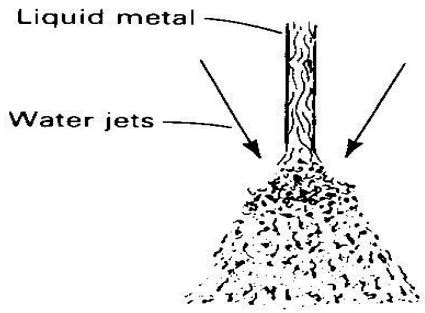
- Parameters that have to be adjusted on water atomization process……

- Melt temperature…
- Melt pouring rate….
- Water pressure….
- Water temperature
- Water angle
- Water orifice size…. (angle, size, shape)

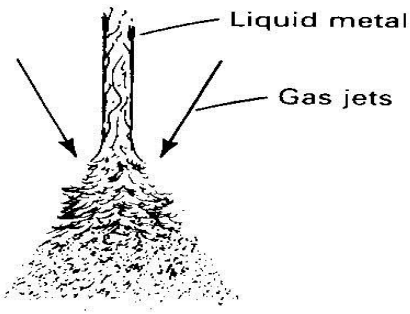
1502-1512-2505…….

- Affecting of atomization parameters on produced metal powders……..

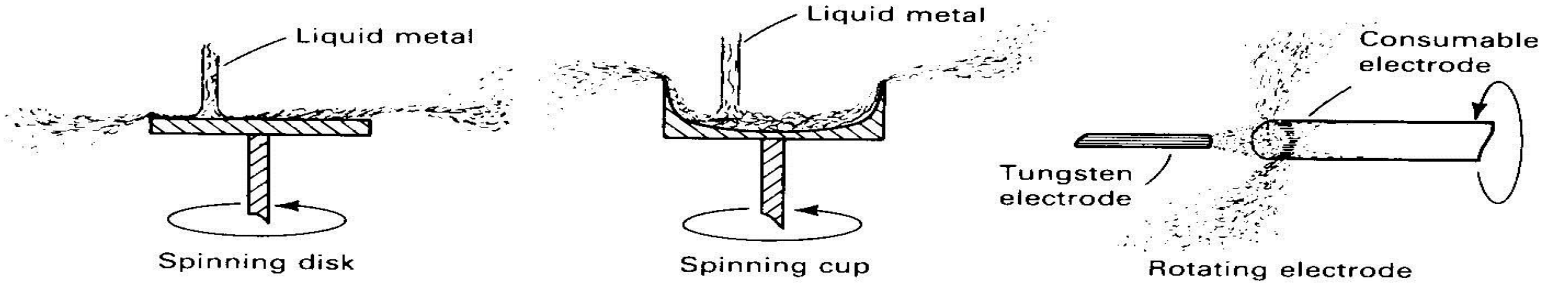
Atomization Process



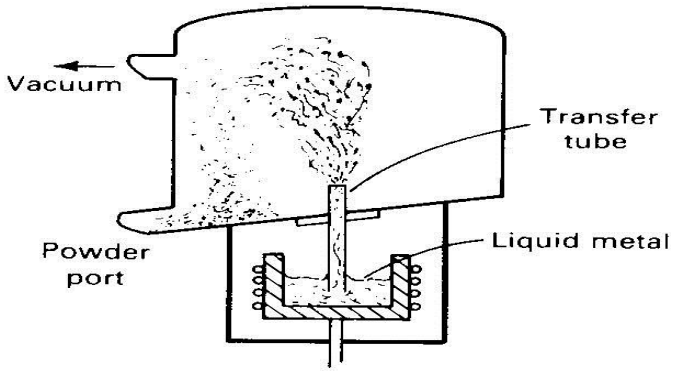
(a) Water atomization



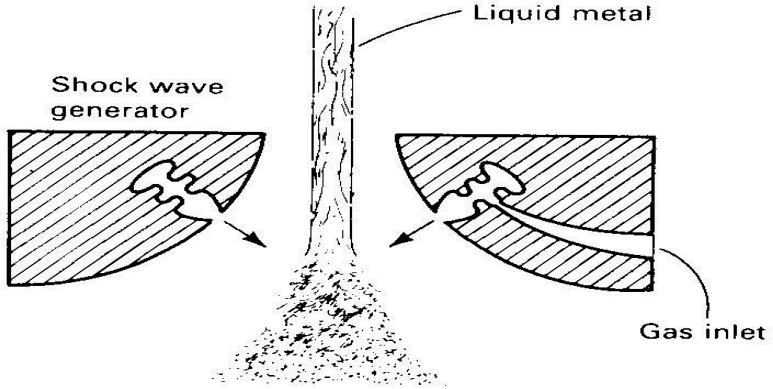
(b) Gas atomization



(c) Centrifugal atomization

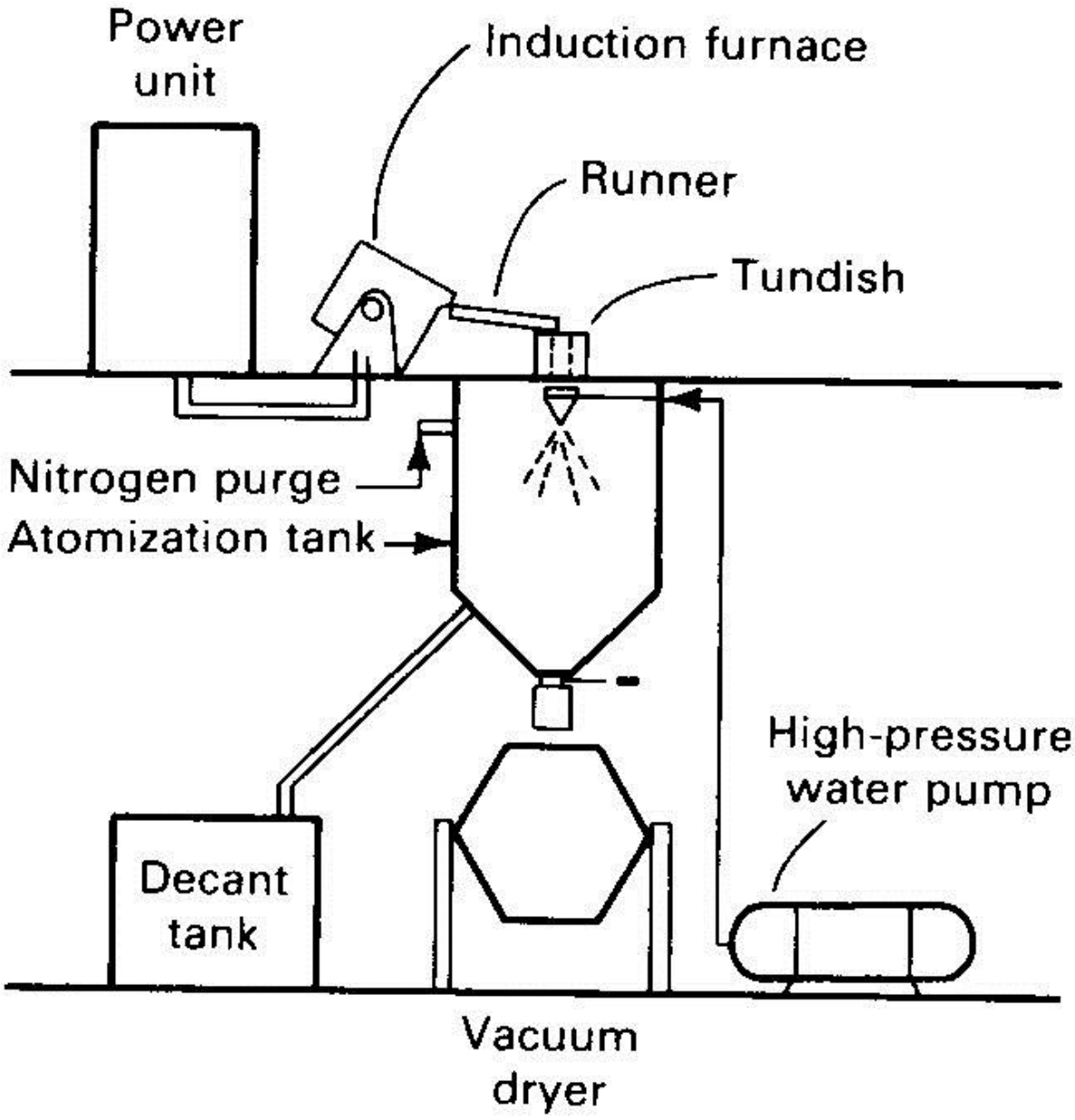


(d) Vacuum (soluble gas) atomization



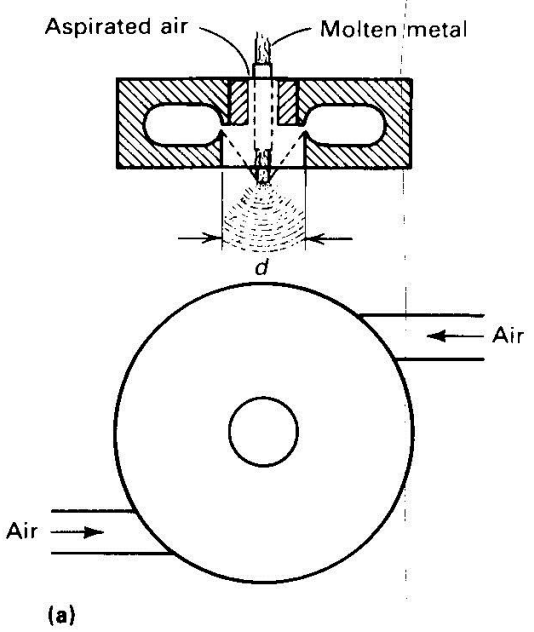
(e) Ultrasonic gas atomization

Water Atomization Setup

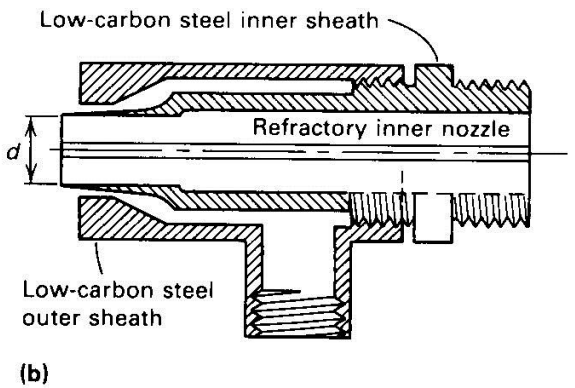


Atomization Nozzle Designs

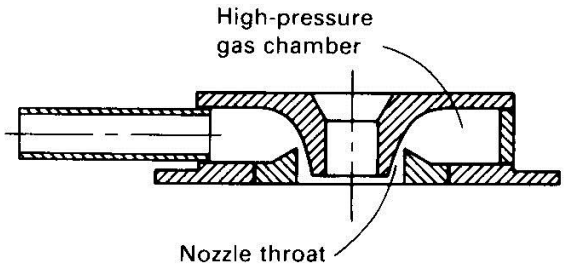
Gas atomization: (a) Mannesmann process design (Ref 2). (b) Thompson design (Ref 3). (c) Naeser design (Ref 4). (d) Probst design (Ref 5). Water atomization: (e) Batten design (Ref 6). (f) Winstrom design (Ref 7)



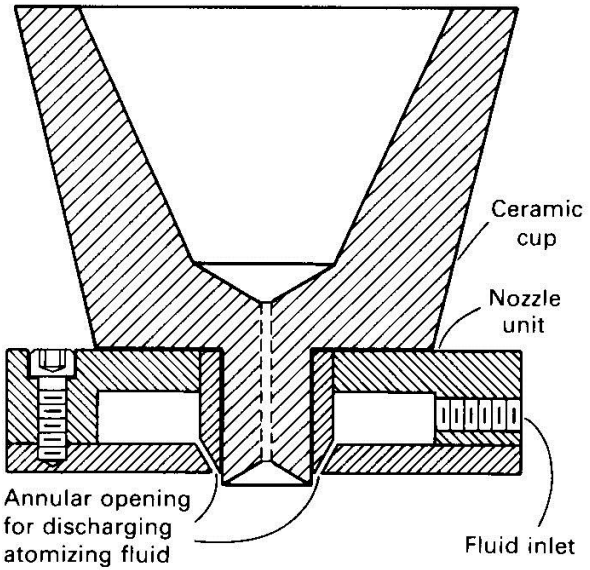
(a)



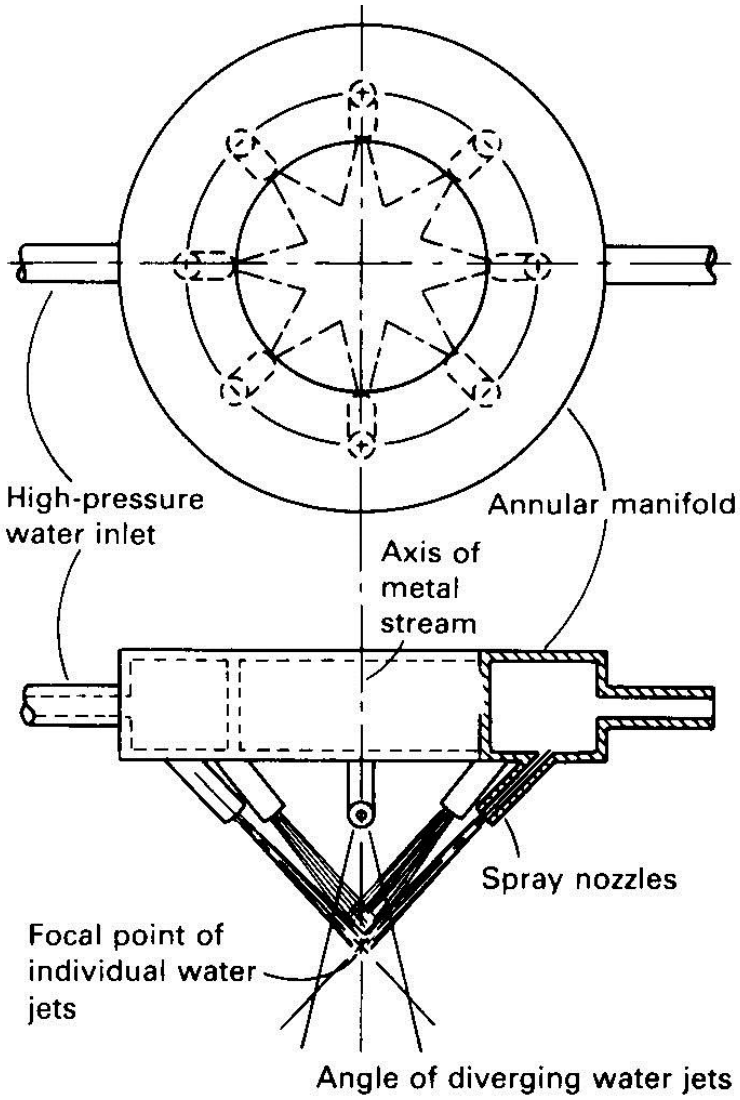
(b)



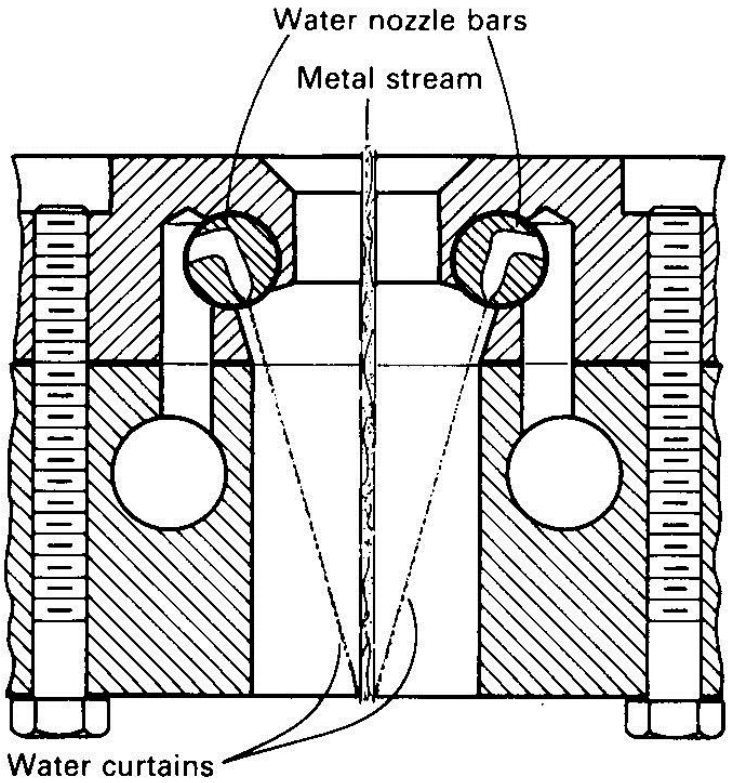
(c)



(d)


High-pressure water inlet
Annular manifold
Axis of metal stream
Spray nozzles
Focal point of individual water jets
Angle of diverging water jets

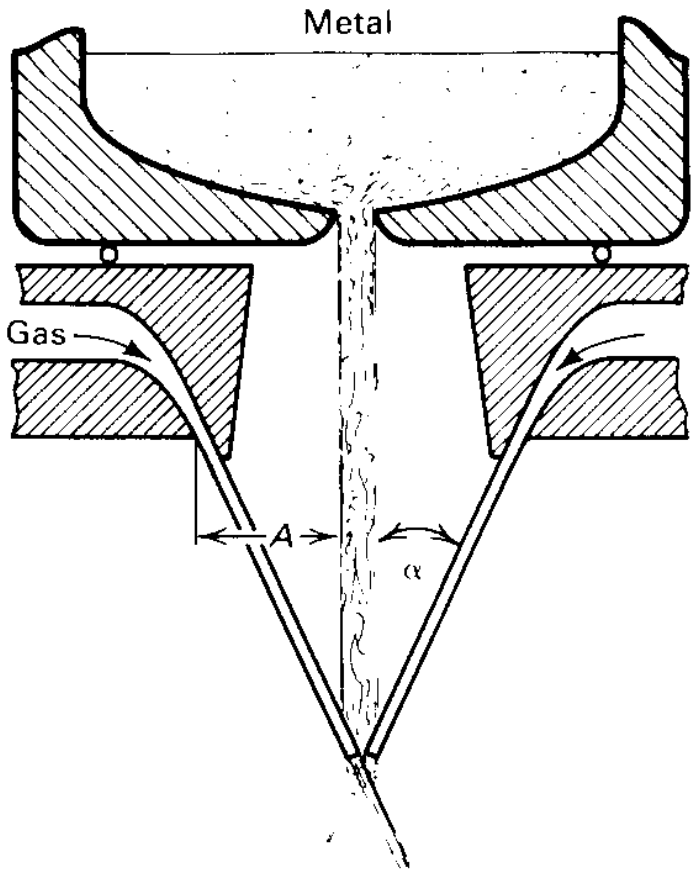
(e)


Water nozzle bars
Metal stream
Water curtains

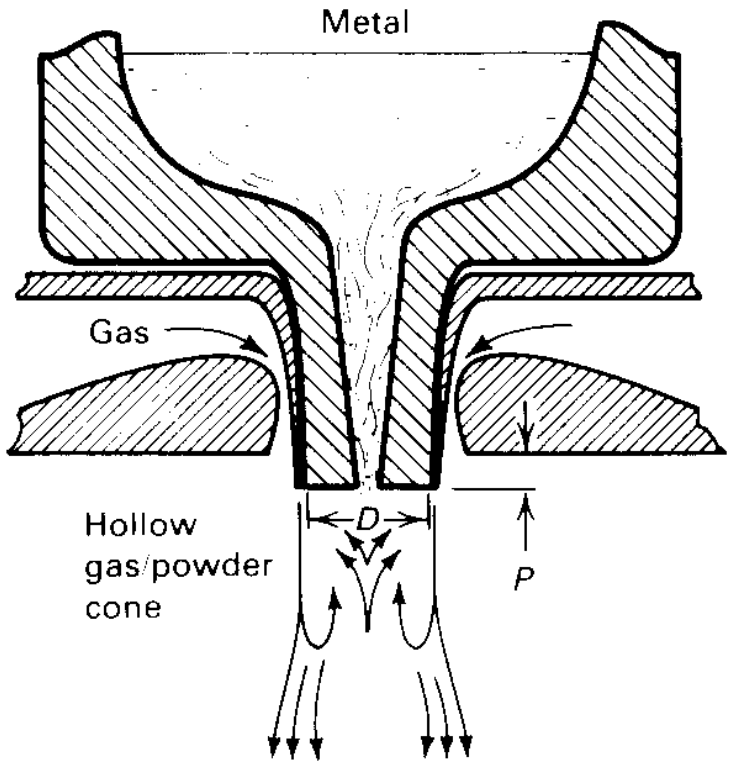
(f)

Two Fluid Atomization Designs

Design characteristics: α, angle formed by free-falling molten metal and impinging gas; *A*, distance between molten metal and gas nozzle; *D*, diameter of confined molten metal nozzle; *P*, protrusion length of metal nozzle. Source: Ref 8



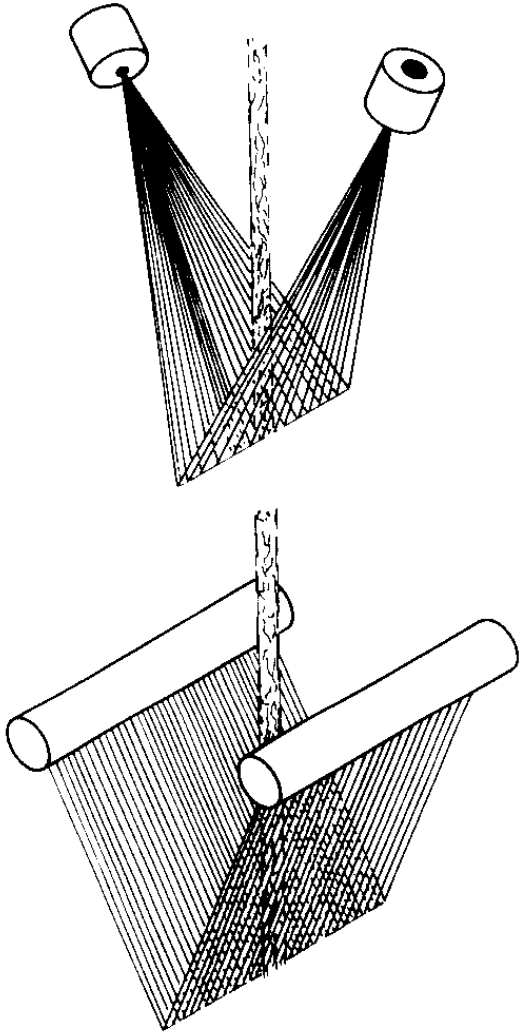
Free fall



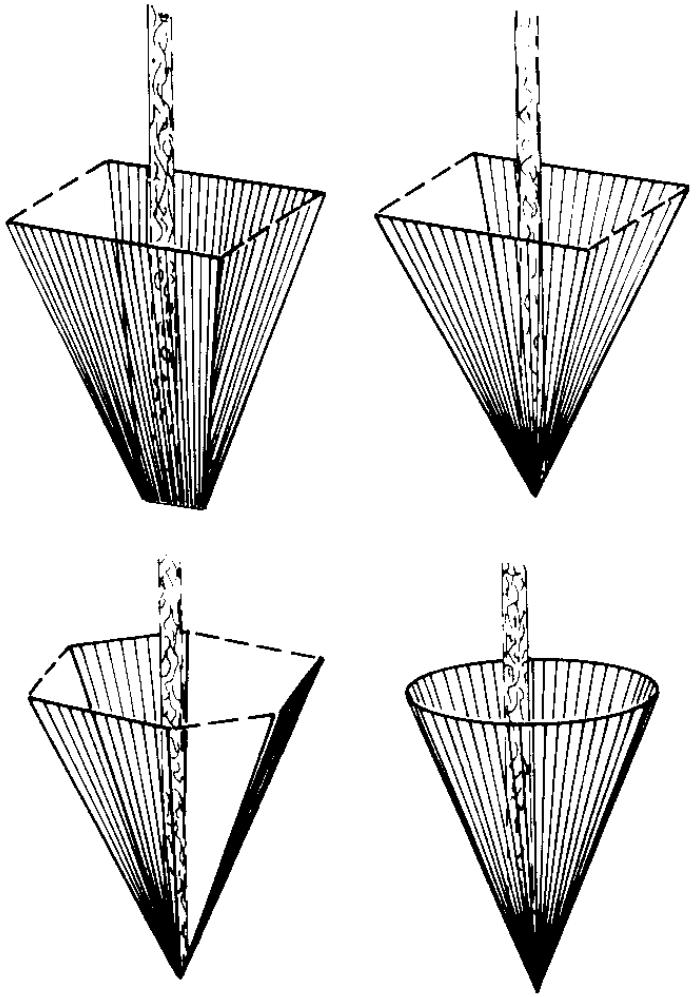
Confined

Water Jet Configurations

(a) Open flat stream V-jets. (b) Closed V-jets. Source: Ref 9

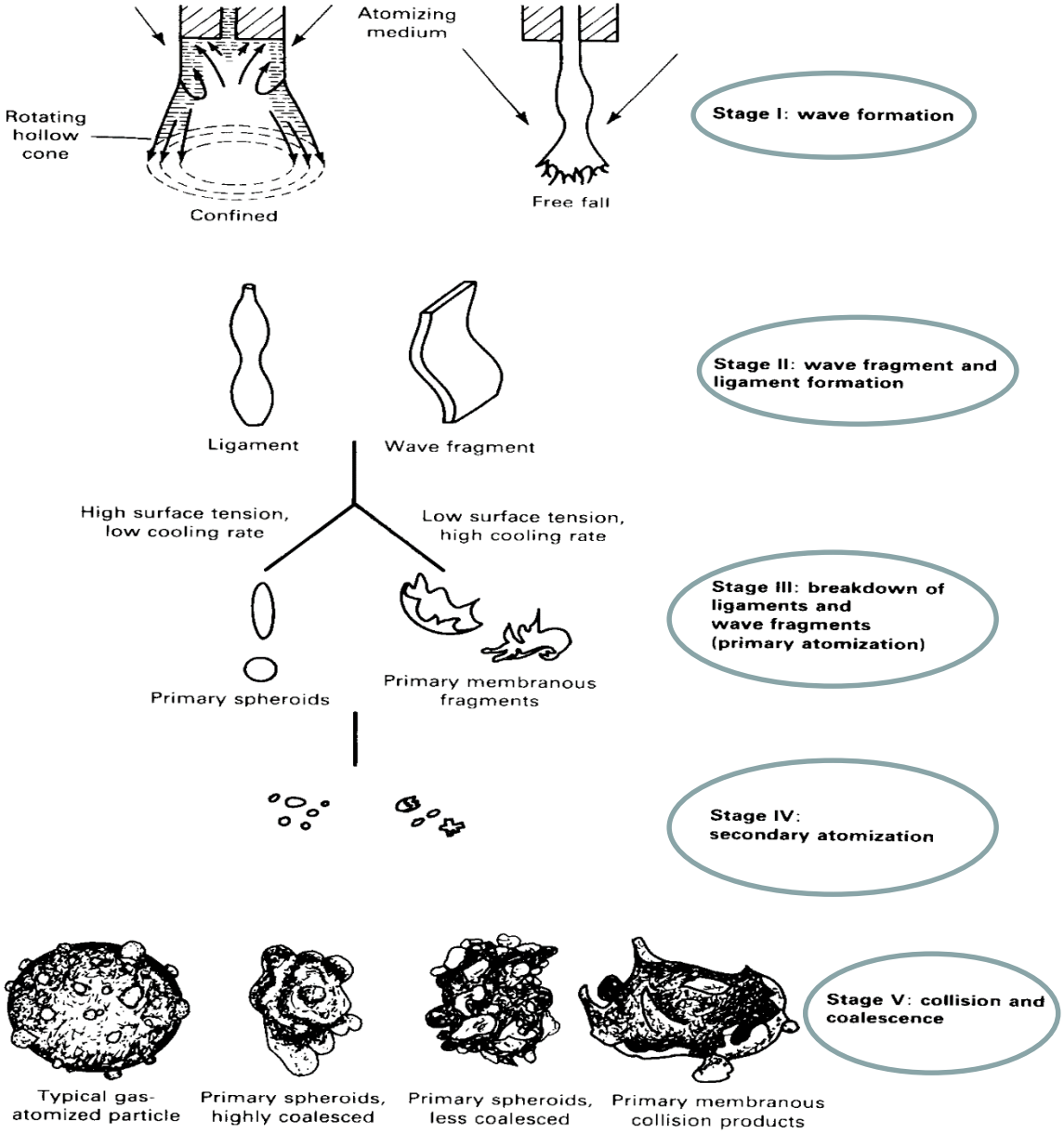


(a)



(b)

Particles Formation Stages During Atomization



Particles Formation Stages During Atomization

- Stage I: Wave formation through initiation of small disturbance at the surface of the liquid.

- Stage II: Wave fragment and ligament formation through shearing forces on the disturbance of stage I.

- Stage III: Breakdown of ligaments into droplets (primarily atomization); regular particle shape formed by high surface tension and low cooling rate; irregular particle shape formed by low surface tension and high cooling rate.

- Stage IV: Further deformation and thinning of droplets and wave fragments into smaller particles (secondary atomization).

- Stage V: Collision and coalescence of particles.

Atomization process

1

2

3

4

5

6