Chapter 1. Introduction

1.1 What is powder?

Powders : Finely-divided solid matter

Size : from nanometers(10^{-9}m) to centimeters(10^{-2}m)

syn) Particulate matter, particles

분체(粉體), 분말(粉末), 입자(粒子)

Examples of Powder: 여러 산업에서 매우 중요

	업 종	관련되는 원료, 제품(중간제품포함)
자원	농업	토양, 종자, 사료, 곡물
	광업	원광, 분탄
가 공 산업	식품	소맥분 등, 화학조미료, 분유, 가루 차, 설탕, 소금, 인스턴트 커피
	섬유	색소제, 염료, 안료
	종이, 펄프	목재칩, 펄프, 톱밥, 도장재, 충전제, sizing제
	고무, 고분자	충전제, 안료, 고분자 pellet, 고분자가루
	안료, 충전제	안료, 카본블랙, colloidal silica, 인쇄잉크
	화학공업	농약, 비료, 촉매, 각종 화학약품
	요업	점토, 흑연, 금속산화물, 규사, 석회석, 알루미나, glass beads, 시멘트, 연삭재
	철강	분광, 궤광, 분진, 광석 pellet
	비철금속	분진, 알루미나, 소광분(燒鉱紛), 금속분
집 적 산업	금속, 기계	금속분, 분진, 연마재, 연삭재
	전기기기	형광재료, 텅스텐, 몰리브덴분, 실리카, 알루미나
	전자재료	산화티탄, 산화철, 알루미나 등, 티탄산바륨, 페라이트, 전도성재료
	의약, 화장품	전분, 활성알루미나, 젖당, 주약(主藥), 안료, 정제, 과립, 치약
	잡화	고분자 pellet, 약품
환 경 · 재해	환경기술	슬러지, fly ash, 규석가루, 분진, 매연, fume, 생활먼지
	자연재해	꽃가루, 황사, 눈, 화산재

화학공업의 예만 보더라도

DuPont 1985, 1992 found among 3000 products

62% : Powders, crystalline solids, granules, flakes, dispersions, slurries and pastes

18% : powder = key intermediate products

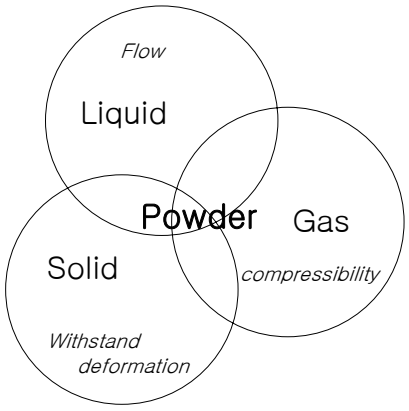
Characteristics of Powders

They differ from molecules, atoms and solids in:

- They are *finely divided, isolated* solids
- They have *probabilistic, statistical* properties
- Their *surface properties* are important in their behavior.

They differ from solids, liquids, and gases in:

- As with solids, bulk powders can *withstand deformation*.
- As with liquids, they can *flow*.
- As with gases, they exhibit *compressibility*.



1.2 What Is Powder Technology?

Science and technology related to the handling and processing of particles and powders

- Characterization(size analysis)
- Processing(fluidized beds, granulation, mixing)
- Particle formation(growth, size reduction)

- Fluid-particle separation(filtration, settling, gas cyclones)
- Safety(dust explosions)
- Transport(pneumatic transport and standpipes)

+ health hazards

+ simulation of particle systems

1.3 History of Powder Technology

수천년 전통의 분체기술

- Egypt:
  - Silts deposited: agriculture, raw materials for brick and ceramic handicrafts
  - Winnowing and crushing of grains, followed by kneading of flour
  - Physical liberation of precious metals and gems by crushing
  - Colloidal rheology : mixing of black soot with water, vegetable gum for ink, production of bricks from mud, sand and straw
- Leading industries for many generations :
  - Production of pottery
  - Milling of flour for bread
  - Mining, mineral processing, metallurgy
  - Soils in civil engineering

산업혁명과 분체공학

- Powder industries in early U.S.(18C - 19C)
  - Potash, indigo dye, salt, saltpeter, gunpowder, lamp black and white lead

화학공학의 태동과 분체공학

- Important role in birth of chemical engineering(early 20C)

・Strong ties between chemical engineering and powder handing industries

・Important part of unit operations

☞ Early Texts in Unit Operations

Walker(1923), Badger and McCabe(1931) :

devoted 40 % to particle processing

무시당한 분체공학

- Following World War II, petrochemical industries: main stream of chemical engineering

☞ gas-liquid, and liquid-liquid systems

・U.S.: neglect on powder technology

☞ lag behind Japan, Germany and U.K.

・Treated as "low-tech"

: Mathematical interpretation : not completely available

☞ Scale-up depends on empiricism

: Messy to handle and store

분체기술의 미래

분체공업의 변화추이

	Powder in mass production (since '60s)	Particles as a Source of Air Pollution(since '70s)	Particles as Advanced Materials(since '80s)
Processes interested	Comminution(Breakown) Size enlargement Transportation Storage Collection(Recovery)	Collection(Removal) Formation Transport	Growth(Buildup) Dispersion Sintering Characterization Applications
Powders interested	Cement/Fertilizer/Sugar/ Mining products/ Pharmaceuticals/ Pigments	Particles related with Public health, Meteorology and Aerosol research Indoor air quality Clean room technology	New materials with new-born properties
Size interested	≥10 μm	Down to submicron sizes	Nano-sized particles

- Powder technology as "New"-Tech vital to:
    - Advanced materials: Nanoparticles
        : information, communication, aircraft, space science, biology, military use
    - Environmental application
        : particulate pollution control, climate control, nuclear control

그러나 분체산업의 현황은!

- Two-year study by the Rand Corporation(1986)
    - Recently built plants perform no better than those built in the 1960's.
    - Operate at only 50% of design capacity(1/5 : less than 20%)
      cf. average: 90-95% of design capacity
    - Start-up time : 6 times as long as liquid/gas processing plants (though 3.5 times expected)

Solutions

- Needs on *basic research* on solids behavior
    - Background theory
    - Equipment performance
- Needs the development of *scale-up strategy*
- Needs information *feedback from plant engineers* to designers and R & D departments.