

IME 100 -.POWDER PROCESSES

BASIC CLASS NOTES

OCTOBER 21, 2015

Reading Review and Class Preparation

This should be filled out prior to class.

Key Concepts to Be Discussed in Class:

Questions About Subject Matter for Class Session:

Outline

- Defintion of Powder Processing
 - Role of Surface Energy
- Powder Processed Materials
 - Products Made From Powder Processes
- Powder Processing Steps
- Advantages and Disadvantages of Powder Processing

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Powder Processing

- A Technique Whereby Powder Particles are Joined to Form a Continuous Solid Part Without Melting
 - Solid State Process
 - A Single Part is Formed From Powder

<u>Casting</u>	<u>Powder Processing</u>
Liquid is Poured into a Defined Shape and Solidified	Powder is Poured into a Defined Shape and the Powder Particles are Joined

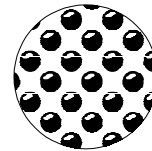
Powder Processed Materials

- Avoid Melting
 - High Melting Temperature Materials
 - Strong Oxide Formers
- Intricate Parts
 - Reduce Need for Machining
 - More Sophisticated Parts than Casting
- Ceramic - Metal Mixtures

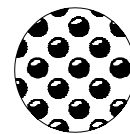
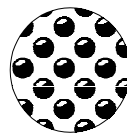
Material	Tm (C)
Aluminum	660
Copper	1083
Iron	1536
Tungsten	3410
Tantalum	3000
Molybdenum	2610
Nickel	1453
Alumina	2050
Silica	1400
SiC	2200
Si ₃ N ₄	1900

Surface Energy

- Atoms on Surface of Particle
 - Have Higher Energy
 - Are More Reactive
 - Are UnderBonded
- Surface Energy (γ)
 - Energy Per Unit Area
 - Not Energy of the Surface



Higher Total Energy



Lower Total Energy

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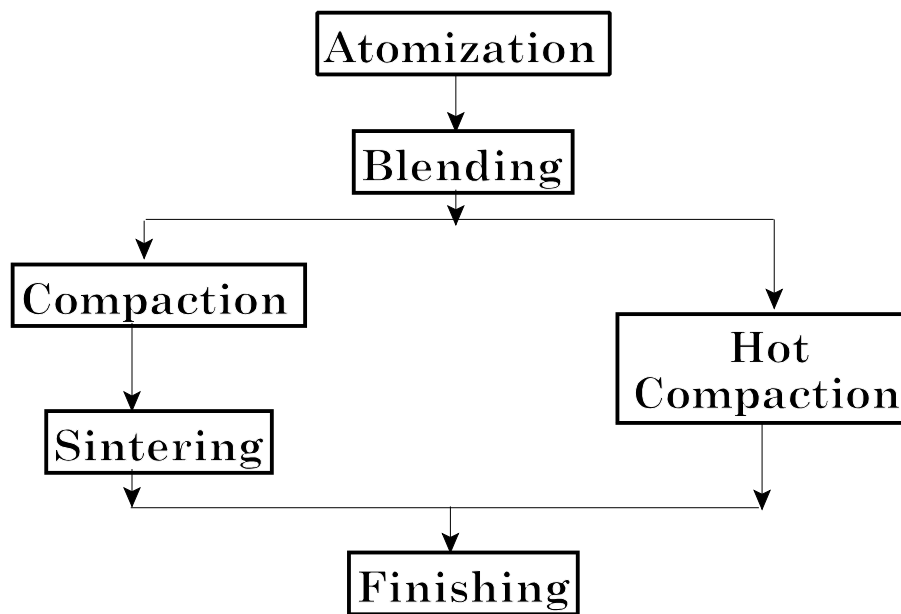
Concept Question

- What Has to Be Done to Make a Part Using Powder Processing?
 - Start With Chunk of Material

- Finish With Part

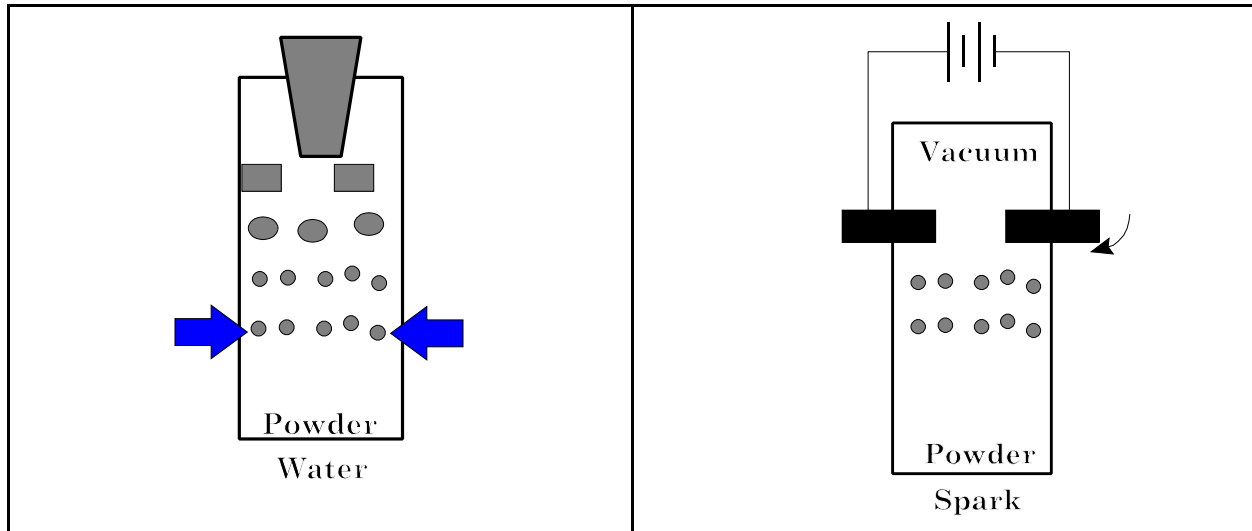
- Think of All Steps (Conceptually)

General Process



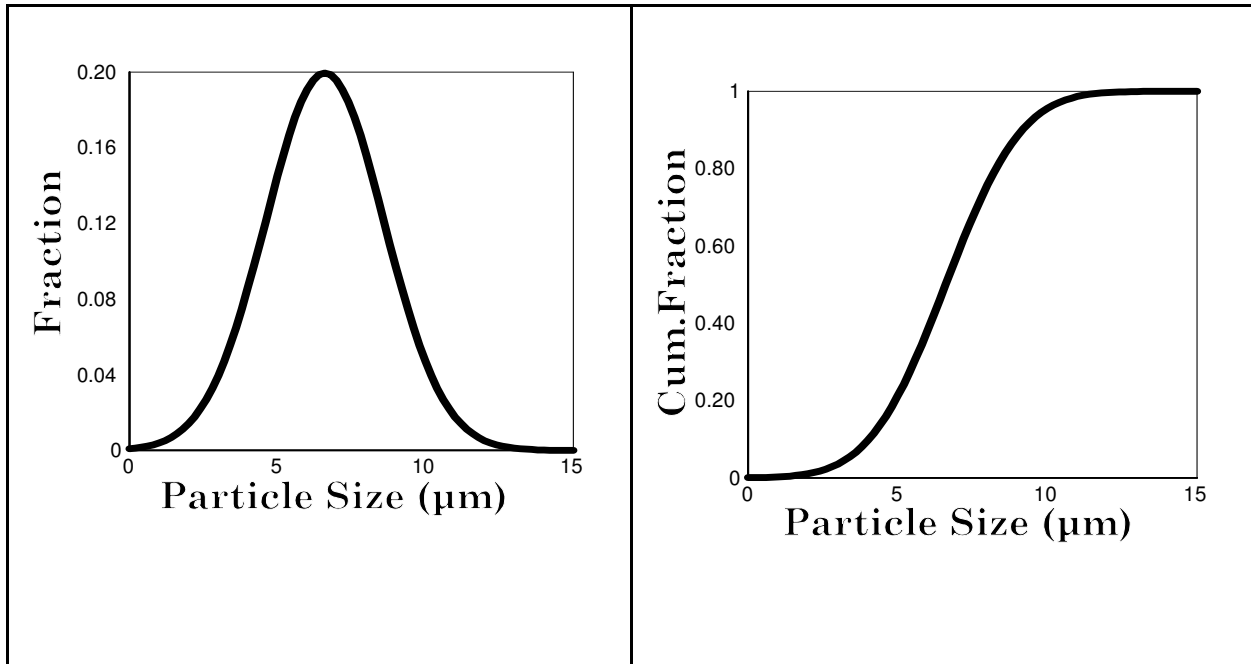
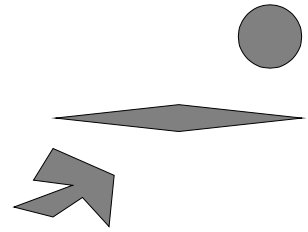
Making Powder

- Atomization
 - Water or Gas



Powder

- Powder Can Have Many Forms
 - Ideally Spherical
 - Needle Like
 - Flake Like
- Powder Size Distribution



Blending

- The Powder Must Be Mixed
 - Different Particle Sizes
 - Different Materials

- Add Lubricant / Flux
 - Removes Air
 - Can Prevent Oxide Formation on Metals

- Add Binder
 - Need to Be Able to Shape Part

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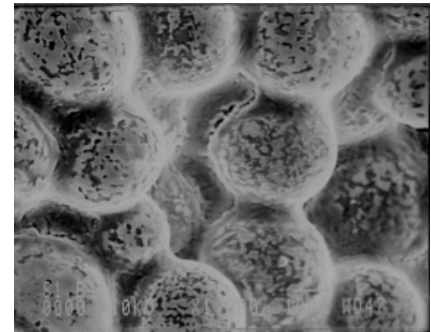
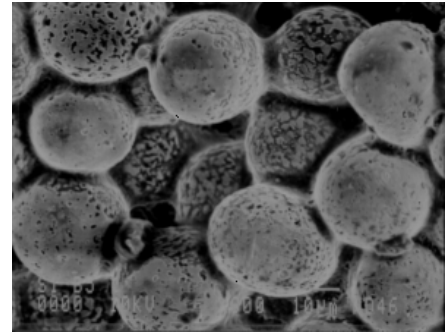
Compaction - Green State

- The Powder Needs to Be Put in Die
 - Initial Shape Formation
- Compaction Method Depends on Complexity of Part
 - Rolling
 - Extrusion
 - Injection Molding
 - Isostatic Pressing

Material	Pressure (MPa)
Aluminum	70-275
Iron	350-800
Tungsten	70-140
Tantalum	70-140
Alumina	110-140

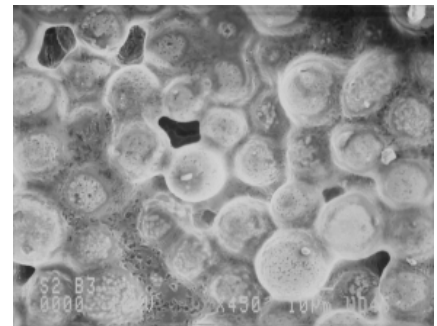
Sintering

- Green Compact is Heated
 - 70-85% of Melting Point
 - Sometimes Under Pressure
- Particles Actually Join
 - Necking
 - Pore Elimination
 - Grain Growth



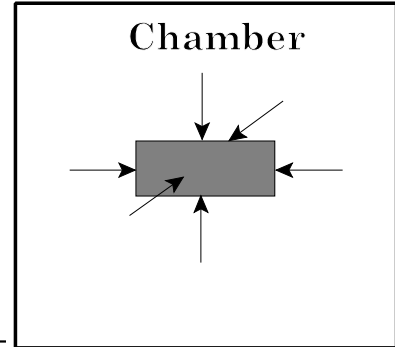
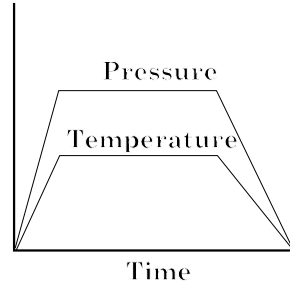
Sintering Continued

- The Pores Between Particles Are Eliminated
- Can Be Enhanced With Liquid
 - Can Remain in Alloy
 - Can React



Hot Isostatic Pressing

- Combines Two Steps
 - Compaction
 - Sintering



Sintering Temperatures

- Lower Than Melting Point

Material	T (C)	Tm (C)
Aluminum		660
Copper	760-900	1083
Iron	1000-1150	1536
Tungsten	2350	3410
Tantalum	2400	3000
Molybdenum	2050	2610
Nickel	1000-1150	1453

In-Class Exercise

- Compare Sintering to Casting

<p style="text-align: center;"><u>Similarities</u></p>	<p style="text-align: center;"><u>Differences</u></p>
<p style="text-align: center;"><u>Advantages</u></p>	<p style="text-align: center;"><u>Disadvantages</u></p>

Summary

- Means to Fabricate Parts Without Melting
 - Requires Several Steps
 - Intricate Parts

Parts Made Through Powder Processing

- Turbine Blades
- Jet Engines
- Gears
- Valve Inserts
- Medical Implants
- Electronic Components
 - Diodes, Heat Sinks
- Tool Dies