High Velocity Adiabatic Impact Technology

FOR

Titanium Powder Compaction

The Advanced Manufacturing Technology

Powder Metallurgy Panel
Titanium 2007
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Adiabatic Application Processes

1. Precision Cut-Off
2. Zero Clearance Blanking
3. Net Shape Forming
4. Powder Compaction
5. Special Applications
Understanding High Velocity Adiabatic Impact Technology

- How did the research evolve?
- What conditions need to be met?
- How does it relate to a press system and tooling?
How was the phenomenon first recognized?

During World War II, scientists observed that piercing armor plates at high velocities produced clean round holes with little distortion or heat transfer to the surrounding material. This became known as “adiabatic softening phenomenon”.
Research Conducted

- In the 1950’s powder compaction research was conducted to confirm through explosive forming that the “adiabatic softening phenomenon” was evident and produced successful results for net shape forming and powder compaction of metals.

- Experiments involving explosives were not practical given that the impact unit was dangerous, not consistent, uncontrollable and tooling didn’t withstand the high velocity impact.
What Conditions Need to be Met for HVAI?

- Minimum Critical Impact Speed Required
  Velocities @ > 10 meters per second
- Tooling must withstand repeated shock loading
- Minimal heat transfer to the surroundings (tooling)
Adiabatic Powder Compaction Capabilities and Benefits

Proven titanium compaction up to 99% density without Sintering

Near to Net Shape Powder Forming.

Expected Reduced Sintering time and Temperature – Saves Energy

Form parts from many types of metal powders.

Minimal tooling wear -- provides extreme die life.

Very energy efficient, low air and electric use.

Quick die change capability.

Reduced fully burdened costs.

Development continuing to fully commercialize
Impacting Velocities

Impact Speed Comparison of Forging Processes

Meet Adiabatic Speed Requirements

- Power Drop Hammer (4.5 - 9.1 m/s)
- Pneumatic Impact Press (3.5 - 7.5 m/s)
- Gravity Drop Hammer (3.65 - 5.5 m/s)
- Hydraulic Impact Press (2.5 - 4.5 m/s)
- Conventional (0.3 - 1.52 m/s)
- Friction Screw (0.3 - 1.21 m/s)
- Hydraulic Press (0.27 - 0.46 m/s)
Density achieved from one single impact by High Velocity Adiabatic Impact Powder Compaction Press compared to conventional presses.

An increase from 95% to 99% in density represents significant improvements in mechanical properties as shown below:

- **Tensile strength**: 11%
- **Fatigue strength**: 25%
- **Elongation**: 50%
Pure Titanium Power – Armstrong Process

Grain structure – HVAI Compacted Without Sintering

Enlarged 2000 times.  
Enlarged 5000 times.

Adiabatic Process does not change composition of Raw Powder
Results the same with both 6-4 alloy or pure titanium
No lubricants in process
No impurities - Oxygen content unchanged by process - No Micro pollutions
Pure Titanium Power – Armstrong Process

Grain structure – HVAI Compacted Without Sintering

Enlarged 5000 times.

Pure Titanium Powder Supplied from Another Production Lot
Density Continues High @ approximately 99%+
Image Shows Almost No Porosity
MATERIALS

- Will form virtually any Powder in its cold state.
  Conventional methods restricted to narrow material range. The adiabatic process can form most all grades of powder.

- The adiabatic process can control temperature in the component.
  Optimize temperature based on material and shape.

- The adiabatic process solidifies the powder to higher densities.
SURFACE QUALITY

- The surface finish of the finished part will be an exact replica of the tooling surface.
- If the tooling has a mirror finish, then the part will have that same finish after forming.
**SPEED**

- The adiabatic impact occurs in a matter of milliseconds.

The remaining cycle time is related to feeding the powder into the die and then extracting the completed part.
ACCURACY

Ability to meet exact tolerances consistently. Higher density allows for more consistent parts. Parts will meet the tolerances of the tooling. Tolerances maintained will be better than other processes.
Adiabatics
Advantages

YIELD

- Powder mass will be fed into the press
  Enables close dimensional tolerances for the part
  creating no flash
  no yield loss in the parting
  no stress overload on tooling – longer die life
Adiabatics
Advantages

**DIE COST**

- Greater die life than tooling for conventional methods. Process precision minimizes stresses. Limited process time minimizes dissipation of heat into tooling.

- The adiabatic process utilizes one stroke -- one die -- produces one part.
Powder Compaction Press Capability

- Use of commercialized High Velocity Adiabatic Impact Units
- Ram Speed Controllable to Meet Critical Speeds
- Impact Units have operated for billions of cycles
- Single impact for time, energy and force.
- Scalable in part mass to over factor of 1,000 times
- High densities should minimize sintering temperature and time
- Research needs to confirm powders, tooling and feed systems
HVAI Press Size Comparison

SIP 508
SIP 100B
SIP 200B
SIP 400B
Thank you for your interest in
High Velocity Adiabatic Impact Technology