Cermet Multipurpose Super Casks: A New Manufacturing Method

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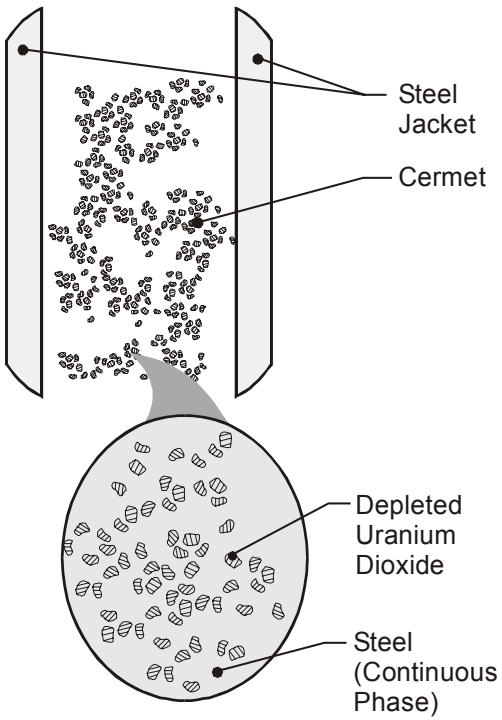
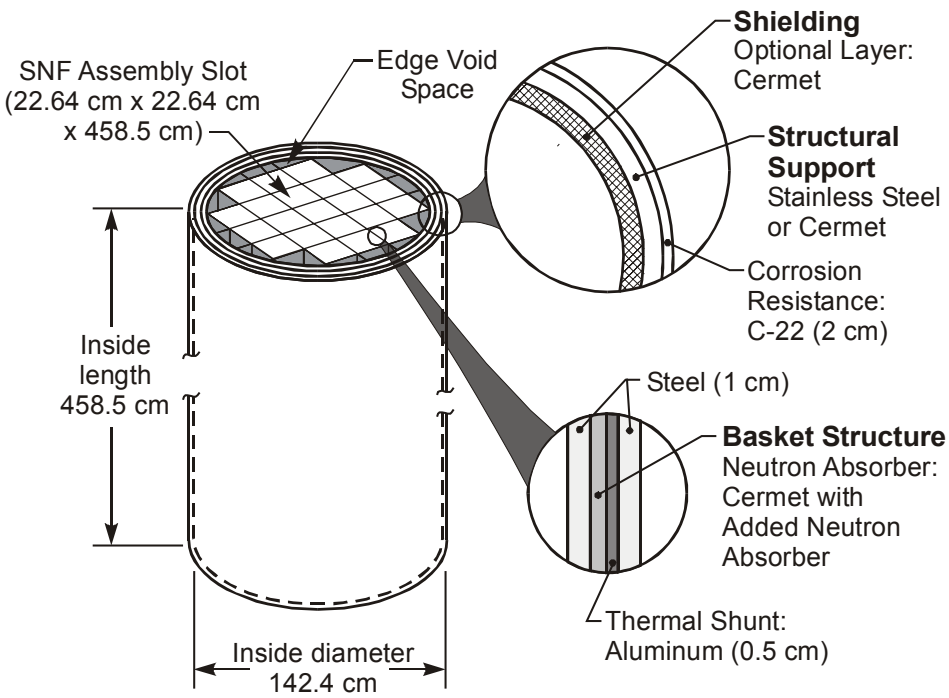
ORNL is Investigating DUO_2-Steel Cermet Casks

Cermet

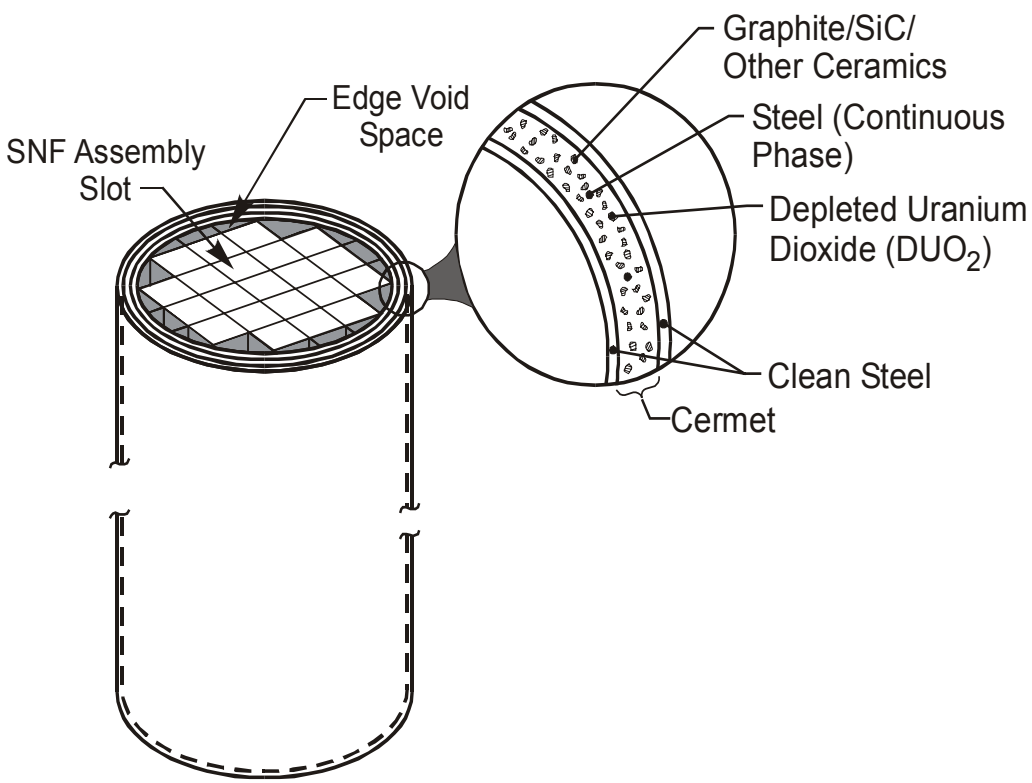


Applications



Cermets Are The Enabling Technology for a High-Performance Super Cask

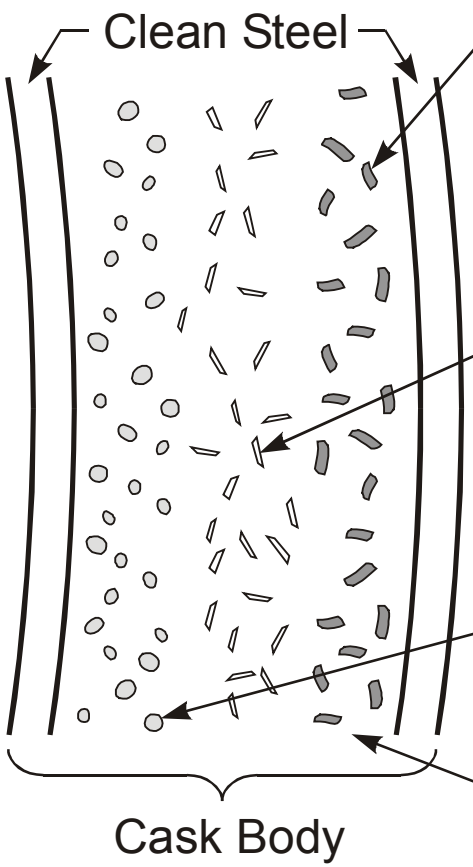
(Ceramics In Metal Matrix To Obtain Advantages Of Both)



Functions

- Radiation Shielding
  - Gamma: High-Density DUO_2/Other
  - Neutron Moderation/Absorption
    - Oxygen in DUO_2
    - Carbon in SiC and Graphite
- Assault Protection: Multilayer Cermet (Traditional Armor)
  - Ceramic (Al_2O_3, DUO_2, SiC, Other)
  - Metal
- Safeguards and Theft
  - Large Mass
  - Vault Construction: Multilayer Cermet
- Decay Heat Removal
  - High Conductivity Steel Matrix

The Composition Across The Cermet Can Be Varied to Maximize Cask Performance
(Including Increased Capacity For a Given Weight Limit)



Ceramics for Armor Protection (Traditional Cermet Application)
- DUO_2
- Al_2O_3
- SiC

Ceramics for Neutron Moderation or Absorption
- DUO_2
- SiC
- Gd_2O_3

Ceramics for Gamma Shielding
- DUO_2

Metal Matrix
- Strength
- Thermal Conductivity

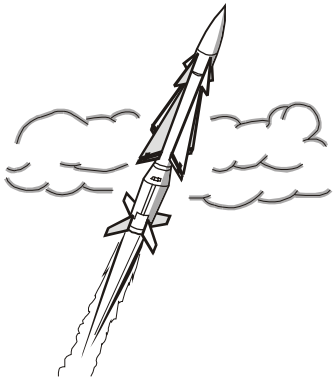
Cermets Outperform Other Cask Materials Because They Enable Combining the Best Capabilities of Different Metals and Ceramics

Cermets Are Traditionally Used In Very Tough Applications

Main Battle Tank Armor

Brake Shoes

Cutting Tools



Nuclear Rockets and Test Reactors

Cermets Are the Preferred Spent Nuclear Fuel Cask Material — If Economic Methods of Cermet Cask Manufacture Are Found

Higher Capacity for a Given Weight

Better Protection Against Assault

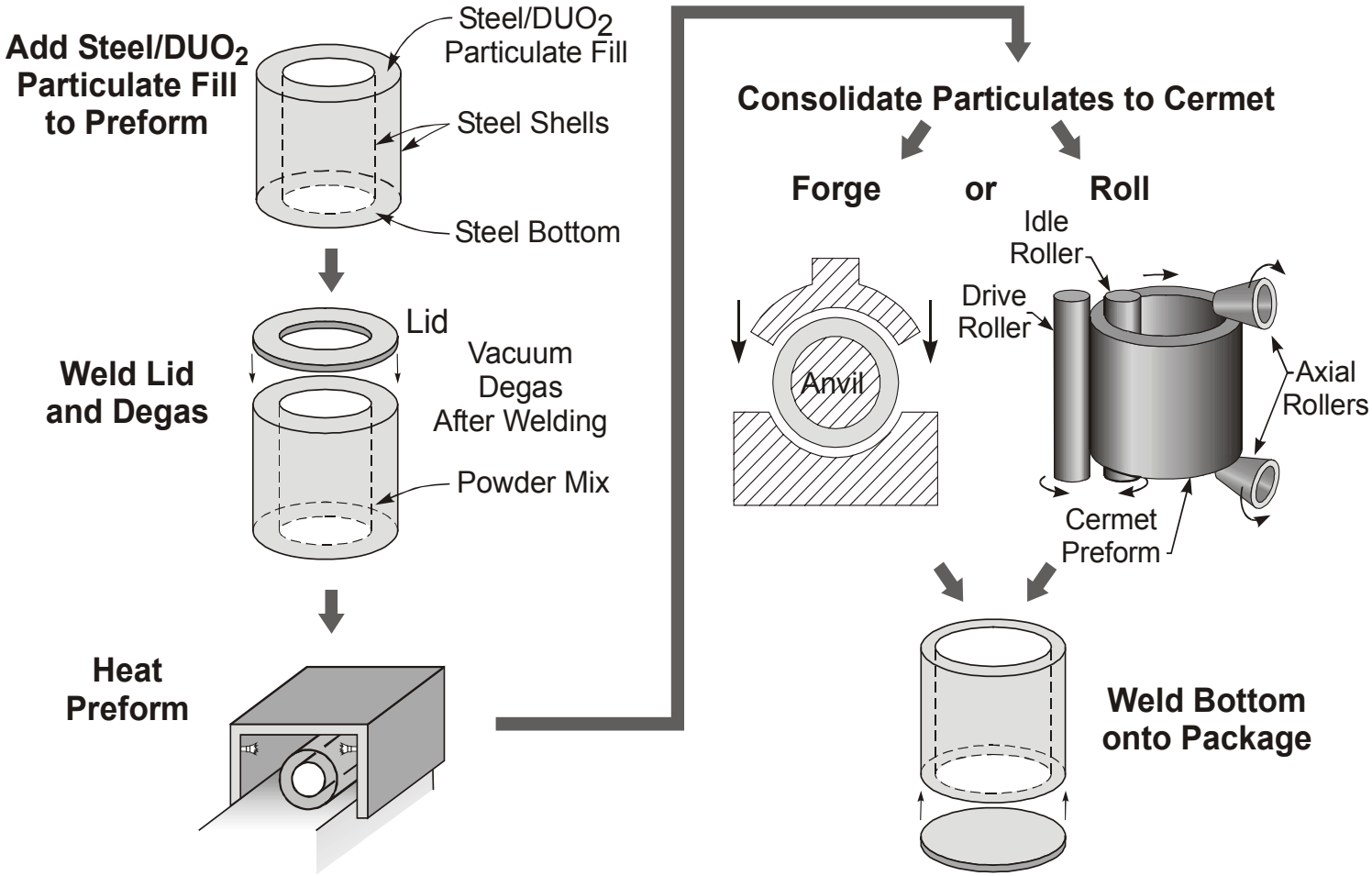
Smaller Dimensions (Thinner walls)

Manufacturing Requirements to Minimize Cask Cost

- Minimum number of operations
- Low cost raw materials
- Minimum plant-area handling DUO_2 (if DUO_2 cermet)
  - Contamination control requirements
  - Regulatory complications
- Appropriate QA/QC

New Production Method for Cermet Casks

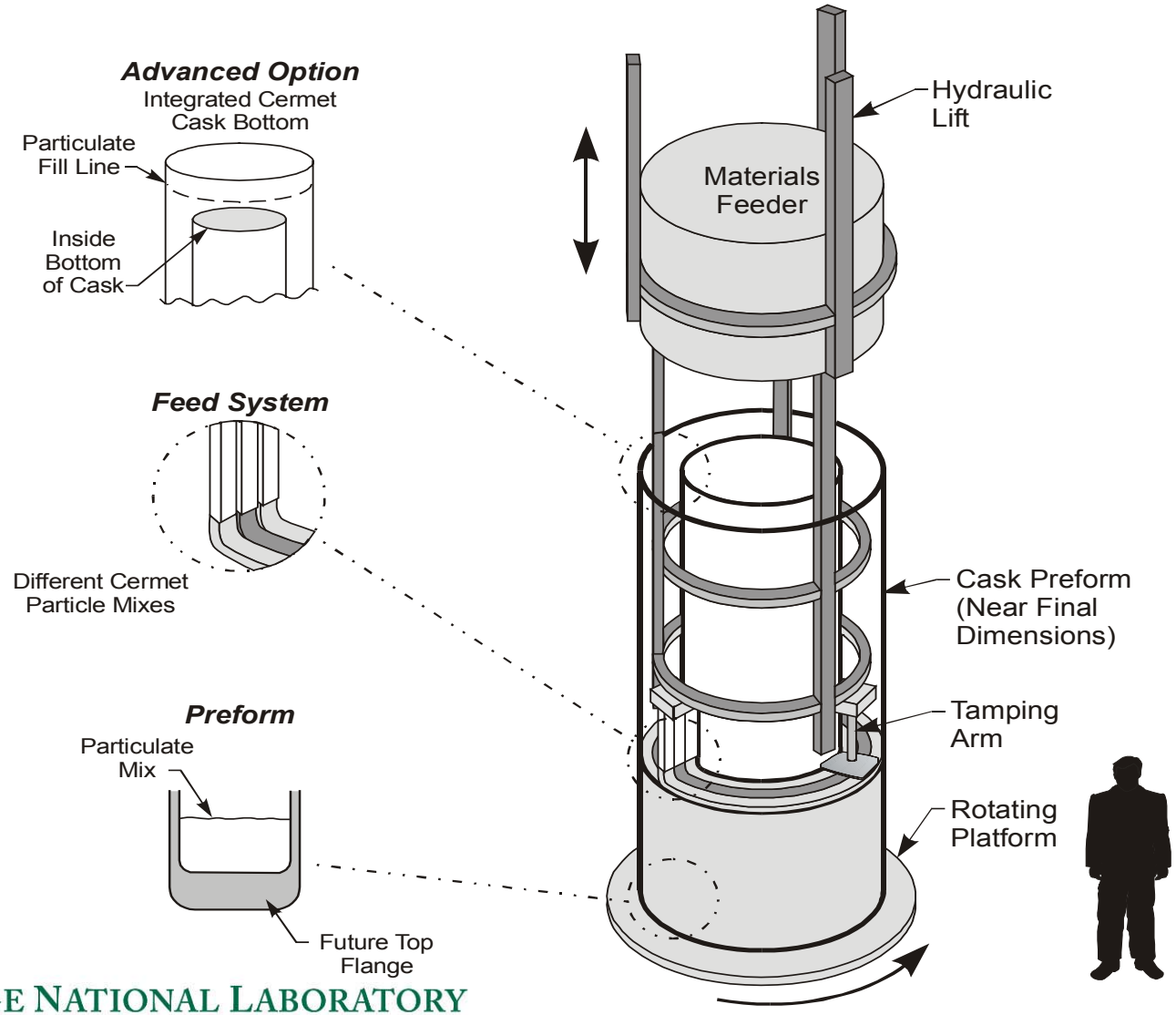
(Patent Applications Filed)



Step 0 (Not Shown) Cermet Preform Fabricated

- The preform is the shell (inside and outside) of the final cask without the bottom
- Characteristics
  - Preform walls are relatively thin (1 to 3 cm)
  - Top of preform is 10s of centimeters thick (lid bolt holes ultimately drilled into this part of the preform in the final cask
  - All welding, drilling, and cutting operations in cask fabrication are into this preform (no drilling, cutting, or welding of cermet)

Step 1: Empty Cask Preform Mounted Upside Down on Turntable and Filled with Cermet Particulates



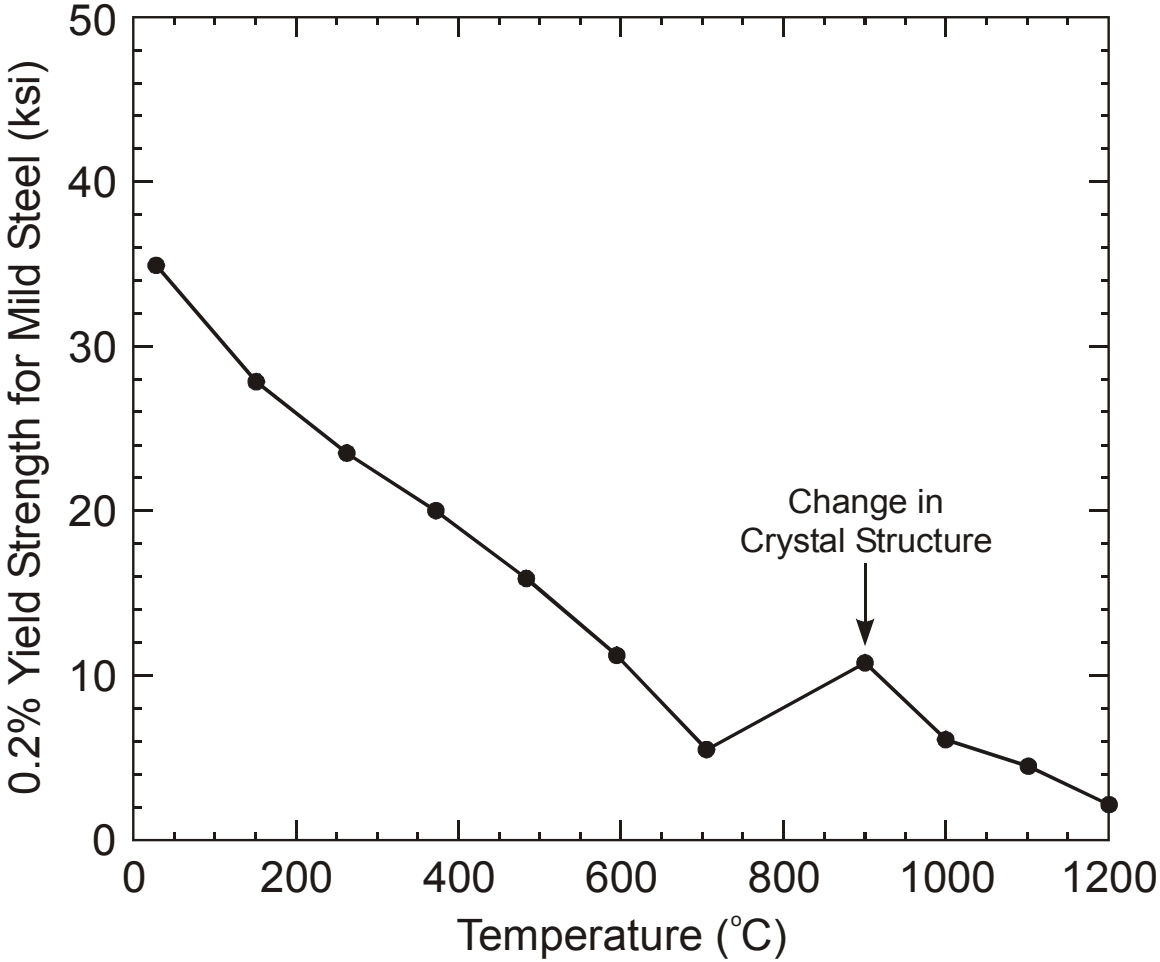
Step 2: Closure of Cermet Preform

- Steel top piece welded onto filled cermet preform
- Preform vacuum degassed

Steps 3 and 4: Pressure and Temperature Convert The Cermet Particulate Mix Into A Monolithic Metal Matrix Cask

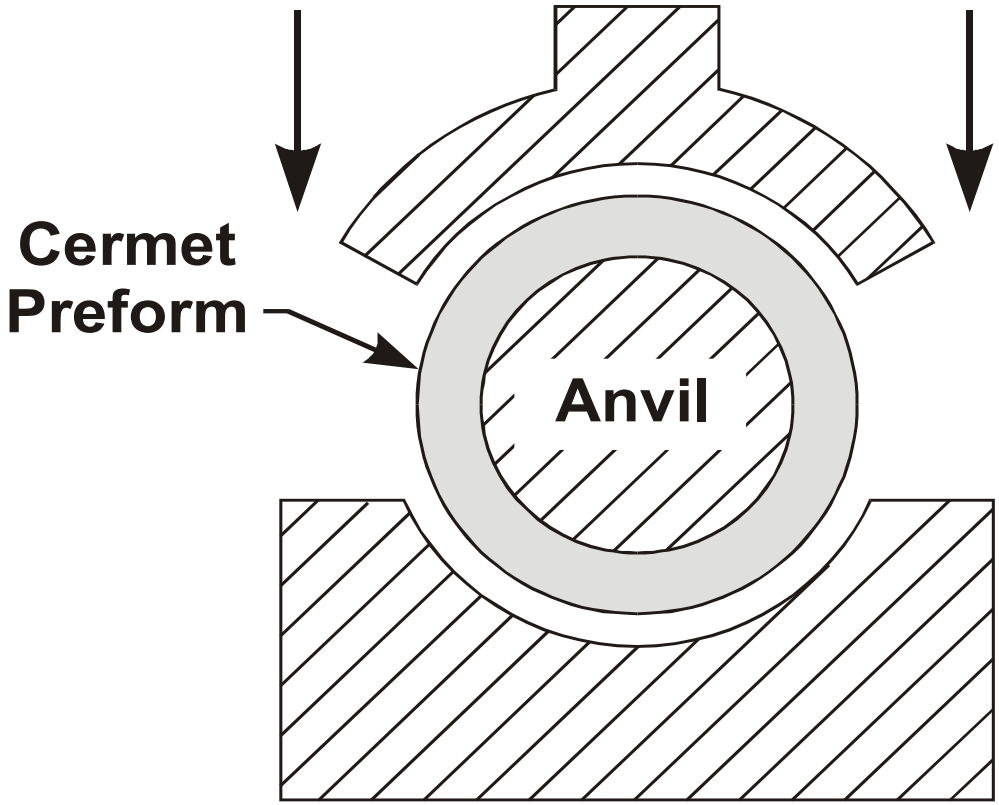
- Filled preform is heated before cermet particulate consolidation operations
  - Heating reduces forces required for latter forging operations
  - Heating assures metal particulates are welded by forging operations
- Pressure (forging) creates monolithic cask (no voids) with preform and cermet welded together

Step 3: The Loaded Preform with the Cermet Particulate Mixture Is Heated to High Temperatures to Reduce Consolidation Forces for Conversion Into a Monolithic Cask



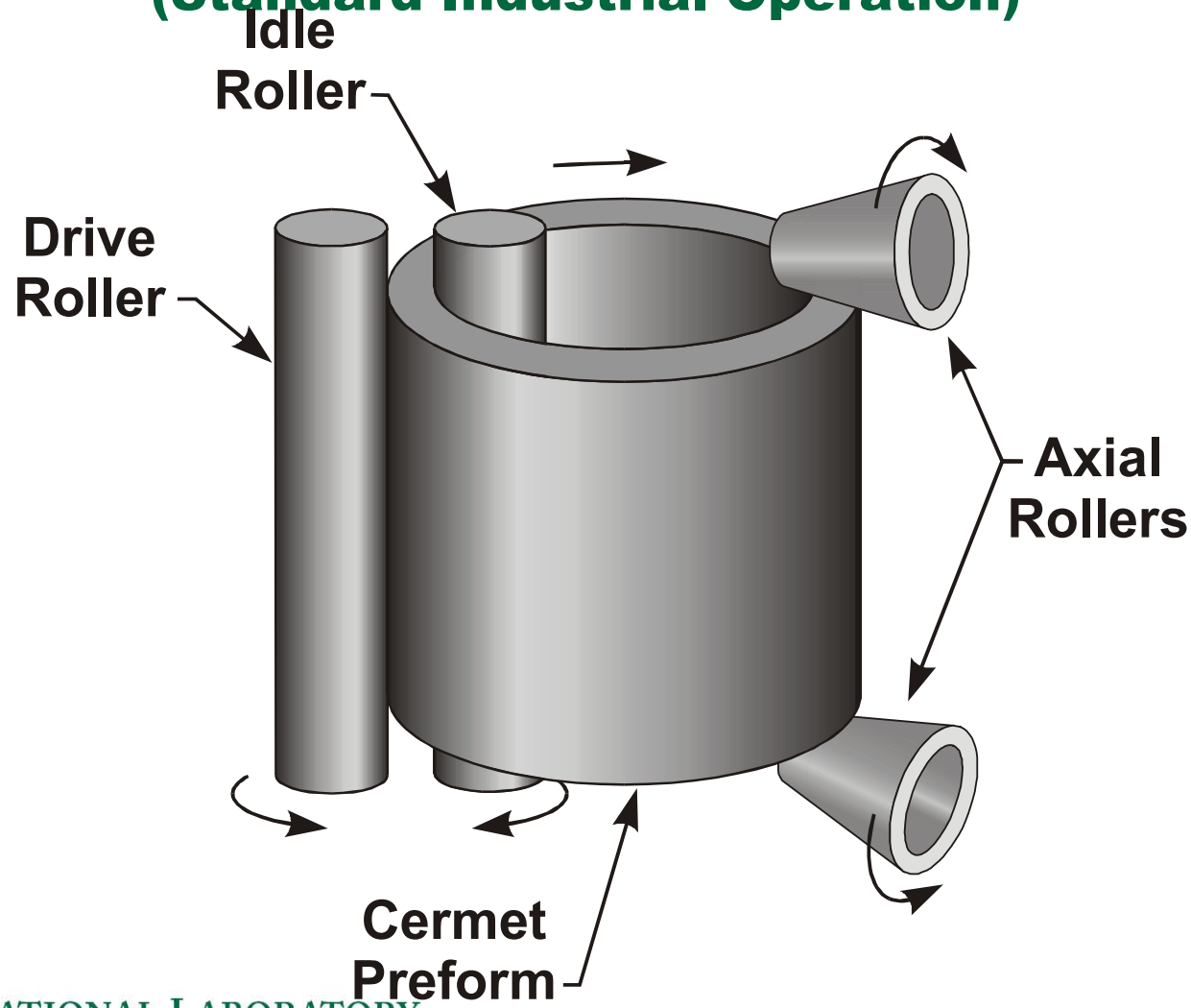
Step 4: Cermet Consolidation Option Using Open Dye Forging

(Standard Industrial Operation)

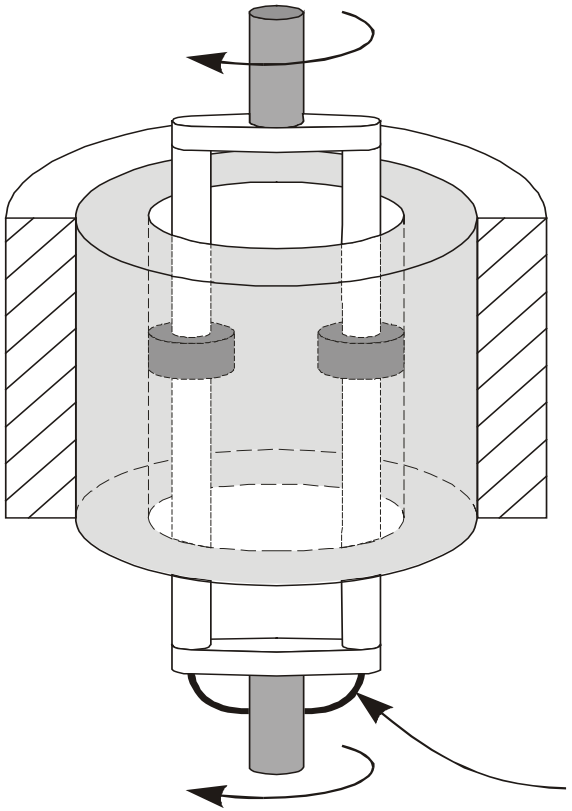


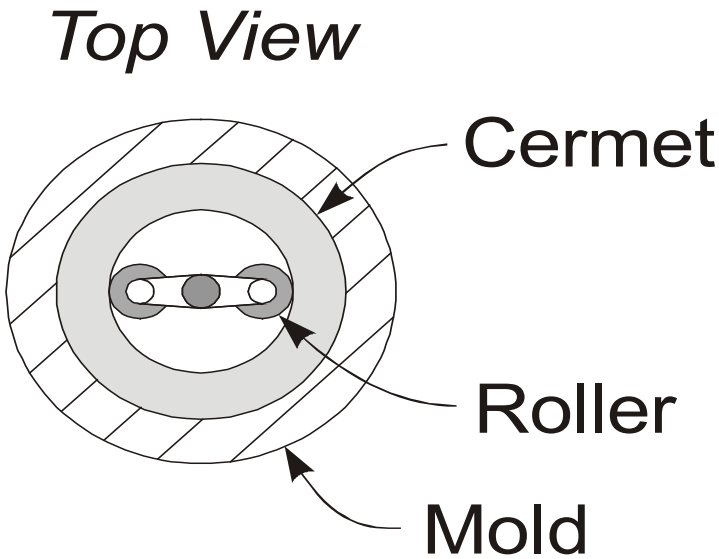
Step 4: Cermet Consolidation Option Using Rolled Ring Forging

(Standard Industrial Operation)



Step 4: Many Other Less-Conventional Cermet "Forging/Rolling" Consolidation Options





Hydraulic Control of Diameter

Step 5: Finishing Steps After Formation Of Monolithic Cermet Cask

- Two options for cask bottom
  - Weld cask bottom to cermet cylindrical cask body
  - Integrated cermet cask bottom with cask walls: not shown (requires special forging techniques for one-piece cask)
- Machining
  - Smooth surfaces
  - Create mating surface for cask lid
  - Drill holes for cask lid bolts

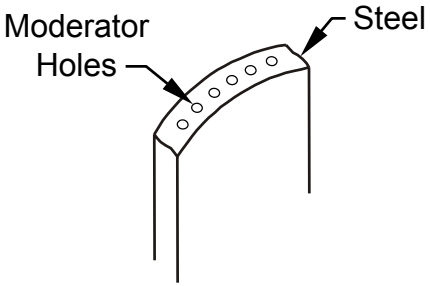
The Potential Exists for Low Costs

- Raw-materials costs are low
  - DUO_2 zero cost or rebate (avoidance of disposal costs)
  - Other cermets: depends upon choices
  - Iron powder: $600/ton
- Labor costs are low
- Option to use existing facilities for forging
  - Sealed preform
  - Several options on cermet consolidation

Cermet Casks May Require Fewer Fabrication Steps Than Traditional Casks

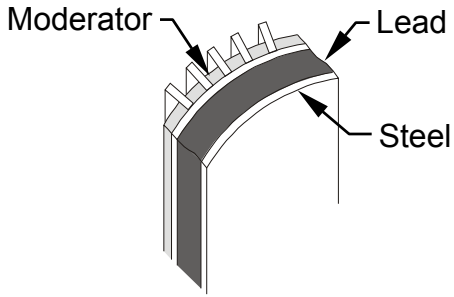
Other Casks

Steel Cask



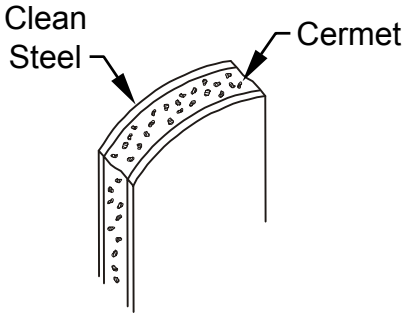
- **Casting**
- **Drilling**
- **Assembly**
- **Machining**

Lead Cask



- **Form Fabrication**
- **Casting**
- **Moderator Placement**

Cermet



- **Form Fabrication**
- **Particulate Addition**
- **Heat and Forge**

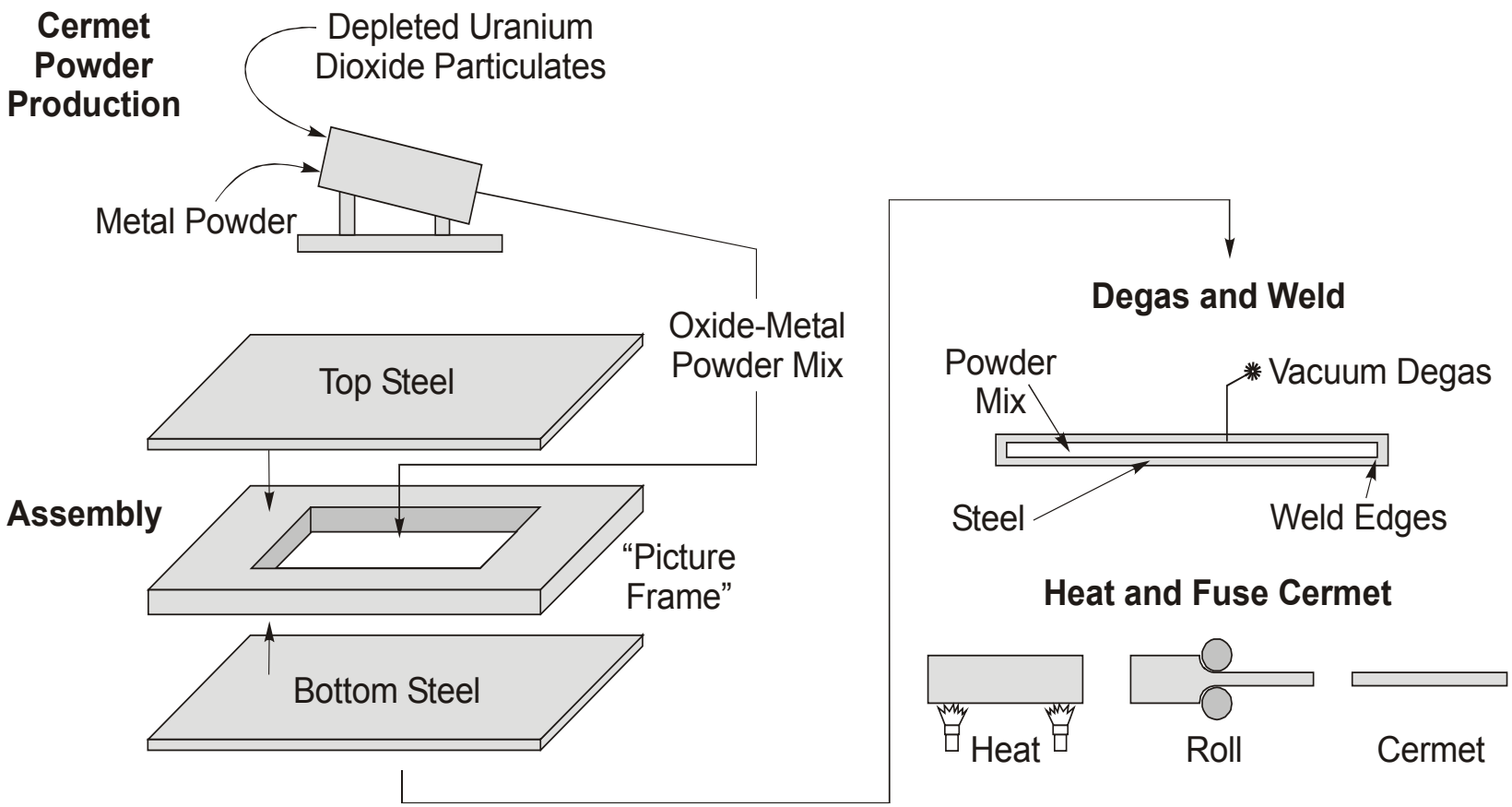
Path Forward

- Initiating manufacturing studies (theory and experimental)
  - Without DUO_2
    - Built in armor
    - Built in neutron absorber
  - With DUO_2
- Initiating cost studies (steel companies)
  - Without DUO_2(option to first introduce non-DUO_2, then DUO_2 cermet)
  - With DUO_2
- Request GNSI assistance and input

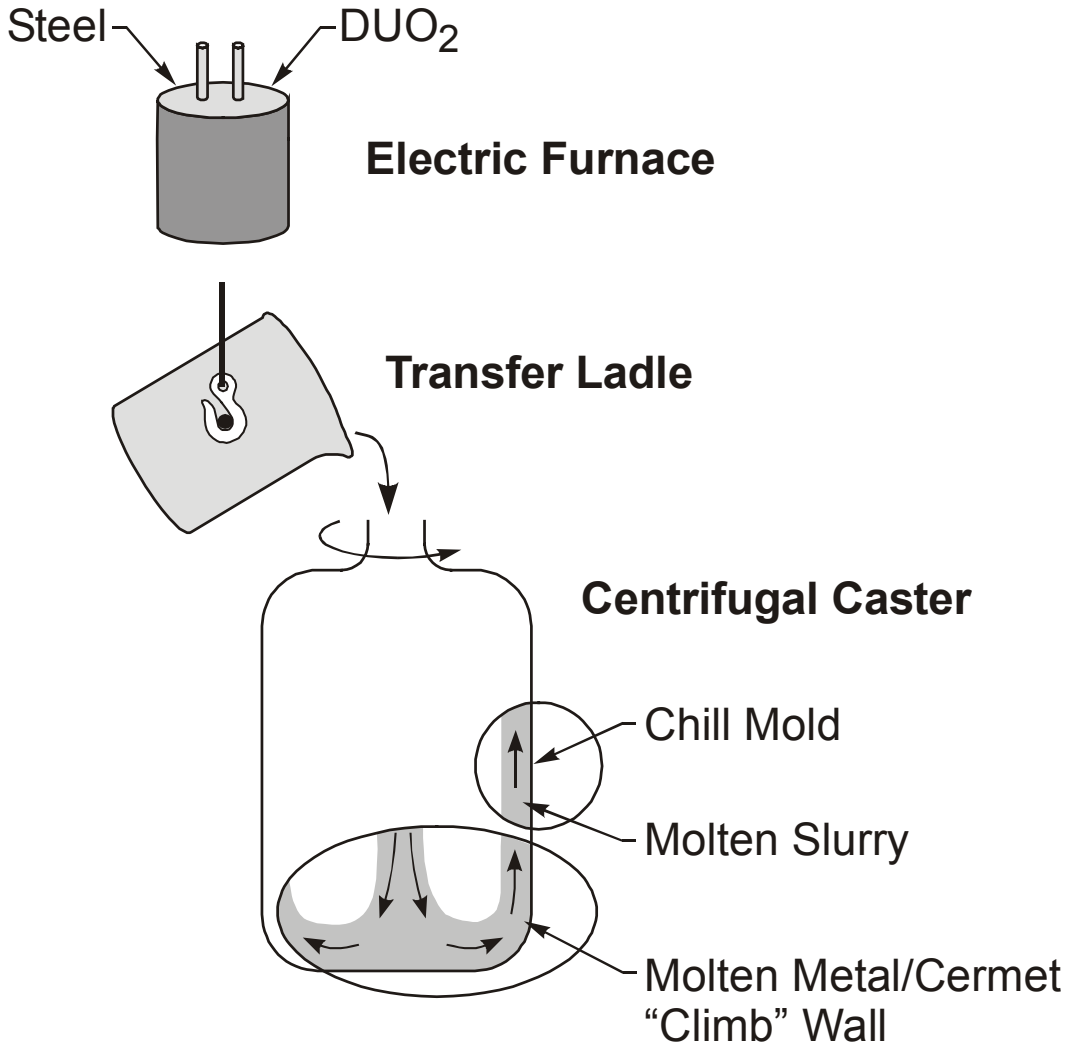
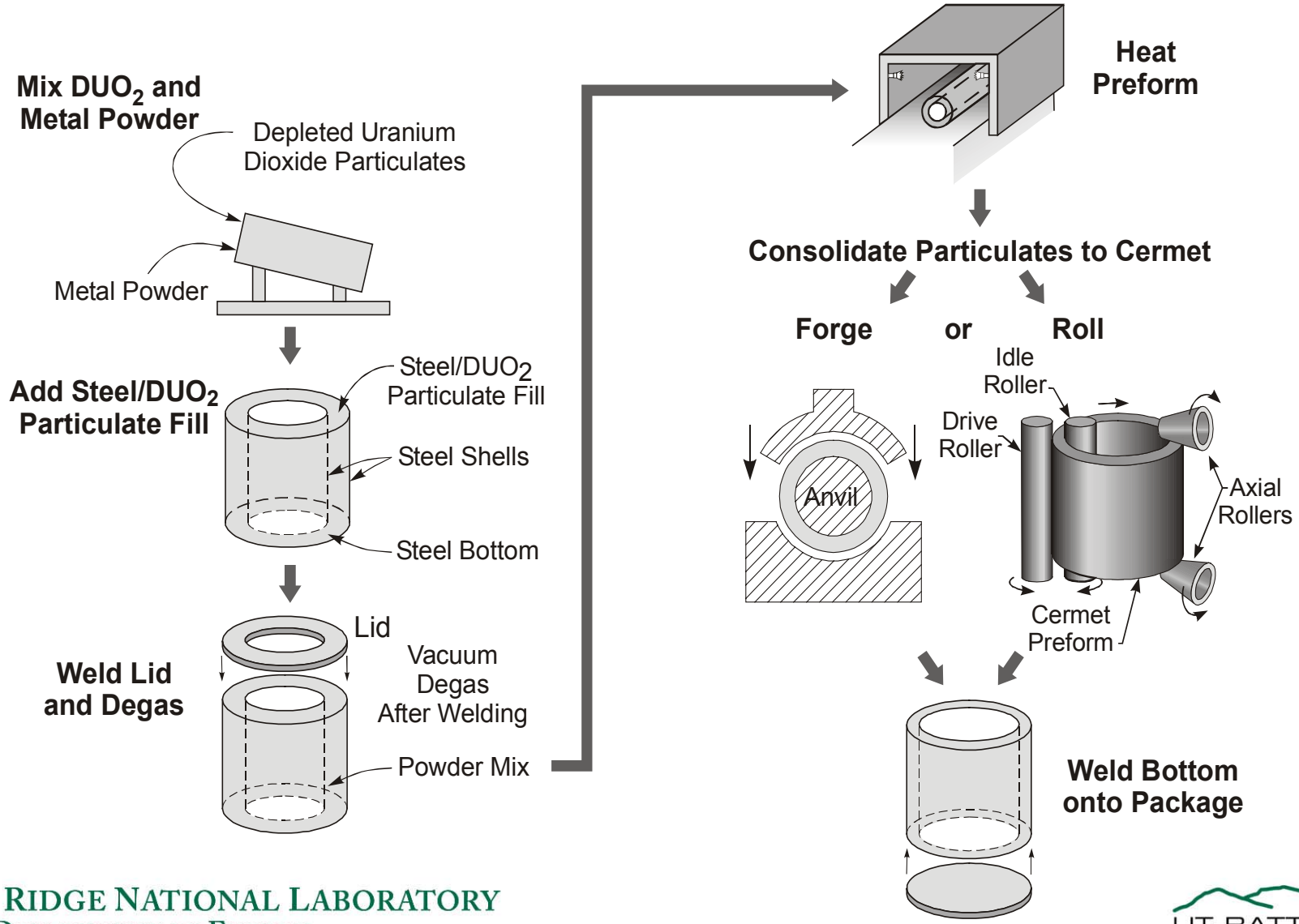
Backup Slides

Traditional "Picture-Frame" Method for Cermet Production

(Requires Assembly of Cask From Cermet Pieces, Welding Cermets Is Extremely Difficult)



Cask Production by DUO_2 Particulate, Molten-Steel Centrifugal Casting



Production Method for Cermet Casks