Processing of Spent TRISO-Coated GEN IV Reactor Fuels: Mechanical Head-End Processing

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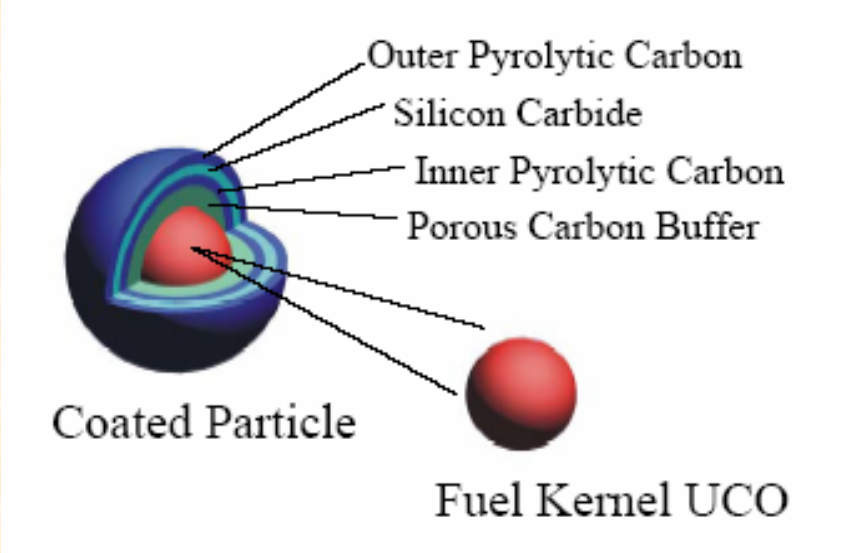
Configuration of HTGR/AHTR Fuels
—General Description—

- Fuel begins with small kernels
- Coated for fission product containment
- Coated particles mixed with carbon-based mastic
  - Formed as “rods” or “pebbles”
- Compacts loaded into prismatic fuel elements
- Large amount of carbon associated with a small amount of fuel



Particles

Compacts

Fuel Elements

Summary of Recent Review & Evaluation of Processing GENIV Fuels

- **Methods developed in the 1960s and 1970s**
  - **Generally the entire fuel element was processed**
  - **Crush-Burn-(Crush-Burn)-Leach**
    - **Large quantities of CO_2 (atmospheric disposal now questionable)**
    - **Large off-gas processing equipment needed**
  - **Grind-Leach**
    - **Grinding to sufficiently small particle size was problematic**
    - **Difficult solid-liquid separations now solved by industry**
- **Alternatives to crush-burn-leach identified**
  - **Two promising approaches**
    - **Grind-leach (modified/improved)**
    - **Carbochlorination**
  - **Both methods minimize combining C with other elements**
  - **Both support a robust carbon-based waste form**
- **Aqueous grind-leach selected for further study**

Fluidized-Bed Jet Mill Selected for GEN IV Processing Tests

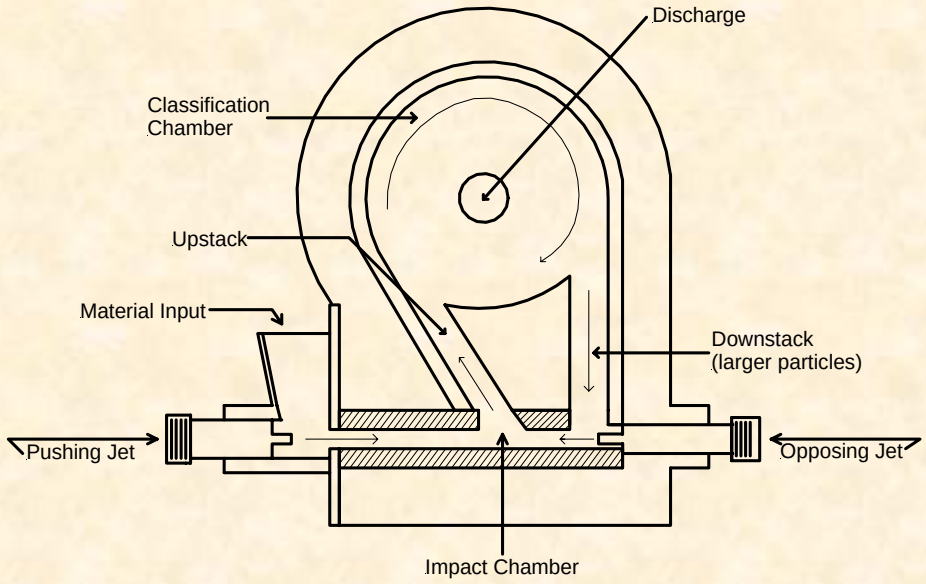
- **Very hard materials are in GEN IV fuels**
  - **Pyrolytic carbon**
  - **Silicon carbide**
  - **Uranium oxide and uranium carbide**
    - **mixed with other actinide and FP oxides**
- **Device longevity and maintenance considerations**
  - **Grinding by particle-particle impact preferred**
  - **Minimal particle-wall impact used**
  - **Liner of grinding chamber replaceable**

Mechanical Processing of TRISO Fuel Being Investigated

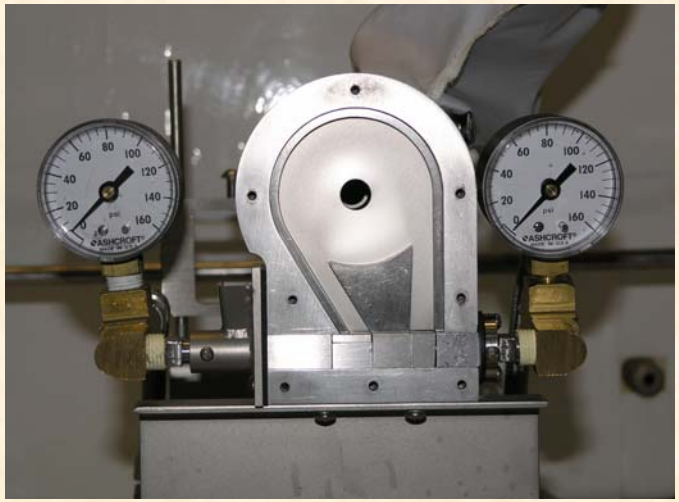
- **Evaluation of fluid energy jet-mill to produce particles ≤ 50µm**
- **Potential particle classification based on density (e.g. carbon vs. heavy metal forms)**
  - **Most tests with inexpensive surrogates**
- **Limited tests with unirradiated fuel due to fuel availability**

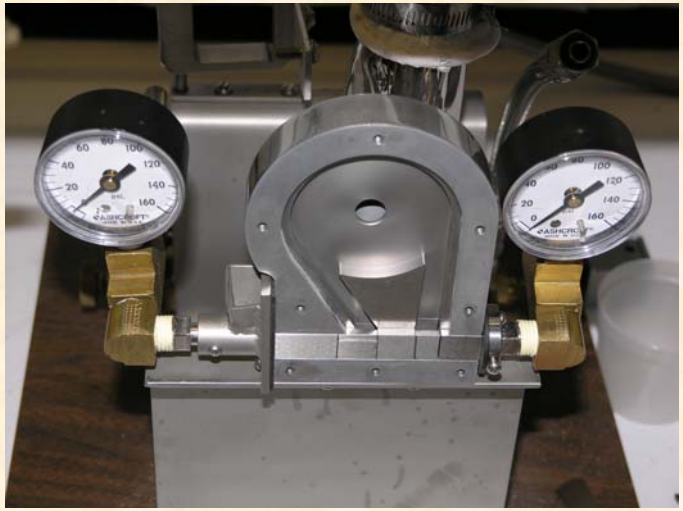
Potential Particle Classification

- **Variables affecting product particle size**
  - **Solids feed rate**
  - **Particle size of feed**
  - **Density of solids**
  - **Gas feed rate**
- **Concepts**
  - **Particles in circular motion**
  - **Particles leave the central discharge when small enough**
  - **Materials of uniform density are ground to a narrow particle size distribution**
  - **Balance of centrifugal and viscous forces depend on both density and size**
- **Anticipate that**
  - **Heterogeneous material will produce a bimodal particle size distribution**
  - **Low density particles will be larger than high density particles**
  - **Potential for some separations**

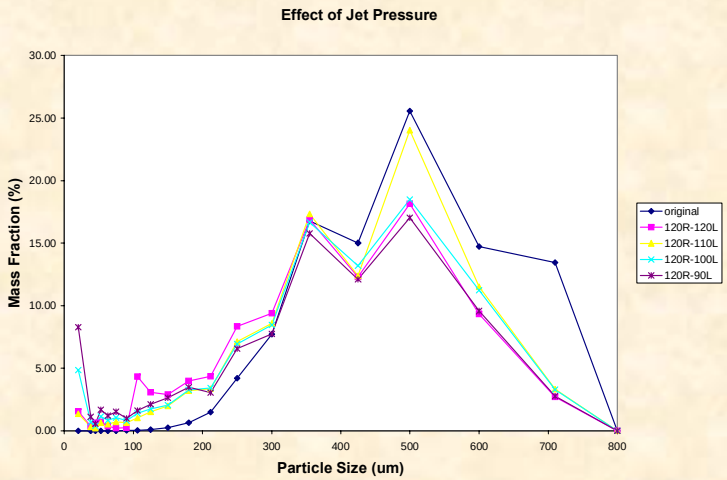


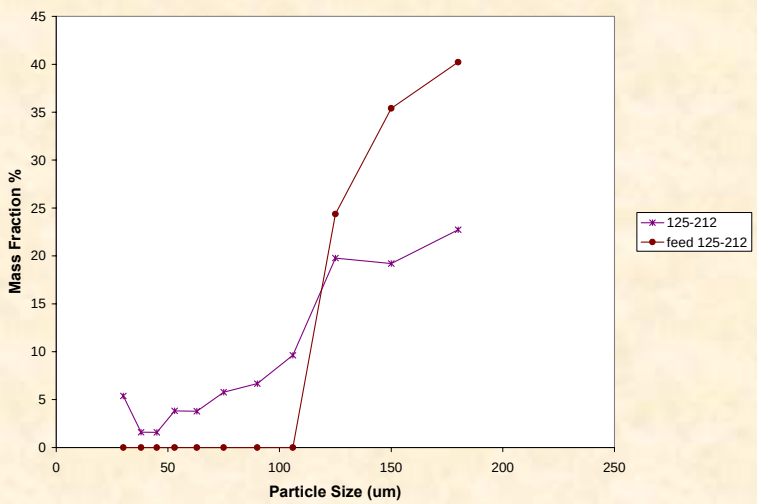
Lab-Scale Jet-Mill





Initial Milling Results





- **Feed particles at upper limit unit can digest (800 um)**
- **Expected a 20:1 to 50:1 size reduction**
- **Milling is evident**
- **A fraction of material is unmilled**
  - **Potential bypassing**
- **Some very small particles are produced**
- **Tested with 200 um feed**
  - **Improved reduction ratio**
- **Indicates adjustments needed, e.g.**
  - **Jet pressure**
  - **Jet position**
  - **Smaller feed particles**

Path Forward

- **Clear covers were fabricated to observe particle trajectories/pathways**
  - **Improve understanding**
  - **Rapid adjustment**
- **Contract has been placed with another jet-mill maker to test two units of different designs**
  - **Combined, gives data on 3 different designs**

Summary

- **Initial tests have been made**
  - **Need to find optimum operating parameters**
    - **Jet pressures**
    - **Particle size (~100—200 μm)**
      - **Ascertain requirements for precrusher, e.g. roller mill**
  - **Particle size of feed (500—800 μm) presumed too large for this small unit**
- **Additional tests are underway with existing unit**
- **Other designs are being tested under subcontract**
- **Stay tuned…..**