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24.07.01

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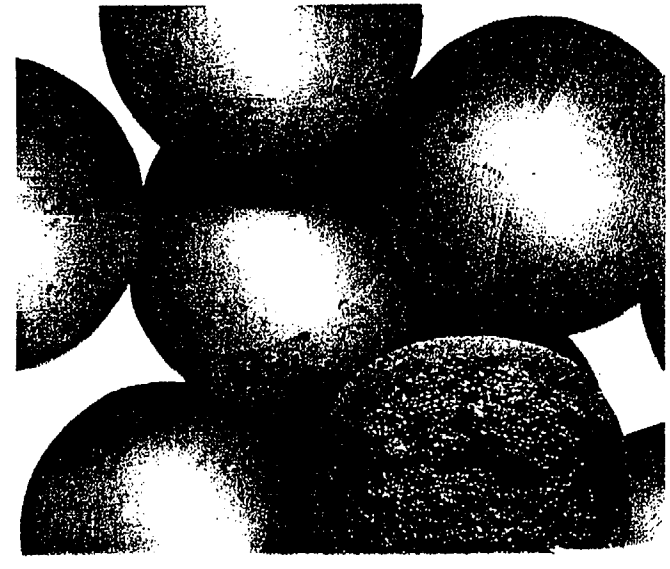
Pebble Bed Fuel Element Research and Development and Industrial Production in Germany

1. Overall View and Progress of R&D and Production
2. Design of the THTR-Fuel Element and the HTR-Module Fuel Element
3. Manufacturing Process
4. Characterization
5. Production Experience
6. Special Quality Assurance System and Philosophy



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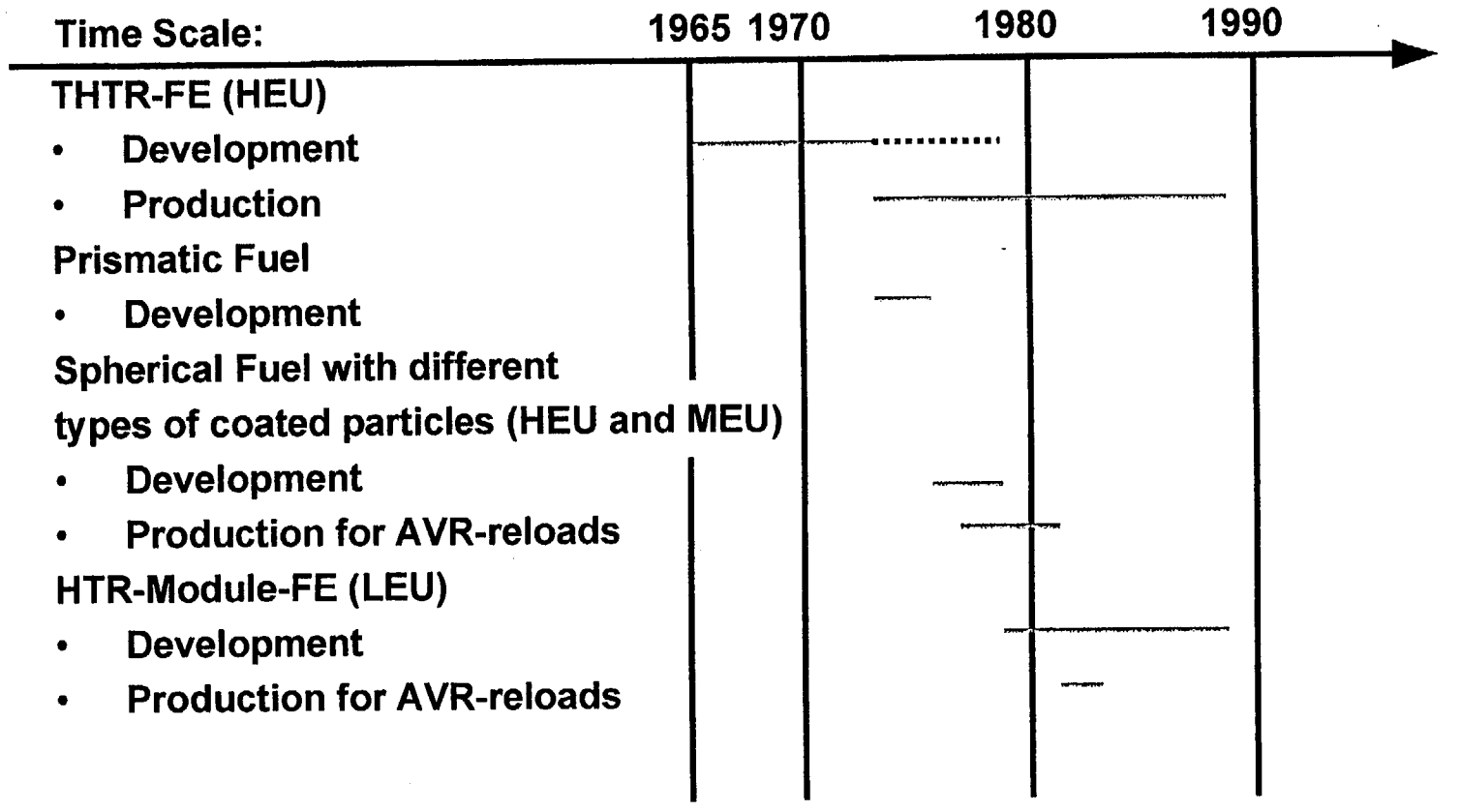
Overall View and Timely Progress of R&D and Production



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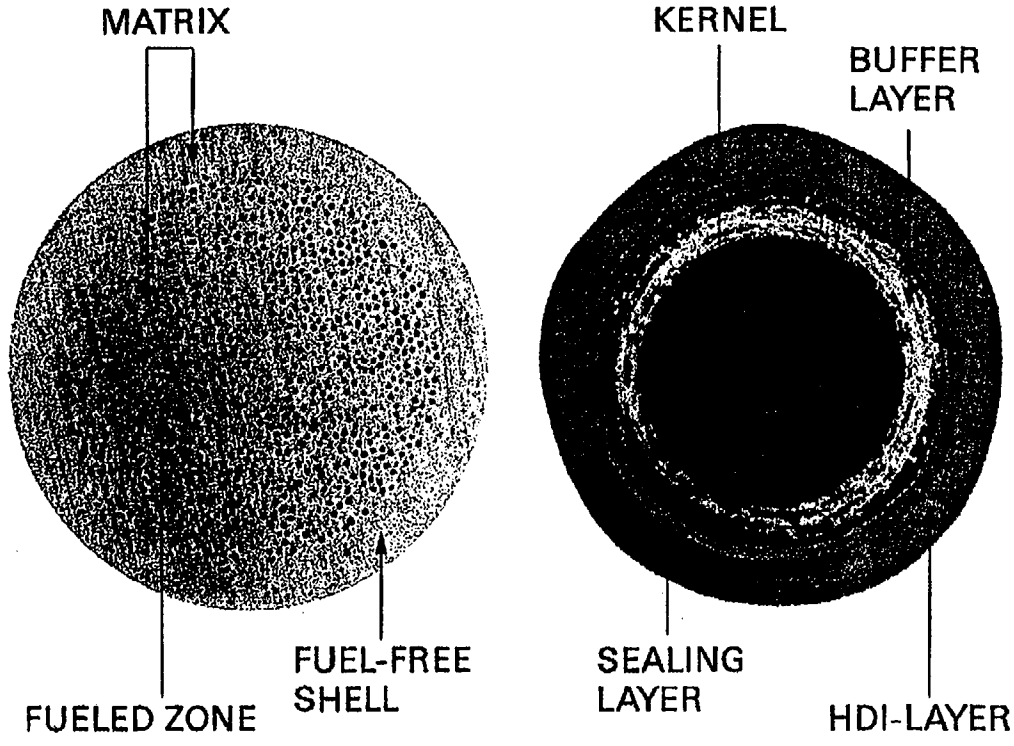
Design of the THTR Fuel Element and the HTR-Module Fuel Element



THTR-Fuel Element

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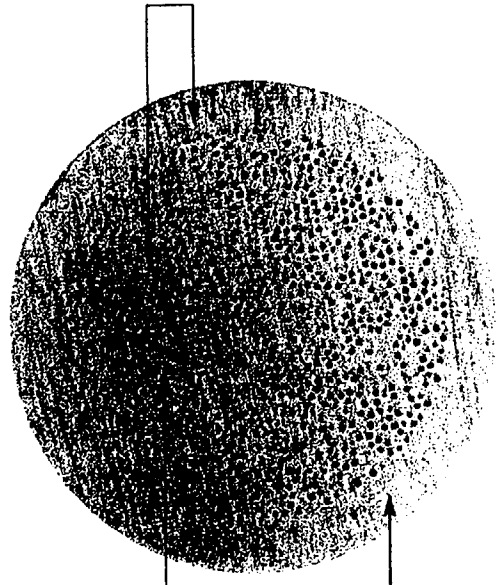
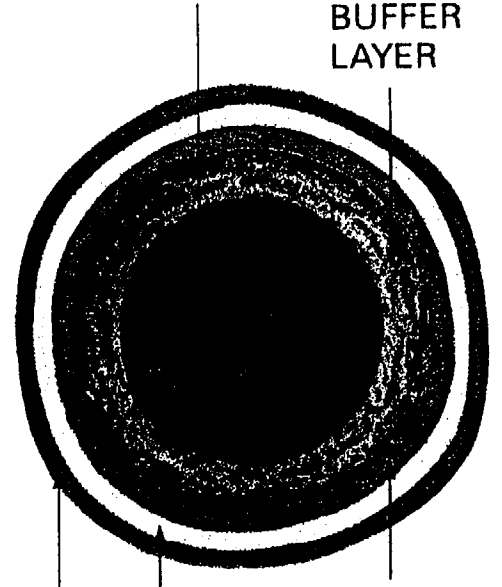
Design of the THTR Fuel Element and the HTR-Module Fuel Element





HTR-Fuel Element

Kernel Manufacture Process Diagram

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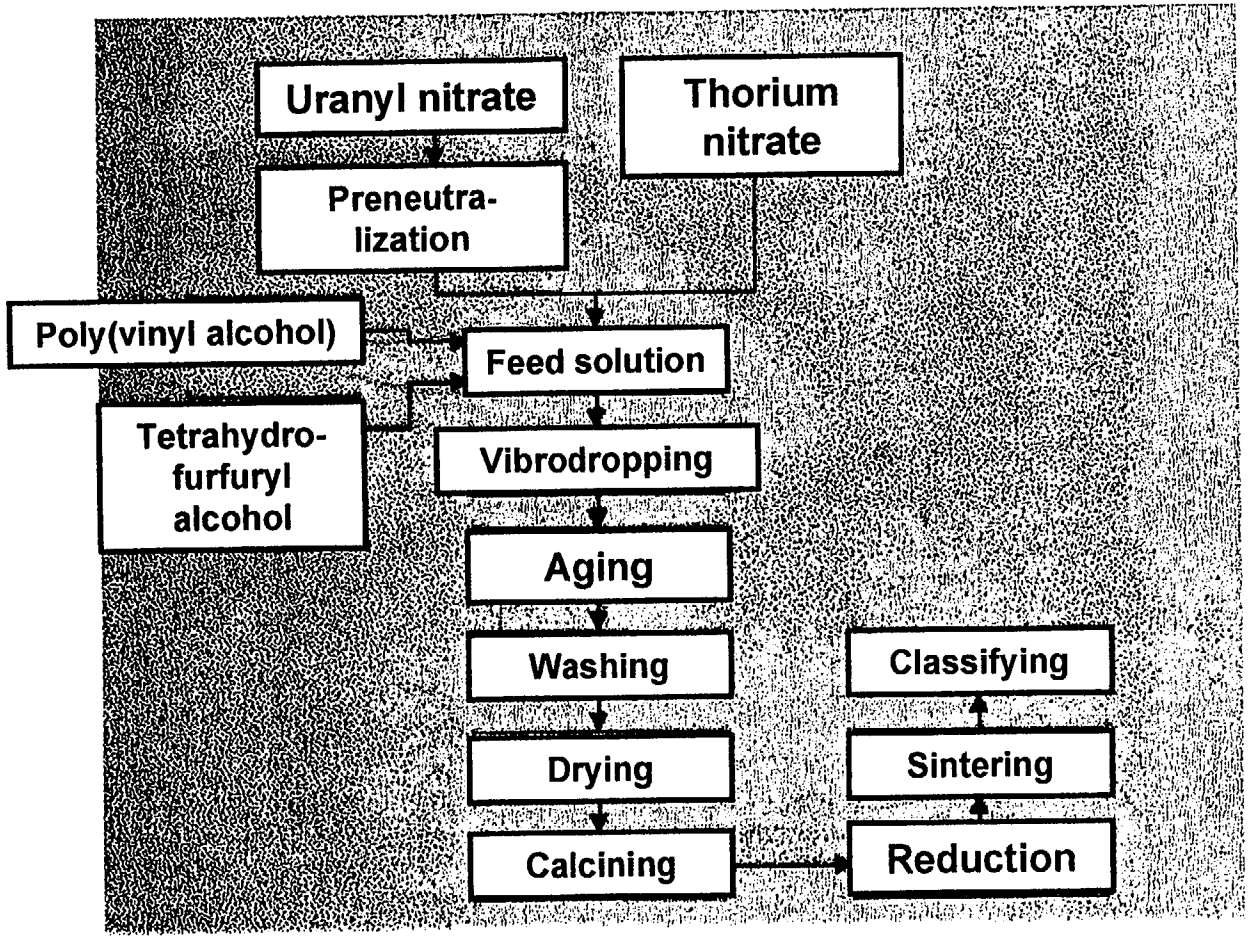

Fuel Kernel Fabrication

Kernel Manufacture

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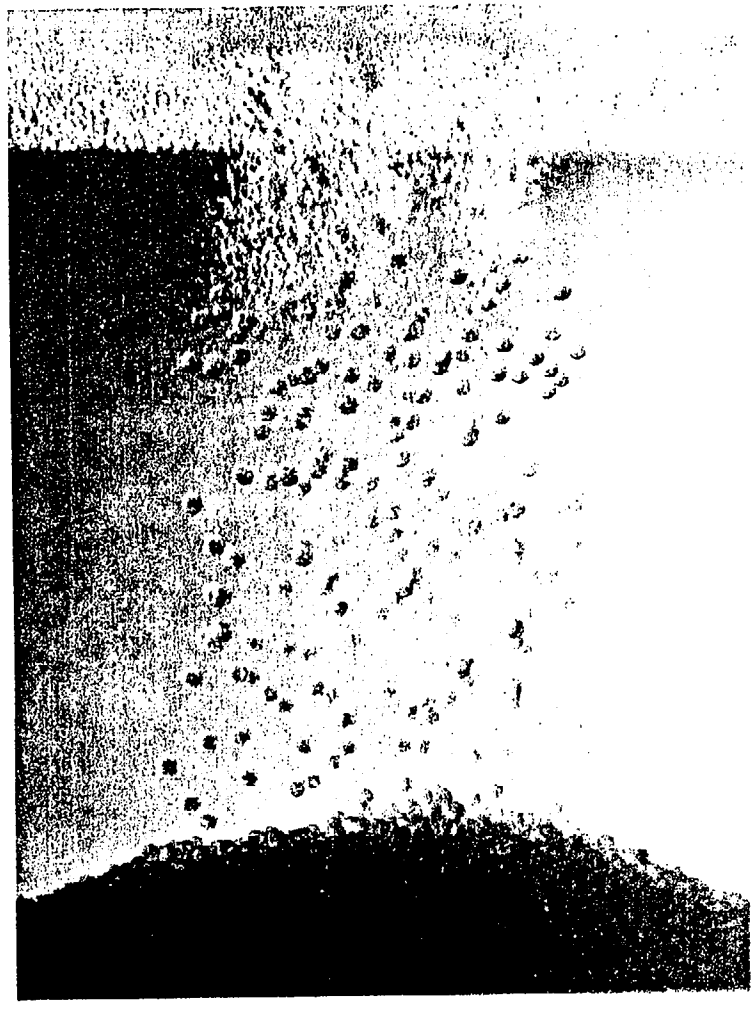

Kernels in the Precipitating Agent

Kernel Manufacture

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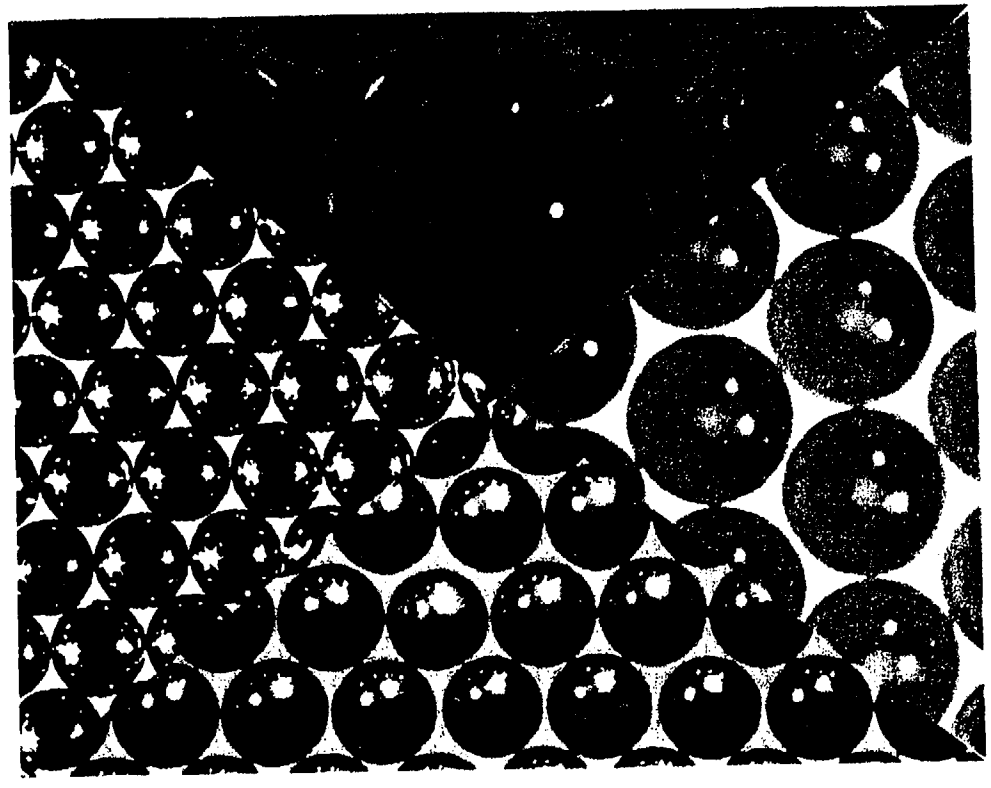
AS VIBRODROPPED

SINTERED



DRIED

CALCINED

Mixed Oxide Kernels after different Stages of Manufacturing

Coating Process Diagram

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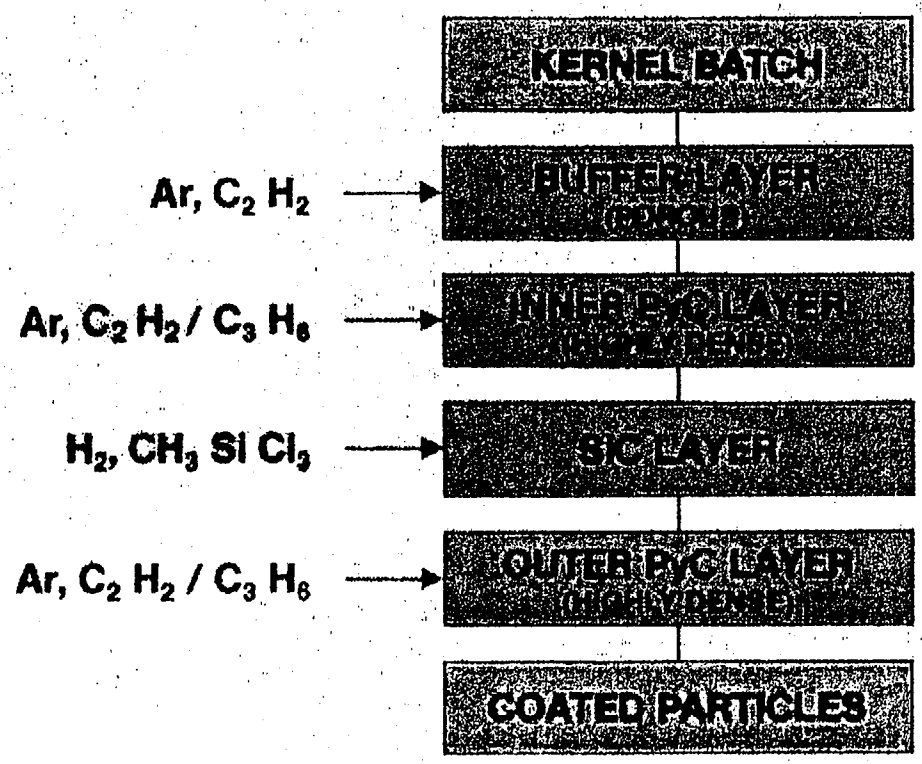

Coating of HTR Fuel Kernels

Coating Process

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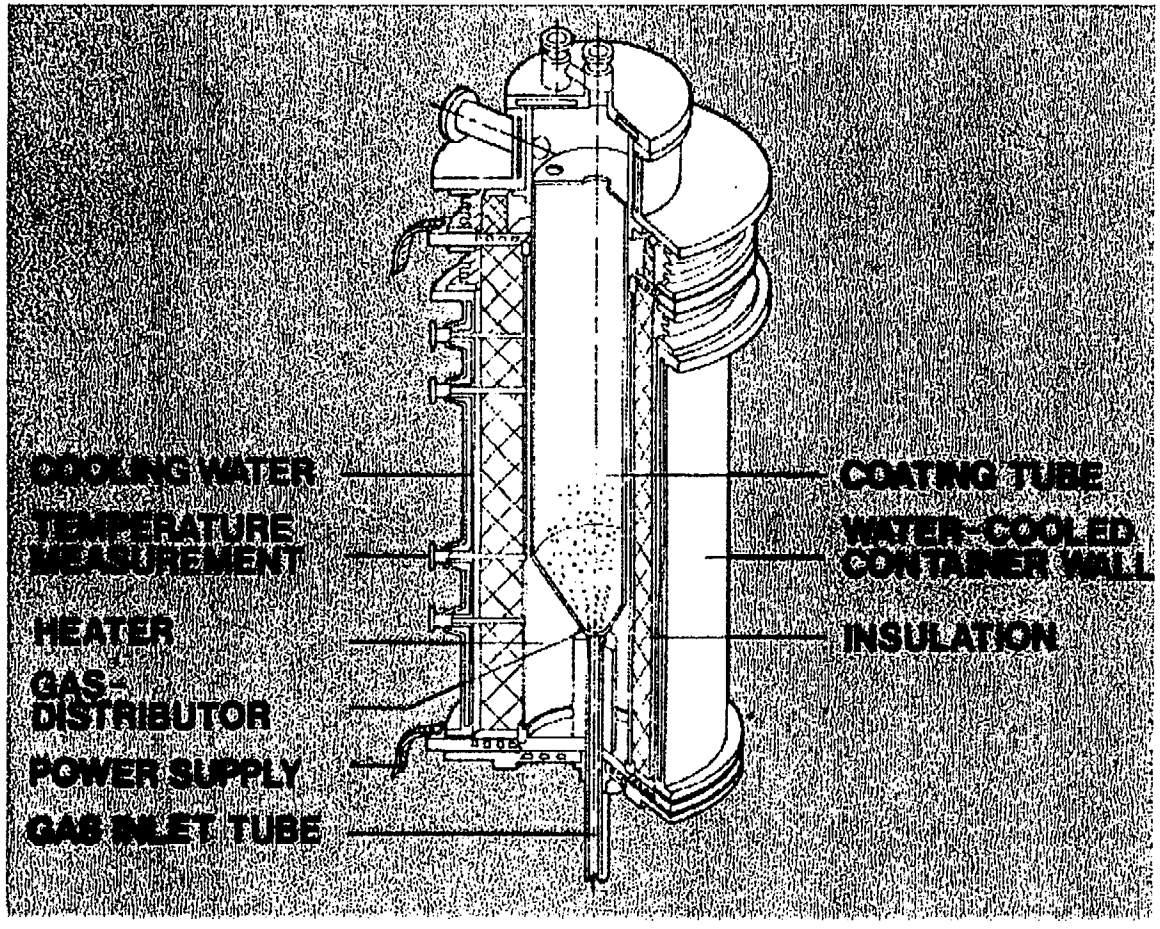

Fluidised Bed Reactor

Fuel Element Manufacturing Process

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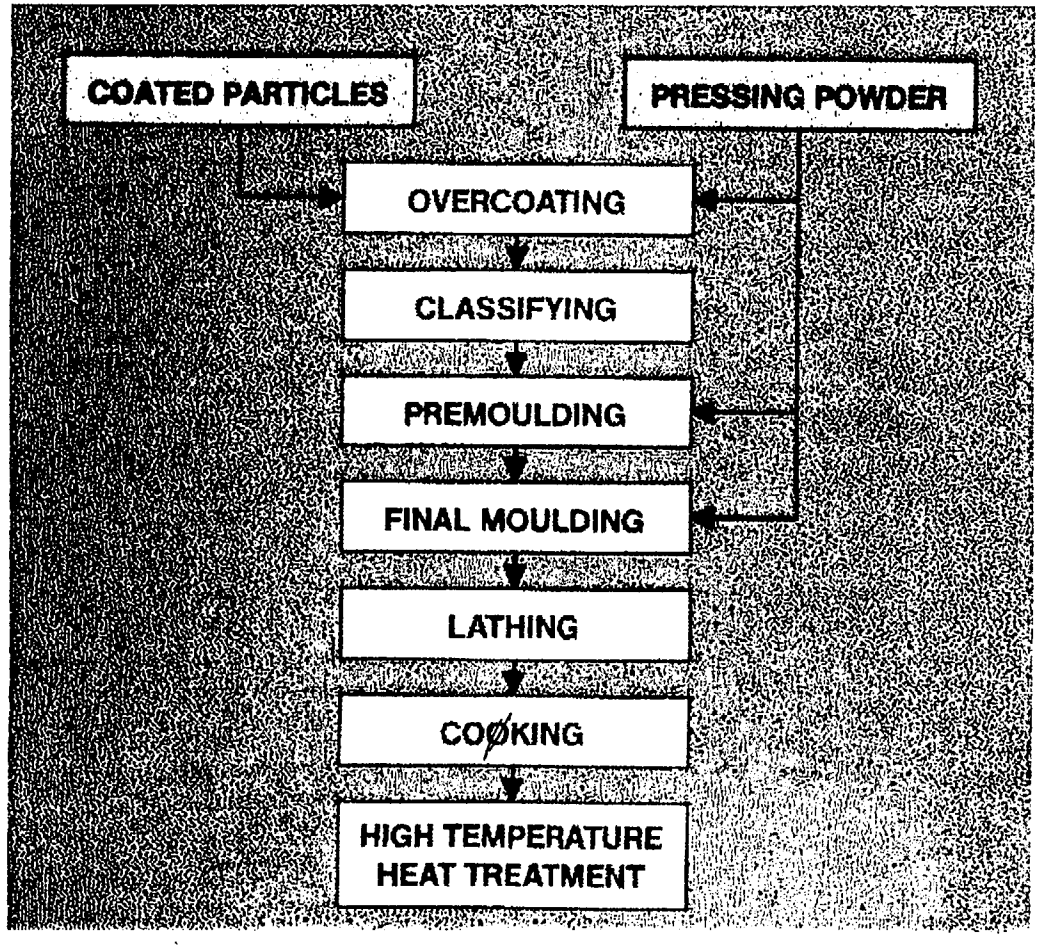

HTR-Fuel Element Fabrication

Fuel Element Manufacturing Process

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Rubber Dies for Fuel Spheres

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HTR Fuel Specific Characteristics

Kernels:

- diameter - sieving
- roundness - tabling

Coated Particles:

- ratio of defect SiC-layers
- diameter
- roundness
- thickness of each layer
- density of each layer
- anisotropy of both dense pyrocarbon layers

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HTR Fuel Specific Characteristics

Fuel Element:

- heat conductivity of the graphite matrix at 25 °C and 1000 °C
- ratio of defective SiC-layers (burn-leach test)
- corrosion rate
- crushing strengths
- fuel-free zone thickness
- abrasion rate

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THTR-Fuel Element Production Experience

Produced:

Kernels: ~ 1000 batches

Coated particles: ~ 4000 batches

Fuel element: ~ 500 lots

(~ 1.000.000 FE)

Yield:

For each of these products > 95% during manf. steps

Reject: rejecting entire lot or acceptance unit

1 lot of coated particles from 1973-89 - bad anisotropy

1 lot of fuel elements - pitting corrosion by metallic particles

Safety:

Not a single safety relevant incident

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Special Quality Assurance System and Philosophy

Development Targets:
- Target product specification
- Provide suitable manufacturing process
- provide suitable components

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Development Stage 1
Standard-Quality 1

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Development Stage 2
Standard-Quality 2

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Development Stage X
Standard-Quality X
Target product specification achieved

→ **Samples for screening test as part of production batches**

Special Quality Assurance System and Philosophy

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- Target product Specification achieved, demonstrated by a "final" standard-quality
- essential targets for process and components achieved (close to the future production conditions)

→ Sample for reference test as part of the standard quality