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REMOTE FABRICATION OF NUCLEAR FUEL PELLETS

by

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Hanford Engineering Development Laboratory

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Introduction

The development of remotely operated and maintained process equipment for the fabrication and inspection of pellet fuel is being conducted. This process is of interest since it produces fuel that is licensable. This equipment will be installed and tested in the High Performance Fuel Laboratory (HPFL), which is to be constructed at Hanford, Washington, with operation presently scheduled for the mid-1980's.

Discussion

The ceramic line unit operations (shown in Figure 1) are used to fabricate fuel pins from oxide powders. The process is equally applicable for carbide fuel pellet fabrication. Within the ceramic line, the powders are blended producing a mixed oxide powder, binder is added for compaction, the powder is pressed into pellets, the pellets are sintered and each pellet is inspected for quality. The acceptable pellets and additional pin components are loaded into cladding tubes and the final end cap welded to produce a fuel pin.

The ceramic line has several offline operations that are used to recondition powder or pellets that do not meet material specifications. These operations include calcining (to expel volatiles), centerless grinding of pellets (to conform to diameter specifications), offgassing of pellets, adjustment of oxygen-to-metal ratio of pellets, and dry scrap recycle.

The conventional process equipment (or appropriate alternatives) used for the ceramic pellet fuel unit operations are being automated and designed to be maintained remotely.

The fuel fabrication equipment will have its own primary containment system even though the equipment will be installed in a shielded facility

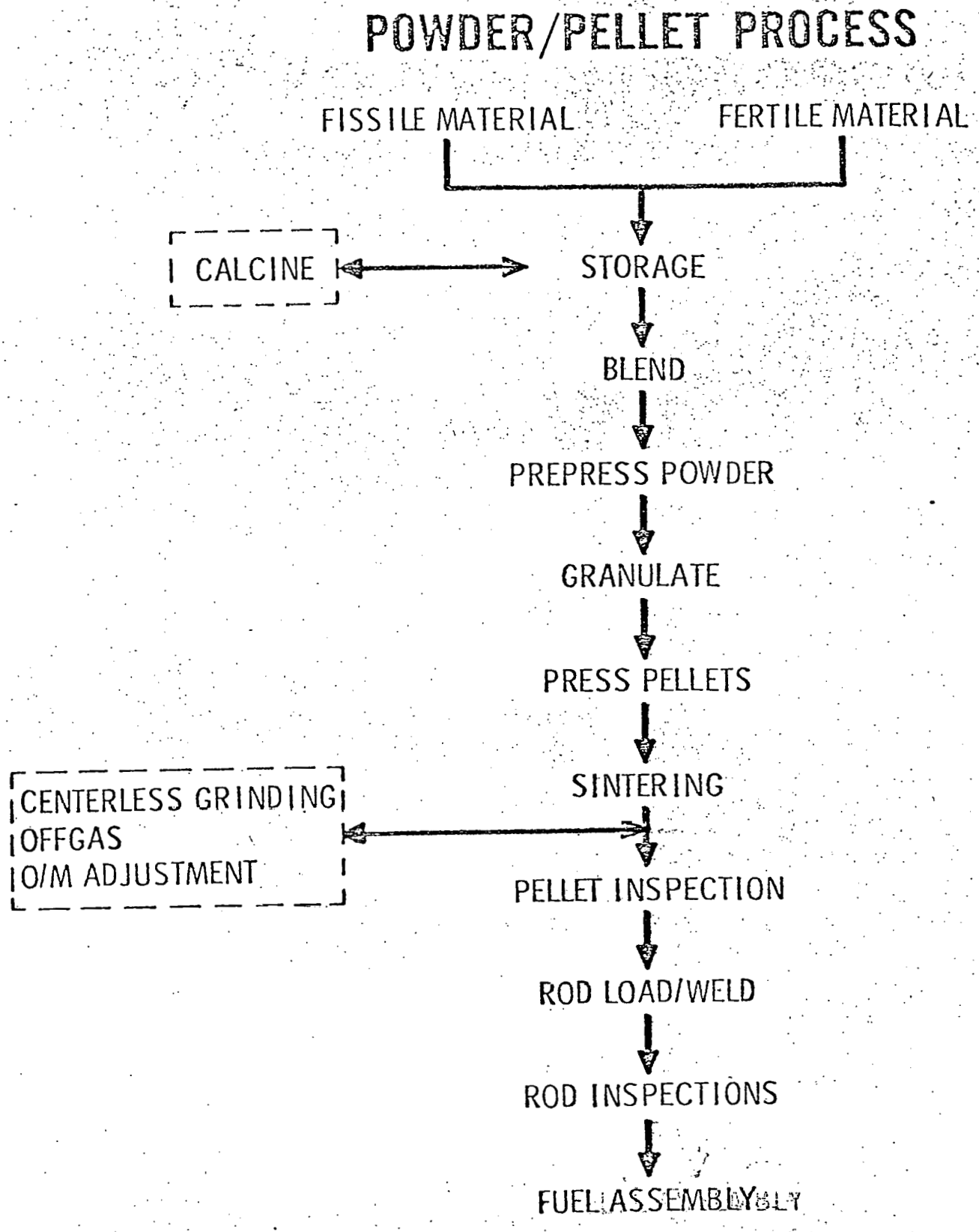
POWDER/PELLET PROCESS
FISSILE MATERIAL
FERTILE MATERIAL
CALCINE
STORAGE
BLEND
PREPRESS POWDER
GRANULATE
PRESS PELLETS
SINTERING
CENTERLESS GRINDING
OFFGAS
O/M ADJUSTMENT
PELLET INSPECTION
ROD LOAD/WELD
ROD INSPECTIONS
FUEL ASSEMBLY

Figure 1

with no manned access. This is to control the special nuclear materials (SNM) and to simplify decontamination operations.

Design Basis

Each unit process features modular design for ease of maintenance. Modules can be removed or replaced remotely with the use of either master-slave or electro-mechanical manipulators.

The equipment is being designed to connect/disconnect to building services such as power, process gases, cooling water, etc., automatically when it is set into place or removed. Where possible, drive motors, mechanical adjustments and electronic sensors are located outside of the primary containment.

Each unit operation will be operated and controlled by a dedicated stand-alone controller.

Instrumentation and Control System

The Instrumentation and Control System (ICS) provides centralized supervision of the unit operations via their dedicated controllers and will eventually coordinate all activities to form an integrated functional process. The ICS is responsible for data acquisition, data recording, data analysis, real-time control, accountability reporting, and communication with other control centers.

Since each unit operation is a stand-alone entity, it can function autonomously when adequate input and output materials are provided. Each unit operation will contain a dedicated electronics controller to monitor the sensor inputs, perform analysis, and output control signals to the process.

The dedicated controller is programmable so that various control algorithms can be implemented. In addition, the programmable controllers will use special routines to calibrate and test unit components.

The ICS will send control parameters and commands to the unit operations to direct fuel fabrication activities. The unit operations' controllers will return status information and sensor data to inform the control center of operational conditions so that additional commands or feedback controls may be applied as required.

Summary

The equipment for remote fabrication of pellet fuels is in various stages of design, testing and evaluation. A pellet gaging system specifically designed to be maintained remotely has been demonstrated and is currently being interfaced with a programmable electro-mechanical manipulator to demonstrate completely automatic and remote disassembly and reassembly of the inspection unit.

Pulsed magnetic welding of fuel rod end closures have been demonstrated.[1] The solid-state welding technique allows the use of ultrasonics for weld inspection in place of traditional x-radiography. This welding and inspection method provides an attractive alternative for remote fuel fabrication.

A new batch sintering furnace concept based upon aerospace technology is being developed.[2] The furnace will have five to ten times the throughput of conventional batch furnaces and is easier to maintain than the horizontal furnaces in use today.

Two high-speed mechanical press concepts (anvil and rotary) are currently being evaluated for remote operation and maintenance. The anvil press is especially attractive for remote fabrication due to its simplicity in set up and die change methods.

All pellet fuel fabrication operations will be developed for remote operation and maintenance and representative fabrication rates will be demonstrated.

References

1. W. F. Brown, J. Bandas and N. T. Olson, "Pulsed Magnetic Welding of Breeder Reactor Fuel Pin End Closures", Welding Journal, Page 22, June 1978.

2. W. W. Bowen and R. W. Buckman, "A High-Temperature, Low-Power Furnace for Processing Nuclear Fuel", Transactions of the 1978 Annual American Nuclear Society Meeting, Vol. 28, Page 269, June 18-22, 1978, San Diego, California.