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AN AUTOMATED SYSTEM FOR LOADING NUCLEAR FUEL PINS

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ABSTRACT

A completely automatic and remotely controlled fuel pin fabrication system is being designed by the Westinghouse Hanford Company. The Pin Operations System will produce fuel pins for the Fast Flux Test Facility (FFTF) and the Clinch River Breeder Reactor Plant (CRBRP).

The system will assemble fuel pin components into cladding tubes in a controlled environment. After fuel loading, the pins are filled with helium, the tag gas capsules are inserted, and the top end cap welded. Following welding, the pins are surveyed to assure they are free of contamination and then the pins are helium leak tested.

INTRODUCTION

The objective of the Secure Automated Fabrication (SAF) Project is to develop remotely operated processes for the manufacture of breeder reactor fuel pins. The SAF line will be installed in the Fuels and Materials Examination Facility (FMEF) presently under construction at the Hanford site near Richland, Washington.

The Pin Operations System will consist of a series of environmentally controlled work stations (Figure 1) that are designed to produce finished fuel pins. The system will be completely automatic and remotely controlled.

The Pin Operations System will receive the

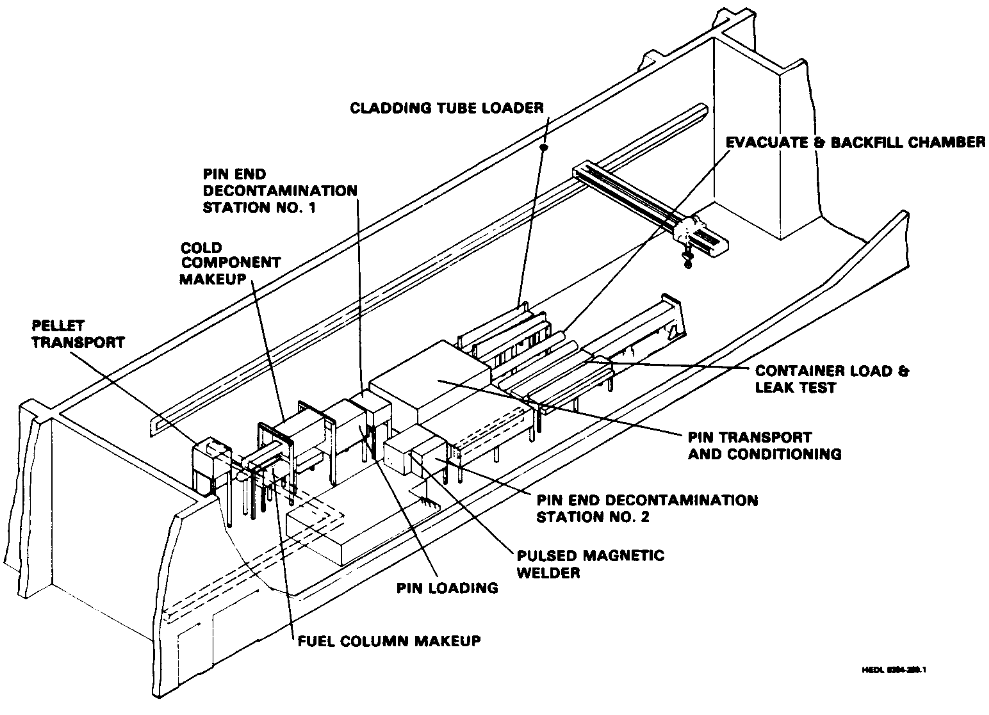

Fig. 1. SAF Pin Loading Equipment Arrangement

components necessary for fabrication of the fuel pins. The FFTF pin is depicted in Figure 2. After receipt of these components, the system will insert the components into the cladding tube, decontaminate the cladding tube ends, provide the required internal helium atmosphere, weld the top end cap, and leak test the pin. The process flow is shown in Figure 3.

SYSTEM OPERATION

Components for making up the pin assemblies will be received by the Pin Operations System as follows:

- Cladding with the bottom end cap welded and preloaded with the lower cold components will be received in magazines
- Sintered, inspected fuel pellets will be received from the Pellet Transport Subsystem and formed into measured and weighed columns
- Upper pin cold components (insulator pellets, reflector, plenum spacer, and spring for FFTF pins or blanket pellets, plenum spacer, and spring for CRBRP pins) will be received in magazines
- Tag gas capsules and top end caps will be received in magazines

The prerequisites for startup of the Pin Operations System are as follows:

- Two magazines of cladding installed at the Cladding Tube Loading Subsystem
- A magazine of tag gas capsules and a magazine of top end caps installed in the Pulsed Magnetic Welding Subsystem
- A magazine of cold components installed in the Cold Component Makeup Subsystem
- An adequate supply of fuel pellets in the interfacing Pellet Transport Subsystem of the Pellet Operations System

System operation commences with the Column Makeup Subsystem receiving fuel pellets from the Pellet Transport Subsystem of the Pellet Operations System. Incoming pellets will be formed into a measured column. A pushrod will be activated to transfer the column onto a weigh track.

The weigh track, containing the fuel column,

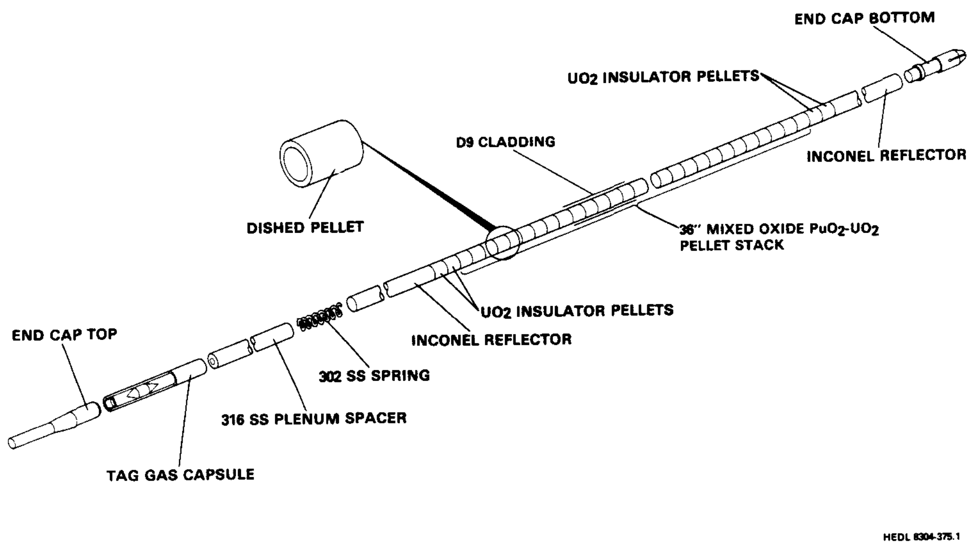

Fig. 2. FFTF Fuel Pin

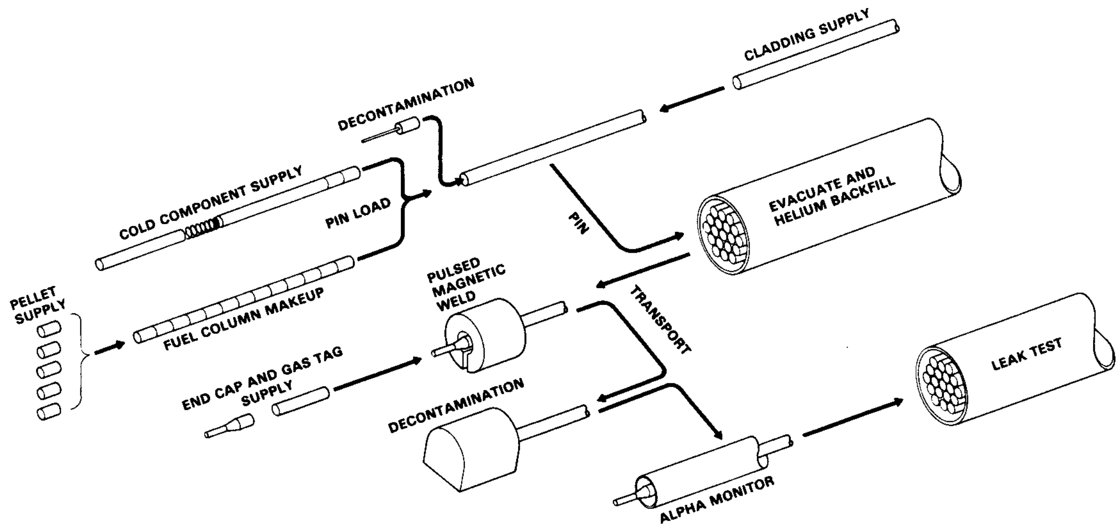

Fig. 3. Pin Load and Weld Process Flow

will be lowered onto an electronic scale and weighed. After weighing, the track will return to the elevated position. A second pushrod will transfer the fuel column into the adjoining fuel surge storage magazine.

The Cold Component Makeup Subsystem will consist of an unshielded enclosure, an X-Y table, a portable magazine, and a pushrod mechanism. In operation, the X-Y table will automatically index to position the magazine in front of the pushrod mechanism. The pushrod will then move forward, pushing a column of cold components out of the magazine and into the adjacent pin loading module.

The Pin Loading and Fuel Storage Subsystem will consist of two separate submodules: the fuel surge storage drum and a transfer mechanism.

Fuel surge storage will receive fuel columns from the Column Makeup Subsystem. The fuel surge storage will incorporate a pushrod mechanism to automatically move fuel columns into the transfer mechanism.

The transfer mechanism will automatically receive cold components one column at a time from Cold Component Makeup and one fuel column at a time from fuel surge storage. Each of these columns will be contained in a transfer wheel. The transfer wheel will rotate back and forth to position either fuel or cold components, as required, in front of the pin cladding being loaded. Pushrod mechanisms will then move the cold components or fuel columns from the transfer mechanism into the fuel pin cladding.

The Cladding Tube Loading Subsystem will receive a magazine loaded with cladding tubes complete with welded bottom end cap and lower cold components. The upper end of the cladding tube will have a loading funnel closed with a plug. The cladding tubes will be delivered individually to the upper transport ramp which in turn will transfer them into the Pin End Decontamination Station No. 1 where they interface with the Pin Loading and Fuel Storage Subsystem. The fuel column and upper cold components are then inserted by the pushrod. The loaded cladding will then be withdrawn to the decontamination station for removal of any fuel particulate from the end cap weld zone area. The cladding is withdrawn to the next station passing alpha detectors which monitor the cladding for contamination. If contamination is detected, a wipe mechanism is activated to remove the contamination. At the last station, a plug is inserted which acts as a stopper for transportation of the cladding to the remaining work stations.

The Pin Transport and Conditioning Subsystem consists of two major elements: the pin transport ramps and the evacuate and backfill chambers. The pin transport ramps transfer loaded fuel pins between the various work stations and provide in-process storage upstream of the evacuate and backfill chambers, and the pulsed magnetic welder. The evacuate and backfill chambers evacuate and backfill the pins with helium prior to final welding.

The Pin Transport and Conditioning Subsystem will receive cladding tubes from the Cladding Tube Loading Subsystem and furnish them to the Pin End Decontamination Station No. 1. After loading and decontamination, the pins will be transported to the evacuate and backfill chambers, where the pin internal atmosphere will be changed to helium. The helium-filled pins will then be transported to the Pulsed Magnetic Welding Subsystem. After welding, the pins will be moved to Pin End Decontamination Station No. 2. The decontaminated pins will then be transferred to the Alpha Monitoring Subsystem. After being checked for contamination, they will be transferred out of the ramp to the Container Loading and Leak Test Subsystem. Rejected pins will be transferred to reject pin storage.

The Pulsed Magnetic Welding Subsystem consists of the pulsed magnetic weld machine and the enclosed work station. The weld machine inductor and the work station equipment will be in the enclosure with the balance of the welder located outside the enclosure.

Loaded cladding is supplied to the pulsed magnetic welder from the lower transport ramp. The gas tag capsule and end caps are preloaded into magazines which are manually entered into the enclosure. After removal of the cladding plug, a capsule and an end cap are inserted into the cladding. The cladding is then positioned in the inductor and the weld is made. The pin is then returned to the lower transport ramp for transfer to Pin End Decontamination Station No. 2.

The fuel pin is moved into the Pin End Decontamination Station No. 2 from the lower ramp and the end cap weld zone surveyed for contamination. If contamination is detected, it is removed. The station also contains a CCTV system for visual inspection of the welded end cap to detect obvious defects.

The entire surface of the pin will then be surveyed. If contaminated, pins will be sent to reject pin storage. If not contaminated, pins will be sent to the Container Loading and Leak Test Subsystem.

The reject storage magazine is located at the lower end of the lower ramp. Pins rejected because of contamination as detected by the alpha monitor, or faulty welds as detected by abnormal weld parameters, or visual monitoring, are collected in the reject storage magazine. The magazine is detached and transported to another area for pin rework.

The Container Loading and Leak Test Subsystem will receive pins from the Alpha Monitoring Subsystem and automatically load them into a shipping cask liner. The shipping cask, with the loaded liner, is then transferred to the helium leak test chamber where the liner is transferred from the cask to the chamber. After the pins are leak tested, the liner is moved back into the cask for transport to the pin storage area in preparation for final pin inspection and assembly into fuel bundles.

SUMMARY

The design of the Pin Operations System has been completed and the equipment is now in the procurement phase.

A working mockup of the head end of the Pin Operations System up to and including the evacuate and backfill chamber has been assembled and successfully tested. This has proven the basic design to be sound.

End cap welds have been successfully made with the Pulsed Magnetic Welder using prototypic components.

All feature testing in support of the design has been completed.