A COLD DEMONSTRATION OF FUEL CONSOLIDATION PART II - THE INTEGRATED TEST

J. E. Matheson
B&W Fuel Company
Andre' Bouchoux
SGN

ABSTRACT

A cold demonstration test of equipment design to consolidate spent fuel assemblies was recently completed. The equipment consisted of two independent automated machines - one for consolidating the fuel assemblies, the other for shearing the remaining cages. All of the design objectives of both machines were achieved. Specifically demonstrated were (1) 2:1 consolidation of fuel assemblies, (2) 10:1 compaction of skeletons, (3) feasibility of three person operating crew, (4) ability to create one space per shift, and (5) the capability for both machines to operate in an automated mode.

BACKGROUND

The first paper in this series described the compaction machine developed by B&W Fuel Company and SGN to deal with spent fuel skeletons or cages. A successful cold demonstration of that equipment was completed in 1989 and achieved greater than a 10:1 compaction ratio of the skeletons. What remained to be demonstrated was an integrated test where both the consolidation of the fuel and the compaction of the skeletons were accomplished together. The purpose of this paper is to describe recently completed tests which demonstrated a machine capable of achieving 2:1 consolidation of the fuel and 10:1 consolidation of the skeletons.

THE TEST SETUP

Cold testing of the Fuel Master™ Consolidation System was conducted in Lynchburg, Virginia between October 1989 and February 1990. Figure 1 is a photograph showing the consolidation machine being set up in the pool test facility. Figure 2 is a closeup of this machine. Note that it consists of an upper structure and a lower structure. Mounted on upper structure are two rod transfer units which are capable of transferring rods simultaneously from two fuel assemblies. On the lower structure there are three stations. Two of these are fuel stations which are shown with fuel in place. In the center is a consolidation station. The rod transfer units directly transfer the rods from the fuel station into the canister located in the consolidation station. A single rod puller is employed. Figure 3 shows the collet attached to the end of the puller in relationship to a fuel rod.

The ability to directly transfer rods into the canister is the key to the Fuel Master system. Note in Figure 2 the nine rod arraying mechanisms located along the length of the canister. These act inside the canister to provide a tight lattice packing of the fuel rods. Two sliding plates are used to accomplish this. Figure 4 provides the details of this operation. Notice how the fingers from the top plate hold the row in place while allowing another row to be formed in a triangular pitch. As each row is formed, the mechanism is actuated and one plate steps off the previous row to create a new sequence of holes for the new row. As loading progresses the rod arraying mechanism simply walks itself out of the canister leaving nothing in the can but the consolidated array of rods.

Although the shear had been tested in France, a second series of tests were performed in concert with the consolidator testing. Figure 5 shows the shear in place at the pool test facility in Lynchburg. In this figure can be seen the feed stack, below it the shear body, and the canister trolley. Once all of the rods have been transferred to the fuel canister, the remaining skeletons (2) are placed, one at a time, in the feed stack. First, the lower end box is sheared and placed in the canister or set aside for later disposition. The door is then closed and the machine automatically shears the skeleton into small pieces less than one inch in length. The entire operation from the time the skeleton is introduced until the last pieces are sheared takes approximately one hour and 20 minutes. Thus, both skeletons can be dealt with in less than half of a shift.

To achieve the required 10:1 compaction ratio of the skeletons we have found it necessary to recycle the upper end boxes. That is, we reuse the upper end boxes as canister lids providing the exact same interface as a fuel assembly. Figure 6 illustrates a B&W end box being adapted to the fuel canister. Thus, only four upper end boxes end up in the scrap canister along with all 10 lower end boxes and all of the grids and guide tubes. Figure 7 illustrates the pieces of grids and guide tubes after they have been sheared. Thus, the concept is to fill up the boxes with the sheared pieces to maximize packing.

THE TEST RESULTS

The goal of the test program was to show that within a single shift two fuel assemblies could be introduced into the equipment, fuel rods could be transferred into the rod canister and both skeletons could be sheared into the scrap canister. Thus, two fuel assemblies are completely dealt with and one space created per shift. During February of 1990, the test program was completed and all of these goals were achieved.

In a mockup of a typical campaign, the following sequence of operations were completed.

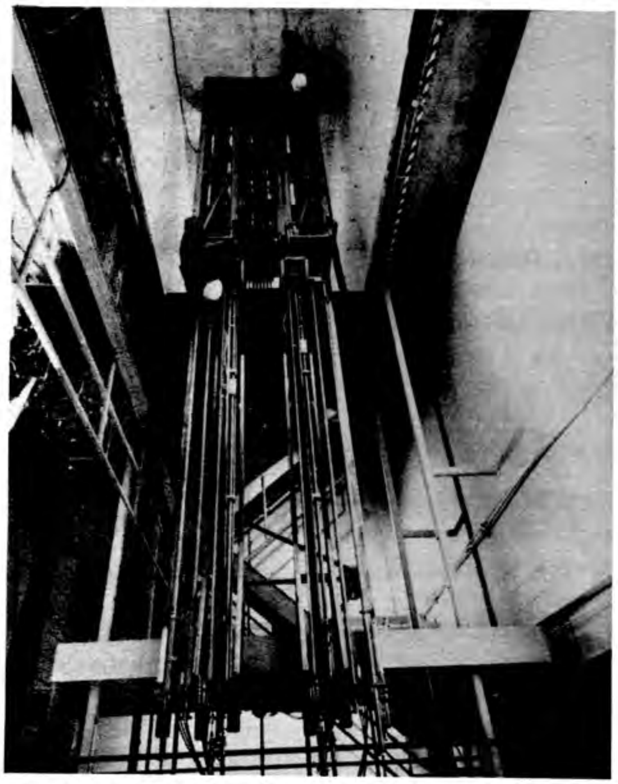

Fig. 1. Fuel Master Equipment Being Assembled at the Lynchburg Research Center.

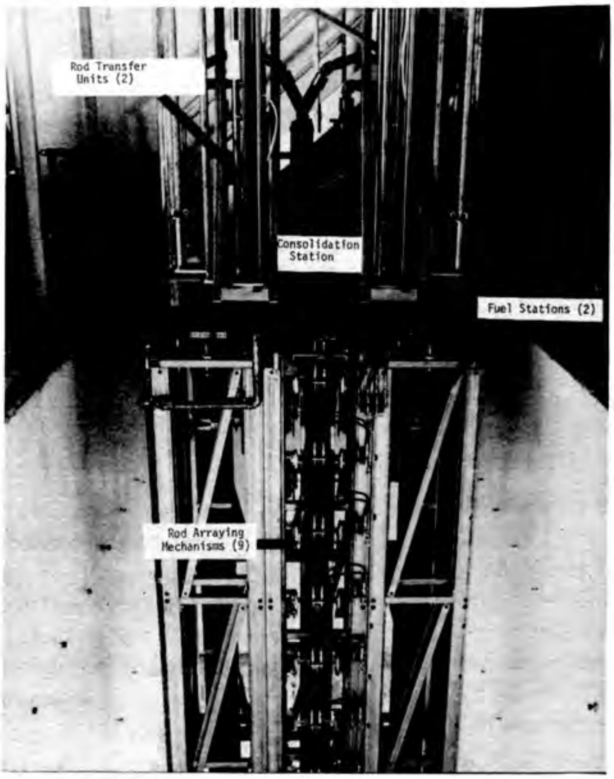

Fig. 2. A Closeup of the Consolidator.

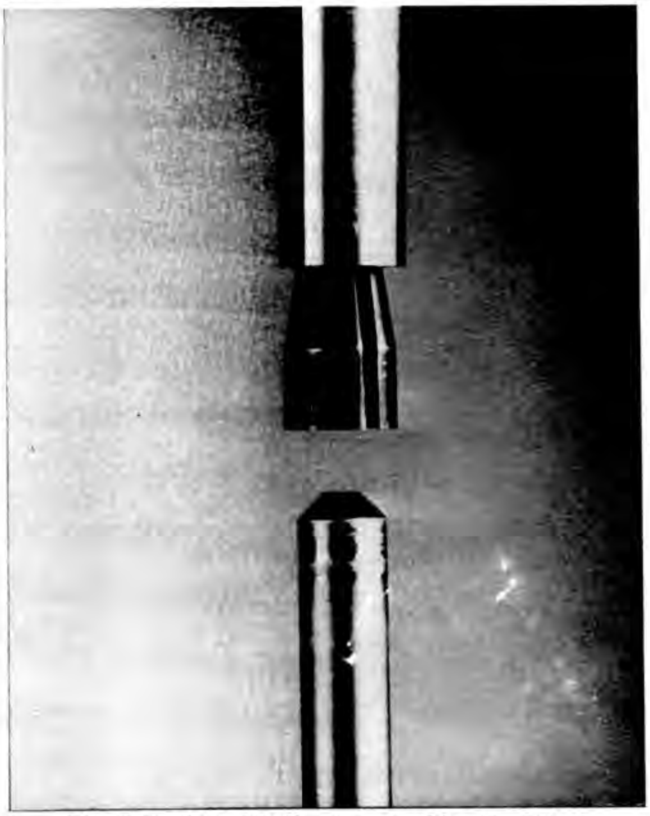

Fig. 3. Fuel Rod Puller Approaching Fuel Rod.

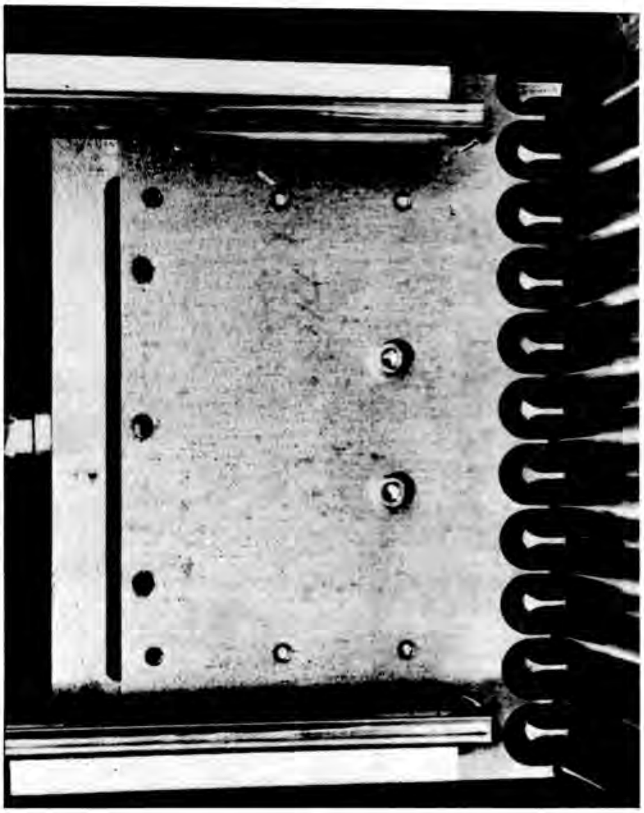

Fig. 4. Finger Plates on Rod Arraying Mechanism.

1.The canisters were installed.

2.The spent fuel assemblies were installed.

3.The upper end fittings were removed by automatically indexing to the guide tubes in cutting each guide tube with an internal cutter.

4.The rods were transferred in fully automatic mode to the rod canister.

5.The rod canister lid was attached via the adapter plate.

6.The skeletons were removed and placed into the shear.

7.The lower end box was sheared.

8.The remaining guide tubes and grids were sheared.

9.The scrap canister was lidded.

For the purposes of this early demonstration, the consolidator was run at a reduced speed. The cycle time for each rod was approximately two minutes. To achieve the process time of two fuel assemblies in a single shift the cycle time will need to be reduced to at least a minute and 1/2 (remember with the Fuel Master equipment two rods are packed in each cycle). The next step during the proofing trials will be to reduce the cycle time to approximately 80 seconds. This is viewed to be completely achievable in light of previous tests.

Also demonstrated during the tests was the ability to run the equipment with three people or less. This is important for economy, ALARA, and operational reasons. The use of automated transfer requires only one operator at the console during the rod transfer process. This operator views the sequencing events on both the computer monitor and the two video monitors which can select any two of three underwater mounted cameras. Likewise, the shear control system requires only one operator who, once the skeleton is introduced, need only monitor the automatic operations.

The critical objective of obtaining at least 10:1 on fuel assembly skeletons was verified during the Lynchburg tests. These were considered to be worst case tests because B&W fuel skeletons were used. These skeletons contain more metal than most other fuel due to the presence of two grid skirts on either end of the fuel assembly. Thus, for fuel other than B&W, consolidation ratios greater 10:1 can be anticipated.

SUMMARY

The recent demonstration program conducted on the Fuel Master Consolidation System proved that production rate performance can be achieved with automated fuel consolidation equipment. Specifically demonstrated were the capability of operating the equipment with three technicians, the capability to operate the equipment in an automatic fashion, the capability to completely consolidate two

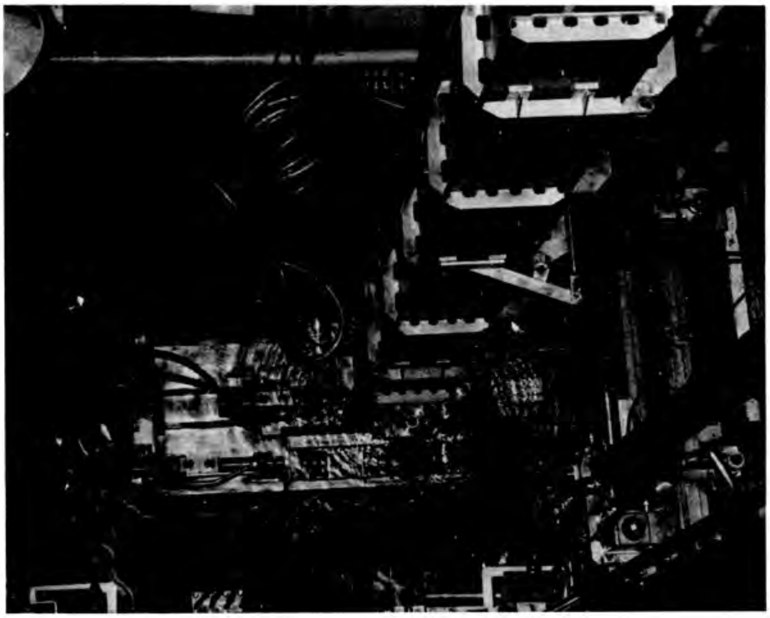

Fig. 5. Shear/Compactor in Place at the Lynchburg Research Center.

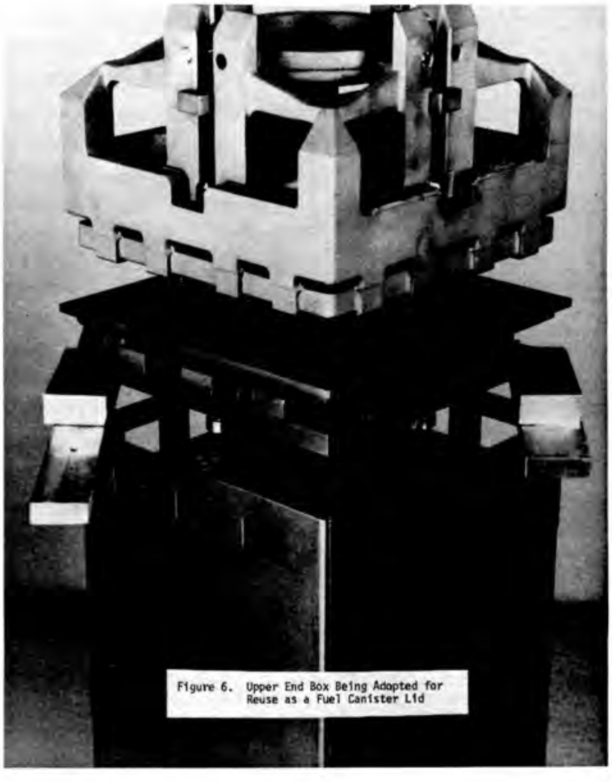

Figure 6. Upper End Box Being Adopted for Reuse as a Fuel Canister Lid

Fig. 6. Upper End Box Being Adopted for Reuse as a Fuel Canister Lid.

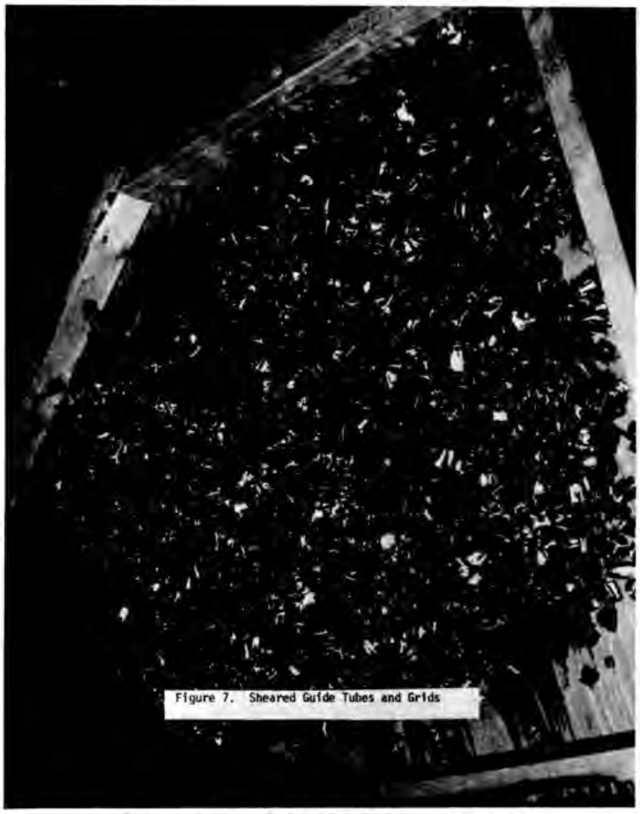

Fig. 7. Sheared Guide Tubes and Grids.

fuel assemblies in one shift, the capacity to achieve 2:1 fuel consolidation and 10:1 skeleton compaction.

Early experiences with consolidation have been technically successfully but operationally disappointing. First generation systems simply took too much time, created too much radiological debris and failed to deal effectively with the scrap. Now available are second generation machines like Fuel Master which have addressed all of the previous concerns about consolidation and demonstrated the ability to achieve production rates safely and efficiently. Thus, consolidation has been validated as a feasible, low cost alternative or adjunct to dry storage.