DEVELOPMENT OF A SHREDDER - HIGH PRESSURE COMPACTOR SYSTEM FOR DRY ACTIVE WASTE PROCESSING

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ABSTRACT

Currently, there are a wide variety of systems available to reduce the volume and to package dry active waste (DAW). This includes conventional drum compactors, large box compactors, various types of supercompactors, Impell's initial design of a shredder mated with a box compactor, and Impell's most recent system design of a shredder mated with a high pressure compactor (1270 psig ram face pressure).

Early in 1985, Impell Corporation, in conjunction with MAC Corporation, tested a horizontal high pressure compactor to determine the effect of increasingly higher compaction forces on the density of shredded DAW. A simulated waste mixture was used for this testing that duplicated, as closely as possible, the EPRI 1981 BWR plant average waste composition. The tests revealed that a shredder-high pressure compactor combination could achieve DAW densities approximately 70% higher than a shredder-box compactor combination and approximately 150% higher than a box compactor without a shredder.

Based on this testing, Impell developed an integrated shredder-high pressure compactor system design. After an economic evaluation of the alternative DAW processing sytems available, the Tennessee Valley Authority selected the shredder/high pressure compactor system as the most cost effective DAW volume reduction system for installation at their Watts Bar Nuclear Plant. This paper will address the details of the developmental testing, provide a technical description of the system, and look at the economics of the system as it compares with other DAW volume reduction and packaging systems.

DEVELOPMENTAL TESTING

Early in 1985, Impell Corporation, in conjunction with the MAC Corporation, tested a horizontal high pressure compactor to determine the relationship of the compacted density of DAW to increasingly higher compactor ram face pressures. The DAW mixture used for this testing was that which had been previously collected and shredded for the acceptance testing of the shredder-box compactor system at Carolina Power and Light's Brunswick Plant. This mixture, as shown in Table 1, duplicated, as closely as possible, the EPRI 1981 BWR Plant Average Waste Composition.[a]

The test activity was initiated by placing a known weight of previously shredded DAW material into the compactor's charging chamber. Using the compactor ram the DAW material was pushed into the compaction chamber and compacted. A total of nine (9) increasingly higher compactor ram face pressures were used to compact each of two (2) known weights of shredded DAW material. At each compactor ram face pressure the ram position was recorded and the compacted material density calculated.

The results of the two (2) tests are provided in Table II and plotted in Fig. 1.

The testing demonstrated that shredded material densities greater than 100 lbs/ft^3 could be obtained in the MAC high pressure compactor. This represented a factor of two or more increase over the density obtainable by the box compactor used in the initial Impell shredder/compactor system design.

Based on the test results, Impell has designed and is currently fabricating an integrated shredder/high pressure compactor system for TVA's Watts Bar Nuclear Plant utilizing the MAC/Saturn Corporation shredder and high pressure compactor.

SYSTEM DESCRIPTION

Equipment

The Dry Active Waste Shredder/High Pressure Compactor system is designed for the specific purpose of processing nuclear power plant wastes. The system consists of the following major components.

- Hydraulic driven shredder
- Waste feed conveyor
- Hydraulic high pressure compactor
- HEPA filter air handling system
- DAW container positioning unit
- System controls.

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a (EPRI-NP-3370, Electric Power Research Institute", Identification of Radwaste Sources and Reduction Techniques," January, 1984, Volume II, Figs. 4-9, P. 4-251).

TABLE I
EPRI 1981 BWR PLANT Average Waste Composition

Compactible - 68% of total
Rubber - (insulation off wire)
Plastic - (sheets, rolls, buckets)
Paper - (sheets, cardboard, sheetrock)
PVC - (pipes, tubes)
Metal - (small pipes, sheets)
Wood - (small pieces of boards, plywood)
Cloth - (canvas, threaded plastic)
Others & Misc. - (tin, barrels, wiring, trailer underpinning)
Noncompactible = 32% of total
Wood - (larger boards, wood frames, pallets)
Lead - (lead sheets, bricks)
Tools - unable to process through shredder
Conduit - (long metal pipes)
Concrete - (blocks, asphalt)
Glass - (broken fluorescent tubes)
Dirt - (soil placed in bags)
Filters - (unused HEPA filter)
Filter Frames - (AC unit, metal/paper units)
Composite Materials - (chairs, cushions)
Pipe - (large/long metal pipes)
Misc. - (3-ply copper tubing/rubber, ladders)

The shredder is a two shaft machine with low speed counter-rotating shafts. One shaft rotates approximately one half the speed of the other which provides excellent self cleaning and helps the shredding process for rubber and plastic material by tearing and ripping the thin tough material. The two hook cutters and the spacers used in the application are one and one-half inch thick high carbon steel carburized to a Rockwell scale range of 50 to 55.

The cutter shafts are driven through a simple large gear box by a low speed, high torque radial piston hydraulic motor. The hydraulic source is a separate skid mounted system utilizing two 75 horsepower electric motor driven, 3000 psig hydraulic pumps.

The shredder control system provides for automatic reversal of the cutter shafts should a particular object require more cutting torque. The object is dislodged momentarily and when the shafts automatically return to the forward direction, a different "bite" is taken on the object. Should the object turn out to be not shreddable, the machine will shut down after a preset number of reversals. An operator may then remove the object and place it directly into the compactor charging chamber.

The waste is transferred from the floor level collection area to the shredder by an inclined, cleated belt, electric motor driven conveyor.

As the waste is processed through the shredder, it drops directly into the compactor charging

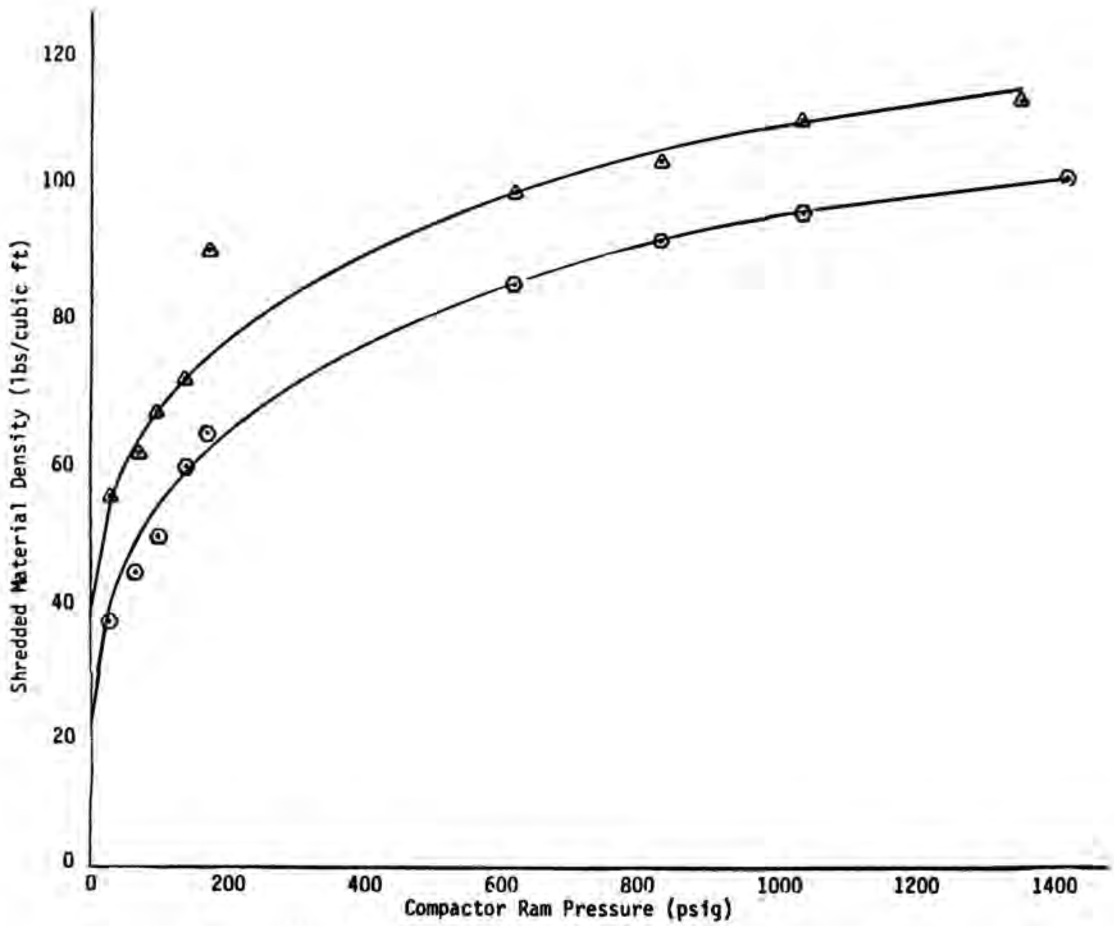

Fig. 1. Shredded Material Density Versus Compactor Ram Pressure.

chamber. The compactor ram cycles back and forth pushing the waste into the compactor chamber and compacting it.

The compactor is a horizontal high pressure compactor which has its own hydraulic system. Ram face compaction force is 600,000 pounds.

DAW containers are positioned at the discharge end of the compactor by the container positioning unit. This unit is specially designed to provide back and forth and up and down positioning of the DAW container utilizing double acting hydraulic cylinders.

The shredder and compactor housing operates at a slight negative pressure to minimize area contamination should the shredding and compacting process release dust contained within the waste. This negative pressure is maintained by an air handling system. It consists of an exhaust blower, roughing filter and a HEPA filter.

The shredder/high pressure compactor system is controlled from a control panel which consists of pushbuttons and status indicating lights arranged in a logical pattern and clearly labeled to facilitate operator control and surveillance.

The control system contains numerous interlock and permissive circuits to ensure safe operation and prevent equipment damage. The control system also includes a programmable controller to provide for automatic operation.

System Operation

Dry active waste is accumulated in an area near the feed conveyor. Starting the filtration fan allows, by the control system, the shredder hydraulic system, shredder drive, high pressure compactor, feed conveyor and container positioning unit to be started. System operation begins by raising the discharge gate, extending the compactor ram and attaching an intermediate lid to the end of the ram. After the compactor ram has been retracted and the discharge gate closed, an empty disposal container is then placed into the container positioning unit and positioned against the discharge end of the compactor.

Waste is loaded on to the feed conveyor at a rate which is comfortable for one man to handle. As the waste reaches the top of the feed conveyor it, drops into the shredder inlet hopper and proceeds through the shredding process. The shredded waste drops from the shredder into the compactor charging chamber hopper. As the shredded waste collects in the charging chamber hopper, the high pressure compactor is placed in the automatic operation mode. The compactor ram will cycle back and forth compacting the shredded material from the charging chamber hopper. The shredding and compacting operations are continued until the compactor ram reaches a location within the compaction chamber where one full charging chamber volume, or less, of shredded material is needed to complete a bale of compacted waste. The control system then determines the amount of ram stroke needed to complete the bale, the compactor ram is retracted this amount, shredded waste falls into the charging chamber and the final compaction stroke is made. By operating in this manner, uniform bale lengths will result, thus maximizing final packaged density. After the last compaction stroke, the hydraulic pressure is relieved which takes the force off the gate at the discharge end of the high pressure compactor. The discharge gate is raised and the compactor ram is used to push the bale into the disposal container. When the bale is fully inserted into the disposal container, the intermediate lid snaps into place in the container compartment opening. The intermediate lid disengages the compactor ram as the compactor ram retracts slightly.

After the intermediate lid is disengaged from the compactor ram, the container is moved back from the compactor discharge opening, and another intermediate lid is attached to the end of the compactor ram. The ram is then retracted, the discharge gate closed, and the disposal container positioned to accept another bale. The process described above is repeated until a total of three bales have been loaded into the disposal container. When full, the container is removed from the container positioning unit and the final lid put in place and secured.

Process Capability

The shredder itself can process Dry Active Wastes at rates up to 10,000 lbs/hr. Experience has shown, however, that the combined steps of feeding the waste and operting the compactor generally results in process rates of between 1,200 lbs/hr and 2,000 lbs/hr.

As shown in Table I, which describes the waste mixture used for the development tests, the system is capable of handling a wide variety of waste materials. Typical wastes include: paper, plastic, rubber, PVC sheet, PVC piping and components, wood, concrete, scaffolding, 55 gallon drums, non-ferrous metals, and mild steel pipe, tubing, and other mild steel pieces and parts up to approximately 1/4" thick.

COST BENEFIT EVALUATION

Purpose

The purpose of the cost benefit evaluation was to review the available DAW volume reduction systems to identify and compare their respective operational costs. The operating costs were then compared with the initial capital equipment costs to determine the overall cost effectiveness of the system.

The economic parameters evaluated were 1) the costs of the disposal containers, 2) the cost per cubic foot for burial, 3) the cost of shipment to the burial site, and 4) the cost of labor to operate the system. Equipment maintenance and power consumption costs were assumed to be comparable for all the systems in the evaluation.

The economics of a given processing option are dependent upon the annual waste volume and the percentages of compactible and noncompactible wastes. For this evaluation, the EPRI 1981 BWR plant average waste composition for a single operating unit were assumed.

The assumptions used and the results of the cost benefit evaluation are tabulated in Table III and IV respectively.

CONCLUSION

The cost benefit evaluation demonstrated that no single economic factor is controlling in the overall evaluation of DAW processing alternatives. All of the economic factors affecting the operating costs as well as the capital investment should be considered before the most cost effective processing alternative is determined. The final selection is a trade-off of final disposal volume, operating costs, and the initial capital outlay. Subjective factors which should be considered are the reliability, functionability, and ease of operation of the system. Labor intensity, particularly that for disposal container surveying, marking, and loading, as well as shipping paper preparation can have a significant impact on the annual operating cost. This impact is not always easily or readily quantifiable.

Another factor which should be considered in the selection of a DAW processing system is the form of the final product. More advanced DAW volume reduction techniques will most likely be required as industry needs change. One such technique which appears to be viable is regional incineration. Any DAW processing system selected today should produce an end product which can be easily prepared for incineration at some future date.

TABLE III

COST BENEFIT EVALUATION ASSUMPTIONS

Waste Volume		
Compactible (68%)	15,350 ft.^{3}/yr.	
Non-Compactible (32%)	7,200 ft.^{3}/yr.	
Burial	$25.49/ft.^{3}	
Shipping	$1,000/Shipment (45,000 lb. wgt. limit)	
Containers		
52 gallon drum	$20	(2 required for supercompactor)
55 gallon drum	$30	7.5 ft.^{3} burial volume
96 ft.^{3} box	$450	100 ft.^{3} burial volume
CPC B25 box	$420	10 ft.^{3} burial volume
Anti-spring back	$15	(2 required for box compactor)
Box for Impell high pressure compactor	$400	45 ft.^{3} burial volume
Labor -		$20/man-hour
Drum Compactor		3 man-hours/drum or box
Box Compactor		4 man-hours/box
Shredder/Box Compactor		8 man-hours/box
Shredder/High Pressure Compactor		8 man-hours/box
Super Compactor		5.2 man-hours/final drum

TABLE IV

Summary of Alternative Dry Active Waste Volume Reduction Systems Evaluation

BWR - ONE UNIT

Alternative Systems	Disposal Containers	Burial	Shipping	Labor*	Total Annual Operating Costs	Initial Cost	Ten Year** Cost-1985 Dollars	Payback Period Years
Conventional Drum Compactor	52,000	307,200	9,000	36,400	404,600	50K	2.54M	Base Case
Box Compactor	49,500	280,400	9,000	8,800	347,700	150K	2.28M	2.6
Shredder/ Compactor	30,900	187,350	8,000	11,750	238,000	400K	1.86M	2.4
Shredder/ High Pressure Compactor	38,800	111,250	8,000	15,500	173,550	425K	1.49M	1.8
Super Compactor	32,000	87,500	8,000	47,500	175,000	750K	1.82M	3.3

* Includes labor for equipment operation, disposal container surveying, marking, loading and shipping paper preparation.

** Present worth factor 6.1446 - (10% for 10 years).