SUPERCOMPACTOR FORCE EFFECTIVENESS AS RELATED TO DRY ACTIVE WASTE VOLUME REDUCTION

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ABSTRACT

The first U. S. permanently installed supercompactor is now in operation at the Babcock & Wilcox volume reduction center, Parks Township, Pennsylvania. Tests with various DAW (dry active waste) material have been conducted, recording press force versus drum height as one means of estimating volume reduction capability of this machine at various compaction forces. The results of these tests, as well as other factors, are presented herein.

BACKGROUND

The first supercompactor in the 1500 metric ton range was built by Machinefabriek A. Fontijne B.V. of Vlaardingen, The Netherlands, for the Energy Center Netherlands (ECN). It became operational in 1978. Dry active waste from approximately 300 low-level waste generators in the Netherlands is delivered to ECN for high force compaction.[1] This installation is shown in Figure 1. A second, 1500 ton press system became operational at Karlsruhe, Germany in 1984.[2] These two machines and the first U.S. machine have reliably compacted approximately two-hundred thousand 100 liter and 180 liter or 210 liter (55-gallon) drums, whichever size drum the given press was designed to handle. Due to the diameter differences of these drums, press force varies from 11,620 psi (800 Kg/cm^2) to 7,250 psi (500 Kg/cm^2). Other machines are available, ranging in force from 200 to 2,000 metric tons.

Fig. 1. First 1500 Ton Press Energy Center Netherlands.

Data published by the Electric Power Research Institute indicates that DAW that is compactible in conventional low-force compactors was about 52% of the waste volume shipped from nuclear power plants to burial grounds in 1977 through 1981. Non-compactible waste, that which cannot be reduced in volume with conventional low-force compactors, was about 48% of the volume shipped to burial grounds. It is estimated that the average density of both the compactible and non-compactible increments of waste shipped from nuclear power plants averages about 30 lbs. per cubic foot (0.5 Kg/dm^3). The DAW volume shipped, per the EPRI data,[3] averages over 10,000 cubic foot (285 m^3) per year per PWR reactor and over 25,000 cubic foot (700 m^3) per year per BWR reactor. We speculate that the percentage of previously non-compactible will increase. This material is more related to replacement of components, maintenance, etc. which will probably increase with the age of the plants. Conversely, the quantity of compactible DAW is probably more controllable by administrative techniques.

The need to reduce the volume of all DAW is emphasized by the uncertainty of the burial ground situation and the escalating cost of waste disposal. Supercompactors will significantly reduce the volume of all compactible and non-compactible waste ranging from paper, cloth and plastic to steel, wood and concrete rubble. Supercompactors and incinerators appear to be the two technologies offering the most promise for significant volume reduction of DAW. While incinerators provide more volume reduction for burnable material, they do not reduce the volume of material that is not burnable and, in most instances, require a limitation of the quantity of chlorine and sulfur bearing plastics. A study of the relative economics of DAW volume reduction techniques was presented at "Waste Management '84'".[4]

The supercompaction system utilized for these tests is a second generation, 1500 metric ton system designed and manufactured by Machinefabriek A. Fontijne and Stock Equipment Company. The basic press is shown in Figure 2. This system is now in operation at the Babcock & Wilcox volume reduction center, Parks Township, Pennsylvania. The system is designed to process thirty 55-gallon drums per hour. After staging drums for a press campaign, a microprocessor controls entrance of the drum through an air lock, press loading, pressing, unloading, height measurement of the pressed drums (hockey pucks), verification of space available in the overpack containers, loading of the overpack and sealing of the overpacks as required by transportation and burial regulations. The CRT and control console is shown on Figure 3.

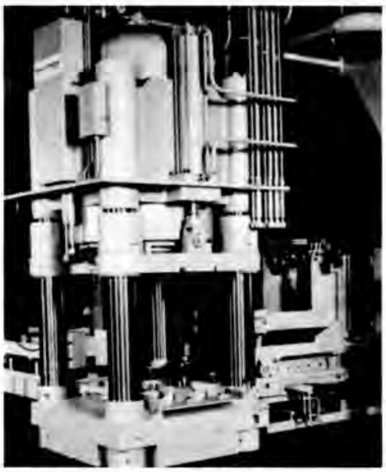

Fig. 2. Second Generation 1500 Ton Press Babcock and Wilcox Co.

Fig. 3. B & W Press System CRT Control

Volume Reduction Capability

Pre-acceptance testing of the press system was accomplished with a number of drums prepared to approximate the range of material expected to be contained in nuclear power plant dry active waste, both separately and combined as mixed wastes. The materials utilized included:

Paper	Plastic vials
Plastic	Hospital waste
Cloth	Concrete paving blocks
Spray cans	Electric motors
Hard wood	Scrap steel
Glass vials	Steel turnings

Photographs of a number of these drums which are more difficult to compact, before and after processing, are shown in Figures 4 through 6.

Fig. 4. Compaction of Electric Motors

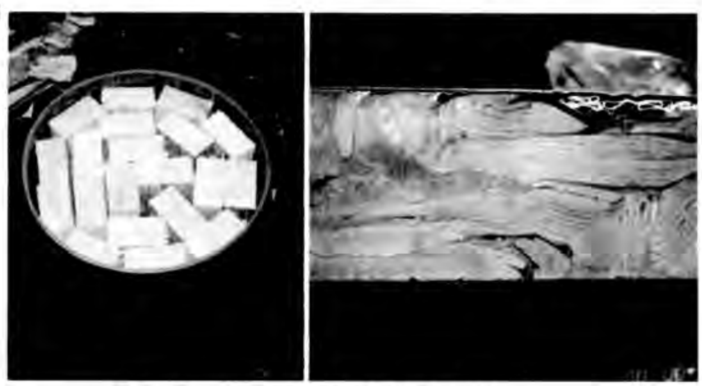

Fig. 5. Compaction of Hard Wood

Fig. 6. Compaction of Concrete Paving Block

To study the kinetics of the press operation and to determine volume reduction effectiveness, a strip chart recorder comparing press force versus drum height was utilized when processing the drums. Figure 7 shows an overlay of a number of these charts. The force peak on the left, shown as dotted lines for only the wood and steel curves, represents a high speed, low force (117 ton) circuit utilized to speed the process. When the high force circuit is needed, the controls automatically change to continue completion of the cycle. The high force (1500 ton) curves and peaks are shown as solid lines for the five materials illustrated.

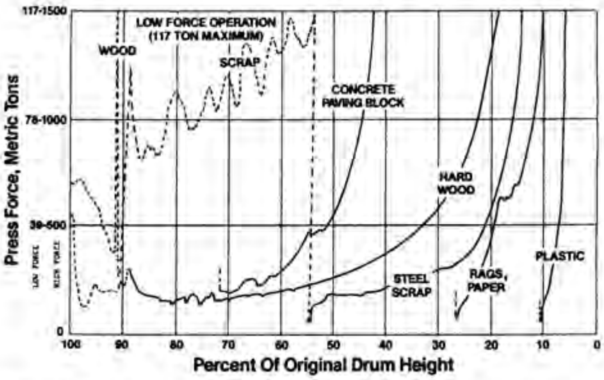

Fig. 7. Typical Force vs. Drum Height Curves

Figure 7 illustrates a number of interesting general points. Caution should be utilized, however, in drawing broad conclusions from this data because each drum, regardless of its content, will have an individual curve based upon a number of factors influencing volume reduction other than press force.

1. Initial press force starts in the 40 to 60 ton range and is applied primarily to overcome the strength of the drum.

2. The force then reduces as the drum collapses, which may also indicate that the drums were not 100% full.

3. The low (117 ton) force circuit then increases to its maximum. This point varies considerably based upon drum content. In these examples, the 117 ton circuit peaked at about 93% of drum height for hard wood versus 58% of drum height for steel scrap. This point is influenced by the type of material being reduced, how full the drum is loaded and other physical characteristics of the drum contents.

4. The high (1500 ton) force curve peaked at 43% of drum height for concrete paving blocks, 19% for hard wood, 14% for steel scrap, etc. Other than the fact that supercompactors provide signifi-cant volume reduction for all DAW, these percentage figures are not particularly significant. The percentages will vary substantially for the same reasons the low force peak will vary plus design features of the particular press being tested.

5. One observation is important. This is the shape of the high force curve. In general above 750 tons force the curves become quite smooth. Also, as would be expected, as the force increases the curves become more vertical, indicating that the amount of volume reduction per unit of energy expended is decreasing. The slope of the curves is similar in the 1000 to 1500 ton range with that for hard materials generally having a somewhat less steep angle.

This illustrates that maximum compaction for most materials requires a similar force although the percentage change for different materials may be different.

Overall outcome of the drums tested resulted in hockey puck (compressed drum) height that varied from 1.75" (45 mm) for plastic to 16" (400 mm) for solid concrete paving blocks.

The average height was 5.9" (150 mm). Density of the compressed waste including the drum varied from 87 to 306 lbs. per cubic foot (1.4 to 4.9 Kg/dm^3). The average density for these tests was 144 lbs. per cubic foot (2.3 Kg/dm^3).

Figure 8 is a plot of average strip chart data as a theoretical attempt to obtain relative volume reduction information related to press force. Force versus drum height strip chart data was plotted at 5 force levels for each drum tested. The drum height at each of the force levels was then averaged to obtain points from which the curve was plotted and extended to include the 2,000 ton level. Table 1 tabulates the average force and volume information utilized to plot Figure 7.

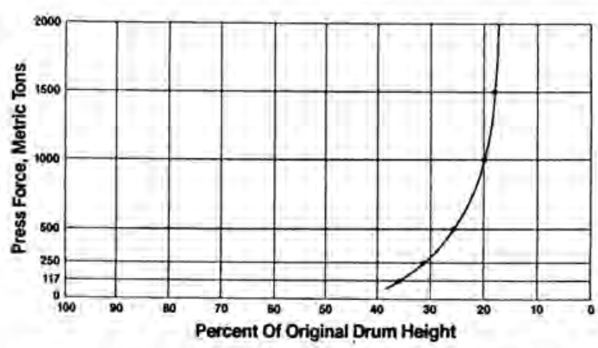

Fig. 8. Average Crushed Drum Height at Various Press Forces

The curve clearly illustrates the following points:

1. As specific force increases, and assuming that all other influences are equal, there is a decreasing return in volume reduction.

TABLE I

Average Press Force and Volume Reduction Comparison

Press Force Metric Tons	Specific Force* PSI	Specific Force* Kg/cm^2	Volume Reduction %	Final Volume %
117	566	38.5	61.4	207
250	1208	82.2	67.6	174
500	2417	164.4	73.0	145
1000	4833	328.8	78.8	114
1500	7250	493.3	80.8	103
2000	9666	658.0	81.4	100

*Based upon drum 55-gallon diameter.

2. If the waste tested is typical of average field material, considering capital, maintenance and operating cost as well as DAW disposal cost, the practical limit of specific force effectiveness is probably somewhere in the 6,000 to 10,000 psi (400 to 600 Kg/cm^2) range.

While this data represents hard data for the specific waste tested in a machine of a specific design, the data must be used with caution for comparative purposes for the following reasons:

1. Force versus height curves were not identical even when identical waste was loaded as nearly as possible, identically into separate drums. There apparently is no such thing as a standard drum applicable to dry active waste.

2. The volume reduction effectiveness is influenced by the following factors in addition to press or specific force.

    a. The type or types of waste being compacted. For example, the theoretical density of various grades of paper varies from less than 60 lb/cu. ft. (1 Kg/dm^3) to over 200 lb/cu. ft. (3.2 Kg/dm^3).

    b. How full the container is loaded. Is the waste initially at 10 lb/cu. ft., (0.15 Kg/dm^3), 20 lb/cu. ft. (0.30 Kg/dm^3), or some other density prior to pressing.

    c. How the waste is physically loaded into the container. (This becomes less important as the maximum force increases.)

    d. Design of the container -- Even at supercompactor pressure some waste retains an ability to cause springback after the force is released. The compressed drum may lengthen, the head may bow or, in extreme cases, the container may separate to relieve elastic pressure.

    The drum material, its thickness, and the design of the press working parts influence the degree of springback. If the drum material is relatively thick, if it is handled in a manner to provide some work hardening of the material, if the configuration of the press chamber maximizes force in two or more planes and if potential head bowing is considered in the design of the presses working surfaces, springback will be minimized.

    e. Under some circumstances press speed and dwell time may also have a minor effect upon volume reduction effectiveness.

The above discussion indicates that there are many factors influencing volume reduction in addition to press force. From a practical standpoint, effective volume reduction may also be significantly influenced by overpack container design and available operating modes as they may influence the efficient utilization of overpack volume. If you only have 20" (500 mm) high compressed drums to fit into a 35" (890 mm) high overpack, the loss is significant. The following steps were taken to maximize overpack filling for the STOCK-Fontijne 1500 Ton Press System.

1. The press feeding mechanism provides the capability of automatically feeding drums of different weight or containing different material to the press in a controlled pattern. This provides compressed drums of various height at the press exit.

2. A number of hockey pucks are staged at the exit of the press and their height is measured and stored in the computer.

3. A number of overpack containers are positioned to permit loading any hockey puck into any overpack under computer control.

4. The available space in each overpack is verified after loading of each hockey puck.

    This procedure, described in Items 1 through 4, automatically provides a 144:1 chance of filling each overpack.

5. The effective drum diameter is expanded significantly during the pressing operation. This reduces the height of each hockey puck, provides more active two directional forces to minimize residual stress in the waste and work hardens the container to increase its effectiveness as an anti-springback device.

6. The shape of the press platens is designed to minimize head bowing and to enhance the application of force in a second direction.

    Our overall conclusions from evaluating this data and that available from other sources is first, the utilization of weight and final density, while not perfect, is a more reliable means of evaluating volume reduction effectiveness than volume reduction factors. For example, initial weight of the container, particularly if the type of contained waste is known, provides some indication of how full the container is prior to processing. Initial and final density can be easily calculated and a number of variables that could create a wide swing in volume reduction factors are eliminated hence enhancing the reliability of the data for comparative purposes. Secondly, there is "no such thing as a standard drum" and many factors other than force influence volume reduction effectiveness. The curves shown on Figures 7 and 8 represent hard data for the specific press system, its operating mode, the specific waste utilized and other criteria but the data probably is not viable for comparison with other press systems, types of waste, etc. except as a very general guide.

SUMMARY

Test data are presented providing some indication of the volume reduction potential of a 1500 ton Supercompactor. This high force machine effectively provides volume reduction for all categories of dry active waste. The volume reduction potential of this machine is greater when processing DAW previously considered non-compactible as compared to waste that can be processed in low-force machines.

Many factors in addition to press force influence practical effectiveness of volume reduction of dry active waste. This data may or may not be representative of results under other site-specific circumstances.

REFERENCES

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