Case Study:

How Champion International Recycles Plant Sludge and Boiler Ash into Portland Cement

Billy Huston, Kenneth L. Hardesty, and Enrique H. Beer

Company:
Champion International Corporation
Location:
Hamilton, Ohio
Number of Employees:
1,500
Business:
Manufacturing of printing and writing grades of paper
Program:
Recycling of nonintegrated paper mill sludge and boiler ash as raw materials for the manufacture of portland cement
Objective:
Find and implement a cost-effective and technically feasible alternative disposal method for process waste materials to reduce the paper mill's dependency on landfills.
Bottom Line:
100 percent of sludge and boiler ash is now recycled as a raw material in portland cement instead of being sent to a landfill. Recycling will soon be achieved at a price of $30 to $35 a ton, which is competitive with state-of-the-art landfill costs.

WIDESPREAD PUBLIC OPPOSITION and the rising costs of using landfills, coupled with compelling economic and environmental reasons to support pollution prevention, are driving businesses to try harder to avoid, reduce, or reuse the waste by-products of industrial processes. Although source reduction is at the top of the hierarchy of waste management techniques, practical financial and technical considerations require companies to pursue cost-effective recycling too. In fact, companies in many industries have made significant progress with a variety of recycle/reuse strategies including in-process recycling, the sale of waste by-products as replacements for commercial raw materials, and waste exchanges between plants.

In particular, the utility and paper industries have made great strides in finding strong markets to sell their wastes for reuse as raw materials in the manufacturing of other products. This article[1] discusses Champion International Corporation's successful recycling of sludge and boiler ash waste by-products from paper manufacturing for use as a raw material in the production of portland cement.[2]

Weighing the Options

Champion International's paper mill, located in Hamilton, Ohio, produces printing and writing grades of paper. About 500 tons of paper are manufactured each day. In the process, the Hamilton Mill generates up to 120 tons of primary waste treatment plant sludge (60 tons dry) and 50 tons of coal-fired boiler ash a day. From 1970 to 1989 all the sludge and boiler ash were deposited in Hodapp Landfill, an industrial landfill six miles from the paper mill and owned and operated by Champion. In 1984, Champion began planning for a replacement landfill for Hodapp. The final selection, made in

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1989, was a site in Reily Township, about fifteen miles from the mill.

Although a state-of the-art landfill was designed, Champion still encountered fierce opposition to the operation from neighbors. As a result, the company intensified its efforts to find alternatives in case legal delays barring the operation of the landfill should occur. The criteria established to judge the alternatives were:

- Technical feasibility
- Economic feasibility
- Environmental soundness
- Strong demand for the final product containing the recycled waste
- Market acceptability for all forms of waste used to replace commercial materials
- A market large enough to use all waste generated

Among the major processes available—the ones with the most potential were:

- Strip mine land reclamation
- Composting
- Aggregate
- Portland cement raw material

The first three did not meet all of the criteria for successful commercial operation in this part of the country. Strip mine land reclamation involved placing the sludge and ash in the excavation area where coal had been removed. Because of the similarity of this process to landfilling, it was felt that strip mine land reclamation was not more environmentally sound than using a landfill. This was further complicated by the fact that Champion had no direct control over the reclamation of land, but still had a high potential liability. Composting by itself was technically not a feasible option to process Champion's material due to the waste material's low organic content. Mixed composting with other materials, such as yard waste, was technically viable, but no composting operations of this type were available in the area at the time. Making the material into lightweight aggregate pellets was also a workable option. Because of the presence of a large number of sand and gravel quarries in the area, however, the market for aggregate was doubtful. The last option, the portland cement process, appeared to best meet Champion's needs. Based on experimentation and field trials at various cement kiln locations arranged by a waste brokerage firm, Systech Environmental Corporation, it was determined that both the sludge and boiler ash could be substituted as a component of the raw material mixture used to manufacture portland cement.[3] Limestone, clay, and silica are typical ingredients in the cement manufacturing process, and large quantities of all three elements appear in the mill waste and boiler ash.

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Experimentation began in mid-1988.[4] Since September 1991, 100 percent of the sludge and boiler ash have been used as raw materials in the production of portland cement. This has eliminated the need to send these papermaking wastes to a landfill, and the cost of recycling the waste and boiler ash into cement is competitive with a modern landfill operation.

Paper Wastes in Cement Production

Cement manufacturing covers an enormous variety of types and chemical composition, but Portland Type I comprises the bulk of the industry's production. It is estimated that 50 percent of industrial by-products are potential raw materials for portland cement manufacture. For example, flue gas desulfurization sludge from fossil fuel-fired boilers contain the same limestone and silica substitutes found in the waste materials from the paper manufacturing process. Electrostatic precipitator dust from steel mills, sludge from lime-soda water softening systems, and some wastewater treatment may also be appropriate substitutes for the Portland Type I cement raw materials.

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As shown in **Figure 1**, the portland cement manufacturing process has four major steps. Rock is quarried, crushed, and each raw material in the stone mixture (limestone, cementous rock, clay, and iron ore) is stored separately. In the second step, the raw materials are carefully proportioned and are ground to a powder and blended. Alternatively, the raw materials are ground, mixed with water to form a slurry, and blended. Third, the raw mix is subjected to high temperatures—1500° to 1800° C (2500° to 2800° F)—in a rotary kiln. The high temperature chemically changes the raw materials into cement clinker. In the final stage of the manufacturing process, the clinker, with gypsum, is ground into a fine powder.

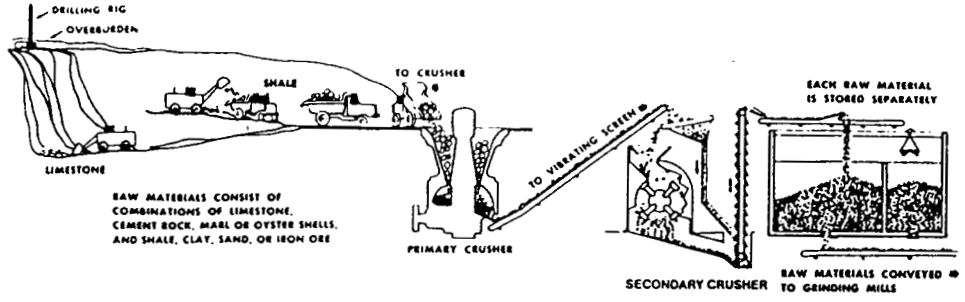
Trials and Success with Paper Waste Recycling

The chemical composition of the sludge and the boiler ash compared to Portland Cement Type I is detailed in **Table 1**. As the table shows, each of the waste materials has the same chemical composition as cement, confirming the suitability of substituting sludge and fly ash for rock in the production of cement. Normal raw material ratios are adjusted slightly to accommodate sludge and ash variations. (Sludge and ash represent only 2 percent of the total mix.)

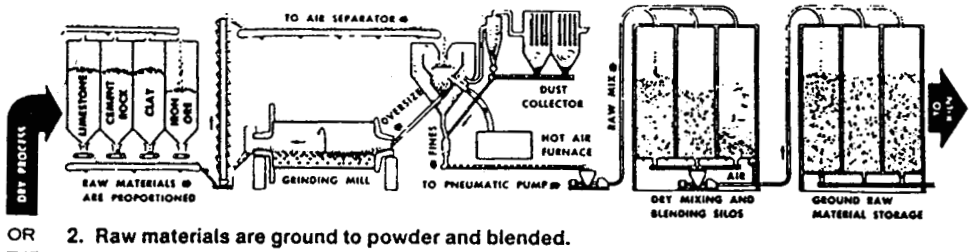
The substitution of the sludge and boiler ash takes place in Step 2 of the portland cement manufacturing process. (See Figure 1.) There was no problem processing the boiler ash from the start. However, two minor problems occurred with the use of the Hamilton Mill's primary clarifier sludge after it was dewatered by screw pressing. First, all cement making feed materials are ground to pass through a 40-mesh screen. (Mesh is the number of wires per inch of screen area.) Because the sludge from the paper making process has 30 percent wood fiber, it tended to get caught and "blind" the screen. (See **Table 2**.)

The other problem with the process was the odor that developed from the sludge after it was kept in storage piles for a few days before

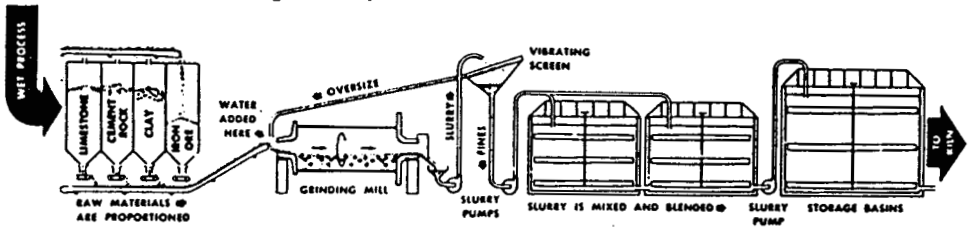
Figure 1. Steps in the Manufacture of Portland Cement



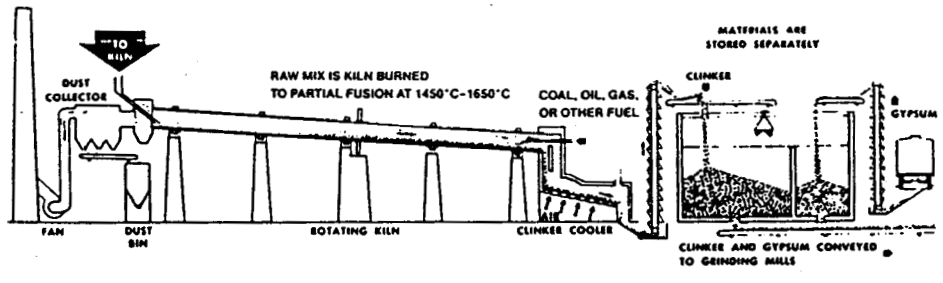
1. Stone is first reduced to 125 mm size, then to 20 mm, and stored.



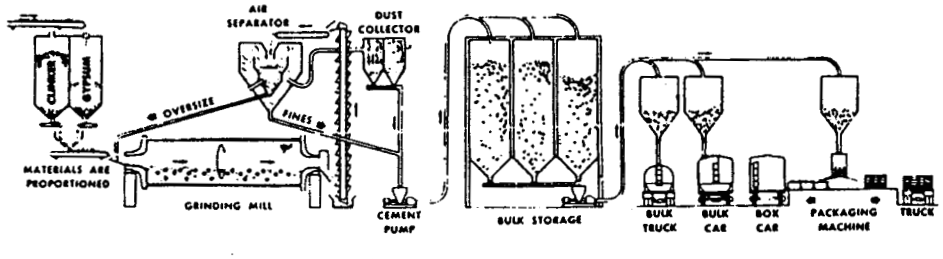
OR 2. Raw materials are ground to powder and blended.



2. Raw materials are ground, mixed with water to form slurry, and blended.



3. Burning changes raw mix chemically into cement clinker.



4. Clinker with gypsum is ground into Portland cement and shipped.

Table 1. Chemical Composition of Sludge, Boiler Ash, and Cement

Material	*Silicon Dioxide*	*Aluminum Oxide*	*Iron Oxide*	*Calcium Oxide*	*Magnesium Oxide*	*Sulfate*
Cement	20.9	5.2	2.3	64.0	2.8	2.9
Sludge	27.0	20.0	.6	19.0	.8	.4
Fly Ash	37.0	17.0	3.4	1.3	.6	2.4

the grinding took place. The odor led to complaints from the operators at the cement plant.

After dewatering by screw pressing, the Hamilton Mill's primary clarifier sludge had a moisture level of about 45 percent. The sludge odor and screening problems were ultimately solved by further drying the waste in a rotary dryer to achieve a 5 percent to 15 percent moisture content. This made it possible to establish a different proprietary feed point that bypassed the screens. Also, it was possible to stabilize the odor when the sludge was dried.

Cost Advantage over Landfill Disposal

From January to July 1989, more than 5,300 tons of boiler ash and more than 5,400 tons of sludge were processed as a component (2 percent of the mix) of portland cement. Further development trials continued through mid-1991. Beginning September 9, 1991, 100 percent of both materials have been processed into portland cement, eliminating the Hamilton Mill's need to use a landfill for process waste materials. The total costs of processing the boiler ash and waste, which are carried by the mill, have ranged from $30 to $50 a ton. The costs are expected to fall to the $30 to $35 a ton range during 1992. The $30 to $35 cost to the mill of processing the paper manufacturing waste materials sludge and passing those waste materials on to the cement producer is competitive with the cost of disposal in a state of-the-art landfill, which averages about $30 to $40 a ton in the region.

Summarizing the Benefits

Recycling of paper mill waste and boiler ash into portland cement has proven to be very attractive. Advantages include the following:

- The solid waste is recycled into a commercial product.
- The recycling of this nonhazardous waste into cement meets all environmental regulations. It requires no special permits and no routing monitoring other than TCLP (toxicity characteristic leaching procedure) analysis annually.

Table 2. General Composition of Primary Clarifier Sludge (Percent)

Clay	40
Wood Fiber	30
Calcium Carbonate	19
Casein and Soy Protein	4
Latex, Dye, and Defoamer	4
Starch	2
Titanium Dioxide	1

- The high process temperature of 1500° to 1800° C destroys the fiber and other organic materials in the waste.
- The high cost of a modern landfill operation has closed the gap with the costs of recycling materials into the cement process.
- The strong domestic and international market for cement prevents a possible glut in the market for recycled raw materials.
- The huge size of the cement industry (U.S. 60 million and the world 1100 million metric tons) provides an abundance of cement plants for recycling paper industry and other industries' waste.
- Truly, one company's wastes have become another company's raw materials.

These factors all reinforce the economic and environmental advantages of recycling rather than simply throwing the material away. The cement industry is an old and stable industrial sector. Its product, portland cement, is a multicomponent product that is able to accommodate a wide variety of trace elements without adversely affecting product quality. In addition, the income realized from the cement kilns by using by-products can enable them to improve their market position against foreign competition. ◆

Notes

1. Formal presentations on this recycling process have been made at the following conferences:

Great Lakes Section Meeting of National Council for Air and Stream Improvement for the Paper Industry (NCASI), September 1990.

Technical Association of The Pulp and Paper Industry (TAPPI) Environmental Conference, April 1991.

University of Wisconsin Symposium on the Utilization of Industrial Sludges and Ashes, October 1991.

University of Dayton Green Manufacturing Conference, December 1991.