Solid Waste Management and Waste Reduction Techniques

An Online Continuing Education Course for Engineers

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SOLID WASTE MANAGEMENT AND WASTE REDUCTION TECHNIQUES

Why Should Engineers Be Interested?

The management of solid waste is one the United States' most protracted policy concerns. Making room for the 236 million tons of solid waste generated per year is of course a problem. But so are the increasing land use and environmental concerns surrounding the current disposal methods. Public decision-makers are faced with a wide range of tough choices and uncertain outcomes. In other words, solid waste is a problem and a problem that should be addressed on many fronts.

The traditional waste management bureaucracy is dominated by engineers, whether working for a city public works department, a regional special purpose agency, or a private waste management firm. Engineers are also intimately involved in many of the activities that produce large amounts of waste, such as construction or industrial processes. We as engineers have been successful at designing better and safer disposal methods. But we have been reluctant to effect strategic planning initiatives that address the whole waste generation and disposal cycle. Source reduction, material reuse, recycling, product packaging constraints, or industrial process changes—all are examples of steps that can be taken toward reducing the amount of solid waste. The current production and management mindset, though, is in many ways still focused only on finding bigger and better methods of solid waste collection and disposal.

This course will outline many of the strategies the engineers can implement to move past the current mentality, to more effectively reduce and manage solid waste. Not all of the techniques listed in this course are pure "engineering solutions." Many are financial or policy-oriented. But since engineers are in the driver's seat in managing solid waste, it is incumbent upon them to be aware of the entire spectrum of possibilities. Indeed, the New Zealand Trust, an organization dedicated to reducing the amount of solid waste produced in its home country, has explicitly listed engineers as key participants in the fight to "waste less."

This course has many parts. First, since examining the past can often help us plan for the future, the course opens with a brief history of waste management in the US, leading up to current practices. It then goes on to describe in simplified terms the technical and operational details of waste management today. Finally, it will conclude with a discussion of waste reduction techniques.

BRIEF HISTORY OF SOLID WASTE MANAGEMENT

Mother Nature as Solid Waste Manager

Humans have been generating solid waste as long as they have been consuming plants and animals. Ancient human settlements disposed of animal bones, plant residues, and other debris into what archaeologists now call middens. Today, these middens are valuable sources of information about ancient cultures.

The Ohlone Indians of the San Francisco Bay area built huge shell mounds or shell middens of discarded abalone, mussel, and clam shells--staples of the Ohlone diet--along with sediment, ash, and rocks. Over time the mounds grew larger and taller from successive use, accumulating shells, animal and human remains, ceremonial burial objects, artifacts of everyday use, and architectural remains. Over a period of about 3000 years, more than 400 of these mounds were built around the Bay, and the largest were over 200 feet long and 30 feet high. Archaeologists now think that these shell mounds had spiritual as well as practical value.

That is a particularly dramatic example of early solid waste management. Most cultures merely disposed of solid waste in nearby piles. When humans were sparsely settled and when the composition of the solid waste was primarily food waste, management wasn't an issue. Often it was composted or fed to livestock. If waste was left in place, it would biodegrade. Mother Nature was the solid waste manager. This system lasted for thousands of years. However, along with the industrialization of the 1700 and 1800's came rising urbanization and rising consumption, and solid waste gradually became more and more of a problem.

Beginnings of Waste Management

At first, many thought that the accumulation of public refuse was merely a noisome symptom of living in a city. Public refuse, which included household wastes, ashes, horse droppings, and litter, certainly wasn't seen as something that required organized and systematic management. If waste accumulation did become a problem, a privately paid scavenger was employed to cart it away. It wasn't until the 1880's that the refuse problem began to receive widespread public notoriety. At this time, so-called sanitarians began addressing municipal water supply and sewer disposal issues. These same sanitarians began to turn their attention to solid waste as a new danger to human health, the "third pollution." The public, who already experienced the benefits of publicly managed water and sewer services, embraced the idea of a publicly managed waste management effort. Boards of health or health commissions were created and given power over waste collection and disposal. These boards were usually comprised of elected officials; very few boards had medical or technical members.

Early disposal methods were crude. Most cities simply dumped their collected wastes into nearby bodies of water, or, if water wasn't handy, onto vacant lots outside city limits or near undesirable neighborhoods. In 1880, 40 percent of cities dumped their waste on land or buried it, 22 percent used it as fertilizer or animal feed, 10 percent dumped it in water, and 1 percent burned it. New York City dumped over one million cartloads of garbage into the ocean in 1886.

As America shifted from a producer to a consumer society from 1880 to 1920, the amount of waste generated skyrocketed. Part of the problem was the nature of the goods consumed. Mass production techniques gave rise to new products like gum, razors, and tin cans that had never been made in the home and were cheap enough to be disposable. Second, rising incomes and declining prices allowed ever increasing consumption of these items. The result was a 43 percent increase in garbage in Pittsburgh between 1903 and 1907. In the same period, Milwaukee's increased by 24 percent, Cincinnati's by 31 percent, and Washington, D.C.'s by 24 percent. In 1905, the average American generated 860 pounds of waste a year.

Quickly, then, the early disposal methods became inadequate, and public health officials struggled with new ways to dispose of the mounting refuse. The 1895 appointment of Colonel George E. Waring, Jr., as street cleaning commissioner of New York City signaled a must-needed shift in solid waste management thinking. Waring was an engineer-cum-sanitarian, already famous at the time for his work with sewers in Memphis. To tackle the daunting solid waste problem in New York, Waring implemented a multi-faceted approach that targeted waste generation and collection as well as disposal. He started a public education campaign to encourage citizens to throw away less, to separate their waste at the curb (into garbage, rubbish, and ashes) to facilitate collection, and not to litter (which was acceptable public behavior at the time). He professionalized the street cleaning corps. He redesigned the garbage barges so they dumped waste more efficiently and farther from shore. Finally, he built rubbish-sorting and garbage-reduction plants, where waste would be sorted and salvageable materials, such as rubber, tin, or grease, picked out and resold. The profits from this were used to offset collection costs. Waring's tenure was short--he left in 1898--but his impact was large. First, he assured the public that the municipal government was the best body to handle solid waste. Second, he showed that technological solutions were very successful. Finally, and perhaps most importantly, he was key in passing the responsibility for solid waste from public health officials to engineers, where it has resided ever since. Unfortunately, his other initiatives, such as curb separation and minimizing waste generation, were not so long-lived.

Emerging Technologies

The engineering community followed Waring's lead and approached the waste problem pragmatically, with the goal of minimizing cost and maximizing efficiency, particularly with respect to collection and disposal. The engineers also focused on technological solutions, ignoring issues of waste generation, consumer behavior, or public participation. Two such technologies emerged in the early 1900's as important forms of disposal: incineration and reduction.

The concept of incineration, or the burning of waste, arrived from Britain in the 1880's. The first incinerator was built in New York City in 1885. By 1908, 180 incinerators had been built around the country. Some cities began experimenting with using the incinerators to generate electricity. New York City built such a plant in 1905. This proved to be too expensive and couldn't compete with traditionally generated electricity. At first, another fuel, such as natural gas or coal, was added to the garbage to facilitate combustion. This became too expensive, so the garbage was burned without the addition of fuel. However, the temperatures achieved weren't very high, which resulted in noxious smoke and incomplete combustion. Incineration lost favor as quickly as it had gained it, and by 1909, only 70 plants still remained in operation.

Reduction refers to a process of extracting oils from city garbage. It appeared in 1886 in Buffalo, New York, and was intended to give the city saleable byproducts like grease or fertilizer. The idea was greeted with enthusiasm, but due to undesirable side effects, especially foul odors, only twenty-six reduction plants were built by 1913.

Therefore, land disposal, by default, became the primary disposal method. But merely dumping on vacant land was becoming increasingly objectionable, so engineers began searching for better

ways of land disposal, and in particular ways to "utilize" the waste, particularly the inorganic waste. Using it as fill or reclamation material became popular. Davenport, Iowa used refuse to build levees along the Mississippi, for example. The idea was especially popular in the San Francisco Bay area. Between 1860 and 1960, the San Francisco Bay decreased in size by 29 percent, from 680 square miles to 430 square miles, as communities dumped millions of tons of garbage and dredging material to generate new land for development.

In 1934, Fresno, California opened the first modern sanitary landfill in the United States. The concept of "sanitary" fill arose in Britain in the 1920's. The method was based on using engineering techniques to control the putrefaction of organic wastes in an open dump. Layers were used: 12 inches of garbage were covered by 24 inches of ashes and street sweepings, which was covered by a layer of dirt, and then the cycle repeated. Fresno used the first "cut and cover" method, in which a huge trench or hole was dug and subsequently filled with the alternating layers of waste and soil. The idea caught on quickly. By 1945, over 100 cities had adopted the sanitary landfill. It replaced incineration and open dumping as the disposal method of choice for local communities.

The sanitary landfill was particularly popular among engineers because it solved several problems as once. It eliminated the need for curbside waste separation. It had enormous capacity to meet future increases in waste generation. It was not labor intensive to operate and so was more cost efficient. It was a one-stop solution that was "out of sight, out of mind". However, in the 1950's and 1960's sanitary landfills were little more than open dumps with some dirt and chemicals sprinkled on top. In many ways, they created more problems than they solved, such as contamination of nearby water sources, methane gas explosions, and uncontrolled fires. In early 1960, the EPA found that 90 percent of landfills could not be called sanitary because of their effects. At the same time, community opposition to landfills was on the rise. In response, in 1965 Congress passed the Solid Waste Disposal Act, which required environmentally-sound methods of waste disposal. These forces combined to precipitate a new interest in incineration.

Incinerators had seen a slow but steady growth since their heyday of the early 1900's. In 1969, there were 364 municipal incinerators in operation. However, new environmental legislation and the new-found interest as a replacement for landfilling sparked radical changes in technology, especially in the idea of "waste-to-energy," or the recovery of energy from burning trash. The idea was not new, of course, but new techniques and economies of scale made the method more cost efficient and more attractive. Large plants, capable of burning up to a thousand tons of unsorted waste a day, began to appear in the 1970's. Private firms entered the market to build these plants. The EPA and many state officials touted incineration as the best method to relieve landfill capacity.

Incineration never took off. Many local communities saw it as worse than landfills. Smoke and odors, the same factors that doomed incineration 60 years earlier, were the main culprits. Many local communities saw it as worse than landfills. In fact, it soon became apparent that the 1965 Solid Waste Disposal Act wasn't strong enough. Furthermore, the issue of "hazardous waste" began to receive attention. The result was the 1976 landmark passage of the Resource Conservation and Recovery Act (RCRA). There is probably no other piece of environmental

The Joliot-Curies (Frederick and Irene) took up the experimentation to confirm the existence of positrons (discovered by Anderson in 1932) and to look for evidence of neutrons. In the course of bombardment by alpha particles to produce neutrons, they found out how to make created radioactive nuclides. This result, reported in 15 January 1934, provided the first proof of artificial transmutation. Joliot, in his part of a joint Nobel Prize address, mentioned the possibility of transmutation of an explosive nature. Szilard, when he heard of the Joliot-Curie's discovery, saw the possibility of a chain reaction, already known in chemistry, in the nuclear sense. Szilard also realized that neutrons would be more effective than alpha particles in producing transmutations, but he did not have resources that would enable him to investigate. Fermi, in Rome, did. Fermi had assembled a well-equipped laboratory and a capable staff. He prepared materials that produced neutrons for bombardment and proceeded to investigate the effect of neutron bombardment on all the [then known] elements. The findings suggested that bombardment of uranium produced elements of atomic number 92; the naturally occurring element. This was startling news and [illegible] what [illegible] Hahn and Strassmann did [illegible] the uranium nucleus, [illegible] radionuclides of [illegible] called fission [illegible]

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As seen from the historical highlights, early researchers found materials that, because of emitted particles and rays, exhibited unusual behavior and produced strange effects. This characteristic they called radioactivity. Most of this material came from the ore mines in the mountains between Czechoslovakia and Germany. From the pitchblende ore, Klaproth extracted, in 1789, a metal he named uranium. Bequerel found that Uranium was radioactive. Schmidt and Curie independently found that Thorium, which had been identified by Berzelius in 1828, was also radioactive. Near the mines in the