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Project Summary

Securing Containerized Hazardous Wastes with Welded Polyethylene Encapsulates

H. R. Lubowitz, R. W. Telles, S. L. Unger, and R. R. Phillips

Full-scale encapsulation of 208-L (55-gal) drums was studied as a means for managing corroding containers of hazardous wastes in the field and rendering them suitable for transport and safe deposit within a final disposal site such as a landfill. Polyethylene (PE) receivers with 6.35-mm-thick (1/4 in.) walls and wide mouths were used for fabricating encapsulates. After insertion of drums, the receivers were weld-sealed with 6.35-mm (1/4-in.) sheet PE. A prototype apparatus was designed and constructed to fabricate the PE encapsulates by welding. The apparatus, which was light weight and transportable, was analogous to that used in the commercial butt welding of PE pipe. Precision alignment of pieces and high regularity of surfaces to be joined were found to be unnecessary. Furthermore, only minimal mechanical pressures were needed to form the welded joints. Results indicated plastics welding to be an effective method for encapsulating corroding drums of hazardous wastes.

This report is a companion to two other documents investigating the use of plastics for the encapsulation of corroding containers of hazardous wastes: "Securing Containerized Hazardous Wastes with Polyethylene and Fiberglass Encapsulates" (EPA-600/2-81-138) and "Securing Containerized Hazardous Wastes by Encapsulation with Spray-on/Brush-on Resins" (EPA-600/2-81-140).

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Corroding containers of hazardous wastes exist throughout the United States, constituting a hazard to man and his environment. Clearing these locations involves transporting the wastes in ensembles that conform to Department of Transportation (DOT) regulations governing transportation of containerized hazardous wastes. Should the waste be placed in a final disposal site, the containers must be constituted to resist degradation by the physical and chemical stresses of the disposal environment.

This report investigates full-scale encapsulation of 208-L (55-gal) drums with welded polyethylene (PE) as a means for managing corroding containers of hazardous wastes in the field and rendering them suitable for transport and safe deposit within a final disposal site such as a landfill. Materials are described along with the design and construction of the encapsulate welding apparatus, the technique used for encapsulate fabrication, and an evaluation of encapsulates. A preliminary economic analysis of the encapsulation process is also presented.

The work performed here continues earlier work carried out for the U.S. Environmental Protection Agency (EPA) to develop encapsulates to secure corroding, 208-L (55-gal) steel drums holding hazardous wastes. This study aimed to provide another option for encapsulating drums in addition to the one developed previously.[1] The establishment of two viable options broadened the base for studying the feasibility of a commercial operation.

The process options were restricted to those that would produce seam-free containers for use as encapsulates. This approach distinguished the work from current developments in container technology and yielded encapsulates with advanced performance qualities. The costs for seamed and unseamed containers were estimated to be comparable. The similar costs were plausible because the resins used were mass produced and of the same type as those used in commercial containers; furthermore, the encapsulate fabrication apparatus was simple enough to counterbalance production advantages associated with expensive commercial apparatuses.

Earlier work had developed laboratory-scale encapsulates characterized by 6.35-mm (1/4-in.) PE outer walls reinforced by fiberglass casings. These encapsulates featured homogeneous, seam-free outer walls and high compressive strengths. Encapsulates of drums, therefore, would not be encumbered by ancillary closure devices associated with conventional containers such as lids, threads, gaskets, hoops, etc.

In this study, the container walls were not reinforced. The resulting encapsulates, though seam-free, exhibited less mechanical strength than the fiberglass-reinforced models; but they were expected to be sufficiently strong for securing drums. (Additional strength, if required, was obtainable by placing filler material such as foam in the free space between the walls of the inserted drums and the containers.)

Use of unreinforced polyethylene containers permitted greater utilization of commercially available materials and techniques, and it allowed a more direct application of current technology to securing 208-L (55-gal) drums in the field. Such advantages counterbalanced the probable losses of mechanical performance.

Though commercial plastic containers were not available for securing 208-L (55-gal) steel drums, the rotomolding industry did fabricate PE receivers large enough to accommodate these drums. Such receivers were successfully used as free-standing tanks for holding corrosive chemicals and for carrying out chemical reactions. The PE resins used in their fabrication were mass produced and were well characterized by their producers. Rotomolded PE receivers were, according to our estimate, the commercially available materials best suited for securing drums. Extruded PE flat stock was selected for sealing the receivers.

Plastic welding was the commercial technique selected for sealing the receivers. Welding is a widely used, high performance technique for joining materials, both metals and plastics. Its structural and sealant performance characteristics are well known, and its wide acceptance attests to its merit. In the field of plastics, welding has been used successfully to join PE pipe, and commercial apparatuses are available for this purpose. Unfortunately, the equipment was not suitable for fabrication of PE encapsulates. To utilize the proven advantages that PE welding offers to encapsulate fabrication, a novel plastic-welding apparatus was designed and built to seal PE covers to PE receivers.

Materials and Equipment

Particular emphasis was placed on using PE receivers fabricated by commercial rotomolding. Equipment was designed and constructed to seal the receivers with PE flat stock by plastics welding. PE pipe welding art was applied to determining equipment requirements and selecting processing conditions.

Materials

Polyolefins, particularly PE (but not excluding high-impact polypropylene and polybutylene), were selected for fabricating encapsulates because such materials were well characterized, mass-produced and low in cost. They also provided a unique combination of properties: excellent chemical stability, flexibility, and mechanical toughness. Earlier laboratory studies showed PE encapsulates to have high retention of heavy metal contaminants when subjected to aggressive leaching solutions.[2]

Commercial PE containers were not available in the proper size and construction for encapsulating 208-L (55-gal) metal drums. The largest plastic vessels that may be transported in compliance with DOT regulations were 208-L (55-gal) drums fitted with bung holes. Wide-mouth drums did not qualify, and other PE vessels were not fitted with the means to effect secure closure. They were used mainly as liners of steel and fiberglass-reinforced vessels, or as free-standing receivers and holding tanks. Their value was particularly noteworthy in process and storage operations involving corrosive chemicals. Plastics fabricators displayed great interest in rotomolding large, free-standing PE tanks to replace plastic-coated or glass-lined steel tanks, stainless steel tanks, and fiberglass-reinforced plastic tanks. These PE tanks were selected as receivers for 208-L (55-gal) drums.

After commercial container art and the mechanics of encapsulate fabrication were considered, rotomolded, wide-mouth PE receivers and PE flat sheet were selected for making encapsulates. Though on-the-shelf receivers were longer than desired, they were capable of being readily constructed to specifications when needed in significant numbers.

The height and diameter of receptacles readily accommodated the 208-L (55-gal) drums. Any free space between receptacle and inserted drum can be filled, if required, with low-cost fillers such as foam to minimize drum movement during handling. Furthermore, the free space allows encapsulation of distorted drums.

Equipment

A new plastic-welding apparatus was designed and built to fabricate PE encapsulates (Figure 1). This apparatus was capable of welding flat PE covers onto the rim of wide-mouth receivers. The welding apparatus for encapsulate fabrication was viewed as a container heat-sealing device comparable with commercially used PE pipe welding devices. This encapsulation apparatus was designed as a prototype experimental device that allowed alteration of various parameters affecting the properties of the welded joint (i.e., heating and cooling times, temperature, welding pressure, etc.). As with commercially used pipe-welding apparatuses, the prototype was designed to be easily transported and sturdy so that it could be used in the field encapsulation of drums.

Procedure

PE encapsulates were fabricated by plastics welding procedures. A 208-L (55-gal) drum was first inserted into a wide-mouth PE receiver with a releasable wire harness. The receiver was then positioned under the H-frame of the apparatus, and the cover fashioned from PE flatstock was clamped to the platen. The cover was then welded to the receiver by means of heat and pressure. After the weld was cooled under pressure, the clamps were removed from the cover and the platen was raised to remove the encapsulated drum.

Results

Welded encapsulates were found to be watertight overpacks for 208-L (55-gal) drums. They were expected to preclude effectively the contact of hazardous waste consignments with aggressive environmental waters even though the drums within might continue to corrode. Performance estimates were obtained by inspection and testing of the welded joints of PE covers and receivers.

Nature of Welded Joints

To investigate the nature of the welded bond, the top portion of a welded plastic encapsulate was removed. Close visual inspection of the weld showed the formation of a continuous, solid, resinous bead surrounding the welded interface. To investigate the watertightness of the welded bond, the specimen was charged with water containing a high-visibility dye detectable at 1 ppm. Over a period of 4 months, no leakage was observed.

Several PE receiver-cover welds were inspected by optical microscopy to determine the quality of the welded bonds. The optical micrographs showed that the welds were continuous, void-free structures that should exhibit the high strength properties expected of high-density PE.

To investigate further the microstructural characteristics of the weld, a thin cross section was mounted in a transparent medium, and transmission optical micrographs were obtained.

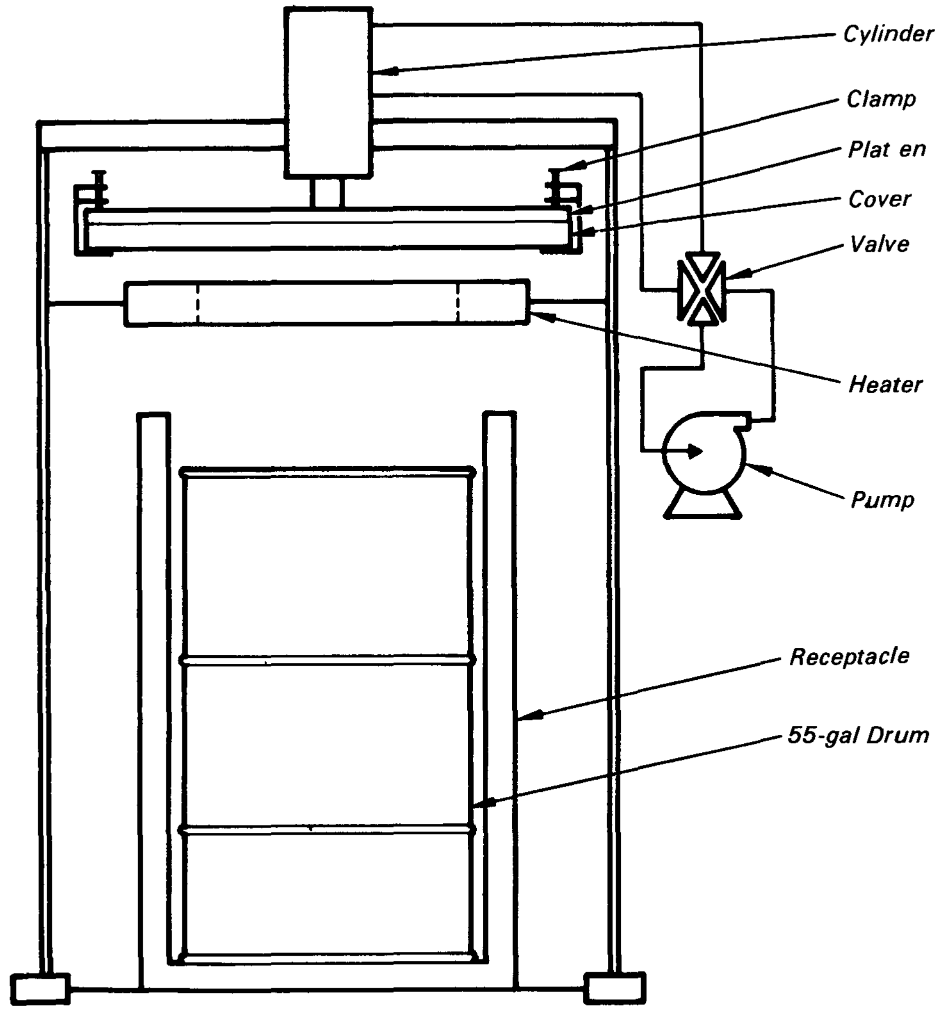

Figure 1. Apparatus for encapsulating 208-liter (55-gal) drums holding hazardous wastes.

These micrographs showed the welds to be continuous, void-free regions in which good wet out and mixing of receiver-cover materials occurred.

Strength of Welded Joints

The mechanical performance of encapsulates was characterized by noting the behavior of welded specimens in tension. These tests showed that encapsulate welded joints are capable of withstanding high mechanical loads and will undergo appreciable elongation before rupture.

Preliminary Cost Estimates

Costs associated with the process were investigated to compare the plastic welding encapsulation process with other hazardous waste management options. Major costs were due to consumable materials (i.e., PE flat stock and receivers), which accounted for some $4.8 million per year to encapsulate 80,000 drums. Labor and capital equipment costs were negligible by comparison—$228,000 and $45,000 per year, respectively. Other costs such as utilities were also estimated to be minor, even when including the contingency factors.

Conclusions

Full-scale encapsulation of 208-L (55-gal) drums can be carried out by inserting drums into wide-mouth polyethylene (PE) receivers with 6.35-mm-thick (1/4 in.) walls and sealing them by welding with PE flat sheet 6.35-mm-thick (1/4 in.). Characterizations of the

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welded joints indicate that the encapsulates will perform satisfactorily (that is, they will comply with DOT regulations concerning the transport of containerized hazardous wastes and their long-term, safe deposit in a landfill).

The apparatus designed and used in this work for making prototype encapsulates was simple compared with commercial plastics fabricating devices, and it was also readily transportable. An apparatus for use in the field need not be more complex than the one used here for making encapsulates. Improvements such as semiautomating can be accomplished at moderate costs.

Important features of the apparatus were its use of a flat ring heater and PE flat stock. These items allowed sealing of PE receivers with flat stock without the need for precise alignment. Furthermore, the surfaces to be joined did not need to be smooth. These features were expected to facilitate management of drums.

Compatibility of PE encapsulates and their contents can be determined from data supplied by vendors of PE resin. Extensive material compatibility data are available for PE, a fact that contributes greatly to the usefulness of this material in waste management. These data should be examined when selecting drums for encapsulation, but it is unlikely that materials deleterious to PE would remain with corroding drums after long-term exposure to the atmosphere.

The cost of the encapsulation process was mainly attributable to the cost of receivers and flat stock. Equipment and labor costs were negligible. Cost reductions will thus depend on making less expensive receivers and flat stock. DuPont has indicated that it will receive unusable 208-L (55-gal) drums, pulverize them, and sell the powder for about one-third the price of commercial PE. This material in turn would be usable for making receivers. Flat stock used for making ice skating rinks (a popular, energy-saving alternative to conventionally maintained ice) must be replaced periodically because of scarring, but it is still usable for weld-sealing receivers.

Recommendations

More intensive investigation of the formation and nature of the welded joint between PE receivers and PE sheet stock should be carried out. This investigation should follow the guidelines presented in the art of PE pipe butt welding. The applied stresses would be appreciably less severe on the encapsulate joints than the pipe joints, thereby lessening the performance requirements of serviceable joints. This advantage is due mainly to the absence of dynamic and cyclical mechanical stresses on encapsulates.

Investigations are needed both to determine how to produce high-performance welded joints and to maximize welding apparatus performance in the field. Various equipment and labor scenarios should be examined for making drum-populated areas safe at a reasonable cost.

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References

1. Lubowitz, H.R., and R.W. Telles. Study of Encapsulate Formation with Polyethylene Resin and Fiberglass for Use in Stabilizing Containerized Hazardous Wastes. In: Fortieth Monthly Report under EPA Contract No. 68-03-2483, draft of final report, U.S. Environmental Protection Agency, Cincinnati, OH, May 1980.
2. Lubowitz, H.R., et al. Development of a Polymeric Cementing and Encapsulating Process for Managing Hazardous Wastes. EPA-600/2-77-045, U.S. Environmental Protection Agency, Cincinnati, OH, 1977.

H. R. Lubowitz, R. W. Telles, S. L. Unger, and R. R. Phillips are with Environmental Protection Polymers, Inc., Hawthorne, CA 90250.
***Carlton C. Wiles** is the EPA Project Officer (see below).*
The complete report, entitled "Securing Containerized Hazardous Wastes with Welded Polyethylene Encapsulates," (Order No. PB 81-231 292; Cost: $9.50, subject to change) will be available only from:
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