POLLUTION PREVENTION

IN RHODE ISLAND

PROCESS PROFILE:

D·E·M

VIBRATORY SOLUTION RECOVERY IN A ZINC DIE-CASTING OPERATION

For more information, contact:
RI Department of Environmental Management
Office of Environmental Coordination
Pollution Prevention Program
83 Park Street, Providence, RI 02903
Phone: 1 800 CLEAN RI (RI only) or 401 277-3434

Foreword

This report is published by the Rhode Island Department of Environmental Management's Office of Environmental Coordination (OEC). OEC provides on-site assistance and technical information to Rhode Island business and industry.

The information and data presented in this report are the direct result of a cooperative effort by the Rhode Island Department of Environmental Management, the University of Rhode Island's Chemical Engineering Department, and Miniature Casting Corporation.

This document is intended as advisory guidance only in developing approaches for pollution prevention. Compliance with environmental and occupational safety and health laws is the responsibility of each individual business and is not the focus of this document. In addition, any and all products and companies identified in this report are for example only. No endorsements are implied nor should any be inferred.

The Office of Environmental Coordination advises that prior to implementation of any pollution prevention methods and technologies, companies should consult with appropriate Federal, State, and Local regulatory agencies. Users are encouraged to duplicate this publication as needed to implement a pollution prevention program.

Funding for this project was provided by the United States Environmental Protection Agency and the Rhode Island Department of Environmental Management.

Questions or comments may be addressed to:

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Contents

Abstract

In this project, membrane technology was applied to a vibratory solution recycling process used for the cleaning and polishing of miniature zinc die-casts. Before the project was initiated, all process water was discharged into the sewer system through ten micron cartridge filters. Two to three hundred gallons per day of vibratory waste solution had been diluted with approximately one thousand gallons per day of non-contact cooling water. Hydrochloric acid (HCl) had been used only occasionally when necessary to adjust the solution pH to below 10. Mineral spirits had also been used to preclean heavily contaminated parts.

While the original project objective had been to rely on the use of acids and filtration methods to minimize waste discharges, development testing and improvements obtained throughout the year-long project indicated that acid is no longer needed and the need for membrane filtration is much less than originally anticipated. Pollution prevention has been achieved through 1.) the elimination of mineral spirits to preclean parts, 2.) the elimination of hydrochloric acid used to settle and remove sludge, 3.) the elimination of a 60,000 gal/year sewer discharge of metal-bearing wastewater, 4.) the recovery of zinc metal for off-site recycling, and 5.) the recycling of an aqueous-based soap. The only filtration needed is occasional cleaning by the membrane system. Except as a prefilter for the membrane, cartridge filters are no longer used and a rinsing step has been eliminated. Product rejection rates have actually decreased as compared to before the project.

The work was carried out in conjunction with Miniature Casting Corp. of Cranston, RI, and funded by an EPA Small Business Pollution Prevention grant.

Introduction

Vibratory Operation

Vibratory and tubbing operations are metal-finishing techniques that are found in a variety of industries. Typical industry types include jewelry manufacturing and machine tool manufacturing. The size of the metal parts to be finished range from small jewelry pieces that measure fraction of an inch to large, heavy metal parts that are several inches long.

In order to clean and/or polish metal parts, aqueous-based chemicals and ceramic or plastic media are typically used in either a vibrating basin or a rotating barrel. Occasionally, metal-based media like steel shot is used. In most cases, the waste effluent from these operations usually consists of soapy water, pulverized media, and both soluble and insoluble metals of the type found in the metal parts being processed. Traditional waste treatment techniques have included chemical flocculation and settling to remove metal contaminants prior to sewer discharge. In most instances, where other types of metal-finishing and plating operations exist in the plant, the vibratory waste effluent is mixed with other metal-bearing waste streams prior to treatment and disposal.

Pollution prevention for these operations generally consists of source segregation, the elimination of treatment chemicals, the reduction of sludge generation, water/soap conservation, and metal recovery. Though no two processes are exactly the same, this report profiles a typical tubbing operation and the types of technologies and methods that can be used by companies to reduce operating/environmental costs and improve overall operating efficiency.

Company Background

Since its founding in the early 1960's, Miniature Casting Corp. has been involved in the manufacture of precision miniature zinc die-castings. As a fully integrated facility, the company is responsible for the design and construction of their own die-casting equipment as well as the production of castings. In the early days of operation, all effluents of the die-casting process were discharged into the city sewer system including 1000 gallon per day of non-contact cooling water and soapy vibratory discharge. When the company relocated in 1988 to its existing location in Cranston, RI, a conscious effort was made to undertake an effective environmental management/pollution prevention program. In 1989, the company contacted the Rhode Island Department of Environmental Management's Pollution Prevention Office. Miniature Casting sought to determine the most efficient and cost-effective means of reducing and managing its vibratory waste effluent. In late 1990, DEM's Pollution Prevention Program helped Miniature Casting apply for and win a $24,000 U.S. EPA Small Business Pollution Prevention Grant to carry out a year-long study on vibratory solution recycling using membrane technologies.

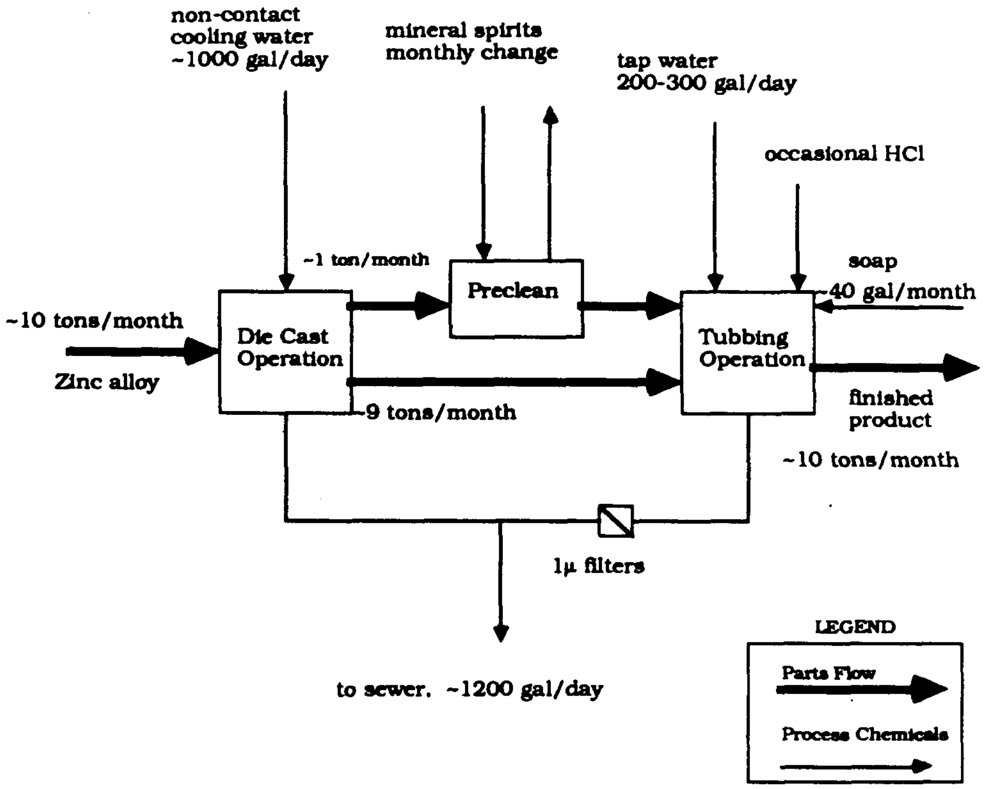

Figure 1: Original Plant Operation

Original Operation

As part of the manufacturing process, precision zinc die-castings are cleaned with vibratory finishing equipment. At the start of the project, about 10% of the die-castings had to be precleaned with mineral spirits prior to vibratory finishing. All of the effluent from the tubbing machines was mixed and diluted with non-contact cooling water and discharged directly to sewer (Figure 1). The objective of the EPA funded study was to incorporate membrane technologies, such as ultrafiltration, into a working pollution prevention program for the cleaning operation. Principal investigators anticipated that the mineral spirits could also be eliminated and replaced with an aqueous cleaner; membranes could be used to clean and recycle all of the spent cleaning solution. An additional objective was to recover all die-cast metal concentrate for off-site recovery.

Ten tons of zinc alloy bars are melted down every month in the die-casting operation of the manufacturing process. Approximately 10% of the die-casts exhibit noticeably more "smudge" or oxide build-up than the remaining 90% of the parts. While all parts were cleaned in the vibratory machines, 10% of the pieces had to undergo an additional preclean step with mineral spirits prior to the vibratory cleaning. The mineral spirits cleaner was changed over every month by an outside solvent supplier. On a daily basis, two to three hundred gallons of water was used with approximately 2 gallons of soap concentrate in the vibratory operation. The effluent was filtered through one micron cartridge filters and mixed with 1000 gallons per day of non-contact cooling water prior to discharge.

Project Description

Procedure

During the year-long study, different hypotheses were tested. In order to gain a firm understanding of the effect of each process modification, only a few parameters could be varied at a time. Also, since a main objective of the study was to determine the long-term cleaning effectiveness of recycled water, conditions could not be varied often.

The project was divided into three phases where several membrane filters and acids were tried, as well as some major procedural modifications. Figure 2 depicts the process flow scheme used in the first two phases of the project, i.e., when acids were used to adjust pH and facilitate sludge removal and the membrane system was used to recycle all rinse waters. Figure 3, which represents the final process design, shows how major procedural changes have vastly simplified the operation.

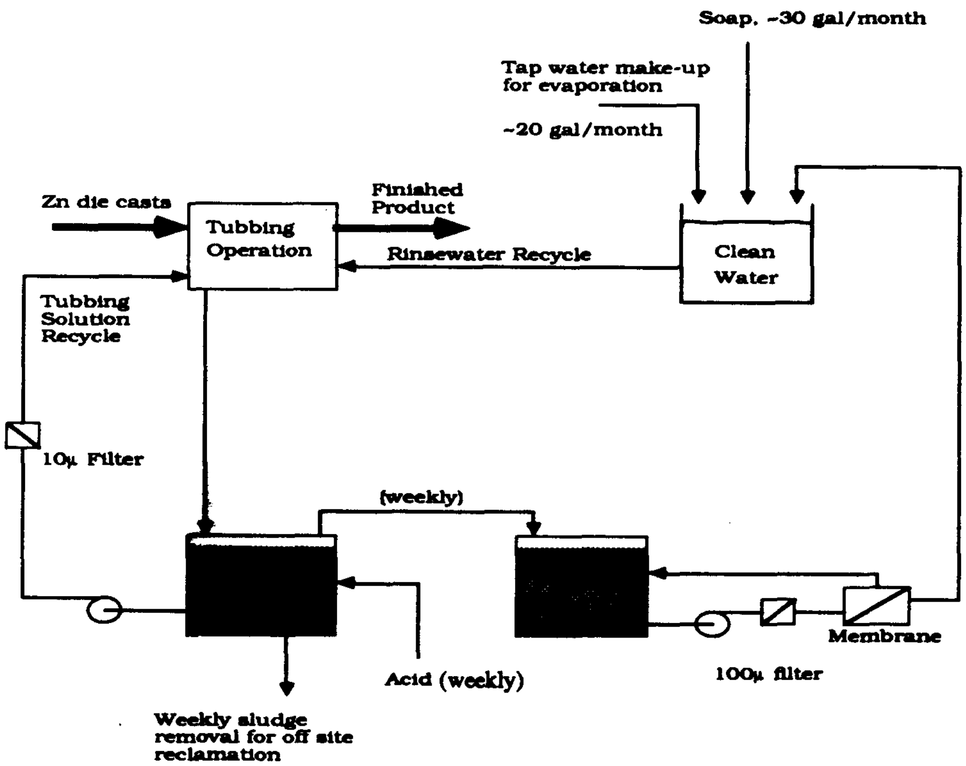

Figure 2: Flow Scheme for Vibratory Solution Recycle (Phases 1 and 2)

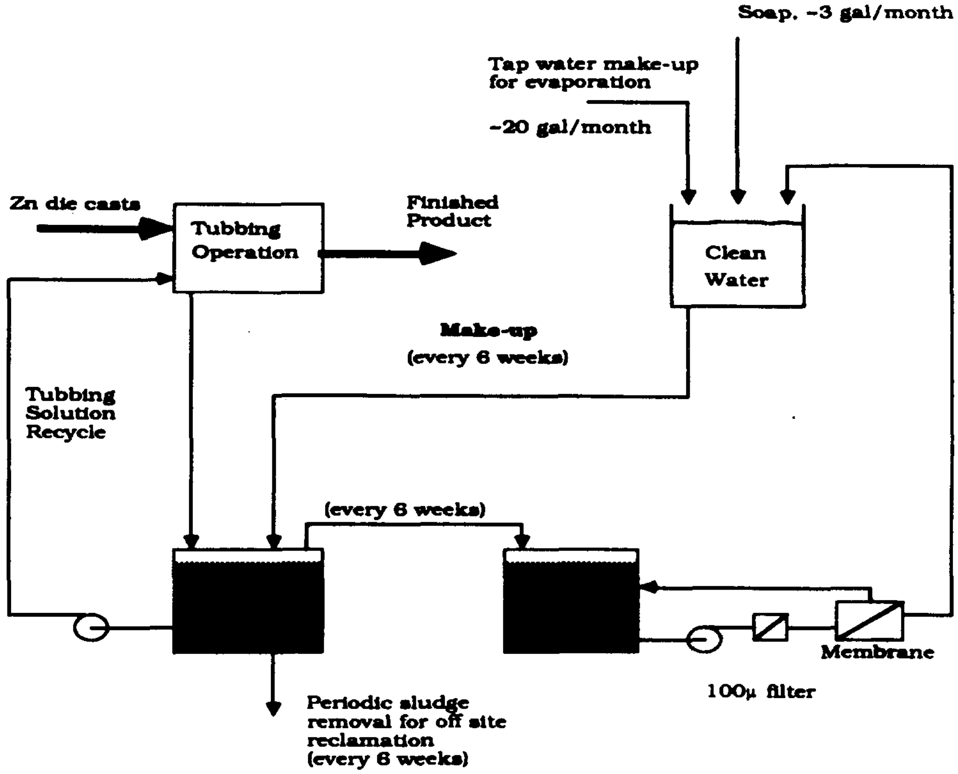

Figure 3: Present Flow Scheme for Vibratory Solution Recycle (Phase 3)

In Phase 1 (Figure 2), mineral spirits was eliminated entirely from the cleaning operation. An aqueous-based cleaner (Oakite M3) was used as an effective replacement. In Phase 2, different acids were tested for pH-adjustment and sludge settling. In Phase 3 (Figure 3), acid use and rinsing were also eliminated. As shown in Figure 3, the final process has been simplified considerably. Not only has discharge to the sewer been eliminated, but soap use has also been reduced by almost 90%. Tap water is actually added to the system to make up for evaporation. A total of 100 gallons of solution is continuously recycled. The sludge that is periodically removed and sent back to the metal supplier for reclamation was also analyzed for metal content.

The cleanliness of the parts resulting from the new process (Figure 3) was monitored in-house against normal production quality requirements. The following section provides a more detailed discussion of the results obtained.

Results

While the original project objective included the use of acids and filtration methods to minimize waste discharges, developmental testing and improvements obtained throughout the year-long project indicated that acid was no longer required and that the need for membrane filtration was much less than originally anticipated. Pollution prevention has been achieved through:

- *the elimination of mineral spirits* to preclean parts by increasing the strength and broadening the use of the aqueous cleaner.
- *the elimination of acid* used to settle and remove sludge. While sludge could be more easily removed through pH-adjustment and settling, it was discovered that eliminating the use of acid did not affect the cleaning and quality of the parts; in fact, the chemistry of the solution could be maintained longer while much less soap was required.
- *the elimination of a 60,000 gal/year sewer discharge of metal-bearing wastewater*. All solutions have been continuously reused for twelve months with absolutely no effluent sewer discharge.
- *the recovery of zinc metal for off-site recycling*. All sludge is recovered from the operation and is sent back to the metal supplier who combines the sludge with other scrap metal for reclamation.
- *the recycling of an aqueous-based soap*. The caustic cleaner is continually reused, while small amounts are added periodically to maintain the necessary soap strength. Soap purchases have been reduced by approximately 90%.

The only filtration required is ultrafiltration for cleaning the whole system every six weeks (Figure 3). Except as a prefilter for the membrane, cartridge filters are no longer used and the rinsing step has been eliminated. Product rejection rates have actually decreased in comparison to rejection rates experienced before the project was initiated.

Economics

In Phase 3, the process was simplified and optimized: acid use was eliminated, the rinsing step was eliminated, the ten micron cartridge filters used prior to the project and during Phases 1 and 2 were also eliminated, less sludge was created, membrane system operation was reduced by 90%, and the product quality had actually improved. In addition to the environmental benefits achieved, many cost savings were quickly realized. The table below shows a direct cost comparison between the present recycling operation and the old, chemical treatment/sewer discharge operation of 1990. Not included in the table are the costs incurred by the test program itself, i.e., University chemical engineers and analytical test costs, which were covered mostly by the EPA grant. Also not listedare the savings obtained by increased productivity which resulted from fewer rejected lots of product. Based on capital expense and annual operating cost calculations, a significant payback was observed in less than one year.

Economic Analysis of Vibratory/Cleaning Operation

	Before Project	After Project
Capital Equipment, including	0	$5,500
membrane system		
tanks		
pumps		
filters/housings		
Annual Operating Costs		(approximate)
soap	$1,526	$100
mineral spirits	1,015	0
cartridge filters	1,189	400
membrane replacement	0	300
energy	negligible	negligible
labor	4,742	1,700
water	161	0
sewer fees	300	0
analytical tests	224	0
Total Annual Operating Costs	$ 9157	$ 2500

Conclusion

This project demonstrates a cost-effective and environmentally sound solution to vibratory waste management. The project has demonstrated success in pollution prevention and the recycling of vibratory solution in a zinc die-casting industry. Similar programs at other Rhode Island facilities have begun. While the vibratory/tubbing operation is ubiquitous, many parameters exist which render each individual operation unique. The type of metal to be cleaned, the type of soap used, the desired finish on the metal, the type of vibratory media used, and even the incoming tap water supply must all be considered.

An economic analysis of this project displays a favorable payback. While direct technology transfer has already been demonstrated in other Rhode Island companies, it is anticipated that the data collected and experience acquired from this project will facilitate programs at other companies to the extent that developmental work and costs are minimized. As of March, 1993, ten to fifteen Rhode Island companies have successfully implemented similar programs at their facilities. If more information on this EPA-funded project is desired, a detailed technical paper is available from the Rhode Island DEM Pollution Prevention Office, 83 Park St., Providence, RI 02903, telephone (401) 277-3434.

Glossary

acid: one of a large class of chemical substances whose water solutions exhibit a pH less than 7

aqueous: made from, with, or by water

caustic: alkaline material such as sodium hydroxide; when mixed with water, exhibits a pH greater than 7

die casting: product from a process where molten metal is injected under pressure into a colder steel mold

effluent: any gas or liquid emerging from a pipe or similar outlet; usually refers to waste products from chemical or industrial plants as stack gases or liquid mixtures

filtration: a means of separation where constituents are separated usually by physical methods

flocculation: the combination or aggregation of suspended colloidal particles in such a way that they form small clumps; usually used in conjunction with additive chemicals (flocculants) to treat waste water

membrane: a microporous structure which acts as a highly efficient filter that allows passage of water but rejects suspended solids and colloidals; depending on the membrane type, ions and small molecules may or may not be rejected (see **ultrafiltration**)

mineral spirits: light petroleum distillate used for cleaning/degreasing

off-site recovery/reclamation: the transport of unusable materials away from the site of operation to a facility that makes use of a process that transforms the unusable material to a usable feedstock for any given operation

pH-adjustment: the act of changing the pH of an aqueous solution by adding acid or caustic

pollution prevention: the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source

source segregation: the act of separating process chemical effluents or wastes at each individual point of origin to facilitate materials recovery

ultrafiltration: the process that utilizes membranes to achieve separation of various constituents; a typical ultrafiltration membrane will allow water, ions, and small molecules to pass through while rejecting large molecules and suspended solids

Appendix

The following is a partial list of vendors that supply equipment and provide start-up assistance. The Rhode Island Department of Environmental Management does not endorse any particular vendor or product. The following list is not complete and is provided for informational purposes only.

Ultrafiltration Equipment

Infinitex Inc.
10100 Main St.
Clarence, NY 14031 — Local Distributor (401) 732-6677

Koch Membrane Systems, Inc.
850 Main St.
Wilmington, MA 01887 — Local Distributor (508) 657-4250

MSC Liquid Filtration Corp.
10 Dusthouse Rd.
Enfield, CT 06082 — Local Distributor (203) 749-8316

Romicon, Inc.
100 Cummings Park
Woburn, MA 01801 — Local Distributor (617) 935-7840

Sanborn Inc.
25 Commercial Dr.
Wrentham, MA 02093 — Local Distributor (508) 384-3181