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Technology Transfer Into the Solid Propulsion Industry

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Abstract

This paper is a survey of the waste minimization efforts of industries outside of aerospace for possible applications in the manufacture of solid rocket motors (SRM) for NASA. The Redesigned Solid Rocket Motor (RSRM) manufacturing plan was used as the model for processes involved in the production of an SRM. A literature search was conducted to determine the recycling, waste minimization, and waste treatment methods used in the commercial sector that might find application in SRM production. Manufacturers, trade organizations, and professional associations were also contacted. Waste minimization efforts for current processes and replacement technologies, which might reduce the amount or severity of the wastes generated in SRM production, were investigated. An overview of the results of this effort are presented in this paper.

Introduction

This paper was prepared under the direction of NASA/MSFC in support of the NASA Operational Environment Team headquartered at MSFC. This paper was prepared from a Technical Report, by the authors, produced for the Solid Rocket Motor Design Branch of the Propulsion Laboratory at NASA/MSFC [1]. The objective of this paper is provide a review of lessons learned from the commercial sector that might be applicable to the SRM industry. Issues related to propellant disposal technology and the operational uses of SRMs were excluded from this study due to the large ongoing efforts in these areas elsewhere.

The RSRM program was chosen as the model for this paper because of it's large size and obvious importance to NASA. Thiokol Corporation has an ongoing waste minimization effort and has reported good progress in reducing and eliminating unnecessary waste. The intention of this paper is not to evaluate the waste treatment or minimization efforts at Thiokol. However, it is hoped this paper will provide some useful ideas for the SRM manufacturers in waste minimization, treatment, new technologies, and recycling.

This effort was begun by reviewing the various processes that go into the production of the RSRM. These include, but are not limited to, case preparation and refurbishment, insulation/inhibitor preparation, propellant mixing and casting, and manufacture of composite materials. Each of these processes generates its own series of wastes that require recycling or treatment and disposal. The generic characteristics of each of these processes were listed and used to identify processes in commercial industries that are similar in nature.

The automotive industry was of particular interest because of its large production capacity, varied manufacturing steps, and diversity of materials used. The production of an automobile, in the broad sense, uses the same types of materials and processes as an SRM. The materials and processes of particular interest are metal fabrication, metal cleaning, painting operations, and polymer recycling and disposal.

Little information was found concerning composites outside of aerospace related industries. The most attractive use for the waste composites that was located is for engineered building materials. With the new materials composed of waste composites and comingled municipal plastic wastes.

Discussion

This paper will highlight four examples of technology that are applicable in the aerospace industry. These four samples that will be cited are the Automotive Pollution Prevention Project, treatment of oily wastewater, removal of zinc from an oily wastewater, and recycling of waste composites from the aerospace industry. Each of these will be discussed in limited detail and are examples from the report prepared for NASA/MSFC.

Automotive Pollution Prevention Project

The Automotive Pollution Prevention Project (APPP) is a voluntary partnership between General Motors Corporation, Chrysler Corporation, Ford Motor Company, American Automobile Manufacturers Association, the State of Michigan, and the United States Environmental Protection Agency. The APPP is chartered with the task of 1) identifying persistent toxics that have been released into the Great Lakes Basin, 2) advancing a pollution prevention agenda within the auto industry, 3) reducing releases of persistent toxic substances, and 4) addressing regulatory barriers that inhibit pollution prevention efforts[2].

The APPP prepared a list of Great Lakes Persistent Toxics (GLPT) which the use and release of was to be reduced or eliminated, where possible. Many of the chemicals listed as GLPT are found in the manufacture of a typical SRM. Some of those listed as GLPT are*:

Methyl Chloride	Methylene Chloride
Phenol	Toluene
Chromium	Zinc

*This is a sampling of the GLPT and not an inclusive list.

Another goal of the APPP is to foster technology transfer among the three major U.S. Auto companies and their suppliers to aid in pollution prevention and treatment. The APPP produced a series of case studies, in a synopsis format. Among the accomplishments cited by the APPP is the annual reduction in the release of GLPT. Their progress since 1988 is detailed in Figure 1. The auto companies also report that a 27.3% reduction has been achieved in the release of GLPT on a per car produced basis.

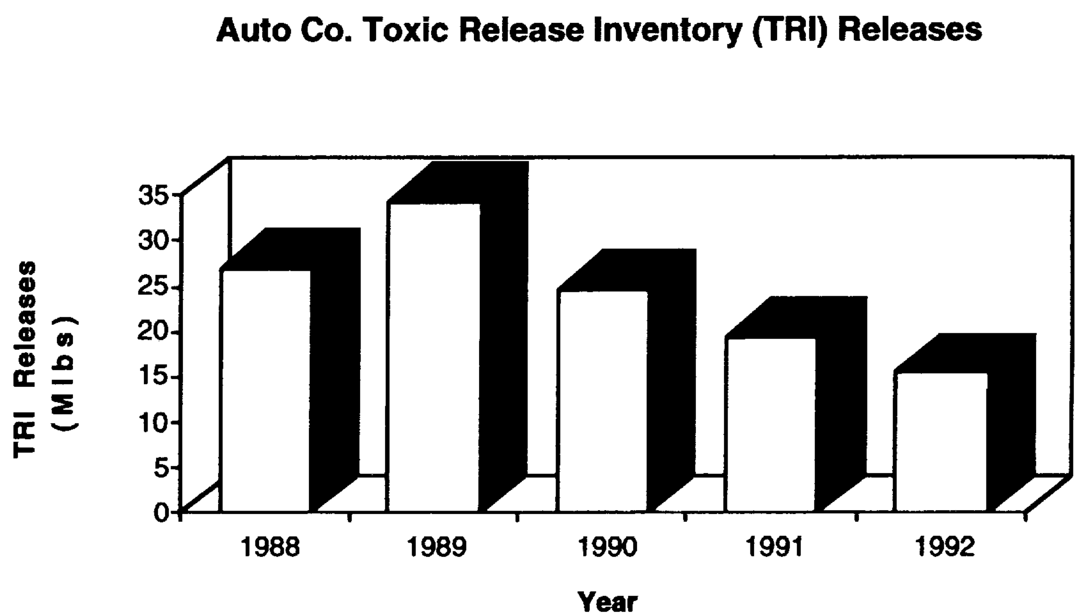

Figure 1 Release of GLPT Substances by the Auto Companies [2].

Many of the case studies are also of interest to the SRM industry. Two of the studies will be reviewed here. They are the elimination of Trichloroethane degreasing and reduction in the use of ozone depleting substances (ODS) for spot metal cleaning.

General Motors in its Lansing Auto Division, as a late as 1990, was using 15,000 pounds per year of chloroflourocarbons (CFCs) for spot metal cleaning. The CFC used was in the form of Freon 11 and Freon 12 in aerosol spray cans. The Freon 11 and Freon 12 were replaced by HCFC-141B. Although HCFC-141B is also an ODS, it has only 12% of the ozone destroying potential of the CFC. The amount of cleaner was also reduced from the 15,000 pounds per year to 9,000 pounds per year.

Ford replaced trichloroethylene vapor degreasing with aqueous cleaning. The plant used vapor degreasing to clean high surface area aluminum parts used in heat exchanging equipment. Although the degreasing unit had a vapor reclamation system, the high surface area aluminum retained a significant amount of TCE which evaporated after removal from the cleaner. This TCE vapor degreasing process accounted for a large percentage of the chlorinated solvents released by Ford.

As is true with any new process, there is concern as to whether it will be as reliable as the previous one. There was concern that going to an aqueous degreasing processing would etch the aluminum or adversely effect the brazing process in assembling the completed units. A pilot process was established to test detergent solutions. This unit consisted of 1) a prewash to remove easily removed oils, 2) a detergent wash to loosen and remove more stubborn oils, and 3) a water rinse. The pilot plant operation was found to be compatible with current and planned brazing operations and did not adversely effect the aluminum surface.

On the basis of on the results from this program, the Ford Climate Control Division has recommended that Ford replace all TCE degreasers with aqueous cleaning world-wide.

Treatment of Oily Wastewater

General Motors installed a membrane biological reactor system (MBR) to treat effluent from a sheet metal machining operation. The water effluent from this operation was heavily contaminated with synthetic machining oils. The manufacturing operations generated a wastewater flow of 151 m^3/day. The untreated effluent contained a chemical oxygen demand (COD) of approximately 6000 mg/l. A new treatment plant would be required to meet stricter effluent standards [3].

The existing treatment plant was 35 years old and required a high degree of operator attention. The waste treatment facility consisted of standard physical and chemical treatments. This treatment scheme generally left soluble organics untreated and discharged them in the effluent.

The new membrane biological reactor consists of a suspended growth biological unit combined with an ultrafiltration unit. The ultrafiltration unit provides a means to assure adequate liquid-solids separation. This combination allows for very high levels of biomass growth in the reactor unit without any being released in the effluent. This technology has the added benefit of treating soluble organics in the waste stream that had previously been discharged untreated.

The installation of the MBR at the plant was a success. The MBR yielded a 94% reduction in COD, reducing oils and greases in the effluent to less than 25 mg/l. The unit met or exceeded design specification even though the COD volumetric loading was more than twice the design parameters.

Removal of Zinc From Oily Wastewater

In another example from General Motors an innovative process was employed to remove zinc from oily wastewater in a transmission facility. This example differs from the previous example in technology in that it is a retrofit to an existing facility. The new treatment system was required to meet new effluent guidelines. Zinc was to be reduced from the current effluent level of 2-5 mg/l to 0.37 mg/l in a flow of 2160 m^3/day and meet a deadline of less than one year [4].

In the removal of zinc from a waste water, it is critical that the oil level be as low as possible. The influent contained approximately 35 g/l oil. This level necessitated that the current oil removal system be optimized. The current system for oil removal consisted of a corrugated plate interceptor and dissolved air flotation and skimming. Enhancement of the existing oil removal system was accomplished by addition of a rotary screen to remove solids, and improve distribution of waste into the dissolved air flotation unit.

To meet the new effluent requirements for the wastewater, the zinc level had to be reduced from 5-10 mg/l to 0.35 mg/l. This reduction was planned to be accomplished with a solids contact clarifier, with chemical floculation. The clarifier was followed by an upflow sand filter. The sand filter was added, because of the tight regulatory time frame, to assure adequate zinc removal. Upon installation and checkout of the system it was determined that the sand filter was not needed to meet effluent requirements. The removal of the upflow sand filter helped to reduce the complexity of the system and served to reduce the amount of solid wastes requiring disposal. The new system flowsheet is shown in Figure 2.

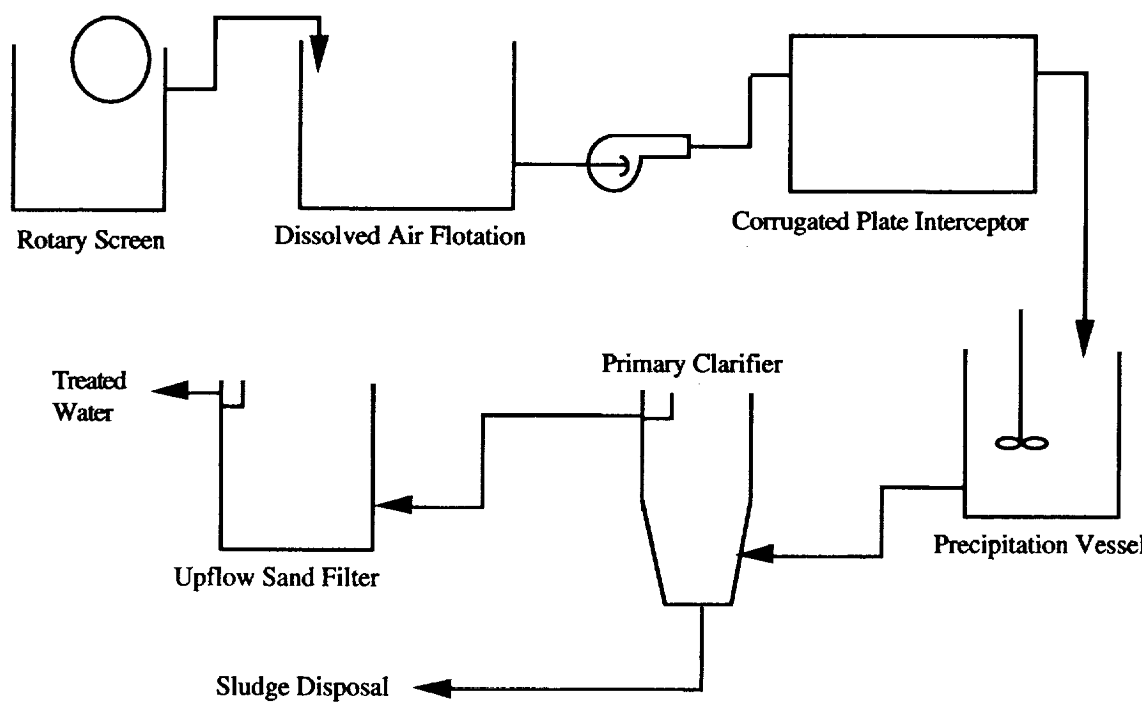

Figure 2 Schematic of Improved Zinc Removal System [4].

<u>Reuse of Composites</u>

Foster-Miller has developed a process to produce engineered building materials from waste materials. The Foster-Miller process combines comingled plastics from municipal wastes with fiber filled composites from the aerospace industry to produce construction materials. They report that their material has the potential of matching the mechanical properties of wood and to be competitive in cost on a life-cycle basis [5].

The product consists of plastic wastes (largely high density polyethylene), fiber filled composites, and resin. The material has exceptional low temperature properties that make it suitable for low temperature structural applications. Foster-Miller believes that the products material properties can be tailored to specific applications by optimizing the fiber orientation and length. Some proposed applications are as structural members, siding, and decking.

Conclusion & Recommendations

The Foster-Miller process, to use waste composites, could provide immediate benefits in the aerospace industry. The reuse of the composites will eliminate the costs associated with their disposal while possibly recouping some of the production costs. The two wastewater treatment processes presented can be adapted for SRM case production and refurbishment facilities. The automobile industry has many more applications that are applicable to SRM production than are reviewed in this paper. Technology such as reduction in solvents used in paint formulations and new finish application technologies are both applicable to SRM production.

This paper is a small sampling of the wealth of innovative technology in the commercial sector that could be applied to the aerospace industry. There are many ongoing efforts within the aerospace industry to reduce or eliminate waste. These efforts are generally shared among the various producers of hardware. There is also a great deal of emphasis placed on finding commercial applications for the technology being developed in aerospace. However, it should be remembered that there is a tremendous amount of high quality technology developed in the commercial sector that can find application within the aerospace industry. Using a synergistic approach to handling production effluents offers the best chance at preserving the environment at the least cost.

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