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Source Reduction and Recycling Programs at a Joint Venture Automobile Assembly Plant

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INTRODUCTION

New United Motor Manufacturing, Inc. (NUMMI) is a vehicle assembly plant in Fremont, California. NUMMI began operations in 1984 as a joint venture of General Motors Corporation and Toyota Motor Corporation. In 1995, NUMMI produced 94,280 Geo Prizms, 135,112 Toyota Corollas, and 123,257 Toyota Tacoma trucks.

NUMMI conducts its manufacturing operations using the Toyota Production System (TPS). A key element of TPS is the elimination of waste. This includes wasted energy, space, labor, and production materials. Waste reduction, i.e., source reduction, is part of NUMMI's corporate culture and every team member is encouraged to continuously seek out new waste reduction opportunities.

NUMMI's management believes that the team members who actually do the work are the people most effective in reducing waste. To motivate team members to aggressively seek out waste reduction opportunities, NUMMI has a very liberal and generous suggestion program. Each year millions of dollars are saved by adopting team member suggestions.

Management's responsibility is to work with the team members to develop and implement ideas for reducing waste. Management supports the team members with the technical and financial resources necessary to successfully implement a waste reduction project. Waste reduction projects are often classic examples of labor - management teamwork in problem solving, and process improvement.

Last year NUMMI and California Polytechnic State University (Cal Poly), San Luis Obispo, conducted a joint waste reduction study. Graduate and upper division environmental engineering students came to NUMMI to evaluate certain waste producing operations for possible reductions. The students prepared detailed analyses of the operations and suggested ways to reduce waste. The project is now at the stage where NUMMI team members and management are reviewing the suggestions for implementation. This paper will discuss ongoing waste reduction and recycling activities at NUMMI and the preliminary results of the Cal Poly student project.

PURGE THINNER SOURCE REDUCTION AND RECYCLING

A very important step in the vehicle manufacturing process is painting the vehicle bodies. Paint quality is very important to NUMMI's customers. The appearance of a vehicle must be attractive to a potential buyer before they will even consider purchasing the vehicle.

Paint is applied to car and truck bodies using a variety of painting systems. The interior is painted manually using hand-held electrostatic spray guns. The exterior is painted by electrostatic reciprocating spray and bell applicators. To ensure a flawless paint job, the application equipment must be cleaned between color changes and after every four or five paint jobs to remove dried paint particles. An organic solvent blend is used to clean the spray equipment. In the trade, this solvent is called *purge thinner.* In 1987 purge thinner usage was 2.2 gallons for each car produced. One-half of the material used was lost either through evaporation or in the water scrubber section of the paint booths. The other half was recovered for disposal as our largest hazardous waste stream (see Table 1). NUMMI's Environmental Affairs Staff decided that purge thinner was a prime candidate for source reduction and recycling.

Kaizen is a Japanese word that means improvement. In the workplace it means continuing improvement of people and processes. Purge solvent was ripe for kaizen.

The first step in the kaizen process was to quantify purge thinner usage, recovery and disposal. After the problem was quantified, investigation of source reduction, spent purge thinner recovery, and recycling opportunities commenced.

Source reduction was accomplished primarily by suggestions from team members. Cost savings through source reduction are easily determined so the prospect of suggestion program cash awards was a great incentive. Examples of kaizen measures implemented by the team members were:

- Reducing the pressure for the automatic purge cycle
- Shortening the length of the paint lines that had to be purged
- Reducing color change frequency

This source reduction kaizen measures resulted in reducing purge thinner usage from 2.2 to 0.6 gallons per vehicle. Spent purge thinner recovery was improved by eliminating leaks in the recovery system and designing a system to capture more of the sprayed purge thinner. Prior to NUMMI's kaizen effort, spent purge thinner was incinerated for heat recovery at a cement kiln. In 1991 NUMMI began a recycling program with Romic Environmental Technologies Corporation. Romic is a solvent recycling plant in Palo Alto, California.

In the beginning there was a lot of trial and error at Romic's chemical plant. Different refining methods were tried until they developed a process that would produce a recycled solvent that met our specifications and had an acceptable yield. Next, samples of the recycled purge thinner were given to NUMMI's paint engineering section for on-line trials. When paint engineering was satisfied with the product's performance, NUMMI began using it for production. Still bottoms from the recycling process are still incinerated by fuel blending. However, now NUMMI reuses almost 50% of the purge thinner used in the process. Recycled purge thinner is less than one-half the cost of new material which means there is a net savings of over $400,000 per year.

NUMMI developed the recycling process using standardized problem solving methods with input from the effected users. The recycled purge thinner has now been used for four years without any problems.

CARDBOARD SOURCE REDUCTION

A typical automobile contains about 10,000 parts. NUMMI manufactures the steel vehicle bodies, bumpers, instrument panels, and fuel tanks. The other parts are delivered to the plant for assembly as a complete vehicle. There are about 4,000 parts and subassemblies NUMMI receives in shipping containers. Most of the parts were delivered in expendable cardboard packages which produced 40 tons of waste cardboard each day.

Handling cost and extreme market price fluctuations make cardboard recycling expensive. To reduce costs and conserve natural resources NUMMI began a program to use returnable packaging for parts from domestic sources.

The largest obstacle to the returnable packaging program was to change material handling procedures. Team members were reluctant to change because returnables increased their workload and standard work procedures. However, NUMMI team members are very aware of the fact that every cost saving measure improves the viability of the company and their own job security. So, through a team effort, smooth transition was made to returnable packaging.

Packaging suppliers were asked to design returnable shipping containers for our parts. Design considerations were:

- Protecting the parts during transportation and storage
- Efficiency of the packaging, i.e. parts per unit volume
- Inbound and outbound packaging volume
- Recyclability of the returnable packaging
- Cost

By January 1996, about 900 of 1900 domestic parts were being shipped in returnable packages. The annual cost savings was over $3 million and the return on investment was only a few months. NUMMI's goal for 1996 is to increase returnable packaging for domestic parts to 80%.

STUDENT RECYCLING AND POLLUTION PREVENTION STUDY

Graduate students and senior level undergraduates from California Polytechnic State University (Cal Poly), San Luis Obispo, California performed a recycling and pollution prevention study at New United Motors Manufacturing, Inc. (NUMMI). The students performed the study as part of a graduate course, Environmental Engineering 541- Energy and Resource Recovery from Wastes. The philosophy of the course and how it utilizes the case study approach is discussed in Reference 1. This section the paper will discuss how the study was organized and how the study benefited both the students and NUMMI.

Background of the Study

Cal Poly and NUMMI have had a long standing relationship through the Cooperative Education Program (CO-OP). Electrical Engineering, Mechanical Engineering, and Computer Science students have participated in the program for several years. The students spend six months at the NUMMI facility in an engineering level assignment. Students are supervised by NUMMI and receive course credit through Cal Poly. Recently several Cal Poly students have been assigned to the Environmental Affairs Division. One of these students, Mr. Dan Mahoney, suggested that a Cal Poly class could assist NUMMI in a recycling and pollution prevention study. NUMMI would benefit from an intense outside look at their operations, and Cal Poly students would benefit from the opportunity to participate in a "real world" project at a world class manufacturing facility.

Preparation of the Assignment

The authors met several months in advance of the project assignment at the NUMMI facility in Fremont, California. A detailed tour of the facility was conducted, with special attention paid to potential new source reduction and recycling opportunities. The project assignment was developed over several iterations, to ensure that it would provide useful information to NUMMI, while providing the students with a rigorous educational experience. NUMMI defined the following goals for the project:

- Reduction, reuse, or recycling of all plastic wastes.
- Reduction, reuse, or recycling of all wastewater and paint sludge.
- Reduction, reuse, or recycling of all paper, cardboard, and packing wastes from all sources.

The project included both a detailed written report as well as an oral presentation to a judging panel. The report included the following sections:

- Schematic and plan views of the Process or System.
- A materials balance.
- A preliminary capital cost estimate of the Process or System and associated equipment.
- An operational cost estimate.
- A construction and implementation time schedule for the Process or System.

Project Execution

Cal Poly operates on the quarter system, with ten week terms, thus a limited time was available for the project. The last six weeks of the class were allocated to the project. The 22 students in the class were divided into six teams, with two teams each focusing on one of project goals identified by NUMMI. The project period began with an overall tour of the NUMMI facility, and detailed tours for each team on their assigned task (i.e., plastic wastes).

To streamline communications, Dan Mahoney, a former NUMMI CO-OP employee, acted as a liaison between NUMMI and the class. All questions were received by him in writing and faxed to NUMMI for replies. This system worked well and minimized time required by NUMMI personnel for fielding questions.

Project Results

Two student teams worked on each environmental goal as defined by NUMMI. Significant findings of the student studies are summarized below:

Plastic Wastes. Polypropylene is the predominate type of plastic used for vehicles at NUMMI. Polypropylene pellets are extruded into bumpers, instrument panels, and other components. The process is highly efficient with only a 3% waste generation rate. The waste is generated by parts that are out of tolerance (rejects), spurs and gates (excess plastic trimmed from the extrusions), and purges (extruded plastic which must be wasted when colors are changed). Reject plastic parts are currently recycled at $60/ton ($.03/lb), while the other plastic wastes, including painted bumpers, are recycled at $15/ton ($.0075/lb). The student teams took two completely different approaches to addressing the issue of low value recycling.

Team 1 - Fluidized Bed Combustion. Energy recovery by combustion and steam production was proposed by Team 1. The system featured state-of-the-art emission control equipment including a baghouse, internal limestone scrubbing, and selective non-catalytic reduction for NO_x control. The students recognized that the economics of the process proposed were currently marginal, but felt that rising energy costs would improve the economics in the future.

Team 2 - Optimization of Recycling. Team 2 proposed optimization of the existing plastics recycling program. First they observed that NUMMI had determined that quality control concerns limited reuse of

recycled plastics in the extrusion equipment to a maximum of 10%. Regrind equipment was installed to permit reject plastic parts to be reused. This regrind equipment was not being used because of the difficulty in obtaining consistent color matching of the parts. Furthermore, the largest component of waste plastic, the purge "patties" (about 225 tons/year), was too large to be fed into the regrind equipment.

Team 2 devised an innovative custom extrusion die which could be attached to the extrusion machine when the color change was to be made. The old color plastic would be extruded out through the custom die, forming a thin rectangular extrusion that could be easily cut into pieces small enough for the regrind equipment. They also identified ASTM color matching standards that could be used to accurately measure plastic formed using the reground recycled materials (ASTM D1535 and ASTM D1792).

Wastewater and Paint Sludge. Wastewater is produced at the NUMMI facility from several sources including rinsewater from several metal pretreatment steps (degreasing, zinc-phosphate rust proofing, etc.), and paint overspray. Wastewater is pretreated prior to discharge to the local sewer system by coagulation and settling. Lime, alum, and polyelectrolytes are used. The wastewater treatment system generates approximately 3.7 million pounds of sludge which has been dewatered to 42% solids. One team proposed a more efficient sludge dewatering system, while the other team proposed source reduction of paint overspray.

Team 3 - Sludge Drying System. Team 3 proposed the use of an innovative high efficiency sludge dewatering and drying system. The Centridy™ system uses an integrated centrifuge and drier to produce a dewatered and dried sludge of 60% solids. This would reduce annual sludge hauling by approximately 670,000 pounds/year.

Team 4 - Dry Overspray Collection System. Team 4 proposed to recover paint overspay with a dry conveyor belt system to replace the existing water trough conveying system. Pigments and their carrier solvents would be separated, for recycling and incineration respectively.

Paper, Cardboard, and Packing Wastes. NUMMI has already implemented an extensive packing waste reduction and recycling program. The largest reduction has been achieved by the use of returnable parts containers. Parts vendors to NUMMI ship vehicle parts in custom parts pallets which are returned to the vendor after the parts are installed. By the end of 1996, 95% of the parts delivered to NUMMI will be shipped in these returnable containers.

The remaining packing materials consist of wooden shipping pallets, cardboard containers, and shrink wrap film plastic. These materials are recycled by source separation. At the present time, office and cafeteria wastes are not recycled. To capture these materials more efficiently, NUMMI was considering the installation of an in-house materials recovery facility (MRF).

Team 5 - Analysis of MRF Operation. Team 5 chose to focus on the economics of the proposed MRF. Their study concluded that it would be more cost effective to improve upstream separation activities than it would be to build the MRF. They also identified vendors for the shrink wrap film waste not being currently recycled.

Team 6 - Optimization of Markets. Team 6 also identified economic issues related to the MRF, but did not perform as intensive an analysis, instead they focused their study on finding new markets. For example, they identified new markets for selling the wood pallets for reuse, instead of selling them as wood waste. In the San Francisco area, usable pallets are worth about $5.00 each, much more than their value as wood chips. Team 6 also identified local markets for beverage cans and bottles from the cafeteria areas, and markets for white mixed office paper.

CONCLUSIONS

This paper has discussed source reduction and recycling techniques at New United Motor Manufacturing, Inc. It has also presented the results of a unique partnership between industry and education. Both NUMMI and Cal Poly students and faculty have benefited from this partnership. Key benefits included:

- Cal Poly environmental engineering students participated in a "real world" problem solving experience.
- Students prepared a professional quality consulting report and presentation.
- NUMMI received a fresh look at ongoing source reduction and recycling practices. Several new approaches were presented.

REFERENCES

1. Vigil, S.A., "Development of a Graduate Integrated Waste Management Course Using the Case Study Approach," Proceedings of the 88th Annual Meeting and Exhibition of the Air and Waste Management Association, San Antonio, Texas, June 18-23, 1995.

Table 1. Purge Thinner Source Reduction and Recycling

	1987	1990	1995
Purge thinner used at NUMMI	413,900 gal	283,900 gal	217,900 gal
Recovered used purge thinner and slop paint	203,100 (49%)	189,500 (67%)	194,500 (89%)
Released to the environment (air, water, sludge TRI Report)	210,800 (51%)	94,400 (33%)	23,400 (11%)
Incinerated	203,100 (51%)	189,500 (67%)	91,000 (42%) recycling residual
Recycled for reuse at NUMMI	0	0	103,500 (47%)
Production	187,412 unit	205,260 units	352,649 units (cars & trucks)
Purge thinner usage	2.2 gal/unit	1.4 gal/unit	0.6 gal/unit