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Project Summary

Automotive and Heavy-Duty Engine Coolant Recycling by Filtration

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Product quality, waste reduction, and economic issues were evaluated for a chemical filtration technology designed to recycle automotive and heavy-duty engine coolants. A fleet-size recycling unit and a portable unit were evaluated. Coolant recycling was found to have good potential as a means of waste reduction and to be economically viable. Further improvements, however, are necessary in the product quality achieved by these units. Product quality was evaluated by conducting selected performance tests recommended in ASTM D 3306 and ASTM D 4985 standards and by chemically characterizing the spent, recycled, and virgin coolants.

This Project Summary was developed by EPA's Risk Reduction Engineering 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

The objective of the U.S. Environmental Protection Agency (EPA) and the New Jersey Department of Environmental Protection's (NJDEP) Prototype Evaluation Program is to evaluate, in a typical workplace environment, examples of prototype technologies that have potential for reducing wastes. The goal of the engine coolant recycling study was to evaluate (a) the quality of the recycled coolant, (b) the waste reduction potential of the technology, and (c) the economic feasibility of the technology.

In addition to simple filtration and chemical filtration, distillation and ion exchange technologies are commercially available for recycling engine coolant. A separate study of a distillation unit was also conducted and is presented in a separate report.

In the study summarized here, two chemical filtration units (shown in Figure 1), both manufactured by FPPF Chemical Co., Inc.*, were evaluated. The first unit tested was a fleet-size unit that can recycle up to 100 gal of coolant in one batch. The second was a portable unit that can be directly attached to a single vehicle and recycle the coolant back to the same vehicle. Both units contain two filters: a 25-µ and a 5-µ filter. The technology also involves the use of aeration to break oil emulsions and form metal oxides. An additive introduced during recycling precipitates metals in the form of their hydroxides, inhibits corrosion, reduces foam, and restores color. The amount of additive introduced during recycling is based on the initial pH of the spent coolant.

The study was conducted at the New Jersey Department of Transportation (NJDOT) vehicle maintenance and repair facility in Ewing, NJ. Currently all the spent coolant at the NJDOT garage (approximately 8,812 gal/yr) is shipped offsite for disposal.

* Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Product Quality Evaluation

Engine coolants are intended to provide protection against boiling, freezing, and corrosion. Through use, the coolants lose some measure of these functions because of the accumulation of contaminants and the depletion of additives such as corrosion inhibitors and anti-foam agents. The recycling process attempts to restore the functions of the coolant to standards specified in ASTM D 3306-89 and SAE J1034 (for automotive coolants) and ASTM D 4985 and SAE J1941 (for heavy-duty coolants).

Primary batches of spent coolant (as received) were run through the fleet-size unit and the portable unit. The "primary" batches represented stored spent coolant from automotive and heavy-duty vehicles operated by NJDOT. Three "spiked" (altered spent coolant) batches were also run. The purpose of these salts- and acid-spiked batches was to create exaggerated conditions to test the limits of the recycling process. A blank, consisting of virgin coolant and tap water, was run through the fleet-size unit. Samples of the spent, virgin, and recycled coolant were collected for analysis.

Results of the analyses were compared against ASTM and/or SAE standards. After recycling, the boiling and freezing points of the coolant were brought as close to the standard as possible through the use of a hand-held refractometer and alteration of the glycol to water ratio. None of the recycled samples from the primary batches met the corrosion standards (Table 1), as measured by the ASTM D 1384 and D 4340 tests. The spiked recycled samples, however, met the corrosion standards for the ASTM D 1384 test (Table 2). This variation may be because the amount of corrosion inhibitor added is based on the pH of the spent coolant. Since the acid-spiked samples had lower pHs, adding more corrosion inhibitor to the coolant resulted in better corrosion resistance.

The spent and recycled coolants were characterized chemically (Tables 3 & 4), and levels of contaminants, such as metals, chlorides, oil and grease, etc., were measured to determine if these constituents affected performance. After recycling, although levels of chlorides and sulfates were not noticeably reduced in the coolant, the level of metals was considerably reduced. This retention of chlorides and sulfates in the recycled coolant may contribute to corrosion.

Waste Reduction Potential

Waste reduction potential was measured in terms of volume and hazard reduction. Volume reduction addresses gross waste streams (i.e., spent coolant, filters); hazard reduction involves individual pollutants (i.e., ethylene glycol, heavy metals) contained in the waste stream.

To estimate the amount of coolant that NJDOT disposes of annually, the amount of new coolant that NJDOT uses annually was decreased by 10% to account for the environmental loss of coolant through leaks in the vehicles' cooling systems. Because the coolant is to be recycled rather than disposed of, the volume of waste reduction for the NJDOT was calculated to be 8,812 gal. Also accounted for were sidestreams generated for disposal during recycling itself (e.g., filters).

Since contaminants contained in the spent coolant will reach the environment whether or not the coolant is recycled (either through spent coolant disposal or spent filters), the measurable hazard reduction comes from the amount of ethylene glycol that does not reach the environment. Ethylene glycol is considered a hazardous waste in some states (such as California). Recycling coolant offers considerable potential for reducing the amount of ethylene glycol released to the environment.

Economic Evaluation

The economic evaluation took into account the capital and operating costs (shown in Table 5) of the recycling equipment, as well as the savings provided by decreasing the needed amount of raw materials (virgin coolant, water) and by reducing disposal costs. Because of the relatively high price of virgin coolant and the high volume of virgin coolant purchased by NJDOT, the payback period for the recycling process was less than 1 yr. Therefore, effective coolant recycling would make economic sense.

Conclusions

Although recycling has great waste reduction and economic potential, this particular recycling unit would require additional improvements to ensure an acceptable quality of the recycled product. Some possible areas of improvement are (a) adjusting the method of determining the amount of additive used and (b) implementing a means of anion (chlorides and sulfates, etc.) removal such as ion exchange.

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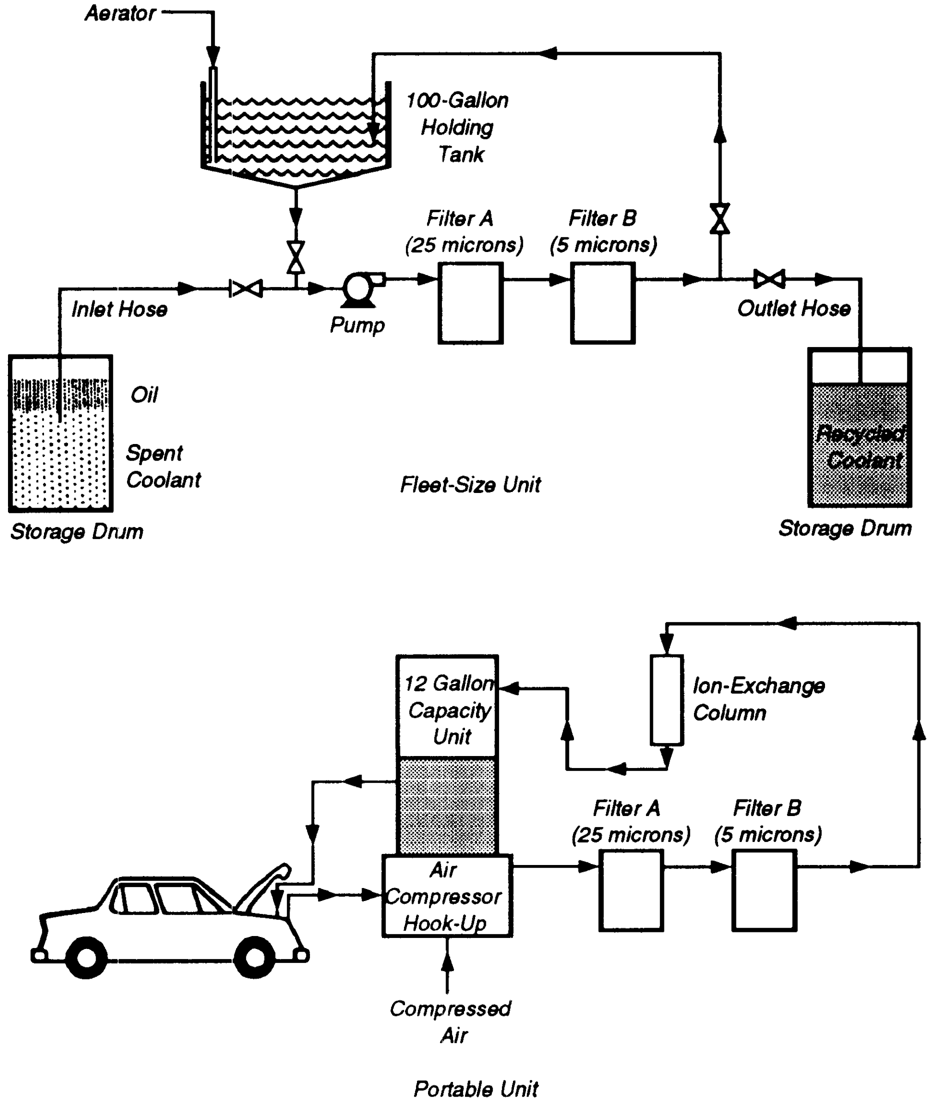

Figure 1. Coolant Filtration Process

Table 1. pH (ASTM D 1287-85) and Corrosivity (ASTM D 1384-87) as Measured in Laboratory

Batch No.	Description	Unit Type *	Sample	pH †	Weight Loss per Specimen (mg) *,§					
					Copper	Solder	Brass	Steel	C. Iron	C. Al
1	Primary	F	Spent	7.68	2	2	2	1	63	3
			Recycled	11.17	17	26	3	0	2	1
2	Primary	F	Spent	8.41	0	3	2	0	30	0
			Recycled	9.64	20	4	11	0	1	0
3	Primary	F	Spent	8.41	0	3	2	0	30	0
			Recycled	10.32	18	2	10	0	48	0
4	Primary	P	Spent	8.41	0	3	2	0	30	0
			Recycled	11.01	NA	NA	NA	NA	NA	NA
5	Primary	P	Spent	NA	NA	NA	NA	NA	NA	NA
			Recycled	9.87	NA	NA	NA	NA	NA	NA
6	Salts Spiked	P	Spiked	NA	NA	NA	NA	NA	NA	NA
			Recycled	8.86	2	1	4	0	3	15
7	Acid Spiked	F	Spiked	NA	NA	NA	NA	NA	NA	NA
			Recycled	10.01	2	5	5	0	3	1
8	Salts/Acid Spiked	F	Spiked	6.21	4	0	8	229	94	1
			Recycled	8.92	4	2	5	0	1	2
9	Blank	F	Virgin	8.74	4	0	6	0	0	1
			Recycled	9.23	3	2	6	0	1	3

* Type of recycling unit (F = Fleet Size, P = Portable).
† SAE Standard for pH 7.5 to 11.0
* Average of triplicate results. Triplicates reported in Appendix B.3 of full report. "NA" indicates not analyzed.
§ ASTM D 3306 Standard for Corrosion:
Copper = 10 mg max; Steel = 10 mg max
Solder - 30 mg max; Cast Iron = 10 mg max
Brass = 10 mg max; Cast Aluminum = 30 mg max

Table 2. Corrosion of Cast Aluminum Test (ASTM 4340-89) Results

Batch No.	Description	Unit Type*	Sample	Corrosion Rate † (mg/cm^2/ week)
1	Primary	F	Spent	20.2
4	Primary	P	Recycled	5.5
5	Primary (Van)	P	Recycled	22.4
9	Blank	F	Virgin	0.9

* Type of recycling unit (F = Fleet size, P = Portable).
† SAE Standard: Corrosion rate not greater than 1.0 mg/cm^2/week.

Table 3. *Concentrations of Metallic Contaminants in Coolant*

Batch No.	Coolant/Sample Description	Unit Type *	ppm in Coolant: Aluminum	Calcium	Copper	Iron	Lead	Magnesium	Zinc
2/3 †	Primary-Spent	F	0.66	5.6	0.49	7.2	1.0	1.1	1.4
2	Primary-Recycled	F	2.14	<1.0	0.19	4.2	0.37	<1.0	0.9
3	Primary-Recycled	F	2.01	<1.0	0.58	3.7	0.53	<1.0	0.9

* Type of recycling unit (F = Fleet size; P = Portable).
† Batches 2 and 3 came from the same storage drum and represent the same spent coolant.

Table 4. *Concentrations of Non-Metallic Contaminants in Coolant*

Batch No.	Coolant/Sample Description	Unit Type *	ppm in Coolant: Chloride	Sulfate	Total Dissolved Solids	Oil and Grease	Glycolates
2/3 †	Primary-Spent	F	95.5	166	2900	307	511
2	Primary-Recycled	F	71.4	149	3010	176	432
3	Primary-Recycled	F	75.1	140	2990	146	432

* Type of recycling unit (F = Fleet size; P = Portable).
† Batches 2 and 3 came from the same storage drum and represent the same spent coolant.

Table 5. *Operating Costs Summary*

Item	Quantity/yr	Unit Cost ($)	Total Cost ($/yr)
Current Practice			
Spent Coolant Storage Drums	160	30	4,800
Spent Coolant Disposal	8,812 gal	105/55 gal	16,823
Labor for Disposal	160 hr	15	2,400
Recycling (Fleet-size Unit)			
Make-up Virgin Coolant	1,234 gal	6.20	7,651
Extender (Additive)	220 gal	1,045/55 gal	4,180
Filter A	22	11.11	244
Filter B	11	11.11	122
Operating Labor	40 hr	15	600
Operating Energy	75 kwhr	0.12	9
Recycling (Portable Unit)			
Make-up Virgin Coolant	1,234 gal	6.20	7,651
Extender (Additive)	167 gal	115/6 qts.	12,803
Filter A	22	11.11	244
Filter B	11	11.11	122
Operating Labor	441 hr	15	6,615
Operating Energy	383 kwhr	0.12	46

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