Zero Waste Machine Coolant Management Strategy at Los Alamos National Laboratory

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Abstract

Machine coolants are used in machining equipment including lathes, grinders, saws and drills. The purpose of coolants is to wash away machinery debris in the form of metal fines, lubricate, and disperse heat between the part and the machine tool. An effective coolant prolongs tool life and protects against part rejection, commonly due to scoring or scorching. Traditionally, coolants have a very short effective life in the machine, often times being disposed of as frequently as once per week. The cause of coolant degradation is primarily due to the effects of bacteria, which thrive in the organic rich coolant environment. Bacteria in this environment reproduce at a logarithmic rate, destroying the coolant desirable aspects and causing potential worker health risks associated with the use of biocides to control the bacteria. The strategy described in this paper has effectively controlled bacterial activity without the use of biocides, avoided disposal of a hazardous waste, and has extended coolant life indefinitely. The Machine Coolant Management Strategy employed a combination of filtration, heavy lubricating oil removal, and aeration, which maintained the coolant peak performance without the use of biocides. In FY96, the Laboratory generated and disposed of 19,880 kg of coolants from 9 separate sites at a cost of $145K. The single largest generator was the main machine shop producing an average 14,000 kg annually. However, in FY97, the waste generation for the main machine shop dropped to 4,000 kg after the implementation of the zero waste strategy. It is expected that this value will be further reduced in FY98.

Keywords:
Machine Coolant, Waste Minimization, Evaporator, Anaerobic Bacteria, Skimmer

Introduction

The main machine shop at Los Alamos has typically produced approximately 14,000 kg of machine coolant waste annually. Through a variety of administrative controls and operational changes, Los Alamos has been successful in reducing this waste stream to only 4,000 kg/yr. This paper describes the strategy undertaken to reduce this waste stream and current plans to further reduce this waste stream to less than 400 kg/yr.
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**Waste Minimization Strategy**

Machine coolants are used in machining equipment including lathes, grinders, saws, and drills. The purpose of the coolant is to wash away metal debris and disperse the heat generated between a part and the machine tool. An effective coolant prolongs tool life and protects against part rejection, commonly due to scoring or scorching. Traditionally, coolants have a very short effective life in the machine, often times being disposed of as frequently as once a week. The cause of coolant failure is primarily due to the affects of bacteria which thrive in the organic rich coolant environment.

**Figure 1**

![Machine Coolant Waste](chart.png)

Bacteria in this environment reproduce at a logarithmic rate destroying the desirable coolant properties by producing acid that lowers the coolant pH and causing potential worker health risks. Workers exposed to coolant with high bacteria levels can incur eye, nose and throat irritations, dermatitis, and respiratory problems. In addition, the bad odors produced by bacteria growth creates a undesirable work environment. Biocides can be added to the coolant to control bacteria growth. However, biocides, which become airborne during machining operations, produce undesirable health risks to the workers.
Bacteria growth can largely be eliminated through aeration, filtration, and the removal of machine lubricating oils which accumulate on the surface of the machine coolant. Aeration provides an oxygen rich environment which destroys anaerobic bacteria. Filtration and lubricating oil removal eliminates the substrate which promotes bacteria growth. A typical processing system for performing these operations is presented in Figure 2.

![Figure 2](Typical Machine Coolant System)

Many variations of this basic processing scheme exist to inhibit the growth of bacteria. Filtration and lubricating oil removal can be performed separately or together at each individual machine or combined into a central processing unit to which coolants are periodically removed from individual machines, processed through the centralized unit, and returned.

An important aspect to this processing to inhibit bacteria growth is periodic coolant testing to ensure that processing time is adequate to inhibit bacteria growth. Coolant testing consists of a simple determination of bacteria levels, pH, and coolant concentrations. Bacteria level measurements are critical to determine an adequate processing schedule. The measurement of pH is an important factor in determining the coolant quality. Lubricity is lost and bacteria growth is enhanced as the pH of the coolant decreases. As pH decreases, it is important to add an additive to increase the coolant pH to preserve the coolant qualities and prevent bacteria growth. Finally, routine machining operations results in changes in the water to coolant ratios present in the machine coolant. These ratios need to be determined periodically with a refractometer and adjusted to ensure that the coolant is maintained with the appropriate ratios for peak performance.
In addition to periodic coolant processing, it is important to establish administrative controls followed up with training to prevent the addition of other machining aids, cleaning chemicals, or other materials to the coolant that may degrade its properties and result in the need for more frequent disposal of the coolant and replacement with new. Besides possibly affecting the life of the machine coolants, many of these materials may also affect the waste category of the coolant for disposal. Most coolants are disposed of as a State Regulated waste. Inadequate controls on the use of these materials may result in the need to reclassify the coolant as a RCRA waste increasing the disposal cost.

Initial efforts at Los Alamos to decrease coolant wastes consisted of the installation of a centralized coolant processing unit with implementation of administrative controls on the use of machining aids, cleaning chemicals, and other materials. The processing unit provided filtration, lubricating oil removal, and aeration. Although effective, because of the large number of machines present, it was not possible to process the coolant in all of the machines in a timely enough fashion to prevent the growth of bacteria. To eliminate this problem, oil skimmers/aerators were installed on individual machines and a portable filtration unit is utilized as necessary. The combination of these efforts have been very successful and have reduced the annual coolant waste generation rate from 14,000 kg/yr to less than 4,000 kg/yr.

Through a coolant testing program, efforts are still underway to determine more effective processing schedules to decrease this waste volume further. However, even with improvements to the processing schedules, our current predictions are that we will only be able to reduce this waste stream to approximately 3,000 kg/yr. The remainder of the coolant is generated during the clean out of machines to switch to different machining operations and waste coolant generated during the lubrication oil skimming operations. To reduce the coolant waste stream further, we are currently in the process of purchasing an evaporator to reduce the remaining 3,000 to 4,000 kg of coolant waste to less than 400 kg/yr of waste. The evaporator system is currently scheduled to begin operations at the end of FY98.

Conclusions

Los Alamos has been successful in reducing the coolant waste produced by machining operations in their main shop from 14,000 kg/yr to 4,000 kg/yr. These reductions were made possible by installation of coolant processing systems to filter, aerate, and remove lubricating oils from the coolants. These systems have proven very successful at eliminating the growth of bacteria, the main cause of coolant degradation. Processing was combined with a coolant testing program to determine the optimum processing schedules for the machine coolants and to maintain the coolants at peak operating concentrations and pH. In addition, an administrative control program combined with training was implemented to prevent the use of machining aids, cleaning chemicals, or other materials which when added to the coolant may degrade its properties or result in the generation of a RCRA hazardous waste. Finally, in order to further reduce the amount of coolant waste generated, an evaporator system will be added in the future to decrease the waste generated to less than 400 kg/yr. At the current handling/disposal cost
for this waste stream of $750.00 per kg, the reduction in coolant waste from 14,000 kg/yr to 400 kg/yr is estimated to result in an annual cost savings to Los Alamos of $102,000 per year.