Commentary

Metalworking Fluids—Clearing Away the Mist?

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Received 26 February 2005; in final form 12 March 2005; published online 21 April 2005

Metalworking fluids (MWFs) are a vital component of a vital process—the machining of metals. They cool and lubricate the metal and tools, carry away waste and swarf and sometimes provide protection against corrosion for the workpiece surface. They have been in use for a century and a half, but the 73 cases of alveolitis and asthma at a British car engine manufacturer in Longbridge, last year, illustrate that the health risks are still with us (BBC News, 2004). MWFs formulated using vegetable oils have been introduced in the hope of further reducing toxicity and increasing biodegradability of waste. This issue includes a paper, by a team from the University of Minnesota, looking at the mist generation of some of these formulations (Raynor et al., 2005).

The use of MWFs grew with the automobile and aircraft industries. Changes in the composition of fluids have been driven by the need to improve performance as well as reduce hazards. Straight oils became available in the middle of the 19th century. Use of crude synthetics began as early as 1883. Soluble oils (oil and water emulsions) came into use around 1915, semisynthetics (containing a small amount of oil) in 1947 and modern synthetics (with no oil) around 1950 (Independent Lubricant Manufacturers Association, 2003).

In the period between 1950 and 1984, improvements in the oil refining process resulted in progressive reductions in the polyaromatic hydrocarbon (PAH) content of base oils. Changes in water-based fluids between 1970 and 1984 included the elimination of alkali metal nitrites and the potential for contamination by nitrosamines. There have been many other developments of these fluids over the years.

The composition of the fluids not only affects their toxicity, but also their propensity to form an airborne mist. Fluid suppliers test the mist-producing properties of their fluids and attempt to show, for a given machine, that their fluid will produce less mist than a competitor’s. This is part of the ongoing evolution of MWFs from the early unrefined oils.

It was this mist-generating process that the University of Minnesota team investigated. They prepared stable, experimental oil-in-water emulsions made from modified and unmodified soybean oil for potential use as MWFs. They fed the MWFs onto a 75 mm diameter cylinder spinning in a wind tunnel, to simulate the action of a lathe, and measured the characteristics of the mist 130 cm downstream. Mist formation by impaction was similar for the experimental fluids and a current petroleum-based soluble oil MWF, although the former produced more by centrifugal force. The paper states that the biggest difference is the mist produced by the evaporation/recondensation mechanism, and on this basis the experimental formulations could possibly lead to reduced worker exposure from mist formed by this process. However, for most machining operations, this route to mist formation is likely to be far less significant than that produced by impaction or centrifugal force.

Raynor et al. (2005) acknowledge that key factors in the control of ill-health are the use of less MWFs, as well as the use of less toxic materials. In the UK, the industry (British Lubrications Federation, Engineering Employers Federation, Institute of Petroleum, Amicus Union, Machine Technologies Association and Envirowise) has worked closely with HSE to help educate the employers in the prevention of ill health. In many ways this industry has been a success story.

With all these developments, occupational disease from MWFs should be largely a thing of the past. But incidents like the Longbridge one still occur. Extrinsic allergic alveolitis [also known as hypersensitivity pneumonitis (HP)] is an inflammation in and around the air sacs of the lung caused by an allergic reaction...
to inhaled organic dust or chemicals. There have been a number of outbreaks of HP in the last decade, mainly in the United States and Canada. Implicated in these cases are the microorganisms, *Mycobacteria chelonae*, and more recently, *Mycobacteria immunogenum*. This is a modern condition and, unlike many occupational diseases, one that most occupational hygienists had not heard of in the classroom.

Passman *et al.* (2002) hypothesized that shifts in MWF chemistry over the past 20 years (e.g. the increased use of synthetic and semi-synthetic MWFs) may be contributing to an increased prevalence of gram-positive bacteria, including mycobacteria (Skerlos *et al.*, 2003). It has also been hypothesized that mycobacteria can proliferate under biocide conditions that are normally detrimental to common metalworking fluid microorganisms. Whether or not this hypothesis is true, there is a more fundamental problem with MWFs—one that has, for many engineering companies, been an ongoing battle ever since they first commenced using MWFs and that is the effective management of their MWFs.

The MWFs are an important part of the machining process, yet are often treated with little regard. The machine sumps containing these fluids are sometimes used as rubbish dumps for unwanted food debris, cigarette stubs and are even occasionally used as urinals. These abused fluids become a rich breeding ground for bacteria. Biocides are often added to combat this, but the surviving bacteria quickly grow and the dead bacteria release endotoxins, which can produce a variable flu-like response and reduce lung function, and exposure may exacerbate symptoms in those with pre-existing asthma. Bacteria and endotoxin contamination in MWF may also contribute to allergic contact dermatitis. Heavy bacterial contamination in MWF can deplete oxygen in the sumps, allowing sulphate reducing bacteria to grow and release hydrogen sulphide, causing the ‘rotten egg’ or ‘Monday morning’ smell when machines are started after sumps have been left static for some time.

Once these heavily contaminated mists get into the air during machining, the operator breathes in a potent cocktail of hazardous substances. The bacteria in these sumps may not always contain mycobacteria, which do not seem to be found as often in European sumps, but they will contain other microorganisms (principally pseudomonads). Many engineering companies do not even take the basic steps to manage these fluids. As a minimum, they should check pH (i.e. bacteria release acidic byproducts) and fluid strength.

Therefore, there are two steps to minimizing ill health: first, keep the fluid as clean as possible, and second, minimize breathing the mist that is generated. Microbial growth can be minimized by using clean water to make up solutions, keeping the fluid aerated, keeping dirt and debris out, preventing microbial overgrowth using biocides and removing biofilm (slime) by cleaning when fluids are replaced. It needs commitment to keep bacteriological levels low; and it would be better than trying to remove them once they have heavily populated a system. Once a system is heavily contaminated, removing bacteria from all parts of the system becomes very difficult. Veillette *et al.* (2004) showed that bacteria can quickly repopulate a system after emptying, cleaning and recharging if residual bacteria (i.e. in inaccessible areas) are not removed. The residual bacteria in the system, in this study, were able to seed the system within 12 h of cleaning.

There are no UK occupational exposure limits (OELs) for MWFs and a workplace exposure limit under the new British OEL procedures is not planned. This is because, the protection of worker health can only be achieved by taking a holistic approach at controlling all aspects of MWFs. Control is achieved by ensuring that inhalation and dermal exposure are controlled; it is also necessary that the fluid is effectively managed to prevent significant contamination. In other words, low personal exposure to mist may still result in cases of ill health, if the fluid is poorly managed, with significant contamination of, for example, bacteria and fines etc. To set an OEL in isolation would detract from the need for holistic approach.

In the absence of an OEL, the Health and Safety Executive worked with industry to develop a package of guidance that represented good practice for MWFs. This package of guidance (Working safely with metal working fluids; ISBN 0-7176-2561-3) describes the measures necessary to manage the fluid and minimize skin and inhalation exposure. It also provides guidance values to assist employers in demonstrating that they have achieved good practice. These guidance values are 1 mg m\(^{-3}\) 8 h TWA for water-mix MWF concentrate and 3 mg m\(^{-3}\) 8 h TWA for mineral oil. There are also good practice values for bacteriological levels, endotoxins and fines. A part of the package is the leaflet for employees, Working safely with metal working fluids, which is free and can be downloaded from the HSE website (http://www.hse.gov.uk/pubns/indg365.pdf).

It is worth noting that, although cancer in this industry is largely due to historical exposures, in the United States the National Toxicology Programme (NTP) has nominated MWFs for review under its 12th Report on Carcinogens (RoC). ACGIH have also proposed a new TLV for mineral oil of 0.2 mg m\(^{-3}\), with the notation A2 (suspected human carcinogen) for poorly refined mineral oils and A4 (not classified as a human carcinogen) for highly refined mineral oils.

We can be certain that metal working will continue to be very widespread, and that, although
Raynor et al. (2005) mention the possibility of dry machining, MWFs will be with us for a long time to come. However, there seems no reason why this should continue to be accompanied by disease.

REFERENCES


