Cradle to Grave Solutions: New Generation Metalworking Fluids (MWFs)

TECHNOLOGICAL ADVANCEMENTS IN THE WASTEWATER TREATMENT OF PROCESS FLUIDS ARE MAKING WATER RECYCLING POSSIBLE, WHILE OFFERING COST EFFECTIVE SOLUTIONS.

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In the metal processing business there are no generic solutions for the quality challenges and economic pressure being exerted on manufacturers in the increasingly competitive global marketplace. The specialty chemical aspect of the metal machining industry is no different. This business is being reshaped by a variety of drivers, such as health and environmental concerns, technological factors, improved part quality, reduction in overall process costs, enhanced chemical lifecycle and more.

Good manufacturing processes result from careful observation, measurement and data collection, as well as rigorous analysis and well-developed intuition. Relying on such observations, data collection and measurements, we present a summary of the new generation metalworking fluid technologies. While these new technologies offer longer fluid life, improved part quality and environmental health and safety benefits, eventually these process fluids get exhausted and have to be disposed.

New advancements in technologies such as mechanical vapor recompression (MVR) in the wastewater treatment of process fluids make water recycling possible while offering cost effective solutions. Our focus is on a holistic approach to summarize such best-in-class, cradle-to-grave solutions in the selection, management and disposal of new generation MWFs.

IN THE BEGINNING

We asked ourselves a simple question almost 20 years ago. If we were buying a fluid and dismissing the cost, what would we want from it? After boiling down all the responses, it came down to one thing: we would want to put it in the sump and forget about it. So back in 1989-90 we started designing fluids that would be less labor intensive to use. This meant it would have to do the job under a variety of conditions, be operator friendly, and not pose any environmental concerns.

To do this, the choice of ingredients had to be changed. The traditional chemistries being used at the time simply could not measure up to the new self-imposed criteria. So we started formulating fluids with different building blocks and ingredients that did not easily change in time and use.

Fluids that break down can produce bad actors ranging from biological conditions that change the chemistry and produce an unhealthy environment to chemical changes that detract from the stability of the fluid in use.

This meant these new ingredients had to remain unchanged, in use, from the biological challenges, the physico-chemical conditions, and the process conditions. In other words, the real world.

The design began with choosing individual molecules that met the above requirements, and putting them together so the sum of the parts gave the intended purpose of the fluid. Interestingly enough, we found in the early R&D stages that some fluids did not change much at all under a variety of chemical and biological stresses, but didn't fulfill their intended purpose, i.e. would not lubricate, cut or grind very well when compared to conventional fluids.

Over time, we became judicious in our choices and found materials that did not change easily in time, in use, and still provided the primary intent of the fluid. In a sense, we worked backwards. This made formulations very complex. If a formulation chemist left this industry ten years ago and came back, he would not recognize the reason why certain ingredients are being used now.

Being immutable is key. Fluids that break down can produce bad actors ranging from biological conditions that change the chemistry and produce an unhealthy environment to chemical changes that detract from the stability of the fluid in use. If you must dump a fluid frequently, it also creates an environmental impact, waste treatment concerns, and is wasteful of water.

Many of the molecules we chose already existed as natural products or could be modified from natural products. These renewable resources, such as vegetable oils, can be easily modified by the synthesis chemist to fit the needs of the modern metalworking fluid and its application. This is also a type of sustainable development. The combination of the renewable resource with the ingenuity of its chemical manipulation can compete economically with those based on petroleum. In many cases they can even out perform the petroleum based fluid.

Basic Mechanical Vapor Compression Evaporator Model

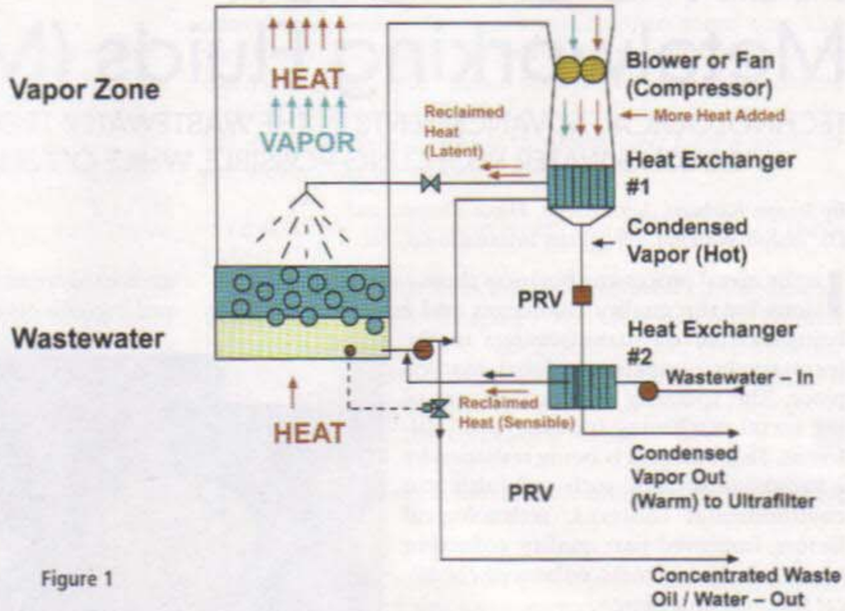

Figure 1

IMPACT ON METALWORKING

Our introductory metal removal fluid represented a breakthrough in coolant technology and pretty much satisfied our original quest for a product that could be charged into a machine and essentially ignored. We still do and will always preach proper concentration control and the removal of contaminants in order to create the best environment for the machine operators.

Our research and development mindset and effort allowed us to introduce this coolant to the metal working industry back in 1997. No guinea-pig product, our coolant is utilized in more than 1000 major customer locations totaling more than 25 million sump gallons in the U.S. alone. Our customers are recognizable icons of the automotive, motorcycle, aerospace, defense, medical implant, bearing, and off-road industries.

Additionally, the unique research and development approach allowed for the use of optimally lubricious materials (many of which we manufacture ourselves) that allow a majority of our customers to achieve dramatically improved tool life and the associated savings. Several customers have documented more than $1 million in tool life cost savings that are attributable to their conversion to our technology. Our bottom line to the industry is simply this: the implementation of our technology into your plant will remove the coolant-related issues from your to-do list. You will be able to focus upon manufacturing and not have to deal with baby-sitting our coolant.

But why end the story there? To further increase the life of the fluid, the supplemental lubes that support the coolant were also proactively engineered. The hydraulic fluid and way lubes used in pumps and process operations will leak into the metalworking fluid as tramp oil. This can raise havoc with the coolant and give it an untimely demise. Leaks don't stop, but if the hydraulic fluid and way lubes had the same composition as the coolant, then who cares (to a point)!

And why stop with the mechanical lubricants? Why not design the aqueous quenchants, drawing compounds, cleaners, rolling fluids and rust preventives around our proven, long-lived, renewable chassis? This work is called congruent chemistry.

Product design in all these arenas is a key entity for success and a major consideration is that we maintain the guidelines outlined by the various regulatory agencies around the world. This involves the development of metalworking fluids that are the same chemically for the Americas, Asia and Europe, yet meet the local regulations on a regional basis. Product design is not a simple matter on a global scale.

FLUID FAILURE AND CONTROL PROGRAMS

Factors referred to as "failure mechanisms" influence the stability of metalworking fluids when working with the general manufacturing environment. These failure mechanisms act directly on the fluid chemistry and are the initiating chemical reactions that begin the fluid failure process. The failure mechanisms are:

1. Type of metal machined, cast iron, aluminum, mild steel, yellow metals, stainless steel, magnesium
2. How machined – bid chip / small chip
3. How filtered – full / side stream / none
4. Residence time in sump – days / weeks / months – TURNS
5. Chip Load to coolant volume
6. Water quality – cations / anions loading
7. Water quality variations – well/ river/ lake/ great lakes

8. Water consumption – Evaporation rates
9. Tramp oil types - hydraulic, way, spindle, gear, and "slushing oils"
10. Tramp oil consumption – per volume of coolant consumption
11. Bacteria / fungus – odors / biofilms/ dead spot identification

In addressing these failure mechanisms and control practices, the only failure mechanisms that cannot be controlled are #1 and #2. The remaining nine failure mechanisms can be virtually eliminated, with diligence, over time. Thus, the overall performance of the fluid will improve.

Further success can be gained by addressing or improving the following areas:

i. Chemical control programs – anti-microbial, measurement, fluid mixing, fluid distribution, pH
ii. Training of chemical control technicians
iii. Chemical control personal – authority to make decisions.
iv. In-plant quality control programs – ISO 9000, ISO 14001
v. Willingness to accept change by the end user
vi. Understanding the cost / payback model

To summarize, using a high quality fluid, controlling failure mechanisms, and implementing effective control programs will result in a multi-fold payback for the end user.

ENVIRONMENTAL CONSIDERATIONS, ADVANCEMENTS IN WASTEWATER TREATMENT

Metalworking fluids are complex substances and are subject to a variety of environmental laws. There are traditional methods for waste water treatment. These are:

a. Chemical salt and / or polymer splitting
b. Membrane separation, microfiltration, ultrafiltration, nano-filtration, reverse osmosis.
c. Thermal Evaporation, atmospheric or under vacuum
d. Biological treatment, aerobic or anaerobic

Some advanced methods utilize combinations of any of the methods above. For example, salt splitting followed by biological treatment. Each method still requires a discharge to the environment, thus continued concern regarding regulations.

A new method has entered the wastewater treatment arena that is a type of distillation with incredibly high thermal efficiency. This is referred to as mechanical vapor recompression distillation, or MVR. With MVR, a clever use of a basic sealed evaporating vessel, followed by a rotary lobe blower and two heat exchangers in series allows oily, plant effluent to be evaporated and condensed into water for 15 times less energy than conventional distillation or thermal evaporation systems (see Figure 1).

By adopting the technology in Figure 1 to a manufacturing facility, the flow schematic in Figure 2 applies. By this proposed method, the facility can be zero water discharge. This MVR/UF concept would comply with the most restrictive environmental regulations and provide a salable oil as a by product. This MVR/UF concept turns oily wastewater into two useful commodities: water for reuse and oil for recovery.

Overall Flow Schematic

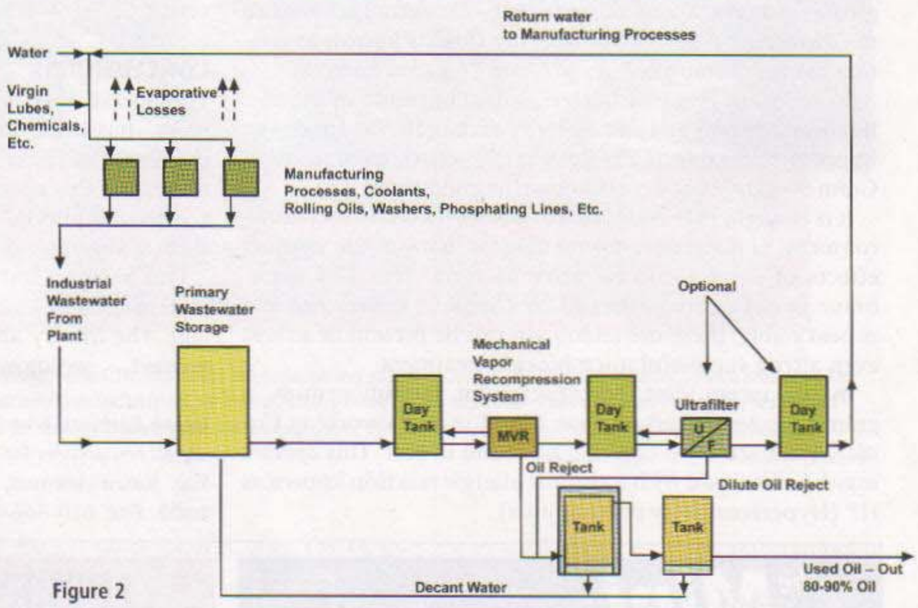

Figure 2

MICROBIOLOGICAL ISSUES

We found early-on that our research and development approach would have to center on addressing microbiological issues. The reasons for this were simple and complex, simple microorganism growth was creating a wide array of problems from offensive odors, to extensive use of microbiocides, to total breakdown of the coolant resulting in costly complete dumps.

Even complete dumps were not always successful because of the presence of biofilm (slimy growths composed of an ecosystem of microflora and their polysaccharide/protein complex that is not always visible to the human eye) on the walls of holding tanks and in conduits throughout the fluid handling systems. These biofilms could quickly initiate new growth in the replacement fluid. The remediation of this type of microbiological problem can become quite complex and extremely costly.

Due to the demands of this unhealthy work environment, we began to require success in microbiological tests before looking at other aspects of producing a long-lasting fluid. We also found that we needed faster tests and more stringent pass/fail criteria in these tests to meet our goals. The result was an extensive testing program that not only helped produce our new technology; it led to the ability to make rapid changes in fluid design for specific job applications. Together with proper control programs, including concentration and pH control, microbiological destruction of metalworking fluids need not occur.

Emerging health and safety issues associated with microorganism growth in metalworking fluids has led to even greater concern about the presence of microorganisms in metalworking fluids. Metalworking fluid is known to contain many common species of Gram-Negative bacteria.

These Gram-Negative bacteria might be found in any surface water or soil and can easily contaminate the fluid. The lipopolysaccharide (LPS) part of the outer membrane of Gram-Negative bacteria is known as endotoxin.

It is thought that endotoxin is always present in our environment. Endotoxin is responsible for many of the virulent effects of some Gram-Negative bacteria. This LPS membrane is not easily destroyed by chemical treatments and is heat stable; therefore endotoxin can be present in a fluid even after a successful microbiocide treatment.

In the recent past, Mycobacterium immunogenum, a gram-positive bacterium, was found in metalworking fluids. Mycobacterium can also be found in soil. This species may be associated with a chronic allergic reaction known as HP (Hypersensitivity pneumonitis).

Mycobacterium species are heat tolerant and are resistant to many commonly used microbiocides. Because of the potentially debilitating effects of HP, many users are so concerned with Mycobacterium growth that extensive routine monitoring programs on-site and pre-use susceptibility testing is required.

As monitoring programs around the world become more intensive, Mycobacterium is being found in more locations globally. The U.S. response, in general, is zero-tolerance of actively growing Mycobacterium. The diligent choice of fluid technologies is critical to these health-related concerns.

CONCLUSIONS

The phrase "sustainable futures" or "sustainable development" has been in vogue for the past several years. From the aspect of chemical manufacturers, it means "producing chemicals that are safer for the environment, workers, and the general public." Products based on renewable resources such as vegetable oils have already been developed.

Our business is to provide innovations of bioresistant and sustainable development technologies as a competitive advantage. The history and success of these innovations is documented . . . we know it works and encourage you to try it.

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