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Review Paper on Maintenance and Treatment of Metal Working Fluids (MWF'S)

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ABSTRACT

The purpose of this project is to design a water distillation system that can purify water from nearly any source, a system that is relatively cheap, portable, and depends only on renewable solar energy. Distillation is one of many processes that can be used for water purification. This requires an energy input as heat, electricity and solar radiation can be the source of energy. When Solar energy is used for this purpose, it is known as Solar water Distillation. Solar Distillation is an attractive process to produce portable water using free of cost solar energy. This energy is used directly for evaporating water inside a device usually termed a "Solar Still". Solar stills are used in cases where rain, piped, or well water is impractical, such as in remote homes or during power outages. Different versions of a still are used to desalinate seawater, in desert survival kits and for home water Purification

Keywords – Purification, Convection, Distillation, Evaporation, Radiation.

I. INTRODUCTION

Metalworking fluids (MWFs) play a significant role in manufacturing processes such as forming, cutting and grinding. They influence heat generation in metalworking processes by reducing friction between tool and workpiece. Cooling is furthermore achieved by dissipating and conducting the generated heat. By their lubricating and cooling properties, MWFs contribute to the avoidance of thermal damage of the workpiece material and reduce wear of the tool. In general we can define metalworking fluids as liquids, which are supplied to a manufacturing process in a way that allows for increased productivity based on lubricating and cooling effects. As general aspects of the fluids are discussed, which are mainly independent from the manufacturing process, commonly used terms such as coolant, lubricant, grinding oil, cutting fluid are summarized as MWFs.

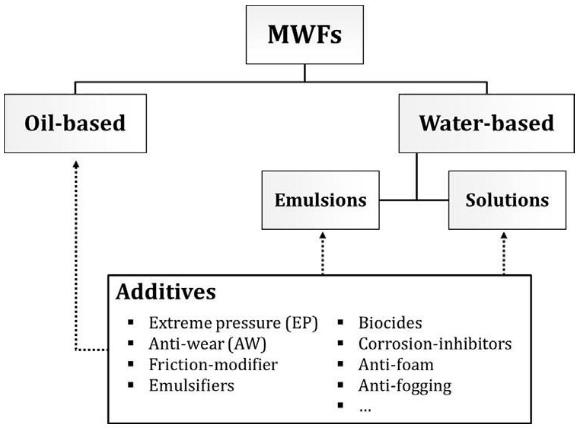

Fig. 1. Classification of the MWF types according to DIN 51385 (simplified).

Liquids which are included in the term MWFs have been classified based on different criteria like formulation (oil-based, water-based), manufacturing process (cutting fluid, grinding oil, forming oil, etc.), or quantity (flooding, MQL, etc.). Not all of these classifications are suitable to discuss MWFs and their properties from a mechanism-oriented point of view. According to DIN 51385, MWFs are classified following their composition as oil-based or water-based MWFs.

Specific properties are achieved by adding specific chemical substances (additives). Fig. 1 shows the classification of MWFs according to DIN 51385.

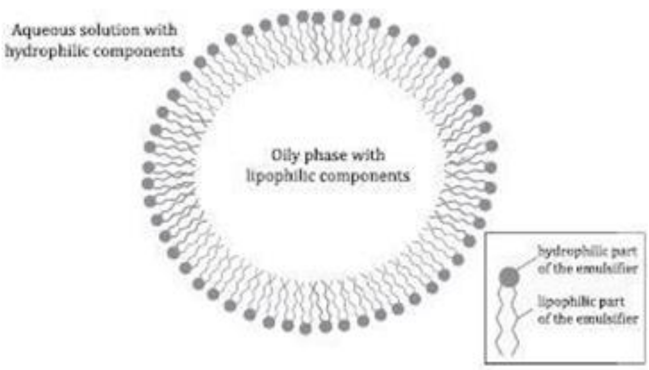

Fig. 2. A micelle of an oil-in-water-emulsion

1.1. History and demand for MWFs in manufacturing technology

Early approaches for the support of metalworking processes by fluids utilize two basic properties of liquids: their ability to dissipate heat and to reduce friction by lubrication. Leonardo da Vinci created several test set- ups allowing for the analysis of friction under varied conditions (Fig. 4). Beside of the use of pure fats and oils, early MWFs were mixtures of water (which has the highest heat transfer coefficient) and additional substances for the improvement of the MWFs' properties, especially the lubrication ability.

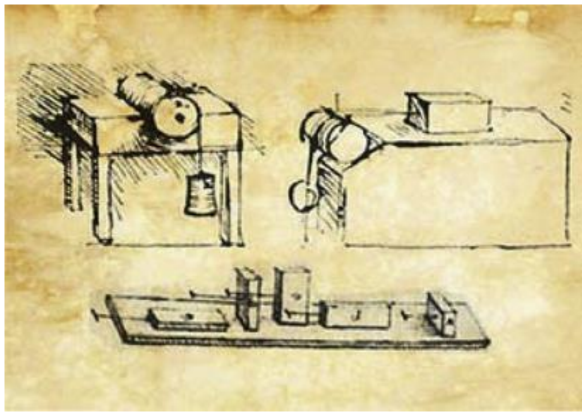

Fig. 2. Leonardo da Vinci's sketches of tribological test set-ups for the analysis of friction.

Natural products such as animal oils and fats (primarily whale oil, tallow, and lard)as well as vegetable oils from various sources such as olive, palm, castor, oil plant and

other seed oils were used to compose the first MWFs.They were applied in manufacturing processes
e.g. for the production of metal artwork and weapons in the middle age.In further work of da Vinci, a mixture of oil and corundum was applied for lubrication purposes in an internal cylindrical grinding machine.Special grooves were inserted to the grinding wheel to allow for efficient supply of the MWF to the tool.

In the early 19th century, the design of machine tools made considerable progress and simultaneously, the techniques for the supply of MWFs were improved. In his autobiography James Nasmyth describes his inventions, e.g. a traversing drill, which had a small tank to supply water or soap in water (“as a lubricator”) directly to the contact zone. The increased availability of mineral oil around 1850 had an intense influence on the composition of MWFs. The oil, which was a by-product of refining kerosene, was chosen to replace animal and vegetable oils in MWFs due to its low price.

With the progress of industrialization in the 20th century, there was an increasing need for MWFs with higher performance. It was found that the addition of substances containing sulphur and phosphor lead to improved lubricating ability of the applied MWFs. The sectors of aviation and automotive industry were the main drivers of these developments focusing on higher levels of productivity in mass production (cf. Fig. 5). “Trial & error” was a base principle for the development of new MWFs with improved functionality.

	Driver	Effect on MWF-composition
< 1800	Demand to machine metals	Development of first MWFs based on natural products e.g. water, animal or vegetable oils
1800 - 1899	Industrialization (machine tools) Availability of mineral oil	Replacement of natural MWF-components First investigations on the lubrication ability of the used MWFs
1900 - 1999	Superior tool and workpiece material Advanced machine tools Mass-production	Addition of numerous chemical substances to increase the technical performance Application of chlorinated MWFs containing boric acid and further harmful chemicals First approaches to reduce amount of mineral oil in MWFs (driven by the rising oil-price)
2000 - today	Regulation Energy- and resource efficiency	Substitution or elimination of chlorine and further harmful substances Assessment of the sustainability of MWFs Interdisciplinary assesment of MWFs

Fig. 3. Chronology development of MWFs

II. METAL WORKING FLUIDS:USES AND CONCERNS.

Metalworking fluids benefit a variety of metal cutting and shaping processes by cooling and lubricating the workpiece and tool, transporting chips out of the cutting zone, and imparting corrosion protection. Metalworking fluid chemistries are complex and vary significantly, depending on the manufacturing operation they are used in. By typical definitions, there are four categories of MWFs: straight oils, soluble oils, semi-synthetics, and synthetics. Straight oils consist of a petroleum or vegetable oil base with or without specialty additives. The remaining three types of MWFs are water-soluble and are classified by the ratio of water to mineral oil in their concentrated form. The concentrate is usually diluted in 80 to 95 percent water when used in process. Typically, soluble oils contain greater than 20 percent mineral oil in the concentrate, while a semi-synthetic will typically contain 5 to 20 percent. Synthetic metalworking fluids contain no mineral oil. Water-soluble metalworking fluids contain varying amounts of specialty additives including lubricants, corrosion inhibitors, emulsifiers, chelating agents, pH buffers, defoamers, and biocides. Figure 4 illustrates the relative percentage of oil, water, and additives found in water- soluble MWFs.

Four major concerns have been raised about the state-of- the-art application of MWFs.4 First, particulates, tramp oils, and bacteria are known to reduce the quality of metalworking operations over time.5,6 Second, these contaminants eventually render the fluid ineffective for metalworking operations, creating significant acquisition and disposal costs that reduce profitability.7,8 Third, the disposal of MWF places a significant burden on the environment. And fourth, bacteria and the biocides used to control their growth in MWFs can be a significant health hazard.

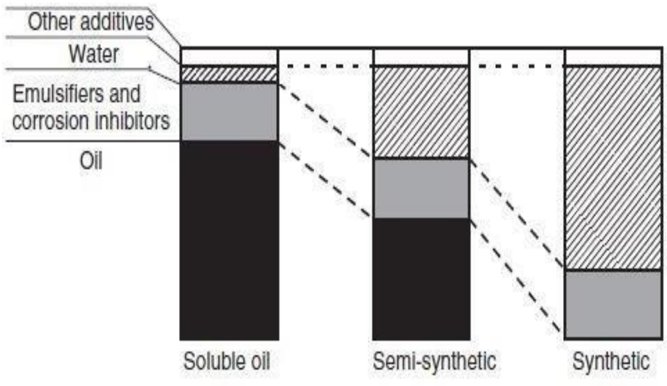

Fig.4. Relative proportion of water, oil, and additives in water-soluble MWFs.

III. CONTAMINATION AND MONITORING TECHNIQUES FOR MWFs

There are several reasons for contamination of MWFs. It might be due to Temperature Change during machining Process, Chemical composition of Work piece, aging of a water-based MWF is its colonization by microorganisms (microbial contaminations or due to surrounding Environment. Metalworking fluids have a variety of environmental liabilities associated with them that the industry is currently trying to reduce. Fundamental solutions to these environmental problems can take the form of MWF volume reduction, alternative MWF application strategies, MWF formulation changes, and MWF recycling technologies. However, most of these solutions require fundamental understanding and change at the metalworking process level. Not surprisingly, the solutions that have been most readily adopted have been those involving the least amount of manufacturing change. This is due to large data and modelling gaps that exist with respect to MWF usage.

Appropriate tests to be carried out on water-mix metalworking fluids in use are set out below. For routine monitoring purposes a limited group of tests is usually all that is needed for each machine/system; these are highlighted in red as a general indication and may be carried out in-house with relatively simple equipment. A wider range of tests may be required if more in depth information is needed, for example to investigate a problem.

- Appearance.
- pH.
- Concentration.
- Emulsion Stability.
- Microbial Aspects.

These parameters are needs to tested in regular intervals Fortunately, maintaining concentration and general fluid condition go a long way to ensuring that pH stays in control. The pH value provides much information on fluid condition because growth of bacteria, low concentration, contamination and incipient separation may be signalled by a fall in pH. Specific additives can be used to restore pH to its correct value, but whether this is the right course of action is best decided by a specialist, taking into account the overall condition of the fluid.

IV. CORRECTIVE ACTIONS

In principle most of the corrective actions required to keep metalworking fluids in good condition can be carried out in house. However, determination of the most appropriate action is not always straightforward. For example, when a very high bacterial count is found from dip slide testing, it may seem reasonable to treat the fluid with biocide. Moreover, the result of such action may seem to have been completely successful when a low count is found following the biocide addition. But although bacteria are very small, when there are millions of them they do have a finite mass and the dead disrupted cells are still floating around in your fluid releasing substances which can be injurious to health. It follows that it is far preferable to control bacteria at a relatively low level, rather than going for mass kill when their numbers have grown out of hand.

If the fluid concentration has become far too high you could just add plenty of water. The trouble with this strategy is that the resulting emulsion may not be stable, especially if tramp oil also present. The preferred practice of keeping concentration in control and adjusting when necessary by moderate additions of half strength emulsion will give much better results.

Tramp oil skimmers come in a variety of configurations, most

of which depend on a similar principle – oil is collected on a material which, owing to surface tension effects, has a greater affinity for oil than for the aqueous emulsion and then removed by physical means such as scraping or squeezing. The materialmay be in the form of a rotating disc, continuous belt, loop of tubular plastic or a mop, partially immersed in the fluid. The efficiency of the process is greatly improved if the skimmer is positioned at a point where the circulation of the fluid is slowed thus enabling oil to separate to the surface. An alternative design involves a container (separator) packed with plastic rings to which tramp oil adheres as the fluid passes through. Separate outlets enable clean fluid to flow back to the machining facility, while oil is collected in a container for disposal. In rolling mills or other large systems the mixture of fluid and tramp oil may be fed to the separator from floating suction heads. Fines from ferrous metals may be removed by magnetic separators which are commonly fitted to grinding machines, the collected material being scraped off for disposal. Weir systems are also used for removing high density fines. Centrifuges are extremely effective in removing all types of fines. However, it is vital to empty the bowl in which the sediment collects regularly. If the bowl is overfilled not only does collection of fines cease, but the disc stack can become blocked resulting in a tedious manual cleaning process. A self-discharging centrifuge eliminates this problem by automatically emptying the bowl without the need to stop; however, such machines have a higher capital cost. Centrifuges are also capable of removing tramp oil from water-mix metalworking fluids. Hydrocyclones (which have no moving parts) work on the same general principle as centrifuges, accelerating the effect of gravity by centrifugal force, to separate solids from fluids. Removal of solids from metalworking fluids by filtration is carried out using paper, fabric and mesh filters. Paper filters may be in the form of rolls (which are moved on automatically to expose a fresh filtration surface), sheets (used in plate and frame filter presses) or as pleated paper cartridges. Selection of the most suitable type depends on the quantity of solids to be removed and the degree of cleanliness required. Paper roll filters and filter presses can remove much heavier solids loadings and are found on larger systems. Cartridge filters, with their much more limited dirt capacity, are more suitable for individual machine tools where cleanliness is critical. They are also useful for secondary filtration when the main bulkof solids have been removed. For neat oils which have become contaminated by moisture 'blotter' cartridges are available which absorb water as well as ensuring a high degree of cleanliness. Cartridge filters must be discarded when their dirt capacity has been reached and are relatively costly, being reserved for critical applications. Fabric filters are available in rolls, as specially designed double to fit recessed plate filter presses and in bag form supported in a cylindrical container.

Rotary drum filters, some models of which operate under vacuum, are capable of continuously removing substantial solids loadings from the fluid. They are available in a range of capacities, the largest serving major machining facilities. Mobile filtration units can be wheeled from machine to machine, removing the contents of the sump (swarf and metalworking fluid) by suction. The fluid is filtered and returned to the machine using the onboard pump. Mobile units also enable the fluid to be held during thorough cleaning of the machine tool coolant system. Some processes, such as cold forming in the manufacture of fasteners and seamless tubes, generate large quantities of fine, solids in the form of a 'sludge' which may require treatment in two stages, the first to remove the bulk of solids and the second stage to achieve the desired degree of cleanliness. Many of the units for the foregoing treatments operate automatically and units combining more than one of the methods are available, for example magnetic separation and filtration. A further option is to incorporate fluid cooling into the treatment process. Complete turnkey installations for coolant treatment and swarf handling are also available.

Control of microorganisms (bacteria and fungi) is mainly effected by use of biocides although a number of physical methods are available or being developed. Some water-mix metalworking fluids contain a biocide (or biocides) in the concentrate as supplied, whilst others depend upon the inherent resistance of the constituents of the formulation to microbiological spoilage to protect the emulsion in use. 'Tankside' additions of biocide may be found to be necessary during service to maintain resistance to spoilage. Such additions should be based on the outcome of monitoring tests and made accurately by trained personnel.

V. CONCLUSIONS

Good fluid management practice, with correct control of concentration, offers a degree of protection against microbiological spoilage by ensuring that pH is maintained. The extent to which pH is an effective means of control of microorganisms is the subject of current research. Alternative or complementary methods for control of microorganisms which have been investigated for use in water-mix metalworking fluids include exposure to heat, ultraviolet radiation, ozone, silver, ultrasound and bacteriophages.

Following the large outbreak of respiratory diseases at the Powertrain plant, which are believed to have been associated with used metalworking fluids containing bacteria, research is being carried out with the objective of achieving a more fundamental understanding of the cause(s) of these disorders. A specific group of metalworking fluids known as Bio concept fluids are formulated to operate with a controlled population of 'friendly bacteria' which are intended to discourage the proliferation of undesirable bacteria. Good fluid management is still required for these fluids.

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