Greater accuracy through digital refractometers

Introduced in the 1990s, these devices now are available in bench-top and portable versions.

KEY CONCEPTS:

- **Problems with using analog refractometers include confusion about the scale, need to use a correction factor and looking at concentration from different perspectives.**
- **Digital refractometers can provide greater accuracy and precision, particularly with oil-contaminated metalworking fluids.**
- **Some digital refractometers can be programmed to give a direct reading for metalworking fluid concentration.**

Monitoring the condition of a water-based metalworking fluid ensures that the coolant is in good condition and continues to provide the characteristics needed in the specific application. There are a number of different techniques available to evaluate the performance of a metalworking fluid, but analysis of a fluid should always start with a determination of its concentration through the use of a refractometer.

The refractometer measures the concentration of a metalworking fluid by determining how rapidly light travels through the coolant. In a traditional analog refractometer, a drop of the fluid is placed on the prism, and as light shines on through the sample a shadowline is projected on an internal Brix scale. The figure obtained where the shadowline crosses the scale has to be multiplied by a factor to obtain the concentration.

The Brix value is proportional to the ratio of the speed of light through the metalworking fluid compared to water. A higher Brix figure directly correlates to a higher metalworking fluid concentration.

Refractometers are available in both portable and lab bench units. They enable the user to very easily obtain a value for the metalworking fluid concentration, but care must be taken in using an analog refractometer, as the value could be misleading.

Michael Rainer, CEO of MISCO in Cleveland, says, "There are several problems that can arise in working with analog refractometers. Two scales used to measure concentration can cause the user to be confused about the meaning of the reading. The Brix scale is actually a measure of sugar content, but there is also a 10440 scale that was designed for specific products. The user must think of the readings as arbitrary values that have no specific meaning until converted to fluid concentration."

Rainer emphasizes that the user needs to know the type of scale used and realize that the value obtained is rarely equal to the actual concentration of the metalworking fluid. He adds, "Rarely does a direct correlation exist between the refractometer value and the metalworking fluid concentration." Metalworking fluid manufacturers usually provide a scale, chart or correction factor on the label of the product to facilitate the calculation of the fluid concentration. But errors still can occur.

The refractometer measures the concentration of a metalworking fluid by determining how rapidly light travels through the coolant.

Problems also can be created between metalworking fluid formulators and end-users who look at concentration from different perspectives. Rainer says, "Some

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determine concentration by weight percent while others evaluate it by volume percent. Issues are created at the end-user facility because the specific gravities of different types of metalworking fluids are different.

Metalworking fluid concentration is a very important parameter that needs to be accurate in order to assess the condition of the fluid. The shortcomings of analog refractometers mean that development of a newer technology is essential to ensure that the metalworking fluid is in good condition and can still meet the requirements of a specific application.

DIGITAL REFRACTOMETER

Digital refractometers were first introduced into the marketplace in the 1990s. They are currently available both as a bench-top version and a portable unit (*see Figure 2*), according to Rainer.

The use of a high-resolution, linear array of photodiodes greatly enhances the performance of the digital refractometer compared to the analog refractometer. Rainer says, "Digital refractometers have an accuracy and precision between +/- 0.1 and +/- 0.2 Brix units. In contrast, analog units have an accuracy and precision of +/- 1 Scale Division, which usually equates to +/- 0.2 Brix units at best."

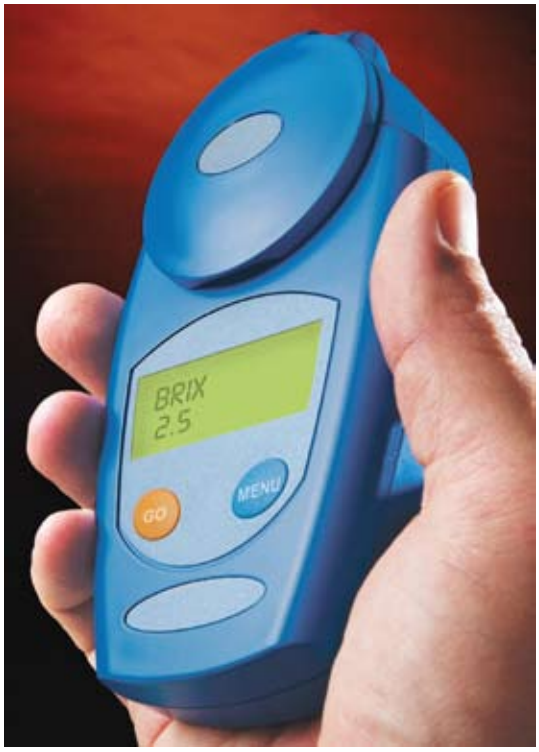

Figure 2 | **A digital refractometer exhibits better accuracy and precision in measuring the concentration of metalworking fluids. Some models can be programmed to directly generate concentration readings.** (Courtesy of MISCO)

Rainer points out that bench-top digital refractometers can demonstrate even better precision. He adds, "Bench-top units can exhibit a precision between +/- 0.01 and +/- 0.02 Brix."

Besides better performance, digital units offer additional features to improve operator use. Temperature compensation remains a very important concern when using refractometers. There is an indirect ratio between temperature and the Brix reading which means that as the temperature drops, the concentration reading from a refractometer can rise if the refractometer does not have the ability to compensate for temperature.

Rainer says, "Temperature is a critical parameter affecting the reading of the refractometer. Though widely known in the metalworking industry, there are still refractometers being used that do not have temperature compensation. We advise that end-users work with refractometers that have temperature compensation and make sure they are calibrated with distilled or tap water every single day." All digital refractometers have temperature compensation.

Reading the Brix value in a metalworking fluid contaminated with tramp oil can often be more difficult using an analog refractometer. Rainer says, "It is common for three people to interpret three different readings for the same sample of a metalworking fluid contaminated with tramp oil."

Digital refractometers display greater accuracy with oil-contaminated metalworking fluids. Rainer explains, "The sample is placed in a well, and the true reading is made from underneath the sample. This feature is beneficial because tramp oil will tend to move to the top of the sample enabling a more accurate reading of the metalworking fluid's actual concentration."

They can also be programmed to enable the refractometer reading to equal the actual fluid concentration. Rainer says, "Some instrument manufacturers can program multiple scales into a single digital refractometer that will give a direct reading for specific fluids."

Digital refractometers are extremely durable. Rainer points out that some portable units can be equipped with rubber armor jackets to prevent damage when dropped in the end-user workplace.

Portable digital refractometers can generate thousands of readings for the user. They are powered by conventional AA or AAA batteries.

Rainer indicates that research is underway to expand the capabilities of digital refractometers. Further information can be obtained by contacting Kathy Widing at **kwiding@misco.com.**