Application note A313

Foam testing of cooling lubricants

Product: SITA FoamTester
Industry: Cooling lubricants
Measuring principle: Structured light (Foam Surface Scanner)

Cooling lubricants are mixtures of substances used in metal cutting. Water dissipates the generated heat, while an oil component is intended to provide sufficient lubrication. Additional additives are added to improve technical properties, especially surfactants for a stable emulsion of oil and water. However, surfactant-containing liquids also tend to foam, which can lead to several problems: Stable foam does not drain off, and the air enclosed in the foam significantly reduces lubricating and cooling performance.

Figure 1: Application of a cooling lubricant during drilling

Foam generation as well as foam decay highly depend not only on the composition of the cooling lubricantt but also on other parameters such as impurities or water hardness. Systematic foam tests provide important insights into these complex connections.

Measurement with the SITA FoamTester

Using the SITA FoamTester, four different cooling lubricants, designated CL1-4, were examined regarding their foam formation and maximum foam production during foaming, as well as subsequent foam decay. The concentration was 80 g/l in standard water with 20 °dH.

For the tests, an automated procedure was created to ensure reproducible and objective examination of all four samples. Foaming was carried out in 20 stirring cycles, each lasting 20 seconds, at a stirring speed of 2000 rpm. Since cooling lubricants are usually weakly foaming products, a so-called foam enhancement ring was used. This metal ring creates additional turbulence near the vessel wall.

Foam Surface Scanner

For weakly foaming liquids, the resulting foam decays very quickly. Therefore, for the analysis of foam formation, the upper foam boundary was captured using the Foam Surface Scanner via the optical measurement principle of structured light, which takes only about five seconds.

The foam surface is illuminated with a sequence of stripe patterns. The topology of the foam distorts the stripe pattern. A camera captures the surface data, from which the total volume in the measuring vessel can be precisely determined.

Figure 2: Detection of the upper foam boundary

For the analysis of foam formation and decay, the gas volume was determined as the difference between the total volume and the known volume of the filled liquid. Foam decay was observed over a period of five minutes without further stirring.

Foam formation

Figure 3 shows the foam formation of the four different cooling lubricants as representation of the gas volumes during the 20 stirring cycles.

A 313/ Version 1.1

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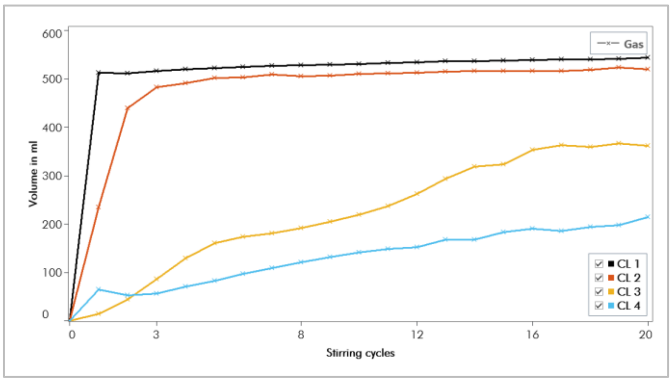

Figure 3: Foam formation over 20 stirring cycles with15 s each at 2000 rpm

Samples CL1 and CL2 foam very quickly. CL1 reaches a high gas volume after just one stirring cycle, while CL2 reaches it after three stirring cycles. Further stirring cycles hardly increase the volumes. Both samples have a similar high maximum gas volume of approximately 550 ml (CL1) and 520 ml (CL2).

Samples CL3 and CL4 foam significantly less. In CL3, a slight plateau of about 360 ml is reached after approximately 16 stirring cycles, while the gas volume in CL4 continues to increase slightly even after the 20 stirring cycles, reaching 210 ml.

Foam decay

Figure 4 illustrates the decay behavior of the generated foams. The weakly foaming cooling lubricants CL3 and CL4 decay into a thin film within the first minute, with CL4 forming a slightly thicker film.

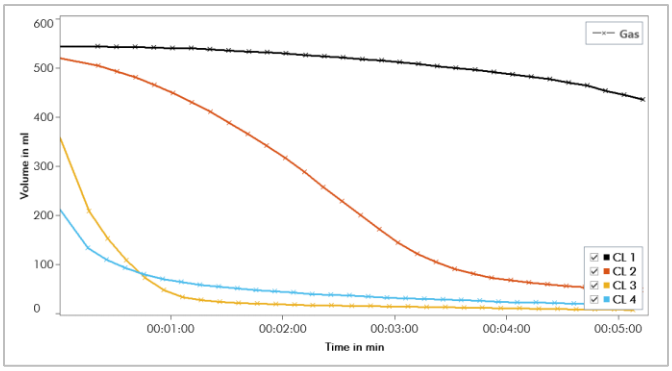

Figure 4: Foam decay over 5 minutes

While samples CL1 and CL2 showed similar foaming behavior, they differ significantly in foam decay. CL1 forms a stable foam that retains nearly its entire volume over five minutes.

In contrast, the foam from sample CL2 almost completely decays within the observed period of time.

Conclusion

The tested cooling lubricants generate different foam volumes, particularly differing in their stability.

The desired behavior for cooling lubricants, with low foam formation and rapid foam decay, is particularly evident in CL3 and CL4. This rapid foam decay also means that, under the chosen parameters, especially the five-second pause between stirring and volume measurement, newly formed foam quickly decays and is therefore not captured.

Figure 5: SITA FoamTester