Application Report

Foamability and foam stability

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Dynamic Foam Analyzer – DFA100

Method:

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Investigating the foaming behavior of cooling lubricants and the effect of foam inhibitors (antifoams)

Value is placed on the formation of as little foam as possible in the use of cooling lubricants (CLs), as foam makes processing the part, its post-processing and finally CL recycling more difficult. This is why foam inhibitors (antifoams) are often added before the CLs are used, or even form part of the CL formulation.

The tendency toward foam formation and the effectiveness of antifoams can be checked in the laboratory by using foam height measurements. Under reproducible conditions such measurements can contribute to improving the CL formulation or to optimizing the antifoam dosage.

In the scope of this Application Note samples of three industrially used CL products were studied with the Dynamic Foam Analyzer – DFA100, with the amount of foam generated being observed in long-term tests and in cyclic foam generation processes.

Background

Frequently called "drilling fluid", cooling lubricants (CL) are almost always used in the mechanical processing of metals, glass or ceramics. The focus is either on their cooling or lubricating properties – depending on the material and speed, either high-oil CLs are used for better lubrication, or low-oil or oil-free water-based mixtures for better cooling.

Foam generation must be avoided for most uses. Foam worsens both the cooling effect and the run-off of the liquid from the part, makes CL filtration before its cyclic recirculation more difficult and, in extreme cases, can even lead to machine standstill.

Fig. 1: Cooling lubricant in use: no foam wanted

During the process foam inhibitors (antifoams) are frequently added; these often form part of the CL formulation. The extent to which foam formation must be countered depends on the type and speed of the manufacturing process for which the CL is intended.

The effect of an antifoam or the foam formation tendency of a CL can be checked before use or during the development of a formulation by carrying out foam tests with the Dynamic Foam Analyzer – DFA100.

Experimental part

Samples studied

5% solutions of three industrially used concentrates, some containing antifoams, were studied. These were two oil-free CLs (samples A and B) and a cleaning agent (sample C), which is used after the part had been processed.

Low foam is also important for the cleaning agent; not only for the cleaning process itself, but also because at the interface between the part-processes of processing and cleaning a residual amount of the cleaning agent is carried over into the recycled CL.

Sample A is a CL without antifoam. The formulation of sample C (cleaning agent) contains antifoam; sample B also contains it but with twice as much as in sample C. The manufacturer claims that sample B is a particularly low-foam product.

Sample	***Product***	***Contains antifoam***
A	Cooling lubricant	no
B	Cooling lubricant, low-foam	yes, twice as much as in C
C	Cleaning agent	yes

Table 1: Samples studied

Foamability mainly depends on the hardness of the process water used, with softer water tending to stronger foam formation. Because fully demineralized water is used in some processes, the diluted samples were made up with distilled water.

Setup and measuring procedure

50 mL of the particular sample was placed in the sample vessel of the DFA100 (Fig.2a).

A constant flow of air (Q = 0.7 L/min) was led through the porous base (G2; pore size 40 - 100 µm) of the sample vessel and passed through the sample (Fig. 2b).

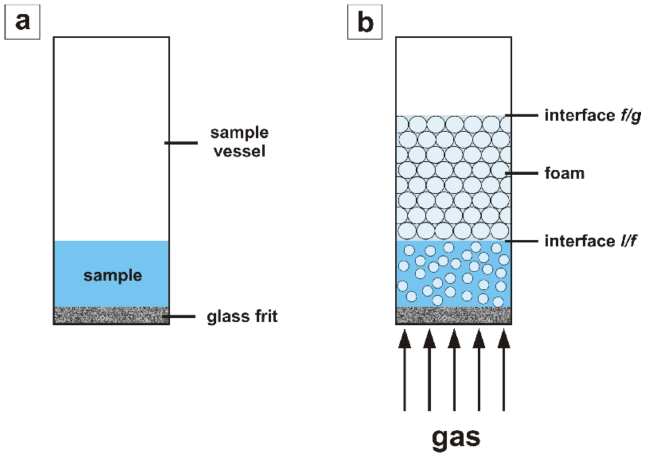

Fig. 2: Foam generation by air flow in the DFA100

The instrument is used to measure the total height h (liquid height h_l + foam height h_f) during foam generation and – if required – during the subsequent foam breakdown process. With transparent liquids the height of the liquid level h_l can be recorded separately to obtain statements about the moisture content. In this case the latter is not relevant; the amount of foam formed stood in the foreground and not its structure.

Height detection takes place *in situ* by time-dependent measurement of the transmitted light using an LED series and a line sensor. The column is located between these (Fig. 3).

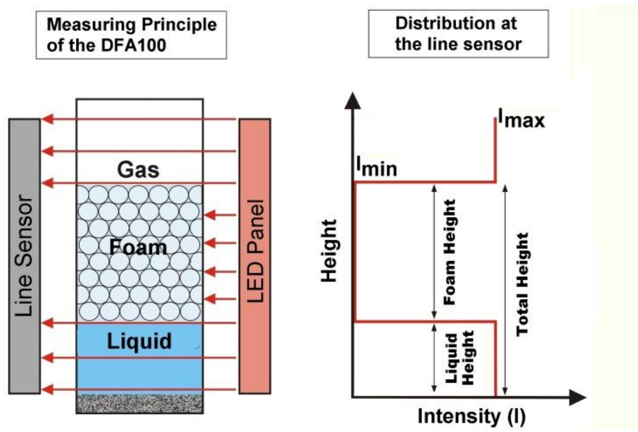

Fig. 3: Height detection with the DFA100 and a transparent liquid

In addition to the comparison of the samples, the long-term behavior was also focused upon, as foam formation frequently changes with time in the cyclic CL recirculation process.

The height of the foam was measured over a period of 100 min under continuous foam generation. In addition, foam height measurements were carried out during 30 cycles – with the DFA100 such fully automatic repeated measurements under exactly the same conditions are possible without refilling. In each case the foam generation time was 12 s and the measuring time 45 s; this was followed by a waiting period of 30 s. After this time the foam columns had completely decayed for all samples.

Results

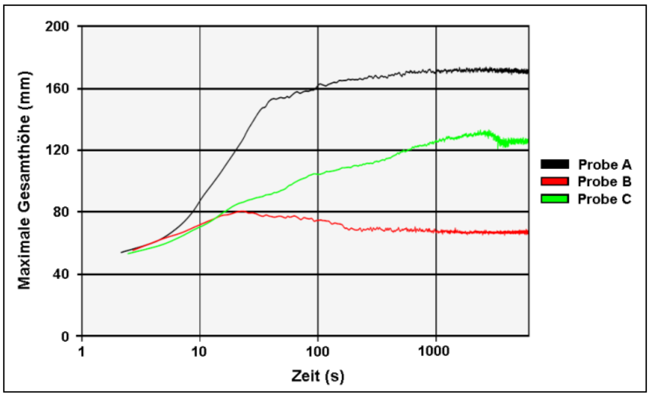

Fig. 4: Long-term foam generation measurements on the three samples

In the long-term measurements (Fig. 4) the total height increases greatly in the first 20 to 30 seconds. Then an equilibrium is established between foam formation and foam breakdown; this can be recognized at the point of inflexion of the curves. The early stagnation of the total height and rapid establishment of the equilibrium are typical for unstable foams. It can therefore be stated that the foams formed will quickly break down for the moderately foaming samples A and C. For the process this means that it is possible that foam may occur during part processing, but that in all probability it will have broken down before the cyclic recirculation of the liquid.

The tendency to foam formation decreases in the sequence A > C > B – product C therefore meets the manufacturer's claim of low foam formation. At the same time this sequence demonstrates the antifoam content (none, some, a lot of antifoam; see Tab. 1).

During long-term observation of samples A and C the position of the formation-breakdown equilibrium changes: The tendency to foam formation increases considerably until a stable final value is achieved between 1000 and 2000 s. CL sample B behaves differently: The already slight tendency to foam formation decreases further with time.

The cyclic foam generation measurements show a similar picture (Fig. 5).

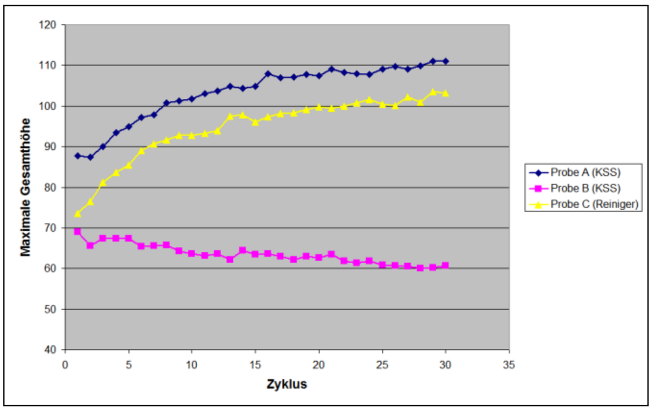

Fig. 5: Alteration in the maximum total height during cyclic foam generation

A plot of the measured maximum height after foam generation for 12 seconds against the number of cycles for samples A and C shows, just as in the long-term tests, an increase in the foam height. As in the long-term curves, the curves for the cyclic measurements also reach a plateau. With low-foam sample B a reduction in foamability can also be noticed in the cyclic test.

The increase in foam formation with time and in the cyclic repeats found with two samples in the test can also be frequently observed with CLs and cleaning agents in technical processes. No statement about the causes of this can be made here. However, the results do not indicate that the effect of the antifoam diminishes. Firstly, samples A and C behave similarly, although A contains no antifoam. Secondly, the low foamability of the antifoam-containing sample B is retained.

Summary

Foam generation tests on two industrially used cooling lubricants (CL) and one cleaning agent – some with antifoams in the formulation – demonstrated clear differences in foam formation. One of the CL samples and the cleaning agent showed a moderate formation of a foam which broke down quickly. In a second CL sample with an increased amount of antifoam the foam formation was very low.

In a long-term test the more strongly foaming CL sample and the cleaning agent tended to increased foam formation. In contrast, the second, optimally low-foaming CL tended to become even better in the long-term test.

The same behavior of the three samples could also be demonstrated in the cyclic foam generation tests.

The foaming behavior of the samples in the test provided a good portrayal of their antifoam content. All in all, height measurement after foam generation by a flow of gas proved to be an effective method of investigating the short-term and long-term foaming behavior of CLs, for quantifying the effect of antifoams and for bringing out the differences between the samples.

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