


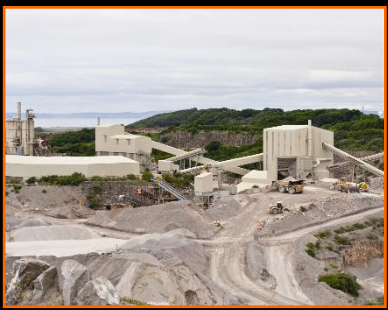




White Paper: What makes Foam Detection So Difficult?

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Foam Detection – What Makes it Difficult?

What is foam?

Foam has the appearance of a simple material, partly because we are all familiar with it, whether in the form of bath foam, bubbles in a milkshake or the head on a glass of beer. However, in reality foam is a very complex, dynamic material with its production involving physical, chemical and biological processes.

Most common foams are an unstable, two-phase medium of gas and liquid with a structure consisting of gas pockets trapped in a network of thin liquid films and plateau borders.

How is it created?

Several conditions are needed to produce foam: you require both a liquid and a gas, and there must be agitation, which may be generated by mechanical agitation, mixing, stirring or sparging. Also, there must be surfactants (surface active components) that reduce the surface tension of the liquid.

Properties of foam

When foam is present, there is always a natural drainage along the thin films of liquid between the bubbles. Liquid gradually drains down from top to bottom, creating a density gradient through the column of foam. The foam at the top of the column collapses as the films become too thin to support the bubbles. An equilibrium develops between this material collapse at the top and the build-up of new foam from the liquid surface below.

This ongoing process limits the maximum height of the foam column. However, in some processes foam stabilising agents such as proteins reduce the drainage, resulting in much more stable foam. In these circumstances, the foam production rate can far exceed the dispersal rate and the foam can build up to a problematic level. Proteins are long chain molecules; by lying along the thin films between the bubbles, they restrict or prevent the drainage of liquid, allowing the column to continue to grow. The stability of such foams clearly has a large impact on their lifetime.

Additional factors such as poor system design and leaking pumps can exacerbate foaming problems. In a digester there are even more complications to consider, such as changes in temperature, feedstock, pH and so on. But regardless of the specific application, in all instances minimising the impact of foam requires effective monitoring, measurement and control. For example, in Anaerobic Digestion foam can block up pressure valves and cause over-pressurisation, damaging the digester and causing leakage. Foam can also get into a gas exit line and damage valuable process equipment like compressors.

It's clear that foam causes major issues in processes when it gets out of control, be it AD, waste treatment or food preparation. In order to counter these problems, it needs to be carefully monitored and should be a major priority for the industry to get right. As industries increase in size, for example in the booming AD sector, there are sure to be a rise in the number of incidents.

We need to understand why it is so difficult to measure foam and why so many current technologies fail. One of the most import reasons is that **foam itself generally only contains 1% liquid and 99% gas**, making measuring the liquid component with a traditional liquid device near impossible. This is why regular liquid probes are unsuitable and cannot be relied upon to accurately detect foam. At Hycontrol we have been developing level sensors for over 35 years, and over the next few pages we will explain both the principles behind each of the leading contemporary liquid technologies, and why they cannot be relied upon for consistent performance in this critical application.

Radar – How it works?

Radar is used for continuous level measurement. Modern devices use high-frequency microwave signals (24-26 or 80 GHz) that are unaffected by dust, pressure, temperature, viscosity or vacuum. The measured level is proportional to the difference in frequency between the transmitted and received microwaves. This technology is suitable for measurement ranges up to 80 m and provides high levels of accuracy for certain applications; however, the effectiveness of radar technology is dependent on the dielectric constant of the material in the vessel. Radar usually works better on products with a dielectric constant of greater than 2.0. In some applications it can measure down to 1.1, but this requires advanced software and very stable conditions.

Radar – Why it can't reliably detect foam

As mentioned above, radar technology relies on the returned energy it gets back and the lower the dielectric, the less energy is returned. The reason radar will ignore foam and measure the liquid beneath is due to the fact foam is 99% gas, meaning the dielectric is far too low for these devices to detect reliably. Also, condensation on the face of the radar may result in false trips. Radar can produce reasonable results on thicker, dirtier foams (typically ones with a crusty layer) as they have a higher dielectric, but this cannot always be relied upon.

Capacitance – How it works

Much like radar, capacitance is based on the dielectric of the product. It is a versatile technology and provides simple, accurate and reliable level control for a wide range of applications. Capacitance is suitable for use on liquids, solids, slurries, pastes, granules, powders and pellets, and operates in high-temperature, high-pressure or corrosive environments.

Capacitance – Why it can't reliably detect foam

Sadly, capacitance also has the same problem as radar with low dielectric products. Even with the devices adjusted to the most sensitive setting it will likely still miss light foam. When the highest sensitivity setting is being used there also tends to be false trips due to build-up on the probe, condensation, or it actually detecting the liquid beneath the foam.

Ultrasonic - How it works

Ultrasonic technology provides a highly cost-effective, easy-install, non-contact solution for a wide range of level measurement applications. The transducer emits high frequency soundwaves (up to 50 kHz) and measures their time-of-flight to and from the material surface in order to calculate the level in the vessel.

Ultrasonic – Why it can't reliably detect foam

Ultrasonic devices struggle with foam as the emitted soundwaves will be absorbed by the foam. The signal will then be lost with nothing returned to the sensor. Some ultrasonic transmitters will also struggle with condensation on the front face, making readings erratic.

Vibrating tuning fork - How it works

Tuning forks are ruggedly-designed switch sensors that are used throughout the process industries, and can be customised for many applications, including corrosive, hazardous or hygienic environments. The technology works by sensing changes in their vibration frequency when in contact with a liquid. The product measured has to be of a certain viscosity or no changes will be detected.

Vibrating tuning fork - Why it can't reliably detect foam

Foam is usually light and has very low viscosity; due to this, a tuning fork cannot sense foam. The vibrating probe can actually excavate a hole in the foam while it continues to form everywhere else in the tank. At the other end of the scale, with more viscous foam it may clog between the forks, leading to false readings.

Conclusion

Foam is only 1% liquid overall and varies in density and liquid content throughout. Therefore, using any device that has been developed to measure liquid will inevitably give unreliable results. It is clear that **to accurately detect foam you need a device that is developed for that purpose**. Hycontrol provides all of the above technologies but would not recommend any of them to detect foam.

So how do we detect foam?

This question was asked of Hycontrol's Stephen Gallagher in 1986, while he was working at Shell Research. Shell had many fermentations. He had tested many sensors and none were reliable on foam, so he set about creating his own. He tried many technologies including infrared, lasers, visible light, induction, and capacitance, before he eventually developed an impedance probe that would detect foam reliably. When Shell sold the Shell Research division Steve was allowed to use the patent to start Charis Technology, selling these probes into the pharmaceutical industry. Charis was later acquired by level measurement specialists Hycontrol Ltd, and Steve joined the R&D team as Head of Foam Control Technology.

Since then, the range has developed further, with the latest addition being the SureSense$^+$. The patented sensing operation passes a small electric current from the sense electrode through the foam, measuring the amount of current it gets back to the controller though an earth. Crucially, there is also a second electrode called the guard, mounted above the sense electrode. This creates an isolation layer between the two, so that the sense electrode will only measure foam which occurs below it and the guard electrode will only measure the fouling which occurs above it. By taking these two measurements, and by very carefully balancing the guard and the sense measurement, we can make this very sensitive probe immune to a very high level of fouling.

Using liquid devices can be dangerous in safety critical situations. The SureSense^{+} has proved itself in many industrial applications around the world in applications in pharmaceutical, waste treatment, AD and biogas, food and more. It is the world’s leading foam control system.

To read more of our applications in the chemical, food & beverage, nuclear, water & waste, recycling, quarrying and metals industries, please go online at hycontrol.com

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