# Using Nanotrac to Identify Gushing in Beer

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Provided By:
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Particle Size Measuring Instrumentation

## Introduction

Beer is world's oldest alcoholic beverage and rivals water and tea as the most popular drink. The brewing requires the fermentation of starch of which the primary source is barley while other sources such as wheat and rice may be used. Usually hops are added to modify bitterness flavor and retard spoilage. Alcohol by volume ranges from less than 1% to as much as 20% depending upon regional, cultural and legal desires.

Brewing is the term given to processing and manufacturing beer. During this process starch is converted to a sugary mass called wort by yeast fermentation which leads to the product known as beer. The first step is to obtain a grain that has undergone carefully controlled germination, called malt, and mix it with hot water. During the next few hours, mashing takes place during which enzymes such as hydrolases are released, which convert starches into sugars to be consumed at a later step by yeast. Solids are removed from the mash and, the liquid "wort" containing the sugars, is recovered and transferred to a kettle and boiled. Boiling removes water but as well destroys the enzymes remaining from the mashing process, sterilizes the wort and develops color. Hops are added during boiling for efficient extraction of bitterness, flavor, and aroma compounds from the flower or petal of the hops vine. After boiling, the hopped wort is cooled and transferred to fermentation vats where yeast is added.

The action of the yeast is to consume sugars, usually maltose and glucose, produced during mashing and to convert them to ethyl alcohol and carbon dioxide which completes the conversion of wort into beer. Typically a strain of *Saccharomyces* is used for fermentation, but genetic engineering has produced stains that provide different aromas and flavors. Also during the fermentation, fine particulate matter and yeast settle, but as well, further flavor components are produced. Following fermentation and removal of sediment, some yeast remains which reduces the concentration of off-flavor diacetyls. This later process is known as "maturation".

Upon completion of fermentation and maturation, the temperature is reduced which removes protein-tannic complexes which are less soluble at lower temperatures and beer is ready for consumption or further storage.

From the above, it becomes obvious that great care must be undertaken to achieve a beer with consistent flavor profile and high quality to satisfy consumers in order to maintain or increase sales volume and market share. Its said that any consumer drinking a "bad" bottle of beer will not return to that product. Thus quality control is a mainstay of increased market share as well as maintained sales. Some of the quality tests include: **Barley** (pesticides), **water** (anions, cations, hardness, trihalomethanes), **Hop** (organic acids, oil content, storage index), **wort** (fermentable carbohydrates, other carbohydrates, Ca, Mg, Zn), **beer analysis** (aroma, metal ions, organic acids, amino acids). In beer analysis, over 800 compounds have been identified to contribute to flavor. Important to quality also is the content of lipid which deleteriously affects the foam development and stability while proteins larger than 8KD are important to foam formation. Another issue that causes quality concerns is gushing which some believe to be caused by the growth of *Fusarium, Aspergillus* or *Penicillium* fungi on barley whereby fungal secretions cause the gushing.

## Gushing

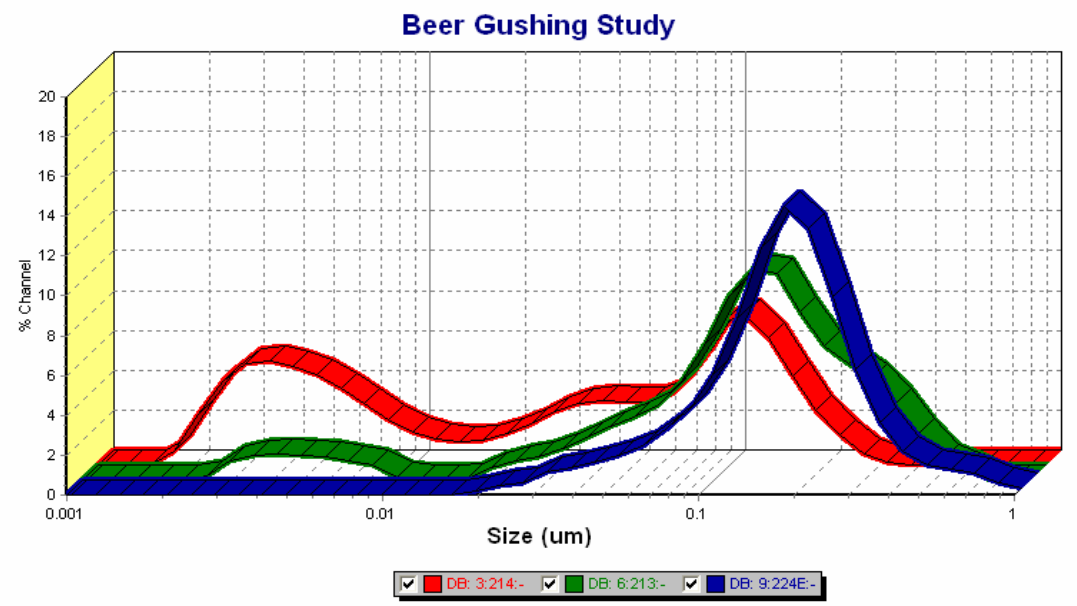
Gushing is an effect, in which, an opened bottle of beer forms a foam that rushes from the container and spoils the flavor profile while at the same time causing great spillage. The exact identity of gushing components is unknown, but some measures can be taken to prevent the beer from distribution or use of poor starting barley.

## Rapid monitoring of beer for gushing.

Dr. V. Ilberg[1] and his coworkers at the Technical University of Munich – Weihenstephan studied the effects of biological components on gushing. His studies show that If the concentration of proteins and enzymes in the malt is too high, gushing can occur. The particle size distribution graph below is showing an experiment for three beers of different gushing potential. The protein/enzyme macromolecules have a size shown in the range 2 – 10nm. One explanation of the gushing effect is explained by the fact, that due to the large surface area of the small protein particles, bubbles tend to stick to them when the bottle is opened. As bubbles escape the bottle, a large amount of foam is produced that escapes the container rapidly, in a gushing action. Therefore it is important to measure the content of these proteins.

Independent of the correctness of the above explanation, many experiments have proven that the content of proteins relative to other particles is critical for predicting gushing. The graphic below shows the amount of 5nm particles present in beers having variable gushing potential.

**Gushing effect evident in the particle size distribution of the beer**



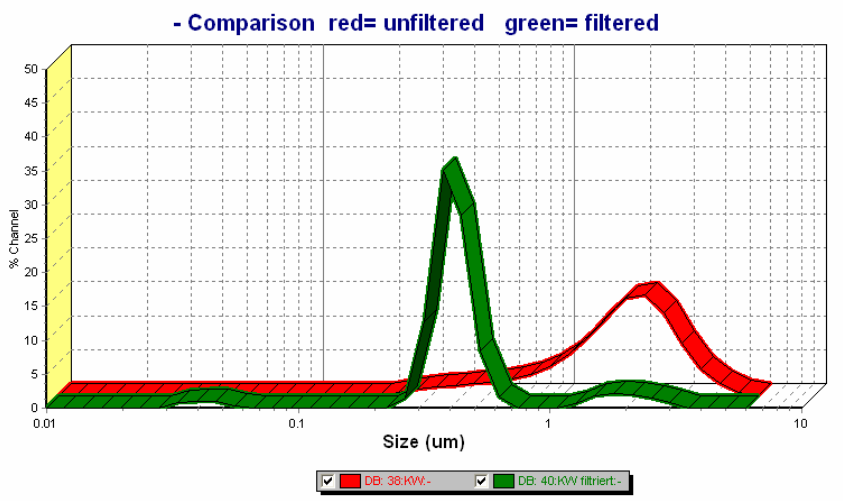

**Red: gushing.** **Green: tendency for gushing.** **Blue: no gushing**

## The solution to gushing.

Adding certain ingredients to the beer can alleviate gushing, but these can cause flocculation and sediment to form causing another quality issue. The production of flocs requires that the beer be filtered before being filled into bottles. In this case, the quality of filtering again can be evaluated with the Nanotrac® by measuring the size distribution and the concentration at the same time. To obtain the concentration, a calibration can easily be performed based upon total light scattering known as the Nanotrac Ci value. Once performed, the value (Concentration Index) can be used to obtain a good indication of the total concentration of particles present following filtration.

**Filtered:** Concentration index = 0.0136

**Unfiltered:** Concentration index = 0.0351



The instrument used in these studies of gushing and filtration is the Nanotrac. Nanotrac® is an optical dynamic backscattering instrument manufactured by Microtrac® Inc. can be used to determine gushing potential. The function of this instrument is explained in the web literature (Microtrac.com). The attractive side of the Nanotrac® design is the probe which can be immersed directly in any sample container which is wider than 8 mm in diameter. In addition, it can be operated remotely, if the measurement should be done online. The online sample cell in connection with the probe is shown below.

Conclusion

Taking into account that the particle concentration in beer is already very low and that bubbles may disturb the measurement, one would believe that no method would be able to measure particle size distributions in such a wide dynamic range. The Nanotrac® has demonstrated this capability. In particular, the sensitivity of the Nanotrac® for very small macromolecules in the presence of bigger particles makes the method even more suitable for this specific application. For automated measurement environments, the remotely controllable set-up of the probe with an online cell is useful.

These measurements provide a rapid method for studying and monitoring gushing and filtration that aides quality control, thus promoting market share and sales while eliminating other time-consuming quality methods and costly product loss.

Nanotrac is uniquely suited to this application of particle size measurements and can provide an opportunity for greater market share through high product quality as well as reduced costs of analysis time and product loss.

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