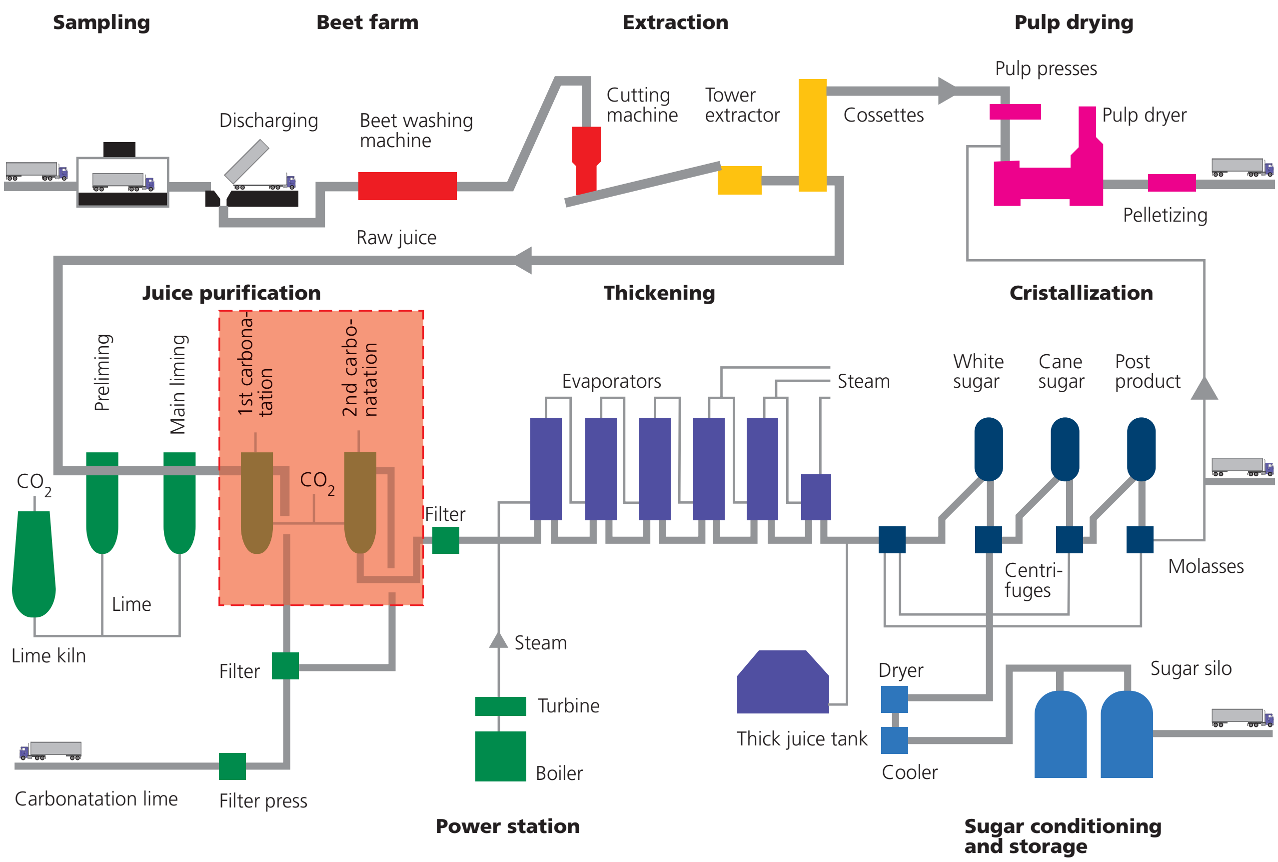
Author: Dr. Dirk Steinmüller

Application Report

pH Measurements during Carbonatation for Sugar Production

Procedure



Knick

Background

Today, sugar is one of the most important staple foods of mankind.
It is also of enormous economic importance:
Sugar is produced in 127 countries. Sugar cane and sugar beets are cultivated on an area of approx. 25 mio hectares worldwide with a sugar production of approx. 120 mio tons. Cane sugar accounts for the major part (2/3) of the sugar produced compared to beet sugar.
The largest sugar-producing countries are:
India (> 12 Mio t), former USSR, Cuba, Brasil, USA, China, France, Australia, Thailand, Mexico, Germany (4 Mio t), Turkey, Italy, and Poland (2 Mio t).
In Germany the per-capita consumption is approx. 35 kg per year.

Procedure

Sugar cane and sugar beet contain up to 20 % sugar (chemical: saccharose). Whether sugar cane or sugar beet serve as source material is only distinguished by different production processes in the beginning, during delivery and cutting, and by different washing procedures.
The hackled pieces are leached with 70 °C hot water in the so-called diffusion tower. The raw juice produced that way contains almost 99% of the original sugar, however also various organic and inorganic constituents, the so-called non-sugar particles.
The juice is purified using lime and carbonic acid. For that purpose, the sugar plants operate lime kilns where lime stone (calcium carbonate) is heated to produce burnt lime (calcium oxide) and carbon dioxide.

$$CaCO_3 + \text{heat} \rightarrow CaO + CO_2$$

The lime is added to the raw juice as lime milk. In the process, loose calcium hydroxide precipitates are formed which bind the non-sugar particles.

$$CaO + H_2O \rightarrow Ca(OH)_2$$

Now, the carbon dioxide is led into this mixture. The lime including the non-sugar particles stably precipitates and can be separated by filtration.

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

This step is called carbonatation. It is repeated in a second stage.

A clear, light-yellow thin juice with a sugar content of approx. 16% remains, which is further processed for thickening. The filtrated carbonated lime is used as fertilizer. The sugar is cleaned by solely physical processes (crystalline transformation and centrifugation). In contrast to widespread assumptions, white sugar is not bleached. Brown sugar only contains more syrup (always brown).

Carbonatation towers

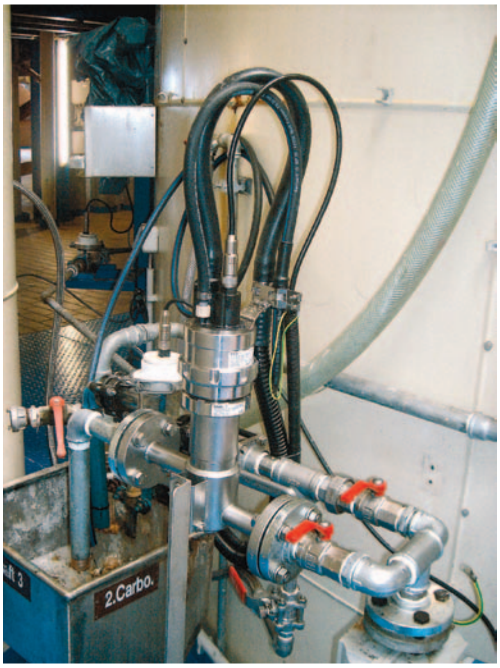
Knick

Measurement and control problems

The efficiency of carbonatation strongly depends on the pH value. The pH value is continuously measured during both carbonatation steps.
During the first step, the pH value is kept between 10 and 11. To do so, carbon dioxide (from the lime kiln process) is introduced at approx. 70 °C so that the lime precipitates together with the impurities. However, the filter cake from this first carbonatation still contains considerable amounts of sugar and is therefore washed. The sugary wash water is returned to the first stage of the process together with the filtrate. However, it still contains undesired calcium hydroxide. Now the remaining lime is precipitated at 90 – 95 °C in a second carbonatation process. If the pH value falls too much due to the introduced carbon dioxide (carbonic acid in water), the lime decomposes to form hydrogen carbonate. If the value remains too alkaline, the precipitation is incomplete.
It is intended to keep the pH around the neutral point at approx. 7.5.
To ensure easy comparability with laboratory values, the pH value which is measured at a process temperature of 90 °C is automatically recalculated to its 20 °C value by smart pH transmitters so that the displayed value is pH 9.

The challenge to a pH measuring point in the second carbonatation stage:
High content of solids,
High temperature (90°C)
Excessive deposit formation by lime, non-sugar particles, and sticky syrup.

During the sugar campaign (in Europe up to 100 days after the harvest of sugar beets in September) these measuring points must be checked and cleaned several times a day.



Often the pH sensors must be cleaned using an acidic cleaning agent, e.g. amidosulphonic acid. Electrode life is reduced by abrasion and blocking of the reference system.
Until today, automation of the cleaning (and calibration) procedure has failed due to the probes and holders used. Metallic ball valve or displacement probes get stuck after a short time thus leading to failure of the pH measurement. Plastic probe holders do not withstand the mechanical and thermal stresses.

Solution:

The Ceramat® WA 150 sensor lock-gate together with the Unical® 9000 automatic cleaning and calibration system allows complete automation of this difficult measuring point with maximum availability. The Ceramat® lock-gate consists of a virtually undestructible, ultrahard, superpolished, rotating ceramic part and a corrosion resistant, carbon reinforced, non-moved plastic (PEEK) housing. The ceramic with its rotary movement is not influenced by the incrustations and the static probe housing shows hardly any deposits.

In conjunction with the automatic Unical® controller, the sensor is automatically cleaned and calibrated at regular intervals. Due to the sluggishness of the process (1 measured value per 30 min), the sensor can stay in the rinsing chamber and just briefly be moved into the process for measurement (e.g. for 10 s every minute) to increase its service life. Cleaning is fully automated using amidosulphonic acid. This system allows fully automated operation of the measurement point during the complete campaign.

Ceramat® WA 150 ceramic sensor lock-gate

Knick
Elektronische Messgeräte
GmbH & Co. KG
Beuckestraße 22, 14163 Berlin
Phone: +49 (0)30 - 801 91 - 0
Fax: +49 (0)30 - 801 91 - 200
knick@knick.de · www.knick.de

The complete measuring system:

- Highest reliability
- Optimal process control
- Low cost of ownership

Applied Components

Ceramat® WA150 –N0AAC1-000

Flow-through fitting YF-AR1225

Unical® 9000-NC301222CN000-000

Protos® 3400C
with Unical module PHU 3400-110

pH combination electrode SE 532/2
(225 mm)

Sensor cable VP ZU 0314

Buffer solutions pH 4,01 ZU 0200 and
pH 7,0 ZU 0201