**Introduction**

Sugar beet is a form of beet which grows mainly in temperate climate zones. Because its juice contains high amount of sucrose, sugar beet is used to produce sugar and is second only to sugarcane as the major source of the world’s sugar.

The agricultural cost of producing beet sugar is significantly higher than the cost of cane sugar, so optimal control and efficiency of production is a high priority.

**Application**

**Diffusion**

After reception at the processing plant, the beet roots are washed, mechanically sliced into thin strips called cossettes, and passed on to the diffuser, a processor used for the extraction of sugar content into a water solution. The diffuser process is slow, so real-time and continuous measurement of the concentration is important to monitor its progress.

**Juice Purification**

The diffusion juice contains, in addition to sucrose, some non-sugar impurities. The process of liming and carbonation is in two stages. The first stage is primarily for the removal of sludge. The second stage involves further addition of carbon dioxide to remove the lime, which remains in the solution. The resulting solution is called thin juice.

**Evaporation**

The thin juice is heated and pumped into the multiple-effect evaporators to create a thick juice. The dissolved solids concentration is raised from its initial concentration to 50-75%.
Crystallization

The thick juice moves on to crystallization. Crystallization takes place in boiling pans or in vacuum pans.

In the crystallizer, the liquor is concentrated further by boiling and then seeded with fine sugar crystals. The crystals grow as sugar from the mother liquor forms around them, thus decreasing the sugar content of the liquor. The resulting sugar crystal and syrup mix is called a massecuite.

Crystallization stops when the crystals have reached the desired size. The massecuite is then passed on to a centrifuge to separate the crystals from the liquid before they are dried in a granulator with warm air.

The remaining syrup stills contains some sugar which is recovered by further crystallization. The resulting sugar is of lower quality and used to make the mother liquor. The separated syrup is molasses, which still contains sugar, but has too many impurities to undergo further processing economically.

Final molasses

Final molasses, in beet sugar manufacturing, is the final syrup, which is centrifuged from the sugar crystals after repeated crystallization. The final molasses still contains a high amount of sucrose and it can be sold as beet pulp pellets for animal feed, or it can be further processed to recover more sugar. Tight control of molasses processing is a must to ensure the economic viability of the process.

Instrumentation and installation

Vaisala K-PATENTS® Process Refractometer PR-43 provides accurate in-line Brix and concentration measurements for the beet sugar refining process.

The performance of all basic steps in this process can be optimized. The refractometer provides rapid detection of process disturbances during diffusion. Control of the concentration levels saves energy by minimizing the quantity of water, which requires evaporation later in the process. In addition, calculations of the diffuser plant output can be made utilizing the process refractometer.

At the evaporators, the PR-43 refractometer assists in regulating the product flow to best suit the evaporator's capacity, thus saving energy. The refractometer’s output can also be used to control the steam flow and optimize the evaporation process.

Refractive index technology is the best option for control and monitoring of crystallization. The controlling refractometer monitors selectively the concentration of the mother liquor to maintain the supersaturation state required for the formation of crystals. Due to our unique technology, the refractometer measurement is not influenced by bubbles or the crystals formed.

<table>
<thead>
<tr>
<th>Instrumentation</th>
<th>Description</th>
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<tr>
<td>Sanitary Compact Refractometer PR-43-AC</td>
<td>for hygienic installations in small pipe line sizes of 2.5 inch and smaller. The PR-43-AC refractometer is installed in the pipe bend. It is angled mounted on the outer corner of the pipe bend directly, or by a flow cell using a 3A Sanitary clamp, I-clamp or Varinline® connection.</td>
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<tr>
<td>Sanitary Probe Refractometer PR-43-AP</td>
<td>for hygienic installations in large pipes, tanks, cookers, crystallizers and kettles and for higher temperatures up to 150°C (300 °F). The PR-43-AP refractometer is installed in the pipe line or vessel through a 2.5 inch or 4 inch Sanitary clamp, I-clamp, APV Tank bottom flange or Varinline® connection.</td>
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<tr>
<td>Process Refractometer PR-43-GP</td>
<td>is a general industrial refractometer for pipes and vessel installations. The PR-43-GP can be installed with 2, 3 and 4 inch flange and 3 inch Sandvik L coupling process connections and a variety of flow cells for pipe sizes of 1 inch and larger.</td>
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<td>Selectable multichannel MI, compact CI or a web-based WI user interface options allow the user to select the most preferred way to access and use the refractometer measurement and diagnostics data.</td>
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<td>Refractive Index (nD)</td>
<td>1.3200 – 1.5300, corresponding to 0-100 Brix.</td>
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