MICROWAVE TECHNOLOGY: AN UBIQUITOUS IN LINE MEASUREMENT INSTRUMENT FOR DENSITY, TOTAL SOLIDS, CONCENTRATION, ESPECIALLY BRIX IN A TODAY SUGAR FACTORY

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1. Introduction

The microwave concentration measurement is one of the most modern technologies used in industry for process measurement and control. Measurement systems have been successfully employed for Brix control on pans (batch and continuous) in the sugar making process. Recent developments allow the technology to be applied to virtually all measurement points requiring the process variable determination and control of concentration, density, or total solids in sugar plants.

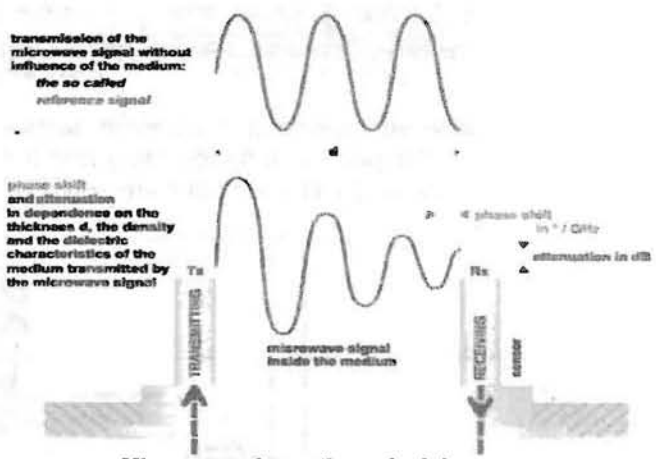
Over the past few months new applications, especially the concentration measurements in large pipelines and measurements in tanks and mixers have shown that microwave technology thereby offers unique and new solutions to the sugar producing industry.

This paper discusses measurement experiences with microwave technology which covers now nearly all needs of online concentration measurement of raw juice to milk of lime in a sugar factory. Particular focus is on the new applications in the sugar factory with discussion of the technical aspects, considerations and advantages of the employment of microwave technology in these new applications.

2. Microwave operating principle

The microwave density and concentration measuring method is an indirect measuring technique. Microwaves which are transmitted through the sugar syrup or massecuite will be attenuated by water molecules. The microwave absorption signal is selectively sensitive to water because of the much higher dielectric constant of water compared to most dry substances. The value of this coefficient can be used as an indication of the water content, and this of course correlates with the total dry substance being used to control an evaporating process. The high sensitivity of microwaves to water makes it possible to distinguish between water and a dry substance. This presents us with an opportunity to generate a signal which correlates to the dry substance in terms of a concentration, density or Brix measurement.

Performing the transmission measurement in the high frequency range of GHz appears not to falsify the results due to varying purity of the syrup. The measurement effect is caused by the rotation of the water molecules stimulated by the transmitted microwave. At high temperatures in the range of 70 to 80 °C a smaller change of the dielectric constant caused by temperature shift was found than at lower temperatures.



Microwave absorption principles

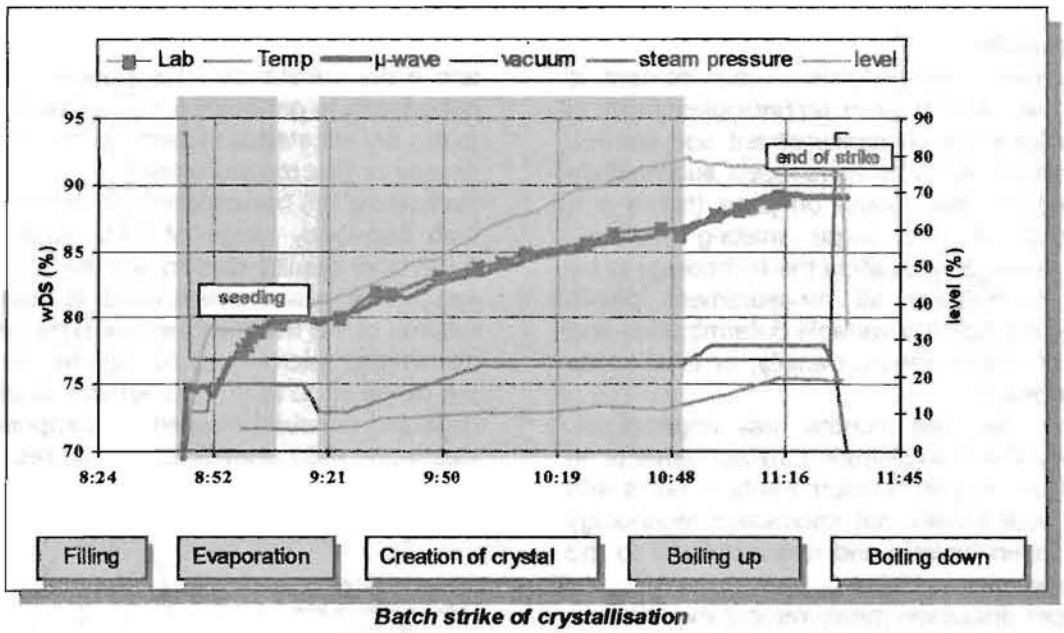
3. The standard application : crystallisation process control in batch pan

By 1996, proMtec had introduced the microwave technology in the sugar industry for the online control of the crystallisation process in batch pan. Since then it has become a standard within less than 10 years for all types of crystallisation processes be it batch, continuous, horizontal, vertical or cooling.

The picture below shows a crystallisation course with a typical increase in the dry substance content, determined by microwave transmission.

The microwave density offers a very high measuring accuracy up to 0,2 % with a direct reading of dry substances. This is a great advantage for the determination of the seeding point. Good crystal quality can be gained only with an optimal seeding point and a sufficient time for crystallisation.

More important for problem-free centrifugation, is that the crystallisation process is finished with an optimal dry substance content. The microwave concentration measurement is also suitable for the determination of this point.



Batch strike of crystallisation

The microwave probes are insertion sensors installed in the pan via a flange plate and hub. But the probe for continuous pans are equipped with an additional CIP (clean in place capability) device.

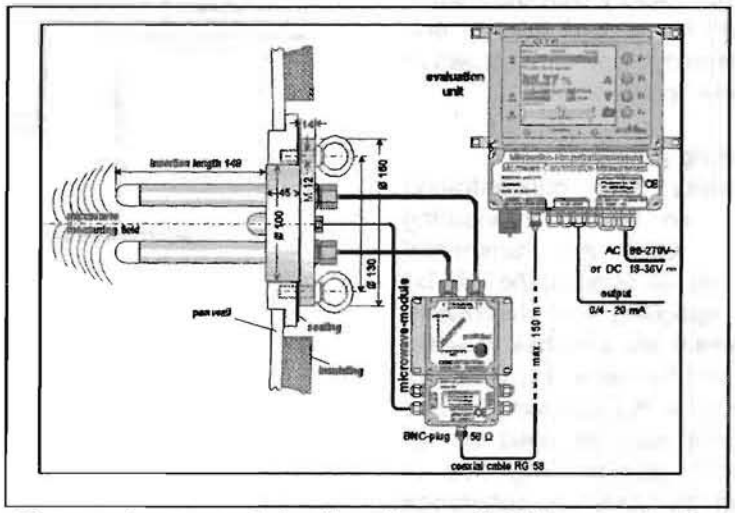


Diagram of components for discontinuous (batch) pan application showing sensor, microwave module and multi channel evaluation unit

4. New breakthrough in online massecuite measurements in continuous pan

In 2005 proMtec launched a new way to measure the massecuite of about 93 Brix on the outlet of a continuous pan.

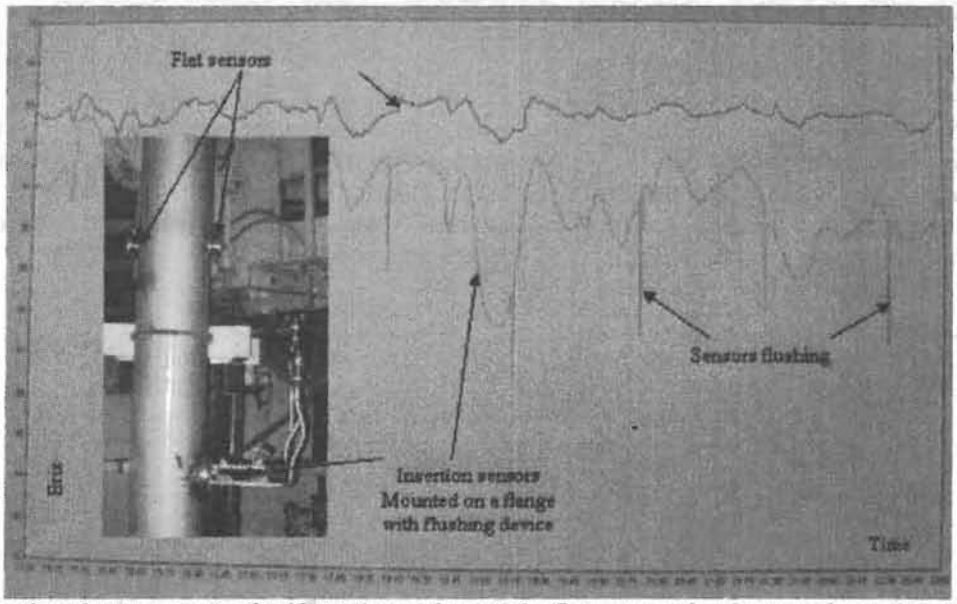
The measurement is performed by the so called microwave "flats sensors", a unique design by proMtec, mounted directly by means of weld-on sockets on each side of the pipe.

The 'flat sensors' provide an obstruction and maintenance free means of measuring directly the concentration in pipelines throughout the complete concentration range spectrum (within 0–98 % dry substance content). Even for high concentration ranges in pipeline arrangements, no flushing or cleaning mechanism is required. The flat sensor arrangement can be supplied for use with standard sections from 1 3/4" (40mm) to 12" (300mm) in diameter. This in-line measuring chamber arrangement is the perfect instrument for density control in any juice or aqueous suspension. The microwave probe/sensor operates without any moving parts; it consists of just the microwave transmitter and receiver, and the robust design can withstand the normal temperature stress resulting from the cleaning process in the pan or pipe.

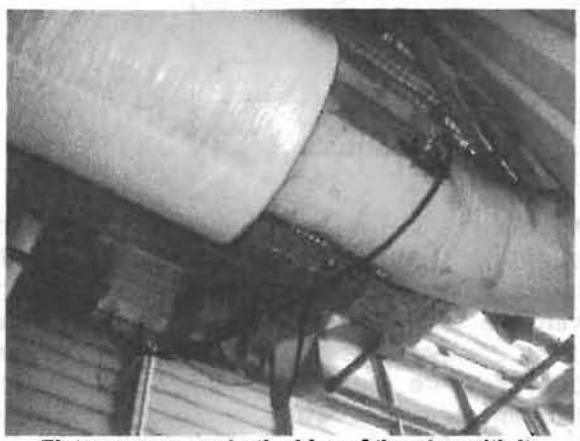
The Brix of the magma is performed in the cross section of the pipe and is therefore highly representative. It delivers a continuous stable value with a very high accuracy.

No water needs to be introduced into the pan or pipeline as it is the case with the standard probe. This type avoids a risk of incrustation.

In order to perform measurements over the cross section of a 300 mm or larger pipe, the microwave signal is boosted at the entrance and amplified for reception.



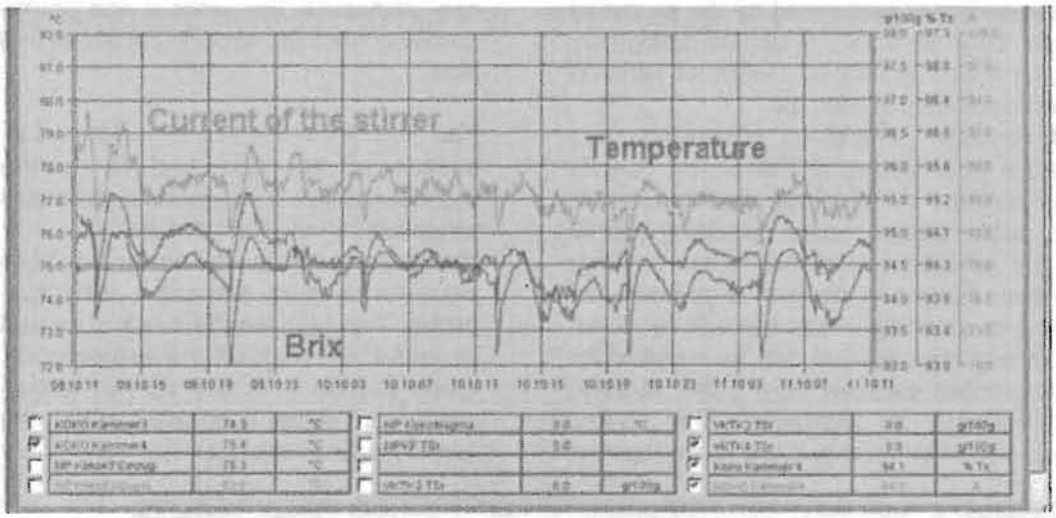
A comparison between a standard intrusive probe and the flat sensors has been performed on a continuous outlet pipe DN 300



Flats sensors on both sides of the pipe with its electronics

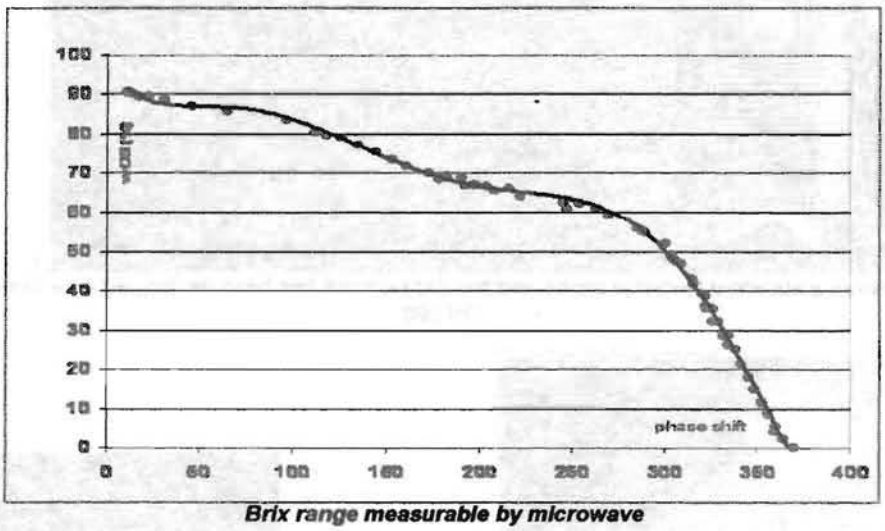
Flat sensor seen inside the pipe

The picture below shows that the Brix is measured in a very narrow range, of less than 1.5 Brix with a very high accuracy. One can see that the Brix value follows the temperature and the current of the stirrer. Therefore a reliable Brix measurement is more suitable to control the process and simplifies trouble shooting.



5. Microwave technology is the ideal tool for measurement in juices and molasses.

The picture shows that the microwave technology can be used for many kinds of Brix measurements, from lower than 1 up to 98 Brix. For these reasons microwave probes are now used for the measurement of raw, thin, thick and storage juices. The online measurement of these juices allows the improvement of the process in order to save energy and improve the quality of the end product.

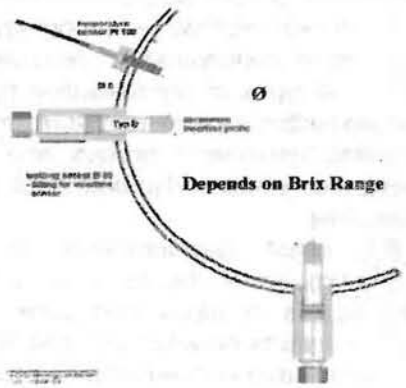


Brix range measurable by microwave

proMtec offers a optimum probe design for each type of pipe and Brix range based on intrusive probes or a in-line measuring chamber equipped with flats sensors. The intrusive probes can be installed in all sizes of pipe. The inline flat sensors are an advanced solution suitable for any type of Brix measurement and especially for high Brix and molasses.

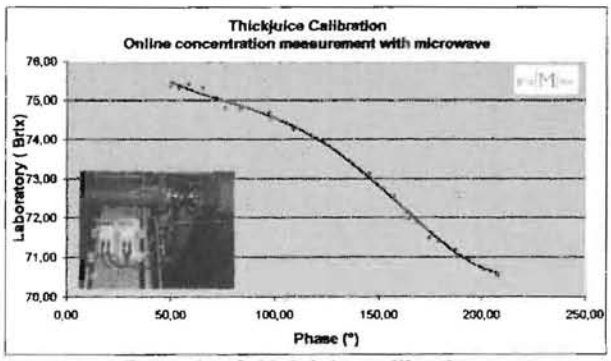
Measurement of the concentration or dry substance content of juices in pipelines with microwaves utilizing the proMtec flat sensors or intrusive probes has become the preference. The disadvantages of other measurement principles are therefore overcome. The inline measurement is not influenced by the velocity of the juice. The transmission measurement, due

to the generally large measurement path, allows a very high accuracy to be achieved.

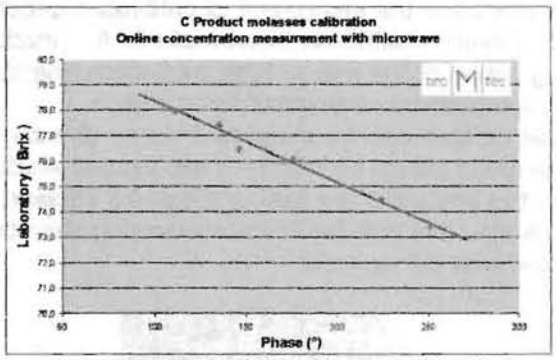


Intrusive probes mounting sensors

In-line measureing chamber DN 150 equipped with flat sensors



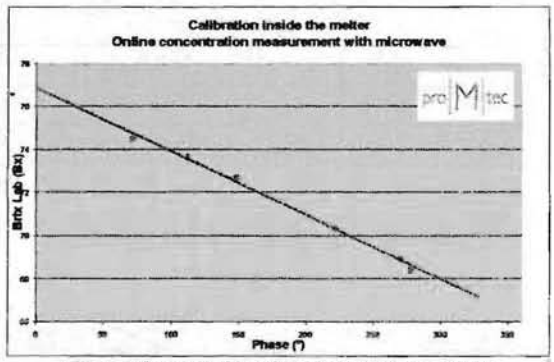
Example of thick juice calibration



Example of C product molasses calibration

6. Brix measurement inside the melter

proMtec has designed some extra long intrusive probes in order to measure inside the melter with a very high accuracy. The probes are installed deep in the middle of the melter and not on the wall as they are with the standard probes mounted on a flange. As the distance between the two probes is also larger than with the standard ones, it ensures a high representative Brix measurement.



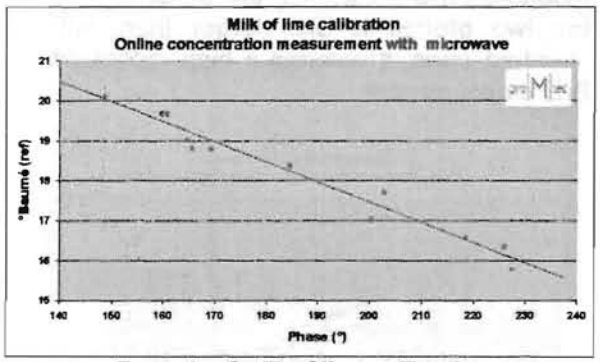
Example of calibration inside the melter

7. On-line milk of lime microwave measurement

Milk of lime is a mixture of water and lime. As the microwave technology is the choice for a direct water content measurement, it is the appropriate tool for measuring the milk of lime. In this case the instrument is calibrated directly in Baumé with an aerometer. A precise regulation of the milk of lime production ensures a high purification treatment of the juice.

Milk of lime can be measured either directly in the mixer vessel by means of two probes welded on the bottom of the wall or it can be measured in a pipe line with the in line measuring chamber fitted with flat sensors.

Direct mounting on the wall



Example of milk of lime calibration

Comparison between the Inline microwave value and the laboratory

8. Summary

proMtec Theisen GmbH has paid special attention to finding unique solutions to the different needs facing the sugar industry in terms of concentration, density and Brix measurement. The proMtec systems were the first to measure density and concentration in the sugar industry via microwave technology.

The microwave concentration measurement is suitable for all types of crystallisation processes in sugar production as well as milk of lime.

The proMtec microwave probes and sensors have been widely installed in both beet and cane sugar factories.

With the latest developments in sensor technology proMtec is able to measure with high accuracy liquids in pipes and pans with dry substance contents between 0% and 98 %. The proMtec microwave concentration measurement technology and equipment has become universal in pipe and pan applications in sugar production.

As a technology leader proMtec is determined to continue to set further standards in microwave concentration measurement.