

Microwave measuring technology for sludge draining

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The paper describes how a microwave measuring method can be used to control the addition of flocculation aids to digested sludges before they are fed to a centrifuge. After one year of operation at the city of Gütersloh (North Rhine Westphalia/ Germany), Putzhagen sewage treatment plant. Considerable cost cuts were achieved thanks to this measurement system. The use of flocculation aids could be reduced by 16 percent.

1 Introduction

Gütersloh operates a sewage treatment plant with an expansion capacity for a population of 195.000 inhabitants. The wastewater treatment takes place at a mechanical level and a one stage biological level (splicing cascade) with a simultaneous P-regeneration. A downstream flocculent percolation causes the rest elimination of phosphate.

The primary slurry and the excess slurry are collected in a primary settling basin and are fed to a digestion without being pre-thickened. Due to the inadequate circulation of the digestion tank, the ignition loss amounts to 56% on a yearly average.

The incidental digested sludge is temporarily stored in 4 slurry stacking boxes and is drained through a re-thickener by means of a high power centrifuge. The remaining coarse materials lead to considerable maintenance needs on the optical solid matter measurement.

A quasi contact-less measurement will be subsequently described. This measurement is used to optimise the operation process of a high power centrifuge, by means of solid load control and automatic dosage of flocculating agent. By means of the latest microwave technology, the solid matter content is determined continuously by low power signals (< 0.005 mW, a millionth of the signal power of a cell phone) and therefore, the flocculating agent addition is controlled. In comparison to radiometry, by which the density of the sewage sludge is measured and therefore, a "mixed density" of solids and water is measured, the microwaves react selectively to the water content.

2 The Microwave Measuring System

Microwave measuring processes have been used in the industrial process control for years. (Ref. 1, 2). Typical applications are, for example, moisture measurement in bulk goods and fluids or level measurement in large tanks and vessels. The determination of solid matter content and the concentration of solid and fluid measuring products are other uses for this process. Radiation and receipt of the microwaves occurs using so-called applicators (Send and receive antenna).

The operation of the microwave measuring technology requires the use of a special microwave applicator, in order to determine continuously the solid matter content of sewage sludge with a high accuracy. The microwave applicator must prove sufficient interaction of the detected microwaves with the product being measured, which increases the dynamics of the measuring system and therefore, the measuring accuracy.

The solid matter content of products being measured in metallic pipelines principally requires the use of the applicator in the pipeline system, for example by using a flange attachment, so that a direct interaction of the electromagnetic waves with the product can take place. The constant detection of a representative proportion of product being measured by microwaves is necessary for the determination of a measuring value in on-line operation.

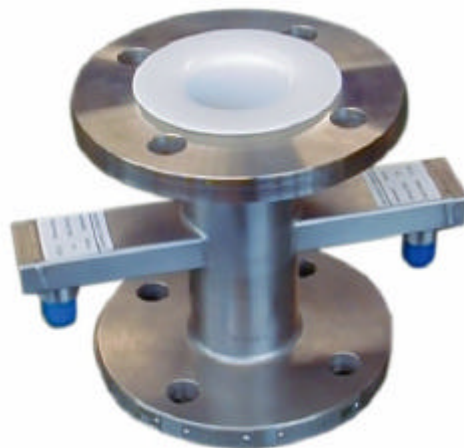


Abb. 1: Microwave-applicator: Measuring cell with NW 50 mm (Berthold Technologies)

2.1 Principles of the Microwave Measuring Technology

The operation of the microwave measuring procedure for the detection of physical parameters such as solid matter content, concentration or moisture of a product has many advantages in comparison to the conventional methods like conductivity or capacity measurements. The interfering influence of ionic power for example in the measuring probe or contact problems decrease during increasing frequency of more than 1 GHz (Ref. 2). Modern strip line circuits make it possible that very compact microwave modules such as synthesisers, modulators or demodulators with large dynamic ranges, relating to attenuation of more than 100 dB and phase decomposition, can be realised up to a tenth of a degree.

The microwave measuring procedure can be traced back to the dielectric characteristics of the product being measured. The electromagnetic waves are changed by the properties of product being measured by means of the applicator. Bound to the applicator form are the corresponding evaluable microwave measuring values, in this case, attenuation and phase shift of the electromagnetic waves which are entering the product.

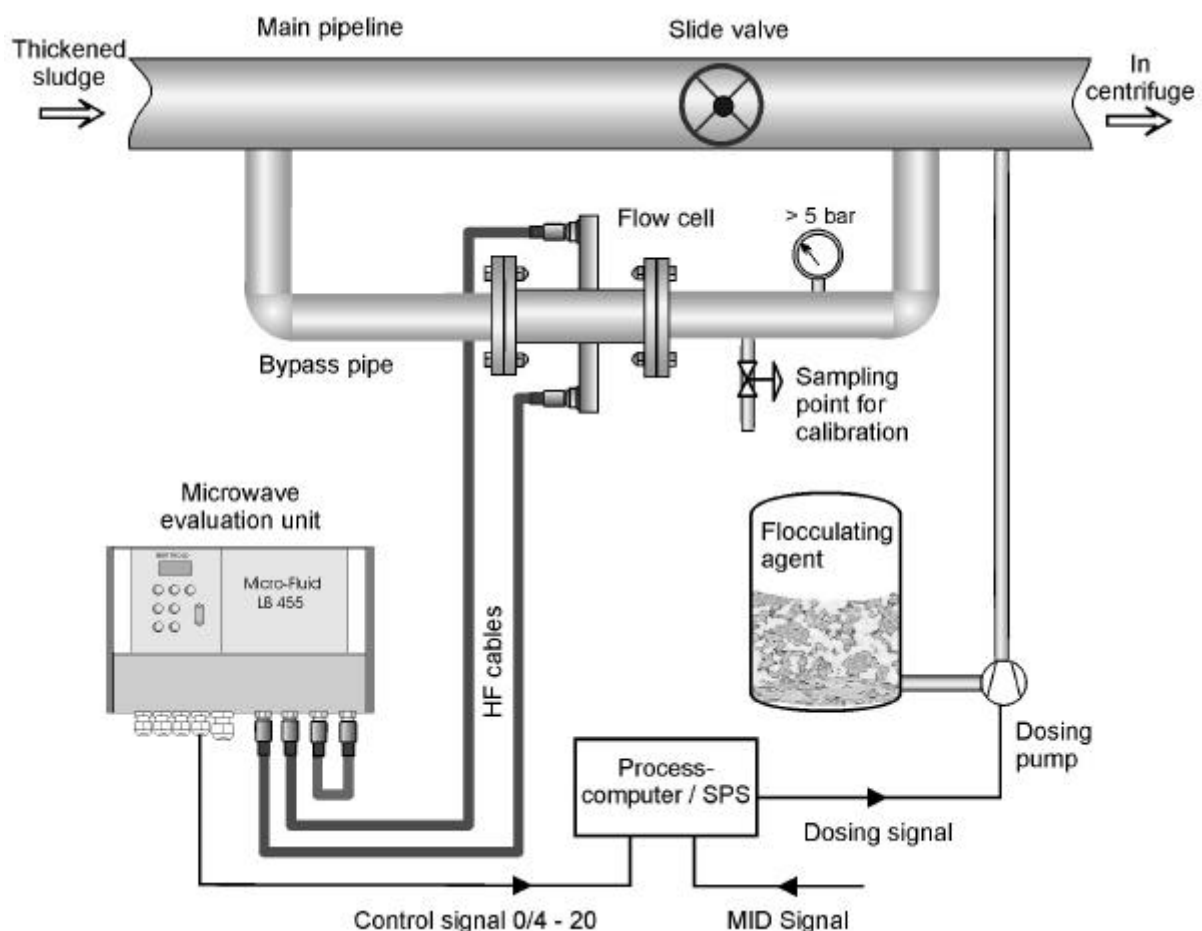


Abb. 2: Schematic display of the measuring arrangement (Evaluation unit + measuring cell) with control of the flocculating agent solution (FHM)

Should a dielectric, such as sewage sludge be present in an electric field, then a relocation of charge carriers occurs and dipoles are developed. If the electrical field changes it's orientation, a dipole can follow the field if enough low frequencies are available. Electrical field and polarisation of the product are in phase. If the dipoles cannot follow the outer field due to an increase in the frequency, then a phase shift occurs between the polarisation and the electric. This causes losses that lead to the warming of the probe and the value of the dielectric constants (DK) decreases. (Dispersion). The connection between electrical alternating field E and the polarisation P is described in detail in the special publication (3).

2.2 Measuring System Construction and Description of the Function

The determination of the complex transmission factor and therefore, the factor arising from the measuring product characters, attenuation and phase, happens using an evaluation unit and the microwave applicator which are connected to each other over a high frequency cable. The new microwave measuring system is shown in figure 1 and 2.

The applicator is a microwave measuring cell. The measuring principle is based on the theory that a microwave enters the product to be measured by means of a suitable wave conduit, depending on the dielectric constant, this will be changed and detected again. The measuring signal is then compared to the reference signal, which runs through a second channel over a reference cable and by this, the phase and the attenuation are used as a direct measure for the solid matter content of the digested sludge.

The measuring cell consists of a stainless steel body with a smooth walled and abrasion proof PTFE lining (PTFE Polytetrafluorethylen = Teflon). By means of this construction, no fixed equipment projects into the product pipe (like clarification devices for optical solid mater measurements.)

Firstly, for the measurement of digested sludge, a basic adjustment is carried out during the normal flow operation. The phase and attenuation values are stored as reference points. After this the calibration is carried out by which the varying solid matters of the phase and/or attenuation values are entered and the co-efficients A, B, and C are determined over the linear context.

Solid matter content [weight-%] = A · Phase [Grad/GHz] + B Attenuation [dB] + C

3 Measuring arrangement and measuring results

The amount of digested sludge which flows from the sludge pumps to the centrifuge is detected over a magnetic inductive flow meter. (see picture. 3). In a bypass pipeline, the digested sludge is continuously fed to the microwave cell. In order to achieve an even flow, the sludge flow is throttled back into the main pipeline by means of a slide valve. Pressure of more than 5 bar in the bypass pipeline prevents the interfering influence of gas cavities in the digested sludge. A ball valve in the bypass pipeline allows sampling at all times for reasons of calibration and control of the measuring unit.

The system computer displays the requested remaining load (product from the sludge flow and solid matter content) as a set value. The measured signals from the magnetic inductive flow meter and the microwave solid matter measurement are automatically converted by the processor mathematically into a freight and compared to the set value. Depending on the solid matter content of the digested sludge, the sludge flow is controlled by adjustable pumps so that the centrifuge is always fed with a constant set value.

Furthermore, the computer will specify the known dosage of flocculating agents as a set value. This value is detected in co-operation with the company Reiflock GmbH in Baden-Baden.

By the use of the microwave measurement, the flocculating agent consumption can be reduced by 16%.

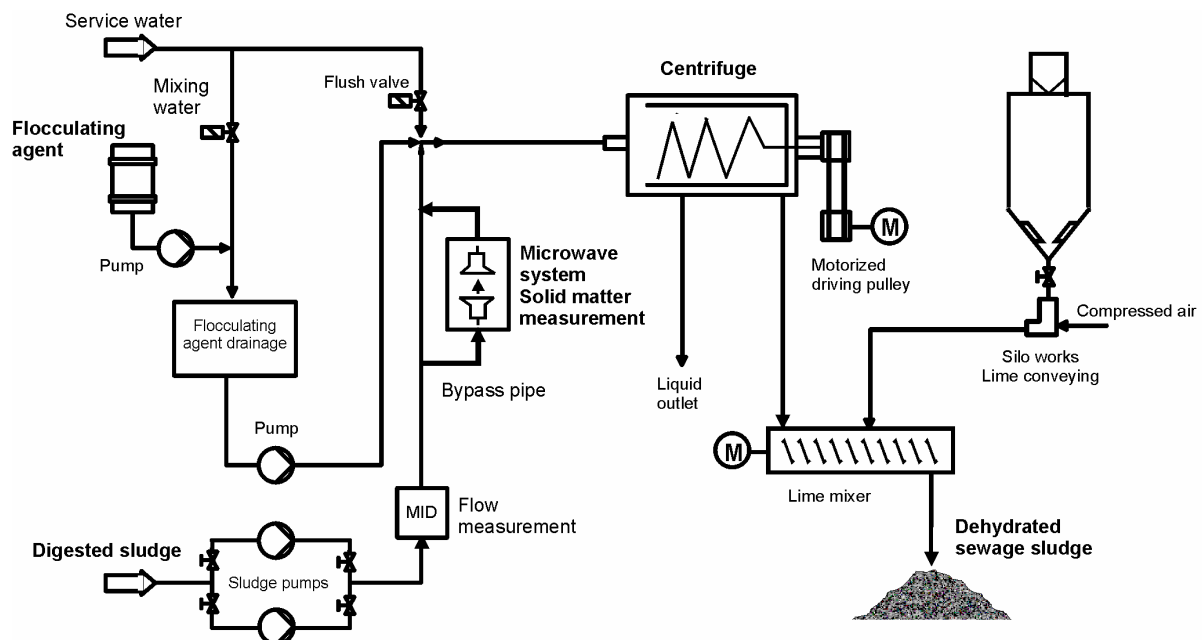


Abb. 3: Flow char of a digested sludge de-watering plant.

Accuracy and influential factors

The temperature drift of the evaluation unit and the measuring cable between the measuring unit and applicator can be compensated to a large extent with help of a reference cable. Varying conductivity due to the fluctuating salt content also have to be compensated.



Abb. 4: Installed measuring system: Measuring cell in a bypass pipeline connected with a high frequency cable with the evaluation unit Micro-Fluid LB 455, sewage treatment plant, Gütersloh

If the main attenuation, during fluctuating salt contents, is sufficiently small through the product being measured, this also has to be compensated. If the salt content is constant however, this does not influence the main attenuation negatively. The salt content in the digested sludge which has been inspected so far was nearly constant at 700 mg/l. The measurement on digested sludge in the range of 2 - 5 weight-% solid matter content show a standard deviation of more than ± 0.2 % of the solid matter weight.

4 Summary

The operation of the new measuring process on the basis of microwave measuring technology in the complete range of process control is in progress. Due to the extremely low power radiant emittance, it has no influence on the environment and no harm is caused by the microwaves to humans (smaller than 0.005 mW)

The microwave technology can be used for the control of the flocculating agent input over the direct detection of the solid matter content. Here, the physical basics of the interaction of the microwave with the product being measured are being discussed as well as the measuring construction and function of such a measuring system.

The microwave measurement has proved itself in the solid matter determination in digested sludge as a reliable and maintenance friendly measurement.

Further measuring possibilities within the sewage treatment plant are presently being tested, a measurement of the raw sludge flow from the primary settling basin to the thickener is in testing. The following sludge flow to the digestion tank can also be controlled with help of this measuring method. Sludge flow transport which is dependant on the solid matter to the digestion tank leads to a considerably high energy saving.

References:

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