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MEASUREMENT THE CONTENT OF SUSPENDED SOLIDS ON LF20 FERMENTER

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Abstract: *In 2004, facilities known as LABI were opened at Tomas Bata University in Zlin, these being laboratories featuring integrated automation. From the total number of 9 actual models, the DE5 type has a specific role as it is a model capable of biochemical processes. The DE5's equipment is a laboratory and technological combination of a biochemical reactor, a measuring and regulating system, and a system of informatics with remote access to the Internet. The operation of it, as experienced thus far, has brought to light some particularities that require explanation and which are necessary to respond to. One such problem is measuring the content of suspended matter during technological processes.*
Key words: *fermenter, biotechnology, turbidity, measurement*

1. INTRODUCTION

The function of the DE5 is to run biochemical processes. In terms of technological equipment it comprises an LF20 fermenter (http://www.labi.fai.utb.cz/newhtml/popis5cz.html). The fermenter unit is of a professional type that is constructed and utilised for biotechnological processes Measuring circuits were designed for basic biochemical processes (Fig.1)

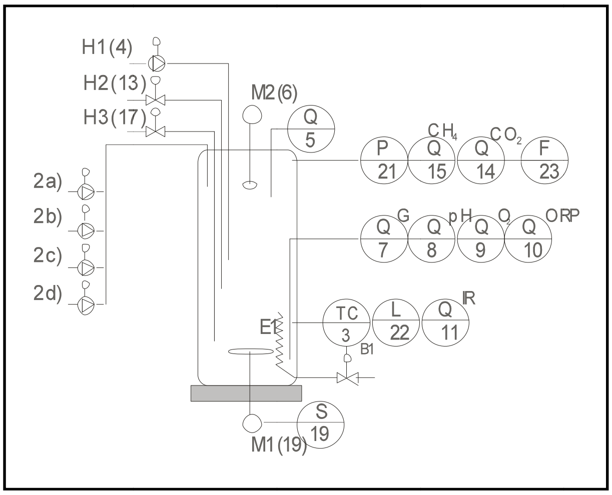

Fig. 1. Schematic of measuring circuits

Temperature measurement T1, type Pt100, range 0-100 °C with transmitter 0-10 V,
(8) Measurement pH (1-14 pH) digital sensor pHD ,
(9) Measurement of dissolved oxygen concentration, range 0-20 mg/l,
(10) Measurement of ORP (-700 mV to 1000 mV),
(11) SOLITAX® sc Suspended Solids and Turbidity Analyzer (0.001 mg/L to 50 g/L, 0.001 to 4000 FNU), Hach Lange
(19) Measurement of rotation of the motor for stirring 0-1000 n/min
(21) Measurement of pressure interior space, range 0-60k Pa, output 0-10V,
(22) Level measurement L, range 0-0,35m, sensor

2. MEASURING OF SUSPENDED SOLIDS ON THE LABORATORY FERMENTER LF 20

2.1 Principles of measuring and related uncertainties when measuring

Turbidity is an indicator often used to find the amount of suspended solids in water (Yuan 2002). Measuring either the turbidity of pure liquids or the content of suspended solids is conducted through the absorption or dispersal of electromagnetic radiation at a particular wavelength. Such measuring is carried out using an optical arrangement with sensors at the angles of 60°, 90°, 120° and 180°. Typical nephelometry utilises a sensor located at the angle of 90°, whilst turbidimetry requires that of 180°, i.e. precisely in the direction of radiation from the source. As for the means of light/radiation, there are either sources for visible white light (a wolfram bulb), a laser beam - a diode with a radiation aperture of the wavelength 660 nm - or infrared radiation (IR) at the wavelengths of 860 nm or 1500 nm. Either one direction is detected or two or more directions at a time, which helps achieve higher sensitivity, precision and superior definition. This method is used to gauge turbidity or suspended matter independently of colour, without calibration, with a cleaning system featuring a wiper, and conductivity in combination with probes, ORP, O_2, NO_3^-, pH, etc. The measurement of turbidity is for pure liquids, i.e. for a low content of suspended particles, and is intended for drinking water or other forms of pure liquid. For waste water this is facilitated by calculating the content of suspended matter, i.e. at higher concentrations. It is possible to work with primary sludge, thickened sludge, activated sludge (Baudu 1995, Urrutijetxea 1993) return sludge, digested sludge, sludge water and lime sludge. Sludge is made up of a varied structure and possesses light or dark colouring.

The measurement range is, for turbidity, 0.001- 4000 FNU. This is conducted via IR radiation using a nephelometer, the wavelength being λ = 860 nm, whilst the angle of 90° for dispersion corresponds to ČSN EN ISO 7027. In addition, a wolfram photometric lamp is used to calculate very low level turbidity. Meanwhile, the range of measurement for suspended matter is 0.001 to 150 g/l. This is carried out via IR radiation for two-way dispersed light according to the norm DIN 37414; precision tolerance is 1% and response time ranges from 1 to 300 s. The construction of sensors varies and can either be of the immersion or passing type. For the latter, the liquid to be measured is fed into an area preordained for that purpose. The light source then illuminates the liquid and, according to the position of the sensor, radiation absorption is gauged (occurring in the arrangement of a line: source - sensor), and/or, at an angle of 60 to 155°, the measurement of radiation dispersion occurs on suspended particles.

3. ACQUIRED KNOWLEDGE

SOLITAX® sc Suspended Solids and Turbidity Analyzer (0.001 mg/L to 50 g/L, 0.001 to 4000 FNU), (Hach Lange

2004) was used for measuring and determining on-line the amount of suspended solids (dry matter) in a bioreactor. Whilst conducting biochemical reactions, the significant influencing of measured values was discovered by aeration and stirring. This phenomenon can be explained, because in the internal space of the fermenter the suspended solid particles may be exposed to gyration and elevation. Moreover, the current of air bubbles during aeration influences analysis much like solid particles do. In Fig.2 the influence of aeration and stirring on measuring turbidity is clearly visible.

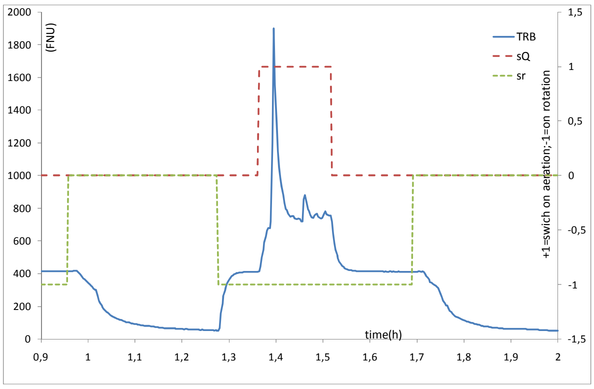

Fig. 2. The courses of TRB turbidity value measured, together with switching aeration sQ and stirring sr on and off

When evaluating the courses of values in Fig.2, significant changes become visible in the values of turbidity TRB measured according to the aeration taking place or the procedures of stopping and/or stirring. During aeration, large quantities of air bubbles arise in the measured volume. Their number, movement and size are caught by a turbidity sensor, and analysis is carried out via the turbidimetry and nephelometry methods as higher absorption or dispersion can occur. The resultant value oscillates over time, and in Fig.2 it fluctuated around the value of 800 FNU. When aeration is switched off the turbidity value drops and remains constant after stabilising. Upon simultaneously switching off the stirring process, the resultant measured value drops to small amounts close to zero.In changes of dry matter content, it is possible to see courses as Fig. 3. The dry matter content was increased to 3.8 g/l. After switching on the aeration and stirring process, the value measured oscillates and is mainly affected by aeration bubbles. Through switching the aeration off but continuing to stir, the FNU value measured drops to a constant which corresponds to the value of the content of suspended matter. On subsequently ceasing to stir, the turbidity temporarily rises slightly above the pre-set and limiting upper boundary of measurement.

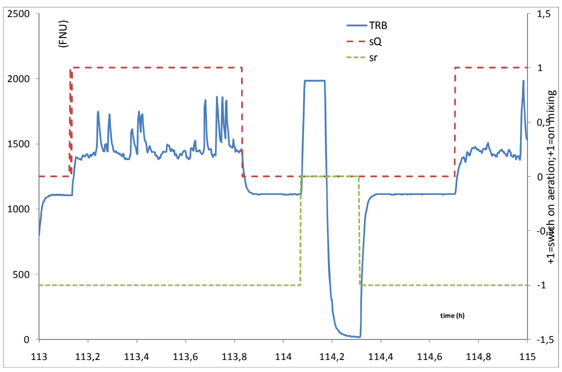

Fig. 3. Turbidity and sedimentation of suspended solid particles

In this state, upon switching off the stirring process, the horizontal movement of flakes ceases. Then the solids sediment at the bottom of the fermenter. During descent at the level of the turbidity sensor, the detection area is filled with sludge and, therefore, it reaches the maximum quantity. Once sludge flakes fall further, below the level of the detection area of the sensor, turbidity drops to a value around zero.

4. DISCUSSION OF RESULTS

4.1 Influences of aeration

In accordance with all the findings available at present and their analyses, having aeration switched on fundamentally influences measurement methods and their results. The value measured is negatively affected via uncertainties from bubbles which are formed upon aeration. The value of the rise in the amount measured is multiplied and its upper level depends on the content of the dry matter.

4.2 Effects through stirring

Analysing various technological experiments also shows the effects of stirring. With aeration switched off but stirring on, it has been confirmed that the suspended particles remain elevated, are dispersed evenly around the measuring head of the turbidimeter and that measuring is not affected by uncertainties, such as from the inhomogeneity of the content of particles in the reaction space. Switching off the stirring process meant that maintaining the homogeneous content is not assured. Initially, after switching it off, super saturation of the measured value follows and then this calculation drops to around zero, because there are no suspended particles floating around the measuring head as they become settled at the bottom of the fermenter.

4.3 Effects of the content of suspended particles

The concentration of the content of suspended particles affects the transition process when switching stirring off.

5. CONCLUSION

Uncertainties in measuring turbidity lie in the existence of air bubbles during the aeration process, the increase in the measured value is many-fold, and measuring during aeration is not correct. Correct turbidity measurement is only possible through having switched stirring on and aeration off concurrently. With a high concentration of suspended particles, it is necessary to count on a transition occurring when the resultant value of turbidity is at a maximum. In order to determine the concentration of suspended matter, it is possible to use the measurement of turbidity installed by the system on the DE5 only with aeration switched off and stirring on. According to the dynamics of the transition that occurs once stirring is switched off, it is possible to deduce the speed and time of sedimentation of the suspended particles in the solution in the fermenter.

6. ACKNOWLEDGEMENTS

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