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THE SIMPLE THERMODYNAMIC SENSORS FOR PROCESS MONITORING IN MILK PRODUCTION

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Abstract:
The thermodynamic sensors (TDS) can be used for characterization and monitoring of thermal processes in thermodynamic systems. The basic idea of thermodynamic sensor is possible to use in many various applications. One of application areas, where the thermodynamic sensor can find the new area for a using, is a production of milk products - cheese, yogurt, kefir, etc. These milk products are often realized by fermenting or renneting process. Ends of fermentation or renneting processes are often determined on the base of sensory evaluation. The simple non-analytical method for determination of process end doesn't exist in this time. Tests of renneting process, yoghurt process and fermentation process was characterized and measured with thermodynamic sensor. First results of simple experiments are shoving, that the thermodynamic sensors will be possible to use for determination of time behavior of these processes. This paper deals with the simple experiments for characterization and monitoring of basic operations in milk production process by thermodynamic sensors.

INTRODUCTION

Characterization of thermodynamic sensor

The thermodynamic sensors (TDS) can be used for characterization and monitoring of thermal processes in thermodynamic systems. The basic idea, basic model and theory of ideal thermodynamic sensor integration as an ideal element in large models of thermodynamic system were presented in [1]. The original theory of ideal thermodynamic sensor as a process and media energy activity monitoring device was presented in [2, 3, 4].
The principle of thermodynamic sensors is based on measurement of energy, which is supplied to circuit to temperature setting and equilibration of temperature element with ambient. The principle schema of simple measuring circuit is shown on fig. 1. The basic part is often integrated with amplifier and U/I converter. The current output signal with range 0-10 mA is better for industrial application and remote measurement.

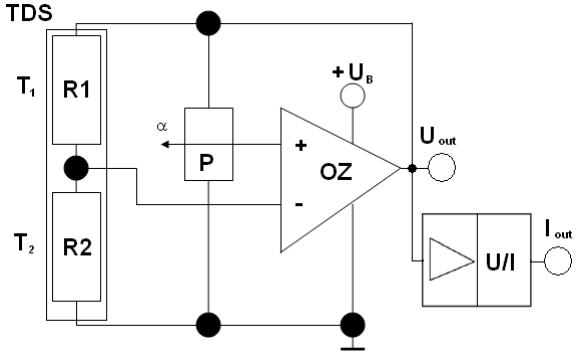

Fig. 1: The principle schema of simple measuring circuit.

The basic idea of thermodynamic sensor is possible to use in various applications. Some groups of influences have effect on TDS (fig.2). First group of influences is influences I1, which have effect on a temperature of sense element T2 only. Temperature, radiant heat, humidity, flow of liquid and next physical quantities, which is possible transformed to temperature energy, is possible theoretically measured in this group. Second group of influences is influences I2, which change the temperature properties between the sense elements T1 and T2. Volume, density, flow of liquid, pressure and next physical quantities is possible theoretically measured in this group. Last group of influences is influences I3, which have effect on a temperature of both sense elements T1 and T2. This group hasn't effect to output voltage signal of thermodynamic sensor.

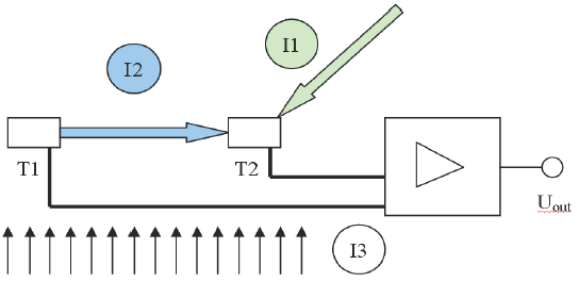

Fig. 2: The group of influences, which have effect on TDS.

The production of milk product

One of application areas, where the thermodynamic sensor can find the new area for a using, is a food production, especially in production which used

fermentation processes. One of these productions is productions of milk products - cheeses, yogurts, kefirs, etc. Milk and products from milk are one of important ingredient of food in people life, especially children. Milk and products from milk are sources of vitamins, proteins, fat, minerals, lactose, etc., which are not fungible in people sustenance. The production of milk product is complicated and sophisticated process [5], which is exacting to precision, temperature stability and hygiene. This is reason to close quality checking.
The production of milk products is often realized by fermenting or renneting process. The simple non-analytical method for determination of process end doesn't exist in this time. Ends of fermenting or renneting processes are often determined on the base of sensory evaluation. One of possible ways for solution of this problem is measuring process ends by thermodynamic sensors.

SENSOR DESIGN AND FABRICATION

The sensor for experiments was fabricated using standard TFT process. Sensor was designed as resistive thick film thermodynamic sensor in [6]. Sensor design is shown on fig. 3, [6]. Sensor was realized on Alumina 96% Al2O3 substrate with dimensions 2" x 2". Thick film pastes, which were used for production, are ESL 9562-G for conductive layer and paste ESL 3100 (3111) for resistive layer. The platinum layer for heating and measuring process was made from paste ESL 5544. After production, the colorless lacquer or epoxide powder was applied to sensor as protective layer and sensor was connected to measuring circuit. Because part of sensor was used for measurement only, two sensors substrate was connected to measuring circuit. The real sensor substrate is shown on fig. 4.

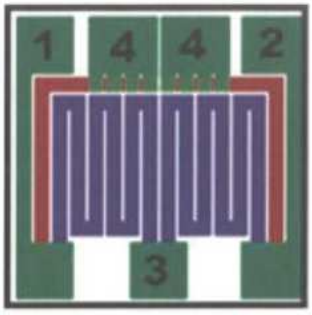

Fig. 3: The design of thermodynamic sensor substrate, [6].

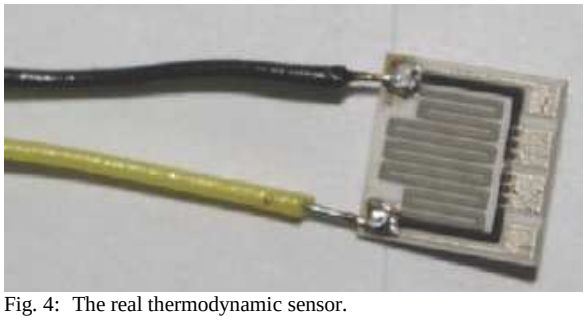
Fig. 4: The real thermodynamic sensor.

EXPERIMENTAL METHOD

Chemicals

First experiments were made with distilled water, caster sugar “Cukr bílý krystal”, Cukrovary a lihovary TTD, a.s., Dobrovice, CZ, and active dried yeast “INSTANTNÍ DROŽDÍ”, S.I.Lesaffre, France.
The basic solution used for measurement of milk products was fresh milk “Mléko čerstvé Selské 3,5%”, OLMA, a.s., Olomouc, CZ. The yoghurt “White country yoghurt with probiotic BiFi culture”, Hollandia Karlovy Vary a.s., Touzim, CZ, was used as start culture for production of yoghurt.

Experiment

All the measurements were done using the fabricated sensors, a simple measuring circuit, power source and multimeter UT 71 D or Metex 3270 D as voltmeter or ampermeter, which was controlled by computer. Experiment was made on the workplace, which is shown on fig. 5. Temperature was 22 °C in case of first experiments with water and 35 °C in temperature-controlled box in case of second experiments with milk products.

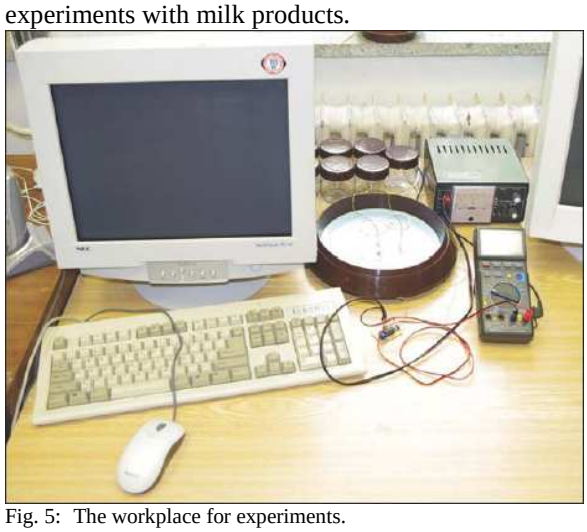
Fig. 5: The workplace for experiments.

RESULTS AND DISCUSSION

Measurement of activity yeasts was tested in first series of experiments. Experiments were made with water in room temperature (22 °C). Volume of water was 100 ml. First experiment (fig. 6) was focused to fermenting process, where the yeasts weight was changed (0,2g; 0,5g; 1g). Weight of sugar was 15 g. Result show a dependence of yeasts activity on yeasts weight in first fermentation phase and stabilizing yeasts activity on constant value in second phase of process.
The weight of sugar was changed (5g; 10g; 15 g) in next experiment (fig. 7). Weight of yeasts was 1 g. The yeasts activity is increases with weight of sugar in first fermentation phase and stabilizing yeasts activity on constant value in second phase of process again.

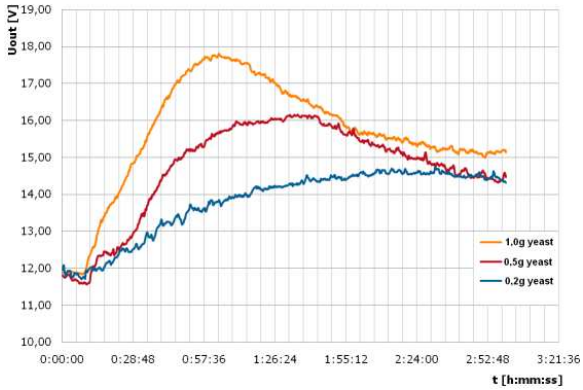

Fig. 6: The fermenting process of yeasts in water - a change of yeasts weight.

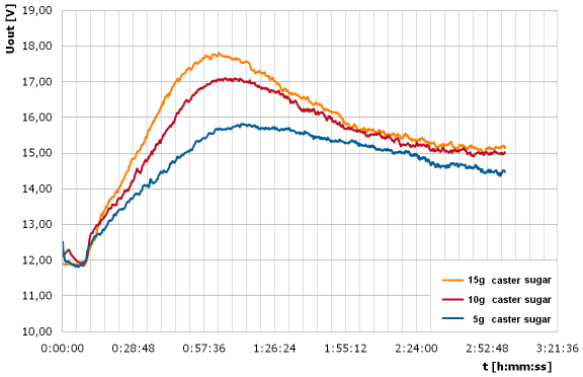

Fig. 7: The fermenting process of yeasts in water - a change of sugar weight.

Measurement of processes in milk production was tested in second series of experiments. Experiments were made with fresh milk in temperature-controlled box (35 °C). Two examples of yogurt process and rennet process are shown on fig. 8 and fig. 9. Both pictures are showing end of processes. The simple yogurt process and rennet process were tested minimally three times with similar results. Therefore is possible, that the thermodynamic sensors will be possible to use for determination of this processes.

CONCLUSIONS

The thermodynamic sensor tested in basic operations in milk production. Tests of rennet process, yogurt process and fermentation process was characterized and measured with thermodynamic sensor, which was designed and construed in thick film laboratory. First results of simple experiments are shoving, that the thermodynamic sensors will be possible to use for time behavior and end determination of this processes.

ACKNOWLEDGMENTS

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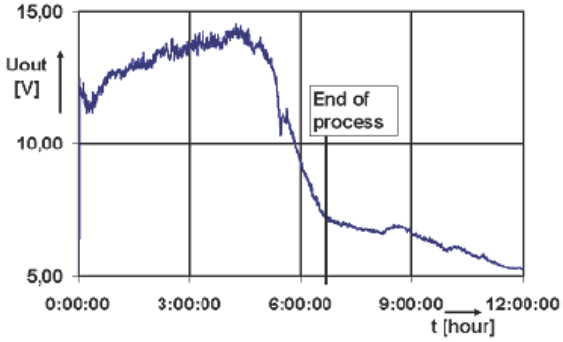

Fig. 8: The yogurt process.

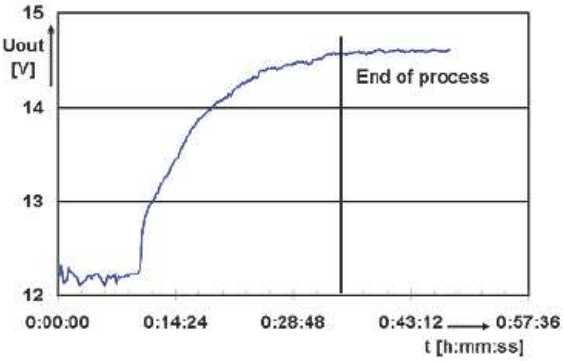

Fig. 9: The rennet process.

REFERENCES

[1] Patent pending Nr. CZ-297066, Technique of referential temperature and temperature difference measurement, asymetric temperature sensor and asymetric referential unit to technique application, Bulletin Nr. 3/2001.

[2] Reznicek M., Szendiuch I.:, Process energy balance monitoring, Proceedings of the11th conference Student EEICT, vol. 1, ISBN-80214-2888-0 no. 1, pp. 33-44,2005.

[3] Reznicek Z., Tvarozek Y., Reznicek M., Szendiuch I., "Temperature balanced process media energy activity monitoring", International Conference EDS-IMAPS CS 2005 Brno, Czech Republic, September 15-16 2005.

[4] Reznicek Z., Tvarozek Y., Reznicek M., Szendiuch I.: Hybrid Constant Temperature Regulator, International Conference EuroSimE It 2006 COMO, Italy, April 15-16 2006.

[5] Semjan Š.: Mliekárstvo, university mimeographed, Slovak University of Agriculture in Nitra, Faculty of Agrobiology and Food Resources, 1994.

[6] Reznicek Z. Sr., Szendiuch I., Reznicek M., Reznicek Z. Jr.: Thick Film Double Thermodynamic Sensor System, 2nd Electronics System integration Technology Conference, Greenwich, UK, 1-4 September 2008.