SiK

RAPPORT

SIK-Rapport

1991 Nr 583

A NEW FIBER OPTIC SENSOR FOR ON LINE MEASUREMENT OF MOISTURE IN FOOD

Christina Skjöldebrand, Karin Thorvaldsson, Claes-Göran Andersson, Per Arne Torstensson

A NEW FIBER OPTIC SENSOR FOR ON LINE MEASUREMENT OF MOISTURE IN FOOD

Christina Skjöldebrand, Karin Thorvaldsson and Claes-Göran Andersson
SIK

Per Arne Torstensson
Radians Innova

Göteborg (Sweden)

SUMMARY

For the development of bakery products it would be a great advantage if the moisture content distribution and the water transport rate could be measured, as these factors influence crumb texture and crust formation.

The authors, in collaboration with Infrared Engineering, have developed a new device for measuring the local moisture content in food. Unlike the commercially available instruments, which can be used for measuring the moisture content of products with a homogeneous moisture distribution, the new device has a sensor with a diameter of only 2 mm. It can be placed inside the product, for moisture measurement at well defined depths.

This text describes the basic features of the instrument and shows some results obtained during reheating of bread in a microwave oven. Although the instrument is not yet commercially available, it can be concluded that it has a considerable potential for the development of new products and processes. Another application will be a better knowledge of the water transport phenomena occuring in a product, with the aim to predict and control the moisture content distribution during production.

A-nr. 810

INTRODUCTION

Many food technologists ask for methods and devices to measure the distribution of the water content or water activity in food as a function of time. At SIK we have developed a fibre optic measurement device for measuring the local water content in foodstuffs during production. This technology has a great potential in research, development and production.

The water distribution in food

Food contains water, which can be chemically bound or occur in the free state. The amount of water can vary from one point to another, for example from the dry crust of a loaf of bread to the moist crumb. By indicating for each point the proportion of water present, a water content distribution profile can be defined, which is closely related to quality properties such as juicyness and crispness. If these proportions are integrated over the whole surface of the cut, the total water content can be determined.

Heating of food leads to water diffusion phenomena resulting in a change of the water content distribution and, in most cases, of the total water content. The water content distribution and the associated transport processes, together with the temperature increase, influence the chemical and physical processes that determine the microbiological and sensory properties of the product. It is obvious that the measurement and prediction of the heat induced water transport in foods is of great interest, with regard to the development of new products as well as to process control improvements.

The measuring system

The water content is measured with a near infrared (NIR) spectrophotometer working with diffuse reflectance at wavelengths between 0.75 and 2.6 μm and generating monochromatic radiation with interferential filters. The basic components of the system are (Fig. 1):

- A halogen lamp emitting light with a temperature of 3000 °K
- Two interferential filters mounted on a rotating wheel
- A geometric optic for focusing and directing the radiation

- An optical fiber sensor with a sending and a receiving fiber

- A detector

In this application the filters generate radiation with wavelengths of 1.45 μm (water peak) and 1.68 μm (reference). The 1.45 μm is a rather weak absorption band for measuring the water content, but appropriate for product with a water content of 30 to 50%. We are now working on a device that will cover a wider range, from a few percent to 90-95%.

The sensor

This is the main subject of our development. Contrary to commercially available instruments, this sensor has a diameter of only 3 mm and can be used to measure the local moisture content.

The basic features of the sensor are shown in Fig. 2. A microlens with 2 mm diameter is fixed in a ceramic tube and attached to the fibre pair. The sensing volume of the sensor depends on the sample texture. The penetration depth can range from a few tenths of one mm up to several mm. The diameter of the cylindrical sensing volume is about the same as the lens diameter, i.e. 2 mm.

All parts of the sensor are made of dielectric materials, quartz, teflon and ceramics, and therefore, the sensor can be used in microwave ovens. When used in conventional ovens, the maximum operating temperature is 250-300°C for the fibre and about 150-175° for the microlens mounting, which should be placed inside the sample. As long as there is some free water in the sample, the temperature does not exceed 100°C.

Applications

A typical example for using this measuring system is the development of bakery products, where the control of water content and water transport is of great importance.

Fig. 3 shows the changes of the water content at the center of a bread cylinder during reheating. The fiber was placed together with thermocouples to measure simultaneously the temperature. The trial was carried out at 105°C. It can be concluded that the water transport is a crucial factor for optimizing the reheating process.

Other examples of process developments for which the measurement of water content changes is promising are for example baking, drying, freezing and freeze-drying of bakery products and probably also other products. During baking, for example, the water content near the surface should be low, while in the centre it should be near the initial value or even slightly higher. The water transport should not be faster than starch gelatinization and aroma formation. By controlling the water transport, problems such as overbaking of the crumb and insufficient thickness of the crust can be avoided.

CONCLUSIONS

This technique for measuring the local water content in food, with the possibility to calculate water distribuition and water transport, is unique, and for the time being there are only two instruments, both of them being installed at SIK laboratories. The instrument has been developed jointly by three companies, namely SIK (Göteborg, Sweden), Radians Innova (Göteborg, Sweden) and Infrared Engineering (Maldon, U.K.).

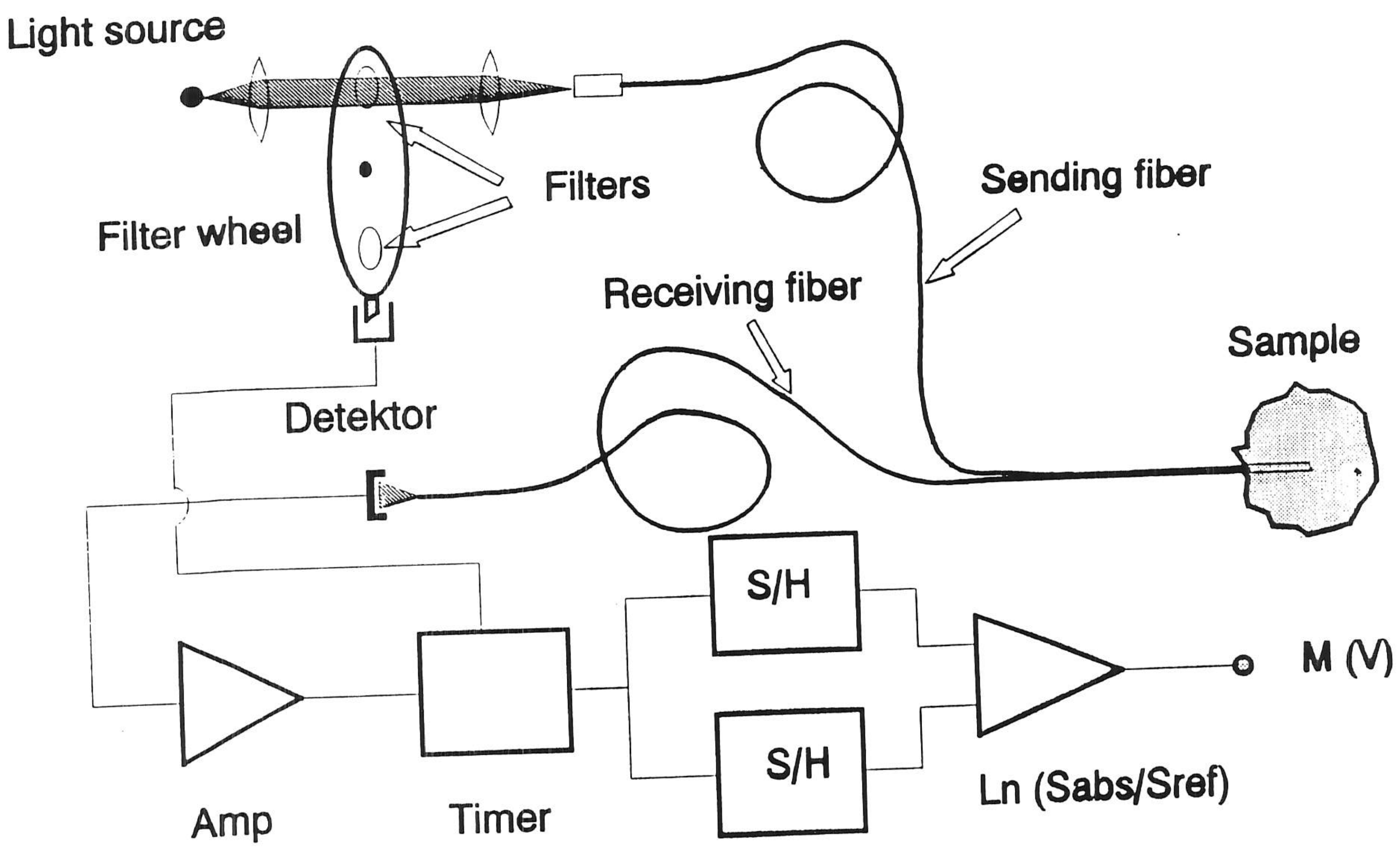
Light source
Filter wheel
Filters
Detektor
Receiving fiber
Sending fiber
Sample
S/H
S/H
Amp
Timer
Ln (Sabs/Sref)
M (V)

Figure 1

Fiber optic probe

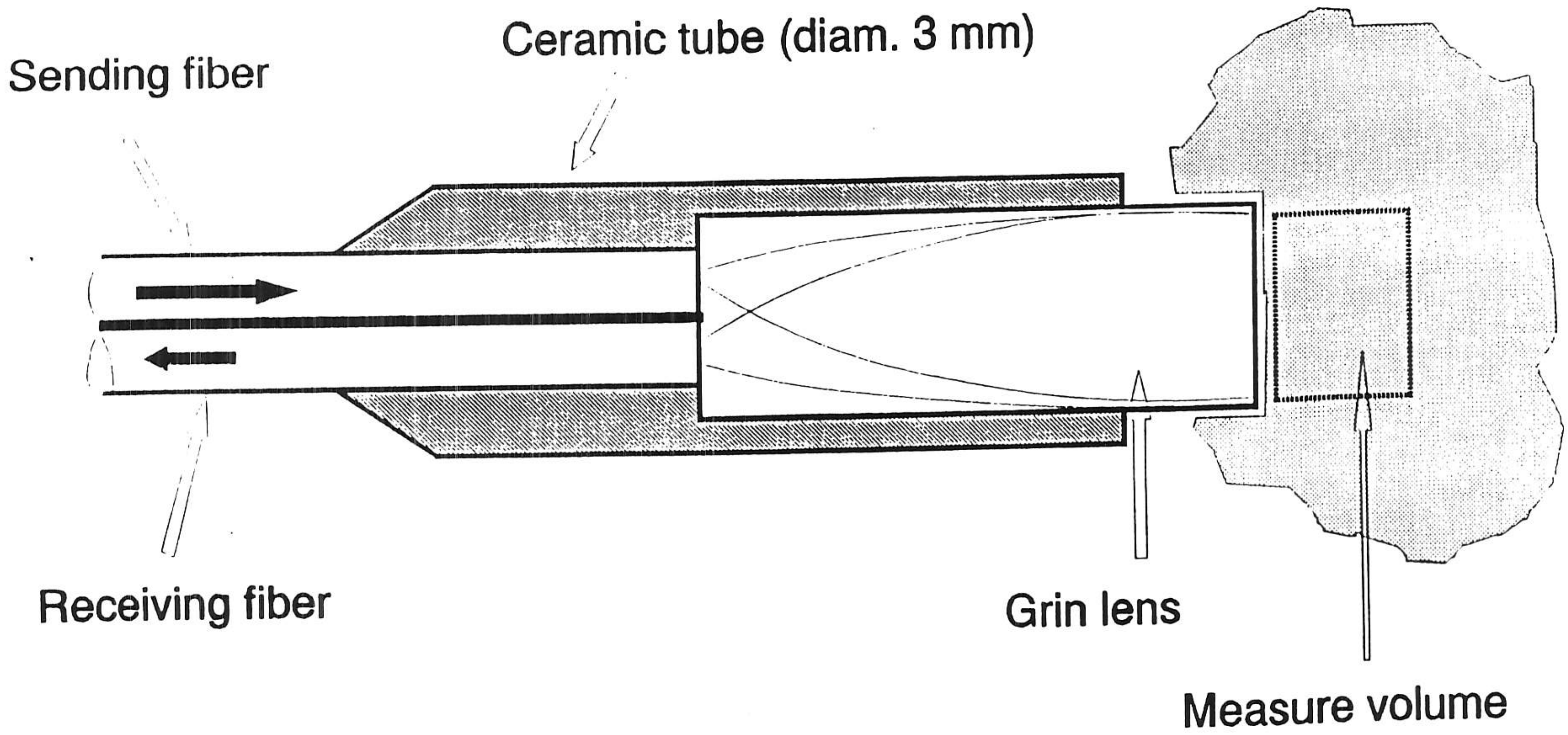

Figure 2

Figure 3

NIR spectroscopy gauge with fiberoptic sensor drying a cylinder of crumb from bread in a oven