

## **X-ray system: Density measurement of Cheese using X-rays**

**Purpose:** An automatic system to control correct weight of cut cheese blocks, based on determination of the mass profile (density profile) of the cheese.'

### **System Description:**

The X-ray system is composed of the following elements:

1. X-ray source  
Long life time X-ray tube (monoblock) 15-70 kVp, 0-6 mA, PLC interfaced
2. Detector  
The detector is a scintillator with a counting module. The detector can make 1 measurement per second.
3. Mechanics  
The X-ray system resides in a cabinet of stainless steel, with two sliding doors. The cheese enter from one side and is positioned on a rotation table. After measurement, the cheese can be extracted from the other side through a similar sliding door.  
The cabinet has the dimensions 600 (width) by 600 (depth) by 1000 (height).
4. Electronics  
The system involves the following hardware:
  - X-ray source controller (PLC based);
  - Counting module (RS232);
  - Servomotor control for rotation table (PLC interfaced);
  - Interlock system;
  - Safety switches;
  - Warning lamp;
  - Power supply units
  - PC with PLC communication/control.
5. System functional mode  
The system functional principle is as follows:
  - a. The cheese is entered to the system. A mark identifies the "0" position (12 o'clock e.g.)
  - b. Prior to measurement of the cheese, a calibration sample is measured;
  - c. The cheese is centered relative to a slit, so that the slit allows the density measurement to be made in a particular section of the cheese, from the center and out to the circumference, at a section width that is pre-determined (e.g. 5 mm)
  - d. The cheese is rotated relative to the slit in steps
  - e. For each step, a measurement is made. The cheese is fixed while the measurement is made.
  - f. When a full rotation is completed, a measurement of the calibration sample is made

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- g. The density measurements for the cheese relative to 12 o'clock (or starting point) is calculated. The weight of the cheese is correlated to the overall density sum. The corresponding weight of each measured section is calculated
- h. The cheese is extracted and a new inserted.

6. System parameters:

- a. Measurement speed: 1 measurement per second. I.e., for a 140 mm Ø cheese measured at 5 mm interval, the inspection takes 1.5 minutes. The slit width may be adjusted to increase speed, or may be a parameter connected to the cheese size.
- b. Accuracy. The accuracy depends on the volume (the volume "within the slit"). We shall expect an accuracy on the order of 2-3 %. To improve it, we must use a more expensive source (see options under item (1) above), or extend the measurement time.
- c. Service. The system must be serviced at 6-monthly intervals. This may be accomplished by remote monitoring (by TCP/IP/Ethernet/Internet)
- d. Duty cycle. The system is designed for 24/7 operation
- e. Environment: 5-25 degrees C, non condensing.
- f. Cleaning. Not to be water jet cleaned.
- g. Warranty: 600 hours on tube, 1 year otherwise
- h. Estimated operation costs per year (spare parts, servicing, excl. travel costs): 4-8 KEURO/yr, over 6 year period

7. Local interfacing of system:

Need definition of available hardware, compressed air, water cooling etc. For example need definition of:

- how the cheese is inserted and extracted
- how data are processed
- handshaking and general control (PLC)
- remote monitoring
- servicing
- load on rotating table (max. cheese weight)
- hygienic requirements
- etc.

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