On-line measurement of the chemical lean content of manufacturing meat

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Introduction

Controlling the fat content of bulk-packed beef is an important part of boning and packing operations. Bulk-packed beef is packed into cartons with a final weight of 27.2 kg. The meat is packed to a specified percentage chemical lean (% CL) and traditional the % Cl of meat cartons has been estimated visually by human operators and checked by core sampling and analysis of the core. Both the visual estimate and the core sampling produce variable results. Staff at one plant described how the estimated % CL value of a carton, using the core sampling method, changed by 7 percentage points by merely repacking the carton. At another plant where cartons were being packed to a target of 85% CL, 600 out of 800 cartons produced that day were downgraded by an automatic measuring instrument as not meeting the specification.

To allow better control of the product before it is placed in the carton, a project was initiated to measure the fat content of the meat before it was packed into a carton. It was decided that the measurement system was to be based on the "NEUGAT" technology already proven in the "Phoebe" fat measurement system developed by the Institute of Geological and Nuclear Sciences Ltd (IGNS). In the 1980s, the fourth author (Dr. Bartle) developed an instrument (Phoebe) for measuring the chemical lean (CL) content of either fresh or frozen cartoned meat and a prototype instrument was tested in a commercial meat processing plant. This paper describes the application of this technology to the task of measuring the CL content of manufacturing beef on-line. The resulting prototype system was designed for plants with a centralised packing area.

The machine's maximum throughput is designed to be 15 tonnes per hour, and all bulk-packed manufacturing meat is passed through it before being cartoned. This will allow the CL content of all manufacturing meat produced by the plant to be measured on-line, and this has the potential to give processors better control of the trimming operation.

The technology is currently being commercialised by an Australian company, and a prototype is expected to be operating in an Australian meat plant this year.

Description of existing NEUGAT measurement system

The simultaneous transmission of neutrons and gamma rays ("NEUGAT" technique) can be used for measuring the percentage, by weight, of fat in boneless meat (Bartle, 1991). In essence, a ^{252}Cf radiation source is used to generate a beam, containing approximately 85% gamma photons and 15% neutron particles, that is projected through a sample of meat, containing lean and fat. The number of detected gamma events is proportional to the thickness of the product in the beam, while the ratio of neutrons to gamma photons gives an indication of the proportion of chemical lean in the product.

Physical layout

The physical layout of the unit is shown in Figure 1. A small source (^{252}Cf) is held at the centre of a radiation shield designed to comply with national standards. Although the source radiates in all directions, the shield absorbs most of the radiation so that only a narrow beam escapes. This beam is directed through the product to the detector.

The detector consists of a vessel containing a scintillation solution. The scintillator converts gamma and neutron events into pulses of light. At each end of the detector, a PhotoMultiplier Tube (PMT) detects the light emitted when energy is absorbed during a collision between a neutron particle or gamma photon and a molecule of scintillator and converts the light pulses to electrical pulses. The electrical pulses from the PMTs are added, amplified and analysed by a pulse-shape discriminator (PSD). The PSD separates the gamma events from the neutron events. Each gamma and neutron pulse is counted, and the number of counts detected in a pre-determined time interval is logged by a personal computer.

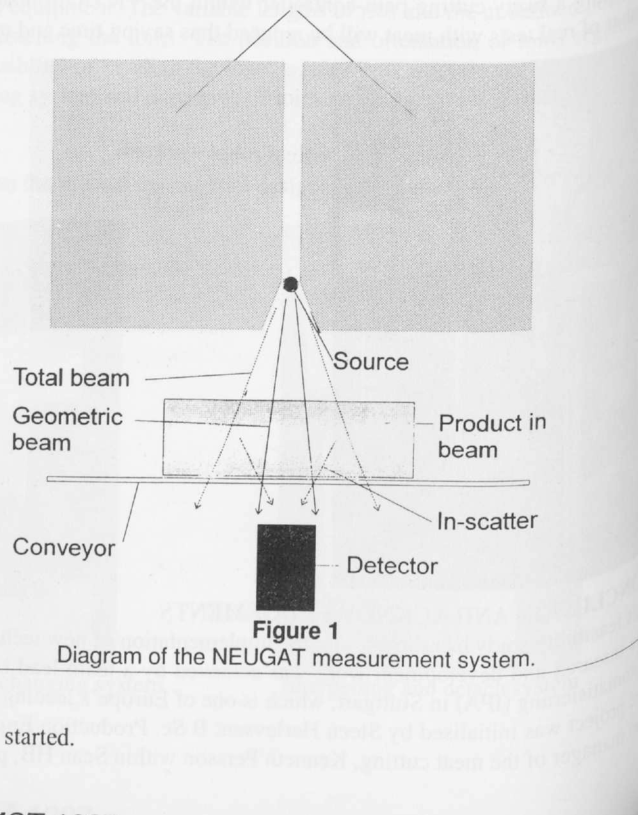

Figure 1
Diagram of the NEUGAT measurement system.

The meat product, whose fat content is to be measured, is transported by a conveyor between the source and detector.

Development Process

The first task was to design a measurement system that could handle a product throughput of approximately 15 tonnes per hour. This placed a number of constraints on the system design, including nucleonics, mechanical, electrical and software. Once the design was complete, the system was constructed by a team of engineers. When completed, commissioning began and the system was tested for safety. Finally the system was made operational and the calibration process was started.

We decided to calibrate the measurement system using frozen blocks of meat manufactured to a specified chemical lean content. Making appropriate blocks turned out to be more difficult than we had first envisaged. We finally made a set of "standard" blocks that were used for system calibration.

The individual blocks were wrapped in plastic, to avoid moisture loss, and frozen. After three months storage, there was no discernable change in weight for any of the calibration blocks. When each block was manufactured (before it was frozen) six samples were taken and analysed in triplicate. Table 1 shows the results of the chemical analyses for each block.

Table 1
Percentage chemical lean content of seven reference blocks.

Average % CL	Standard deviation
51.65	0.81
60.28	1.31
70.42	0.69
79.74	0.97
82.34	0.59
89.18	0.42
94.94	0.17

The standard deviation column in Table 1 was calculated from the results of the eighteen chemical analyses done for each block. The laboratory doing these analyses has a stated coefficient of variation of 3% fat, which means that the expected standard deviation for a particular analysis will be 3% of the mean fat value. For example, a sample with an average CL of 70% contains 30% fat. The expected standard deviation for the laboratory analyses of this sample will be 3% of 30%, or 0.9% fat, equating to just over 1% CL.

We wanted to calibrate the instrument to better than 1% CL. This was clearly going to be difficult with these errors inherent in the laboratory analysis technique. In the early calibration trials we achieved a Residual Standard Deviation of 1.3% CL. Later, after changes to the system geometry, we lowered this to 1.1% CL.

Once the system was calibrated, we were able to test its operation with meat flowing through it. Tests were conducted at flow rates up to and including 15 tonnes per hour and the results showed excellent agreement with % CL measurement of samples from the stream.

This instrument provides meat processing plants with the ability to measure the Chemical Lean content of all their bulk beef before it is packed into cartons. This capability opens up new possibilities for the plant. The ability to measure this variable early in the process, as opposed to once the meat has been packed into cartons, allows the measurement to be fed back to the boning room, for example. With appropriate data presentation, the boning room staff could be given an immediate visual feedback of the % CL of the product they were producing. As an example, in a situation where boning room staff were producing boneless meat to a specification of, say, 80% CL, if both the target and actual value were displayed in the boning room, staff could alter their trimming as required based on the difference between the current measured value and the target value.

Another possibility is for the instrument to be used as a measurement element in a blending or sorting operation. Many plants manufacture meat for forming hamburger patties whose % CL is specified to remain within certain limits. Measuring the % CL of all the meat processed by this type of plant is not currently possible. This technology will allow this to occur and with suitable software, allow the blending process to be optimised closer to the specification limit.

Conclusions

We have described the design and development of a prototype novel instrument for continuously measuring the chemical lean content of a stream of manufacturing beef on-line. The instrument is based on the NEUGAT technology and a prototype instrument for boxed beef was developed by the fourth author. The novel instrument has been constructed and tested and a commercial prototype is now being developed in Australia and is expected to be installed in a meat processing plant before the end of the year.

Acknowledgements

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References

Bartle, C.M. (1991) Simultaneous transmission of neutrons and gamma rays (NEUGAT) to measure fat in meat. *Appl. Radiat. Isot.* **42**, 1115.