Simplify Quality Control with Electronic Nose

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Quality expectations of typical consumers have increased as result of more choices in the marketplace along with targeted advertising, which emphasises product quality. Competition for market share and the added emphasis on quality have increased pressure on product development and QA/QC to meet consumer expectations. Organoleptic characteristics of in-coming materials and finished products are essential to the food, beverage and packaging industry to assess product integrity and to meet the customer acceptance.

Consumer panels and expert sensory panels are widely used for product development, product optimisation and product matching in the food and beverage industry. Therefore it naturally follows that QC/QA managers have implemented a trained human panel to monitor production quality. Unlike the product development phase, the production environment is not really compatible with such expert and train panels. The pressure of normal production, a hostile environment with different odours among some of the factors that make sensory analyses very difficult.

The implementation of a factory human panel is far from easy and it requires permanent re-training to maintain reliable and established sensory control. These requirements therefore make this method of quality control difficult to implement and maintain in terms of routine operations and costs. A failure of this QC process can be very costly for every company. Thus there is a clear need to simplify Factory Quality Control to monitor product quality consistency and to get a fast, accurate and cost-effective technique as well as an additional insurance against product recalls.

Nowadays, odour control and aroma evaluation can be performed by gas sensor array system so-called electronic nose. They have been extensively used by major food, cosmetic and packaging companies in various applications such as quality control, product matching, origin identification, spoilage detection, flavour quantification [1, 2, 3, 4, 5]. The instrument analyses, without any separation the fingerprint of a complex volatile compound mixture by an array of semi-specific sensors coupled to a pattern recognition system. Just as humans do, electronic nose operates by recognising the overall pattern of components. Besides, the "odour/aroma fingerprints" could then be stored in a data base in analogy to human olfaction perception memorised in the brain.

ALPHA M.O.S. has focussed its efforts to address the needs of a reliable factory quality control system to monitor the batch quality variability. The ALPHA MOS αGEMINI system has been developed specifically for this purpose. The odour/aroma test performed with αGEMINI is completed within few minutes and provides immediate and objective results. The improvement of raw material selection and the better control of quality variability can help plants to manufacture more consistently and even to possibly manage operations more effectively.

Fig.1: αGemini system equipped with a 64-position autosampler located in QC laboratory

Fig. 2: Statistical Quality Control chart showing the initial training step of the quality variability followed by the analysis of unknown batches

Description of the αGEMINI system

The system consists of a gas sensor array, headspace sampler, a Windows-based computer and the αGEMINI software package (Fig. 1). A method library is provided with the software for the raw materials and finished products found in the food, cosmetic and packaging industries to quickly set-up the various operating parameters (sample incubation time and temperature, sample size, injection rate and volume). These conditions are optimised for each product, so that a factory operator can easily create an analysis sequence without any method development.

To analyse a sample, the operator introduces a certain amount (e.g. 1 g) of the product into a 10-ml or 20-ml vial which is then capped and placed into the autosampler tray. According to the selected product method, the sample headspace is generated into the 6-position oven and a determined volume (e.g. 1 ml) of the gas phase (containing the volatile compounds) is injected into the sensor chamber. Since each sensor allows to detect differently a wide range of chemical class of volatile compounds (aldehydes, ethers, ketones ...), the sensor array provides meaningful data and creates a specific fingerprint for each product. The normal acquisition time is 2 minutes, and the maximum of each sensor response is recorded. The return of the sensor baseline is fast allowing to shorten the runtime down to 5 minutes and to offer a high sample throughput.

Quality monitoring with αGEMINI

The αGEMINI is operational to monitor product quality after a short initial training that required only 1 hour. Indeed, a teaching sample set selected by a proved technique (e.g. human panel or chromatography) is analysed to estimate the product variability at first. Statistical treatment of the sensor response is performed in order to calculate an average and a standard deviation. A statistical quality control (SQC) chart is then displayed to clearly represent the difference between the training sample set and an unknown sample (Fig. 2). On the chart, the maximum quality variability (so-called warning limit) is also computed to fix the limits of the acceptability domain.

Following this initial training, unknown samples are analysed and the result are shown on the SQC chart. If a unknown sample is projected below the limit, the sample will be recognised as similar as the reference product. If not, the sample will be projected above the limit and the sample will be recognised as out of specification. The maximum quality variability defined during the initial training are stored in the system. No re-training is necessary on routine basis since a quick calibration procedure is performed before a new analysis sequence.

The αGEMINI throughput reaches a runtime of 5 minutes between 2 products- this feature is an aspect of considerable importance in food ingredients and fragrance industries when several dozen of different type of raw materials and finished products are controlled every day. Unlike sensory panelists, the αGEMINI is always available and it can perform under a production environment without special conditions.

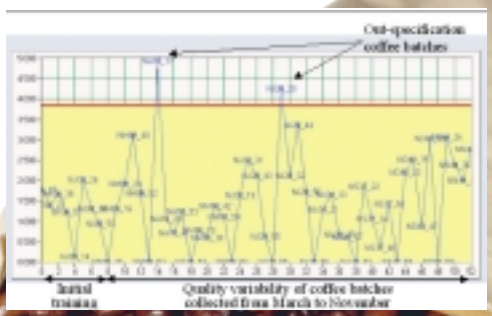

Fig. 3: Quality monitoring of coffee manufactured over 7 months using the αGEMINI

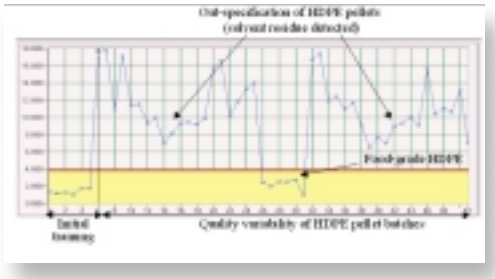

Fig. 4: Assessment of HDPE pellet quality by detecting residual organic compounds after the drying process step

Industrial application examples

The αGEMINI system can offer simple and reliable solutions in many industrial fields where odor/aroma and VOC QC methods need to be implemented or simplified.

Coffee Application

The αGEMINI system has been used to monitor the coffee quality over several months of manufacturing. Following an initial training phase using 10 batches of samples that were selected by expert sensory panellists to be representative of typical acceptable manufacturing variations, the system was used to evaluate 7 months of coffee production. The initial training phase took an hour. Following this, the αGEMINI system was fully operational.

The 7 months of production were then evaluated and the results were plotted on the αGEMINI SQC chart. Fig. 3 shows both initial training sample set results and typical production samples. 2 batches were detected to be out of specifications in comparison to the defined acceptable variation. The typical operator would have had an alarm indicating out of specifications. The setting using SPC chart is an advance function designed for the production engineer to provide important historical data on the manufactured product. The SPC data allows a realistic production variation to be set taking into account intrinsic manufacturing tolerances and also important key characteristics preferred by consumers and customers.

Packaging application

Another typical example of the use of the αGEMINI is the packaging industry using HDPE pellets. These materials are used for water pipeline manufacturing where no or very low residual organic compounds must be present in the HDPE pellets. The quality control of these materials are usually difficult because only a few HDPE pellet batches have residual organic compounds. Further, the production environment is not compatible with the requirements of the sensory panellist. The αGEMINI was trained with several HDPE batches selected as food-grade quality by an expert human panel. After the 1-hour training phase on the instrument, new batches have been analysed to rapidly assess the HDPE pellet quality. See Fig. 4 for the SPC chart of results. As expected only a small percentage of the manufactured HDPE pellets reached the food quality level for the water pipe manufacturing. The results obtained with the αGEMINI reduced the workload of the sensory panellists, increased automation and objectivity and also performed the work 4 times faster than the QC sensory panel [5].

Conclusion

The αGEMINI system is an ideal tool for simplifying odor/aroma and VOC control in factory environment. A simple alarm for the out of specification samples are provided to factory operators who do not want any interpretation and the more advanced feature of SPC chart allows feedback to the production engineer for improvement in productivity and quality that makes both economic sense and also impacts consumer and customer satisfaction. The implementation of the αGEMINI is very fast, automated and only requires minimum operator intervention. It represents a cost effective investment that is compatible to the manufacturing plant environment.

Literature

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