NEW TECHNOLOGY FOR ONLINE **SEAL INTEGRITY** ASSESSMENT

Automatic detection and rejection of sealing imperfections, seal contamination, packaging integrity and package content conformity

InnospeXion
the invisible made visible

THE **SEAL INTEGRITY** PROBLEM

Modern food packaging aims at user friendly packaging that is easy to open, that safeguards the product during transport and display, while securing the product from contamination towards the exterior. Most products are packaged in an inert atmosphere, and hence the packaging integrity is important for the shelf life and the consumer safety. The latter is especially relevant for food packages aimed at babies, toddlers, and even pets. Toxicity of the food can arise due to leaking seals, causing air ingress to the product with consequential deterioration and toxic development in the product.

The solution towards the detection of leaking seals is typically the application of “sniffing” technologies, based on sensors that can detect the inert gas that may escape from a leaking seal. Unfortunately, these technologies are off-line and the inspection is carried out on a bulk portion of packaged products placed in a chamber which is vacuum evacuated. Hence, the assessment is slow and the technology only detects leakers, not faulty packaging which is just closed, but may leak upon transport and handling.

From a production point, the current ability to detect faulty packaging very late in the production cycle is unsatisfactory. It is requested, that the detection can take place immediately after sealing at best. A late detection of faulty production causes losses due to non-recoverable products, packaging and efforts, as well as costs of waste handling and dumping.

On-line technologies such as vision systems have a large number of disadvantages that prevent these from providing a general solution.

There is thus a large demand for a novel on-line approach that can improve user safety, improve production efficiency, lower production costs, and improve quality.

Faulty packaging is a big concern for food manufacturers, and until now there has not been any technology reliable enough to eliminate the problem altogether.

X-RAY TECHNOLOGY

The use of X-rays is widespread in the food manufacturing industry. It is imposed as a demand from the large food retailers, convenience food companies, and supermarkets, in order to ascertain that food product remains uncontaminated by foreign objects such as steel parts and pieces, stones, glass and large bones. This on-line inspection at the food producers is accomplished using traditional X-ray systems which are optimal for the detection of these contaminants, even at high speed and with a high probability of detection. The technology used is basically the same for all X-ray system providers, however the system design, hygienic details, and software for detection and quantification may differ. This X-ray technology is thus based on using an X-ray spectrum relevant for contaminants detection, and the technology is similar to X-ray systems in medical use and for security applications.
The fundamental principle of traditional X-ray inspection is the different attenuation of the X-rays based on the composition and thickness (or density) of the object inspected. Steel, glass, large bones, stones and other similar substances have an abundance of elements which are heavy, such as Iron, Calcium, silicates, etc.

When such substances are present in a product that basically contains low atomic number elements (organic material, water), they will provide a significant contrast in the X-ray image. By digital image analysis methods, it is typically relatively easy to detect the presence of such foreign objects automatically.

However, traditional X-ray systems cannot be used to detect seal imperfections, such as leaking seal due to product contamination of the seal, or due to other errors such as folds, wrinkles, misaligned foils, and others. The reason is that very small thickness or density variations involving plastics, water, and organic materials, is invisible in a traditional X-ray image. There is simply no contrast.

LOW ENERGY X-RAY TECHNOLOGY

The parameter controlling the contrast in X-ray imaging is the X-ray energy, the power of the X-ray source as described by the kilo voltage (kV) used for the imaging. New detection technology combined with new X-ray source technology, has facilitated that X-ray systems can be used at much lower energies than traditional X-ray systems used for foreign object detection.

The usage of X-rays with an energy between 15 and 20 kV in on-line applications thus facilitates imaging of very small composition, density and/or thickness differences, down to the nano-scale.

This is the fundamental basis for making it possible to inspect and detect in real-time seal imperfections and leakers in food packaging, pharmaceutical production, and general process and quality control. Deviations in the seal thickness down to fractions of a micron can thus be detected and the object rejected, at production speed up to 180 units per minute.

THE **FIRST USE** OF THE TECHNOLOGY

Low energy X-ray inspection was initially applied for cork quality inspection. Quickly, it became apparent that packaging integrity assessment is a major application area, with numerous obvious cost-benefits. Interestingly, the first applications for the packaging integrity were aimed at pet food packaging. This is an area where the risk of leakers is high and where the consequence of improper closed packages can be fatal for the pet. Other obvious first applications areas were with baby and toddlers ready meal products. Again this is an area where the food safety is severely compromised by a faulty packaging, particularly if the product is not boiled before serving.

Fast and reliable real-time assessment is among other things what sets the low energy X-ray technology apart from conventional technologies.

ONLINE APPLICATIONS

Cod roe is a well known, healthy and tasty product which, among others, has been the basis of the success of Bornholms A/S, a large manufacturer of Cod roe, and other canned seafood products and ready meals. In 2011, Bornholms A/S took the decision to upgrade the entire production with the newest filling and packaging technology. One consequence was a shift from traditional canning to sealed plastic cans. The risk assessment however unveiled that the long shelf life, the high product quality and the long distance transporting of products could be compromised if the seal inspection was not performed continuously, on-line.

Consequentially, Bornholms A/S performed a large number of tests and verifications with the InnospeXion technology, leading to the installation of a dual lane system in 2013. This system runs one product (Cod roe) constantly in line 1 at 150 cans per minute, and other products of different formats and dimensions on line 2.

EXPERIENCES FROM ONLINE APPLICATIONS

At Bornholms A/S, the consumer safety has the overall focus, and health and safety procedures are required to be functional for the production to run. Therefore, the low energy X-ray system has gained a very central place, as it safeguards the production chain.

A re-structuring of an entire production chain, which has been based on many traditions and procedures, is not trivial. The line operation relative to the X-ray system thus required a number of adjustments, as well as significant training and instruction of operators and service personnel, including for cleaning and maintenance. Non-intented errors and mistakes appeared in various aspects of the line control, causing wrong in-feeding, wrong timing, contamination of the X-ray system by product spillage, and many others. X-ray system design changes were required in order to match the characteristics of the new production chain, and multiple acceptance tests and trials were required for each product. High false reject rates had to be correlated to manufacturing irregularities, to deviating tolerances of packaging materials and to other causes.

Eventually, after about a year, the complete line including the X-ray based on-line seal inspection, was running, and all procedures implemented within the production. The X-ray system has proven capable of detecting leaks, which appear to happen in less than 1 out of 100 to 200 cans. The leaks detected are typically not open leaks but leaks where product has contaminated the seal to a smaller or larger degree, resulting in a potentially reduced shelf life time, and hence correct rejection. Additionally, the system safely detects other seal imperfections, especially deviating tolerances which requires contingency corrective actions by the line personnel, once the X-ray system gives signal. False rejects are typically below 1%, however subject to variations in the canning in-feed and other dependent parameters. Classification of rejects in different categories helps the reject handling so that reject pile up is minimized.

The low energy X-ray system is designed to fit into the existing production line

Although the packaging area is typically considered a “dry” environment, the low energy technology has proven successful also in wet areas, such as fish and chicken fillet lines. Based on experiences from the areas, the design has included the focus on cleaning, maintenance and hygiene. For example, lead curtains are not necessary in most applications, and cleaning with water is possible. Outer surfaces are self drainable and low surface roughness helps maintaining cleanliness. Systems are air tight, so build up of lethal bacteria (listeria, e.g.) is unlikely.

THE VALUE GENERATED BY THE **LOW ENERGY X-RAY** TECHNOLOGY

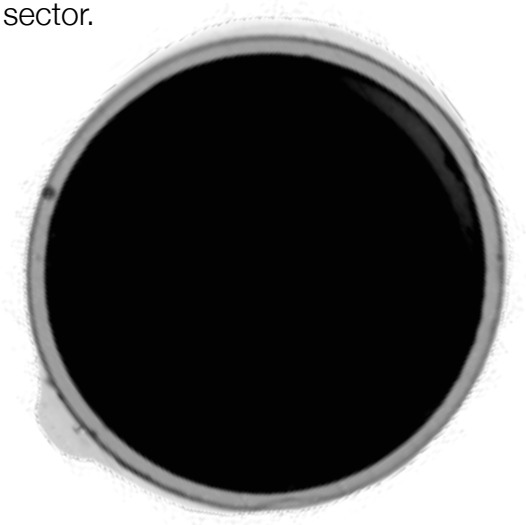
The InnospeXion packaging integrity assessment system is based on the newest and most effective X-ray technology, providing high contrast and high resolution X-ray images. These high quality X-ray images is a necessity for the automatic identification and detection of seal defects and packaging irregularities, on-line, of pouch, blister and plastic canned products.

Apart from the Bornholms A/S application, the unique technology has been proven in numerous applications during many years, e.g. for fish bone detection in the fish processing industry. Since 2008, the technology has been used for on-line packaging integrity assessment in the food sector.

The ***value creation*** relates specifically to:

- Instantaneous signal-giving upon detecting deviations of conformity of the packaging integrity
- Avoiding production of defective packages
- Eliminating call-backs
- Avoiding leaking products during transport
- Extending product shelf life
- Safe-guarding the consumer safety.

The system is not (only) designed for simple “go - no go” inspection, but is an advanced automatic multi-functional system that through advanced software functionality can accomplish a large variety of measurement and inspection tasks relevant to the product. Through a central PLC control of the system, all results can be made available through a number of registers that easily are interfaced to other production equipment along the production line. Hence, the automation and ready notification of deviations is central for validation of the system pay-back horizon.



The high contrast and high resolution clearly depicts every detail of the inspected product, and instantaneously detects possible leaks, folds or other flaws in the package.

TYPICAL DETECTION AND **QUANTIFICATION CAPABILITIES**

The low energy X-ray systems contribute to the much improved line control through the ability to unveil and quantify important variations of the packaging, including but not limited to ensuring that:

- The plastic can is of correct dimensions (+/- 0.2 mm)
- The plastic can thickness and density conforms to the acceptance criteria
- The plastic can is undamaged
- The aluminum or plastic foil is correctly placed within the acceptance seal zone
- The aluminum or plastic foil is free of wrinkles and folds
- There is no product in the seal zone
- There is no product outside the seal zone
- There is no contamination of the product
- The right amount of product is filled into the plastic can
- The distribution of product within the can is homogeneous
- The density of product corresponds to acceptance criteria
- The homogeneity of product meets acceptance criteria

Importantly, the system can be used for plastic cans, pouches, and other packaging for convenience food where the seal can be inspected without overlap by the product. Additionally, for packages involving a total product thickness below approximately 30 mm, also foreign objects in the product may be detected.

CONCLUSION ON THE **LOW ENERGY** X-RAY

The low energy X-ray technology systems differ significantly from other X-ray systems by using longer wavelength X-rays which are preferentially attenuated by small thickness/density or compositional differences. Therefore, the use of low X-ray energy implies a significantly improved detection capability, and a much better discrimination between thin and/or light element objects. Traditional X-ray systems generally are unable to image objects below 25 kV, owing to the poor sensitivity of the detector used to acquire the images. Using low energy X-rays, thickness differences down to a few micrometers can be discerned and quantified, even for low density materials such as plastics.

The use of low X-ray energy also means much reduced radiation health issues. This is manifested by the systems being sufficiently shielded by 2-3 mm stainless steel only, in place of hazardous lead.

Due to the very high sensitivity, the inspection can be accomplished at line speeds up to 120 m/min. However, in general, and especially with seal inspection, 30 m/min is the limit. This typically translates to 2 to 3 units per second, per X-ray system. At this speed, the technology has significant potential for the automatical detection and reject signalling of seal imperfections of nanometer thickness, with surface area down to less than 2 x 2 mm, as well as other packaging imperfections, can imperfections and foreign object contamination of the product.

The assessment of the product is carried out in real-time, making it the most cost-effective inspection solution available.

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