Reducing product effect through advanced metal detection technology

Foods that have a high moisture content, or are packaged in a metalised film for example, can produce what is known as ‘product effect’, a phenomenon that can cause unwanted false readings when using metal detection as a means of contaminant detection. This can lead to a higher wastage level due to false rejects, particularly in products that are challenging to inspect – such as meat, poultry, seafood and dairy – all of which increases costs.

In order to understand the fundamentals of product effect, it is important to also understand how a metal detector works. This knowledge will make it clearer as to how and why product effect occurs and why it needs to be overcome in food production facilities.

**Metal detection**

Metal detectors consist of three sets of copper coils, made up of wire wound around a coil former, that are said to be ‘balanced’. In the centre you have the transmit coil and on either side of that the receive coils, which are wound in opposite directions to each other with one end of each coil connected. Products are passed through the coil former to be inspected, which is more commonly known as the metal detector aperture.

A high frequency signal is transmitted to the centre coil, which generates a magnetic field in the aperture. This field in turn induces a small voltage into each of the receive coils, which will have reversed polarities due to them being wound in opposite directions. The control electronics of the detector measures the difference between the voltages which, if correctly balanced, should be zero volts.

When a metal object passes through the aperture it will disturb the magnetic fields of both receive coils by slightly differing amounts. This is then detected through a change in the balance condition and interpreted as a metal contaminant. Metal exposed to such an alternating magnetic field will create an eddy current – a small amount of current induced into the metal due to its ability to conduct electricity (conductivity) – which alters the total magnetic field and leads to a further difference in voltage induced into the receive coils. These differences in the voltages is what triggers a detection event.

A material’s ability to be magnetised is referred to as permeability. High permeability metals, for example, allow the magnetic field from the transmit coil and the eddy currents to pass through it more easily than free air. Different metals alter the magnetic field in the aperture by different amounts, making some metals easier to detect than others.

**What is product effect?**

It is not just metal that has the ability to generate magnetic fields and to conduct electricity. Common food items can also do this, albeit to a lesser extent than metal itself. Saline rich products have the ability to conduct electricity and can form eddy currents if subjected to magnetic fields – leading to the product forming a magnetic field of its own. Although saline has low permeability, if the product is large enough, it would still create a magnetic field of sufficient size to affect the metal detector in the same way as a metal contaminant. Instances where a product is able to affect the metal detector in the same way as a metal contaminant are referred to as product effect.

Products with high moisture content are often referred to as ‘wet’ products – items such as fish, poultry and fresh meat for example. These items are reasonably good conductors and are more likely to produce a signal within the metal detector that is similar to that of a metal contaminant. This makes distinguishing product from contaminant far more difficult. Moisture and salt content can of course change from pack to pack, animal to animal. Different cuts of beef, for example, could have different levels of both elements, making things more complicated still.

‘Dry’ products, by contrast, are less likely to cause significant change in the magnetic field of the metal detector. Items such as flour, for example, will not have a significant impact on the balance state of a metal detector due to its low conductivity and permeability.

However, there are some wet products that exhibit product effect but when in a frozen state produce nearly no product effect, so it is important to work closely with an expert in order to ensure your metal detector is correctly configured for these products.

**Factors that influence product effect**

There are many factors that affect the characteristics of a product, and these variations are difficult to control on a production line. To compensate for such variations, metal detector sensitivity is often reduced, so that the majority of products can pass through the detector without false triggering – however, this means that overall detector sensitivity is reduced.

Reducing the sensitivity of the metal detector increases the risk of smaller metal contaminants going undetected in a product.

There have been a number of product recalls due to this very issue over the years, which can have quite catastrophic effects on brand reputation, not to mention the associated costs of withdrawing a product from the retail supply chain.

As well as moisture and salt content affecting the performance of a metal detector, temperature of the product being inspected has a major impact on its ability to affect the magnetic field in the detector.

Changing the product temperature alters the product’s conductivity, thus altering the formation of eddy currents and the resultant magnetic field. A frozen product may present like a dry product to begin with due to the frozen water affecting its conductivity. As it begins to thaw, however, condensation can form on the outside of the product which changes its influence on the magnetic field. Relatively small temperature changes have the ability to change the signal in a metal detector due to the change in the characteristics of the voltage induced into the receive coils.

The size and shape of a product can also influence its detectable

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product signal. Typical packaged products have a uniform shape that gives a consistent product signal, which is easily interpreted by the detector.

Other products, such as whole chickens, vary significantly in size, shape and weight. In general, a bigger chicken will give a bigger product signal than a smaller chicken.

Orientation of such products also has a similar impact on the product signal. How the product passes through the detector aperture can make it appear smaller in one orientation (sideways) compared to another orientation (head first).

Controlling the orientation of a product in production can present a challenge and increase the variation in the product signal dramatically.

The consistency and density in a product being inspected is one of the biggest challenges when inspecting products such as, for example, ready meals.

A tray with mashed potatoes, sausages and gravy has a product signal, which varies significantly, with variations in both the quantity and ratio of the ingredients (or bone content in meats).

In the main, packaging materials used in the food industry do not impact on a metal detector's sensitivity. However, a metallised film packed product can impact on metal detection capabilities, as the relatively high conductivity of the thin layer of aluminium film allows for the formation of eddy currents that generate a large enough magnetic field detectable by the metal detector.

In such cases, historically, it was recommended that products be inspected before they are packaged into metallised film.

However due to the development of multi-simultaneous-frequency metal detectors on the market that are very good at inspecting metallised film packaged products that also deliver excellent levels of sensitivity inspecting the wrapped product is now seen as the accepted norm.

Detection sensitivity

Modern metal detectors available on the market today, such as the Profile Advantage from Mettler-Toledo Safeline, have been specifically designed to increase detection sensitivity dramatically for products that are difficult to inspect as we have outlined above.

Metal detectors operating at the most sensitive levels utilise a technology called Multi-Simultaneous-Frequency (MSF) – quite simply, they use more than one frequency at the same time.

MSF enabled systems use a combination of high and low frequencies, coupled with built-in Product Signal Suppression technology with two stages of discrimination, frequency and phase.

The effect of this is to cancel the information from the combinations of high and low frequencies to remove the product signal. This allows for much smaller contaminants to be detected.

MSF is also able to deal with product variations in a very effective manner. The electronics adjust for variations in product effect for each product inspected, applying the product signal suppression technology to give an increased performance over traditional single frequency detectors of up to 50% – both product effect or metallised film applications.

Benefits and compliance

In addition to increased contaminant detection, it is also important to consider the efficiency of your metal detector with regard to productivity. If we take the Profile Advantage as an example, an onboard condition monitoring system has been developed to support preventative maintenance.

The Profile advantage monitors its own performance and functionality and if a change is detected an alarm is triggered to alert the relevant operator.

The innovation element is that the alarm is able to sound in advance of a failure developing within the system, enabling maintenance engineers to rectify the problem quickly and avoiding costly and unnecessary downtime.

On board OEE reporting makes reporting on availability, reliability and quality easy, allowing the system to be scrutinised as the system data can be reviewed remotely as part of overall production line performance.

Such detectors can be supplied with a Fieldbus Integration Module (FIM) to allow connection to a range of industry standard protocols (EtherNet/IP, Profinet IO or Modbus TCP) enabled devices such as PLCs and Manufacturing Execution System (MES). Profile Advantage for example also supports OPC DA integration.

To aid HACCP compliance, the Profile Advantage metal detector is equipped with on-screen HACCP reporting. Login processes can be monitored through a Metal Detector Access Log, which gives details of all logins to the controls of the metal detector, the name of the operator and the time and date of all change occurrences.

For increased access security, a high level access software routine is also provided which complies with FDA 21 CFR Part 11. Access to the controls of the metal detector is protected by a dual level username and password login.

The ability to inspect products with a higher level of confidence that the smallest amount of metal contaminant can be detected and removed from the production line leads to significant uptime benefits, as does the ease of use operators experience with this metal detection technology.

Combining these advances with Mettler-Toledo’s commitment to work in partnership with its customers will not only ensure that productivity is as streamlined as it can be – it will also ensure that all possible measures have been taken to combat product effect and to ensure the products you send into the retail supply chain are as safe as they can be in terms of metallic contamination.

Fig. 1. Factors that contribute to product effect.