3 RISKS TO MAGNET EFFECTIVENESS FOOD PROCESSORS CANNOT IGNORE

By John Ormerod

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A third-party auditor just showed up at your food processing facility. How confident are you in the performance of your magnetic separation equipment? Are the magnets at your critical control points still performing at full strength and how would you know? While magnets generally have a long and effective life, certain food products and processes can permanently damage them, resulting in loss of strength. If your operation has any of **the three process-related risk factors for magnets**, learn how to reduce your compliance and safety risks, as well as protect your equipment from damage.

WHAT MAKES MAGNETS VULNERABLE?

While it's commonly known that modern permanent magnet materials can lose effectiveness when exposed to elevated temperatures and extreme external demagnetizing fields, what is not as well-known are the risks caused by certain types of products or processes.

Your magnets can be at risk if:

- **You process acidic products.**
  Acidic products can deteriorate the structure, or the housing, around a magnet. Once the housing is breached, the magnet is directly exposed to the acidic products, causing corrosion and rendering the magnet ineffective.

- **Your process requires a caustic cleaning solution.**
  If your process requires a caustic cleaning solution, be aware it may impact the metal contact point. That wears down the housing around the magnet. If this is how you must clean, then be aware of the impact of the cleaning solution on your processing equipment.

- **You process or clean at high temperatures.**
  Processing or cleaning at high temperatures can partially or completely demagnetize magnets. Rare earth magnets, in particular, are vulnerable to extremely high temperatures. Once a magnet becomes ineffective due to a high temperature exposure, the damage is irreversible.

HOW NEW PRODUCTS AND PROCESS CHANGES INTRODUCE RISK

One of the challenges in a food processing plant is making sure your separation equipment matches the applications **over time**. When your separation equipment is originally implemented, the magnets are selected to fit the products and processes **at that time**. Risk occurs when you add a new product or implement a new process. If a new product is highly acidic, or requires a caustic cleaning solution or high temperature processing or cleaning, suddenly your magnets are at risk for damage.

CONSIDERATIONS FOR ACIDS, CAUSTIC CLEANERS, & CORROSION

Even though the magnet is covered in stainless steel, the alloy chemistry at the welds may be a weak point of the enclosure. You may be able to see some wear on the surface of the magnet, perhaps discoloration or actual corrosion when acidic products or caustic cleaners are used. Over time, a very acidic product can wear through the stainless covering and directly contact the magnet, causing corrosion and rendering the magnet useless. Rare earth magnets, particularly those based on NdFeB alloys, are very susceptible to corrosion. When the magnet corrodes, it is ineffective. If this is a risk in your operation, consider using other alloys or stainless steel grades that are appropriate for highly acidic environments or caustic cleaners.

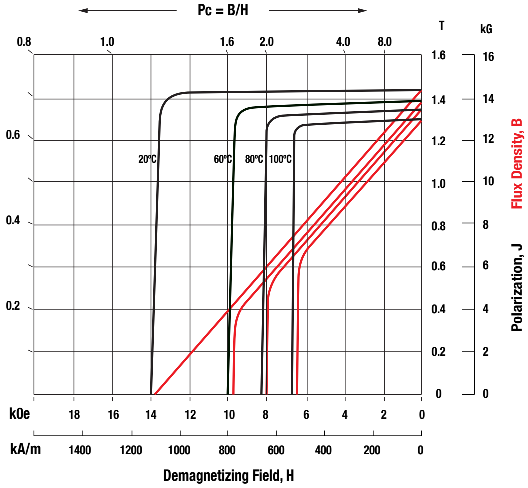
CONSIDERATIONS FOR MAGNETS IN HIGH-TEMPERATURE APPLICATIONS

Let's examine the science behind high-temperature damage. When designing a circuit for permanent magnets, it is essential to consider the temperature range that the magnet(s) will experience during the duty cycle of the application. In addition, details of the load line of the magnet are also required to estimate the magnetic flux loss with temperature. These losses are both reversible and irreversible. Yet, with so much information available and some of it misleading, it is possible to associate the wrong magnetic property with the type of magnetic material you are considering, particularly where thermal stability is concerned. This results in an unpredicted magnetic performance.

All permanent magnet materials experience a change in flux density (i.e., the level of mechanical force on a metallic particle relative to the area around a magnet) as their temperature increases and decreases from an ambient temperature. For example, most magnets, with the exception of ferrite (ceramic), will actually display an increase in resistance to demagnetization as the temperature drops. **All** permanent magnets, including ferrite, will lose a percentage of their performance for every degree of temperature **increase**. If the magnet circuit is properly designed, this lost performance is recovered upon cooling as long as the maximum recommended operating temperature of the magnet material(s) and the temperature the magnet is exposed to are not exceeded.

When extremely high temperature exposure reduces the magnet strength, it is critical to measure the potential impact of the thermal damage after the fact to calculate any reduction in pull strength. Exposure above a certain temperature permanently diminishes the magnet's pull force.

The demagnetization curve below shows a particular magnet grade's (N52M) demagnetization characteristics at different temperatures. The horizontal axis is the measure of the magnet's resistance to demagnetization. (Note the declining level from left to right with increasing temperature.) As you follow the red lines representing demagnetization characteristics at different temperatures, the knee of the demagnetization curve may cross the load line (Pc) of the magnet, resulting in irreversible losses. The higher the temperature, the higher the risk of demagnetization will be for a given load line, resulting in a reduction of the magnet's strength.



HOW IS MAGNET EFFECTIVENESS MEASURED?

Magnet effectiveness is measured by a **pull test**. The test involves physically attaching a test point to the magnet and calculating the pull value with a digital scale. In essence, the test measures the force it takes to break the magnet's bond. The pull test is an industry best practice to evaluate magnet strength and detect changes in magnet strength over time that can indicate damage or loss of effectiveness. Pull tests should be built into a maintenance or quality program to periodically check the magnet effectiveness. Testing every magnet at least once per year is recommended.

A reduction in the holding value of a magnet impacts your OEE (overall equipment effectiveness). For example, equipment that loses 30 percent of its strength compared to the prior year is likely passing 30 percent of the metal that was caught last year. Some processors retain all the ferrous contamination they catch on a magnet as part of their Quality Assurance program. Processors that retain historical contamination can compare the physical samples from a production run or a time span by weight and validate the results of their pull strength testing.

A decline in pull test results is a strong indicator that a magnet is losing effectiveness since magnets generally lose only one percent of their flux density every 100 years — unless there is damage, such as from high heat or corrosion. Therefore, the pull test should be performed each year. A big change in a test result should trigger further investigation by your Quality Assurance or maintenance group.

HOW DOES MAGNET EFFECTIVENESS IMPACT COMPLIANCE AND FOOD SAFETY?

When a magnet's pull force is reduced from damage, less metal is removed from the food in process, meaning you are passing higher levels of metal through the process and on to the consumer. This is a **compliance issue** if the magnet is identified as a critical control point.

Not only is this a compliance and safety issue, but the metal that is not stopped can damage YOUR equipment downstream.

HOW TO ENSURE MAGNET EFFECTIVENESS OVER TIME

1. Be aware of the causes of magnet damage and determine your risk level. Are you processing acidic products, using caustic cleaners, or exposing magnets to high temperatures?

2. Check your documentation. Are pull tests being performed and documented at least annually for each magnet? Are changes in magnet strength being appropriately investigated?

3. Avoid equipment mismatches. Evaluate magnet and housing compatibility with your current products and processes.

Is your equipment compatible with your current products and processes? When your separation equipment was installed years ago, it was likely compatible with your products and processes at that point in time. But, if you have added an acidic product or a caustic cleaner, or if you have added a high-temperature process, you may be in a situation of mismatched equipment.

If cleaning or processing requires a high temperature, remember you will not physically see the temperature damage because the magnet is in a tube. But you can measure the impact of temperature damage using the pull test. If your magnet is exposed to a high-acid product or caustic cleaning agent, consider a different material for the contact parts of the housing and the shell around the magnet.

About The Author

Dr. John Ormerod holds bachelor of science, master of science, and doctoral degrees in metallurgy from the University of Manchester (U.K.). Now exclusively a consultant, Ormerod was the president of Res Manufacturing, a privately held manufacturer of stamped metal components and assemblies and a provider of value-added services. His knowledge also came from over 20 years of industry experience in bonded magnets and permanent magnets, including acting as development engineer and general manager of the Rare Earth Magnets group at Philips Electronics.

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