How to make better soup – with mathematics

Making a good soup is an art, but it is also a science. Tetra Pak has developed new mathematical models and tools for building tubular heat exchangers that will deliver the target temperature for particulate foods such as soups with a precision not previously possible.

A common practice for designers of heat exchangers is to use the same traditional calculation tools for food with particles as for food without. The problem is that the presence of particles changes the flow and heat dynamics significantly in a heat exchanger. New research by Tetra Pak has investigated exactly how particles affect heat transfer.

The research shows that some conventional formulas can result in deviations by as much as 12°C between the calculated outlet temperature and the actual measured temperature of particulate food leaving a heat exchanger. To avoid this, the heat exchanger is typically over-dimensioned.

On the other hand, if the actual temperature is much higher than expected, the particulate food can be partially destroyed with loss of flavour and colour. In terms of investment costs, the heat exchanger may be over-dimensioned for its purpose, and this is a waste of money and space.

The research, which was carried out over more than two years at Tetra Pak's Product Development Centre in Lund, Sweden, involved a group of about ten experts, including an external professor and research associates specializing in heat transfer at the University of Lund. Different kinds of particulate foods were tested, such as mango preparations, soup concentrates, chutneys and carrot slurries.

The findings clearly showed how the heat transfer coefficient varies in the presence of particles. As expected, the particles actually improve mixing in the tubes and therefore increase the overall heat transfer coefficient of the liquid phase.

A tool for optimizing process design

The influence of particles has now been quantified, and Tetra Pak has been able to devise a new heat-transfer coefficient formula for particles, and a new calculation tool for particulate food. The new tool is called PartCalc and has been validated by experimental data. It is now being used to help customers optimize their process design for particulate foods.

Tetra Pak's experiments show that the carrier liquid temperature of a variety of particulate foods leaving a heat exchanger, as calculated by PartCalc, deviates by less than 3°C on average from the actual temperature. This is a considerable improvement on traditional calculations, and gives a good correlation with actual temperatures, thus allowing Tetra Pak to more accurately dimension heat exchanger systems for particulate foods.

The potential benefits to the food processing industry include:

» Improved food quality with assured food safety

» Reduced operating and maintenance costs

» Reduced product losses

» Reduced environmental footprint

"A key factor in process design is to minimize heating without compromising food safety. This demands knowledge about heat transfer in particulate foods," says Helena Arph, Technology Specialist, Viscous and Particulate Foods at Tetra Pak in Lund, Sweden. She has been closely involved in the research work and presented papers on the findings.

Modern separators are of two types: semi-open and closed (or AirTight™). In a closed separator, the bowl is filled with milk and there is no air in the centre. This construction offers a number of performance advantages. Here are five key ways an AirTight™ separator could benefit your business.

Superior skimming efficiency: Air and mechanical treatment are a risky combination. The presence of air can lead to product deterioration and cause damage to fat globules. This makes separation harder and creates a potential risk of free fat. For smooth product acceleration and improved efficiency, an AirTightTM separator is the way to go.

Low energy consumption: AirTightTM separators use up to 50% less energy than their traditional counterparts, because of a combination of gentle product treatment and the use of efficient pumps rather than paring discs. This saves you cost and reduces your environmental impact. In some cases, it is possible to vary the rotational speed of the separator to achieve even higher energy efficiency.

Enhanced flexibility: An AirTightTM separator allows you to produce 60% fat content in cream without compromising skimming efficiency. Tetra Pak's AirTightTM design also enables a wider range of capacities for different recipes to run in the same machine.

No risk of overflow: With an open-type separator, there is always a risk of product overflow in certain conditions. An AirTightTM separator is fully sealed, eliminating this hazard.

Zero added risk of foaming: The absence of air entering the separator eliminates all additional risk of product foaming.

Did you know? Tetra Pak launched its first hermetic separator in 193