Using heat pipes to reduce energy consumption in the production of meat and meat based products

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By

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Introduction

A small project has been carried out to study the potential of the application of heat pipes to save energy and improve the cost effectiveness, of three food-processing operations. The work looked at:

1. The cooling of sauces/fillings for ready meal and product production.
2. Beef carcass chilling.
3. Cooking and cooling of solid pieces of meat.

Cooling of sauces for ready meal production

Initial industrial investigations of sauce cooling revealed that each cooling tunnel consumed approximately 6 kW of energy to maintain its temperature and remove the heat input via the fans used to circulate the air. Calculations showed that if by using heat pipes the cooling time could be reduced by an average of 6 hours per day it would save 36 kWh per tunnel per day. The total saving over the year would be 162,000 kWh (£8100). However, if we only needed one heat pipe per tray at the current heat pipe cost, £100 per pipe, the outlay per tunnel would be £6,400 to £8,000. If all the tunnels were equipped with the minimum number of heat pipes, one per tray, then the payback would be over 10 years on a pure energy saving costing.

Further experimental studies demonstrated that to obtain the required reduction in cooling time far more than one heat pipe per tray would be required and the payback period was likely to be in the region of 40 to 50 years. The cost of food friendly heat pipes would have to be reduced from the current £100 per pipe to <£1 to produce a sensible payback from energy reductions.

In a ready meal production operation, maintaining and increasing throughput to meet changing customer needs is the key to financial success. The potential of heat pipes would be in increasing the flexibility of the operation. This could be achieved by using heat pipes to increase the cooling rate in selected product so that packing operations could commence earlier in the day. However, we feel that food friendly heat pipes would have to be readily available at a unit cost of <£10 before the ready meal industry would seriously consider their use.

Since there are other areas in the food industry with greater marketing potential for the introduction of heat pipes (see below) we would not recommend any further activity in the cooling of sauces.

The use of an ambient cooling phase prior to blast cooling has been shown to significantly reduce overall energy consumption. Further studies should be funded to optimise a two stage, ambient then refrigerated, cooling system for racks of sauce and other products. These studies should look at energy consumption, product yield and overall throughput.

Meat carcass cooling

Initial studies showed that if, by using heat pipes, the average cooling cycle for beef sides could be reduced to 24 hours this would save 16.2 kJ per kg of meat chilled. Most abattoirs kill five days per week and, using average throughput figures of sides chilled per chiller in the UK, the overall energy saving per year per chill room would be 125 million kJ per year costing £1,750. In addition to the energy saving, sides lose approximately 0.2% in weight during the second day in a conventional chilling system. By eliminating this loss, the potential saving is £122 per batch or approximately £30,000 per year per chiller. If the chilling time to 7°C for each side could be reduced to <24 h with a single heat pipe then the payback period with current prices would be less than one year.

Further studies clearly showed that the insertion of heat pipes into beef sides can significantly reduce the required cooling schedule and consequently the energy required during the chilling operation. However, with the current price of food quality heat pipes and the extra manpower required it would not be possible to justify the routine use of heat pipes.

Heat pipes may offer a cost effective solution, even at current heat pipe prices, in abattoirs where a wide weight range of sides is chilled in one operation. In such cases, a small number of heat pipes used to reduce the internal temperature of the heaviest sides may allow a whole batch of sides to be transported.

A ten-fold reduction in the cost of heat pipes would increase the cost effectiveness of their use. However, much of the meat industry is still adverse to the use of new technology and the market would be limited. There is also the problem of maintaining the sterility of the pipes and convincing meat inspectors and veterinarians of its potential.

Cooking and cooling of solid foods

These results show that the use of heat pipes in the cooking and cooling of meat joints has substantial potential. Heat pipes can halve the cooking time and help guarantee that joints are cooked to a safe internal temperature. They can also produce a 30% plus reduction in the cooling time of joints.

In the domestic situation where a single joint is cooked in an oven the energy saving would be substantial since most of the energy is just used in maintaining the oven temperature. Studies have shown that a poorly insulated domestic oven consumes approximately 3000 kJ each hour when operating at 175°C and a well insulated oven approximately half this value. A single heat pipe could reduce the cooking time of a 2.25 kg meat joint from 3.6 to 1.8 hours. In a poorly insulated oven, this would save approximately 5.4 kWh, worth approximately 30 p, giving a payback of 333 uses with current heat pipe costs. Assuming one roast per week this would give a payback of 6 years. A price of £10 per heat pipe, a tenth of current costs, would be required to reduce the payback to a reasonable period.

If a simple heat pipe could be mass produced for under £1 and fitted to all domestic and catering ovens it could have a substantial effect of UK energy consumption. If we assume all the ovens are well insulated and used for a roast on average 25 times per year the potential energy saving is 20,000,000 (ovens) x 25 (times per year) x 2.7 kWh which equals 1,350 million kWh per year. The actual saving could be much higher.

If further funding could be obtained, we would like to carry out more studies in a range of domestic and commercial ovens with a range of products. We have good contacts with the manufacturers of both types of oven and would be confident of their willing participation. We would also investigate the development and mass production of food grade heat pipes with a substantially lower selling price. The availability of a low cost heat pipe would substantially widen their appeal and consequently lead to a substantial reduction in energy consumption.