Final report

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Feasibility and technical study of the use of ammonia heat pumps to reduce plant water heating energy consumption in Australian beef processing facilities

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Executive summary

Primo Smallgoods (P & M Quality smallgoods) engaged a refrigeration consultant to assess the current refrigeration practices and other intensive energy applications at their Scone beef processing facility.

An opportunity was identified to explore the application of a newly developed energy reduction system which has been successfully employed in food processing facilities overseas – Ammonia Heat Pumps.

It has been shown overseas that the application of heat pumps using existing high stage refrigeration as a heat source reduces the specific energy consumption for heating and cooling by between 37 and 40 % in the case of livestock processing plants without rendering.

This project included a feasibility and technical study, including a business case costing for an Ammonia Heat Pump System to be developed and commissioned at the scone beef processing facility to reduce plant heating costs.

Initial calculations have indicated that such a system would have the potential to reduce the current fuel gas consumption used to heat water by 36 % (Based on heating 600,000 litres of water to 92 degrees c at present butane prices).

Uptake is strongly anticipated with these significant energy savings when using Ammonia heat pumps are added to and integrated into the main refrigeration systems within a food processing environment.

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1 Background

In many food processing operations there is a need for simultaneous cooling and heating, with both being part of the same process. This is the case in livestock conversion plants like beef, pork and chicken processing plants as well as milk and vegetable processing plant, and beer breweries.

Refrigeration is required for post slaughter processes such as chilling, process area cooling, product chilling and freezing and cold storage. Refrigeration at the processing plant is the first and most important step in an effective cold chain and driven by food safety. Two stage ammonia refrigeration plants are often used and it is simple and inexpensive to add a third stage to the two stage plant to heat water to 60 to 70°C.

In most plants cleaning is carried out with 65°C potable water, requires 85°C hot water, again driven by food safety.

Within the red meat processing sector the application of heat pumps using existing high stage refrigeration as a heat source reduces the specific energy consumption for heating and cooling by between 37 and 40% in the case of livestock conversion plants without rendering.

2 Project objectives

This project included a feasibility and technical study, and business case costing for an Ammonia Heat Pump System to be developed and commissioned at the scone beef processing facility to reduce plant heating costs.

Areas analysed were;

a. The quantity of hot water needed daily
b. Seasonal variations in heating loads by analysing gas deliveries to the plant over a number of years
c. Construct heat pump design requirements for scone abattoir application
d. Budget construction cost so the plant can assess/ determine the financial viability

3 Results and discussion

In many refrigeration applications in food processing plants the compressor discharge heat is rejected to the environment using condensers. It is clear there exist many opportunities from refrigeration systems to capture this heat using heat pumps, particularly in cases where waste material is sent off site for rendering into meat meal and tallow.

Energy savings of 37 to 40% are to be expected when using heat pumps added to and integrated into the main refrigeration systems.

Australia produces carbon dioxide emissions of 1.2 kg of CO_2 per kW of electrical power, amongst the worst in the world. Global warming emissions contributable to energy consumption for electrically driven heat pumps are sometimes greater than the reduced emissions from the natural gas providing the same amount of heat value as the electrically driven heat pump.

When using a heat pump, it is not necessary to run condenser or cooling tower fans and pumps thus saving both energy and water. This technology has not been implemented within the Australian red meat industry to date. It is anticipated that possible future projects around the construction and commissioning and subsequent assessment of such technology may be resultant if the initial financial and technical feasibility study project proves the concept viable

Further aspects specifically relevant to the primo feasibility study undertaken by the refrigeration expert;

- Normally water is heated to 85°C and supplied through insulated mains. Insulating the hot water main would save 10% of the water heating bill or 4% of the total gas bill. This would amount to some $75,000/annum at current LPG prices

- The next opportunity is to use a two stage ammonia heat pump using the existing ammonia plant high stage as a heat source - this would reduce the gas consumption by a further 36%.
- The heat pump would consume a total of 1,250,000 kWhrs which would cost about $126,000.00.
- Therefore, a two stage ammonia heat pump would reduce fuel consumption by 36%, operating costs by $557,000 and emissions by a nett 693 tonnes.

4 Conclusions

Although the application of an ammonia heat pump was proven to be viable through the studies undertaken by the refrigeration consultant, Primo at this stage have decided not to progress with the development and commissioning of an ammonia heat pump due to a change of business strategy whereby a state of the art low temperature render plant has recently being acquired and commissioned.

If an ammonia heat pump were to be installed and such a heat pump were big enough it could heat 600,000 litres of water from an initial temperature of 45 to 85 degrees C in 8 hours, consuming 6720 KWhrs at an off peak rate of $0.0424 / kwhr - $ 285.00.

To affect the same amount of water heating with stream would require 135 GJ at a boiler efficiency of 80 %.

At the current butane rate price / litre the price of one GJ of heat would be $ 20.774. based on 49.1 GJ / tonne. Thus to heat 600,000 litres of water from 45 to 85 degrees C would cost $2,805. i.e. $ 2,520 more than using a heat pump. This assumes that the hot water distribution pipes are insulated. In the current situation it would cost about $ 3295 to heat 600,000 litres of water / day from 45 to 92 degrees C

In summary it is possible to reduce the total heat requirement by some 20 % by insulating the hot water pipes and ensuring heat exchangers are clean. And a heat pump making hot water off peak would reduce your heating costs by a further 90 %.

The combination of both measures would be a reduction of 91.35% in water heating costs. This equates to annual saving of about 36 % in average fuel costs, which would be nearly $ 700,000 per annum at present butane prices.

5 Reference list

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