Carbon Footprint/Energy Efficiency in the Supply Chain

Bananas light the way

Perfect ripening and storage are all about channelling the right amount of energy to the right equipment at the right time. Bananas are helping to shed light on these energy issues.

THE BANANA RIPENING CENTRE at the Tshwane Market is an energy-intensive operation. Fifty-five cold rooms, each around 200m³ in size and equipped with four fans, operate around the clock, every day of the year, to either store or ripen tons of bananas.

The fruit arrives completely green from the Mpumalanga and Limpopo provinces' subtropical fruit growing areas. Depending on their export schedule, the unripe bananas are either cooled down and stored for a few days at around 12°C, or ripening is induced straight away at between 15°C and 16°C. Under normal circumstances ripening takes nine days but when demand threatens to outstrip supply, the process is compressed into six days.

Temperature control is both a science and an art, because bananas can 'hold a grudge'. Any mistreatment while the fruit is still green shows up in black spots or uneven ripening later on.

Given its combined energy use for cooling, storage and ripening and the demands that this places on temperature control, the Banana Ripening Centre was the ideal testing ground for a study into the options available to reduce the energy consumption in the fruit export cold chain by introducing energy efficient technologies.

Experience in other markets has shown that the energy use of cold rooms can be cut by 20-30% by adopting measures such as reducing the heat load, introducing variable speed drives (VSDs), optimising airflow patterns, improving operating and maintenance practices and implementing automatic controls.

An appreciation of the value that more energy efficient practices can add to the fresh fruit industry, prompted the Post-Harvest Innovation Programme to collaborate with the Tshwane University of Technology (TUT) in Pretoria in a project to identify energy conservation measures that can be applied in cooling facilities in the fruit cold chain.

The study was done by Master's degree student, Jean-Claude Mulobe, under the supervision of Prof. Zhongjie Huan from the TUT Department of Mechanical Engineering.

1 Cool bananas! By reducing the speed of an electrical motor by just 10%, its energy use can be cut by 20%.
2 Each cold room has four of these electrical fans that circulate cold air. They enable the required cooling and ripening processes, but consume a considerable amount of energy.

PROJECT DESIGN AND RESULTS

The study involved the experimental and/or theoretical investigation of energy saving technologies that can be implemented in cooling facilities that have both cooling (temperature dropping) and cold storage (temperature maintaining) functions.

The project started with an energy audit of the Banana Ripening Centre at the Tshwane Market. The facility consumes just more than 668MWh of electricity in a year. The biggest consumers, at almost 60% of the total, are the refrigeration facilities, namely the cooling rooms, refrigeration compressors and cooling plant.

The energy audit mapped the centre's overall energy consumption, isolated the energy consumption of the refrigeration system and recommended energy conservation measures.

Based on the results of the audit, Mr Mulobe built and verified a numerical simulation computer code to simulate the refrigeration system. This allowed him to test, in theory, the impact it would have to run the motors of the evaporative coil fans in the cool rooms with VSDs. Two VSD modes were tested, namely constant and variable.

Mr Mulobe's computer modelling also investigated how airflow patterns and stacking methods influence energy consumption. Staff members at the Banana Ripening Centre already know that the two-way pallets, which are open on two sides to allow easy forklift access, is better for airflow than the four-way pallets. Two-way

WHY EFFICIENCY MATTERS

Cooling facilities that are more energy efficient is good news for the industry because of:

- Reduced energy costs.
- Reduced operation and maintenance costs.
- Improved system reliability.
- Improved safety.
- Increased productivity.
- Better matching of refrigeration load and equipment capacity.
- A better working environment.

PROJECT TITLE
Energy efficient technologies and energy saving potential for cooling facilities in the fruit cold chain

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DURATION
One year

PHI-2 CONTRIBUTION
R260 000

LEAD INSTITUTION
Tshwane University of Technology (Department of Mechanical Engineering)

BENEFICIARY
The entire fresh fruit industry

FOCUS AREA
Energy sufficiency in the supply chain

HUMAN CAPITAL DEVELOPMENT
One post-doctorate, two MTech and two BTech students

PRESENTATIONS AND PAPERS DELIVERED
Six

PUBLICATIONS
Two

VSDs combined with airflow optimisation have the potential to reduce energy usage in the cold rooms at the Banana Ripening Centre by up to 18%.

pallets' two open sides can be closed with metal strips to 'trap' the circulating air. This allows the air to circulate more evenly and efficiently between the boxes stacked on the pallet. Four-way pallets, that are open to the floor on all four sides, cannot be closed off as easily, making it more difficult to achieve sufficient airflow between the boxes. With the computer modelling, airflow and stacking practices are elevated from anecdotal evidence and trial-and-error to verified science.

The VSD and airflow studies were also put to the test in real life. In a small experimental cold room on the TUT campus, pallets of bananas were subjected to different experiments with VSDs and ways to optimise airflow to determine the impacts on both energy consumption and fruit quality. The variable VSD was proposed and verified as an effective way to save energy and maintain fruit quality. The experiments concluded that VSDs, combined with airflow optimisation, have the potential to reduce energy usage in the cold rooms at the Banana Ripening Centre by up to 18%.

The other theoretical part of the study was the mathematical modelling of how a cold room's colouring and shading can contribute to energy savings by reducing the transmission heat load. The findings indicate that colouring and shading have the potential to reduce the heat load on a cold room by as much as 36%.This technology has the potential to be applied and patented.

WIDER APPLICATION

Although this energy efficiency project used the Banana Ripening Centre as its laboratory, its results and insights are directly relevant to the broader fruit cold chain, since its scope covered technologies that are applicable to all types of fruit that need a low-temperature environment.

There are also wider application possibilities. For example, the software Mr Mulobe developed can be used to model food freezing, cooling and heating for purposes of processing and equipment design, optimisation and understanding.

Beyond technical returns, the cost savings that result from improved energy efficiency directly benefits people by making money available for business expansion. The result is more jobs, often to the advantage of women, since they seem to be more involved in trading and marketing of fruit than men.

Better matching of refrigeration load and equipment capacity will greatly reduce post-harvest losses. This should encourage specifically emerging farmers to increase production leading to positive cash flow and higher net incomes.

The employment benefits extend beyond the fruit industry. Increasing demand for energy efficiency solutions will have positive effects on employment, directly by creating new business opportunities and indirectly through the economic multiplier effects of spending the money saved on energy costs in other ways.

WHAT IS A VSD?

A variable speed drive (VSD) is a piece of equipment that regulates the speed and rotational force, or torque output, of an electric motor.

There are millions of motors in use in industry and offices around the world. They operate pumps, milking machines and ski lifts, paper machines and power-plant fans, sawmill conveyors and hospital ventilation systems, to name just a few examples.

In fact, more than 65% of industrial electrical energy is consumed by motors.

In many cases, motors are controlled by means of a valve that regulates the flow of fuel, or a vane that controls the airflow, while the speed of the motor itself remains unchanged. These and other methods, such as using two-speed motors or controlling motors by switching them on or off, are inefficient from an energy point of view.

One of the main reasons why drives save energy is because they can change the speed of an electrical motor by controlling the power that is fed into the machine. Reducing the speed of an electrical motor by just 10% can reduce its energy usage by 20%.

Source: www.abb.com

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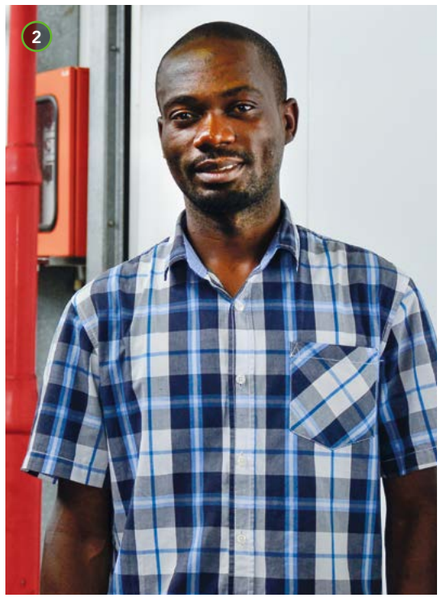

1 Prof. Zhongjie Huan and Jean-Claude Mulobe.
2 The results and insights that Jean-Claude Mulobe gained in this project are relevant to the broader fruit cold chain.
3 The energy consumption of the refrigeration facilities of the Banana Ripening Centre at the Tshwane Market has been decreased considerably by minor adjustments to the speed of the cooling fans.