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Reducing energy use in an industrial tea drier

QSEIF Fact sheet
Reducing energy use in an industrial tea drier

Summary

QSEIF Funding: $119,000

Electricity for operating drier fans reduced by 60%, yielding savings of $30,000/year.

Six month payback for additional capital cost of drier.

Steam consumption reduced more than 10% by "flash steam" recovery, saving $8,000/year.

Nerada Tea Estates Pty Ltd and Foodstream Pty Ltd

Photographs (above left to right) show the specially-engineered vanes, the perforated deck plate, and horizontal ducts housing the fans and steam-heated coils.

Photos: Nerada Tea Estates Pty Ltd

Drying is an energy-intensive process that is widely used in the food processing industry. Drying is the major process used at the Nerada Tea Estates plant in north Queensland, the largest tea growing and processing enterprise in Australia, where green leaf tea is converted into dry black tea (which is packaged as tea bags or loose leaf tea). High electricity consumption needed to operate drier fans motivated Nerada to consider a fundamental redesign of the tea driers used in their factory.

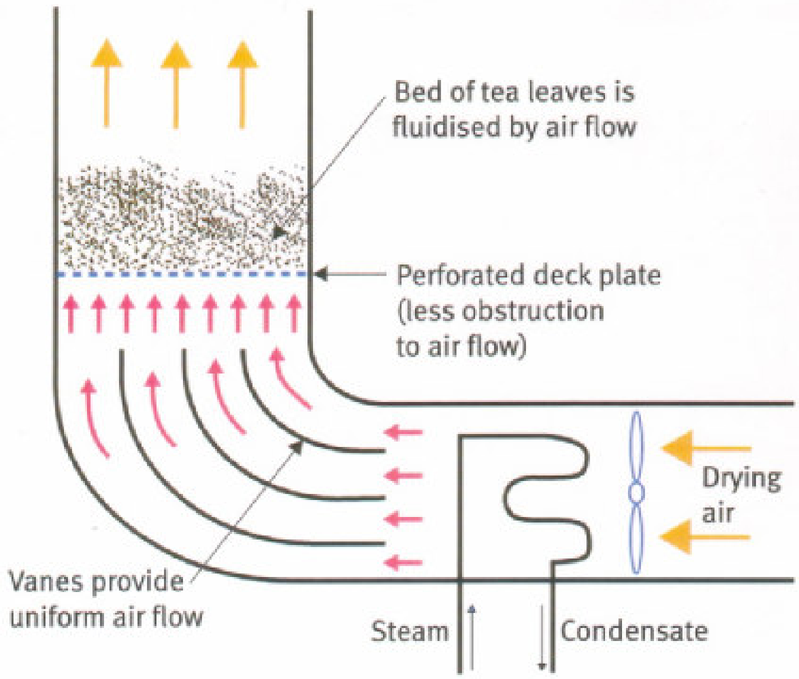
When Nerada Tea Estates decided to build a new pre-drier to increase the plant's throughput and product quality, they commissioned Foodstream Pty Ltd to develop innovative design approaches to reduce drier energy consumption, and applied for QSEIF funding to offset 60% of the development costs.

The Nerada factory employs a series of "fluidised bed driers". This type of drier suspends particles of tea in a rapidly-moving upward flow of heated air. The airflow causes tea particles to be mixed in a turbulent "boiling"-type motion. Suspending the tea particles in the airstream in this way (with the particles said to be "fluidised") provides excellent contact with the drying air.

However, a major technical challenge was posed by the high moisture content of freshly chopped tea leaves. Water comprises about 80% of the weight of the tea leaves. Moist tea leaves tend to clump together in dense clods, rather than becoming "fluidised", in the upward-flowing airstream. This would lead to poor contact with the drying air and very poor drying efficiency.

Thus, maintaining uniform airflow through the drying bed is critical for efficient drying. Conventional driers use a perforated deck plate, in which small holes obstruct the airflow and build up air pressure below the plate. Forcing air to flow against this high "back pressure" requires powerful blower fans, using about 2.5 kilowatts of power for each cubic metre/second of air blown through the drier.

This project aimed to design and construct a new drier that used the minimum fan energy. This would be



Energy-efficient drier

achieved by using a perforated deck plate with the holes spaced closely together, providing less resistance to air flow - and thus, developing less pressure drop. Without high "back pressure" being produced by the perforated plate, an alternative approach was needed to ensure the airflow is spread evenly across the bed of tea leaves. Foodstream proposed that uniform airflow be achieved with a series of vanes inserted in the air stream.

The basic layout called for air to be blown horizontally through steam-heated coils, and then turned 90° to pass vertically upwards through the drying bed. A simple duct with a rounded bend would create turbulence and uneven airflow, so a series of curved vanes were designed to be inserted into the duct to achieve uniform airflow.

Foodstream found that the size, shape, and position of the vanes was critical to achieving uniform flow, and used the sophisticated technique of Computational Fluid Dynamics (CFD) to test alternative designs.

Foodstream's initial design, based on simple intuition, produced a concentrated area of high velocity air surrounded by areas of much lower velocity air. Utilising a CFD software package, Foodstream modified the design until it produced an airflow that was essentially uniform.

With design complete, Nerada Tea Estates constructed a new tea drier "from scratch" with a drying bed area of about 15 m^2, capable of evaporating up to 2,000 kg of water per hour.

The specially-designed vanes, with the lower resistance through the bed plate, significantly reduces the fan power required to operate the drier. The low "back pressure" allows the use of axial fans, costing about half as much as centrifugal fans that are normally used in conventional driers.

Fans used in the new drier consume 40 kilowatts of electrical power when operating at full speed. This corresponds to a specific power consumption of 1.0 kW of fan power per m^3/s of air delivered. To achieve the same airflow in a conventional drier requires about 100 kilowatts. Thus, fan energy usage in the new drier is 40% of that used by fluidised bed driers of traditional design.

Reduced electrical power consumption for the new drier yields an annual energy saving of about 250 megawatt-hours, saving over $30,000 per year in electricity costs and avoiding emissions of 260 tonnes/year of the greenhouse gas carbon dioxide (based on the plant running for 200 days per year, averaging 20 hours per day).

The total capital cost of the new drier is about $15,000 more than conventional driers, primarily due to engineering and construction of the vanes. The net additional capital cost of the new drier would be recovered within about six months through reduced energy costs.

Even further savings of fan energy are expected as drier operation is optimized. Installation of variable speed drives allows the fan speed to be reduced to the minimum required to fluidise the tea leaves (rather than reducing the airflow with dampers, as in conventional driers). If a 10% reduction in fan speed proves feasible, annual electricity costs would be reduced by a further $4,400.

Additional energy savings are achieved through more efficient utilization of steam that provides heat for the drying process. "Flash steam" recovery extracts an additional 12% of the heat energy from the steam, and reduces the amount of coal fuel that needs to be burned in the boiler. This saves around 85 tonnes/year of coal, yields fuel cost savings of $8,000, and reduces carbon dioxide emission by around 240 tonnes/year.

Conclusion

This project has demonstrated energy savings in an industrial tea drier, including:

- More than 60% saving in fan power.
- Further reductions in fan power expected by using variable speed drives to reduce airflow.
- Steam consumption reduced by more than 10% through "flash steam" recovery.

Project contact details:

Bill Benson
Nerada Tea Estates Pty Ltd
Ph (07) 4096 8222 Fax (07) 4096 8290
Email: bill.benson@neradatea.com.au

Gordon Young
Foodstream Pty Ltd
Ph (07) 3018 2800 Fax (07) 3102 6252
Email: gyoung@foodstream.com.au
Website: www.foodstream.com.au

For more information

- **visit** www.epa.qld.gov.au/sustainable_industries
- **email** sustainable.industries@epa.qld.gov.au
- **call** 3225 1999

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