RESEARCH AND DEVELOPMENT

Electrocuting logs to kill bugs

Joule heating, a new world-first technology developed right here in New Zealand, could be a sustainable alternative to methyl bromide fumigation for the treatment of export logs. It is now ready to move a step closer to commercialisation.

A team from the University of Canterbury's Electric Power Engineering Centre (EPECentre), led by Dr Bill Heffernan, has been working on the Joule heating project since 2007.

Electricity is fed through logs to heat them long enough to kill bark beetles and other pests in the sapwood.

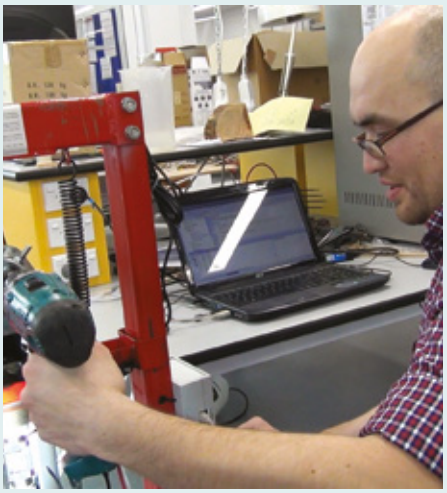
But there is another potential use as a pre-treatment for veneer peeling.

The phytosanitary use of ozone depleting methyl bromide for logs under the current process runs out in October. An alternative is needed.

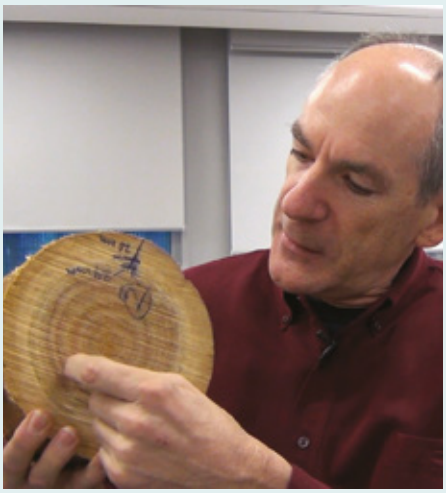
A question from Grant Knight, who was then employed by the Ministry for Primary Industries – "What would happen if you put some electrical current through a pine log?" – started the team on its voyage of discovery.

The development of Joule heating has been on a very tight budget – just under $1.1 million up to 2019. Initial testing was funded by EPECentre itself, augmented by a $30,000 grant from MPI in 2009. In 2012, this was followed by another grant of $30,000 from the Stakeholders in Methyl Bromide Reduction (STIMBR) and MPI Primary Growth Partnership. This led to a $1m contract from 2013 to 2017, as part of the MBIE/STIMBR-funded Market Access Programme (MAP) study. The EPECentre was subcontracted to Scion.

During the research period, Dr Heffernan identified electrical engineering work on veneer peeling by the US Forest Service in the 1950s. While that work had not progressed, luckily the information had been archived. This knowledge helped to add the second dimension to the team's research.



Dr Nurzhan Nursultanov



Dr Bill Heffernan

"Later on, we realised we needed to do computational modelling to be able to fully understand the process, as well as measure the heating," he says.

Nurzhan Nursultanov – then a PhD student from Kazakhstan – was brought into the UC team to help develop a computer model to study the behaviour of the electric current at it passed through a log. The modelling was vital to enable it to work reliably, says Heffernan: "Which it now does."

Commercially, the advantage is that the log can be treated and assessed simultaneously, with vital statistics being harvested at the same time. This gives processors real-time feedback, he explains. The supplier can attach some very detailed information for the customer for every single log: size, length, shape of log ends, how much is heartwood or sapwood, and even what treatment temperature was achieved. This gives the receiving country's biosecurity agents excellent traceability and also adds value for the end users, he says.

Further down the track it might be possible to actually alter the properties of the wood – not just measure it.

Nursultanov's "outstanding work", which he subsequently tested and proved on 50 radiata pine logs, is a "world first," says Heffernan.

The team's MBIE/STIMBR work, with Crown Research Institutes Scion and Plant & Food, resulted in four peer-reviewed papers, including the 2019 paper which appeared in *Applied Thermal Engineering* – 'Computational calculation of temperature and electrical resistance to control Joule heating of green *Pinus radiata* logs'. It also involved multi-disciplinary work with UC forestry, chemical and process and the electrical and computer engineering departments.

The work earned the team High Commendations in UC's Sustainability Awards in 2018 and 2019. It also won now Dr Nursultanov the 2018 Research Award for a Young Scientist in the Forest Growers Research Awards, which he recalls, "was a very big surprise!"

Why Joule heating?

The Joule heating process is non-toxic, does not use any harmful chemicals and is also fast.

In addition, conditioning before peeling and slicing logs for veneer sheets currently uses hot water baths or steam tunnels to heat the logs from the outside. This process is relatively cheap, if wood waste is used, but it is time-consuming and energy inefficient.

"Big logs need to be treated for up to 20 hours to reach peeling conditions. If Joule heating is applied, the same temperature conditions can be reached within minutes in the sapwood and right through to the pith in at most two to three hours," notes Dr Nursultanov.

The forest industry has invested in the research to date, through STIMBR. Russell Dale, New Zealand Forest Owners Association research and development manager has been "pretty impressed" by the innovation and technical skills from the UC team.

"They have overcome all of the technical issues to get the logs up to the correct temperature to meet phytosanitary standard ISPM 15. No one else in the world has done that through the direct application of electric current to logs," he says.

Bill Heffernan explains ISPM 15 requires the entire log temperature to reach and be held to at least 56°C for at least 30 minutes to kill all the pests and pathogens of concern in the sapwood. While other forms of treatment often only treat the outer sapwood portion of a log, Joule heating also treats the heartwood (with slightly greater energy use) as well as the sapwood.

Treatment right through to the core of the log may provide an answer to importing countries, such as Australia, with impending log shortages due to forest fires last summer. Australian authorities demand a log treatment which can kill fungal pathogens, which may exist far deeper in the log than insects of concern do.

15%

of the annual electricity production of Tiwai Point is all that would be necessary to treat the 20 million m^3 of our export logs

The UC team's work has also shown the average energy requirement of raising the temperature to 56°C from ambient was 38 kWh per cubic metre: "About the same energy as two average-sized hot-water cylinders," Bill Heffernan says, adding most of the logs tested were smaller than one m^3.

"If all of the 20 million m^3 of logs exported each year were treated in this way, it would use about fifteen percent of the electricity used annually at the Tiwai Point Smelter – or one eighth of Manapouri's output."

Electricity costs would vary depending where in the national grid a processor was drawing power but would typically be between six and nine cents per kWh, he says.

Heffernan and Nursultanov have already had interest from Boise Cascade wood processors in the USA. The team also have been talking to the plywood and LVL industry about the rapid-pre-peel conditioning and turning the log electrodes into a tool to assess the structure and properties of logs before peeling, or milling.

Next steps

The forest industry is interested in the technology as a long-term investment as it offers an alternative to chemical fumigants, says Russell Dale.

"Because it is heat-based, it will also kill insects and pathogens and there is also potential for the plywood and LVL manufacturers for both domestic and export purposes."

Capital cost has been the major barrier to progress to date, he notes, pointing to a desk-top study in 2017 by engineering consultants, which indicated a $40-60 million price tag for a full production plant using the new technology. That would be prohibitive for a wood processing company unless it had a guaranteed supply contract.

However, the UC team was given approval late last year to move onto the next step: a $360,000 project funded by STIMBR with support from AGMARDT to de-risk the building of a small-scale industrial pilot plant.

The $2-8 million pilot plant will be transportable, enabling it to be moved around the country taking the treatment process to the logs – for example for companies to try out on the wharf, on the ship, or in an existing plywood mill, says Heffernan, acknowledging companies' differing logistics.

Dale says: "There is strong interest from FOA members in approaching the Provincial Growth Fund to support the development of the pilot plant, which will require matching industry investment."

While the technology will not be in operation in the immediate future, it is a way forward, says Heffernan.

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