

Upgrading Sugar Cane Mill to Produce Refined Sugar: Making Sugar Production More Efficient (Patented)

Dr Chung Chi Chou

sugar

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The sugar industry is a giant, producing hundreds of millions of tonnes of refined sugar each year. In the USA, most sugar is produced from sugarcane, but the process of growing sugarcane, milling it into raw sugar, then refining it into the product we're familiar with, is remarkably energy- and water-intensive. Dr Chung Chi Chou proposes a process to improve the efficiency of sugar production by combining the milling and refining stages in one plant, increasing profits and reducing the environmental impact of the sweet stuff.

The Sugar Rush

Sugar is ubiquitous in our modern diet. It's addictively delicious, and it also acts as a preservative, a texture modifier, a fuel for fermenting alcohol, and a flavouring and even a colouring agent. While many of us are trying to reduce the sugar in our diet due to health concerns, the demand is still enormous, and production is at an all time high of 175 million metric tonnes a year.

However, demand isn't the only constraint on production. In the USA, the sugar industry is contending with global competition, as well as the social and moral imperatives of social health and environmental protection. Thus, research and development in the sugar industry has increasingly focused on improving efficiency to maximise profits and reduce environmental impact. This includes managing energy, raw materials, water and environmental emissions.

Dr Chung Chi Chou, the principal scientist and engineer of *Dr Chou Technologies, Inc.*, is trying to tackle these problems. Funded by a USDA Small Business Innovative Research award, his project focuses on a specific issue hampering efficiency: producing refined cane sugar from sugar mills without an attached refinery.

How is Sugar Produced?

Most sugar in the USA comes from a combination of imported refined sugar and American-grown sugarcane, a tall perennial grass with sucrose-rich stems. Once farmers have grown and harvested the sugarcane, a sugar mill extracts the raw sugar from the plant as a juice or syrup. This is then purified and treated with slaked lime and heat to stabilise and neutralise the syrup, as well as deactivate enzymes from the plant. This juice is then evaporated, eventually crystallising into a sticky, brown, raw sugar.

However, this requires refining before being sold to the public. First, the impure outer coating of the sugar crystals is removed by mixing the raw sugar with a heavy syrup and putting it through a centrifuge producing 'affined' (washed) raw sugar which is then dissolved into a liquid syrup. Next, phosphoric acid and calcium hydroxide are added to the phosphatation process for clarification, entrapping and absorbing impurities which then float to the top of the tank for easy removal. Alternatively, a carbonatation process involving the use of calcium hydroxide and carbon dioxide can be used for clarification.

The clarified syrup is passed through a coal or wood-based activated carbon and/or ion exchange process which absorbs and removes the remaining colour impurities. Finally, the syrup is concentrated and crystallised repeatedly in vacuums, resulting in the classic refined white sugar we're familiar with in our kitchens.

Industrial/Commercial Plant Application

Purification Process



Dr. Chou Technologies, Inc. <http://www.onegotech.com>

There are some efficiencies to this process. For example, the residual dry fibre from the processed sugarcane, called bagasse, is often used as a fuel or agricultural mulch rather than discarded. Molasses is another byproduct and a major constituent of brown sugar and rum. However, the process is still energy and water intensive, with the production of every single tonne of refined sugar requiring several hundred thousand litres of water for irrigation and processing, and emitting the equivalent of several hundred kilograms of CO₂. Dr Chou argues that improving the efficiency of this process could improve profits while also reducing the environmental impact of sugar production.

Making Local Efficiencies

Dr Chou notes that this two-part process introduces inefficiencies as the sugar mill is often separate (and very distant) from the refinery.

For example, the milled raw sugar is evaporated and crystallised from a juice, but upon arrival at a refinery, it is re-dissolved with additional water, re-evaporated and re-crystallised into refined sugar. By eliminating the refining process and producing refined sugar directly from sugar mills, not only can additional water and energy be saved but investment in refinery equipment, operating expenses and labour can also be avoided. Of course, the elimination of refining would also reduce the transportation demand.

Dr Chou is studying American sugar production from cane and beet, comparing production in Florida, Hawaii, Louisiana, Texas, and imported sugar in order to calculate which parts of the production process produce the most water and energy saving and measure the impact of his proposal.

Crystallisation consumes around 60% of the energy. This is because the juice must undergo evaporation, which requires heating the water into steam. Water has one of the highest specific heat capacities of any substance, meaning it requires an exceptional amount of energy to heat a unit of water by 1 degree, and so the boilers, which provide steam/heat for processing, need a lot of heating oil and/or natural gas.

For comparison, in the 2016–2017 season, the heating of water for sugar production in America cost just under a third of a billion dollars, and required 40.2 petajoules of energy – equivalent to 0.8% of total American household electricity use across 2016. This mostly came from natural gas, pumping 2.2 million tonnes of carbon dioxide into the atmosphere. And, as Dr Chou points out, this only accounts for steam generation and ignores transport requirements. Elimination of sugar refineries will require the addition of updated filtration and/or clarification technologies in Cane sugar mills

So, how much energy would Dr Chou's proposal save? Altogether, he estimates this could reduce overall energy consumption by up to 50%.

Benefits to the Public

Dr Chou argues that these efficiencies wouldn't just save sugar companies money but would also benefit the public. As we've discussed, the proposed process would dramatically reduce the consumption of water and energy, as well as reduce the amount of carbon dioxide emission and other hazardous solid waste production from refineries. Overall, this is a great opportunity to decrease the environmental impact of sugar production.

Further, the adoption of this process would provide an economic alternative for producing American Food Grade sugar across the world. Currently, plantation white sugar is often produced by sulfitation in developing countries, which has negative global health and social impacts. However, Dr Chou believes that if the USA can prove that this one-step sugar process is economically viable, it may be adopted as an alternative to sulfitation, allowing high-quality sugar to be produced worldwide with a smaller environmental footprint. It goes without saying that this American-developed technology can be sold worldwide.

Dr Chou now plans to put the one-step production technique to the test, and to do so he first plans to conduct a market survey of refined cane sugar products. He will go on to verify the efficacy of the systems via an ultrafiltration membrane system, and further develop updated clarification technologies as a cheaper alternative to ultrafiltration. Finally, he intends to perform process development, scale-up, and economic analyses.

The sugar industry isn't likely to disappear any time soon, as supply and demand are both steadily increasing. Dr Chou highlights the potential improvements that could be made to sugar production, and his proposal for this breakthrough a one-step process is a great example of how the incentives in industry to maximise profit can and should be aligned with the public interest in reducing sugar production's environmental impact.



Meet the researcher

Dr Chung Chi Chou
President/Principal Scientist and Engineer
Dr Chou Technologies, Inc.
Austin, TX
USA

Dr Chung Chi Chou is the president, principal scientist and engineer at Dr Chou Technologies, a corporation devoted to saving resources and preserving the environment for the next generation. Funded by a USDA Small Business Innovative Research award, Dr Chou is currently trying to optimise the refinement of cane sugar. He has served, as a consultant, over 40 international corporate clients in the world sugar industry and is co-author and co-editor of the 12th edition of the Cane Sugar Handbook and the editor of the 1st edition of the Handbook of Sugar Refining (both published by John Wiley & Sons). Throughout his career, Dr Chou has collaborated with universities across the world. He lectured at the Cane Refinery Institute at Nicholls State University in Louisiana from 1986 to 2016, served as a research/visiting /advisory professor for the South China University of Technology, China, from 1993 to 2015, and as an adjunct professor at Louisiana State University from 1993 to 1997 and at Guang Xi University from 2001 to 2004. Before his retirement, he worked for formerly Domino sugar corporation for 30 years serving in various capacities, including as a research scientist, manager of process development and the director of the Technical Division. Impressively, Dr Chou has lectured in over 26 countries and published 65 papers and patents on the topic of sugar technologies and management. Dr Chou is also the founder and president of Wellbrook Foundation, Inc., a charitable organisation focusing on education since 1989. In recognition of this work, the foundation has received numerous proclamations/ certificates of appreciation for community service from New York governmental agencies, and most recently, received a prestigious Acquisition International award – Best Educational Lecturing Foundation (New York, 2022).

CONTACT

E: drchouusa@gmail.com

W: <https://www.esugartech.com/>; <https://wellbrookfoundation.org/>

KEY COLLABORATORS

Dr Jeff Le Blanc, formerly at the University of Louisiana at Lafayette, USA

Dr William Chidon, University of Louisiana at Lafayette, USA

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FURTHER READING AND RESOURCES

[Production of Refined Cane Sugar from Sugar Mills without an Attached Refinery](#) (USDA-RFA-0001619:Topic number: 8.13-1).

US Patent, [US-6485574-B1](#), Process for pretreating colored aqueous sugar solution to produce a low colored crystallized sugar.