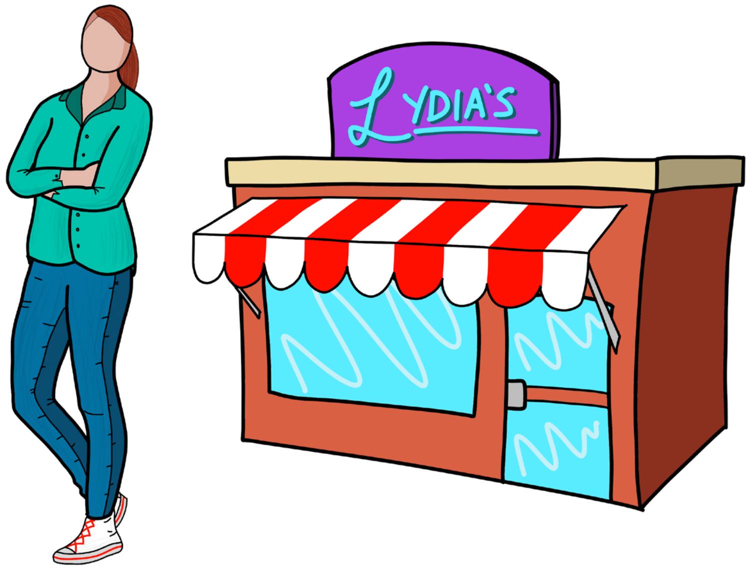
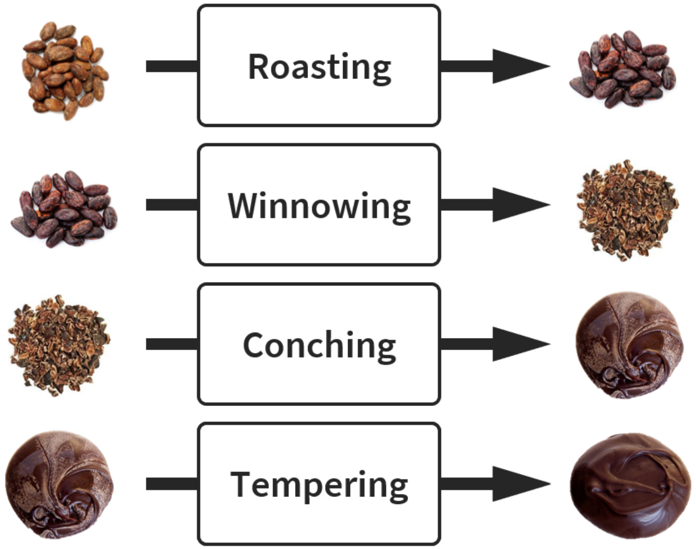
TOOT SWEET TEMPERING

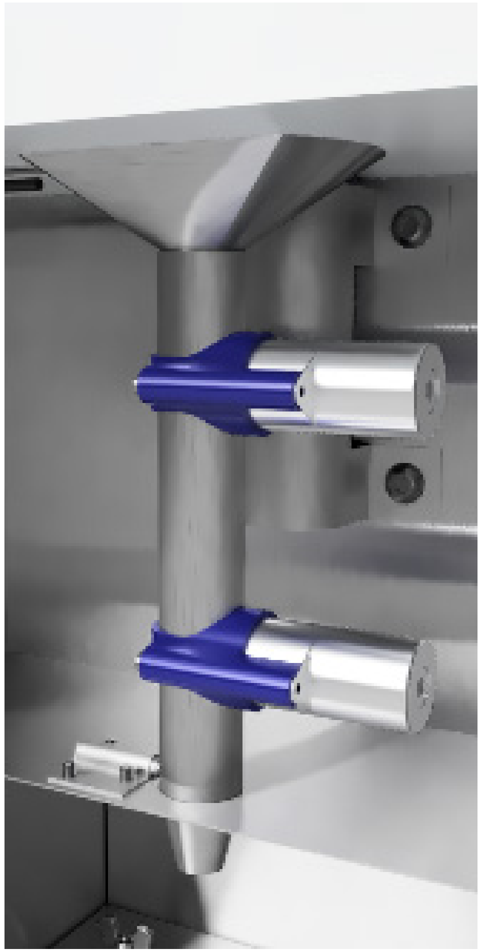
UTILISING ULTRASONIC CAVITIES TO TEMPER CHOCOLATE FASTER.

by Scott Simpson

Context







Who is this product for?

Small-to-mid scale chocolate manufacturers. Suitable for those who make from bean-to-bar and for those who buy in untempered chocolate.

What does it do?

Tempering is the final stage of the chocolate making process, and this machine cuts the time needed to do so by more than half.

How does it do that?

Using ultrasonic cavitation, it creates more nucleation sites in chocolate as it sets which allows the desired crystalline structure to form.

Where should they use it?

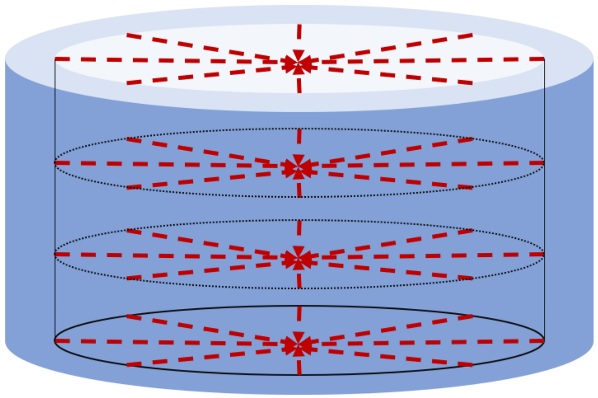
This is suitable for use in a designated chocolatiering space with consistent use, but is compact and cleanable to allow it to be used at home and put into storage.

Why is this an improvement?

A faster temper allows users to manufacture more chocolate each day to boost their business. The reduced time factor also allows for more creativity and exploration with smaller batches. Additionally, all components are easily accessed to allow for maintenance.

Key Research

Polymorphs of Chocolate	Melting Temperatures
Form I	17.3°C
Form II	23.3°C
Form III	25.5°C
Form IV	27.3°C
Form V	33.8°C
Form VI	36.3°C



Chocolate is polymorphic, and so has can have a variety of crystalline microstructures.

Tempering controls the solidification process to ensure the most desirable polymorph is dominant - Form V.

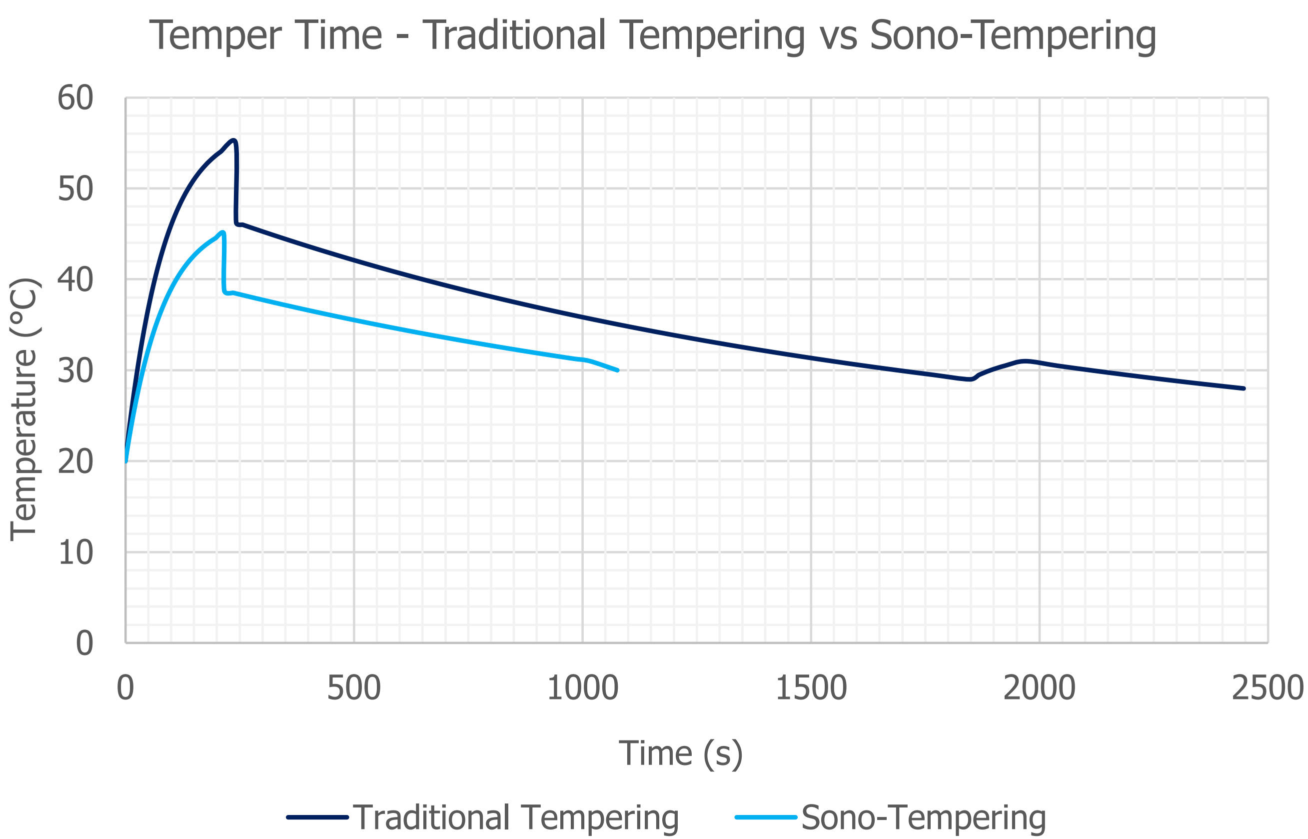
Ultrasonic cavitation can be used to introduce more nucleation sites for the crystals to propagate from, speeding up the process.

These cavities can be introduced via high intensity focused ultrasound.

When an ultrasonic transducer is coupled with a pipe, the waves focal point is the pipe’s central axis.

If chocolate is flowing through this pipe, it will be exposed to cavitation and tempered rapidly.

Improvement



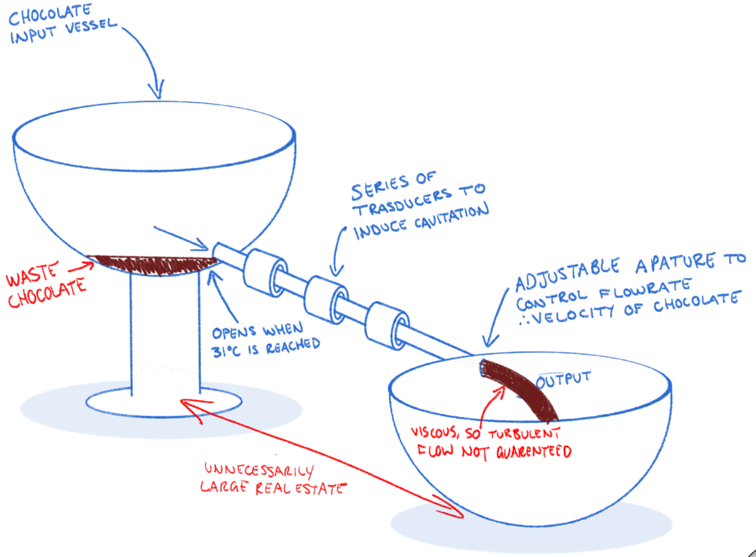
Sono-tempering not only truncates the cooling time at the end of the tempering process, but also allows it to be shortened in the earlier stages.

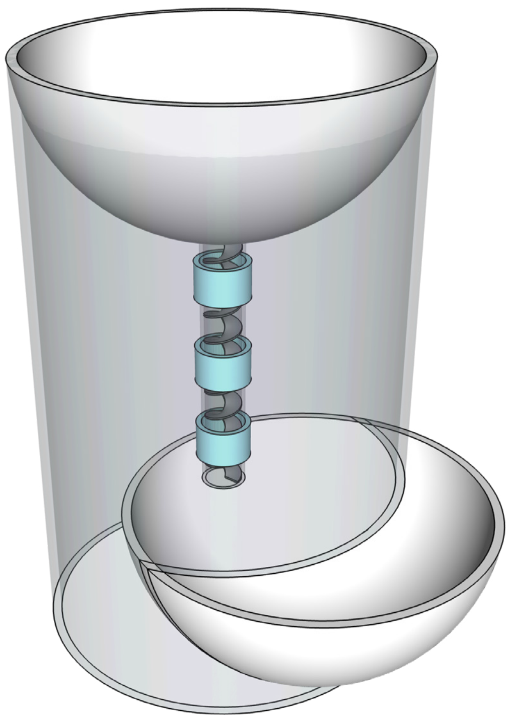
Traditional tempering requires the temperature to be raised significantly above all polymorphs' melting points to ensure the desired structure is the only one obtained, but when the end of the cooling time is removed this is no longer necessary.

Instead, the chocolate can be heated 10C lower, shortening both the initial heating and cooling time as well.

This reduces the overall tempering time approximately from 41 minutes to 18.

Early Iterations



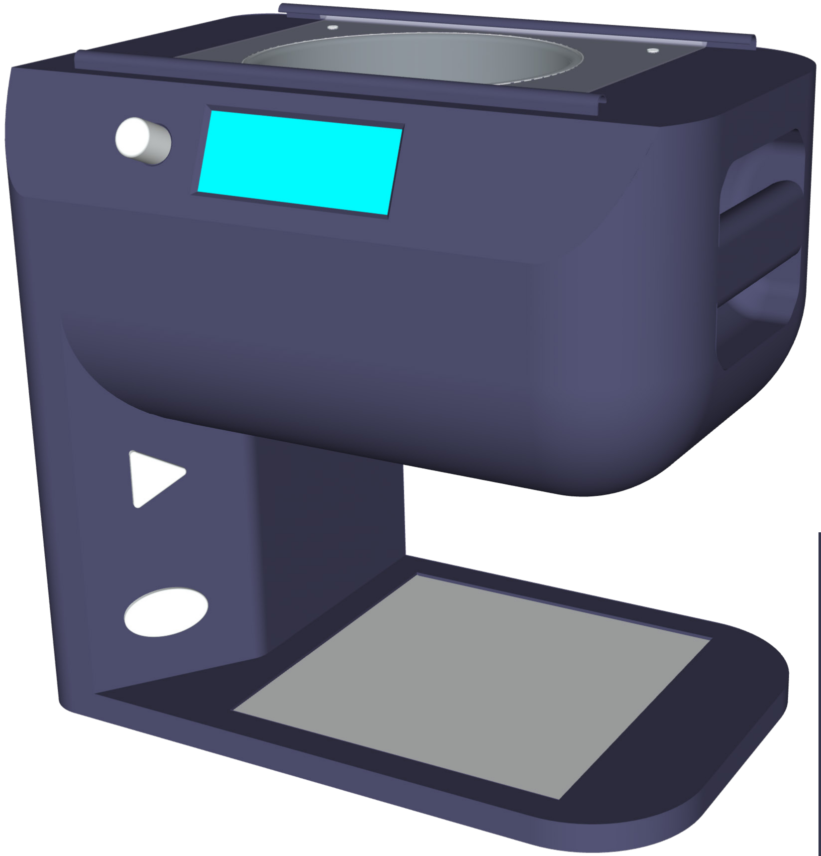


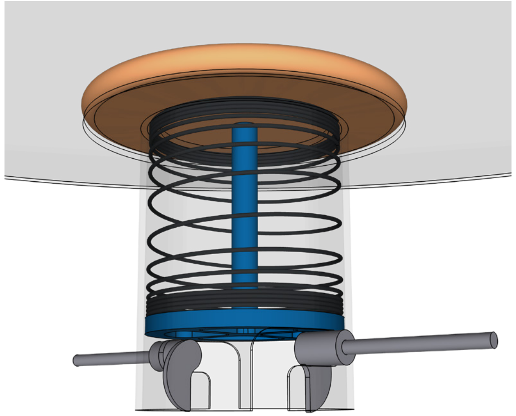
Once it was concluded the chocolate would have to travel through a pipe, it was initially put at an angle to control the flowrate and ensure adequate exposure to cavitation.

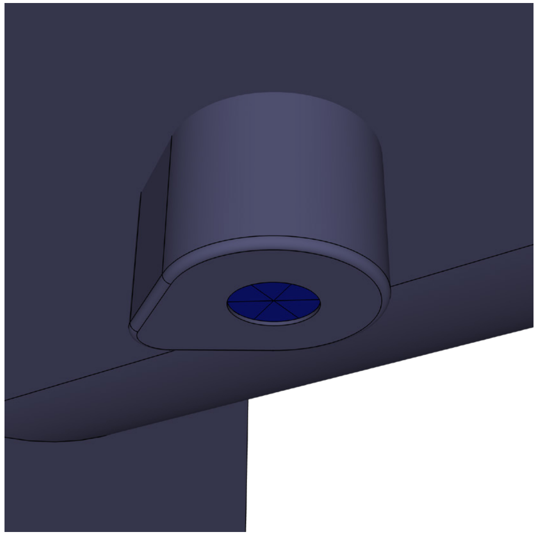
It was then redesigned to take up less space on a work surface, and the flowrate can be controlled through an iris style nozzle at the end.

This redesign has the added benefit of ensuring acoustic coupling between the pipe and the chocolate.

Development







A later design saw the addition of a lid and vibrating plate. The user interface is an LCD screen and is designed to be controlled by a rotary encoder with a push button. Two separate buttons control the nozzle and plate respectively.

The nozzle button was changed to a switch to reduce risk of user error and the plate button was removed all together as most machines in the industry have the plate running constantly.

In this iteration, the valve at the top is opened by rotating cams and the one at the bottom is an iris style lens. These were both later simplified to a sliding grate and a standard butterfly valve respectively to reduce manufacturing costs and risk of mechanical failure.

Redesign

Electronics

Iris changed for a butterfly valve

Top cams valve removed and replaced with drain

Stirrer added and powered by motor underneath

Heated coil changed to a silicone pad

Temperature sensor removed from bowl (in pad)

Heating added to pipe

Vibrating plate with solenoid unit

Aesthetic

Slender and central aligned

Controls next to each other

Electronics at back

Bowl at front

Steel, sheet metal, industrial aesthetic

Transducers

Attached to coupler with adhesive

Coupler attached to pipe with buckle

Middle transducer removed due to redundancy

UX

Stirrer added

Buttons central for both dexterity polarities

Vibrating plate slightly bigger

Lid removed - constant bowl access needed

Nozzle closer to front for accessibility

Body

Compartmentalisation of components

Addition of front, back and top removable panel

Motors accessible from front

Heater accessible from top

Power and signal generator at back

Controls electronics accessible from front

Taper removed from bowl, ease manufacturing and allows for stirrer addition

Bowl incorporated into form, more consistent with larger machines

Suitable for sheet metal forming

Mechanical tap easier, but there has to be communication between the flow and the transducers.

Losing sight of 'these are chocolatiers, not scientists'.

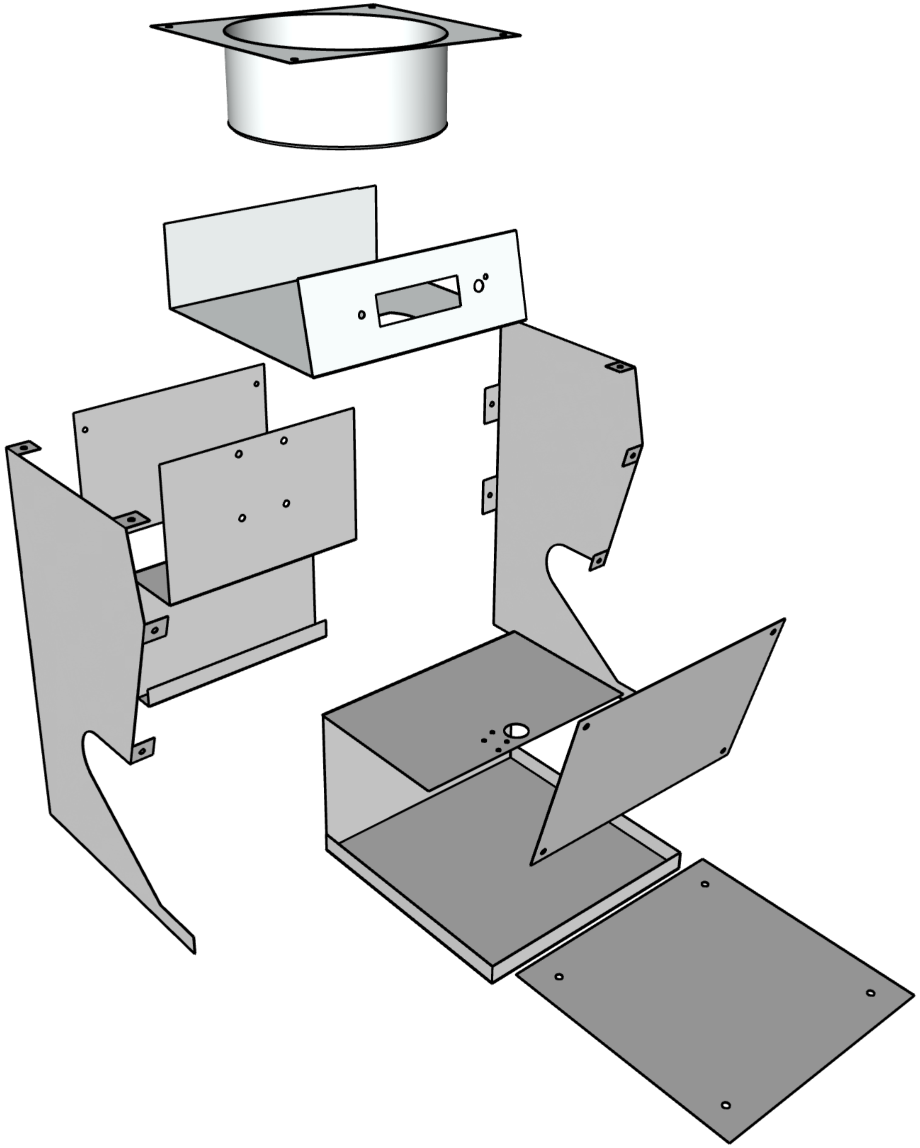
After some discussion with industry contacts, a final major redesign was executed. The most controversial changes are the removal of the lid and the securing of the bowl.

The lid was removed because a key park of the process is pouring chocolate back into the machine once the insides of moulds are coated, and this stage of the user cycle had been ignored until now.

The bowl is no longer removable because not only is frequent cleaning of tempers uncommon, it can actually be detrimental to the process. If water residue mixes in with the chocolate it bonds with the sugar molecules in what's called sugar bloom. More common practice is to 'flush' the machine out with a sacrificial batch.

The machine can be deconstructed with a hexagonal wrench so if the user so desires they can clean it thoroughly, but as above this is not common practice.

Body



The body has been designed to be sheet metal formed out of 0.9mm thick stainless steel 304. The parts all join together as shown.

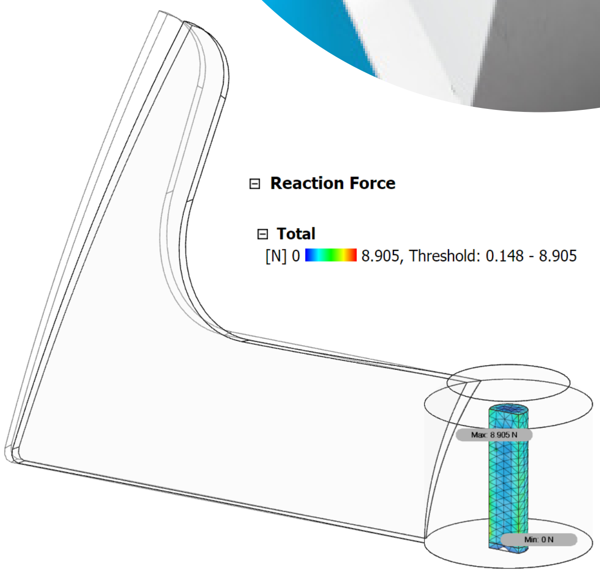
Bar the top, each panel can be cut, drilled and bent in a simple process.

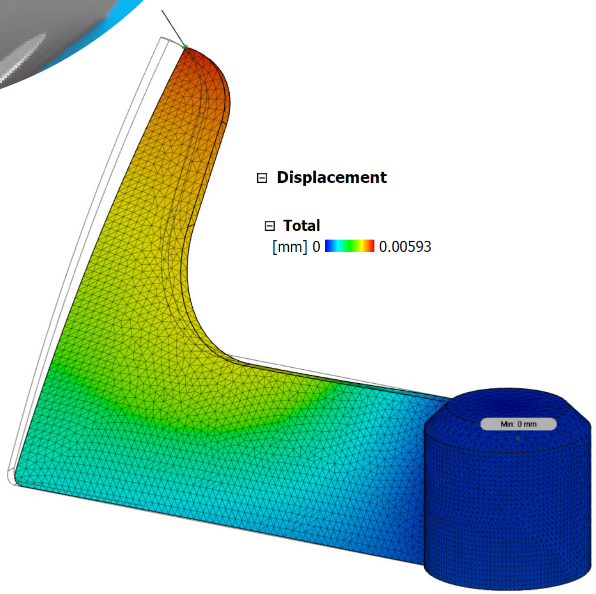
For the bowl, this part would ideally be formed by deep drawing. The sheet would be inserted into a punch and die of the perfect size and pressed into shape.

However, the small scale at which this product would be manufactured is a factor. Although more skill is required, spinning is a cheaper alternative with results as good as identical from the end user's perspective.

Given either technique, the rectangular top would need cut out after the processing.

Key Features



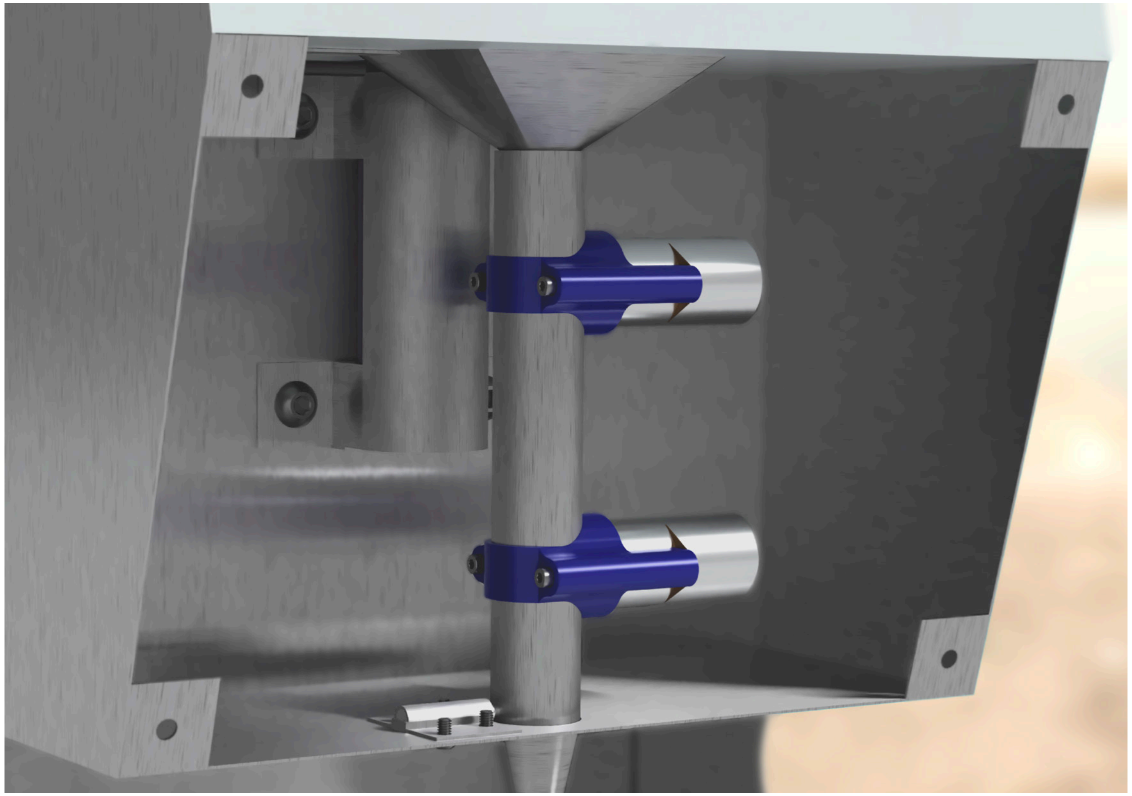


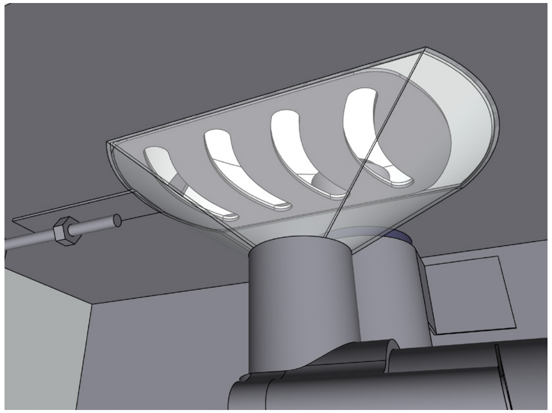
Inside the top bowl is a motorised stirrer to increase the temperature dispersion from the heated bowl.

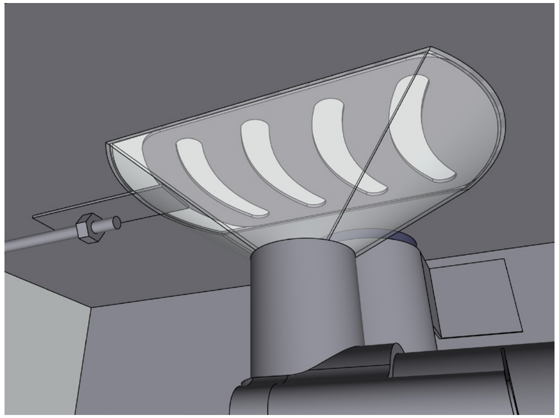
To determine what size of motor would be necessary, a finite element analysis study was done of the arm to simulate it pushing a maximum load of 3kg of chocolate.

The maximum torque required was then calculated to be 0.6 Nm. With a generous safety factor, the motor selected has a torque just over 1.8 Nm and a rotational velocity of 30rpm.

Key Features







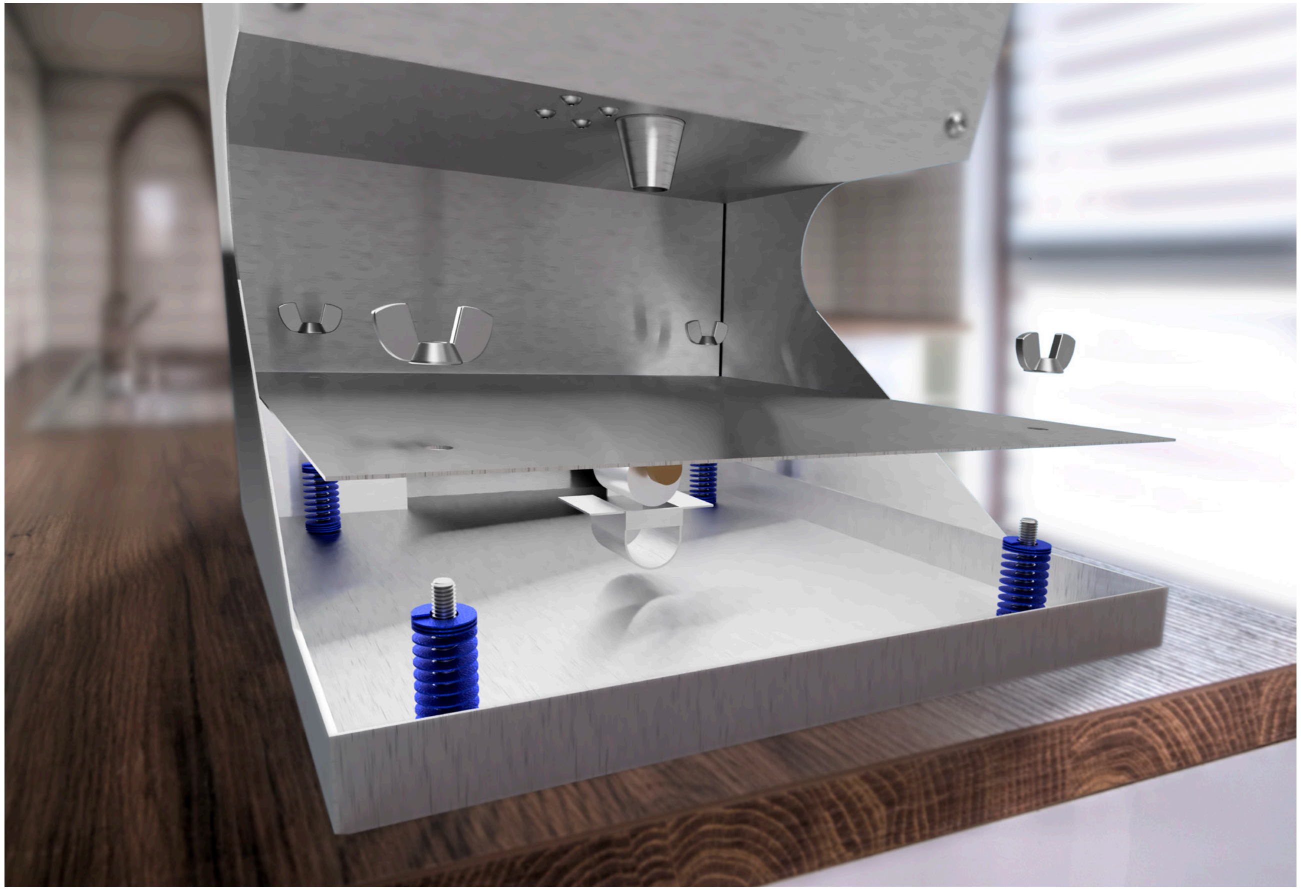
On the underside of the bowl is a vent, opened by a threaded shaft motor. Unlike the cams, this opening is big enough to allow the chocolate to flow through.

The vent cover is sheet metal and built with a kink between the face and neck to allow it to be completely flush with the bowl when closed.

The funnel sheet metal also, and due to the more complex geometry it has to be deep drawn. This won't be as expensive due to the smaller size compared to the bowl, but will still raise the tooling costs.

To attach, it is welded to the panel below the bowl, which is not attached to the bowl itself. If the user wishes to clean thoroughly, the bowl sheet can be unscrewed to provide access.

Key Features



The bottom surface is home to a vibrating plate. The vibration motor is tucked into a casing, attached to the underside with an adhesive. When the connections are unsoldered, the motor can be removed if need be.

The plate is free to vibrate in the z direction because it is not secured to the bottom of the machine. 6M bolts are welded in place and medium load blue die springs are put over the top. When the wing nuts are secured, the plate can still move up and down without coming off the shafts.

The user has full control of the starting and stopping of the nozzle from the switch at the top. The plate, however, will turn on automatically from the first temper unless the user navigates the menu with the rotary encoder to turn it off. This is common for most units with a vibrating pate.

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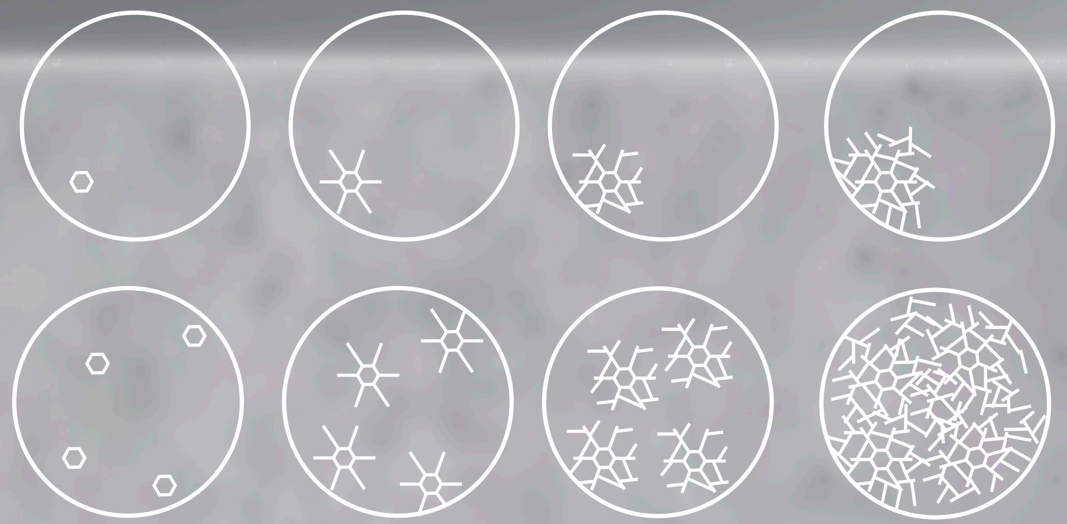
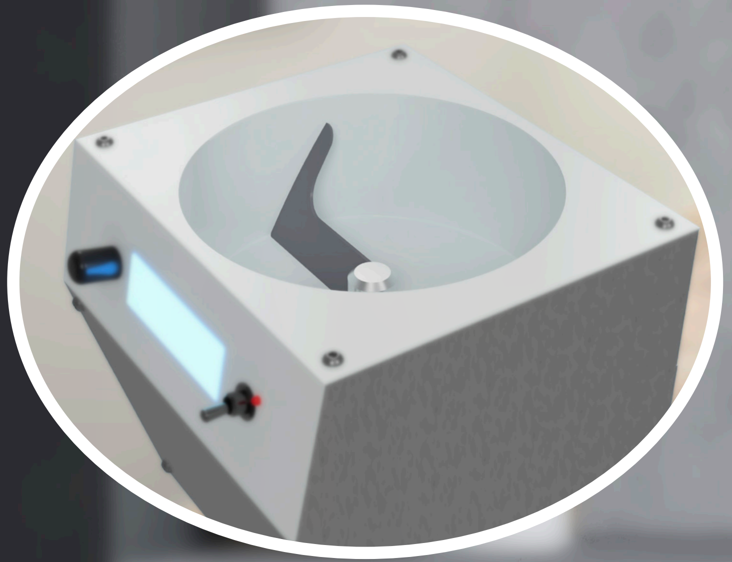
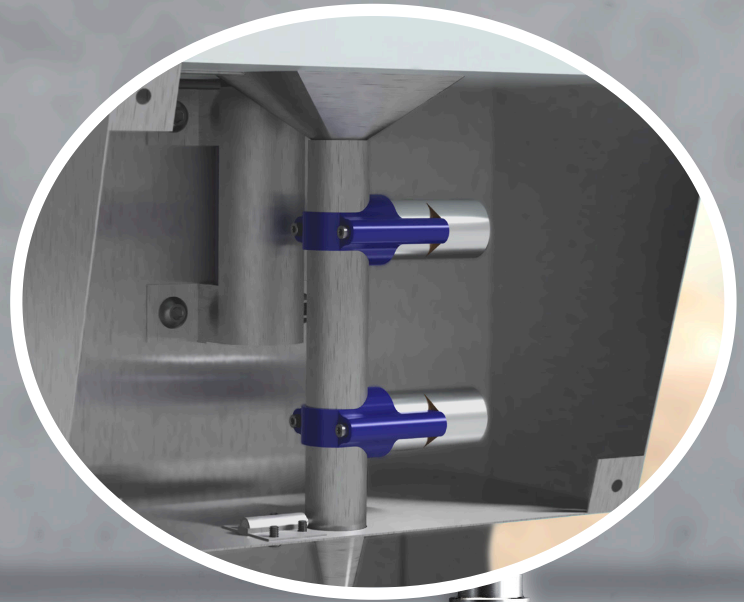
Utilising Ultrasonic Cavitation to Temper Chocolate Faster

While traditional tempering allows nucleation sites to form naturally during cooling...

...sono-tempering encourages more nucleation sites. This allows the chocolate to reach full temper much faster.







Chocolate is first added to the bowl on top, where it is heated and stirred to melt.

It then passes through the transducer tube, where ultrasound is applied to encourage crystal growth.

The flowrate is controlled to ensure a full temper when it comes out the nozzle.

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