PCCA™

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PCCA RAM Compounder Unit

User's Guide

Resodyn ACOUSTIC MIXERS

Table of Contents

Safety, Support and Warranty Information

Every effort has been made to assure that the PCCA RAM is easy to use, reliable and safe. This section will outline general safety considerations and define caution and warning symbols used in this document.

General Safety Considerations

For safe operation, the PCCA RAM should be operated only within the limits outlined in the system specifications. Specifically the following classification defines acceptable use for the PCCA RAM:

- Indoor Use Only.
- Main supply voltage fluctuations are not to exceed ±10% of the nominal supply voltage.
- This equipment is suitable for continuous operation.

Warnings and Cautions

Throughout the manual, the following symbols are used to identify warnings and cautions:

	*The caution symbol indicates a potential hazardous situation which could result in minor injury or damage to the product*
	*The high voltage symbol indicates the possibility of electrical shock.*
	*Electrostatic Discharge (ESD) sensitive components*

Other Symbols

	*Calls the user's attention to practical ideas or tips*

Important Safety Notes

This equipment should only be operated by trained and qualified personnel.

Mixing operations can generate heat and internal pressure depending on material and mixer accelerations. Do not mix material longer than what has been characterized as safe.

Do not attempt to run the machine without a mix container holder, equipment damage may result.

Do not disable or tamper with any safety items on the PCCA RAM.

Do not mix reactive materials in sealed containers as pressure may build and explode the mixing container, potentially causing serious injury or death.

Do not mix materials that build pressure in sealed containers as pressure may build to a level that explodes the mixing container, potentially causing serious injury or death.

Troubleshooting and Service

The PCCA RAM systems should only be operated when it is in good working condition. If the system shows any signs of visible damage or fails to operate as outlined in this manual, the system should not be operated.

For operational errors and troubleshooting, refer to the Troubleshooting section.

If necessary, contact your PCCA customer service representative for formulation questions or the contacts provided below for additional technical support related to the mixer.

Technical Support for Mixer Operation:

Phone: (406) 497-5333 Fax: (406) 497-5206 e-mail: service@resodynmixers.com	Resodyn Acoustic Mixers 130 North Main, Suite 630 Butte, Montana 59701

Warranty

1. **LIMITED WARRANTY:**

Seller warrants that for a period of one (1) year from the date of Seller's shipment of Product to Purchaser or 2,000 hours of machine time, whichever occurs first, its Product is free from defects in material and workmanship. Some newly manufactured Seller Products may contain, and Seller Service may use, remanufactured parts which are equivalent to new in performance. The warranty period for the Product is a specified, fixed period commencing on its date of shipment, or the date of installation if installed by Seller. Seller does not warrant that the operation of Products will be uninterrupted or error free.

If Seller receives written notice of defects from Purchaser during the warranty period, Seller will, at its option, repair or replace the affected Products.

The warranties provided herein will apply only to those Products and integral components thereof that are identified by a unique PCCA RAM part number and for any Service provided by PCCA employees or their authorized agents. Seller does not warrant any third party Products or Service even if included with other PCCA RAM Branded Products or Service. Furthermore, Seller provides all such third party Products and Service AS IS. However, the original manufacturers or suppliers may provide their own warranties as specified in the documentation accompanying such third party Products and Service.

The above warranties do not apply to defects resulting from:

a.) Improper or inadequate maintenance by Purchaser.
b.) Unauthorized modification.
c.) Improper use or operation outside of the Specifications for the Product.
d.) Abuse, negligence, accident, loss, or damage in transit.
e.) Improper site preparation.
f.) Unauthorized maintenance or repair.

THE ABOVE WARRANTIES ARE EXCLUSIVE AND NO OTHER WARRANTY, WHETHER WRITTEN OR ORAL, IS EXPRESSED OR IMPLIED. TO THE EXTENT PERMITTED BY LAW, SELLER SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE, AND NONINFRINGEMENT.

In no event shall Seller be liable for any consequential damages, or damages of any kind, or nature alleged to have resulted from any breach of warranty.

Introduction

The PCCA RAM is an advanced, low-frequency, acoustic mixer. The patented, enabling technology, ResonantAcoustic® mixing (RAM), is an innovative approach to multiple mixing applications. These include applications such as powder-powder systems, liquids, creams, highly viscous gels and pastes, as well as sieving and grinding (with the proper vessels and attachments).

RAM Mixing provides:

- Exceptionally uniform mixing demonstrated for a broad range of pharmaceutical products.
- Short mixing times.
- Completely sealed process, eliminates dusting during the mixing process resulting in enhanced operator safety.
- Repeatable results from mix-to-mix, ensuring batch-to-batch product quality

All of this leads to the conclusion that PCCA RAM Compounder Unit will rapidly become "The Pharmacist's Best Friend."

System Overview

The PCCA RAM is a ResonantAcoustic® Mixer specifically manufactured for compound pharmaceutical applications. Figure 1 illustrates the main external features of the PCCA RAM. The machine is composed of four main components, which include the Platform, Acoustic Enclosure, Control Dashboard, and the Standard Vessel Fixture.

Figure 1: PCCA RAM Mixer External Features

ResonantAcoustic® Mixing Platform

The PCCA RAM is made possible through patented technology known as ResonantAcoustic® Mixing (RAM). RAM mixing delivers energy to the mix material by accelerating the platform, shown in Figure 2 at forces of 40, 60 or 80 g's of acceleration. (Three user settings of low, medium, and high are provided; one at each of these three g levels.) Two silicone bellows assemblies protect the user from contact with the resonator assembly beneath the payload as well as preventing any spilled pharmaceutical material or residue from contact with the moving parts in the dynamic environment of RAM technology.

⚠	During operation the Driver Plate, Fixture, and Vessel, are vibrating up to 80 g's at nominally sixty times per second. Serious bodily injury is possible if one comes into contact with these moving surfaces.

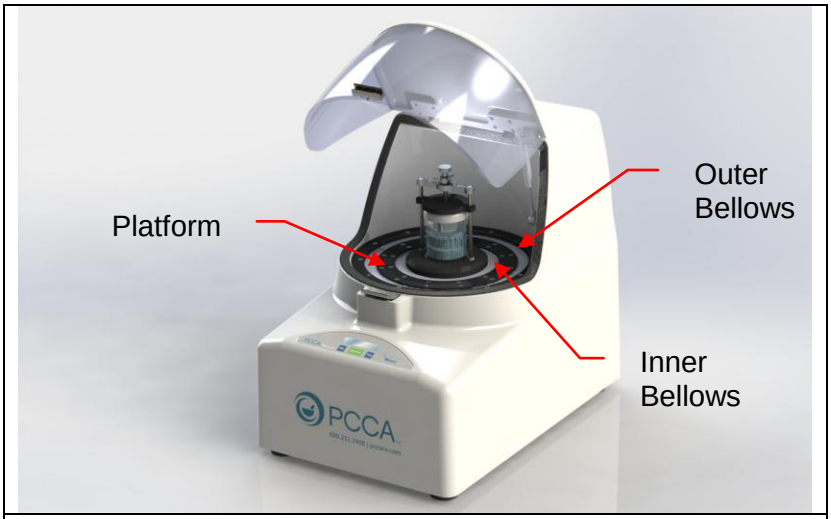


Figure 2: PCCA RAM Platform

Acoustic Enclosure

The Acoustic Enclosure surrounds the patented resonator system. See Figure 3. The enclosure reduces sound of the PCCA RAM, and covers moving parts that could pose a risk to operators. A gas cylinder assisted lid provides access to the mixer to load and unload mixing containers. The lid is opened via a stainless steel latch on the front of the Acoustic Enclosure.

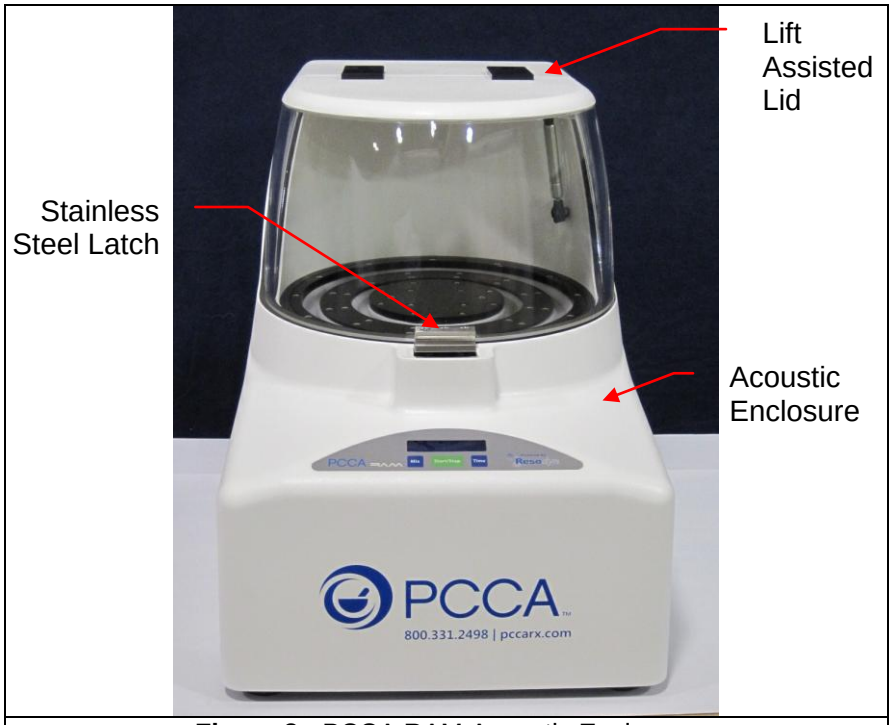


Figure 3: PCCA RAM Acoustic Enclosure

Control Dashboard

The Control Dashboard is the user's primary source for interaction with the mix materials. See Figure 4. The mix button enables selection of the three mixing levels (low, medium, or high), while the time button enables selection of the desired discrete length of mixing (10 seconds, 30 seconds, 1, 2, 3, 4, or 5 minutes). Similarly, the start/stop button enables commencement of mixing or cessation in the event something is observed prior to the expiration of the pre-designated mix time. An on/off switch is located on the back of the machine near the power cord. (See Figure 9 below.)

Figure 4: PCCA RAM Control Dashboard

Standard Vessel Fixture and Vessels

Vessels of various sizes and a Hold-down Fixture are available through Resodyn Acoustic Mixers. Other vessel applications are adaptable to the PCCA RAM system. (A custom Hold-down Fixture to handle most any shape of vessel for your particular mixing application can be designed for unique applications).

Hold-down Knob Turning the Hold-down knob clamps the vessel in place. The knob is coupled to an ACME thread which in turn is connected to the Upper Base. Turning the knob raises and lowers the Upper Base.

Jam Nut The Jam Nut is used to lock the vessel in place. The Jam Nut discourages the Hold-down knob from vibrating loose during operation. The jam nut is set after the mixing vessel is tightened down using the Hold-down Knob.

Vessel Spacer (Optional Accessory Not Shown) Vessel Spacers are used to accommodate various vessel heights. When using shorter vessels, one or more spacers are stacked together. That way, the vessel will be positioned within the clamp stroke of the Hold-down knob.

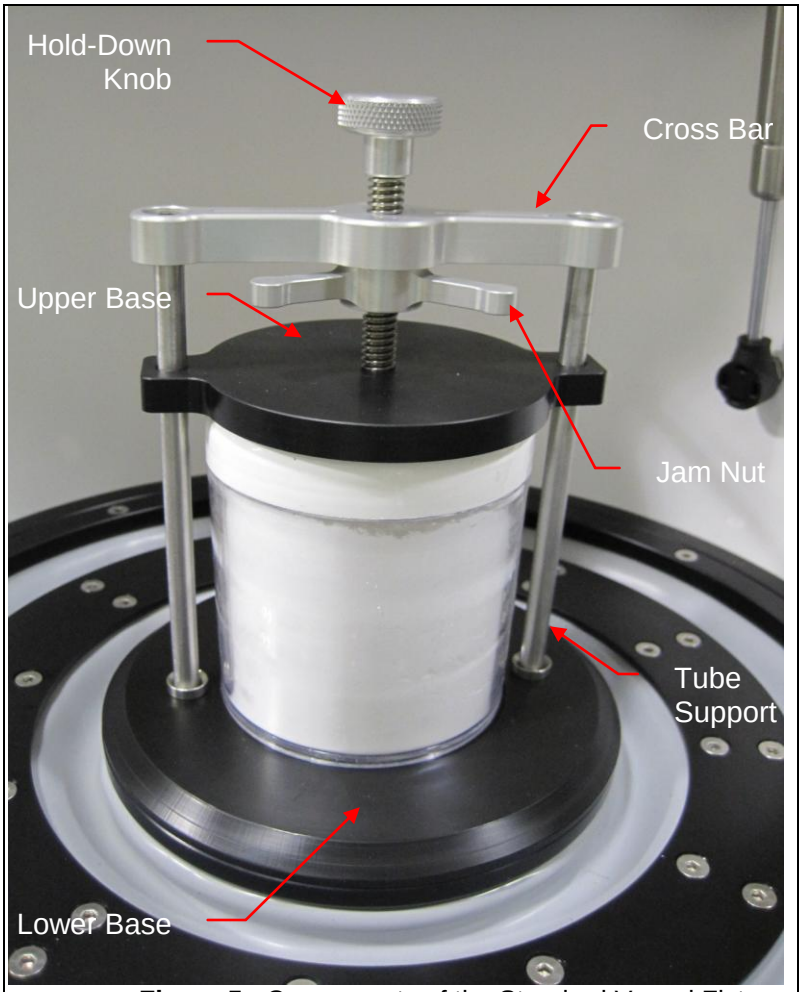


Figure 5: Components of the Standard Vessel Fixture

Unpacking the Machine

Two people should remove the PCCA RAM from its box by lifting in the front and rear of the machine as indicated in Figure 6.

⚠	*Do not lift alone! Your PCCA RAM weighs 153 pounds. Serious injury or machine damage may result if the user attempts to unpack without proper assistance.*

Please retain all packing materials in the unlikely event the mixer needs to be returned to the manufacturer for warranty or service work.

Figure 6: Two people unpacking the PCCA RAM

Setup

The PCCA RAM should be installed on a stable rigid surface capable of supporting 175 pounds.

Positioning the PCCA RAM

The PCCA RAM footprint is represented in Figure 7(all dimensions are stated in inches):

The PCCA RAM is cooled by drawing room air from behind the mixer and exhausting out the upper section of the back panel. For correct operation, the PCCA RAM should be installed with a minimum air gap of 2 inches between the wall and back panel. The manufacturer envisions placement on a standard laboratory bench, however if the user's specific environment involves the use of overhead shelves please note that an additional 11 inches of clearance would be required to accommodate opening of the lid.

Figure 7: Machine Footprint Occupied by the PCCA RAM

Remove the Shipping Lock Bar

The PCCA RAM is shipped with a Lock Bar to secure the resonator during transportation. Accordingly, in order to properly operate the machine it is necessary to remove the Lock Bar for access to the Platform.

Remove the 3/16" Allen Wrench from its shipping bag.

Using the provided Allen Wrench, remove the two screws securing the lock bar across the mixing platform.

Remove the Lock Bar and retain along with screws for future transport of mixer.

Figure 8a: Removing the Allen Wrench

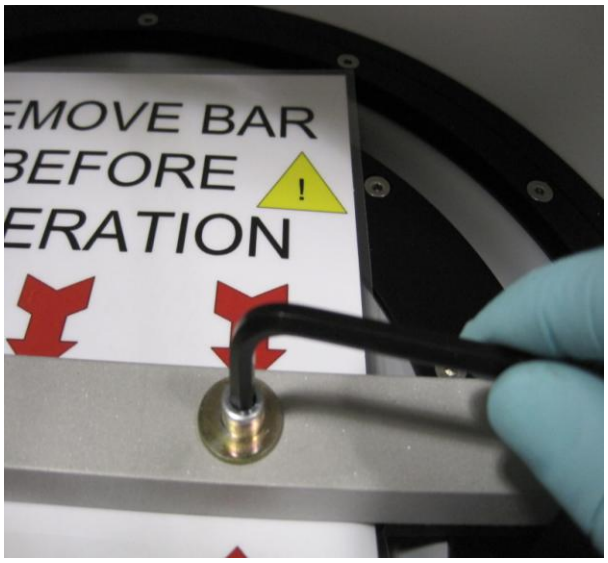


Figure 8b: Removing the Lock Bar

Connect Power Supply

To connect the Power Supply to the PCCA RAM, refer to Figure 9.

Attach the AC power supply cable to the Power Supply in the location shown and to an appropriate 110 Volt, 15 amp source.

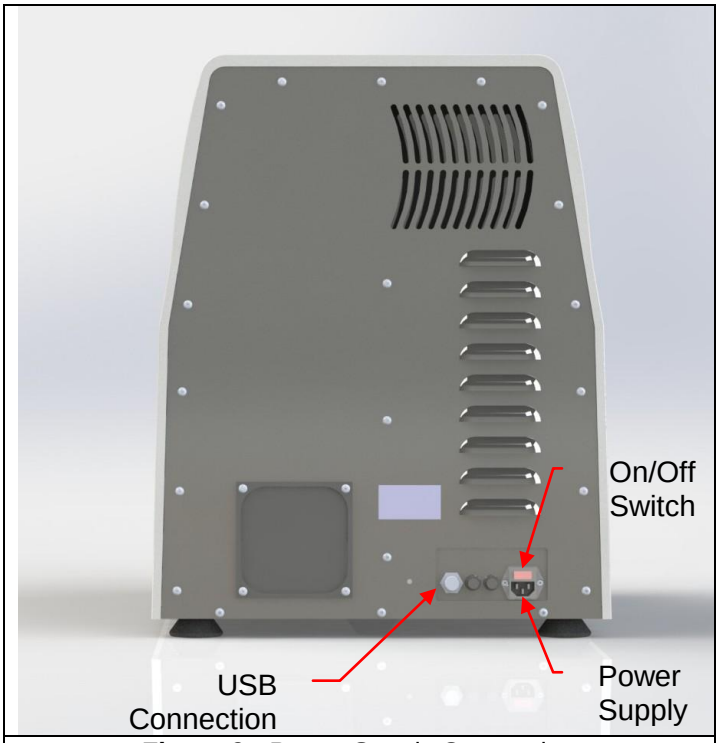


Figure 9: Power Supply Connection

Attach Hold-Down Fixture

Mounting holes for attaching the PCCA RAM Hold-Down Fixture are provided in the Platform. Tighten the ¼-20 Socket Head Cap Screws as far as possible using the provided 3/16" Allen wrench (it is not possible to over tighten) as seen in Figure 10.

⚠	On the highest setting, the PCCA RAM Mixer accelerates at 80g's, where 1 g equals the acceleration of gravity on the surface of the earth Care should be taken to secure the screws as tightly as possible with the tool provided to avoid the Fixture and Vessel vibrating loose during operation.

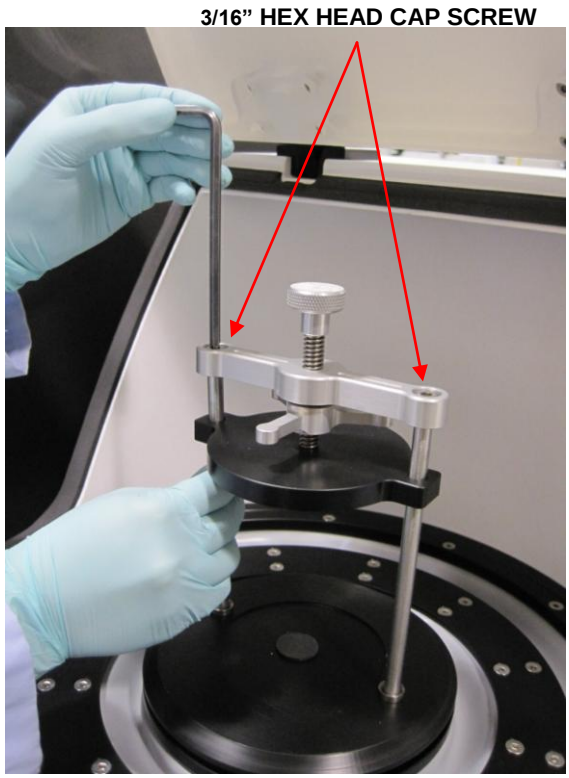


Figure 10: Attaching the Hold-Down Fixture

Specifications

The following specifications highlight key features of the PCCA RAM.

Description	Range		
Mixing Acceleration	40, 60 or 80 g^		
Mixing Frequency	58 – 66 Hz Varying Load		
Acceleration Control	"Mix" selector button for three acceleration settings of "Low" "Medium" "High"		
g equivalent acceleration for mix setting	40	60	80
Mix Time Selection	"Time" selector button to facilitate choice of seven time durations from 10 seconds, 30 seconds, 1, 2, 3, 4, or 5 minutes.		

^**1 g =acceleration of gravity on the surface of the earth**

Mix Container Load Capacity

Description	Specification
Maximum Mass per Batch	300 grams

Operating Mode

Description	Specification
Program – Timed	Fixed acceleration and time, with a countdown timer visually representing the relative time remaining in the mix cycle.

System Specifications

Description	Specification
Input Power	500W Max, 90-125V / 60Hz
System Weight	153.2 lb
Size (H X W X D)	25"H x 18" x 24"
Operating Temperature & Humidity	15°C - 40°C Maximum 95% relative humidity (non-condensing)

 # At "High" mix setting, fully loaded, back panel 2" from wall. The amount of noise may vary nominally with the placement of the PCCA RAM within the room, total payload being mixed, and mixing intensity.

Operation – Quick Start

This section defines the minimum steps required to operate the machine. This assumes machine has been set on a rigid surface, machine power is on, and a vessel hold-down fixture has been properly installed.

Open the Lid

Press down firmly on the stainless steel latch located on the front of the machine, just above the control dash board and allow the lid to open fully.

Secure the Vessel

Insert a vessel.

Tighten down the Hold-Down Knob clock wise at the top of the fixture until snug.

Tighten the Jam Nut clock wise to lock the vessel into place.

Close the Lid

Secure the lid with one hand, while holding the latch open with the other.

Push downward on the lid until the lower edge of the lid bracket has cleared the upper edge of the latch, and release the latch (ensuring that the lid remains in place).

Start

Pushing the start button will commence mixing of the vessel for the mixer's default time setting of ten (10) seconds.

Completion

Opening the lid and removing the mix container completes the mixing cycle.

- When the status bar contains the word "Stopped", the mixer lid can be opened by depressing the stainless steel latch on the front of the lid.
- When the lid stops moving open, release the Jam Nut by turning counter clockwise and Hold-Down Knob by turning counter clockwise until the vessel can be removed from the fixture.
- Remove the vessel.

Operation

Turn on Power

To turn on the power, simply toggle the rocker switch on the rear of the PCCA RAM, to the "ON" position.

Open the Lid

To access the Vessel Fixture, it is first necessary to open the lid as indicated in Figure 11.

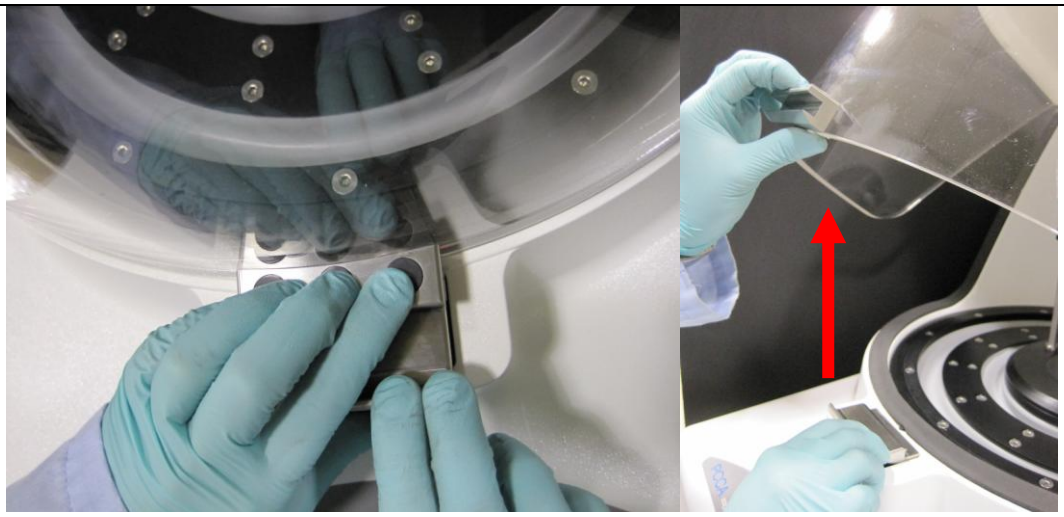


Figure 11: Opening the Cast Acrylic Lid for the PCCA RAM

Press down firmly on the stainless steel latch located on the front of the machine, just above the control dash board.

The lid will now release, and fully open thanks to the gas driven lid assist cylinder.

Operators are cautioned to not stand directly over the latch when opening, as the efficient motion of the lid assist device, as well as the hinge design automatically sends the lid outward and upward.

Install Vessel & Close the Lid

To install vessels into the fixture refer to Figure 12.

Insert a vessel.

Tighten down the Hold-Down Knob clockwise at the top of the fixture until snug.

Tighten the Jam Nut clockwise until secure against the crossbar to lock the vessel into place.

⚠	Do not overload mix vessel. Adherence to the maximum weight is required for proper operation and machine life.

⚠	The Hold-Down Knob and Jam Nut must be firmly seated in place. Failure to do so may result in the vessel vibrating loose during operation.

Depending on the size of your vessel, one or more of the Vessel Spacers (**not included**) can be inserted into the bottom of the fixture to help ensure a secure fit.

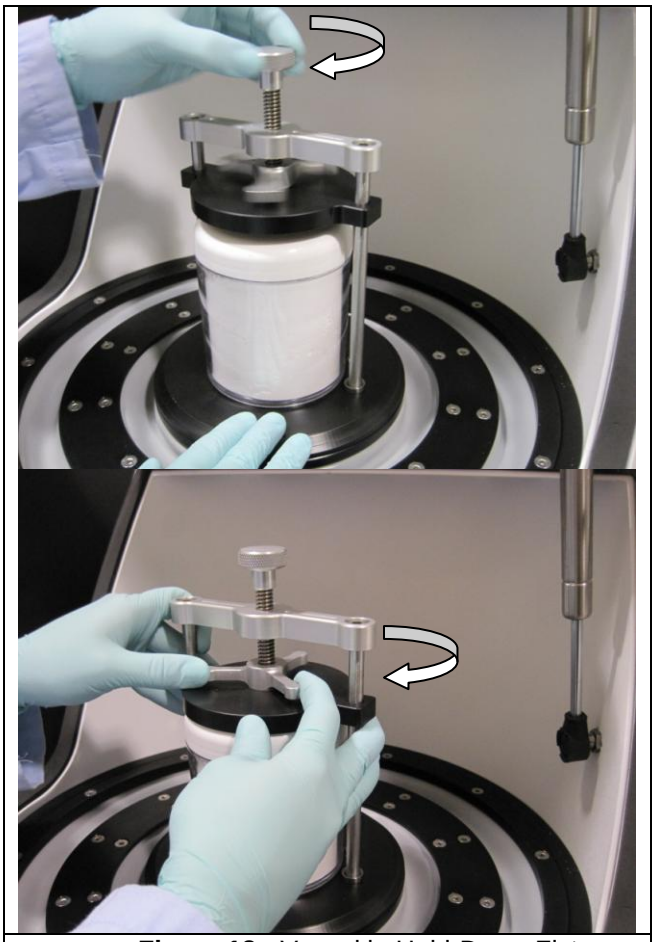


Figure 12: Vessel in Hold-Down Fixture

Close the Lid

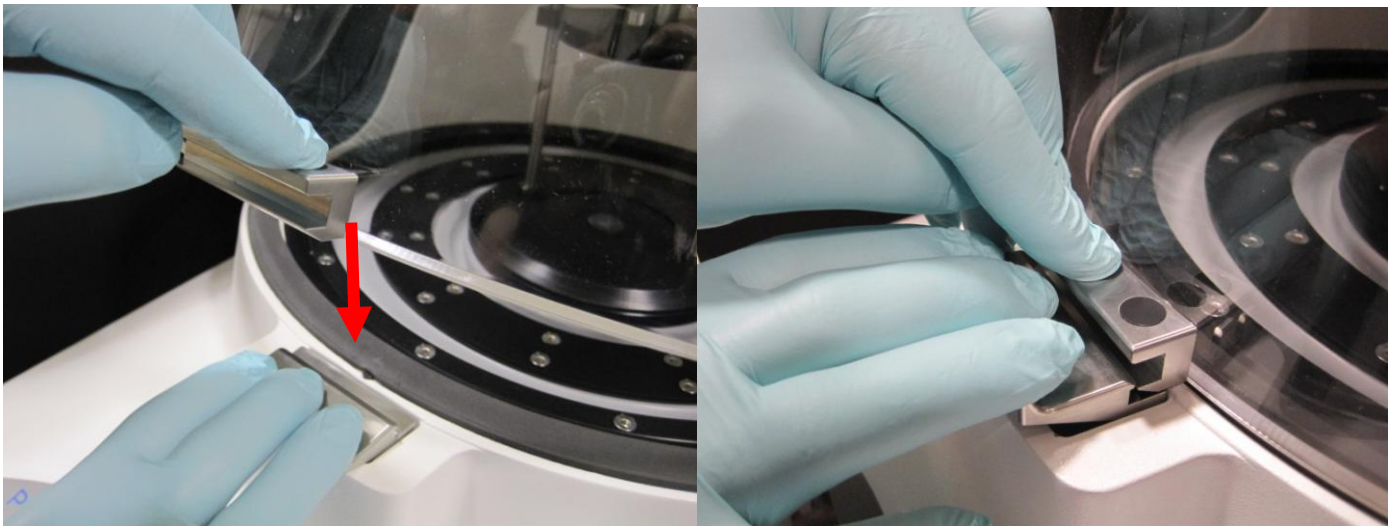


Figure 13: Closing the Cast Acrylic Lid for the PCCA RAM

Secure the lid with one hand, while holding the latch open with the other as seen above in Figure 13.

Push downward on the lid until the lower edge of the lid bracket has cleared the upper edge of the latch, and release the latch (ensuring that the lid remains in place).

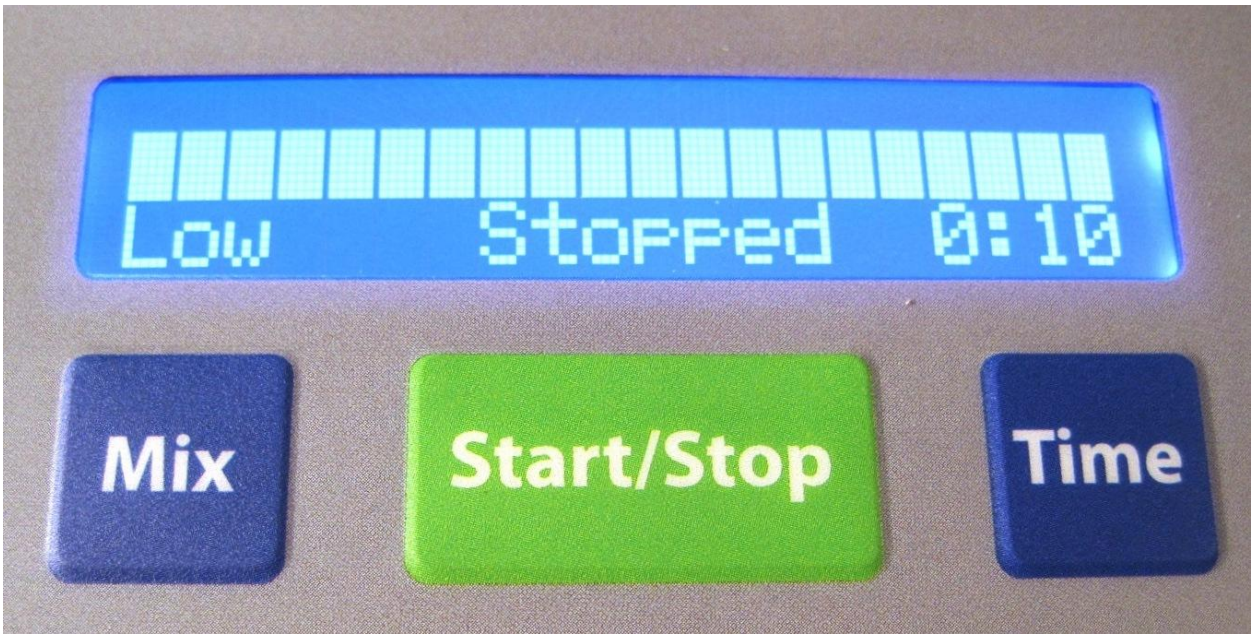
Note: The lid is equipped with a SAFETY INTERLOCK SWITCH. If the lid is not fully secured, the PCCA RAM will not commence mixing.

⚠	Do not attempt to override the SAFETY INTERLOCK SWITCH! During operation the Platform, Fixture, and Vessel vibrate up to 80 g's. Serious bodily injury may occur if one comes into contact with these moving surfaces.

Startup and Mixing Procedure

The user should find the simplified control dashboard, intuitive and very straightforward to use. To begin mixing follow the steps as outlined below:

When one Powers on the toggle switch in the rear of the machine, the following screen will be displayed:



Note that it displays:

- Mix Setting
- Status of the mixer (Stopped),
- Selected mix duration, and
- A bar indicating the proportional amount of time remaining in the current mix cycle. Here, no mixing has taken place so the bar fills the screen.

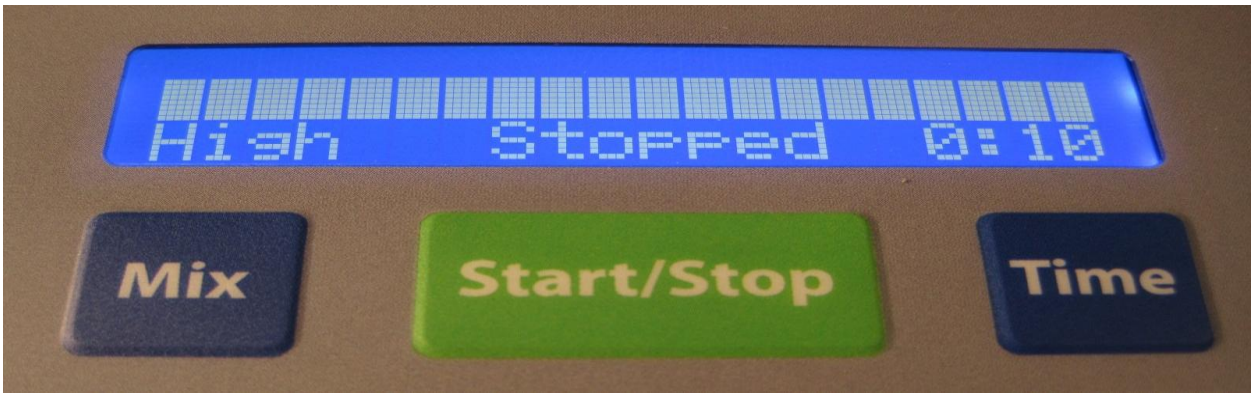
If the user were to push the "Start/Stop" button now, the mixer would operate for ten seconds at the "Low" g level (40 g's) before again coming to rest and displaying the same screen indicated above. Instructions for altering the mix parameters are found in the following section.

Adjusting Mix Acceleration

The PCCA RAM is equipped with a single, one directional "Mix" button for selecting between the three available acceleration choices of Low , Medium, or High.

To increase the mix acceleration press the "Mix" button once to go from Low to Medium;

or from Medium to High.



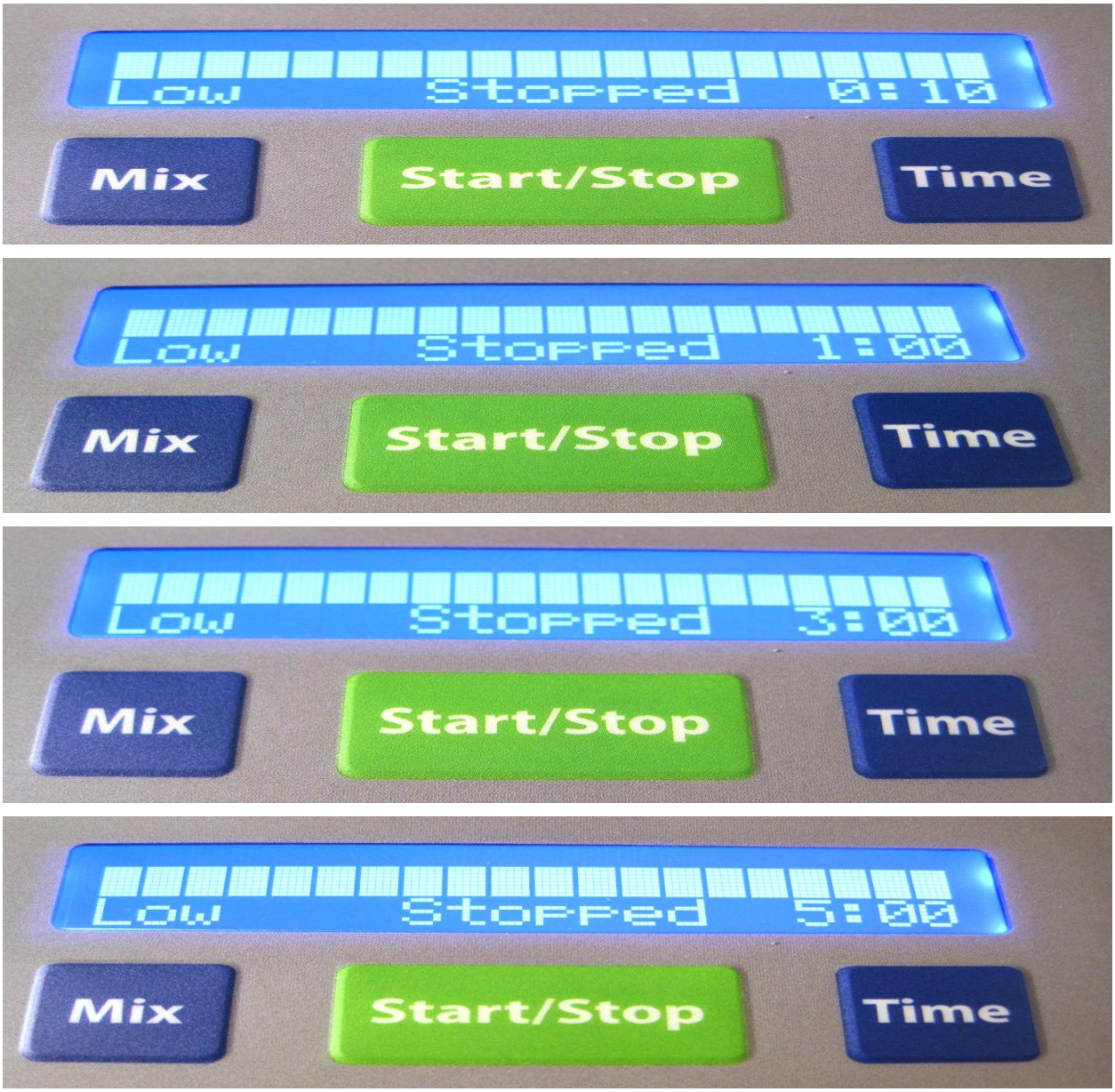
Pressing the "Mix" button once more returns the selection back to Low acceleration.

At any time during an active mix cycle, it is possible to adjust acceleration by pressing the Mix button until the new desired acceleration setting is displayed.

Time Duration

Much like the choice of mix acceleration, the PCCA RAM is equipped with a single, one directional "Time" button for selecting the user's choice of ten seconds to five minutes for a batch.

Pressing the time button once at the default screen will change the allotted time from ten seconds to thirty seconds, one, two, three, four, or five minutes as applicable.



Much like the Mix feature, pressing the time button again at five minutes returns the user to the low end of the scale (or ten seconds).

Unlike the mix feature, once a mix has commenced it is not possible to adjust the time duration (absent stopping the mix or opening the lid as discussed below).

Starting & Stopping a Mix

With the appropriate mix acceleration and time duration chosen, press the "Start/Stop" button to commence the mix.

Note that the status bar has changed to reflect "Running" and the count down timer is visually indicating the proportional amount of time remaining in the current mix cycle.

Stopping the mix at any time prior to the expiration of the selected time duration will pause mixing. This is true whether the user presses the green "Start/Stop" button, or if the lid is opened in the course of mixing triggering the safety interlock switch.

Depending on the reason for pausing the mix, a User may want to start again from the beginning or simply resume the current mix cycle. By pressing the "Start/Stop" button the user is prompted to either restart the mix from the beginning by pressing "Mix," or to finish the remainder of the current mix cycle by pressing "Time."

Troubleshooting

Here are some simple solutions to check before contacting your Resodyn Acoustic Mixers service representative. Use the following chart to resolve operational problems. If the problem persists contact your customer service representative.

Description of Problem	Potential Problem	Solution
Mixer will not power up	Power cord unplugged	Ensure that the power cord is plugged into the mixer and a wall outlet.
	Main fuses blown	Contact Resodyn Acoustic Mixers for replacement fuses.
	Power switch off	Ensure that the power switch (located on the back of the machine above power cord) is in the on position, "**I**".
Error: Lid Open	Lid opened before mixer stopped	Lid was opened when the mixer was running, which stopped the machine. Do not open the lid unless the mixer screen shows "Stopped" on the bottom line.
Error: Broken Accel.	Accelerometer cable or accelerometer has failed	Accelerometer and cable assembly must be replaced
Error: Amp Overheat	Mixer amplifier is too hot	Ensure adequate ventilation on the backside of the mixer.
		Ensure room temperature is within specified range.
Error: Over Temp.	Mixer enclosure is too hot	Ensure adequate ventilation on the backside of the mixer.
		Ensure room temperature is within specified range.
Error: Amp Fault	Vessel overloaded	Remove mix material until it is within the maximum specified load limits.
	Shorted wire	A wire to the mixer's motor is damaged and needs to be replaced.
	Broken wire	A wire to the mixer's motor is damaged and needs to be replaced.
Error: Overloaded	Vessel overloaded	Remove mix material until it is within the maximum specified load limits.
Error: Over Current	Vessel overloaded	Remove mix material until it is within the maximum specified load limits.
	Shorted wire	A wire to the mixer's motor is damaged and needs to be replaced.

Only trained maintenance and service personnel should remove acoustic enclosure

Care and Maintenance

Resodyn Acoustic Mixers are assembled at our corporate facilities in Montana, under a strict quality manual and overriding corporate philosophy of building world class equipment for our customers that are built to last.

In order to help ensure long life and pristine maintenance however, it is important to participate in general cleaning and maintenance as indicated below.

General Cleaning Instructions

Plastic Acoustic Enclosure

The Plastic Acoustic Enclosure is coated with a Gloss White, Polyurethane, Textured powder coating. Clean with a soft, non-abrasive cloth and water with slight additives of neutral washing agents (pH 5 – 8). Greasy or oily substances may be removed by rubbing with a cloth wetted with isopropyl alcohol (IPA) or white spirit free of aromatic compounds.

If IPA is used for cleaning, do not allow overspray to contact cast acrylic lid. Significant damage to finish will occur.

Rinse with damp, cold water after every cleaning process to remove any remnants of the cleaning process.

Do not use solvents or similar containing esters, ketones, aromatics, or halogenated hydrocarbons. Do not use strong acids alkaline detergents or abrasives.

Cast Acrylic Lid

Clean with soft, non-abrasive, 100% cotton cloth and water with slight additives of neutral washing agents (pH 5 – 8). Commercially available ammonia-free acrylic and plastic cleaners with anti-fog, anti-static, and dust repellent additives may also be used.

Do not use detergent, abrasive cleaners or isopropyl alcohol and do not use paper towels.

Recommended Spare Parts

Despite our pristine service and maintenance record, we do understand that some customers operate in environments where any downtime is catastrophic. Accordingly, we do offer a line of user replaceable parts.

Spare Parts List		
Description	**Part Number**	**Quantity**
Accelerometer & Integrated Cable Assembly	102103	1
Ball End, Gas Spring	002051	1
Inner Bellows Gasket	101841	1
Outer Bellows Gasket	101842	1
Lid Gasket	101844	1
Fuses	002187	1

Appendix A – RAM Mixing Overview

ResonantAcoustic® Mixing (RAM) Overview

The RAM technology approach for acoustic mixing works on the principle of creating micro-mixing zones throughout the entire mixing vessel, as well as macro (bulk) material flow fields. This approach differs from conventional mixing technology where mixing is localized at the tips of the impeller blades, at discrete locations along the baffles, or by co-mingling products induced by tumbling materials. This new technology provides faster, more uniform mixing throughout a vessel than can be created by conventional, state-of-the-art mixing systems. RAM technology has an added advantage that it does not use impellers or other intrusive devices to mix, and does not require unique vessel designs for a broad range of mixing applications.

RAM technology is compatible with many types of materials, which include liquid-liquid, liquid-solid, gas-liquid, and solid-solid systems. The technology can be utilized to mix low viscosity, highly viscous and non-Newtonian systems, as well as solid-solid systems in the same types of vessels, without changes to impeller design, baffles, or other complicated, intrusive components, such as injectors and nozzles.

RAM technology is designed to operate at mechanical resonance. At this operating condition the RAM technology results in a near lossless transfer of the mixer systems' mechanical energy into the materials being mixed. This is created by the propagation of a pressure wave in the mixing vessel. This condition is achieved by matching the mechanical operation of the mixer with the properties and characteristics of the range of materials to be mixed. The operating characteristics of the mixer are automatically sensed and controlled to keep the system at the mixing acceleration established to provide the best mixing performance.

Achievement of these mixing conditions requires a methodology that is patented and unique to RAM and RAM control technology; unachievable by any other mixing technology in the industry. For example, in conventional mixers the mechanical systems are typically designed to specifically avoid operating at resonance. This condition can quickly cause violent motions, which leads to catastrophic failure of the system. However, when designed correctly a mechanical system operating at resonance enables even small periodic driving forces to produce large amplitudes of vibration that can be harnessed to produce useful work. For RAM, this operating methodology is enabled through a system designed to conserve energy by balancing kinetic and potential energy in a controlled resonant operating condition.

In the RAM systems, the potential energy is stored in the springs and the kinetic energy is kept in the plates, or masses, that are coupled to the springs. The masses oscillate in a vertical motion, Figure 14. The resonant frequency is defined as the frequency at which the mechanical energy in the system can be conserved between potential energy stored in the springs and as kinetic energy in the moving masses.

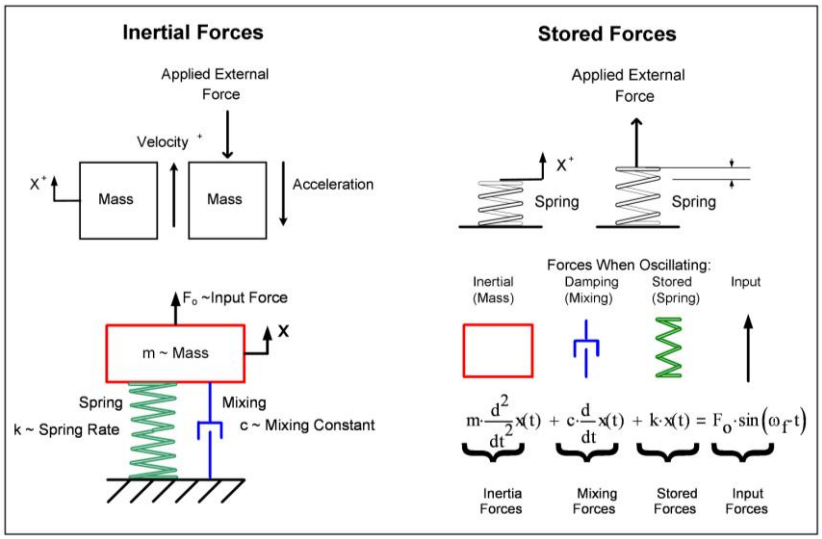


Figure 14: Simplified Representation of the Mass, Spring and Damper (Mixing Media) System In Resonance.

For the RAM technology, it is the mixing system as a whole that is operated at mechanical resonance, which is nominally at 60 Hz. The exact frequency of mechanical resonance during mixing is only affected by the payload vessel (plus contents). The mix vessel contents are termed the "Mixture".

The resonant mechanical system is the "Mixer". The mixer operates on mechanical resonance. The mixture affects the mixers mechanical resonance frequency, by 1) the amount of material in the mixing vessel, 2) how well the material couples to the vessel, and 3) how much energy the mixture absorbs during mixing.

The amount of mixture mass affects the operating frequency because, as the payload mass increases, the operating frequency decreases. Conversely, a lighter mass will produce a higher operating frequency. The vessel weight, volume of contents, and specific gravity, are all components of the "static" payload mass. If the mixture mass is fully coupled, i.e., riding along with the vessel and not mixing, the resonant frequency will drop to the same frequency as if a mass of equivalent weight as the mixture was added to the mixer. Conversely, if the material is fully decoupled, i.e., not mixing, then the resonant frequency will become very close to that of an empty vessel. However, for all conditions of coupling between the two extremes, the resonant frequency will change depending on the amount of coupling.

Payload damping affects the amount of input force (intensity) required to accelerate the payload. Damping is a difficult number to predict for materials. However, a general understanding of what influences the amount of damping, and how damping affects the system has been compiled, which will serve as talking points in this discussion. The primary factors that affect damping are: 1) viscosity; 2) head space (amount of air or void in the mixing container above the mixture), 3) internal mix vessel pressure (vacuum, partial vacuum, ambient pressure, or pressurized); 4) temperature, and 5) vessel acceleration. Higher damping imposed by the materials being mixed requires higher input forces (intensity) to achieve a specific acceleration on the payload vessel. Damping is defined as the energy going into the mixture during mixing.

Payload acceleration is a measure of the amount of acceleration imparted onto the mixture vessel. It is measured in units of *g*. One *g* = 9.81 m/s^2. Through mixing trials and experience,

the amount of acceleration required for a specific process will be determined. Higher damped mixed materials, i.e., higher viscosity materials, will typically absorb more energy during mixing than lower damped materials, i.e., low viscosity materials. As such, higher damping materials typically require higher intensities to achieve the same payload acceleration compared to the lower damped materials. The PCCA RAM mixer is controlled by setting the desired acceleration and the mixer automatically controls the frequency.

The diagram in Figure 14, above, shows a mass moving with some velocity. In order to slow down the mass (decelerate) there needs to be an applied external force. When the mass decelerates, the lower velocity results in the mass having lower kinetic energy. Figure 14 shows that a spring can store potential energy when an applied external force compresses, or stretches the spring. The energy stored in the spring is greater when the deflection is large, and reduces to zero when the spring is not distorted. The lower left diagram in Figure 14 provides a representation of a spring-mass system. In this case, the "mixing" function is modeled as a damper, which absorbs energy when the system is in motion. A second order non-homogenous differential equation that describes the forces present during oscillation is shown in Figure, lower right. This equation shows the relationship between the forces due to the moving masses, the deflected springs, and the mixing process. The expression shows that these forces are equal to the mechanical force driving the system.

The principle of Resonance in ResonantAcoustic® Mixing is illustrated in both Figure 14(above) and Figure 15. ResonantAcoustic® mixers are comprised of multiple masses and multiple springs, known as a three-mass system, that are simultaneously moving during mixing. The basic behavior of the mixer is best understood by considering the simplified case shown in Figure 15.

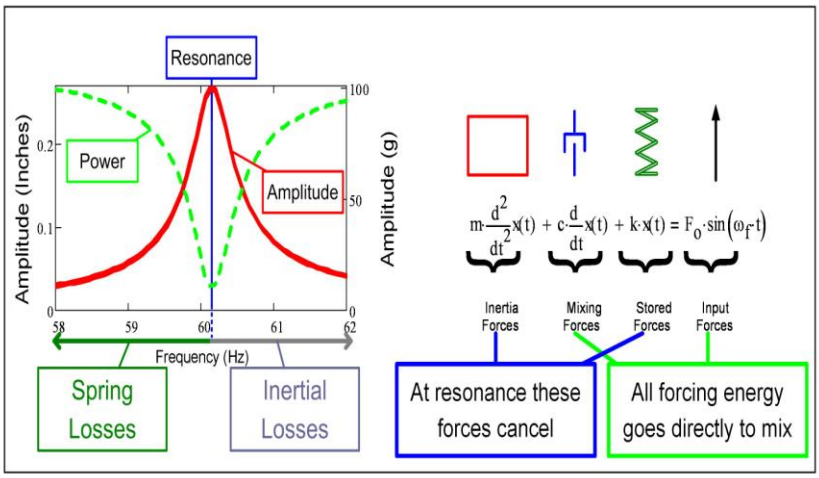


Figure 15: Differential Equation and Plots of Oscillation Amplitude and Power vs. Frequency Showing the Benefit of Resonance.

The differential equation is repeated in Figure 15, and is coupled with the diagram above, as a means to illustrate when resonance occurs. At a particular oscillation frequency, the resonant frequency, the stored forces in the springs are directly offset by the inertia forces of the masses, and cancel over one period of oscillation. Thus, the system can oscillate without the need for charging the spring, or providing energy to the mass during the cycles. The plot on the left side of Figure graphically illustrates that for frequencies below resonance, energy is lost in charging the springs, and above resonance energy has to be added to maintain the inertial energy. The result of operating at resonance, as shown by the red and green curves, is that the amplitude of the oscillations reaches a maximum, while the power required is at a minimum. The power consumed by the system is transferred directly into the mixing media.

With the system oscillating at resonance, the acceleration of the load-plate imparts a boundary condition on the vessel contents that is transmitted through the vessel contents as a pressure wave. Energy used in creating the mixing movement will add to the damping of the overall system, and the material contents will add to the mass. However, the amount of energy that must be transferred into the materials in order to satisfy the boundary condition will be dependent on a combination of many material and vessel geometry constraints. Some of these constraints are: the height of column of material to be moved (vessel fill height), the compressibility of the material, and its stickiness, or coupling of the material to the vessel walls, material density, vessel geometry, internal vessel pressure, vessel percent fill, and mixing regime.

During the mixing operation, the mix media may transition through different regimes. A regime is defined as mixing with a defined flow pattern. A regime change typically causes the materials coupling with the payload vessel to change. Because a change in the coupling causes a shift in the resonant frequency, a resonant tracking feature termed "Smart Mixing Technology" (SMT) is included. SMT controls the mixer frequency and acceleration, which keeps the mixer operating on the resonant peak at the desired preset acceleration.