

Calculating Mixing Power

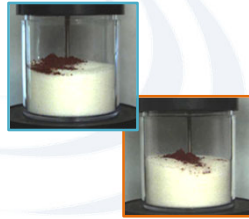
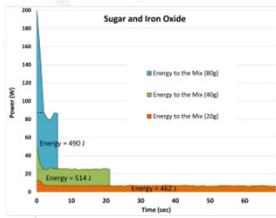
Justin Whaley
Engineering Manager
Resodyn Corporation



The United
InterChange 2025

Power Into the Mix

- Mix Power Transmission is Driven by the of the Resonator but is Dependent on Mix Properties
- Mix Power is a Quantitative Measure of Mixing Performance



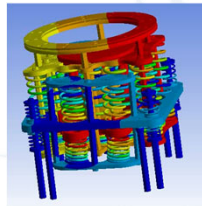
2

The United
InterChange 2025

Lumped Parameter Mixing Model

- Power Into the Mix is Driven by the Oscillating Motion of the Resonator and is Dependent on Mix Properties
- The Lumped Parameter Method is a Simplified, but Effective Approach that Correlates System Inputs with RAM Mixing Performance

Mixing Parameters	
RAM Parameters	Acceleration
	Frequency
	Temperature
	Vessel Pressure
Vessel Choice	Processing Order
	Vessel Dimensions
	Fill Height
Mix Material	Order of Addition
	Viscosity / Cohesion
	Density
	Particle Size

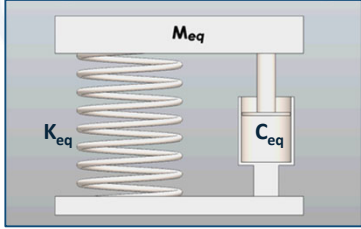


3

The United
InterChange 2025

Lumped Parameter Mixing Model

- Power Into the Mix is Driven by the Oscillating Motion of the Resonator and is Dependent on Mix Properties
- The Lumped Parameter Method is a Simplified, but Effective Approach that Correlates System Inputs with RAM Mixing Performance



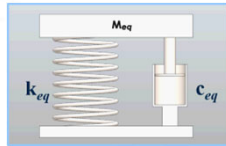
Lumped Parameter Mixing Model

• Mixing Parameters

Numerous Physical Parameters are Simplified to 4 Equivalent Lumped Mixing Terms

Mixing Parameters

RAM Parameters	Acceleration
	Frequency
	Temperature
	Vessel Pressure
	Processing Order
Vessel Choice	Vessel Dimensions
	Fill Height
	Order of Addition
Mix Material	Viscosity / Cohesion
	Density
	Particle Size



$$m_{eq} \ddot{x} + c_{eq} \dot{x} + k_{eq} x = f(t)$$

- m_{eq} = System Mass
- c_{eq} = Equivalent Damping
- k_{eq} = Equivalent Stiffness
- $f(t)$ = Motor Force

Lumped Parameter Model & Resonance

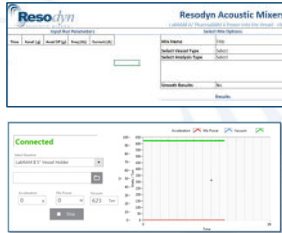
- On Resonance Inertial and Potential Forces Exchange Without Loss

$$m_{eq} \ddot{x} + c_{eq} \dot{x} + k_{eq} x = f(t)$$

- Changes to Mix Power are Reflected in Changes to the Motor's Force

LabRAM Mix Power Calculators

- Worksheet can be used to simplify calculation based on historical data.
- Power Viewer app logs mix power in real time using a laptop.
- Custom baselines can be calculated on request.



The United InterChange 2025

LabRAM Mix Power Calculators

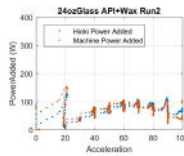
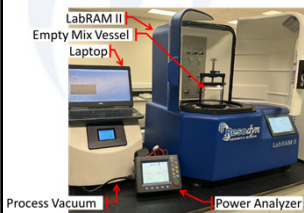
- Mix Power calculated on a USB connected laptop
- Results graphed in real-time as the mix progresses



The United InterChange 2025

Validating Mix Power Equation

- Mix power results validated using a line power analyzer



Test #	Test Description	Avg Error (W)	STD (W)	Relative Error
1	Water 200 gm Run 1	5.7	5.9	3.1%
2	Water 200 gm Run 2	5.7	6.3	3.1%
3	Water 200 gm Run 3	7.5	7.7	4.1%
4	Water 400 gm Run 1	11.3	16.2	2.7%
5	Water 400 gm Run 2	9.8	12.6	2.4%
6	Water 400 gm Run 3	7.6	7.9	1.8%
7	AlOx 200 gm Run 1	6.1	7.2	2.4%
8	AlOx 200 gm Run 2	4.1	5.0	1.6%
9	AlOx 200 gm Run 3	8.9	10.7	3.5%
Average		7.4	8.8	2.7%



12

The United InterChange 2025

Mix Power Considerations

- Limitations when Measuring the RAM Mix Power
 - Small samples (<30 gm)
 - Low accelerations (<20 g)
 - Operating with a different vessel holder from baseline
 - Work done on air does not always contribute to material mixing in the vessel



16

Summary

- Lumped Parameter Model Effectively Correlates System Inputs with the RAM Mixing Performance
- Mix Power Measures the Change in Power Level Relative to a Known Baseline
- Mix Power can be Calculated while Running or by Using a Run's Datalog

17

Thank you for your time
and attention.