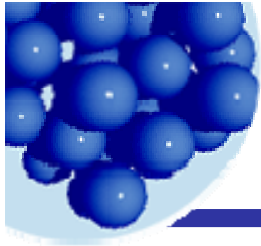


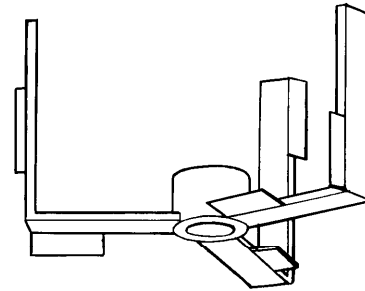
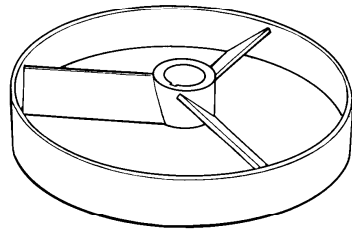
Lecture 9

Processing emulsions and suspensions

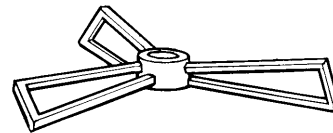
Dispersions in liquids: suspensions, emulsions, and foams



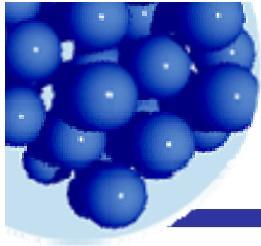
High Speed Mixers



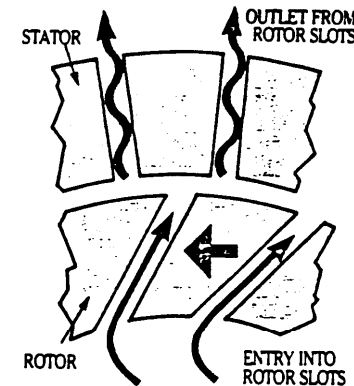
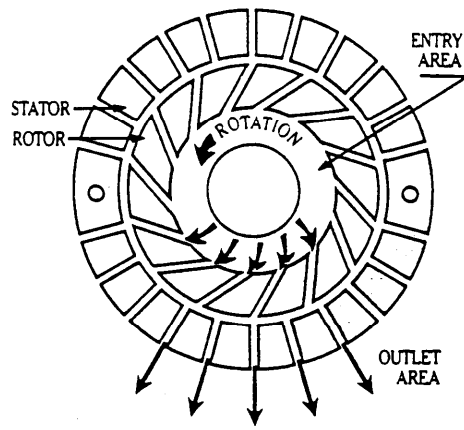
Typical speeds are 3,000 to 4,000 RPM, the cavitation limit.



$$\begin{aligned} \text{Shear rate} &\approx \frac{3,000 \text{ RPM} \times 1 \text{ meter circumference}}{0.5 \text{ M from blade to wall}} \\ &= \underline{100 \text{ sec}^{-1}} \end{aligned}$$



Kady Mills

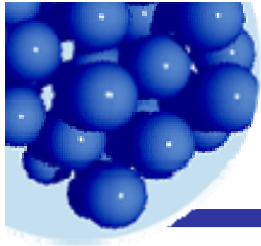


Disadvantages: Not suitable for ultrafine particles, 1 poise maximum viscosity.

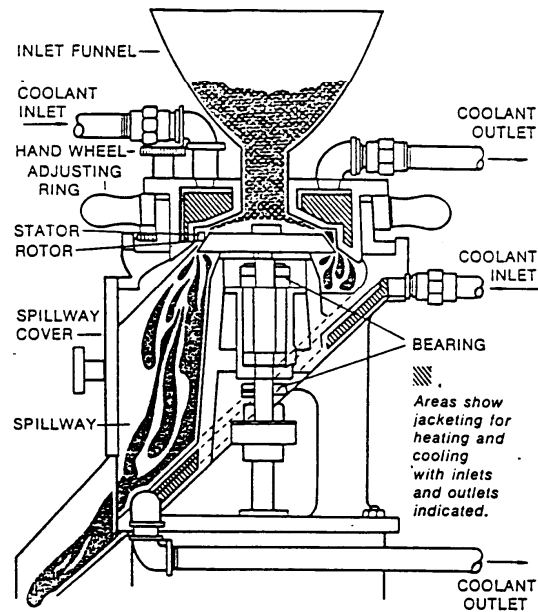


Advantages: High throughput, inexpensive, few moving parts.

[/www.eigerus.com](http://www.eigerus.com)



Colloid mill



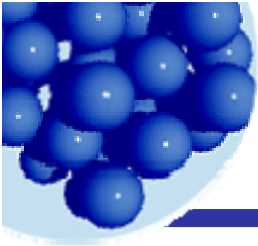
Sherman, 1968, p. 10



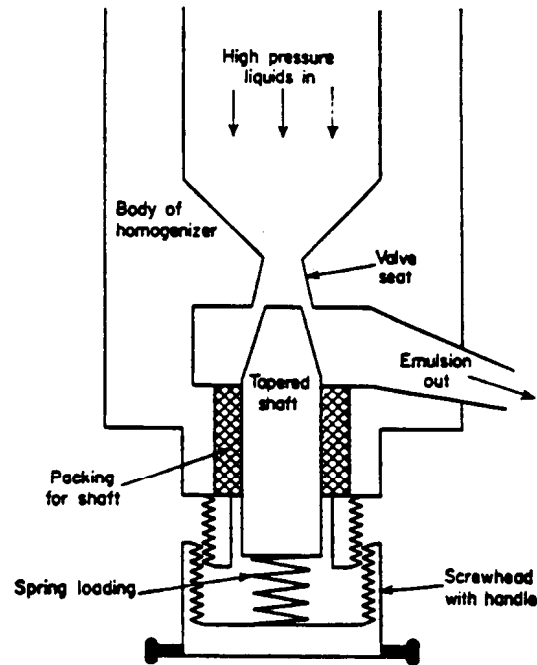
www.gowcb.com/sites/premiermill/colloid.asp

Liquid, drawn by gravity, passes a spinning rotor adjusted to give a narrow gap between the rotor surface and the stationary walls.

The spinning rotor pulls the liquid into long thin films which break into droplets as they emerge.

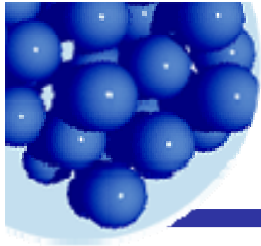


Homogenizer



One type of single stage homogenizer.

Gopal in Sherman, Ed., 1968, p.11.

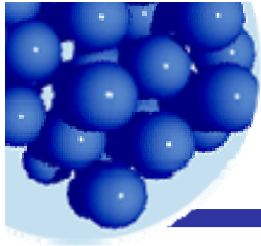


Microfluidizer

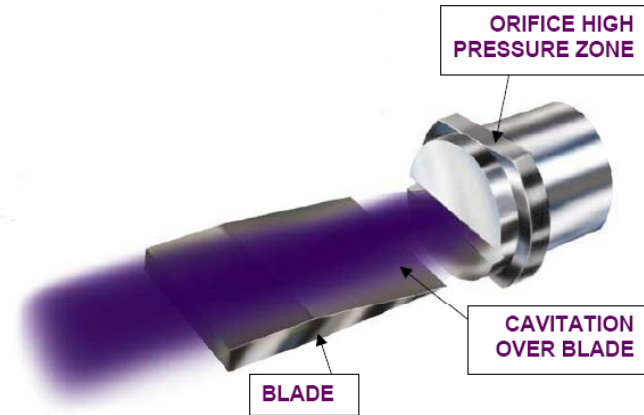
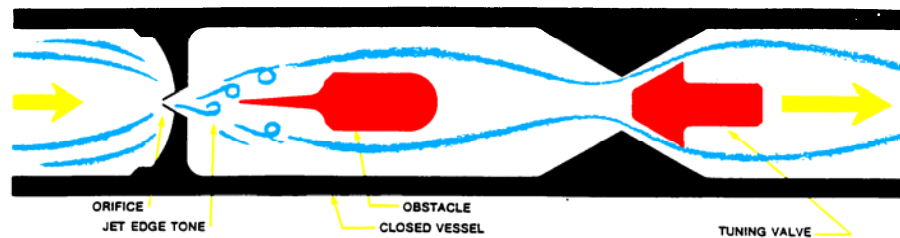


A variation of a homogenizer in which fluid streams at high velocities are forced against each other in geometrically defined microchannels.

www.microfluidicscorp.com



Sonolator



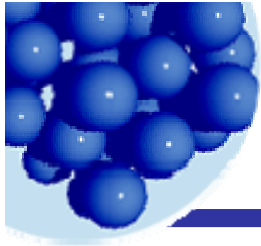
Converts the kinetic energy of high-velocity stream of liquid into high-intensity mixing action.

Runs at 200-2000 psi compared to 3000-5000 psi in the homogenizer.

System is “tuned” by adjusting the tuning valve to produce a maximum of acoustic energy!

The obstacle oscillates at high frequencies resulting in cavitation, turbulence, and shear.

Courtesy of Sonic Corporation,
Stratford, CT



Ultrasonic mills*

Typically are in the shape of a blunt horn of various diameters.

An electrostrictive material (alternating voltage makes it expand and contract) is used to convert 60 Hz line current into 20 kHz ultrasonic vibrations.

The ultrasonic vibrations cause cavitation

Capable of bringing particle sizes down to a few tenths of a micron.

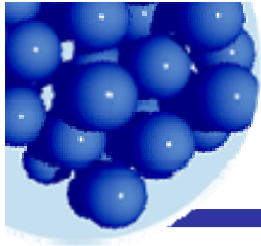
Steady-state size is a function of the additive and the horn-tip amplitude.



www.omni-inc.com

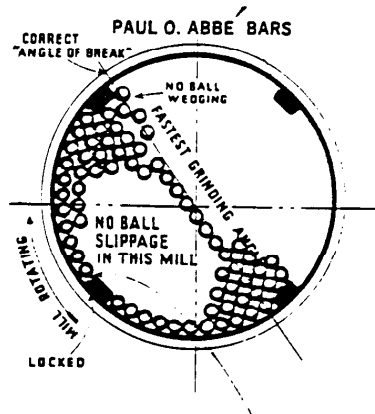
Don't use in the lab what can't be used in production!

(*More recently these are called “homogenizers” from their use in biology.)



Ball Mills

Ball Mill – any mill in which steel or iron balls are used as the grinding medium. The cylinder is usually also made of steel.



Courtesy of Paul O. Abbe, Inc.

Variables:

- amount of grinding medium
- amount of material
- viscosity
- wet versus dry
- size of grinding medium
- composition of grinding medium

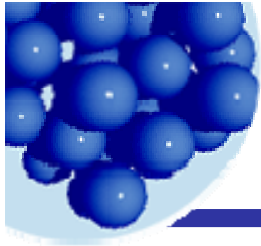
Pebble Mill – any mill in which flint pebbles or porcelain balls are used as the grinding medium, and the inside of the cylinder is lined with some non-metallic substance.

Advantages:

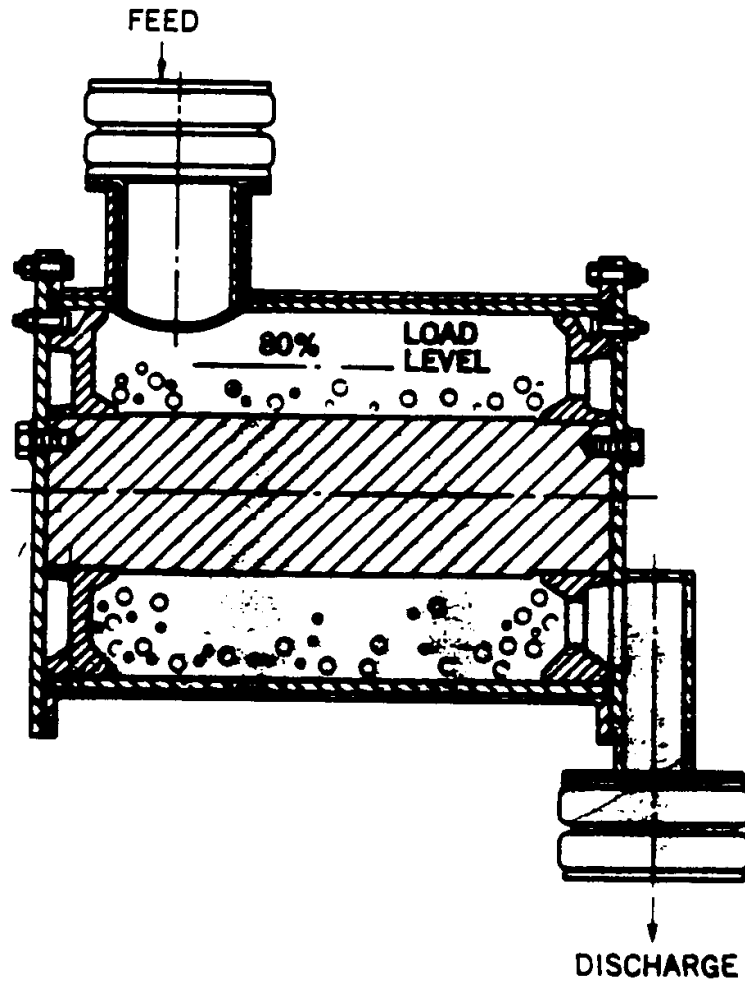
- handles a wide variety of materials
- easy (safe) to use
- closed container

Disadvantages:

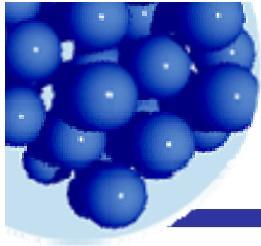
- difficult to empty
- steady milling requires constant speed adjustment
- difficult to cool
- difficult to vent



Vibrating ball mill



www.sweco.com



Attritors

Stirred Ball Mills

Advantages:

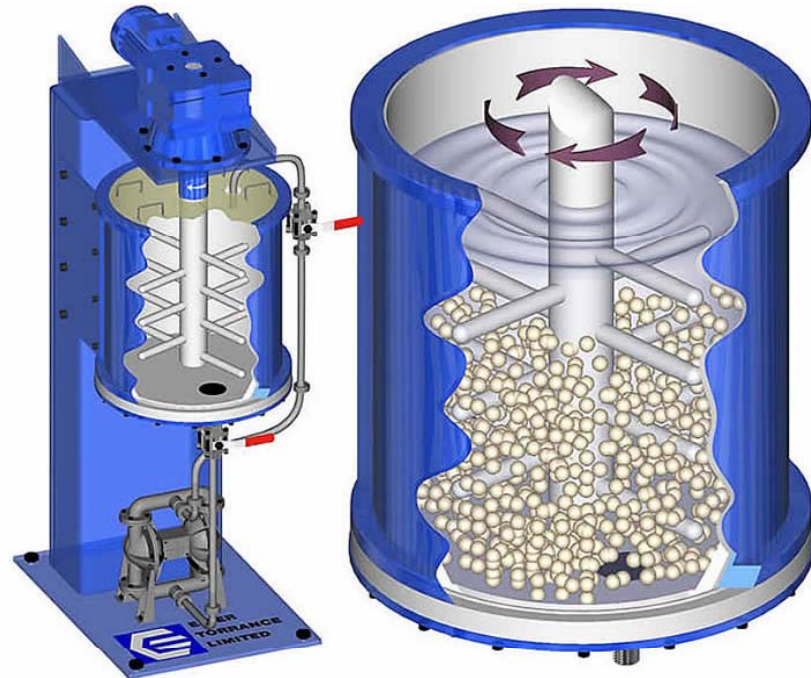
The milling action is controlled effectively by adjusting the rotation of the stirring blades.

Cooled with a water jacket

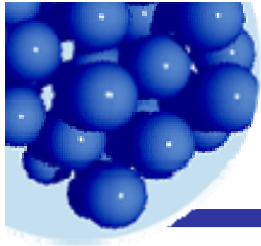
Disadvantages:

Small particles may deform rather than break.

Contamination



www.eigerus.com



Horizontal media mills

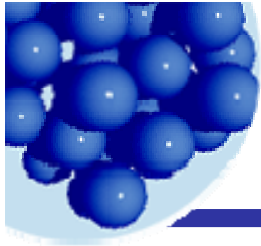
More control over the physics of the milling - size , concentration, and composition of the milling media; temperature, milling rates and variations over time including feedback algorithms.

Previous students have sworn about the control enabled by horizontal media mills, including variations in media and temperature dynamically changed.

Expensive.

www.eigerus.com and several more.





Sand mills

Impeller disk attached to a shaft rotating at a selected speed in a container of standard grinding medium and the dispersion mixture.

Essentially highly efficient ball mills.

Typical grinding medium:

Ottawa sand 20-30 mesh

Advantages:

Very high quality of dispersion.

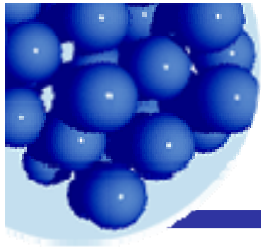
High through-put.

Disadvantages:

Difficult to clean

Requires good pre-mix.

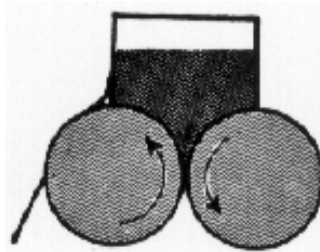




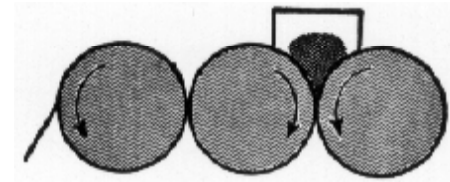
High viscosity mixtures - Roll mills



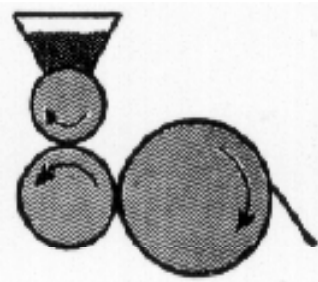
Dodge mill



Two-roll paste mill



Three-roll ink and paint mill

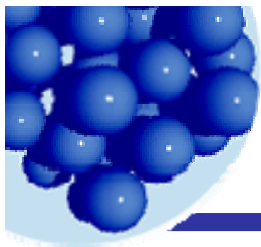


Plymouth mill

Fisher, p. 281.



www.threerollmill.com



Roll Mills

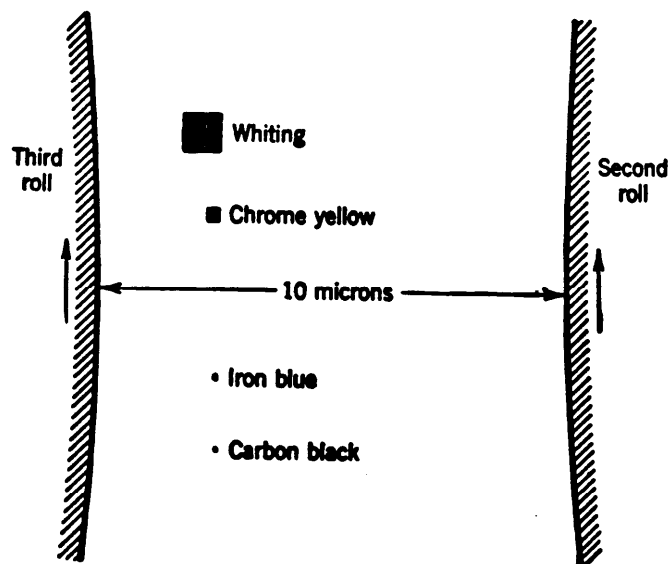
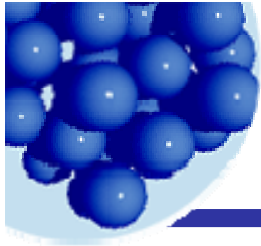


Diagram comparing clearance between rolls and size of primary pigment particles as approximated for three-roll mill during operation.

Large gaps mean low shear rates - milling is only possible at high viscosity.

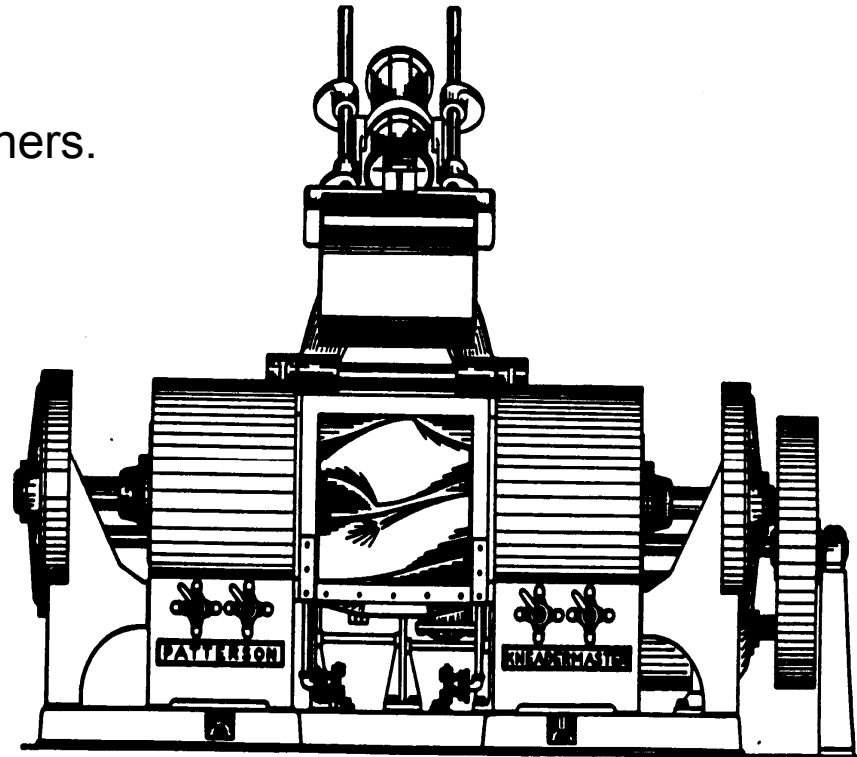


Mills for high viscosities

Most common for plastics, e.g. toners.

Generally heated, high torque, low shear rates.

Not very efficient mixing or dispersion.



Courtesy Patterson Foundry and Machine Co.